July 15, 2021

SENT VIA EMAIL AND OVERNIGHT MAIL

Administrator Michael Regan
U.S. Environmental Protection Agency
1301 Constitution Avenue, NW
Washington, DC 20004
Email: Regan.Michael@epa.gov

RE: Petition for Rulemakings Regarding Hydrofluorocarbons Under the American Innovation and Manufacturing Act of 2020

Dear Administrator Regan:

The California Air Resources Board (CARB) and the Attorney General of California, the Attorneys General of Massachusetts, Connecticut, Delaware, the District of Columbia, Illinois, Maryland, Minnesota, New Jersey, North Carolina, Oregon, Vermont, and Washington, the City of New York, the Connecticut Department of Energy and Environmental Protection, the Delaware Department of Natural Resources and Environmental Control, the Maryland Department of the Environment, the Massachusetts Department of Environmental Protection, the New York State Department of Environmental Conservation, the Oregon Department of Environmental Quality, the Vermont Department of Environmental Conservation, and the Washington State Department of Ecology (collectively, the States) submit this petition for rulemaking pursuant to the Administrative Procedure Act (APA)[1] and the American Innovation and Manufacturing Act of 2020 (AIM Act).[2]

Hydrofluorocarbons (HFCs) are extremely potent greenhouse gases that proliferate in cooling systems, building foams, and aerosols, among other uses. Eliminating the production and consumption of HFCs is critical to addressing climate change. Therefore, the States respectfully request that the U.S. Environmental Protection Agency (EPA) use its AIM Act authority to: (1) reinstate the HFC prohibitions that it originally promulgated under the Clean Air Act's Section 612 Significant New Alternatives Policy (SNAP) program[3]; (2) promulgate additional federal standards, modeled on California's proposed standards, that further reduce HFC emissions from the largest HFC-consuming end-uses; and (3) at a minimum, reinstate the refrigerant management requirements for HFCs that were previously part of EPA's regulations under the Clean Air Act's Section 608 Refrigerant Management Program.[4]

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[1] 5 U.S.C. § 553.
[2] 42 U.S.C. § 7675, Pub. L. 116-260, § 103.
[3] *See* 42 U.S.C. § 7671k(a).
[4] *See id.* § 7671(g).

1. Background

a. HFCs and their Federal Regulatory and Legal History

In 1987, the United States signed the Montreal Protocol, an international treaty that requires signatory nations to regulate the production and use of ozone-depleting substances (ODSs), which degrade the ozone layer in the Earth's stratosphere. To comply with the Montreal Protocol, in 1990 Congress amended the Clean Air Act to add Title VI,[5] which authorizes EPA to protect the global ozone layer by phasing out the production and consumption of ozone-depleting substances.[6] It also controls the use of certain ozone-depleting substances and their replacement substances (Section 612 authority)[7] by imposing specific maintenance, reporting, repair, and disposal requirements on cooling equipment to prevent ozone-depleting emissions (Section 608 authority).[8]

Beginning in 1994, EPA used its Section 612 authority to regulate and phase out certain uses of ozone-depleting substances, principally chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).[9] Specifically, EPA created the SNAP Program, a listing system by which EPA identifies acceptable and unacceptable substitutes for CFCs and HCFCs—including HFCs—in certain end-uses,[10] and establishes timelines by which those allowed substitutes must "replace" CFCs and HCFCs in those end-uses.[11] EPA also promulgated regulations under its Section 608 authority to develop a Refrigerant Management Program as it applied to ODSs. EPA's Section 608 Program provides that persons maintaining, servicing, repairing, or disposing of air-conditioning and refrigeration equipment containing more than 50 pounds of refrigerant must observe certain service practices that reduce emissions of ozone-depleting refrigerants.

ODSs have since been replaced with alternatives authorized under the SNAP program, including HFCs, in refrigeration and air conditioning equipment, insulation foam, and many other uses.[12] Unfortunately, although HFCs do not deplete ozone, they are powerful greenhouse gases,

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[5] Stratospheric Ozone and Global Climate Protection, S. 1630, 101st Cong., tit. VII (as passed by Senate, Apr. 3, 1990).

[6] *See* 42 U.S.C. § 7671, et seq.

[7] 42 U.S.C. § 7671k.

[8] *Id.* § 7671g.

[9] 40 C.F.R. Pt. 82, Subpt. G; 59 Fed. Reg. 13,044 (Mar. 18, 1994).

[10] 60 Fed. Reg. 31,092, 31,092-101 (June 13, 1995). These sectors include: refrigeration and air conditioning; foam blowing; solvent cleaning; fire suppression and explosion protection; sterilants; aerosols; adhesives, coatings, and inks; and tobacco expansion.

[11] 42 U.S.C. §§ 7671c, 7671d.

[12] *See*, *e.g.*, 59 Fed. Reg. 44,240-01 (Aug. 26, 1994); 60 Fed. Reg. 38,729 (July 28, 1995); 61 Fed. Reg. 4,736 (Feb. 8, 1996); 63 Fed. Reg. 28,251 (May 22, 1998); 64 Fed. Reg. 68,039 (Dec. 6, 1999); 67 Fed. Reg. 47,703 (July 22, 2002); 67 Fed. Reg. 77,927 (Dec. 20, 2002); 68 Fed. Reg. 50,533 (Aug. 21, 2003); 72 Fed. Reg. 56,628 (Oct. 4, 2007); 73 Fed. Reg. 33,304 (June 12, 2008); 74 Fed. Reg. 21 (Jan. 2, 2009); 74 Fed. Reg. 50,129 (Sept. 30, 2009); 75 Fed. Reg. 34,017 (June 16, 2010); 77 Fed. Reg. 33,315 (June 6, 2012); 78 Fed. Reg. 29,034 (May 17, 2013); 79 Fed. Reg. 62,863 (Oct. 21, 2014); 80 Fed. Reg. 19,454 (Apr. 10, 2015); 80 Fed. Reg. 42,053 (July 16, 2015); 80 Fed. Reg. 42,870 (July 20, 2015); 81 Fed. Reg.

with relative climate forcing (a measurement of how effectively they heat the atmosphere) that can be thousands of times greater than carbon dioxide. In the United States, HFC emissions are increasing more quickly than emissions of any other greenhouse gas, and they are projected to triple by 2030.[13] New global scenarios show that baseline (or business-as-usual) annual emissions of HFCs could reach 4.0–5.3 billion metric tons of carbon dioxide equivalent in 2050.[14] The Intergovernmental Panel on Climate Change indicates that immediate action to drastically reduce HFCs is needed to mitigate the most severe risks of catastrophic climate change.[15]

Because HFCs are potent greenhouse gases, in 2015, EPA promulgated a SNAP Program final rule, Rule 20,[16] that listed certain HFCs as prohibited in certain end-uses and required manufacturers to use other alternatives that pose lower overall risk to human health and the environment. EPA followed that rule in 2016 with Rule 21,[17] which took the same steps with other HFCs and end-uses. Also in 2016, EPA extended the requirements of the federal Refrigerant Management Program under its Section 608 authority to end-uses utilizing HFCs.[18] These rules also became critical components of the United States' plans to comply with the 2016 Kigali Amendment to the Montreal Protocol, which President Biden has committed to ratify.[19] The Kigali Amendment adds HFCs to the Montreal Protocol by setting deadlines and percentages for countries from different economic groups to phase out and replace HFCs.

Despite their importance in addressing climate-damaging HFCs, many of EPA's HFC restrictions were short-lived. In response to EPA's placement of HFCs on the prohibited SNAP list in 2015, two chemical manufacturers, Mexichem Flour, Inc. and Arkema, Inc., challenged SNAP Rule 20 in *Mexichem v. U.S. EPA*, 866 F.3d 451 (D.C. Cir. 2017).[20] The D.C. Circuit Court of Appeals granted the manufacturers' petitions and partially vacated Rule 20 to the extent it required manufacturers to replace HFCs with a substitute substance. The majority held that, while EPA could bar *new* uses of HFCs, it could not require a manufacturer to stop using a previously authorized HFC. *Id.* at 459. Shortly thereafter, Mexichem and Arkema challenged

32,241 (May 23, 2016); 81 Fed. Reg. 86,778 (Dec. 1, 2016); 83 Fed. Reg. 38,969 (Aug. 8, 2018); 83 Fed. Reg. 50,026 (Oct. 4, 2018): 85 Fed. Reg. 79,863 (Dec. 11, 2020), 86 Fed. Reg. 2,444 (May 6, 2021).

[13] *See* EPA Web Archives, *EPA Finalizes Rule to Reduce Climate-Damaging HFCs*, July 2, 2015, https://archive.epa.gov/epa/newsreleases/epa-finalizes-rule-reduce-climate-damaging-hfcs.html#.

[14] G.J. Velders, et al., *Future atmospheric abundances and climate forcings from scenarios of global and regional hydrofluorocarbon (HFC) emissions*, 123 ATMOS. ENVIRONMENT 200 (2015).

[15] J. Rogelj et al., Intergovernmental Panel on Climate Change, *Chapter 2: Mitigation pathways compatible with 1.5°C in the context of sustainable development*, *in* GLOBAL WARMING OF 1.5°C 2-38 (2018), http://ipcc.ch/report/sr15/.

[16] 80 Fed. Reg. 42,870 (July 20, 2015); *see* 40 C.F.R. Pt. 82, Subpt. G.

[17] 81 Fed. Reg. 86,889 (Dec. 1, 2016); *see* 40 C.F.R. Pt. 82, Subpt. G, App. V.

[18] 40 C.F.R. Pt. 82, subpt. F; 81 Fed. Reg. 82272-01 (Nov. 18, 2016).

[19] Although the Kigali Amendment became effective in 2019, during the Trump Administration, the United States did not ratify the Amendment.

[20] Petitioners argued that EPA lacked authority to require manufacturers to replace HFCs with alternative substances, and that the decision to remove HFCs from the acceptable SNAP list was arbitrary and capricious.

Rule 21,[21] in *Mexichem II*, arguing the *Mexichem I* decision applied to Rule 21. The court agreed and partially vacated Rule 21 to the same extent as Rule 20.[22]

In response, EPA issued a "guidance document" in 2018,[23] explaining that it would not apply Rule 20 even to the extent the D.C. Circuit's *Mexichem* decision had not vacated it. A multi-state coalition led by New York, along with the Natural Resources Defense Council, successfully challenged this guidance document in *New York v. Wheeler,*[24] on the grounds that it went well beyond the *Mexichem* decision and was issued without proper notice and comment.[25]

Then in 2020, over the objections of many of the undersigned States, EPA rescinded important parts of the Section 608 Refrigerant Management Program requirements.[26] Pursuant to the new regulation, entities that own or operate refrigeration and air conditioning appliances using HFCs no longer face restrictions on the servicing of appliances or the sale of refrigerant to certified technicians.

b. State, Congressional, and Biden Administration Response

In the face of these efforts to roll back critical federal HFC regulations, there have been several recent efforts to strengthen limits on HFC emissions across the country. For instance, states responded to the vacuum of federal HFC regulation with a flurry of legislation and regulations to backstop the SNAP Program as it applies to HFCs produced and used in their states. At least 10 states, including, California,[27] Washington,[28] Vermont,[29] Maryland,[30] New York,[31] New Jersey,[32] Virginia,[33] Delaware,[34] Massachusetts,[35] and Colorado,[36] have either adopted or are in the process of adopting laws or regulations that prohibit the sale and manufacture of HFC-containing products and equipment by certain dates. HFC prohibitions at the state level demonstrate that the States share a substantial interest in protecting the health of our residents and natural resources from the risks of harmful HFC emissions.[37]

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[21] *Mexichem Flour v. EPA* (Case No. 17-1024, consolidated with 17-1030).
[22] *Mexichem Fluor v. EPA*, 760 F. App'x 6 (D.C. Cir. 2019).
[23] 83 Fed. Reg. 18,431 (Apr. 27, 2018).
[24] *New York v. Wheeler,* Case No. 18-1174 (consolidated with *NRDC v. Wheeler,* Case No. 18-1172).
[25] *Nat. Res. Def. Council, et al. v. Wheeler*, 955 F.3d 68 (D.C. Cir. 2020).
[26] 85 Fed. Reg. 14,150 (Apr. 10, 2020).
[27] S.B. 1013; Cal Code Regs., tit. 17, § 95371 et seq.
[28] H.B. 1112; Ch. 173-443 WAC.
[29] 10 V.S.A. § 586; Vt. Code R. 12 031 003, Ch. 38 [Lexis].
[30] COMAR Ch. 26.11.33.
[31] 6 NYCRR Part 494.
[32] N.J. Stat. Ann. 26:2C-60 to -67.
[33] H.B. 30 (Chapter 1289, Item 378).
[34] 7 Del. Admin. Code 1151.
[35] 310 CMR 7.76.
[36] Regulation 22.
[37] *See also Nat. Res. Def. Council*, 955 F.3d at 77 (finding "the release of HFCs contributes to climate change" that harms states).

At the national level, in December 2020, Congress passed the AIM Act through the Congressional Appropriations Act of 2021 (H.R. 133). Section 103, Division S of the AIM Act authorizes and requires EPA to regulate HFCs in multiple ways. First, it requires EPA, within 270 days of enactment, to establish a program to phase down the production and consumption of HFCs over a 15-year period in a manner consistent with the Kigali Amendment.[38] As particularly relevant here, the Act also authorizes EPA to restrict the use of certain HFCs in certain applications and otherwise manage the transition to HFC substitutes as well as to establish sector-based use restrictions.[39] Any person may petition EPA to promulgate regulations to restrict use of HFCs, and EPA must respond to the petition within 180 days. If EPA grants a petition, EPA must promulgate the final rule within two years of granting the petition.[40] Lastly, the Act authorizes EPA to establish standards for the management and reclamation of HFCs used as refrigerants, such as in equipment servicing and repair, and for the recovery of "used" HFCs for purification and resale.[41]

The Biden Administration has also prioritized combatting climate change. On January 20, 2021, President Biden issued Executive Order 13990, which stated the Administration's policy and commitment to reduce greenhouse gas emissions and instructed the heads of all agencies to review existing regulations and policies issued under the Trump Administration that may be inconsistent with climate goals. President Biden also issued Executive Order 14008, which states the Administration's policy to "deploy the full capacity of its agencies to combat the climate crisis." More recently, President Biden announced a goal for the United States to achieve a 50–52 percent reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030.[42]

c. AIM Act Rulemaking Petitions and Next Generation Substitutes with Lower Warming Potentials

In light of the urgent need to address HFCs and the new authority to do so that the AIM Act provides, environmental groups and industry alike urged EPA to take action. On April 13, 2021, petitioners submitted multiple rulemaking petitions to EPA under the AIM Act:

(1) Petition submitted by Natural Resources Defense Council (NRDC) and its co-petitioners—"*Petition to Reinstate Hydrofluorocarbon (HFC) Prohibitions from the SNAP Rules 20 and 21 Under the AIM Act*";
(2) Petition submitted by the Environmental Investigation Agency (EIA) and its co-supporters—"*Technology Transitions Under Subsection (i) of the American Innovation and Manufacturing Act of 2020 (AIM Act)*";

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[38] EPA has already proposed a program to implement this requirement. *Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act*, 86 Fed. Reg. 27,150 (May 19, 2021).
[39] 42 U.S.C. § 7675(i)(1).
[40] *Id.* § 7675(i)(3).
[41] *Id.* § 7675(h).
[42] *The United States' Nationally Determined Contribution* 1, 6 (2021), https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

(3) Petitions submitted by the Air Conditioning, Heating & Refrigeration Institute (AHRI)—"*AHRI Petition Technology Transition under the AIM Act of 2020 (Air Conditioning)*" and "*AHRI Petition for Technology Transition under the AIM Act of 2020 (Commercial Refrigeration and Chillers)*"; and,

(4) Petition submitted by Association of Home Appliance Manufacturers (AHAM)—"*Petition for Technology Transition Under the American Innovation and Manufacturing Act of 2020.*"

Together, these petitions requested that EPA swiftly reinstate the HFC prohibitions previously established by SNAP Rules 20 and 21 and adopt additional requirements that CARB had proposed on a California state-wide basis.[43]

Industry's support for the AIM Act and stronger HFC prohibitions reflects its development of lower-GWP substitutes including hydrofluoroolefins (HFOs)—next generation synthetic substitute gasses for use in equipment currently using HFCs.

2. Petition for Rulemakings Under the AIM Act, § 103(i) (H.R. 133) and 5 U.S.C. § 553(e)

Building on the already submitted rulemaking petitions and recognizing the urgent need to reduce HFC production and consumption to address the climate crisis, the States respectfully submit this rulemaking petition pursuant to the AIM Act and the APA to urge EPA to take steps now to prohibit the use of certain HFCs in certain end-uses and to reduce emissions of HFCs during maintenance, repair, and disposal of refrigeration equipment.

As noted above, under section 103, subsection (i)(3) of the AIM Act, any person may petition EPA to promulgate a rule to restrict use of regulated substances, and EPA must grant or deny the petition within 180 days of receipt of the petition. EPA shall base its determination on a list of factors including, without limitation, best available data, the availability of substitutes (taking into account a variety of issues like commercial demands, consumer affordability, and safety), the overall economic costs and environmental impacts relative to historical trends, and the remaining phase-down period of the regulated substances. Additionally, the APA allows for interested persons to petition for the issuance, amendment, or repeal of a rule.[44]

Pursuant to AIM Act section 103 and the APA, the States make three rulemaking requests of EPA, detailed below. In support of this Petition, the States request that EPA review CARB's Initial Statement of Reasons (Attachment A) and Standardized Regulatory Impact Assessment (SRIA) report (Attachment B), both of which are incorporated herein by reference and were prepared for CARB's December 10, 2020 Board hearing, in which it approved HFC regulations. These documents reflect the best available information about HFCs, and the States

[43] The States support the requests by NRDC and EIA, as well as those by AHRI and AHAM to the extent they ask EPA to promulgate regulations reinstating the HFC restrictions in Rules 20 and 21 and adopting California's stricter requirements for HFCs. The States do not support the more relaxed deadlines and standards that AHRI and AHAM proposed as part of their requests.

[44] 5 U.S.C. § 553(e).

believe they will be useful to EPA in its analysis of this petition and consideration of the factors enumerated in the AIM Act.

a. EPA Should Reinstate HFC Prohibitions Established in SNAP Rules 20 and 21.

The States respectfully request that EPA use its new AIM Act authority to create regulations that effectively reinstate the HFC prohibitions that were established in SNAP Rules 20 and 21,[45] and also make clear that those HFC prohibitions apply to motor vehicle air conditioning.[46] In so doing, EPA should not include any language that would limit states' ability to further limit or phase out the use of HFCs in their jurisdictions.

The AIM Act provides EPA with expansive authority to set requirements to reduce HFC use and emissions through end-use application prohibitions on certain HFCs.[47] This authority permits EPA to address the regulatory gaps created by the *Mexichem* decision and subsequent rollbacks by the prior administration. The SNAP Program provided rules for all original equipment manufacturers (OEMs) and other users of HFC-using equipment within a regulated end-use that those OEMs and users understood and, for the most part, followed. Now, notwithstanding the *Mexichem* decision, there is no question that EPA has broad authority to regulate HFCs under the AIM Act. Crafting regulations that restore the requirements of SNAP Rules 20 and 21, as the States propose, would eliminate the ill effects of *Mexichem* and would clear the confusion and uncertainty for OEMs and other users left in *Mexichem*'s wake. It would ease the significant burden on the States that endeavor to backstop the partially vacated SNAP rules, and it would reverse the increase of HFC emissions in States that did not create their own backstop programs to address the regulatory gaps *Mexichem* caused.

The provisions the States request to be reinstated set dates certain by which entities are prohibited from using HFCs in certain end-uses. In reinstating these requirements, it is critical that EPA not select later compliance dates than those provided in Rules 20 and 21. Any later dates would be unnecessary and would lock in the harmful effects of emissions of short-lived climate pollutants for many years. Alternatives to HFCs for these end-uses are readily available and are already being used in multiple states, as explained above. There is no reason to prolong the harmful emissions of these substances.

[45] As mentioned above, NRDC submitted a rulemaking petition on April 13, 2021, with the same request. The States support that petition. AHAM and AHRI submitted similar rulemaking petitions the same day, with requests for later deadlines for certain end-uses. The States do not support these later dates and urge EPA to keep the dates established under the SNAP Program.
[46] 40 C.F.R. Pt. 82, Subpt. G, App. B. States that have subsequently adopted or considered adopting state-level SNAP equivalents have excluded motor vehicle air conditioning for various reasons. Thus, it is particularly important that EPA clarify that its regulations cover this end-use.
[47] 42 U.S.C. § 7675(i).

b. EPA Should Issue Additional Federal Standards Modeled On the HFC Requirements CARB Has Proposed and Intends to Adopt.

In addition to reinstating the requirements of SNAP Rules 20 and 21, the States respectfully request that EPA use its AIM Act authority to further restrict the use of harmful HFCs in new equipment or products in the largest HFC-consuming and -emitting sectors: stationary refrigeration and air conditioning (AC).[48] Pursuant to its AIM Act authority, EPA can and should issue regulations that limit the use of HFCs with a global warming potential (GWP) that exceeds a certain level in specified subsectors, and establish a refrigerant reuse, recovery, and reclaim program. For a model of how to do so, EPA need look no further than the standards that the CARB Board approved on December 10, 2020, and that it intends to adopt, which are incorporated by reference herein and attached as Attachment C.[49]

CARB's proposed regulations are intended to reduce the demand for high-GWP HFCs across major end-use sectors to the largest extent currently feasible in each sector. CARB's proposed regulations provide the most ambitious yet feasible HFC-reduction strategy in the country. They reflect the most up-to-date information available, are supported by robust data gathered during CARB's rulemaking process, and follow years of extensive consultation with regulated stakeholders about feasibility. They also incorporate sufficient compliance time to accommodate necessary updates to safety standards and building codes.

Specifically, together with CARB's existing regulations, CARB's proposed standards will do the following:

- Make it a violation, after certain compliance deadlines, for anyone to sell, rent, install, or use any product or equipment containing prohibited substances;
- List substances that are prohibited from use in certain end-uses[50] and the dates by which those end-uses may no longer use such prohibited substances;
- Add GWP limits for new equipment under certain end-uses,[51] while allowing flexibility for existing retail food facilities to attain a company-wide GWP target by either attaining a weighted average GWP or reducing their GWP potential by a certain date;
- Establish a Refrigerant Recovery, Reclaim, and Reuse (R4) Program to enhance the use of reclaimed high-GWP refrigerants. This program will require AC manufacturers to use at least 10 percent reclaimed R-410A (an HFC-blend with a GWP of 2088) in

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[48] EIA submitted a petition on April 13, 2021, making this same request. The States support that petition.

[49] Cal. Code Regs., tit. 17, §§ 95371-95379 (as proposed), Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-Conditioning, and Other End-Uses, Modifications to the Proposed Regulation Order, https://ww2.arb.ca.gov/sites/default/files/classic/regact/2020/hfc2020/15dayatta.pdf?_ga=2.233551454.1953607013.1621543282-1232853637.1558394411.

[50] End-uses include refrigeration, vending machines, foam systems used to manufacture, aerosols-propellants, air conditioning, and chillers.

[51] All air conditioning equipment, variable refrigerant flow systems, chillers, refrigeration systems containing more than 50 pounds of refrigerant in cold storage warehouses, ice rinks, industrial process refrigeration, and retail food refrigeration.

new equipment or in servicing existing equipment and also provides an early action credit option for those who comply before the deadlines;

- Add flexibility by providing a variance process in the event of impossibility or force majeure events; and,
- Provide for recordkeeping, disclosure, labelling, and reporting requirements.

CARB's proposed regulations offer a meaningful template that EPA may use to mitigate HFC emissions substantially. Specifically, CARB's analysis has shown that requiring use of lower-GWP refrigerants in new commercial and industrial refrigeration systems and cutting the use of HFCs in existing products and equipment, as CARB's proposed regulations require, is expected to reduce the emissions from the commercial and industrial refrigeration end-uses by nearly 40 percent below business-as-usual levels by 2040 in California.[52] Moreover, the requirement that the GWP of refrigerants used in new AC equipment be below 750 is expected to reduce emissions from the AC sector by 50 percent below business-as-usual levels by 2040 in California.[53] Finally, new requirements regarding the use of reclaimed refrigerant promotes better recovery of refrigerant from equipment, which lowers end-of-life leak rates and results in a more resource-efficient economy. The actions CARB has taken are critical now because each year of deferred action "locks in" emissions of high-GWP refrigerant for a given product or piece of equipment's entire lifetime, which can be over 15 to 20 years.

The States request that EPA promulgate regulations on a nationwide basis that are modeled on CARB's proposed regulations, more particularly described in Attachments A, B, and C. The AIM Act authorizes this type of action,[54] and it is imperative that HFC-intensive sectors like supermarkets, which can feasibly transition to use the safest and most climate-friendly refrigerants available, do so. CARB's proposed standards facilitate that transition and reflect the best available data while also considering the availability of substitutes based on technological feasibility, commercial demands, affordability, safety, consumer costs, building codes, efficiency standards, training costs, and other relevant factors. Furthermore, as CARB's analysis demonstrates, *see* Attachment B, the overall economic cost of such regulations is minimal compared to the harm of taking no action. And, as EPA phases down the production and consumption of HFCs over the next 15 years, implementation of nationwide regulations modeled on CARB's would improve the effectiveness of that phasedown. CARB's regulations essentially "lock-in" the potential reductions from the national HFC phasedown by reducing HFC demand while the national phasedown reduces their supply. Thus, nationwide regulations modeled on CARB's regulations would help actualize the vast emission and climate benefits expected from the national HFC phasedown in the shortest timeframe possible. For these reasons, EPA should use CARB's proposed regulations as a model for federal standards.

[52] CARB, Initial Statement of Reasons, Executive Summary (Oct. 20, 2020), attached as Attachment A.

[53] *Id.*

[54] *See* 42 U.S.C. § 7675(i)(1).

c. EPA Should, At a Minimum, Restore Federal Section 608 Refrigerant Management Program Requirements As They Pertain to HFCs.

The States also request that EPA restore the HFC-related requirements that EPA established in 2016 under its Section 608 authority by (1) rescinding its 2020 regulation that eliminated leak inspection, leak repair, retrofitting, reporting, and maintenance of records requirements relating to HFC refrigerants in appliances with 50 pounds or more of HFCs (85 Fed. Reg. 14,150 (Mar. 11, 2020)); and (2) by engaging in a rulemaking under the AIM Act that would, at a minimum, reestablish the requirements of EPA's Section 608 Refrigerant Management Program as they apply to HFCs, *see* 81 Fed. Reg. 82,272-01 (Nov. 18, 2016).

The existing Section 608 Refrigerant Management Program focuses on reducing harmful emissions from refrigeration and air conditioning systems, which are the largest sources of HFC emissions. Indeed, large commercial refrigeration systems in the aggregate are responsible for extensive emissions. In California alone, there are roughly 6,800 facilities with systems that contain more than 50 pounds of high-GWP HFC refrigerants. Based on data reported to CARB, these systems often contain hundreds to thousands of pounds of refrigerant and can leak an average of 10 to 20 percent of the refrigerant on an annual basis.[55] Refrigerant leaks at these facilities can occur frequently during appliance servicing and maintenance due to the common practice of re-charging leaky, poorly designed, or poorly maintained appliances. Reducing leaks through best management practices required by the Refrigerant Management Program not only reduces harmful emissions but also saves refrigeration equipment owners and operators money because they do not need to purchase as much replacement refrigerant.

Many of our States submitted comments opposing EPA's 2020 regulation rescinding the HFC requirements under its Refrigerant Management Program.[56] Some of our States also challenged EPA's 2020 regulation in the D.C. Circuit.[57] As we have explained in our prior comments and in litigation, EPA's decision to rescind the HFC refrigerant management requirements is unlawful and will result in unnecessary emissions of harmful greenhouse gases. There is no practical reason to exclude HFCs from these critical management requirements. Indeed, because EPA has previously regulated HFCs within its Refrigerant Management Program, it knows how to do so and understands that such regulation is feasible. Moreover, even if EPA's existing authority to regulate HFCs under Section 608 of the Clean Air Act were uncertain (it is not), EPA now certainly has authority to do so under the AIM Act. Subsection (h) specifies that EPA "shall promulgate regulations to control, where appropriate, *any practice, process, or activity* regarding the servicing, repair, disposal, or installation of equipment (including requiring, where appropriate, that any such servicing, repair, disposal, or installation be performed by a trained technician meeting minimum standards) . . . ."

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[55] Based on data reported to CARB via the Refrigerant Registration and Reporting System (R3), 2012-2018.

[56] Comments of Massachusetts, California, by and through the Attorney General and California Air Resources Board, Delaware, Illinois, Iowa, Maine, Maryland, Minnesota, by and through its Minnesota Pollution Control Agency, New Jersey, New York, North Carolina, Oregon, Vermont, Virginia, Washington, and the District of Columbia, EPA-HQ-OAR-2017-0629-0300 (Nov. 14, 2018), https://www.regulations.gov/comment/EPA-HQ-OAR-2017-0629-0300.

[57] *New York, et al. v. Wheeler*, Case No. 20-1151 (D.C. Cir. filed May 11, 2020).

Given the breadth of EPA's AIM Act authority, refrigerant management requirements should be at least as stringent as—if not more stringent than—the refrigerant management requirements issued under Section 608. The States therefore respectfully request that EPA immediately engage in rulemaking under the AIM Act to establish a robust refrigerant management program for HFCs.

3. Conclusion

EPA must take prompt action through its expansive authority under the AIM Act to tackle climate change by reducing HFC emissions. The actions that the States request are necessary to achieve the Biden Administration's goals to combat climate change. EPA has previously taken action under its SNAP Program and Refrigerant Management Program to limit HFC emissions, and now California and many of the undersigned States have gone further by prohibiting HFCs in additional end-uses and limiting the permitted GWP of HFCs in specified end-uses. The experiences of our States demonstrate that such regulatory options are feasible, result in quantifiable emission reductions, and are low-cost, particularly compared to the significant costs of harm caused by climate change. The States urge EPA to use its AIM Act authority to reinstate the HFC prohibitions that it had established under the SNAP Program, promulgate additional federal standards, modeled on California's proposed standards, that further reduce HFC emissions from the largest HFC-consuming end-uses, and establish a robust refrigerant management program for HFCs, as described herein.

Please contact Elizabeth Scheehle at *Elizabeth.Scheehle@arb.ca.gov* or by telephone at 916-322-7630 should you have any questions.

Sincerely,

FOR THE CALIFORNIA AIR RESOURCES BOARD

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Attachment(s) (via email attachment and CD)
Attachment A: CARB Staff Report: Initial Statement of Reasons
Attachment B: Standardized Regulatory Impact Assessment
Attachment C: Proposed Regulatory Order (May 13, 2021)

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State of California
AIR RESOURCES BOARD

PUBLIC HEARING TO CONSIDER THE PROPOSED AMENDMENTS TO THE PROHIBITIONS ON USE OF CERTAIN HYDROFLUOROCARBONS IN STATIONARY REFRIGERATION, CHILLERS, AEROSOLS-PROPELLANTS, AND FOAM END-USES REGULATION

Staff Report: Initial Statement of Reasons

Date of Release: October 20, 2020

Scheduled for Consideration: December 10, 2020

Location:

California Environmental Protection Agency
California Air Resources Board
Byron Sher Auditorium
1001 I Street
Sacramento, California 95814

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

Hydrofluorocarbons (HFCs) are among the most harmful greenhouse gases (GHG) emitted today. While they remain in the atmosphere for a much shorter time than carbon dioxide (CO_2), their relative climate forcing (how effectively they heat the atmosphere) can be tens, hundreds or even thousands of times greater than CO_2. The importance of HFC mitigation was identified in the early 2000s, and several early action measures were proposed as part of a comprehensive, ongoing program to reduce greenhouse gas (GHG) emissions in California. The California Air Resources Board (CARB) adopted the Refrigerant Management Program[1] as one of the early action measures to address HFC refrigerant use. Further recognizing the importance of reducing HFCs, the Legislature enacted Senate Bill 1383 (SB 1383) [2] in 2016, requiring a 40 percent reduction of HFC emissions below 2013 levels by 2030.

California continued working to develop additional regulatory efforts to reduce HFC emissions and meet this goal. Unfortunately, beginning in 2017 – the United States Environmental Protection Agency's (U.S. EPA) key HFC prohibitions – Rules 20[3] and 21[4] under the Significant New Alternatives Policy (SNAP) Program[5] were partially vacated by the D.C. Circuit Court of Appeals. [6] To prevent the harmful impacts of the litigation, in 2018, California incorporated both SNAP Rules 20 and 21—first through adopting an HFC Regulation[7] and then the Legislature enacted the "California Cooling Act" or Senate Bill 1013 (SB 1013). [8] In 2019, CARB incorporated SB 1013's statutory provisions into its HFC Regulation to provide clarity to the regulated industry.[9] Despite these current rules, California statutory mandates for HFC reduction requires CARB to take further actions to reduce HFC emissions.

Summary of the Proposed Amendments

The majority of HFC emissions in the State come from their use as refrigerants in stationary refrigeration and air conditioning (AC) equipment. In this rulemaking, CARB staff proposes to address these emission sources by amending the existing California HFC Regulation (hereinafter "Proposed Amendments") to (1) impose further limits on

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[1] Management of High Global Warming Potential Refrigerants for Stationary Sources, Cal. Code Regs., tit. 17, § 95380 et seq.
[2] SB 1383 (Lara, Stat. 2016, Ch. 395); Health & Saf. Code § 39730.5.
[3] 40 C.F.R. Pt. 82, Subpt. G, App. U; 80 Fed. Reg. 42870-01 (July 20, 2015); 81 Fed. Reg. 86778-01 (Dec. 1, 2016).
[4] 40 C.F.R. Pt. 82, Subpt. G ,App. V; 81 Fed. Reg. 86778-01 (Dec. 1, 2016).
[5] 42 U.S.C. § 7671k; 40 C.F.R. Pt. 82, Subpt. G.
[6] *Mexichem Fluor, Inc. v. Environmental Protection Agency* (D.C. Cir. 2017) 866 F. 3d 451 (Mexichem I) and *Mexichem Fluor, Inc. v. Environmental Protection Agency* (D.C. Cir. 2019) Case No. 17-1024 (Mexichem II) (collectively the "*Mexichem decisions*").
[7] Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration and Foam End-Uses, Cal. Code Regs., tit. 17, §§ 95371, et seq.
[8] SB 1013 (Lara, Stat. 2018, Ch. 375) ; Health & Saf. Code § 39734.
[9] Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End Uses, Cal. Code Regs., tit. 17, §§ 95371, et seq.

HFCs used in non-residential (e.g. commercial) stationary refrigeration equipment, and (2) to regulate new AC equipment used for both residential and non-residential purposes. Additionally, some administrative changes are proposed for the purposes of enhancing clarity of the existing regulation. CARB collaborated with the U.S. Climate Alliance to share California's experience and additional states are adopting similar regulations – as such CARB is proposing administrative changes that provide clearer alignment with those regulations, providing clarity and convenience to the regulated industry. A variance process has also been added to address impossibility and force majeure events.

Expected Emissions Benefits

Reducing the GWP of refrigerants used in new commercial and industrial refrigeration systems and cutting the "banked" HFCs in the existing facilities is expected to reduce the emissions from these sectors by nearly 40 percent below baseline by 2040. Reducing the GWP of new AC equipment to below 750 is expected to reduce emissions from this sector by 50 percent below baseline by 2040 offering a substantial and critical opportunity to mitigate HFC emissions. Action now is key as each year of deferred action "locks in" emission of high-GWP refrigerant for the lifetime of the equipment over 15 to 20 years. Reducing HFC emissions from these sectors is critical in meeting HFC-specific targets and long-term carbon neutrality goals.

While some AC manufacturers and stakeholders have conveyed support for the 2023 compliance date, several stakeholders have requested that CARB delay the effective date for the 750 GWP limit for new AC equipment from January 1, 2023 to January 1, 2025. The reasons put forth for this request include: (1) allowing additional time for AC manufacturers to transition refrigerants; (2) the A1 alternative (R-466A) may require more time to be ready as a substitute refrigerant; and (3) the California Building Standards Code may not have the necessary updates to allow A2L refrigerants to be used in 2023. These stakeholders have provided ideas for incorporating an additional compliance pathway in addition to the 2023 compliance pathway. AC manufacturers and other stakeholders have proposed achieving needed emission reductions through use of reclaimed refrigerant in new equipment, servicing existing equipment, refrigerant destruction, as well as a potential crediting system based on type of refrigerant used to account for charge and GWP reduction. CARB is evaluating the feasibility of additional compliance pathways as well as a hybrid of them, from the standpoint of enforcement, implementation, and emissions benefits and may incorporate changes through a 15-day notice.

Under the business-as-usual scenario, including the current regulations already in place, annual HFC emissions in the year 2030 are expected to be approximately 20 million metric tons of carbon dioxide equivalent ($MMTCO_2e$). Under SB 1383, these emissions must be reduced to below 10 $MMTCO_2e$ by 2030. Impacts of major regulations are typically analyzed over one lifetime of equipment. For these Proposed Amendments, CARB staff analyzed both benefits and costs to 2040, which reflects an average equipment lifetime of 15 years. From 2022 to 2040, the Proposed Amendments for refrigeration and AC equipment combined are expected to result in annual average GHG emissions reductions of 4 $MMTCO_2e$, helping California move closer to achieving the legislative target.

Cumulatively, by 2040, the Proposed Amendments are expected to reduce statewide GHG emissions by more than 72 $MMTCO_2e$. Because HFCs have very high global warming potential (GWP) values, the damages avoided due to the additional warming these emissions would have caused are substantial. CARB uses the social cost of carbon ($SC\text{-}CO_2$) to estimate the avoided damages from GHG emissions, which provides a monetary benefit today of reducing carbon emissions in the future. The total avoided social cost of carbon due to the Proposed Amendments ranges between $1.7 billion and $7.2 billion dollars by 2040, depending on the discount rate. It is important to note that due to their short atmospheric lifetimes, the warming impact of HFCs in the near term are even worse. To estimate more near term impacts, HFC emissions and reductions can be calculated using their 20-year GWP values. For the HFCs used in refrigeration and AC equipment, the average 20-year GWP is approximately double the 100-year average GWP. Thus, using 20-year GWP values, the Proposed Amendments are expected to yield cumulative GHG emissions reductions of more than 140 $MMTCO_2e$ by 2040. While we use 100-year GWP values throughout this document and for the purposes of the rulemaking, using 20-year GWP values highlights the impact of the Proposed Amendments.

I. Introduction and Background

Climate change is one of the most serious environmental threats facing the world today. Climate scientists agree that global warming and other shifts in the climate system observed over the past century are caused by human activities and that these recorded changes are occurring at an unprecedented rate (Cook et al., 2015). California is already feeling the impacts of climate change, and projections show that these effects will continue and worsen. The impacts of climate change on California have been documented by the Office of Environmental Health Hazard Assessment (OEHHA) in the *Indicators of Climate Change Report* (OEHHA, 2018). In cognizance of these facts, California has committed to take action. The passage of Assembly Bill 32 (AB 32),[10] the California Global Warming Solutions Act of 2006, marked a watershed moment in California's history. By requiring sharp reductions of greenhouse gas (GHG) emissions, California set the stage for its transition to a sustainable, low-carbon future. To further the goals of AB 32, the Legislature enacted Senate Bill 32 (SB 32) [11] requiring a 40 percent reduction in GHG emissions below 1990 levels by 2030.

Once these overarching GHG reduction mandates were in place, California then enacted legislation to curb emissions of specific climate pollutants. Among those were hydrofluorocarbons (HFCs), which are a class of very potent GHGs that have a disproportionate warming impact on the climate. In 2016, the Legislature enacted Senate Bill 1383 (SB 1383) to specifically mandate a 40 percent reduction in HFC emissions below 2013 levels by 2030.

A. What are Hydrofluorocarbons?

HFCs are synthetic gases that are used in a variety of applications, including refrigeration, air-conditioning (AC), foam blowing, solvents, aerosols, and fire suppression. HFCs were developed to replace ozone-depleting substances (ODS), including chlorofluorocarbons (CFCs) that have already been phased out, and hydrochlorofluorocarbons (HCFCs) that are currently being phased out under the Montreal Protocol—the international treaty governing the protection of the stratospheric ozone layer (UNEP, 1987). HFCs do not harm the ozone layer; however, they are short-lived climate pollutants (SLCP).

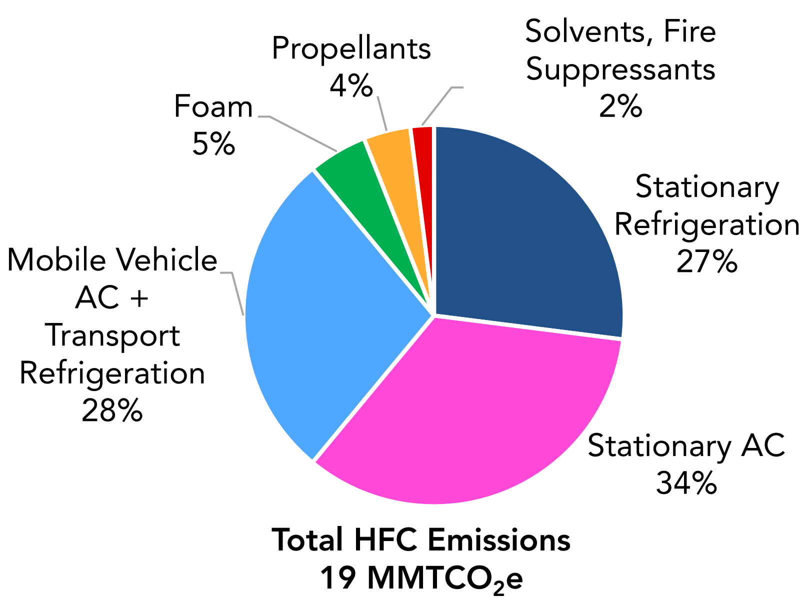
SLCPs are powerful climate forcers that remain in the atmosphere for a relatively short period of time, but trap thousands of times more heat in the atmosphere per unit of mass compared to carbon dioxide (CO_2). A major concern with respect to HFCs is that their contribution to climate forcing is expected to increase rapidly in the future – not only because HFCs continue to replace ODS but also the demand for refrigeration and air conditioning (RAC) is growing (Velders et al., 2009; Velders et al., 2013). In fact,

[10] AB 32 (Núñez, Stat. 2006, Ch. 488); Health & Saf. Code § 38500 et seq.
[11] SB 32 (Pavley, Stat. 2016, Ch. 249); Health & Saf. Code § 38566.

atmospheric observations show that the concentration of HFCs in the atmosphere is already increasing rapidly (Carpenter et al., 2014; Doherty et al., 2014).

The emissions of HFCs from RAC equipment depend on the following factors: amount of refrigerant used in the systems (also called system "charge size"), the amount of refrigerant that leaks out of the systems every year (annual leak rate) as well as at equipment's end-of-life (EOL leak rate), and the GWP of the refrigerant.
If no measures are taken, it is estimated that HFCs will amount to 9 to 19 percent of total GHG emissions globally by 2050. [12] In California, HFCs currently comprise 5 percent of GHG emissions, but are the fastest growing source of GHG emissions, primarily driven by the increased demand for RAC and the replacement of ODS with HFCs (CARB, 2019a; UNEP, 2011). Nearly 90 percent of HFC emissions in California come from their use as refrigerants in the commercial, industrial, residential, and transportation sectors as shown in **Figure 1** (CARB, 2020a).[13]

Figure 1. *California HFC emissions by sector (2018)*



B. What is Global Warming Potential?

SLCP emissions are analyzed using global warming potential (GWP) value. The Intergovernmental Panel on Climate Change (IPCC) developed the concept of GWP as an index to evaluate the climate impacts of different GHGs, including SLCPs. This metric provides a comparison of the ability of each GHG to trap heat in the atmosphere relative to CO_2 over a specified time horizon. GWP depends on the

[12] *Ibid.*
[13] California HFC emissions (in CO_2-equivalents) by sector in 2018 using the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment (AR4) 100-year GWP values (IPCC 2007).

lifetime of different GHGs in the atmosphere, and accounts for the amount of energy they absorb on a per-kilogram basis, relative to CO_2, to represent the relative climate forcing of a kilogram of emissions when averaged over a time period of interest (typically 20 or 100 years). The larger the GWP value, the more that a given gas warms the Earth compared to CO_2 over a given time period. The mix of all HFCs in current use in California, weighted by usage (tonnage), has an average 100-year GWP of 1,700, and an average 20-year GWP of 3,800.

The GWP limits being proposed in this rulemaking are in terms of 100-year GWP values from the 4th Assessment Report of the IPCC (AR4), which was released in 2007 (IPCC, 2007).[14] This is consistent with CARB's official GHG inventory and for accounting for emissions in programs adopted under AB 32 as well as most GHG emissions inventories around the world. CARB does evaluate emissions scenarios using 20-year GWP values, which better reflects how damaging HFCs can be to the climate in the near term and is consistent with the SLCP Strategy (CARB, 2017a). However, CARB's current F-gas inventory uses 100-year GWP values to estimate emissions. To be consistent with the inventory, the GWP limits and emissions benefits calculations utilize 100-year values unless specifically stated otherwise. The GWP values of common refrigerants in use in RAC sectors range from 2,000 to over 3,000 GWP (100-year).

C. What is the Current California HFC Regulation and why is CARB Amending it?

When CARB finalized its SLCP Strategy in 2017 (which outlines the strategy to reduce SLCPs, including HFCs in California), CARB was relying on implementation of SNAP Rules 20 and 21 to achieve substantial emissions reductions and lower baseline emissions. The SNAP prohibitions take a "worst first" approach by banning specific HFCs with the highest GWP values in use by end-use. However, on August 8, 2017, in *Mexichem Fluor. v. U.S. EPA*, [15] the D.C. District Circuit Court of Appeals limited U.S. EPA's ability to require manufacturers using HFCs to replace the refrigerant with a lower-GWP refrigerant. A later decision extended the limitations to SNAP Rule 21. California took action and backstopped the changes to the federal SNAP prohibitions. In 2018, CARB adopted a regulation, "*Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration and Foam End-Uses Regulation*."[16] This regulation prohibited specific HFCs with high-GWP values from use in certain stationary refrigeration and foam end-uses but did not incorporate all end-uses from SNAP Rules 20 and 21.

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[14] Where IPCC AR4 GWP values are not listed for specific F-gases. CARB uses the 100-year GWP values listed in IPCC Fifth Assessment Report (AR5) (IPCC, 2013), and where IPCC AR4 and IPCC AR5 values are not available, CARB uses the 100-year GWP values as listed in the IPCC Third Assessment Report of the IPCC (TAR) (IPCC, 2001).
[15] *Mexichem Fluor, Inc. v. Environmental Protection Agency* (D.C. Cir. 2017) 866 F. 3d 451.
[16] Cal. Code Regs., tit. 17, §§ 95371-95377.

That same year, the California Legislature adopted the California Cooling Act (SB 1013), which incorporated both SNAP Rules 20 and 21 into state law. CARB then followed an administrative process to incorporate the SB 1013 provisions into the existing HFC Regulation and retitled it *"Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End-Uses Regulation*" (hereinafter "HFC Regulation") to be reflective of all end-uses.[17] This action simply consolidated requirements into one regulation to provide clarity to the regulated industry. [18] The requirements took effect January 1, 2019.

CARB is now amending the HFC Regulation to adopt GWP limits for new RAC equipment, which ensures that industry not only shifts away from the highest GWP refrigerants, but swiftly transitions to technologies with the lowest GWP that is technologically and commercially feasible. These GWP limits are consistent with CARB's SLCP Strategy, which proposed GWP limits for new equipment.
The Proposed Amendments will help California meet several HFC reduction objectives, including SB 32,[19] AB 32,[20] SB 1383,[21] SB 1013,[22] the 2008 Climate Change Scoping Plan, the 2014 First Update to the Climate Change Scoping Plan (CARB, 2014), 2017 Short-Lived Climate Pollutant Reduction Strategy (CARB, 2017a) , and the California's 2017 Climate Change Scoping Plan, (CARB, 2017b).

D. Who will be Impacted and What End-Uses will the Proposed Amendments Cover?

The Proposed Amendments would apply to any person who sells, leases, rents, installs, uses, or enters into commerce, in the State of California, refrigeration systems and air conditioning equipment – collectively known as RAC. [23] One equipment type falls into both refrigeration and AC (chillers). This includes manufacturers who have either developed, or will develop compliant materials and equipment as well as contractors, installers of equipment, and service technicians who need to understand how to purchase, install, and service only compliant equipment. For refrigeration systems, the most directly impacted entities are the end-users of those systems. These end-use sectors are discussed briefly below:

[17] The current regulation covers the follow end-uses: retail food refrigeration, vending machines, cold storage refrigerators, household refrigerators, foams, chillers, and aerosols-propellants.
[18] With the addition of the SB 1013 provisions, the citation is now Cal. Code Regs., tit. 17, §§ 95371-95378.
[19] Senate Bill 32 (Pavely, Stats. of 2016, Ch. 249, Health & Saf. Code § 38566).
[20] Global Warming Solutions Act of 2006, Assembly Bill 32 (Nunez, Stats. of 2006, Ch. 488, Health & Saf. Code §§ 38500 et seq).
[21] Short Lived Climate Pollutants, Senate Bill 1383 (Lara, Stats. of 2016, Ch. 395, Health & Saf. Code § 39730.5).
[22] California Cooling Act, Senate Bill 1013 (Lara, Stats. of 2018, Ch. 375, Health & Saf. Code § 39764).
[23] NAIC Code 333415.

1. Refrigeration.

Refers to the process of cooling products and/or processes, and storing chilled and/or frozen products at the appropriate temperatures. The Proposed Amendments will be applicable only to refrigeration systems containing more than 50 pounds of refrigerant. Facilities that use stationary refrigeration systems above that size threshold typically include, but are not limited to retail food facilities, for example, supermarkets and grocery stores; cold storage warehouses, food preparation and processing facilities; hotels and recreational facilities; facilities with other types of industrial process refrigeration (IPR) equipment. Generally, refrigeration systems containing more than 50 pounds are large systems used in commercial and industrial refrigeration. Based on CARB's F-Gas Inventory, they have among the highest annual average refrigerant leak rates out of all HFC end-uses and systems.

2. Air Conditioning.

Refers to the use of a refrigerant to cool, heat or dehumidify air. An AC that uses a refrigerant to provide heating in addition to cooling is referred to as a heat pump and these types of systems are included in the Proposed Amendments. Stationary AC includes room ACs meant to condition air in a single room as well as central ACs used in residential, commercial and other non-residential settings.[24] This includes all types of AC systems including those that use a refrigerant to provide heating in addition to cooling (heat pump), room ACs as well as ductless split and ducted split and packaged ACs used in residential, commercial and non-residential settings. For the purpose of this rulemaking, the term AC also includes dehumidifiers.

AC systems are used in very large numbers and tend to have high refrigerant release rates at end-of-life due to poor refrigerant recovery. The vast majority of buildings in California, including homes, office buildings, retail space, schools and hospitals use AC. As a result, over half a million new ACs are sold to California each year to replace old units and for newly constructed buildings, having a substantial impact on HFC emissions.

AC systems are used in very large numbers and tend to have high refrigerant release rates due to poor end-of-life recovery of refrigerant. The vast majority of buildings in California, including homes, office buildings, retail space, schools and hospitals use AC. As a result, over half a million new ACs are sold to California each year to replace old units and for newly constructed buildings, having a substantial impact on HFC emissions.

[24] The term AC is used for ACs and heat pumps that directly cool or heat air.

3. Chillers.

Refers to equipment that uses water or heat transfer fluid to chill. They can be used for AC or refrigeration applications. For refrigeration, they are most commonly used in industrial processing refrigeration (IPR) facilities and sometimes in commercial facilities. The primary refrigerant used in a 'refrigeration chiller' is chosen based on the temperature needs of the facility (i.e., how cold the process and/or products need to be) and is usually coupled with a secondary fluid like glycol that circulates through the facility.

Based on CARB's Refrigerant Management Program (RMP) data, at least an estimated 50 percent of the systems registered under IPR facilities are chillers. Larger buildings are often cooled by a central chiller that pumps chilled water to heat exchangers in air handling or fan-coil units that deliver conditioned air. Chillers are typically located in a machinery room or outdoors. Chillers can also be used to provide AC to multiple buildings by using a centralized plant to deliver chilled water via underground insulated pipes to multiple buildings in a process referred to as district cooling.[25]

E. What Changes are Being Proposed?

To further reduce HFC emissions in California, CARB is proposing amendments summarized below. All GWP limits refer to the 100-year values.

1. GWP Limits for New Refrigeration Systems.

New refrigeration systems containing more than 50 pounds of refrigerant and used in newly constructed and fully remodeled facilities will be required to have refrigerants with GWP less than 150. This includes the following end-uses: retail food refrigeration, industrial process refrigeration (except chillers), cold storage, and ice rinks. Enforcement mechanisms include labeling and recordkeeping requirements.

The proposed requirements for new equipment are summarized in **Table 1.**

[25] SB 1013 banned specific refrigerants with high GWP values and the compliant refrigerant options for AC chillers are below the 750 GWP limit. Manufacturers of chillers have already commercialized equipment using next generation refrigerants in accordance with SB 1013's requirement prohibiting high-GWP refrigerants from being used in new chillers starting 2024.

Table 1. *Summary of Proposed Amendments for New Equipment*

General End-Use	Specific End-Use	Prohibited Substances	Effective Date
Stationary Refrigeration	New refrigeration systems containing more than 50 pounds of refrigerant (non-residential) in newly constructed / remodeled facilities[a]	Refrigerants with GWP greater than or equal to 150	January 1, 2022
Stationary Refrigeration	New refrigeration systems containing more than 50 pounds of refrigerant (non-residential) in existing facilities[a]	Refrigerants with GWP greater than 1,500 and 2,200 depending on end-use.	January 1, 2022
Stationary AC	All new AC equipment, residential and non-residential	Refrigerants with GWP greater than or equal to 750	January 1, 2023
Chillers	All new chillers used for air-conditioning	Refrigerants with GWP greater than or equal to 750	January 1, 2024
Chillers	All new chillers used for industrial process refrigeration	Depending on the minimum evaporator temperature, refrigerants with GWP greater than or equal to 750, 1,500 and 2,200[26]	January 1, 2024
Ice Rinks	New refrigeration systems containing more than 50 pounds of refrigerant and new chillers in newly constructed / remodeled facilities	Refrigerants with GWP greater than or equal to 150	January 1, 2024
Ice Rinks	New refrigeration systems containing more than 50 pounds of refrigerant and new chillers in existing facilities	Refrigerants with GWP greater than or equal to 750	January 1, 2024

[a] Includes facilities used for retail food refrigeration, industrial process refrigeration excluding chillers, and cold storage.

[26] An important exception to the chiller requirements are chillers used for refrigeration in retail food facilities like supermarkets. Supermarket chillers, also referred to as indirect supermarket refrigeration systems will be subject the GWP limit of 150 in new facilities, consistent with the proposed rules for all other refrigeration systems used in retail food.

2. GWP-Based Company-wide Standard for Existing Refrigeration Systems in Retail Food Facilities.

Existing retail food facilities (e.g. supermarkets and grocery stores) will be required to reduce their company-wide, weighted-average GWP[27] for all refrigeration systems containing more than 50 pounds of refrigerant to less than 1,400 GWP by 2030 with a progress step in 2026. This is similar to a "fleet" standard in the vehicle context. An optional compliance pathway for achieving similar emissions reductions is to reduce their "Greenhouse Gas Emissions Potential" or "GHGp"[28] from their existing systems by 55 percent by 2030. Enforcement mechanisms include registration, recordkeeping, and reporting requirements for existing retail food facilities.

Across all non-retail food facilities (e.g. cold storage and industrial process refrigeration or "IPR"), any new systems being installed in existing facilities must use refrigerants with GWP values less than 1,500 or 2,200, respectively. For cold storage facilities, this is already required under the current HFC Regulation. Under the Proposed Amendments, HFCs with GWP values greater than 2,200 (e.g. R404A and R507) will also be prohibited for new systems being installed in existing IPR facilities. This is a preventative measure to disallow high-GWP refrigerants from being used in any new equipment in an existing refrigerated facility. New systems in new ice rinks must use refrigerants with GWP values less than 150. The original CARB proposal was a prohibition on refrigerants with a GWP 750 or greater in new systems in new ice rinks. However, new information was made available by stakeholders and ice rink construction firms that confirms the feasibility of building new ice rinks using refrigerants with GWPs less than 150. For example, more than 80 percent of ice rinks operating in California currently use ammonia refrigerant with a GWP of zero. For those new ice rinks where the use of ammonia may not be permitted, due to toxicity and safety reasons, low-GWP hydrofluoroolefin (HFO) chillers and low-GWP transcritical CO_2 systems can be been used in ice rinks. In addition, any new systems being installed in existing ice rinks must use refrigerants with GWP values less than 750. Most ice rinks use chiller systems and this aligns with the GWP limits for chillers with the same effective date.

The proposed requirements for equipment in existing facilities are summarized in **Table 2**.

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[27] Weighted-average GWP is defined as the average GWP of all refrigerants used by a retail food company across all their stores and systems with more than 50 pounds of refrigerant each, weighted by the pounds of each refrigerant. For more information, see Section F.1.

[28] Greenhouse Gas Emissions Potential (GHGp) is defined as the pounds of each refrigerant multiplied by its GWP, summed over all refrigerants used across all stores owned by a company in systems containing more than 50 pounds of refrigerant. For more information, see Section F.1.

Table 2. *Summary of Proposed Rules for Refrigeration Equipment in Existing Retail Food Facilities*

Regulated Entity	Compliance Requirements	Compliance Date
Companies owning or operating 20 or more retail food facilities in California, and national supermarket chains operating in California[29]	Attain a company-wide weighted-average GWP of less than 2,500 or a 25% or greater reduction in GHGp below 2019 levels	January 1, 2026
	Attain a company-wide weighted-average GWP of less than 1,400 or a 55% or greater reduction in GHGp below 2019 levels	January 1, 2030
Companies owning or operating fewer than 20 retail food facilities in California	Attain a company-wide weighted-average GWP of less than 1,400 or a 55% or greater reduction in GHGp below 2019 levels	January 1, 2030

3. GWP Limits for New AC Equipment.

The Proposed Amendments require new air conditioners would be required to use refrigerants with a GWP value less than 750. While some AC manufacturers and stakeholders have conveyed support for the 2023 compliance date, several stakeholders have requested that CARB delay the effective date for the 750 GWP limit for new AC equipment from January 1, 2023 to January 1, 2025. The reasons put forth for this request include: (1) allowing additional time for AC manufacturers to transition refrigerants; (2) the A1 alternative (R-466A) may require more time to be ready as a substitute refrigerant; and (3) the California Building Standards Code may not have the necessary updates to allow A2L refrigerants to be used in 2023. These stakeholders have provided ideas for incorporating an additional compliance pathway in addition to the 2023 effective date. AC manufacturers and other stakeholders have proposed achieving needed emission reductions through use of reclaimed refrigerant in new equipment, servicing existing equipment, refrigerant destruction, as well as a potential crediting system based on type of refrigerant used to account for charge and GWP reduction. The stakeholder proposals can be found in Appendix D and are incorporated by reference. CARB is evaluating the feasibility of additional compliance pathways as well as a hybrid of them, from the standpoint of enforcement, implementation, and emissions benefits and may incorporate changes through a 15-day notice.

[29] "National Supermarket Chain" means a retail food chain, brand name, or business operating more than 100 retail food facilities in the United States.

4. Variance.

The Proposed Amendments include a process for regulated entities to apply for and receive an extension of time to comply or other compliance variations if they are a niche end-use or niche circumstance that meets the criteria for impossibility for or a force majeure event where best efforts were used to achieve compliance. Applicants who meet the criteria must follow both a mitigation plan and compliance plan, which will be incorporated into an Executive Order.

5. Recordkeeping, Reporting, Registration and Labeling.

The Proposed Amendments include labeling and recordkeeping requirements for refrigeration, AC, chillers, as well as some registration and reporting requirements for retail food facilities. Existing labels meeting the requirements may be used. For retail food facilities, existing reporting and recordkeeping requirements under the Refrigerant Management Program regulation will help end-users comply with the reporting requirements under the Proposed Amendments.

An attestation provision for foam end-users subject to recordkeeping requirements has been added. Foam end-users that no longer use any prohibited substance listed in section 95374(a) may attest under penalty of perjury that the end-use does not use a prohibited substance in lieu of complying with the recordkeeping requirements.

6. Definitions.

Definitions were added, including but not limited to aerosol propellants, specific end-uses of foam, chillers, household refrigerators and freezers, and cold storage. Some existing definitions were also modified to conform to existing U.S. EPA definitions.

7. Clarifying Changes.

CARB is also including grammatical fixes to typographical errors, clarifications, and re-organization of the rule that do not materially affect the requirements. The title of the HFC Regulation was modified to reflect all of the end-use categories. For consistency, changes were made to the applicability, purpose, prohibitions, exceptions, disclosure, and recordkeeping requirements. The disclosure statement was modified to make it shorter and align with other states to ensure consistency.

F. What are the Compliance Options?

The development of alternative refrigerants and technologies is quickly evolving in the RAC sectors. This section describes the currently available and under development refrigerants that would be compliant with the Proposed Amendments.

1. **Compliance Options for Stationary Refrigeration.**

The currently available low-GWP (i.e., GWP < 150) refrigerant options for stationary refrigeration are as follows: carbon dioxide (CO_2) and ammonia (NH_3), which have GWP values of 1 and 0, respectively, and hydrocarbons (e.g., propane), which typically have GWP values below 10. CO_2, NH_3, and hydrocarbons were used as refrigerants in the late 19th and early 20th centuries, before the first generation of synthetic fluorinated refrigerants (i.e., CFCs) were invented.

These synthetic fluorinated refrigerants are commonly dubbed "natural refrigerants" because unlike HFCs, these are naturally occurring gases and no companies hold patents on manufacturing them. Natural refrigerants have excellent thermodynamic properties, which make them ideal refrigerants. However, they do present some risks and occupational safety challenges due to their toxicity (for NH_3), flammability (for NH_3 and hydrocarbons) and higher operating pressures (for CO_2).

Their decline in use came after World War II with the development of synthetic CFC refrigerants, which proliferated rapidly due to being relatively safe for humans to handle (lower toxicity and no flame propagation properties). In the 1970's, CFCs were found to be ozone depleting substances (ODS), responsible for the formation of the ozone hole over Antarctica (Molina and Rowland, 1974). In response, the international community rallied to solve the problem and signed the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) in 1987, which was the first international treaty to combat a global environmental crisis, and was ratified by all countries. CFCs were replaced, first by HCFCs and later by HFCs.

Early on, it was discovered that fluorinated refrigerants are capable of absorbing infrared radiation and causing an increase in global surface temperatures (Ramanathan, 1975; Ramanathan et al., 1985). Over the last 70 years, all three generations of fluorinated refrigerants have proven to be very damaging to the environment by either causing ozone depletion or global warming or both. In light of the extreme health and climate damaging impacts of CFCs, HCFCs and then HFCs, the "natural refrigerants" are now re-gaining popularity because they are deemed environmentally benign – unlike the current fluorinated refrigerants, they are not and ODS and have very low to zero GWPs.

Additionally, over the last few decades, advances in technology coupled with rigorous safety regulations have made it possible to manage the occupational risks associated with NH_3, CO_2 and hydrocarbons, and use them safely in refrigeration systems.

i. <u>Carbon Dioxide.</u>

CO_2 is classified as a lower toxicity refrigerant with no flame propagation by The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Being a naturally occurring substance, CO_2 is not a patented refrigerant; this keeps the cost of CO_2 low compared to synthetic HFCs. For these reasons, since the 1990s, CO_2 has steadily regained its popularity as a commercial refrigerant.

In the past, there have been two main challenges for CO_2 systems: (1) CO_2 systems have higher operating pressures than HFCs systems, and (2) CO_2 transcritical systems, where CO_2 is the only refrigerant, can consume more energy than HFC systems in hot climates where the ambient temperature exceeds 87 degrees fahrenheit. Both of these challenges are related to the thermodynamic properties of CO_2. The first challenge can be managed by experienced service contractors and the second one can be mitigated with technology enhancements.

In 2017, A European Commission completed an assessment of CO_2-based refrigeration systems and determined that CO_2 transcritical systems coupled with enhancements like adiabatic gas coolers/condensers, parallel compression, advanced ejectors technology, etc. can exceed the energy efficiency of traditional HFC systems in colder climate zones and at least be at parity in the hotter ambient climate zones with the new technology developments (European Commission, 2017). As of 2018, more than 16,000 transcritical CO_2 supermarkets and grocery stores are in operation in the European Union across different climate zones.

While CO_2 systems were first designed for medium-to-large format stores, technology is evolving rapidly and smaller remote condensing units are already starting to enter the market, which are aimed at smaller format stores, "mom-and-pop" shops, small breweries and dairies (Garry, 2019a). Additionally, CO_2-based technology is expanding into newer end-uses, for example, the use of CO_2 is now being expanded into industrial refrigeration (Garry, 2019b).

ii. <u>Ammonia.</u>

Like CO_2, ammonia has been in use since vapor compression cooling technologies were first developed. NH_3 continues to hold its place in the world of refrigerants. Even today, NH_3 is the most widely used industrial refrigerant, with more than 80 percent of cold storage and IPR facilities using NH_3. This is mainly due its thermodynamic properties and much lower cost as compared to synthetic refrigerants. However, ammonia is acutely toxic and a flammable gas at room temperature, and its use is strictly governed under several local, state and federal regulations. Existing safety regulations ensure the proper use of ammonia, allowing the industry to fully utilize its benefits as a highly energy-efficient refrigerant. The industrial refrigeration industry in particular, is very familiar with ammonia and the workforce of industrial refrigeration service technicians have numerous training courses already available.

Just as CO_2 is gaining popularity as an industrial refrigerant, the advent of low-charge ammonia technology is expanding its use to commercial applications such as in supermarkets. Low-charge ammonia systems contain much smaller quantities of ammonia than the traditional ammonia systems, which mitigates some of the safety-related risks and compliance costs associated with ammonia use. ASHRAE, a premier standards-setting body in the U.S. for the refrigeration and AC sector, encourages the continued use of NH_3 "for - industrial and commercial refrigeration, food preservation, indirect space conditioning, heat pumps and other applications" (ASHRAE, 2017).

iii. Hydrocarbons.

Propane and other hydrocarbons (e.g., isobutane) are now the choice of refrigerant for small, "hermetically sealed" systems. They are highly energy efficient refrigerants. However, they are flammable and can pose a risk to human safety if used inappropriately. For this reason, there is a strict limit of the amount of hydrocarbons that can be used in a system. In refrigeration, this is called the "charge limit" of the system. For propane, the current charge limit in the United States in 150 grams, while globally, the limit was recently raised to 500 grams.

Technology is progressing rapidly to make the best use of these highly efficient refrigerants even in such small quantities. Micro-distributed refrigeration systems using propane are now available for use in supermarkets – in this format, several small, sealed units of propane are used to cool individual fixtures (e.g., display cases), each with its own condensing unit, and may be connected by a water loop to release the heat outside the facility in hot ambient climates. Unlike large, centralized systems, the refrigerant in micro-distributed systems does not circulate all over the store via long lengths of piping, thus minimizing potential for leaks. One supermarket company installed such a system in an 83,000 square foot supermarket in Texas in 2013 and has reportedly experienced no refrigerant leaks to date (McLaughlin, 2019). It also allows for redundancy – if one or two units stop functioning, it does not make the entire refrigeration system for the whole store, dysfunctional. Attempts are currently underway in the U.S. to increase the charge limit for propane and expand its uses.

iv. Low-GWP Hydrofluorocarbons (Under Development).

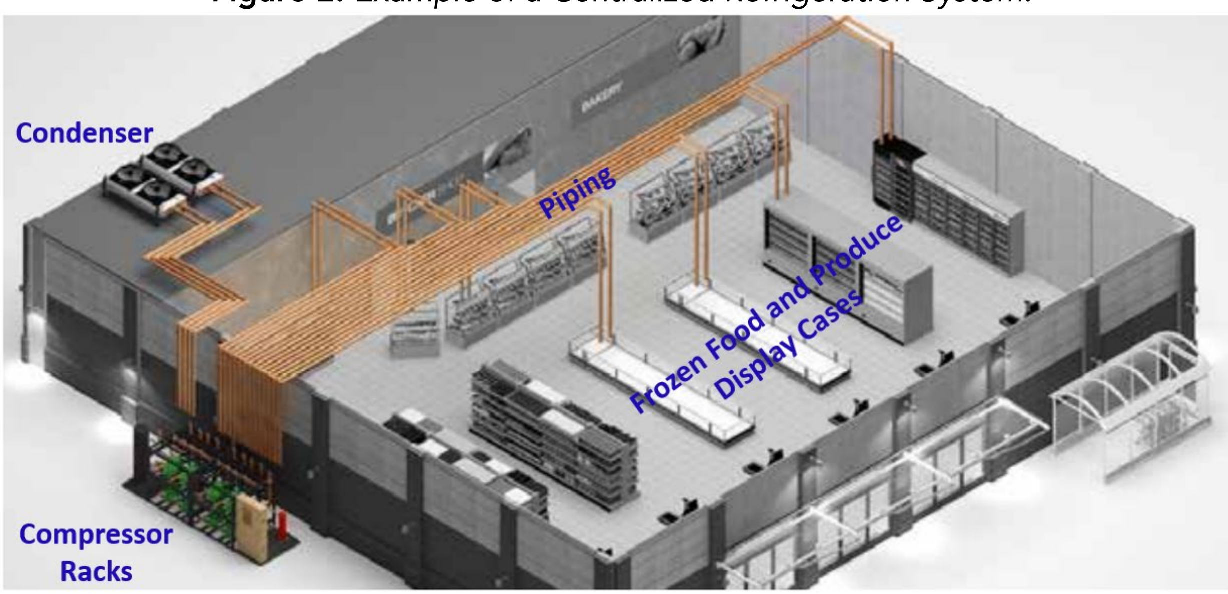
Apart from these options, refrigerant manufacturers are already actively working towards developing and optimizing the next generation of synthetic fluorinated refrigerants with low-GWP values, for example, R-455A and R-454C (GWP 148). Field trials of low-GWP hydrofluoroolefin (HFO) systems are already underway in Europe (Cooling Post, 2019). For the purposes of this regulation, CARB remains technology neutral, and will allow the use of all refrigerants with GWP values below 150.

v. Challenges for Existing Facilities in Adopting Low-GWP Refrigeration Technologies.

The original rule proposed by CARB in the public workshops for refrigeration systems was a GWP limit of 150 for all new equipment, irrespective of whether the new system is used in newly constructed facilities, in remodeled facilities, or to replace retiring equipment in existing facilities (CARB, 2017c; CARB, 2018a; CARB, 2019b; CARB, 2019c). Based on discussions with stakeholders (end-users, original equipment manufacturers or "OEMs," and engineering and design firms), CARB staff determined that while the requirement of low-GWP systems is feasible for newly constructed and remodeled facilities, existing facilities have different circumstances to be considered (see Regulatory Alternative 1 for more details). The main reason is that currently available low-GWP refrigerants (example CO_2, ammonia, propane) are not compatible with the refrigeration infrastructure in existing facilities, which were designed for synthetic fluorinated refrigerants. Changes would likely require complete redesign of the refrigeration infrastructure and may result in temporary closure of the facility with loss of revenue. This is best illustrated with an example.

Figure 2 below shows the typical layout of the refrigeration equipment in a supermarket – broadly, it consists of the following: (1) compressors (often located in a machine room, mezzanine level or at the back of the facility, (2) condenser often located on the rooftop, (3) fixtures like display cases for storing and showcasing produce and frozen foods inside the supermarket, (4) expansion valves or metering devices (not shown), and (5) refrigerant piping or lines connecting the display cases to the compressors and condensers. The refrigerant piping carries cold, mostly liquid refrigerant to the display cases for chilling the products. Inside the display cases, the cold refrigerant absorbs heat and vaporizes, and refrigerant piping carries the refrigerant vapor from the cases back to the compressor and eventually the condenser, to reject heat. In typical supermarkets with centralized refrigeration systems, the length of piping can be fairly extensive.

Figure 2. *Example of a Centralized Refrigeration System.*



The differences in thermodynamic properties and safety-related requirements for the currently available low-GWP refrigerants make them incompatible with the above design. For example, CO_2 has higher operating pressures and a higher volumetric capacity than HFCs – this results in CO_2 systems having smaller compressors, and CO_2 systems require thicker refrigerant piping with a smaller diameter. Ammonia is classified as a toxic and mildly flammable chemical (i.e., is classified as a B2L chemical under ASHRAE's Standard 34) and has several safety regulations governing its use, especially if the amount exceeds 500 pounds. Propane, due to its flammability has very stringent limits on the amount that can be present in a system and cannot be used in the large, centralized systems in the same way that HFCs are used.

Thus, any existing equipment, whether display cases, piping, compressors or condensers in a supermarket which uses HFC refrigerants today, cannot simply be "retrofitted"30 with the currently available low-GWP refrigerants. To use CO_2, NH_3 or hydrocarbons, any existing HFC-based equipment will need to be completely replaced. Supermarkets typically carry out piece-meal replacements and upgrades of the refrigeration systems' parts based on the age and condition of the equipment.

From a GHG emissions standpoint, excluding existing supermarkets and grocery from the requirement means that supermarkets and grocery stores will continue to have high-GWP HFCs banked inside their refrigeration systems for several more decades and leaking into atmosphere causing warming. Alternative regulatory measures are needed for reducing those HFC banks and emissions.

vi. Weighted-Average GWP Reduction Program.

To avoid the substantial cost of full replacements while minimizing the emissions from supermarkets and grocery stores (hereafter referred to as "retail food facilities"), the Proposed Amendments will instead require supermarkets and grocery stores to reduce their current banks of high-GWP HFC refrigerants. To provide flexibility to end-users, CARB staff propose a company-wide standard where each retail food company will be required to reduce their company-wide average GWP (weighted by the pounds of refrigerant, across all their stores) to below 1,400. Hereafter, this is referred to as the "Weighted-Average GWP Reduction Program."

The weighted-average GWP of a chain of supermarkets or grocery stores can be calculated as:

Equation 1:

$$\text{Weighted-Average GWP} = \frac{\Sigma\ (GWP \times charge)}{\Sigma\ charge}$$

Where:

- The numerator is the sum of the pounds of each type of refrigerant used by a company multiplied by their GWP values.

30 The term "retrofit" means to change out refrigerant.

- The denominator is the total pounds of all refrigerants used by a company across all their stores.

This ratio is the average GWP of all refrigerants used by a given company across all their stores, weighted by the amount of refrigerants of different types.

For example, a hypothetical retail food company owns 100 supermarkets in California, and across all their stores, they use the following refrigerants:

Table 3. *Hypothetical Store Information*

#	Refrigerant	GWP (IPCC AR4, 100-year)	Baseline Charge in pounds (lb)
1	R-507	3,985	30,000
2	R-404A	3,922	80,000
3	R-407A	2,107	40,000
4	R-22	1,810	90,000
5	R-448A	1,386	10,000
Total Charge (lb)			**250,000**

Then the weighted-average GWP for this supermarket chain is calculated as:

$$= \frac{(3{,}985 \times 30{,}000) + (3{,}922 \times 80{,}000) + (2{,}107 \times 40{,}000) + (1{,}810 \times 90{,}000) + (1{,}386 \times 10{,}000)\ lb}{(30{,}000 + 80{,}000 + 40{,}000 + 90{,}000 + 10{,}000)\ lb}$$

= 2,777

Under the Proposed Amendment, each company will have to reduce its weighted average GWP to below 1,400 by 2030 (with an intermediate progress step for large companies[31]). In effect, this will be a performance standard for the retail food industry and will reduce the emissions in CO_2-equivalents from current retail food systems, while encouraging transitions to low-GWP technologies, without mandating the latter in existing supermarkets and grocery stores. The benefit of this approach to the industry is, it allows companies flexibility of meeting the standard using measures most suitable for them without being prescriptive. It also allows companies the choice of not impacting every single store they own, since the target is set at a company and not a facility or store level.

The weighted-average GWP reduction program has one target value (i.e., 1,400) for all supermarkets to achieve. This target is independent of a company's current average GWP, which minimizes the implementation challenges associated with this approach. It also rewards early adopters of low-GWP refrigerants since they are already closer to achieving their target. Additionally, all new facilities opened by a company until 2030 will also be included in that companies weighted-average GWP. Any new facilities will

[31] For the purposes of this proposed rule, "Large" retail food companies are defined as those owning 20 or more stores in the State of California.

be considered to be part of the company's portfolio and since new facilities will be required to use refrigerants with a GWP less than 150, inclusion of those facilities in this metric will further reward and incentivize the adoption of low-GWP refrigeration systems.

vii. Greenhouse Gas Potential (GHGp) Reduction Program.

Large retail food companies will also have an alternative compliance pathway, under which they can comply by reducing both refrigerant charge and GWP across their stores. Mathematically, this is the numerator of Equation 1: the term of Σ(GWP × charge) can be called the "Greenhouse Gas Potential" or GHGp and represents the potential HFC emissions that can result from the systems.

Equation 2:

Greenhouse Gas Potential = Σ (Charge × GWP)

Mathematically, GHGp is the sum of the pounds of each type of refrigerant used by a company multiplied by their GWP values. In the same hypothetical example above, the baseline GHGp of the company is 314,952 $MTCO_2e$.

#	Refrigerant	GWP (IPCC AR4, 100-year)	Baseline Charge in pounds in 2019 (lb)	Baseline GHGp: charge × GWP (lb CO_2e)
1	R-507	3,985	30,000	119,550,000
2	R-404A	3,922	80,000	313,760,000
3	R-407A	2,107	40,000	84,280,000
4	R-22	1,810	90,000	162,900,000
5	R-448A	1,386	10,000	13,860,000
Total Company-Wide Baseline GHGp in 2019 (lb CO_2e)				**694,350,000**
Total Company-Wide Baseline GHGp in 2019 ($MTCO_2e$)[a]				**314,952**

[a] Converted pounds of CO_2-equivalents to metric tons of CO_2-equivalents by using the conversion factor: 1 metric ton = 2204.62 pounds.

Under this option, end-users will be required to reduce their company-wide GHGp by 55 percent below their 2019 baseline by 2030. For this hypothetical example, the target GHGp in 2030 is 314,952 – (314,952 × 0.55) = 141,729 $MTCO_2e$. The GHGp reduction option offers flexibility to the end-users where they get equal credit for reducing charge and GWP, but because it is a relative reduction target, it will place additional implementation-related requirements on them related to tracking their baselines and providing sufficient records for charge reduction. This compliance option was suggested by a group of supermarket companies to CARB.

It is important to note here that since GHGp reduction is a relative reduction target, new stores opening after the baseline year of 2019 will be excluded from the calculation. Any new store, even one that uses low-GWP refrigerants, will mathematically increase the company's GHGp and thus the compliance obligations of that company. So new stores opening after 2019 will be excluded from GHGp to avoid increasing the emissions reductions requirements for companies that choose to use this compliance pathway.

Both, the weighted-average GWP target of 1,400 and a GHGp reduction pathway of 55 percent below current levels will achieve similar emissions reductions at a state-wide level, although the former is easier to implement.

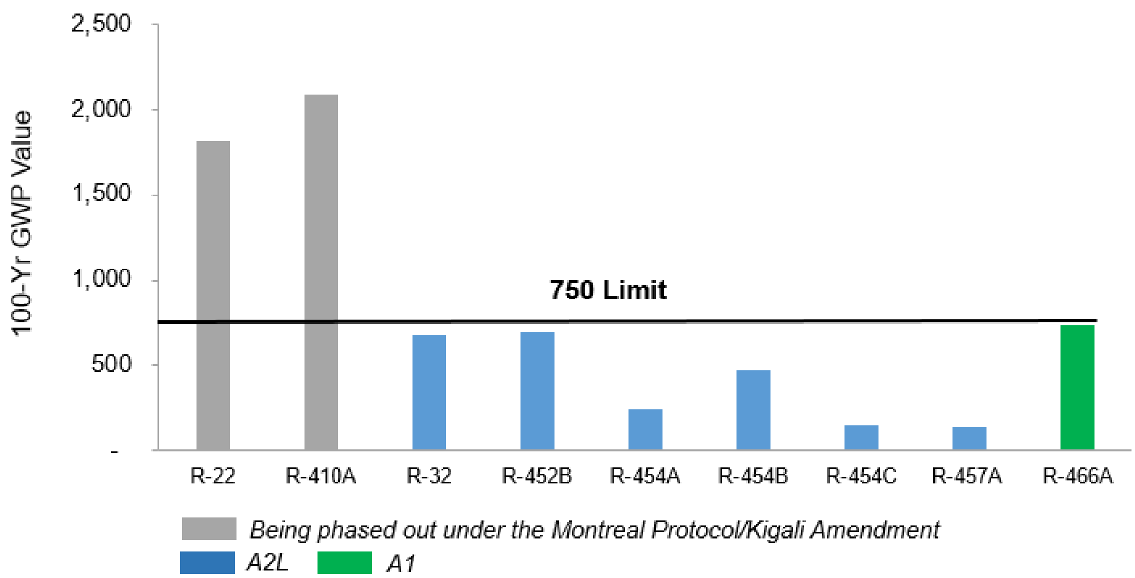
The following are some options for complying with the weighted-average GWP and/or GHGp reduction targets:

- Reduce GWP by:
    - Retrofits to refrigerants with GWP below 1,400.
    - Partial system conversions to low-GWP (GWP < 150) refrigerants in the store.
- Reduce refrigerant amount (or charge) and GWP by:
    - Replace a current system with distributed systems using refrigerants with GWP less than 1,400. These systems use smaller amounts of refrigerants than the current systems.
    - Replace a current system with an indirect system, i.e., systems which use smaller quantities of HFC refrigerants as the primary refrigerants and a secondary heat transfer fluid or low-GWP refrigerant to cool products e.g., cascades.
    - During a refrigerant retrofit, replace certain components that reduce amount of refrigerant needed, for example, using plated heat exchangers.

2. Compliance Options for Stationary AC.

Most AC equipment on the market today uses R-410A, an HFC refrigerant. Prior to 2010, most ACs were designed to use R-22, an HCFC refrigerant that is being phased out globally because it harms the ozone layer. To protect the ozone layer, U.S. EPA banned R-22-for use in new equipment in 2010 and manufacturers switched to R-410A. While R-410A has zero ozone depletion potential, it has a GWP value of 2,088. Industry has long recognized that the use of R-410A is not sustainable because of its impact on climate and have been working to commercialize low-GWP alternatives (**Figure 3**).

Figure 3. *Refrigerant Alternatives to R-410A*

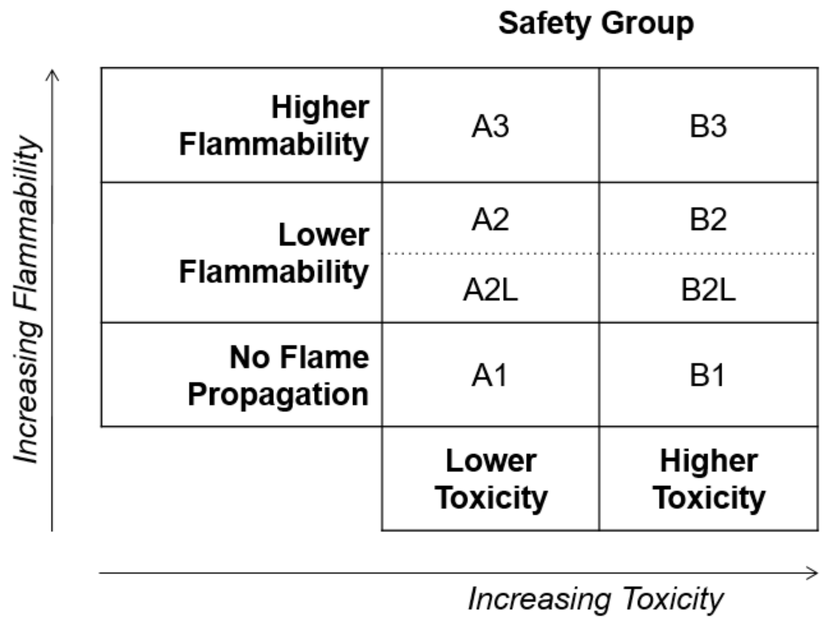


i. <u>Overview of Safety Classifications.</u>

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 34 assigns safety classifications to refrigerants based on toxicity and flammability (see **Figure 4**). The classifications set by ASHRAE Standard 34 are used to determine requirements for safe refrigerant use. The capital letter indicates the toxicity and the numeral denotes the flammability. Class A refers to lower toxicity refrigerants and Class B signifies higher toxicity refrigerants.[32] Refrigerants are also assigned a flammability classification of 1, 2, 2L or 3 in order of increasing flammability.

[32] Lower toxicity refrigerants are defined as refrigerants for which toxicity has not been identified at concentrations ≤ 400 parts per million (ppm) by volume. Higher toxicity refrigerants are defined as refrigerants for which there is evidence of toxicity at concentrations < 400 ppm by volume.

Figure 4. *Refrigerant Safety Classification from ASHRAE Standard 34*



The flammability classification "1" is given to refrigerants that, show no flame propagation under test conditions.[33] The flammability classification "3" stands for "higher flammability." Class 3 refrigerants will propagate a flame and have a low lower flammability limit (LFL) (meaning they require a relatively low level of refrigerant to ignite) and release more heat when they do combust.[34] Examples of Class 3 refrigerants include Propane (R-290) and isobutene (R-600a), which are currently used in household refrigerators in the United States. Class "2" refers to refrigerants that, exhibit flame propagation at test conditions, but do not release as much heat. In addition, Class 2 refrigerants have a higher LFL meaning that they require a higher concentration of refrigerant in air to ignite.[35] Refrigerants are classified in the lower flammability subclass "2L" if they also have a maximum burning velocity of 10 cm/s.[36]

ii. <u>A2L Refrigerants.</u>

Many of the refrigerant alternatives that have been identified as viable alternatives to R410A are categorized as "A2L." A2L refrigerants are a relatively new class of refrigerants that industry developed in anticipation of global and national policies to phasedown high-GWP refrigerants. A2L refrigerants can offer a significant reduction

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[33] Flammability testing is conducted using a spark ignition source at 60 °C and 101.3 kPa.
[34] Class 3 refrigerants have a heat of combustion of 19,000 kJ/kg (8,174 BTU/lb) or greater or a lower flammability limit (LFL) of 0.10 kg/m^3 or lower. The LFL is a measure of what concentration in air a refrigerant needs to reach before it is possible for it to ignite.
[35]Class 2 refrigerants are defined as refrigerants have a heat of combustion less than 19,000 kJ/kg (8,174 BTU/lb), and have a LFL greater than 0.10 kg/m^3.
[36] When tested at 23.0 °C and 101.3 kPa.

in GWP with lower flammability characteristics than the very low-GWP but highly flammable refrigerant options.

Extensive research and testing has been conducted to characterize the risk associated with using A2L refrigerants and inform the development of safety standards. AHRI, CARB, and the U.S. Department of Energy collaborated on a $5.6 million dollar research program to produce publicly available technical results to support code and standard activities related to the use of flammable refrigerants. A number of research activities were included in this collaborative research program ranging from leak assessments, ignition testing, charge limit determinations, viability of ignition sources and safe servicing practices in various equipment types.

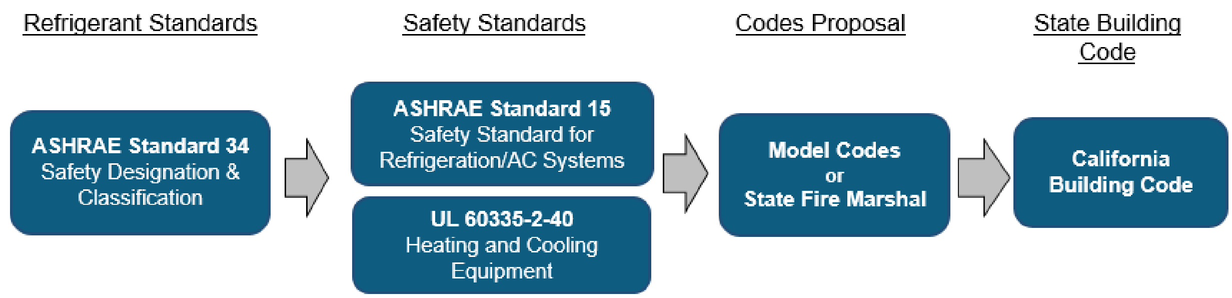
In many cases, research testing simulated low-probability events to evaluate the risk of fire in worst case scenarios. A majority of the research has been completed and the findings have been used to update safety standards that govern the safe use of these refrigerants, namely ASHRAE 34, ASHRAE 15 and UL 60335-2040. There is additional research being conducted to further inform future revisions of these safety standards, which are continuously revised based on the latest research.

These research efforts have informed safe equipment design and safe installation, operation and servicing practices such as the amounts of refrigerant that can be safely used in residential and commercial air conditioning equipment, safety mitigation measures such as detectors and ventilation, safe operating temperature ranges, and common ignition sources that should be avoided in the vicinity of the equipment among others. In addition to these industry-wide efforts, individual manufacturers as well government and non-governmental organizations in Europe, Japan and other parts of the world have done extensive testing for A2L refrigerants. Having determined safe use criteria, several countries have transitioned a significant portion of their air conditioning equipment market to A2Ls.

A2Ls are currently allowed in room ACs in California. A2Ls are also permitted for use in large refrigeration and AC systems located in machine rooms in commercial facilities. These larger systems are typically indirect systems, where the refrigerant does not directly cool the conditioned space but is contained within the machine room. To use an A2L refrigerant in other AC products such as residential central ACs and commercial ACs would require updating the California Building Standards Code to incorporate the new standards. Updates are made to the California Building Standards Code every few years and generally follow updates to safety standards (**Figure 5**). In addition, all refrigerants require approval for use by the U.S. EPA. In order to use a refrigerant in the United States, the refrigerant must be listed as acceptable for that end-use by the U.S. EPA.

ASHRAE and UL safety standards have been updated with provisions that allow for use of A2Ls in AC products. This includes the recent publications of ASHRAE Standard 15-2019 and UL-60335-2-40 3rd Edition. ASHRAE Standard 15 is an application standard (governs installation etc.) and UL-60335-2-40 is an equipment standard (equipment design and testing). The updated standards include provisions for A2L refrigerants to be used in residential and commercial ACs with additional safety features compared to conventional A1 refrigerants. These safety features include warning markings, limits on refrigerant amount, greater ventilation requirements, refrigerant leak sensors, alarms, safety shutoff valves, and more.

Figure 5. *California Building Standards Code Adoption of Safety Standards*



The standards are one step in the process. In order for A2L refrigerants to be used in California residential and commercial AC, ASHRAE Standard 15-2019 and UL-60335-2-40 3rd Edition need to be adopted into Title 24 of the California Code of Regulations. Title 24, also known as the California Building Standards Code is amended through a rulemaking process conducted by the California Building Standards Commission (CBSC). Updated building codes are adopted every three years through the Triennial Code Adoption Cycle. There is also an intervening code adoption cycle that takes place in between the triennial cycle. The next opportunity to update the California Building Standards Code is the 2022 Triennial Code Adoption Cycle, which goes into effect January 2023.

Typically, once new standards are completed, they are adopted by national codes bodies into model codes as an intermediary step. Model building codes organizations are independent organizations that develop building codes that state governments can choose to adopt in whole or amend to meet the state's specific needs. California adopts model codes developed by International Code Council (ICC) and the International Association of Plumbing and Mechanical Officials (IAPMO).

ICC and IAPMO recently voted against adopting UL 60335-2-40 3rd Edition and ASHRAE 15-2019 for the 2021 model code cycle, which is for the 2022 California Building Standards Code cycle. At that point in time, ASHRAE 15-2019 had recently been published and UL 60335-2-40 3rd Edition had been finalized but had not yet been published. The next opportunity to adopt these standards into the model codes is the 2024 model code cycle, which corresponds to the 2025 California Building Standards Code cycle. However, model codes are not the only avenue for new standards to be adopted into the California Building Standards Code.

Some state agencies have the statutory authority to make code change proposals to the CBSC. The State Fire Marshal is a subject matter expert with authority to propose code changes for the California Building Standards Code pertaining to refrigerants. The Department of Housing and Community Development (HCD) has authority to make code changes proposals for codes affecting the residential sector. Typically, the State Fire Marshal and HCD work collaboratively on code change proposals that overlap with their jurisdictions. The State Fire Marshal is currently convening an A2L workgroup regarding adopting the latest safety standards into the California Building Standards Code. The A2L workgroup consists of HCD staff, codes and standards experts, staff from other state agencies including CARB, trade organizations, fire service personnel and other stakeholders. The State Fire Marshal is expected to come to a conclusion as to a code change proposal by December 2020. If the State Fire Marshal recommends a code change proposal, it could be folded into the rulemaking process for the Triennial Code Adoption Cycle, the process for which begins in 2021, with publication by 2022, and an effective date of January 2023.

In addition to updating the California Building Standards Code, A2L refrigerants must also be approved under the U.S. EPA SNAP Program. Under the U.S. EPA SNAP Program, U.S. EPA staff evaluate HFCs and other chemicals used in a variety of end-uses where ODS have traditionally been used. The SNAP Program lists refrigerants and other ODS replacements as acceptable, acceptable subject to use restrictions or unacceptable for specific end-uses. U.S. EPA issues these determinations based on overall risks to human health and the environment. R-32, an A2L refrigerant, received SNAP approval for room ACs in 2015. In May 2020, U.S. EPA proposed SNAP Rule 23,[37] which expands the list of approved refrigerants for refrigeration, air conditioning and foam end-uses. The proposed new rule would list six A2L refrigerants (R-32 and five A2L blends; R-452B, R-454A, R-454B, R-454C, R-457A) as acceptable, subject to use conditions, for residential and light commercial air conditioners and heat pumps.

A transition to A2L refrigerants is already underway. In the United States, the majority of new vehicles use R-1234yf (an A2L refrigerant) and A2L refrigerants are readily available in room AC products. For example, end-users can purchase a window or portable AC using an A2L refrigerant with a GWP less than 750 in California today. For larger residential and commercial products, the United States is behind the rest of the world. About 100 million ACs using the A2L refrigerant R-32 have been sold worldwide in Japan, Australia, Europe and Asia.

In 2019, AHRI created the Safe Refrigerant Task Force to develop an end-to-end supply chain transition strategy to enable the safe commercialization of residential air conditioning products containing mildly refrigerants prior to January 1, 2023. The goal of the task force is to evaluate the entire supply chain and address issues to enable the safe and reliable use of mildly flammable refrigerants in preparation for an industry transition. A similar approach was taken in Australia to safely transition to the

[37] 80 Fed. Reg. 35874 (June 12, 2020).

industry to A2L refrigerants. The task force consists of members across the supply chain including equipment and component manufacturers, equipment and refrigerant distributors, contractors and technicians, code officials, consulting firms, government agencies and non-profit organizations.

The primary goals of the task force are to identify any barriers pertaining to flammable or toxic refrigerants in the supply chain and develop pathways for a safe transition. The task force is addressing the following elements among others:

- Safe installation, operation and maintenance practices;
- Safe equipment design;
- Adoption of safety standards and building codes;
- Outreach and training for technicians, contractors, consumers, first responders, local government officials and building code inspectors;
- Procedures for bulk storage;
- Procedures for manufacturing facilities;
- Department of transportation regulations and other regulations for the shipping, packaging, handling and warehousing; and
- Equipment and procedures for the safe recovery, reclaim and destruction of refrigerants.

iii. A1 Refrigerants.

Another compliance option to replace R-410A is to use an A1 refrigerant (R-466A). First announced in 2018, R-466A has a GWP of 733 and an A1 classification. R-466A contains both R-32 and R-125, similar to R-410A, but adds trifluoroiodomethane (CF_3I) to create a low-GWP refrigerant with A1 properties. U.S. EPA issued a letter of completeness for the use of R-466A in commercial and residential AC equipment in 2019. The use of fluoroiodocarbons, including CF_3I, in refrigerant blends is not entirely new and was first considered in the 1990s. These refrigerant blends were of interest because of their A1 classification, high performance (energy efficiency and capacity), essentially zero ozone depletion potential, and low-GWP.

Commercialization of these refrigerants, including for AC end-uses, was recommended after promising performance testing and initial studies funded by the U.S. EPA and others. (McCullough et al., 2001 and 2003). With the absence of regulations requiring low-GWP refrigerants, the availability of less expensive refrigerants, and other market forces, this class of refrigerants was never deployed commercially for residential and commercial ACs. With the growing pressure to transition to more climate friendly refrigerants around the world and California's SB 1383 target to reduce HFC emissions, manufacturers are revisiting CF_3I.

iv. What About Natural Refrigerants for AC?

Natural refrigerants, including CO_2, hydrocarbons, water and ammonia have been investigated for use as refrigerants in AC applications by research institutions and manufacturers alike because of their environmentally friendly characteristics and desirable heat transfer properties. While stringent safety regulations and product design allow their safe and efficient use in commercial and industrial refrigeration, currently, there are limited commercially available products employing these refrigerants in AC equipment. As an AC refrigerant, CO_2 has demonstrated low energy efficiency in some prototypes. Because of its toxic nature, ammonia has not deemed a suitable refrigerant, particularly in residential and light commercial applications. Hydronic AC systems using water are gaining more traction. There continues to be active research and development to develop commercially viable AC systems using natural refrigerants.

Of the natural refrigerants, hydrocarbons are used in some commercially available units. Hydrocarbons are naturally occurring substances, have GWP values of 3, and owing to their thermodynamic properties, are excellent refrigerants. There has extensive research and development worldwide exploring the applicability of hydrocarbons (particularly propane and isobutane) as refrigerants given their favorable attributes. While they have gained traction in some applications, the primary limiting factor to using hydrocarbons in many applications is their flammability. Hydrocarbons are categorized as A3 refrigerants i.e. lower toxicity and higher flammability.

Currently, safety standards and building codes in the U.S. allow a maximum of 150 grams of hydrocarbons and only in hermetically sealed, self-contained and factory charged refrigeration and AC units. The 150 grams limit has worked fairly well in refrigerated cases but has not proved to be viable in AC units. Self-contained window/wall hydrocarbon AC units are common in other countries, but these contain approximately 300 grams of hydrocarbons at minimum.

Nonetheless, a few companies are exploring alternative technologies such as polymer membranes and advanced heat exchanger designs to design self-contained AC units within the constraints of the 150 gram limit. Even if these efforts lead to fruition, it will take 2 to 3 years at the earliest and the applications will be limit to small window units. While the rest of the world has embraced self-contained smaller AC units, the U.S. has taken a different path; larger central ACs are the norm here. There is little to no discussion at present to use hydrocarbons in central AC units, which utilize much larger quantities of refrigerants and are neither self-contained nor hermetically sealed.

v. Additional Compliance Pathway.

CARB staff intend to keep the 2023 date for those who can comply with that date. While some AC manufacturers and stakeholders have conveyed support for the 2023 compliance date, several stakeholders have requested that CARB delay the effective date for the 750 GWP limit for new AC equipment from January 1, 2023 to January 1, 2025. The reasons put forth for this request include: (1) allowing additional time for AC manufacturers to transition refrigerants, (2) the A1 alternative (R-466A) may require more time to be ready as a substitute refrigerant, and (3) the California Building Standards Code may not have the necessary updates to allow A2L refrigerants to be used in 2023. These stakeholders have provided ideas for incorporating an additional compliance pathway.

AC manufacturers and other stakeholders have proposed achieving needed emissions reductions through use of refrigerant reclaim in new equipment, servicing existing equipment, refrigerant destruction, as well as potential crediting system based on type of refrigerant used to account for charge and GWP reduction. Stakeholder proposals can be found in Appendix D, which is incorporated by reference.

CARB staff are considering incorporating a compliance pathway. An additional compliance pathway for AC manufacturers and other regulated entities could include the allowance of a two-year delay or temporary exemption from the 750 GWP requirement for AC manufacturers if the manufacturer is able to offset the CO_2 equivalent amount of refrigerant equal to the initial refrigerant charge size through the purchase and use of reclaimed refrigerant in equipment placed on the market in California during the delay. If reclaimed refrigerant is not used in equipment during the delay then manufacturers would need to offset the initial charge plus the anticipated additional service gas for the lifetime of the exempted equipment within five years. In addition, manufacturers would likely be subject to additional requirements:

- Manufacturers must show contractual agreements to purchase reclaimed refrigerants for use or distribution with reclaimers or distributors.

- All activities related to the exemption or delay are subject to verification. CARB staff is considering this verification and reporting being done through a third-party audit, reporting on an annual basis to CARB, or annual self-certification to CARB.

- Non-compliance is subject to strict liability penalties equivalent to the California cost of carbon estimates per CO_2e offset not met.

CARB is evaluating the feasibility of these additional compliance pathways as well as a hybrid of them, from the standpoint of enforcement, implementation, and emissions benefits and may incorporate changes through a 15-day notice. CARB may consider needs for collecting research and development information for specialized systems. CARB may also consider other changes to the sections affected during the course of this rulemaking process. Any changes to the proposal would be presented to the Board for consideration during the Board Hearing scheduled for December 10 – 11, 2020.

G. Standardized Regulatory Impact Assessment.

In March 2020, CARB submitted a Standardized Regulatory Impact Assessment (SRIA) to the Department of Finance (DOF) for its review. CARB has updated the Proposed Amendments and SRIA since the original SRIA submittal, and updated the economic and emissions analysis to address DOF comments. DOF generally concurs with the methodology used to estimate impacts of the proposed regulations but had two main comments for CARB:

DOF Comment 1: "First, the baseline should include a description and breakdown of affected populations by business types and by household income in order to augment the analysis of disparate impacts. The SRIA assumes that costs and benefits are the same for small businesses and typical businesses, however no justification is provided and it is unclear how many small businesses fall into each regulatory category and compliance timeline. Moreover, the SRIA does not discuss disparate impacts on individuals. An analysis of compliance costs as a proportion of business revenue and household income would help support CARB's assessment of no differential impacts on regulated entities."

Response: In the subsequent sections, CARB includes a description and breakdown of the affected populations by business type (for both the refrigeration and AC requirements) and also by household income (for AC). In addition, CARB includes additional information about the costs and benefits for small versus typical businesses as well as an analysis of disparate impacts on individuals. This analysis includes compliances costs as a proportion of business revenues and household income. For refrigeration, on average, the annualized cost of compliance is less than 0.01 percent of the average business revenue. Additionally, the impact on small businesses is lower than that on typical businesses.

DOF Comment 2: "Second, the SRIA should include a discussion of how impacts will change under different growth and emissions scenarios. We recognize that economic data tends to lag, however, given current circumstances and uncertainties, future impact assessments for this regulation should incorporate the most up-to-date forecast issued by Finance, to the extent possible, as well as sensitivity analysis to model how impacts may vary in case of deviations from the assumed baseline."

Response: The emissions and cost analysis in the ISOR has been updated to reflect the newly released 2020 population forecast from DOF, that CARB uses to project refrigeration and AC growth. The average population growth rate from 0.7 percent from 2022 to 2040 to an average of 0.5 percent (California DOFa and b). This changes (reduces) the total cost of the regulation and the associated emissions benefits by less than approximately 5 percent. In addition, staff considered the most recent recession in the late 2000s. During this time, AC sales reported by AHRI declined an average of 10 percent from 2005 to 2010 before returning to a pre-recession growth rate. CARB conducted a sensitivity analysis in which a 10 percent decline in AC sales occurs from the period of 2020 to 2025. This may represents a worst case scenario as in current conditions, home sales and construction has not been as affected as in the previous recession. In this worst-case scenario the cost would decrease from $3.8 billion to $1.6 billion. The annual emissions reductions decrease from 2.3 $MMTCO_2e$ in 2030 to 1.2 $MMTCO_2e$ and the cumulative reductions decrease 50 $MMTCO_2e$ from to 24 $MMTCO_2e$. However, the change in sales would also have a corresponding impact on the baseline. Therefore, the relative emissions reductions compared to baseline would remain unchanged as would the cost-effectiveness.

H. What are the Expected Emissions Benefits?

The Proposed Amendments are estimated to achieve reductions of approximately 3.8 $MMTCO_2e$ in annual emissions in the year 2030. On a cumulative basis, emissions reductions of 72 $MMTCO_2e$ are expected by the year 2040. These benefits are based on 100-year GWP values and take into account the 2020 population forecasts by the California Department of Finance. For more details on the anticipated benefits from this regulation, see **Section VIII.D.**

I. What are the Expected Costs?

The Proposed Amendments cover the following categories of businesses that use RAC systems and have an annual average cost as outlined in table below.

Table 4. *Regulated Businesses and Overview of Costs*

General End-Use	Specific End-Use	Entities Affected	Average Annual Direct Costs, 2022-2040 (million 2018$/year)
Air Conditioning	Air conditioning equipment (new) residential and commercial	Air conditioning equipment manufacturers	$201
Refrigeration	Systems containing more than 50 pounds of refrigerant	Supermarkets and grocery stores (i.e., retail food facilities); cold storage warehouses; industrial processes including, but not limited to, food production	$25.9

General End-Use	Specific End-Use	Entities Affected	Average Annual Direct Costs, 2022-2040 (million 2018$/year)
		and manufacturing, wineries, breweries, chemical manufacturing etc.	
Average Annual Cost (AC and Refrigeration) (million 2018$)			**$227**

The average annual direct costs between 2022 and 2040 are $25.9 million for the refrigeration end-use sectors and $201 million for the AC end-use sectors. The direct costs comprise costs related to equipment, installation, maintenance, refrigerant replenishment, electricity, retrofit of manufacturing facilities, and in case of refrigeration, the costs associated with compliance with the weighted-average GWP reduction requirements for retail food facilities. For more details, see **Section VIII** and **Appendix B** for the Standardized Regulatory Impact Assessment.

J. California Legislative Mandates and Legislative Authority to Regulate.

California is committed to lead and support pioneering efforts to protect the environment and improve public health while maintaining a vibrant economy. California made a groundbreaking commitment to address climate change with the passage of AB 32 – the "California Global Warming Solutions Act of 2006." AB 32 charges CARB with reducing statewide GHG emissions to 1990 emission levels by 2020, and to continue and maintain reductions beyond 2020, stimulate investment in clean and efficient technologies, and improve air quality and public health. In 2016, California strengthened its commitment when the Legislature enacted SB 32, the "California Global Warming Solutions Act of 2006: Emission Limit," codifying an additional reduction target for statewide GHG emissions of 40 percent below 1990 emission levels by 2030.

Achieving deep reductions in HFC emissions and other SLCPs is specifically called for and necessary to meeting the GHG emissions reduction mandates set by AB 32 and SB 32. Recognizing this, the California Legislature passed Senate Bill 605 (SB 605),38 the "Short-Lived Climate Pollutants Act," requiring CARB to develop a plan to reduce

[38] SB 605 (Lara, Stat. 2014, Ch. 523).

emissions of SLCPs, and SB 1383, requiring CARB to approve and begin implementing the plan by January 1, 2018. SB 1383 also set targets for statewide reductions in SLCP emissions by 40 percent below 2013 levels by 2030 for HFCs as well as targets for black carbon and methane. The Board adopted CARB's SLCP Strategy in March 2017, which describes CARB's strategy for reducing annual HFC emissions to meet the SB 1383 2030 goal.

The SLCP Strategy describes four potential HFC emissions reduction measures to achieve the SB 1383 reductions goal:

(1) Prohibition on high-GWP refrigerants in new refrigeration and AC equipment (the proposed measure of this ISOR).

(2) Financial incentives for early adoption of low-GWP refrigeration. SB 1013 created the F-Gas Incentive Program. In 2019, the Legislature appropriated one million dollars from the California Greenhouse Gas Reduction Fund (GGRF) to fund the incentive program to offset the purchase of low-GWP refrigeration equipment.

(3) Prohibition on the sales of very-high GWP refrigerants. This measure has not been recommended in the current proposed rulemaking, although CARB continues to assess the potential necessity of a refrigerant sales prohibition at a later date.

(4) HFC supply phasedown (to be achieved through the global HFC phasedown). This measure has not been recommended in the current proposed rulemaking. A global HFC production and consumption phasedown was agreed to on October 15, 2016, in Kigali, Rwanda (often referred to as "The Kigali Amendment to the Montreal Protocol," or "The Kigali Agreement")(U.N., 2019). The United States has not ratified the Kigali Agreement as of September 2020. In 2019, the American Innovation and Manufacturing Act of 2019 (S.2754) (AIM Act)[39] was introduced (as well as variations of this bill) and if passed into law, will mandate an HFC production and consumption phasedown similar to the requirements in the Kigali Agreement. As of September 2020, no national legislation has been signed into law.

[39] AIM Act, S.2754, available at https://www.congress.gov/bill/116th-congress/house-bill/5544?s=1&r=62.

K. Regulatory Context.

1. Existing CARB HFC Measures.

California has existing regulations to reduce emissions from non-residential stationary refrigeration equipment, motor vehicle air-conditioning, self-sealing valve requirement for small cans of automotive refrigerants purchased by "do-it-yourself" (DIY) mechanics, consumer product aerosols-propellants, and semiconductor manufacturing. A brief description of current California HFC regulations follows:

Refrigerant Management Program (RMP).[40] RMP is modeled after the U.S. EPA Clean Air Act, Section 608 program to protect the stratospheric ozone layer by reducing usage and emissions of ODS. In addition to ODS, CARB included non-ODS HFC refrigerants with a 100-year GWP of 150 or greater (considered "high-GWP").

California HFC Regulation.[41] In 2018, California backstopped key U.S. EPA SNAP Program prohibitions on high-GWP HFCs through two avenues. First, by adopting a new CARB HFC regulation ("*Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols, Propellants, and Foam End-Uses Regulation*"), and secondly, through new legislation—SB 1013. For more details about this, see Section I.C.

Consumer Product Aerosol Propellant Regulations.[42] The consumer products regulation prohibits the use of HFC propellants or chemical compound with a GWP greater than 150 in pressurized gas dusters, certain insecticides, certain aerosol adhesives, multipurpose aerosol solvents, aerosol paint thinners, and certain aerosol lubricants. See California Code of Regulations, title 17, section 94509(n)(1) for a complete list of all prohibitions.

Semiconductor Manufacturing Fluorinated gas (F-gas) Regulation.[43] The semiconductor manufacturing F-Gas reductions program requires reductions in the emissions of F-gases, including HFCs, used in the manufacture of semiconductors.

Motor Vehicle Air-conditioning (MVAC) "Small Cans" Program.[44] The Small Cans program requires a deposit fee and return recycling program for cans of HFC-134a AC refrigerant used by at-home mechanics. Refrigerant cans are also required to have a self-sealing valve.

[40] Cal. Code Regs., tit. 17, §§ 95380, et seq.
[41] Cal. Code Regs., tit. 17, §§ 95371, et seq.
[42] Cal. Code Regs., tit. 17, §§ 95409, et seq.
[43] Cal. Code Regs., tit. 17, §§ 95320, et seq.
[44] Cal. Code Regs., tit. 17, §§ 95360, et seq

2. Existing Federal HFC Measures.

U.S. EPA regulates[45] HFCs under two separate sections of the Clean Air Act. The existing federal regulations on HFCs include the following provisions:

U.S. EPA Rule 612.[46] U.S. EPA implements the SNAP Program under Section 612 of the Clean Air Act[47] to identify and evaluate substitutes for ODS. [48] California does not maintain a state-specific list of acceptable refrigerants and other ODS substitutes, California relies upon and uses the U.S. EPA SNAP list of acceptable substitutes to ODS. The U.S. EPA SNAP program evaluates all ODS substitutes for environmental and occupational safety before they are approved as acceptable for use in specific end-use sectors.

U.S. EPA Rule 608.[49] Section 608 of the Clean Air Act prohibits the known release of refrigerant during the maintenance, service, repair, or disposal of AC and refrigeration equipment. The U.S. EPA requires proper refrigerant management practices by owners and operators of refrigeration and AC systems, technicians, and others.[50] On February 26, 2020, U.S. EPA rescinded the November 18, 2016, extension of the leak repair provisions to appliances using substitute refrigerants, which are non-ODS substances, such as HFCs. This rollback specifically reverses the leak repair requirements and associated recordkeeping and reporting provisions found in 40 C.F.R. section 82.157 for appliances using substitute refrigerants.

3. Building Codes and Industry Voluntary Standards.

The American National Standards Institute (ANSI) is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. Both the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and Underwriters Laboratory (UL) are ANSI accredited standard setting bodies.
UL develops and publishes product safety standards, which contain design criteria for appliances. Manufacturers build products in accordance with these safety standards and submit them to UL for testing. UL provides certification for these products if they meet the safety standards design criteria.

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[45] Due to the *Mexichem* decisions, manufacturers are no longer required to replace HFCs where they previously replaced an ODS, but U.S. EPA does continue to approve safe substitutes for CFCs and HCFCs.
[46] 40 C.F.R. Pt. 82, Subpt. G, App. U and V.
[47] 42 U.S.C. § 7671k, et seq.
[48] 42 U.S.C. § 7671g, et seq.
[49] 40 C.F.R. Pt. 82, Subpt. F.
[50] U.S. EPA released a final rule that removed HFCs from the 608 requirements. See Protection of Stratospheric Ozone: Revisions to the Refrigerant Management Program's Extension to Substitutes, 85 Fed. Reg. 14150 (Mar. 11, 2020).

ASHRAE develops and publishes application safety standards that describe equipment design and safe installation, often referred to as application safety standards. ASHRAE and UL have representative consensus guidelines for committees that develop standards to engage a diverse set of stakeholders. UL and ASHRAE standards are designed to complement one another and work in conjunction. Standards are adopted into state building codes, whereby they become law. In order for a refrigerant to be used in California, it must be permitted for use in the building code subject to certain restrictions such as charge amounts and concentration limits. In addition, products using that refrigerant must be designed and installed in accordance with safety standards included in the building codes. Products used in California and the U.S. are certified by organizations such as UL and Intertek that are approved for safety testing and certification.

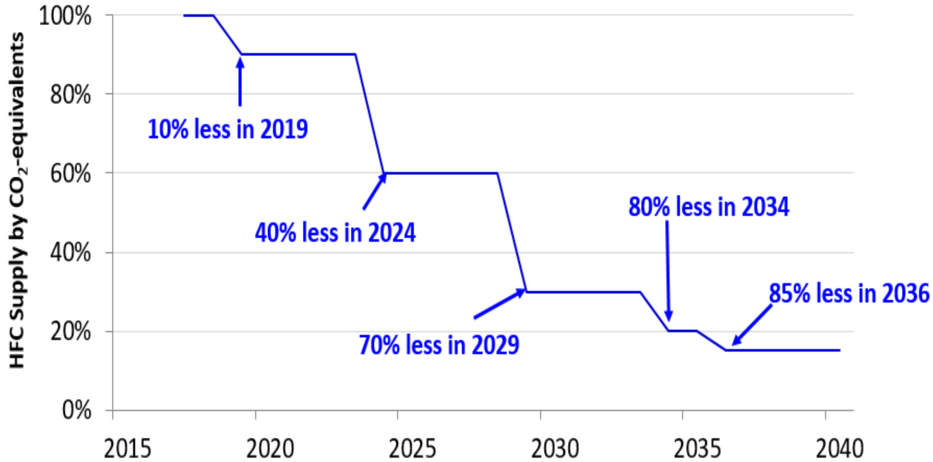
L. International Context.

The global community has recognized the importance of reducing HFC emissions to alleviate the worst impacts of global warming. In 2016, representatives from 197 nations signed "The Kigali Amendment" to amend the existing Montreal Protocol (to reduce ODS production and consumption) to include a gradual phasedown in the production of HFCs beginning 2019. The Kigali Amendment were ratified and entered into force on January 1, 2019. As of February 2020, 85 nations have ratified the Kigali Amendment. Although the United States was a signatory, it has not ratified the Kigali Amendment as of September 2020.

Under the Kigali Amendment, Non-Article 5 Parties,[51] including Japan, Australia, Canada and the European Union (EU) have committed to reducing production and consumption of HFCs by 85 percent below 2012-2013 average annual usage baseline levels by the year 2036. Most Article 5 Parties have committed to reducing HFCs 80 percent by the year 2040, as compared to future average annual baseline usage of HFCs in years 2020, 2021, and 2022. **Figure 6** shows the phasedown schedule for Non-Article 5 countries. The majority of AC and refrigeration equipment manufacturers selling equipment to California are international corporations transitioning product lines away from high-GWP HFC refrigerants and have invested billions to bring next generation refrigerants and equipment to market (AHRI and ARAP, 2019).

[51] The Montreal Protocol separates countries into two different classifications based on the special situation of developing countries. Non-Article 5 Parties are developed countries and Article 5 Parties are developing countries whose annual calculated level of consumption of the controlled substance is less than 0.3 kilograms per capita on the date of the entry into force of the Protocol or any time thereafter within ten years of the date of entry into force. Article 5 Parties are entitled to a delay in compliance with certain control measures under the Montreal Protocol.

Figure 6. *International HFC Phasedown for Non-Article 5 Countries*



M. Energy Efficiency.

Refrigeration and AC equipment also contribute to climate change through indirect emissions due to the electricity consumed in operating the equipment. CARB does not expect any increase in the indirect CO_2 emissions from increased energy usage, as the lower-GWP replacement refrigerant technologies that would be chosen are either more energy efficient or equal in energy efficiency to the baseline high-GWP refrigerants.

The energy efficiency performance of most heating and cooling equipment is regulated by the National Appliance Efficiency Conservation Act (NAECA) and California Appliance Efficiency Regulations (Title 20) which are administered by the United States Department of Energy (U.S. DOE) and the California Energy Commission (CEC), respectively. Requirements promulgated under these regulations as well as voluntary labeling and incentive programs have resulted in significant emissions reductions and cost savings for end-users.

II. The Problem that the Proposal is Intended to Address

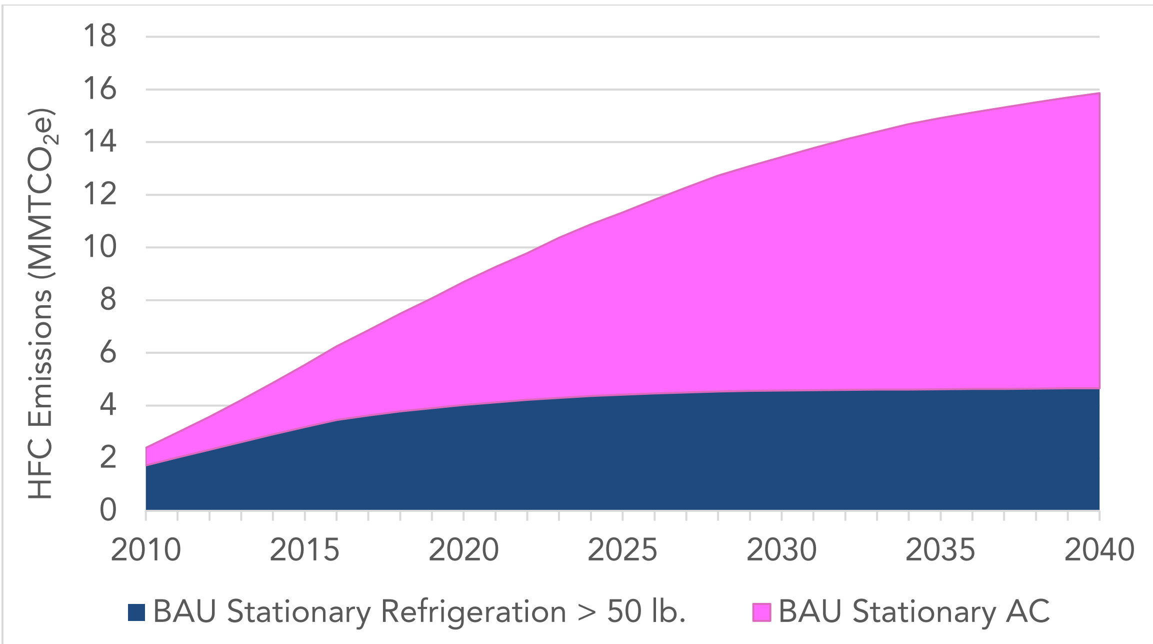
Scientific research indicates that an increase in the global average temperature of 2°C (3.6°F) above pre-industrial levels, which is only 1.1°C (2.0°F) above present levels, poses severe risks to natural systems and human health and well-being (CARB, 2017a). Replacing high-GWP HFCs with low-GWP alternatives could avoid 0.1 degree Celsius (°C) of global warming by 2050 and warming of up to 0.5°C by 2100, offering one of the most effective climate mitigation strategies available (Xu Y. et al., 2013).

Stationary RAC equipment are the largest source of HFC emissions in California, comprising more than half of all HFC emissions from all sources (**Figure 1** above).[52]

[52] Note that the terms "systems," "equipment," and "units" are often used interchangeably in the cooling industry.

Emissions from RAC are expected to increase significantly into the future as demand for RAC equipment grows (**Figure 7**). HFC emissions from stationary refrigeration (systems greater than 50 pounds) and stationary AC together, are expected to increase more than 50 percent by 2030 if left unchecked. This growth in HFC emissions would greatly undermine efforts to address climate change. Replacing high-GWP HFCs with low-GWP alternatives breaks the negative feedback loop that could significantly exacerbate the climate crisis. The rapid growth in HFC emissions jeopardizes efforts to reduce GHG emission and prevent the worst impacts of climate change, which include higher temperatures and more frequent and more severe extreme heat events.

Figure 7. *Business-As-Usual HFC Emissions in California from 2010 to 2040*



The primary factors driving the large increase of HFC emissions in the AC sector is the increase in overall cooling demand coupled with a turnover of older equipment using ODS refrigerants to new equipment using HFCs. ACs have become standard in new homes, population continues to grow, and warmer weather is increasing demand for ACs in existing homes that previously did not have an AC. California's AC use is well below the national average of approximately 90 percent of homes with an AC (EIA, 2018a-d). In California, between 65 to 70 percent of homes use an AC (U.S. Census, 2020b). CARB anticipates the percentage of homes with an AC to increase to over 90 percent as population grows and Californian's increasingly feel the effects of climate change in the form higher average temperatures and increasing number and severity of heat waves.

Similarly, for refrigeration, the need for critical cold chain services for production, storage and sales of food, pharmaceuticals and other essentials are expected to increase as well. After stationary AC, stationary refrigeration is projected to be the second largest sector responsible for HFC emissions in the year 2030 and beyond. Although SB 1013 prohibits the highest GWP refrigerants such as R-404A (GWP 3,922) and R-507 (GWP 3,985), many other high-GWP refrigerants are still currently allowed for use in new refrigeration equipment. Emissions from the existing base of refrigeration equipment must also be addressed. In particular, refrigeration systems currently used in the retail food sector represent the largest source of emissions from among all refrigeration equipment in use today. Based on user-reported data from the RMP in 2018, 30 to 40 percent of all regulated refrigeration systems in the State today use R-404A or R-507; which are HFC refrigerants with very high-GWP values of nearly 4,000.

The timing is also important because R-22 is being phased-out. As of January 1, 2010, the manufacture and installation of new R-22 (HCFC-22) appliances is prohibited by U.S. EPA (U.S.EPA, 2020a; U.S.EPA, 2020b). The average lifetime of AC equipment ranges from 15 to 20 years (U.S. DOE, 2015a and 2016a). As R-22 equipment reaches retirement, AC end-users are replacing their old R-22 ACs with equipment designed to use R-410A, which is a high-GWP blend of HFCs. R-410A has a GWP of 2,088 and it is used in ACs sold after 2010. For refrigeration, more than 30 percent of the systems continue to use R-22, and these systems in particular are aging and nearing their retirement. Under business-as-usual over the next 10 years, they will be replaced by refrigerants like R-407A, which has a GWP of 2,100, higher than that of R-22. If California does not take the opportunity to ban high-GWP refrigerants in new equipment beginning 2022, another generation of equipment will be locked into using high-GWP refrigerants during their equipment lifetimes of 15 to 20 years.[53]

RACs eventually leak. While there are rules to help prevent and remedy refrigerant leakage from certain refrigeration systems, this does not include ACs and not all refrigeration systems. Leaks can be accidental and once they occur, the damage cannot be undone. Furthermore, end of life disposal creates its own problems. In light of this, the most effective strategy to get permanent, guaranteed emissions reductions is to reduce the GWP of the refrigerants used in these equipment types as much as technically feasible.

California has legislative mandates to reduce both GHG and HFC emissions. In 2006, the California Legislature adopted AB 32 requiring a reduction of GHG emissions to 1990 levels by 2020. In 2016, the Legislature adopted SB 32, further strengthening the previous mandate by requiring GHG reductions to 40 percent below 1990 levels by 2030. That same year, the Legislature adopted SB 1383 requiring a 40 percent reduction in HFC emissions below 2013 levels by the year 2030. CARB adopted several plans and regulations to meet these mandates. Despite this, additional actions

[53] According to CARB's F-Gas Inventory, the average lifetime of commercial and industrial refrigeration systems containing more than 50 pounds of refrigerant is between 15 and 20 years (see **Table 6**).

are necessary to meet California's legislative mandates and meet its specific HFC mandates. Based on CARB's 2017 F-gas Inventory (published in 2019), with existing regulations in place, annual HFC emissions in California are projected to be approximately 20 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 2030 (CARB, 2019d). By 2030, the state needs additional annual emissions reductions of at least 10 $MMTCO_2e$ from new regulatory measures and/or incentive programs.

In addition to taking action during a critical time period for preventing the worst impacts of climate change, industry has stressed the importance of regulatory certainty to signify that the time to transition the market to more climate friendly refrigerants is now. The United States currently has more than 300 low-GWP refrigeration systems successfully operating in supermarkets around the country. An overarching goal of regulating these sectors is to drive the market towards low warming-impact refrigerants so that as the demand for cooling increases, sustainable cooling technologies and services are available affordably to the public.

III. The Specific Purpose and Rationale of Each Adoption, Amendment, or Repeal

In this chapter, CARB provides a brief summary of the provisions included in the proposed regulation, explaining the rationale for CARB's determination that each provision of the regulation is: (1) reasonably necessary to carry out the purpose of the statutes or other provisions of law that the action is implementing, interpreting, or making specific; and (2) reasonably necessary to address the problem for which the regulation is proposed.

Sections 95375 and after have been renumbered to provided clarity and consistency such that all the requirements can be found under one section number. In addition, the California Code of Regulations did not have sufficient numbers available to accommodate the numbering scheme in place.

Section 95371. Purpose.

Summary. This section states that the purpose of the regulation is to reduce HFC emissions for certain substitutes in refrigeration and foam end uses and to support California's progress toward the 2030 greenhouse gas and HFC emission reduction goals as well as CARB's Short-Lived Climate Pollutant Strategy. CARB is amending this section for the purpose of including additional substances used in AC, chillers, ice rinks, cold storage and aerosol-propellants end-uses in addition to refrigeration and foam end-uses currently specified in this section.

Rationale. The Proposed Amendment is reasonably necessary to inform the regulated community why the proposed regulation is being amended – to expand HFC and GHG emissions reduction requirements to other end-uses and achieve greater emission reductions. This is necessary for California to comply with its legal mandates—under AB 32, SB 32, SB 605, and SB 1383. Specifically, for California to meet its mandate to reduce HFC emissions by 40 percent below 2013 levels by 2030 and reduce GHG emissions by 40 percent below 2013 levels also by 2030.

Section 95372. Applicability.

Summary. This section identifies who the regulation applies to—"any person who installs, uses, or enters into commerce, in the State of California, any substance in end-uses listed in Table 1, section 95374 of this subarticle." CARB is amending the regulation to include "leases" and "rents" and add Tables 2, 3, and 4 of section 95374 to inform and provide notice to the regulated community that the regulation applies to them. This also makes the regulation consistent with the requirements of SB 1013, which includes "lease" and "rent" in the language.

Rationale. The Proposed Amendment is reasonably necessary to ensure uniformity and consistency for purposes of implementing and enforcing the regulation and ensure the HFC Regulation is consistent with SB 1013. Also, because CARB is adding tables, it is also necessary to set forth the intent that all end-uses within those tables understand that the regulation applies to them. This will remove any competitive disadvantage amongst the industries and provide clarity that the provisions of the regulation apply to the entire supply chain of the equipment, from manufacturer, to distributor, seller, installer, operator, and the end-user. CARB is adding lease or rent to the applicability section because SB 1013 contains these provisions and CARB's intent is for all regulatory provisions to apply to those who lease or rent equipment or materials. All of the tables contain lease or rent, the applicability section is meant to encompass all of the provisions where the regulated entity has to comply. This is to ensure all affected entities are on notice.

Section 95373. Definitions.

Summary. This section sets forth definitions for the terms used in the HFC Regulation. CARB is amending the regulation to add additional definitions and modify some existing definitions. CARB is also removing the provision that says "excepting sections 95374(b) and 95376."

Rationale. The Proposed Amendment is reasonably necessary to establish definitions for end-use categories that were not previously defined and to establish definitions for compliance pathways. For all definitions, changes/additions are necessary for the regulated community to understand the scope of the requirements and whether their end-use is included. Changes to the definitions fall into seven categories:

1. *Removal of "excepting" language in section 95373(a)*. The provision "excepting sections 95374(b) and 95376" was added during a Title 1, Section 100 change. The reason for this was to not extend any of the regulatory

definitions to the provisions that were being added as a result of a statutory change (under SB 1013). It is necessary to remove this language to allow for the extension of all definitions to the entire regulation.

2. *Modifications to align with federal definitions*. For existing definitions, staff were made aware that several current definitions were insufficient and lacked clarity needed by the regulated community. For other terms used in the regulation, they were not defined at all and produced equal confusion. The changes to the existing regulations and the additions were necessary to harmonize with language U.S. EPA uses in its SNAP program to define the scope and provide clarity as well as provide more certainty and specificity. The following definitions were added or modified for this purpose:

Modified	flexible polyurethane	integral skin polyurethane	new refrigeration equipment	phenolic insulation board and bunstock
	polystyrene extruded sheet	refrigeration equipment or refrigeration system	remote condensing units	rigid polyurethane laminated boardstock and polyisocyanurate laminated boardstock
	stand-alone units or equipment	supermarket systems		
New	aerosols	air-conditioning equipment or air-conditioning system	chiller	commercial ice machine
	foam	full charge, optimal charge or critical charge	household refrigerators and freezers	household refrigerators and freezers-built in
	household refrigerators and freezers-compact	ice rink	industrial process refrigeration	low-temperature refrigerator system
	medium temperature refrigerator system	metered dose inhaler or medical dose inhaler or MDI	polyolefin	polystyrene extruded boardstock and billet (XPS)
	polyurethane	propellant	residential consumer	rigid polyurethane

			refrigeration products	
New	rigid polyurethane appliance foam	rigid polyurethane commercial refrigeration and sandwich panels	rigid polyurethane high-pressure two component spray foam	rigid polyurethane low-pressure two component spray foam
	rigid polyurethane marine flotation foam	rigid polyurethane one-component foam sealants	rigid polyurethane slabstock and other	very low temperature refrigeration or cooling

3. *Definitions necessary to improve enforceability*. Each enforcement provision is clearly identified so as to provide notice to the regulated entities and ensure the proposed regulation is not interpreted in such a way to mean that a regulated party is not subject to enforcement action. This ensures that the regulated parties will comply with the requirements of the regulation. However, certain provisions are not defined, leaving ambiguity. Defining the terms below are necessary to ensure no loopholes exist in the regulation. Moreover, CARB has historically worked with the air pollution control districts to help enforce stationary regulations such as this. The enforcement section adds the air pollution control officer to the enforcement officials and is necessary to place the regulated entity on notice that this regulation will be enforced by CARB and the air districts. The following definitions were added for this purpose:

Modified	blowing agent	end-use	hydrofluorocarbon or HFC	refrigerant or refrigerant gas
	retail food refrigeration or commercial refrigeration	retrofit or refrigerant retrofit	stationary	substance
New	air district	air pollution control officer or APCO	change in ownership	company
	date of manufacture	own	owner	operate
	operator	refrigerant registration and reporting system or R3 database	responsible official	retire

4. *Non-substantive modifications*. Certain provisions contained grammatical errors or terms that were unnecessary. Modifying the terms below are necessary to ensure the regulatory language is clear and understandable. The following definitions were modified for this purpose:

Modified	class I substance	class II substance	vending machines	use

5. *Definitions necessary to define the technical scope of the regulation*. After CARB adopted this regulation, it became clear that the lack of definitions created much confusion for the regulated industry. Because of this, it is necessary to add technical definitions to define the scope of who is regulated and to minimize confusion and complexity of the regulated community. The following definitions were added for this purpose:

New	bear spray	cold storage	heat transfer fluid	new air-conditioning equipment
	new chiller or new chiller equipment	retail food facility	other refrigeration	

6. *Definitions necessary to define the scope of the compliance pathway*. As indicated below, in section 95375(d), CARB added portfolio compliance pathways for retail food facilities as a way to provide flexibility. Definitions were necessary to define the scope of these pathways, under what circumstances these pathways may be used, and the how to comply with the requirements. The following definitions were added for this purpose:

New	baseline greenhouse gas potential or baseline GHGp	charge or refrigerant charge	charge reduction	full charge optimal charge or critical charge
	global warming potential, GWP, global warming potential value, or GWP value	greenhouse gas potential or GHGp	national supermarket chain	new facility
	weighted-average GWP			

7. *Definitions necessary to define the scope of the variance*. As indicated below, in section 95377, CARB added a variance procedure as a necessary compliance pathway to reduced HFC emissions in the event of impossibility or a force majeure event. The variance procedure defines who can apply and under what conditions an Executive Order may be granted as well as revocation and appeal processes. Definitions were necessary to define the scope and parameters of what is allowed. The following definitions added for this purpose:

New	applicant	executive order	impossibility	force majeure

Section 95374. List of Prohibited Substitutes.

Summary: This section established a list of specific types of refrigeration and foam end-use sectors, effective dates, and HFCs that are prohibited in new and retrofitted equipment for retail refrigeration, vending machines, foams, and SB 1013 end-use sectors, which included chillers, aerosols-propellants, and additional foam end-uses. There was a table for the originally adopted list (Table 1) outlined in section 95374(a). The second table included the SB 1013 list (Table 2) outlined in section 95374(b). The Proposed Amendments adds Table 3 in section 95374(c) and Table 4 in section 95374(d). There are also clarifying changes to Tables 1 and 2. Below is a summary of the relevant amendments to the tables:

- *Table 1.* The word "refrigerant" was added before "retrofit." The header "Foam" was modified to add "Systems Used to Manufacture." The term "laminated boardstock" was added to the end of "Rigid Polyurethane" in the "specific end-use" column. Footnote "a" was added to clarify the size of the systems regulated under Table 1.

- *Table 2.* Chillers were removed from Table 2 and moved to Table 3. Footnote "a" was added to clarify the size of the systems regulated under Table 1. Chiller end-uses include "centrifugal chillers (new)" and "positive displacement chillers (new)." The specific end-use "Cold storage warehouses (new)" was modified to "Cold storage warehouses (new refrigeration equipment in existing facilities)." A new header "Refrigeration" was added to the top of the table. The header "Foam" was modified to "Foam Systems Used to Manufacture." A non-substantive change was made to the end-use "Aerosols-Propellants" to correct the spelling. Footnote "a" was added to the table for the purpose of specifying that for specific cold storage end-uses, the prohibitions listed in Table 2 apply to new systems in existing facilities while the prohibitions for new cold storage systems in new facilities in given in Table 3.

- *Table 3.* Sets forth GWP limits and lists certain types of equipment as well as the effective date. Specifically, the equipment subject to Table 3 include AC equipment, industrial process refrigeration chillers, ice rinks, and new refrigeration equipment, including equipment with more than 50 pounds of refrigerant – including cold storage warehouses, industrial process refrigeration (excluding chillers), non-residential refrigeration, and stationary refrigeration equipment for industrial process refrigeration in existing facilities with more than 50 pounds. For chillers, Table 2 previously listed chillers as two different types depending upon their mechanical structure: centrifugal chillers, and positive displacement chillers. The Proposed Amendments change the chiller types from a mechanical structure to an operating temperature basis (the minimum evaporator temperature), using three separate temperature ranges to indicate the type of chiller and its regulated category. Beginning January 1, 2024, new chillers used for industrial process refrigeration will have three different GWP limits depending on the temperature of heat transfer fluid (such as water, glycol, or brine) leaving the system (750, 1,500, 2,200 GWP). For new chillers used for air conditioning and existing ice rinks, the GWP limit will be 750 with the same effective date as the other chillers.

- *Table 4.* Sets forth a GWP limit of 150 for new retail food refrigeration facilities with more than 50 pounds of refrigerants by a certain date. For existing retail food facilities, Table 4 sets forth requirements for companies owning or operating 20 retail food facilities containing more than 50 pounds of refrigerants—to either attain a companywide weighted--average GWP of 2,500 by 2026 and 1,400 by 2030 or reduce the GHGp by 25 percent or greater below 2019 levels by 2026 and 55 percent by 2030. The regulatory options give flexibility to retail food stores on how they will meet weighted--average GWP or GHGp requirements. Stores can continue to use existing equipment retrofitted with a lower-GWP refrigerant, can replace equipment with new systems using less refrigerant charge and/or a lower-GWP refrigerant, or can modify existing equipment to reduce the refrigerant charge size.

Rationale. The Proposed Amendments are reasonably necessary to reduce HFC emissions, provide flexible compliance options, and provide clarity and specificity to better describe the regulated industry. Each table is discussed separately.

- *Table 1.* The modifications to Table 1 fall into four categories:

    - *Retrofit.* The term "retrofit" for refrigeration systems is generally understood to mean the removal and replacement of existing refrigerant in a system with a different type of refrigerant. However, the term "retrofit" could be mistaken for a mechanical change to the system. For example, one definition of retrofit is to "add (a component or accessory) to something that did not have it when manufactured." Therefore, the term "refrigerant" before "retrofit" makes clear the type of retrofit regulated.

- *Foam Header.* The foam header language was necessary to provide clarity that the regulatory requirements are the primary responsibility of the original manufacturer of the foam ingredients, commonly called a "foam system," and not the sole responsibility of manufacturers buying pre-made foam that they then used in the finished product. For example, a shoe maker buying foam panels to be cut and shaped into shoe soles would not necessarily be informed of the foam expansion agents used to make the foam, but the original manufacturer of the foam ingredients and foam panels would be expected to have control and knowledge of the foam expansion agent (HFCs or other expanding gases) used in the foam.

- *Laminated Boardstock.* The term "laminated boardstock" was necessary to add after "rigid polyurethane" to specify that not all rigid polyurethane (foams) were included in this end-use. This was important to end confusion.

- *Footnote.* The footnote was necessary to separate the more stringent requirements from the less stringent requirements. Table 1 refrigeration end-uses originally applied to all new refrigeration end-uses in existing and new facilities. The amendments now include more stringent prohibitions for refrigeration systems containing greater than 50 pounds of refrigerant, for example supermarket systems and some remote condensing units, in new facilities. Those proposed prohibitions are listed in proposed Tables 3 and 4. Therefore, there are now two different sets of requirements for new refrigeration equipment with more than 50 pounds of refrigerant: one applies to new equipment in existing facilities (Table 1), and the other applies to new equipment in new facilities (Tables 3 and 4). The requirements of Tables 3 and 4 are more stringent than Table 1. Therefore, it was necessary to make clear that the requirements in Tables 3 and 4 supersede the Table 1 requirements for refrigeration systems.

- *Table 2.* The Proposed Amendments are reasonably necessary to provide clarity, consistency, and specificity in the regulation. The modifications to Table 2 fall into five categories:

  - *Refrigeration.* The word "Refrigeration" was added as a heading at the beginning of the table to clarify that all following end-uses were a sub-set of refrigeration, and to be consistent with the rest of the table, which had headings for "Chillers," "Foams," and "Aerosols – Propellants."

  - *Cold Storage Warehouses (new).* This modification was necessary to provide notice to the regulated industry on what is included and remove any confusion. The existing description could be unintentionally interpreted as limiting the new refrigeration equipment requirements to only brand new cold storage warehouses, rather than the intended new refrigeration equipment requirements for both new and existing cold storage warehouses.

- *Chillers.* This modification was necessary to remove confusion and unnecessary text as the new GWP prohibitions in Table 3 for chillers are more stringent than the specific HFC prohibitions in Table 2. The chiller requirements in Table 3 are similar to the requirements in Table 2, except the requirements are now stated in terms of GWP limits and not individual prohibitions. The effective date is the same. Therefore, having prohibitions in one chart and GWP limits in another had the potential to create confusion and were unnecessary because all of the prohibited substances in Table 2 are still prohibited under Table 3 because they are all above the GWP limit.

- *Foam Header.* Same rationale as Table 1 above.

- *Footnote.* Same rationale as Table 1 above.

- Table 3. This section is necessary to set applicable refrigerant GWP limits for new systems to reduce HFC emissions, mitigate climate change, and for California to comply with its legal mandates. Furthermore, it was determined, based on several years of CARB research and analysis, meetings with various stakeholders, that a GWP value of 150 for new refrigeration equipment in new facilities and 750 for AC were necessary to allow for natural refrigerants such as hydrocarbons, CO_2, HFOs, and ammonia. It was also necessary to align with the global requirements – since many manufacturers sell to a global market. The different "tiers" of GWP was based was necessary to strike the fine balance between not placing undue burdens on industry, aligning with the global market, while gaining the maximum HFC emission reductions technically feasible.

- Table 4. This section is necessary to set applicable refrigerant GWP limits for new systems to reduce HFC emissions, mitigate climate change, and for California to comply with its legal mandates. Furthermore, it was necessary to treat retail food facilities separately because they represent the largest source of HFC emissions from stationary refrigeration and the annual leak rates tend to be higher than leak rates from cold storage or industrial process refrigeration, due to lengthy refrigerant piping and many fittings that can leak due to equipment wear. Even well-maintained refrigeration equipment leak 10 percent or more of their refrigerant charge each year, which represents significant emissions. Also, due to the implementation challenges with existing facilities (low-GWP refrigerants are not interchangeable with existing systems), and working closely with stakeholders, it was clear that a different approach was necessary to allow for flexibility—to reduce regulatory burden and avoid negatively impacts on small businesses and disadvantaged communities while achieving the greatest HFC emission reductions.

Section 95375. Requirements.

Summary. This section sets forth prohibitions, exceptions, disclosure, labeling and recordkeeping requirements for end-use categories as they relate to section 95374. The Proposed Amendments move Table 2's prohibitions and exceptions to section 95375 and create additional requirements for Tables 3 and 4—each Table corresponds to subsections (a), (b), (c), and (d). The following changes were made:

- *Subsection (a) - Requirements Applicable to Table 1 of Section 95374(a).* This section already set forth prohibitions, exceptions, disclosure and recordkeeping requirements for refrigeration end-uses, and recordkeeping requirements for foam end-uses. The Proposed Amendments modify the word "may" to "shall" and add "lease" and "rent" to subsection (a)(1) of the prohibitions section; add very low temperature refrigeration or cooling uses and certain refrigeration end-uses to the exceptions; modifies the disclosure statement; and modifies the recordkeeping requirements for refrigeration to make the disclosure statement available to the "person" purchasing, rather than the "buyer" and clarifies that it is "made available" instead of "issued." An attestation provision for foam end-users subject to recordkeeping requirements as been added to section 95375(a)(4). This was added for the purpose of addressing end-users that no longer use any prohibited substance listed in section 95374(a) and allows them to attest under penalty of perjury that they do not use a prohibited substance in lieu of complying with the recordkeeping requirements.

- *Subsection (b) - Requirements Applicable to Table 2 of Section 95374(b).* This section already set forth prohibitions and exceptions applicable to Table 2 in section 95376. The Proposed Amendments moved this section to subsection 95375(b); modifies the word "may" to "shall" in subsection (b)(1), adds "sell," "install," and "use" as well as removes certain language from the prohibitions subsection in (b)(1); removes chillers from the exceptions category; and adds "unless otherwise prohibited by state regulation" language to the aerosols-propellants exception as well as adding bear spray, HFC-227ea and blends of HFC-227ea and HFC-134a for metered dosed inhalers.

- *Subsection (c) - Requirements Applicable to Table 3 of Section 95374(c).* This section is new and establishes prohibitions on end-use categories identified in Table 3 of section 95374(c), making it illegal for any person to "sell, lease, rent, install, use, or enter into commerce in the State of California" any end-use that does not comply with the regulatory requirements. It also adds exceptions for chiller end-uses, refrigeration equipment with 50 pounds or less of refrigerant, very low temperature refrigeration or cooling, and facilities with an approved building permit. In addition, in requires manufacturers to label and maintain records.

- *Subsection (d) - Requirements Applicable to Table 4 of Section 95374(d).* This section is new and establishes prohibitions and compliance pathways for retail food facilities, making it illegal for any person to "sell, lease, rent, install, use, or enter into commerce in the State of California" any end-use that does not comply with the regulatory requirements in new retail food facilities. Further, it lists requirements for existing retail food facilities to comply with GWP limits – either through a weighted average GWP or a GHG potential (GHGp) reduction. Companies complying with the first option must have a weighted average GWP for all aggregate stores less than 2,500 in all refrigeration systems greater than 50 pounds or reduce GHGp by at least 25 percent of their 2019 baseline GHGp by January 1, 2026. By January 1, 2030 the weighted-average GWP must be less than 1,400 aggregated or the GHGp must be at least 55 percent lower than their 2019 baseline GHGp. Exceptions were added for new facilities with approved building permits and refrigeration equipment with less than 50 pounds refrigerant. There are also registration requirements beginning on January 1, 2022 and reporting requirements beginning March 1, 2022 as well as recordkeeping requirements.

Rationale. The Proposed Amendment is necessary to reduce HFC emissions, mitigate climate change, and for California to comply with its legal mandates. See **Section I.H.** for explanation as to why the emission reductions are necessary and **Section I.J.** for an explanation of California's legal mandates. It is also necessary to ensure enforceability as well as provide clarity to better describe the regulated industry. Each requirement related to each table is discussed separately.

- *Subsection (a) - Requirements Applicable to Table 1 of Section 95374(a).* Modifications to this section are necessary ensure the prohibitions are not viewed as discretionary (hence, switching "may" with "shall") and to create consistency amongst the different requirements applicable to the different tables (Table 1 and Table 2 each contained different prohibitory language) – to provide uniformity. As to the addition of the exceptions, they are necessary to allow for normal and non-substantial replacement of various refrigeration system components that no longer function, without triggering the requirement to buy an entirely new refrigeration system—to keep regulatory burden low. In regards to the disclosure statement, it was necessary to make it more general and broad to be consistent with other states with a purpose to remove regulatory burden (since multiple states are adopting similar regulations to prohibit HFCs) (AHRI, 2020a).

  It was also necessary to modify the disclosure statement language to reflect the true nature of the transaction. An attestation provision for foam end-users subject to recordkeeping requirements was added to address sectors of the foam industry that have transitioned away from the use of HFC's in foams and provides an alternate compliance pathway in lieu of complying with the recordkeeping requirements.

- *Subsection (b) - Requirements Applicable to Table 2 of Section 95374(b).* Amendments to this section are necessary to make clear the prohibition is not discretionary and to align with the applicability section. Also, adding the words "install" and "use" to the prohibitions section are required to make the prohibitions consistent amongst all the different sections and provide clarity on what is prohibited. In addition, removing "chillers" from this section was necessary to align the requirements with the tables in section 95374. Because chillers are now in Table 3, the requirements also needed to be in Table 3. Adding the language that compliance with this regulation does not mean compliance with other State regulations that may prohibit HFC-134a in products was necessary to put the regulated industry on notice that it must comply with all laws. (See Consumer Products Regulation, Cal. Code Regs., tit. 17, §§ 94509.) The regulated community must comply with all applicable regulations so if one regulation allows it and another does not – this regulation does not provide for an exemption from the other requirements.

  As for the category of exemptions for aerosols-propellants, allowance for bear spray and HFC-227ea and blends of HFC-227ea and HFC-134a in metered dose inhalers (MDIs) approved by the U.S. Food and Drug Administration (FDA) for medical purposes were necessary to add. SB 1013 already allowed for the use HFC-227ea and blends of HFC-227ea and HFC-134a in metered dose inhalers (MDIs)—this amendment aligns the current regulation with the current statute. As for bear spray, according to U.S. EPA staff, bear spray was inadvertently left off the HFC-134a propellant exceptions during the original rulemaking for SNAP Rule 20. Substitutes to HFC-134a propellant in bear spray have not been successful; only HFC-134a has the proper density to form a cloud of repellant vapor at the proper height from the ground to coincide with a charging bear's face, eyes, and breathing zones.

- *Subsection (c) - Requirements Applicable to Table 3 of Section 95374(c).* This section is necessary to provide enforceable mechanisms to achieve the HFC emission reductions expected by section 95374(c). Not only does this provide clarity to the regulated industry to explain what is prohibited, but it also ensures CARB can confirm that products are compliant by requiring labeling and recordkeeping. The exceptions were necessary to align with the federal SNAP exceptions, remove redundant regulatory requirements, and remove burdens on very low temperature refrigeration systems that often are used in medical and laboratory settings, and to not create economic hardship on companies that have already been planning prior to the regulation. For example, there is a very long planning time that goes into building or opening a new grocery store or supermarket, often two to three years before the store is open for business. Part of the planning is to select and design a refrigeration system that uses a specific type of refrigerant. The exception to allow high-GWP refrigeration equipment as long as the building permit was approved prior to the effective date of the regulation will minimize disruption to the retail food industry and avoid very costly store re-design.

- *Subsection (d) - Requirements Applicable to Table 4 of Section 95374(d)*. This section is reasonably necessary to provide a path for retail food facilities to reduce their HFC emissions while providing flexibility to retail food facilities that can be located in disadvantaged communities or qualify as small businesses—all while achieving California's HFC and GHG emissions reductions and outlining enforceable requirements. They are to ensure fairness and to avoid the loophole of companies breaking up into smaller chains to avoid the regulation. The registration, recordkeeping, and reporting requirements are necessary for CARB to enforce the regulation.

Section 95376. Enforcement.

Summary. This section sets forth the "Enforcement" of the HFC Regulation—which was renumbered from the previous section 95377. The Proposed Amendments remove the word "applicable" in subsection (a) and "Excepting sections 95374(b) and 95376" in subsection (d), which states that "violations of this subarticle, excepting sections 95374(b) and 95376 in subsection 95379(d) are subject to penalties under the Health and Safety Code section 38580." The Proposed Amendments also add "including violations of any condition imposed pursuant to section 95377" since there is also a new variance provision. Subsection (e) was deleted and previous subsection (f) was renumbered to subsection (e). In addition, subsection (f) added that the Air Pollution Control Officer may enforce the HFC Regulation.

Rationale. The Proposed Amendment is necessary for CARB to enforce the regulation with potential assistance from local air pollution control districts, and to provide clarity to industry on CARB's enforcement authority and potential penalties as well as remove redundant language that was unnecessary. It is also necessary to place the regulated community on notice that the same statutory penalties apply to all violations. There is no discrepancy between SB 1013 and the regulation as SB 1013 cites to the 42400 series and the Proposed Amendments cite to section 38580, which also cited to the 42400 series of the Health and Safety Code. This was necessary to reduce confusion about what penalties applied.

Section 95377. Variance.

Summary. This section establishes procedures and requirements for Applicants to request and receive an Executive Order allowing for modifications to the regulatory requirements if, through either impossibility or a force majeure event, after using best efforts to comply, the Applicant cannot comply. The intent of the impossibility variance is for a niche end-use or circumstance only. A niche end-use is where the end-use production, application or function is unique and specialized within its corresponding end-use. A niche circumstance is an instance in which an Applicant experiences a unique individual event or action making compliance impossible.

It also creates criteria and requirements that an applicant must satisfy (including an HFC mitigation plan and compliance plan) as well as the approval and disapproval process, and an appeal process and timelines. Trade groups are not considered applicants.

Rationale. The Proposed Amendment is reasonably necessary to allow for a compliance pathway that reduces HFC emissions in the event of impossibility or a force majeure event. It is also necessary to reduce regulatory burden in these very unique circumstances.

- *Applicability*. Section 95377(a) is necessary to put Applicants on notice that the Applicant must prove by clear and convincing evidence that all criteria and application requirements must be met. This is important to provide notice that the application must be complete and the need must be real and what the standard will be.

- *Variance Types*. Section 95377(b) is necessary to identify what circumstances a variance may be granted so as to limit requests to only two scenarios—impossibility and force majeure. These two variances are necessary to exclude other reasons, such as financial burden. The impossibility criteria is necessary to align with SB 1013, which requires a showing that a lower risk substitute is not currently or potentially available and there will not be an increase in the overall risk to human health or the environment. The best efforts language was necessary to place the requirement on industry that they try to comply and to eliminate industry members who decide to do nothing and then apply for a variance. This was necessary for both variance types as companies must plan for events.

- *Application for Variance*. Section 95377(c) is necessary to notify potential applicants of what must be included in the application to be complete and to provide the Executive Officer with the criteria to issue the Executive Order and to provide a path that mitigates emissions and brings the Applicant into compliance. Amongst the requirements, are:

    - *Compliance Plan*. Applicants must provide a compliance plan and a mitigation plan. The compliance plan is necessary to bring the non-compliant entity into compliance with the law so a variance is not necessary.

- *Mitigation Plan*. A mitigation plan is necessary to reduce emissions. The intent of the mitigation plan is to reduce excess GHG emissions to a level equal to or below what would have been emitted had the Applicant been in compliance and to demonstrate how the Applicant will mitigate any negative impacts to human health or the environment. Emissions reductions should be at least equivalent to the difference in emissions as calculated under the emissions quantification requirement and the emissions if the Applicant had been in compliance.

- *Emissions Quantification*. The emissions quantification requirement is necessary to understand the extent of the harm so CARB understand the amount of emissions reductions that are required.

- *Other Provisions*. The rest of the requirements are necessary to evidence and support the criteria identified in the variance types.

- *Penalty or Perjury Certification*. There is a requirement that the applicant certify under penalty or perjury that they are the responsible official and have authority to apply and implement the provisions of the Executive Order and that the information is accurate. This provision is necessary to ensure enforceability of the Executive Order and to ensure companies take the application process seriously, do not lie, and do not submit false, inaccurate, or misleading information, and that someone at the company is charged with implementation.

- *Address and Language*. There is also the address for the submission and a requirement that it be in writing and in the English language. This is necessary so Applicants know where to send the documents and so CARB staff can understand the materials, especially because some manufacturers are abroad.

- *Confidentiality Provision*. There is a provision that informs the Applicants that they may claim confidentiality. This is necessary because the Applicants may submit information that they identify as trade secret and in this scenario, the Applicant must understand the requirements so their information is protected from disclosure.

* *Approval and Disapproval Process*.

    - *Timelines*. This provision provides a timeline for the completeness determination, posting, approval and disapproval. These timelines are necessary to ensure the applications are processed in a timely manner.

    - *Approval and Disapproval Process*. These provisions are necessary to put the Applicant on notice of the process for both approval and disapproval so the scope of both decisions are known to the Applicant and the Executive Officer. It also allows for an expeditious approval in the event of a force majeure event that allows the Executive Officer to approve of the request prior to the public comment period. This is necessary because many force majeure events, such as the current situation, come with a sense of urgency and this is necessary to allow flexibility.

  - *Public Posting*. This provision places an affirmative requirement to publicly post the Application, which is necessary for transparency and also to allow the public to comment before making any final decisions.

- *Failure to Comply with Terms or Conditions of the Executive Order*. This provision places the requirement to comply with all terms of the Executive Order if a variance is granted, and puts the Applicant on notice that non-compliance will void the Executive Order. This is necessary for enforceability of the Executive Order.

- *Revocation or Modification of Variance*. This provision puts the Applicant on notice that the variance can be revoked or modified if it does not meet the criteria or if the provisions of the Executive Order are violated. This is necessary to hold the Applicant accountable and to provide a path forward in the event of changed circumstances or non-compliance with the grant of the variance.

- *Review of Agency Decision*. This provision allows for review of the Executive Officer's decision, which is necessary for due process.

IV. Benefits Anticipated from the Regulatory Action

CARB maintains a California specific Fluorinated Gas (F-Gas) Inventory as a part of the statewide GHG Emission Inventory that is used for establishing historical emission trends and tracking California's progress in reducing GHGs. To determine the baseline scenario for the economic and emissions analysis, CARB used its F-Gas Inventory and the 2020 DOF population forecasts as a basis for the analysis. The regulatory proposal and alternative scenarios result in economic and emissions changes relative to the baseline scenario.

CARB has estimated annual emissions in 2013, the baseline year for the SB 1383 target, to be 16.5 $MMTCO_2e$. By 2030, annual HFC emissions are expected to grow to 20 $MMTCO_2e$ even with existing CARB Rules in place (as of January 1, 2017). To meet a 40 percent reduction in HFC emissions below 2013 levels, as mandated by SB 1383, the annual emissions under the business as usual (BAU) scenario of 20 $MMTCO_2e$ in California in 2030 must decrease by 10.1 $MMTCO_2e$ to reach 9.9 $MMTCO_2e$ per year in annual emissions in 2030.

The Proposed Amendments are expected to reduce annual HFC emissions by approximately 4 $MMTCO_2e$ annually by 2030, achieving 40 percent of the SB 1383 reductions goal. The remaining 60 percent of HFC reductions (approximately 6 $MMTCO_2e$) are expected to be achieved by additional California HFC emissions reduction measures to be determined.

V. Air Quality

All quantified air quality benefits are from the reductions of GHGs. As discussed in the preceding section, annual GHG reductions are estimated to be up to 4 $MMTCO_2e$ in the year 2030, with cumulative reductions of 72 $MMTCO_2e$ by the year 2040. The Social Cost of Carbon discussion in Section VIII.D provides monetary estimates of the damages that would be avoided by reducing GHG emissions under this Proposed Amendments.

While there are no direct health benefits that can be quantified using present methodologies, there is mounting evidence that climate change can impact local air quality. For example, atmospheric warming can lead to an increase in the formation of ground-level ozone and photochemical smog. Thus, there are co-benefits of controlling global warming by removing GHG emissions (Knowlton et at., 2011). The direct impacts of climate change are becoming clearer and have a disproportionate impact on the sensitive age groups as well as disadvantaged communities (State of California, 2018). Wildfires are becoming more frequent and severe (Singleton, 2019) and in addition to the death and injury from the fires, millions are exposed to harmful smoke (Abatzoglou and Williams, 2016). The number of extreme heat days is increasing. The highest ever number of extreme heat days was recorded in 2019. Illnesses and deaths from extreme heat events will likely increase (OEHHA, 2018), causing heatstroke and other heat-related illnesses, particularly for vulnerable individuals such as the elderly and those who are more isolated.

Millions of residents across the state live in disadvantaged communities that experience a combination of increased vulnerability to adverse health effects from air pollution and increased exposure to pollution sources. These communities are also extremely vulnerable to the health effects of climate change. For these residents, actions to reduce GHG pollution is even more critical. Health, equity, and resiliency are integrally related. Those individuals and communities that are at a social and financial disadvantage are less able to deal with stresses caused by climate change such as food and water scarcity, high temperatures, and wildfires, and they are more likely to suffer physical and psychological harm.

Across some refrigerated facilities prohibiting the use of low-GWP alternative refrigerants is expected to result in increased energy efficiency, particularly for the cold storage and IPR sectors. Additionally, supermarkets and grocery stores retrofitting to lower-GWP refrigerants are also expected to benefit from improved energy efficiency of systems undergoing the retrofits. Similarly, many of the alternative refrigerants that may be used to comply with the Proposed Amendments pertaining to AC equipment have better energy efficiency or refrigerant performance characteristics. Manufacturers may elect to use more efficient refrigerants to comply with the Proposed Amendments. It is speculative to predict the market share of these refrigerants and refrigerant choice is only one factor for how manufacturer's choose to meet minimum efficiency requirements set by the U.S. DOE. Therefore, CARB does not quantify air quality benefits from less electricity generated resulting from the Proposed Amendments.

VI. Environmental Analysis

A. Introduction.

This chapter provides the basis for CARB's determination that the Proposed Amendments is exempt from the requirements of the California Environmental Quality Act (CEQA). A brief explanation of this determination is provided in section B below. CARB's regulatory program, which involves the adoption, approval, amendment, or repeal of standards, rules, regulations, or plans for the protection and enhancement of the State's ambient air quality, has been certified by the California Secretary for Natural Resources under Public Resources Code section 21080.5 of CEQA (Cal. Code Regs., tit. 14 § 15251(d)). Public agencies with certified regulatory programs are exempt from certain CEQA requirements, including but not limited to, preparing environmental impact reports, negative declarations, and initial studies. CARB, as a lead agency, prepares a substitute environmental document (referred to as an "Environmental Analysis" or "EA") as part of the Staff Report prepared for a proposed action to comply with CEQA (Cal. Code Regs., tit. 17 §§ 60000-60008). If the Proposed Amendments are finalized, a Notice of Exemption will be filed with the Office of the Secretary for the Natural Resources Agency for public inspection.

B. Analysis.

CARB has determined that the Proposed Amendments are categorically exempt from CEQA under the "Class 8" exemption (Cal. Code Regs., tit. 14, § 15308) because it is an action taken by a regulatory agency for the protection of the environment. The Proposed Amendments set end-use-specific GWP limits for RAC equipment. In response to the new system requirements set by the Proposed Amendments, RAC equipment manufacturers are expected to transition to using a different refrigerant type in the new equipment they sell for use in California. While some of the compliant refrigerant options have mild flammability properties, all refrigerants must undergo a comprehensive evaluation for health and human safety by entities such as the U.S. EPA as well as code and standard setting bodies which govern their use. Therefore, there is no reasonable possibility that use of these refrigerants would result in a public health and safety issue.

Under the Proposed Amendments for refrigeration equipment, existing retail food facilities (e.g. supermarkets) with current refrigeration systems containing more than 50 pounds of refrigerant will be required to reduce the company-wide weighted-average GWP of their refrigeration systems to less than 1,400 by 2030. The most common way to comply will likely be a "refrigerant retrofit," where the existing refrigerant in a system is replaced with one that has a lower GWP value and is more climate friendly. Changes associated with retrofits are not expected to result in changes to the sales floor area and are part of best management practices as recommended by the refrigerant manufacturers.

These measures are expected to reduce emissions of HFCs, which are potent GHGs. The Proposed Amendments are designed to protect the environment and CARB has determined there is no substantial evidence indicating the proposal could adversely affect air quality or any other environmental resource area.

CARB has also determined that the proposed regulation is categorically exempt from CEQA under the "Class 1" exemption for the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures or facilities involving negligible or no expansion of use (Cal. Code Regs., tit. 14, § 15301). RAC equipment manufacturers may have to make some modifications to their existing facilities. The changes may involve replacement of equipment for manufacturing the systems and other updates to the facilities to meet applicable building standards. Similar changes may also be needed at existing distribution facilities that store and distribute equipment as well as refrigerants.
In addition, some alterations are expected to occur at existing retail food facilities as they reduce the GWP and/or the amount of refrigerants they use in their facilities.

Under the most likely compliance pathway of retrofitting the refrigerant, the old refrigerant would be removed and replaced by a refrigerant with a lower-GWP within the existing system, with minor component changes or adjustments (e.g., changing out seals and valves, and in some cases, changing the condenser). In addition to retrofit, the amount of refrigerant being used may also be reduced at the facility by either adding or replacing some existing components of the refrigeration system (e.g., adding plated heat exchangers) or relocating some system components closer to the display cases to reduce piping length and, thus, the amount of refrigerant used by the system (e.g., directly above the display cases on the roof or a mezzanine level). None of these changes are expected to expand the facility use.

CARB has determined that the proposed regulation is also categorically exempt from CEQA under the "Class 2" exemption for replacement or reconstruction of existing structures and facilities (Cal. Code Regs., tit. 14 § 15302). AC and refrigeration equipment manufacturers and distributors may modify portions of existing structures to transition product lines or sell a higher proportion of equipment that use a more climate friendly refrigerant. For retail food facilities, the refrigerant retrofits or modifications to reduce the amount of refrigerant used by the system will be made to refrigeration systems on the original site where the facilities and systems already exist.

Based on CARB's review, there is no foreseeable possibility that the proposed regulation may result in a significant adverse impact on the environment or that any of the exceptions to these exemptions apply (Cal. Code Regs., tit. § 14 15300.2); therefore, this activity is exempt from CEQA.

VII. Environmental Justice

State law defines environmental justice as the fair treatment and meaningful involvement of people of all races, cultures, incomes, and national origins, with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (Gov. Code, § 65040.12, subd. (e)(1)). Environmental justice includes, but is not limited to, all of the following: (A) The availability of a healthy environment for all people; (B) the deterrence, reduction, and elimination of pollution burdens for populations and communities experiencing the adverse effects of that pollution, so that the effects of the pollution are not disproportionately borne by those populations and communities; (C) governmental entities engaging and providing technical assistance to populations and communities most impacted by pollution to promote their meaningful participation in all phases of the environmental and land use decision making process; and (D) at a minimum, the meaningful consideration of recommendations from populations and communities most impacted by pollution into environmental and land use decisions (Gov. Code, § 65040.12, subd. (e)(2)).

The Board approved its Environmental Justice Policies and Actions (Policies) on December 13, 2001, to establish a framework for incorporating environmental justice into CARB's programs consistent with the directives of State law (CARB 2001). These policies apply to all communities in California, but are intended to address the disproportionate environmental exposure burden borne by low-income communities and communities of color. Environmental justice is one of CARB's core values and fundamental to achieving its mission.

Climate change is an environmental justice issue because it disproportionately affects the health and well-being of those who are socially or economically disadvantaged. California is already experiencing the impacts of climate change, which includes more frequent and intense extreme weather and climate -related events as well as changes in average climate conditions. Future climate change is expected to further disrupt many areas of life, exacerbating existing challenges and inequities. People who are already vulnerable, including lower-income and other marginalized communities, have lower capacity to prepare for and cope with extreme weather and climate -related events and are expected to experience greater impacts.

CARB developed this proposal consistent with its mandates to protect Californians against the worst impacts of climate change, which harm socially and economically disadvantaged communities the most, by enacting fast-acting measures to reduce GHG emissions. CARB identified the RAC sectors as particularly impactful in terms of HFC emissions from refrigerants. This proposal is expected to achieve approximately 4MMTCO_2e of GHG emissions reductions annually by 2030 and, cumulatively, more than 72 MMTCO_2e by 2040. Additionally, it is important to note that due to their short atmospheric lifetimes, the warming impact of short-lived climate pollutants such as HFCs is even worse in the near term. If HFC emissions and reductions were calculated using their 20-year GWP values, emission reductions are expected to almost double. Although, to be consistent with California's GHG inventory, CARB staff uses the 100-year GWP values in all calculations for the Proposed Amendments.

In the development of this proposal, CARB considered, not just the impact of the refrigerants used in RAC sectors on climate change but also, the impact of climate change on these sectors. As discussed above, there are several environmental justice implications and the importance of affordability of AC and access to cold services provided by commercial and industrial refrigeration systems are critical for Californians, including environmental justice communities.

A. Air-Conditioning.

Access to cooling is expected to continue to be an important factor for limiting heat stress during heat waves and maintaining human comfort in hot climates. Climate change is causing more frequent and severe heat waves and increasing average temperatures. Californians are adapting by increasing their demand for ACs, especially in coastal population centers, which historically did not have many hot days. This is an environmental justice issue because there is disparity in people's ability to access cooling. Statewide, a greater proportion of households in lower income groups do not have AC.

CARB considered the impact of Proposed Amendments on AC affordability as a part of the economic analysis SRIA. The Proposed Amendments were developed to reduce HFC emissions from the AC sector while minimizing potential added costs to purchase and operate an AC. As such, CARB selected a 750 GWP limit, which is not expected to increase the cost for room ACs such as window/wall and portable ACs that are the lowest cost option for Californians looking to purchase an AC. Room AC products are already available for purchase in California that meet the proposed 750 GWP limit at no additional cost compared to baseline R-410A products.

For residential central AC/HP, the total incremental cost, including equipment, installation and maintenance/repair, is estimated to result in approximately 4 percent higher cost for the end-user over the lifetime of the equipment. In addition to increased demand for ACs, Californians are expected to increase the operational hours of their ACs as a result of climate change. The Proposed Amendments are not expected to impact the energy efficiency of AC products in California and new ACs are becoming increasingly energy efficient due to minimum standards set by the CEC and U.S. DOE. In addition, this will decrease the relative cost impact of transitioning refrigerants compared to the lifetime costs of AC ownership. CARB has sought to minimize cost impacts above baseline while reducing climate impacts related to HFC emission from this sector, which would further exacerbate the need for ACs due to climate change.

There are a number of existing financial assistance programs from federal, state and local agencies to assist Californians with the upfront costs of purchasing an AC and ongoing costs of electricity to operate an AC, which are described in a subsequent section, which help offset the increased cost of AC equipment. AC costs have overall become increasingly affordable over the last few decades. CARB anticipates this trend to continue, especially as the AC market grows worldwide and manufacturers experience increasing economies of scale as countries such as India and China increase their demand for not only ACs, but ACs with more climate friendly refrigerants. CARB views these programs as important for increasing access to cooling for those who may be disadvantaged and in need.

In addition, local agencies provide public cooling centers that are open to the public, to reduce risk of heat-related illnesses for residents that don't have access to or may not be able to afford air conditioning. Cooling centers are usually located in existing public structures such as recreation centers, community centers, senior centers, and libraries and are designated as refuges during heat waves. These buildings are already equipped with AC, and are repurposed to serve as temporary cooling centers. CARB does not expect any added equipment costs from cooling centers, except the incremental cost of purchasing new equipment to replace old aging equipment.

B. Refrigeration.

Similar to the environmental justice concerns regarding access to comfort cooling, a large proportion of California's population lives in economically disadvantaged areas that may lack adequate access to essential cold chain services. Facilities using refrigeration systems, particularly retail food facilities like supermarkets and grocery stores as well as those facilitating the production and storage of fresh food meet critical, essential needs for all populations including disadvantaged groups. Access to fresh fruits and vegetables is vital for public health, and preserving that access to nutritious food in disadvantaged communities and food deserts is a priority for CARB. However, these refrigerated facilities are also among the largest emitters of HFCs in the State.

CARB's proposal was designed to balance the need for emissions reductions while minimizing potential impacts on disadvantaged communities. Since the refrigeration requirements do not affect the residential sector, the general public are not directly impacted by the Proposed Amendments for refrigeration. However, to prevent any potential disruption to access to supermarkets and other essential cold chain services in disadvantaged communities, CARB staff developed the requirements for stationary refrigeration systems with the goal to minimize the economic impacts on the end-users, so as to then minimize the chances of any facility closures and limit the costs that may be passed on to the consumers of those goods.

Under the Proposed Amendments, companies with retail food facilities will be required to reduce the weighted average GWP of all their systems across their stores or comply with a percentage reduction across all stores with a progress step. To minimize the impact on small businesses, companies with fewer than 20 stores in California that are not a national chain will only be required to comply by 2030, without a progress step at 2026. This is intended to provide small businesses a full eight years from the regulation's effective date to plan and spread out the costs. Additionally, since large companies will be complying with a progress step, service contractor familiarity with refrigerant retrofits and other compliant technology solutions will increase, which will likely bring down the upfront installation costs as well as ongoing costs associated with maintenance and repair of the systems.
Overall, the Proposed Amendments are consistent with and help advance CARB's environmental justice policies and goals. Reducing GHG emissions will help stabilize the climate, which will benefit all communities, including low-income and disadvantaged communities.

C. Air Conditioning and Refrigeration Financing.

Investor Owned Utility (IOU) and Publicly Owned Utility (POU) programs and state programs can help offset the cost of energy efficient equipment as well as lower the cost of utility bills. Please contact the relevant agency or utility for additional information.

i. <u>Fluorinated Gases Emission Reduction Incentive Program (FRIP).</u>

The legislature appropriated the California Air Resources Board (CARB) one million dollars in the 2019-2020 budget to create the Senate Bill 1013 (SB 1013, Lara, Ch. 375, Statutes of 2018) Fluorinated Gases Emission Reduction Incentive Program, or F-gas Reduction Incentive Program (FRIP). FRIP's goal is to provide incentive funds to increase the voluntary adoption of low-GWP climate-friendly refrigerant technologies that reduce GHG emissions in advance of any regulatory requirements.
Funding is restricted to existing and new retail food facilities, which are one of the largest sources of high-GWP HFC emissions. To reduce the economic burden on small businesses and facilities located in low-income and disadvantaged communities and avoid facility closures, independently-owned facilities and facilities located in low-income or disadvantaged communities will receive preferential funding and in some cases, will be eligible to receive higher amounts of funding.

CARB has partnered with the Los Angeles Department of Water and Power (LADWP) and the Emerging Technology Program managed by Southern California Edison (SCE) to provide supplemental support for FRIP. LADWP has allocated $200,000 for facilities located in LADWP territory, with potentially higher funding amounts available for facilities located in low-income or disadvantaged communities. SCE will provide comprehensive measurement and verification support to quantify the performance of climate-friendly refrigeration technologies, a barrier to their widespread adoption.

The goals of the FRIP are to accelerate the adoption of climate-friendly low-GWP refrigerant technologies in existing and new retail food facilities, demonstrate the reliability and benefits of these technologies and help the retail food sector transition to a low carbon future.

ii. <u>Utility Bill Assistance Programs</u>**.**

Utility bill assistance programs provide support to low-income households to reduce their energy costs. The California Public Utilities Commission (CPUC) mandates that Investor Owned Utilities (IOUs) in their purview provide programs that offer discounts on utility bills or weatherization services that reduce utility bills through the adoption of energy efficiency measures. IOUs offer the following utility bill assistance and weatherization services programs to low-income households:

- California Alternate Rates for Energy (CARE) Program
- Family Electric Rate Assistance (FERA) Program
- Energy Savings Assistance (ESA) Program

CARE and FERA both provide discounts on energy bills for income qualified households. Low-income customers that are enrolled in the CARE program receive a 30 to 35 percent discount on their electric bill and a 20 percent discount on their natural gas bill. CARE is offered by electrical corporations serving over 100,000 customers. Families whose household income slightly exceeds the CARE allowances can qualify to receive FERA discounts. The FERA program offers an 18 percent discount on electricity bills. FERA is available for IOU customers of Southern California Edison (SCE), San Diego Gas and Electric (SDG&E) and Pacific Gas and Electric (PG&E), which supply 75 percent of California's electricity.

The ESA program provides no-cost weatherization services to low-income households who meet the CARE income guidelines. Services provided include attic insulation, energy efficient refrigerators, energy efficient furnaces, weather-stripping, caulking, low-flow showerheads, water heater blankets, and door and building envelope repairs, which reduce air infiltration. The ESA program not only provides free services and appliances but also reduces utility bills costs through energy efficiency services and appliances. This program is offered by Large IOUs and some smaller utilities.

Although CARE, FERA and ESA are only available for IOU territories, most Public Owned Utilities (POUs), particularly the larger ones, offer similar programs. In addition, the California Community Services and Development Department administers state and federal programs to low-income Californians to reduce their energy costs.

iii. Rebates and Financing Programs for Residential Customers.

All the IOUs and many of the larger POUs provide rebates for residential appliances that save consumers money. Rebates are typically limited to high efficiency Energy Star-certified products, which are more efficient than minimum efficiency compliant products but also more expensive. Offsetting the higher upfront cost through rebates saves consumers money on their utility bills over the lifetime of the equipment. Rebates are typically available for various heating, ventilation, and AC (HVAC) products such as smart thermostats, room AC, central ACs, ceiling fans as well as weatherization services. Utility rebates for central HVAC equipment generally require installation by certified contractors to ensure that the systems are installed correctly and operate efficiently.

Several utilities offer multi-family incentive funding programs for upgrading HVAC equipment and applying other energy efficiency measures in multi-family buildings either at no cost or low cost. The amount of incentive funding available depends on the energy efficiency improvement. Many utilities also offer weatherization services to tighten the building envelope that make HVAC systems operate more efficiently and reduce utility bills. Some utilities offer low-cost financing programs for high-efficiency HVAC equipment for single-family homes to alleviate the economic burden of the upfront equipment and installation cost.

iv. Rebates and Financing Programs for Commercial Customers.

Small and large businesses are eligible for a number of funding and financing programs that help them save money on utility bills. Incentive funding and rebates are available for specific energy efficiency measures and appliances. These “express solutions” are pre-determined funding amounts available for specific high energy efficiency equipment only. In addition, custom incentives are also available based on the energy savings obtained through the implementation of pre-determined energy efficiency measures. Custom incentives are available for optimization of refrigeration systems and HVAC equipment, among other measures by a number of utilities.

Savings by Design is a statewide program encouraging high-performance design and construction of new buildings for the commercial and industrial sector. This program is sponsored by all major California utilities. Up to $150,000 may be available in funding for highly efficient buildings that surpass the requirements of the California Building Standards Code i.e. Title 24.

Additionally, millions of dollars of zero-interest financing programs are also offered by several utilities for energy efficiency upgrades at little to no cost. Applicants can repay funds through their utility bills over long periods of time.

v. Additional Financing Programs from the State Treasurer's Office.

The California Alternative Energy & Advanced Transportation Financing Authority (CAEATFA), a division in the State Treasurer's Office, through its administration of the California Hub for Energy Efficiency Financing (CHEEF) has launched a number of affordable financing programs for energy efficiency upgrades for hard-to-reach groups, such as low-to-moderate income groups. CAEATFA's programs leverage millions of dollars of private capital at attractive interest rates and terms, rapidly and conveniently. These programs are only available in IOU territory.

The Residential Energy Efficiency Loan (REEL) program provides 100 percent financing for owners and renters of all types of homes (up to 4 units). Long term repayment options with affordable monthly payments are available. A number of energy efficiency measures are eligible for financing including HVAC equipment and refrigerators. The Affordable Multifamily Financing program targets multifamily properties where at least 50 percent of the units are income restricted and has many of the same features as the REEL program.

The Small Business Financing (SBF) program offers affordable financing options to small California businesses to reduce their energy usage. Measures that improve the energy efficiency of refrigeration systems such as commercial ice machines, commercial refrigerators and freezers, compressor and condensing units, evaporator controls, rapid close doors, vending machines, HVAC equipment and others are eligible for SBF financing. Loans, leases, equipment financing agreements, service agreements and savings-based payment agreements are permitted under the program for energy efficiency projects. An on-bill repayment option is planned to be added to the program in 2021.

vi. Senate Bill 1477 Incentives.

SB 1477[54] mandates the CPUC, in consultation with the CEC, to develop programs aimed at reducing GHG emissions associated with buildings. Up to $200,000,000 will be allocated in incentives over the course of fiscal years 2019-2020 to 2022 to 2023 for advancing the adoption of near-zero-emission space and water heating technologies in new and existing residential buildings. Space heating heat pump technologies are covered in the Proposed Amendments. SB 1477 programs are in development right now, but legislative mandates require that a substantial portion of the funding is reserved for low-income communities, and in ensuring that the adoption of clean technologies does not result in higher utility bills for low-income households.

[54] Senate Bill 1477 (Stern, Stats. of 2018, Ch. 378).

VIII. Standardized Regulatory Impact Analysis

A. Refrigeration Costs

The Proposed Amendments will require end-users of commercial and industrial refrigeration systems[55] to use refrigerants under certain GWP limits depending on whether the systems are used in new or existing facilities:

- New Facilities: New systems will be required to have refrigerants with a GWP value less than 150, starting January 1, 2022. New facilities includes facilities that are newly constructed or existing facilities that have been re-purposed or fully remodeled.

- Existing Facilities: Existing retail food facilities will be required to reduce their company-wide weighted-average GWP to below 1,400 by 2030 (with a progress step in 2026 for large companies). Under an alternative compliance pathway, companies can reduce the GHGp by 55 percent below their 2019 baseline. New systems in industrial process refrigeration and cold storage facilities will be required to use refrigerants with GWP below 2,200 and 1,500, respectively.

1. Cost Methodology and Baseline Upfront Costs for New Refrigeration Systems.

To analyze any additional costs and / or savings resulting from compliance with the Proposed Amendments, CARB staff first estimated the current costs of buying and using new refrigeration systems under the "business-as-usual" (BAU) conditions – these are referred to as the baseline costs. Then, any costs or savings likely to be experienced due to the Proposed Amendments are estimated relative to the baseline costs – these are referred to as the incremental costs or savings. To calculate the total costs of compliance with the Proposed Amendments, all incremental costs and savings are aggregated over all affected refrigeration systems over a period of approximately one average lifetime of a refrigeration system. It is important to note that all costs estimated for refrigeration are conservative and do not take into account any experience or learning curves, even though the costs of new refrigeration technologies are expected to decline as their market adoption increases.

i. Refrigeration Baseline.

The Proposed Amendments affects refrigeration systems containing more than 50 pounds of refrigerant. For the purpose of this analysis, CARB is categorizing these systems into the following general categories consistent with the F-Gas Inventory:

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[55] The Proposed Amendments only apply to refrigeration systems containing more than 50 pounds of refrigerant.

- *Commercial Refrigeration:* This end-use sector comprises mainly retail food facilities designed to store and display chilled or frozen goods for commercial sale, for example, in supermarkets and grocery stores. In addition, some commercial systems are used in merchant wholesale facilities, hotels, amusement parks, etc.

- *Industrial Process Refrigeration:* This sector includes systems that cool process streams in industrial applications. This includes, but is not limited to, food and non-food production and manufacturing, respectively. The choice of refrigerant for specific applications depends on ambient and required operating temperatures and pressures (U.S.EPA, 2018).

- *Cold Storage Warehouses:* This sector includes systems in facilities that store meat, produce, dairy products, and other perishable goods. According to the U.S.EPA, "the majority of cold storage warehouses in the United States use ammonia as the refrigerant in a vapor compression cycle, although some rely on other refrigerants" (U.S.EPA, 2018).[56]

CARB's system classification broadly aligns with the U.S.EPA's SNAP end-uses of retail food refrigeration, industrial process refrigeration and cold storage warehouses. These systems are currently subject to CARB's Refrigerant Management Program (RMP) under which they have to provide annual reports on their refrigerant purchase and use and follow best leak management practices (CARB, 2020b). The RMP has three size classes for the refrigeration systems, which are as follows:

Table 5. *Refrigeration system size classes in CARB's Refrigerant Management Program*

System Size	Full charge of system (amount of high-GWP refrigerant contained)
Large	2,000 pounds and above
Medium	200 to under 2,000 pounds
Small	Over 50 to under 200 pounds

The same size classes are used for this analysis. This helps align the implementation of the Proposed Amendments with the already established RMP. Here on, stationary refrigeration systems containing more than 50 pounds of refrigerant are referred to as "regulated refrigeration systems" in this document. Baseline characteristics for regulated refrigeration systems are based on CARB's F-Gas Inventory and the RMP database, and are given in **Table 6.**

[56] *Ibid.*

Table 6. *Baseline Characteristics for New Stationary Refrigeration Systems*

System Type	Baseline Refrigerant for New Systems	Baseline GWP (100-year, AR4[57])	Lifetime (Years)	Average Full Charge (pounds or lb)	Average Annual Leak Rate (%)
Commercial Refrigeration					
Large	R-407A	2,107	15	3,352	24.2%
Medium			15	684	22.9%
Small			20	103	15.6%
Industrial Process Refrigeration					
Large	R-404A, R-507, R-134a	3,066	20	5,873	12.3%
Medium			20	660	12.5%
Small			20	104	9.1%
Cold Storage					
Large	R-448A / R-449A	1,391	20	7,252	14.8%
Medium			20	552	10.3%
Small			20	113	3.7%

For all refrigeration systems, the average end-of-life leak rate is 20 percent.
For commercial refrigeration and cold storage, the baseline GWP for new systems in new construction is the maximum allowable GWP value under the current California SNAP regulation and SB 1013. Industrial process refrigeration systems are not currently included in the original California SNAP regulation or SB 1013; the baseline GWP for new systems in that sector is based on the F-Gas Inventory and is the weighted-average GWP of all the refrigerants used in the sector. The average system lifetimes and refrigerant charge sizes are from the F-Gas Inventory (CARB, 2016). To reflect the current state of emissions, the average annual leak rates used in this analysis are based on refrigerant leak data reported by end-users to CARB's RMP in 2018. The average end-of-life leak rates are from CARB's F-Gas Inventory and align with the U.S. EPA's estimates (ICF, 2016).

Based on the F-Gas Inventory, commercial refrigeration systems, most of which are used in supermarkets and grocery stores comprise more than 75 percent of all high-GWP refrigeration systems, followed by industrial process refrigeration and cold storage, which account for 21 percent and 3 percent of the high-GWP refrigeration systems, respectively. Since the majority of the regulated refrigeration systems are used in retail food industry, that is to say in supermarkets and grocery stores, the Proposed Amendments include additional requirements for existing supermarkets and grocery stores.

[57] (Forster et al., 2007).

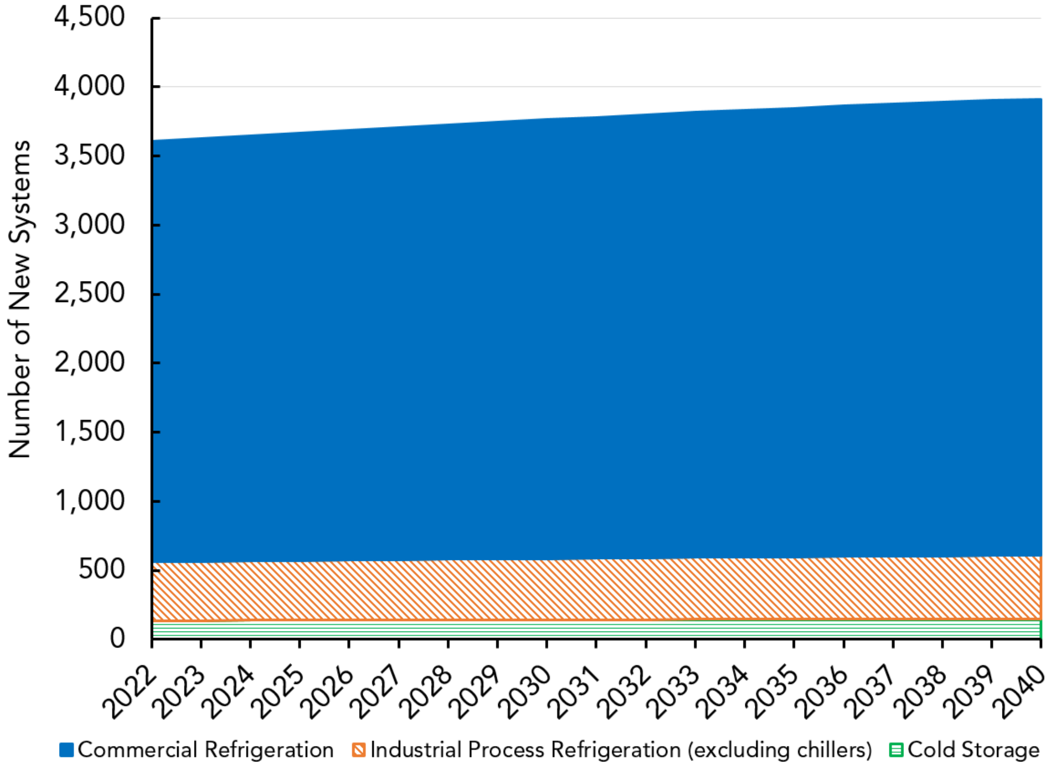
ii. Projected Populations of Regulated Refrigeration Systems

CARB staff used the F-Gas Inventory to estimate the number of new systems entering the California market to quantify baseline emissions and costs related to the Proposed Amendments. The F-Gas Inventory uses data from the following sources to estimate stationary refrigeration system populations:

- Research report by Armines, "Inventory of Direct and Indirect GHG Emissions from Stationary Air conditioning and Refrigeration Sources" for CARB, 2009 (Saba et al., 2009).
- 2012 Report on Greenhouse Gas Performance Analysis by ICF International (ICF, 2012).
- Data from CARB's Refrigerant Management Database—Refrigerant Registration and Reporting System or R3 (CARB, 2020b).
- Projected population growth from the California Department of Finance (California DOF, 2019).

The number of refrigeration systems within California is growing due to (1) new construction of refrigerated facilities, and (2) due to replacement of retiring equipment in existing facilities. On average, the annual growth in regulated refrigeration equipment correlates with population growth in the state. This is based on the assumption that as population increases, facilities like supermarkets and cold storage warehouses will increase proportionally to serve the additional population. In 2019, DOF projected an annual average population growth rate of 0.7 percent for the period between 2022 and 2040. Recently, DOF released the latest population forecasts which lowers the average growth rate to 0.5 percent for the same time period. Throughout this document, the updated 2020 growth rate is used to project statewide growth in refrigeration systems, and to estimate costs and emissions reductions from those systems. **Figure 8** below shows the projected number of new regulated refrigeration systems based on the 2020 DOF-projected growth rates by end-use sector:

Figure 8. *New refrigeration systems between 2022 and 2040*



As mentioned earlier, most regulated refrigeration systems are used in commercial refrigeration, followed by industrial process refrigeration and cold storage. Annually, new refrigeration systems can either be installed in newly constructed or fully remodeled facilities or they can be used to replace equipment reaching end of their useful life in existing facilities. Based on CARB's F-Gas Inventory, majority of new systems in any given year are used to replace retiring equipment in existing facilities. For example, even though the figure above shows more than 3,500 new regulated refrigeration systems being added in 2022, most of the new units annually are used to replace systems reaching end of life and approximately only 7 to 9 percent of those are used in new construction.[58] In the baseline scenario, the new systems use refrigerants with GWP values between 2,000 and 4,000 depending on the end-use sector. Under the Proposed Amendments, new systems in new facilities will be required to use refrigerants with a GWP less than 150, while existing facilities will have varying requirements based on end-use.

[58] Since new construction is assumed to correlate with population growth, in any given year, an average of 0.5 percent of the operational systems are assumed to be added in newly constructed facilities. Depending on average system lifetime, 0.5 percent of operational units equates to 7 to 9 percent of all new systems per year installed in new construction.

Table 7. *Post-Rule Projected Populations of Retail Food Refrigeration Systems*

Year	New Systems in New Facilities[a]	Existing Facilities New Systems Replacing Retiring Systems[b]	Existing Facilities Existing Systems (not yet reached end-of-life)[c]	Total Projected Population of Retail Food Systems[d]
2022	178	1,953	34,584	36,715
2023	357	3,917	32,744	37,019
2024	537	5,888	30,887	37,312
2025	716	7,850	29,030	37,596
2026	894	9,796	27,185	37,874
2027	1,069	11,716	25,359	38,145
2028	1,241	13,601	23,566	38,408
2029	1,410	15,439	21,815	38,663
2030	1,574	17,233	20,105	38,912
2031	1,734	18,980	18,441	39,155
2032	1,888	20,655	16,851	39,393
2033	2,037	22,273	15,316	39,626
2034	2,182	23,841	13,830	39,854
2035	2,317	25,304	12,453	40,075
2036	2,445	26,677	11,168	40,290
2037	2,567	27,999	9,934	40,500
2038	2,683	29,243	8,779	40,705
2039	2,790	30,385	7,729	40,904
2040	2,887	31,417	6,794	41,098

[a] New systems in newly constructed facilities – required to use refrigerants with GWP less than 150, starting 2022 under the Proposed Amendments.
[b] New systems replacing retiring equipment in existing facilities -– required to have an average GWP less than 1,400 under the Proposed Amendments on a company-wide basis.
[c] Existing systems that have not reached their end of life – required to have an average GWP less than 1,400 under the Proposed Amendments on a company-wide basis.
[d] Total population of retail food systems = new systems + existing systems (i.e., footnotes *a* + *b* + *c*).

Projected populations of other regulated refrigeration systems (i.e., cold storage and industrial process refrigeration) are given in the SRIA Appendix.

2. Costs for New Facilities.

i. New Facilities: Baseline Upfront Costs – Equipment and Installation.

In almost all cases, regulated refrigeration systems are designed to serve large cooling needs and are built and installed per the needs and specifications of the facility. Unlike smaller systems like residential refrigerators, estimates of baseline system costs are not available directly online. End-users of these systems, for example supermarket companies, use the services of design / engineering firms and equipment manufacturers to receive competitive bids for purchase and installation of all equipment needed for the facility, which may or may not necessarily be on a per-system basis. Thus, to estimate upfront costs per system, CARB staff first estimated the baseline equipment costs on a per-facility basis using stakeholder input and a few publicly available estimates (Hillphoenix, 2014; Arthur, 2014). Currently, the most common type of refrigeration system used in large refrigerated facilities like supermarkets are centralized, direct expansion systems using HFC refrigerants like R407A. The baseline costs for current facilities using these types of HFC systems were shared and discussed with stakeholders during a public technical working group meeting (CARB, 2019c) and through several individual phone meetings.

Emissions reductions in CARB's F-gas inventory are tracked on a per-system basis and not per facility. To evaluate the cost-effectiveness of emissions reductions from these regulatory proposals, facility-level costs were converted to per-system costs. Baseline facility-level costs were apportioned to systems based on the average amount of refrigerants they contain (i.e., average system full charge). The methodology for conversion of baseline facility equipment and installation costs to system costs is discussed in the SRIA Appendix. Baseline costs per refrigeration system size (large, medium, and small) and type (commercial, industrial process, and cold storage) are given below in **Table 8**.

Table 8. *Baseline Upfront Costs for HFC Refrigeration Systems (2018$)*

End-Use Sector	System Size [a]	Average System Full Charge (lb)	Baseline Upfront Costs (HFC DX system)	
			Equipment	Installation
Retail Food Refrigeration	Large	3,352	$958,000	$431,000
	Medium	684	$219,000	$98,500
	Small	103	$76,500	$34,400
Other Commercial Refrigeration	Large	3,352	$670,000	$144,000
	Medium	684	$153,000	$32,800
	Small	103	$53,600	$11,500
Industrial Process Cooling	Large	5,873	$912,000	$411,000
	Medium	660	$293,000	$132,000
	Small	104	$99,000	$44,600
Cold Storage	Large	7,252	$1,130,000	$507,000
	Medium	552	$245,000	$110,000
	Small	113	$108,000	$48,400

[a] System size classification under CARB's Refrigerant Management Program.

ii. Baseline Ongoing Costs.

The recurring costs experienced by end-users of regulated refrigeration systems include costs associated with replenishment of leaked refrigerant and compliance with CARB's RMP regulation. Baseline ongoing costs per system are given below in **Table 9** and discussed in the table's footnotes.

Table 9. *Baseline Annual Ongoing Costs for HFC Refrigeration Systems (2018$)*

End-Use Sector	System Size[a]	Baseline Ongoing Costs($ per year)	
		Refrigerant Replenishment[b]	Regulatory Compliance with RMP[c]
Retail Food Refrigeration	Large	$5,700	$3,100
	Medium	$1,100	$650
	Small	$110	$150
Other Commercial Refrigeration	Large	$5,700	$3,100
	Medium	$1,100	$650
	Small	$110	$150
Industrial Process Cooling	Large	$5,100	$3,100
	Medium	$580	$650
	Small	$70	$150
Cold Storage	Large	$7,500	$3,100
	Medium	$400	$650
	Small	$29	$150

[a] System size classification under CARB's Refrigerant Management Program.
[b] Baseline cost for refrigerant replenishment per year = Average full charge of system (in pounds) x Average Annual Leak Rate x Average baseline cost of refrigerant (i.e., $7 / pound). This is the estimated amount of money spent each year for replenishing leaked refrigerant from each system (rounded to two significant figures).
[c] Baseline costs for RMP compliance are based on original estimates in the Initial Statements of Reason for CARB's RMP regulation (CARB, 2009), converted to 2018 dollars. The original cost estimates were on a per-facility basis. These were converted to system costs based on the following assumptions: "small facilities have approximately 5 systems in the small refrigerant charge size category, medium facilities have approximately 5 systems in the medium refrigerant charge size category, and large facilities have approximately 2 systems in the large refrigerant charge size category"(CARB, 2009). NOTE: RMP-based costs are gross costs estimated in 2009. The RMP regulation is estimated to save end-users costs due to avoided refrigerant leakage costs. However, as a conservative estimate, only the gross costs (not net savings) are used for this analysis.

Additionally, there are ongoing costs for electricity consumption for all facilities. Except for large cold storage and IPR systems, no change in electricity costs are expected for any other systems. Apart from these, end-users also incur regular routine maintenance costs. Based on stakeholder input, those costs are not expected to differ significantly between HFC systems and the low-GWP systems. Thus, these ongoing costs are excluded from the table above.

iii. <u>New Facilities: Incremental Costs.</u>

To assess the increase in costs resulting from the Proposed Amendments, incremental costs as a percentage above baseline were estimated by seeking direct input from stakeholders during the public technical working group meetings and phone meetings referenced above, and are discussed in detail below. To obtain incremental costs per system in dollars, the incremental cost percentages were multiplied with the baseline costs for each type of refrigeration system, i.e.,

Incremental Cost per System (in 2018$) = Baseline Cost per System (in 2018$) x Incremental Cost as a Percentage above Baseline.

Because there are several refrigerant and system options available to end-users for compliance, the baseline and incremental costs in this analysis are meant to be representative averages across the available options. The assumptions for these costs are detailed in the following sections.

- **Equipment Cost:** Currently, equipment using low-GWP refrigerants is more expensive than the baseline HFC systems and is the main source of added costs for compliance with the Proposed Amendments. Since these are custom-built systems, information about incremental costs are not directly available from any published reports. Based on direct input from stakeholders and a few publicly available estimates (Hillphoenix, 2014; Arthur, 2014), for low-GWP equipment in newly constructed or fully remodeled facilities, CARB staff assumes the incremental cost to be between 15 and 25 percent, and on average, 20 percent above baseline. Equipment costs for compliant systems are higher than baseline primarily the differences in the design of the low-GWP systems compared to the current HFC systems. Since it is speculative to quantitatively parse out incremental costs due to the different design factors, here we describe them qualitatively: Different compliant refrigerants have differing thermodynamic, physical or chemical properties that may require specialized system architecture. For example, for CO_2, the systems are built to withstand higher pressures than baseline systems and may require some additional features like adiabatic condensers to achieve energy efficiencies in hot ambient climates; in micro-distributed propane systems, very small quantities of propane (less than 150 grams per system) are used to cool/freeze products in display cases directly and the heat is rejected through a water loop running through the facility; in low-charge ammonia systems used primarily in IPR and cold storage, small completely sealed units containing ammonia may be placed on rooftops – this helps mitigate the costs associated with managing very large quantities of ammonia and the associated safety risks. In addition, the refrigerant lines or piping, which can be very extensive and runs throughout the facility is different for each of the low-GWP refrigerants and different from the current baseline system piping.

- **Installation Cost:** For commercial refrigeration systems, CARB staff assumes that the cost of installation, mainly tied to labor, could be higher on average by 10 percent, due to the fact that service technicians that are trained to handle the low-GWP systems are not as easily available as technicians for traditional systems. The currently available technicians familiar with the low-GWP systems may have to work extra hours to meet the initial demand or may charge higher rates. It is important to note that availability of technicians is directly linked to market adoption of the technologies. As low-GWP systems become more common, the technician base servicing those systems will grow, bringing parity in installations costs. Additionally, the added installation cost is offset to some extent by a few factors: based on stakeholder input, costs of electrical installation of the low-GWP systems, e.g., transcritical CO_2 can be lower since it requires less after-market electrical installation because the wiring for the case controllers and electronic expansion valves come factory installed (Hillphoenix, 2014). In contrast, baseline HFC refrigerant cases need to have additional after-market electrical installation of temperature sensors.

On the other hand, in the industrial and cold storage sectors, a low-GWP refrigerant like ammonia is already widely used and there is no shortage of a trained and experienced technician base servicing ammonia systems. However, there is a lack of technicians familiar with the system architecture of the newer types of ammonia systems. Based on stakeholder input, some electrical upgrades may be needed in IPR and cold storage facilities to be able to use low-GWP systems and that can contribute to higher installation costs. Thus, for IPR and cold storage, CARB assumes a 20 percent incremental cost for installation, mainly to account for the potentially higher electrical costs associated with the installation of low-charge NH_3 and NH_3/CO_2 cascade systems.

Table 10 shows the incremental upfront costs per system per end-use sector. Incremental costs were calculated by multiplying the baseline costs in Table 8 with the incremental cost percentages discussed above. All values are rounded up to three significant figures.

Table 10. *Incremental Upfront Costs for New, GWP < 150 Refrigeration Systems (2018$)*

End-Use Sector	System Size	Incremental Upfront Costs (%)[a]		Incremental Upfront Costs[b] (2018$)	
		Equipment	Installation	Equipment	Installation
Retail Food Refrigeration	Large	20%	10%	+$192,000	+$43,100
	Medium			+$43,800	+$9,800
	Small			+$15,300	+$3,400
Other Commercial Refrigeration	Large			+$134,000	+$14,400
	Medium			+$30,600	+$3,280
	Small			+$10,700	+$1,150
Industrial Process	Large		20%	+$182,000	+$82,100
	Medium			+$58,700	+$26,400

End-Use Sector	System Size	Incremental Upfront Costs (%)[a]		Incremental Upfront Costs[b] (2018$)	
		Equipment	Installation	Equipment	Installation
Cooling	Small			+$19,800	+$8,910
Cold Storage	Large			+$225,000	+$101,000
	Medium			+$49,100	+$22,100
	Small			+$21,500	+$9,690

[a] Incremental costs above baseline for compliant systems in percentages.
[b] Incremental costs are calculated by multiplying baseline upfront costs with incremental costs in percentages.

In contrast to the upfront costs discussed above, some savings are expected on an ongoing basis for new refrigeration systems. These savings are associated with replenishment of leaked refrigerant, electricity costs and compliance costs associated with CARB's RMP regulation. Each of these are discussed below.

- **Refrigerant Replenishment:** Annually, regulated refrigeration systems leak on average, between 4 to 24 percent of the total refrigerant amount they contain (see **Table 6**) for baseline leak rates). For example, a large retail food system containing 3,352 pounds of refrigerant, with an annual average leak rate of 24.2 percent leaks an average of 810 pounds of refrigerant per year. When multiplied by an average annual refrigerant cost of $7 per pound results in an annual cost of replenishing leaked refrigerant of approximately $5,700 per year. Across different system sizes and types, annual baseline costs for refrigerant replenishment per system can range widely, and depending on the full charge and leak rate, are estimated to between $29 and $7,500 per year per system (see SRIA Appendix for details). The current, market-ready low-GWP refrigerants like CO_2 and NH_3 are naturally-occurring gases which are cheaper than synthetic on- and off-patent HFC refrigerants. On average, CO_2 and NH_3 cost between $2 and $4 per pound, at least 50 percent lower than the baseline HFC refrigerant costs, which can range between $5 and $10 per pound (average: $7 per pound). Costs associated with refrigerant replenishment are listed in **Table 11**.

Table 11. *Incremental Refrigerant Costs for New Refrigeration Systems with GWP < 150*

Description	In new construction/full remodels, new systems with GWP < 150
Average Incremental Cost Percentage	–50%

Description	In new construction/full remodels, new systems with GWP < 150
Incremental Annual Cost per Commercial Refrigeration System ($ / year)	- $56 to -$2,800 [a]
Incremental Annual Cost per Industrial Process Refrigeration System ($ / year)	- $33 to -$2,500 [a]
Incremental Annual Cost per Cold Storage System ($ / year)	- $15 to -$3,800 [a]

[a] The range of values represent the average savings for the different system sizes (large, medium and small) for each type of refrigeration system (i.e., commercial refrigeration, industrial process refrigeration and cold storage).

- **Electricity:** Energy usage and thus, electricity costs vary widely by facility type. For example, the electricity costs for a cold storage warehouse can be very different from that of a supermarket. In addition, for some low-GWP refrigerants like CO_2, energy usage by the refrigeration system is heavily influenced by the climate zone. Despite the evidence that currently available low-GWP refrigeration systems can be at energy parity or in some cases, be more energy efficient than baseline HFC systems, the performance of commercial systems e.g., those in supermarkets can still vary due to a number of factors, like operation and maintenance. Due to lack of overarching U.S. DOE energy efficiency requirements on the systems themselves and lack of adequate benchmarking of baseline energy performance of commercial refrigeration systems in the field, CARB staff did not include energy-related costs or savings for the new low-GWP systems in newly constructed / fully remodeled commercial refrigeration facilities.

  For IPR and cold storage, because the industry is already well-acquainted with the use of low-GWP refrigerants like ammonia, there are documented studies and real-world examples of energy cost-savings associated with their use. There are several accounts of end-users installing low-charge ammonia systems and experiencing significant energy savings over HFC systems in cold storage and IPR facilities, reportedly up to 30 percent savings in some cases (Amarnath, 2018; Garry, 2016; Garry, 2018). In addition to ammonia, CO_2 is emerging as an industrial refrigerant, whether used alone or in combination with NH_3. Ammonia and CO_2 used together in cascade systems minimizes the amount of NH_3 thus, lowering the associated risks, and removing any energy penalty issues that can arise from purely CO_2 systems in hot climates, while maximizing the use of environmentally benign, low-cost refrigerants. Using a NH_3/CO_2 cascade system, energy savings of 10 to 25 percent have been measured relative to an HFC baseline system by a California utility company (SCE, 2017).

As a conservative estimate and based on the data discussed above, CARB staff assumes a 10 percent savings in energy for large IPR and cold storage systems being installed in new or remodeled facilities. For the small and medium systems, there is a lack of studies comparing the use of low-GWP refrigerants with high-GWP HFC systems. Thus, no savings are assumed for this analysis for the small and medium IPR and cold storage systems (although energy parity with baseline systems and even savings in some cases are likely). On the whole, for IPR and cold storage, a 10 percent energy savings estimate for large systems only is likely an underestimate. Based on available reports, on average, the baseline annual cost of electricity for a large cold storage or IPR system used to serve the needs of a whole facility is estimated to be $350,000 per year.[59] Thus, a 10 percent annual savings equates to savings of $35,000 per year for each large IPR and cold storage system. Incremental electricity costs for refrigeration systems are listed in **Table 12**.

Table 12. *Incremental Electricity Costs for New Refrigeration Systems with GWP < 150*

Description	In new construction/full remodels, new systems with GWP < 150
Average Incremental Cost Percentage	–10% for large IPR and cold storage systems; no change for others
Average Annual Incremental Costs for Large IPR and Cold Storage Systems ($ / year)	- $35,000

- **Regulatory Cost:** Currently, CARB's RMP regulation affects all facilities using regulated refrigeration systems using a high-GWP refrigerant, where "high-GWP" means a GWP value of 150 or greater. Cost of compliance with the RMP rule includes paying an annual implementation fee (based on facility size) and costs associated with record-keeping and reporting. Baseline annual costs for RMP compliance per system are estimated to be $151, $645 and $3,100 for small, medium and large systems, respectively. These baseline costs do not include savings expected under the RMP due to avoided leaks. The Proposed Amendments will require these same types of systems to use refrigerants with GWP less than 150 in newly constructed and fully remodeled facilities. Those

[59] Baseline electricity costs estimated as follows: Specific energy consumption for cold storage warehouses ranges between 0.8 and 1.4 kWh per cubic feet per year (Becker Engineering Company, 2013). Average size of cold storage facility is 2.4 million cubic feet (USDA, 2016). Thus, the energy consumption per facility ranges between 2.0 and 3.3 million kWh per year, with an average value of 2.7 million kWh per year. The 12-month annual average price of electricity for the industrial sector in California from June 2018 to May 2019 was $0.13 per kWh (U.S. Energy Information Agency, 2019). Thus, the average baseline electricity cost for a large cold storage facility is estimated to be 2.7 million kWh/year x $0.13/kWh = $350,000 per year (rounded to two significant figures). Due to lack of separate data sources, a similar baseline cost is assumed for large IPR systems.

new facilities will thus be exempt from RMP's annual implementation fee, recordkeeping and reporting requirements. This will result in cost-savings for those facilities and the RMP implementation costs borne by the State.

Under the Proposed Amendments, new facilities will have to complete a one-time free registration in CARB's online refrigerant management database, R3. Since most companies that own these facilities already register their existing facilities in R3 under the RMP regulation, this requirement is not expected to add any costs. In addition, equipment manufacturers will be required to add labels and keep records of sales. The current HFC regulation requires recordkeeping and a disclosure statement. Here, a labeling requirement is being proposed in lieu of the disclosure. Some labels are required under the current product standards for various components of built-up refrigeration systems and, if sufficient, those existing labels may be used to comply with the proposed rules. Thus, the Proposed Amendments are not expected to add any regulatory costs on any entities. Incremental regulatory costs are listed in **Table 13**.

Table 13. *Incremental Regulatory Costs for New Refrigeration Systems with GWP < 150*

Cost Categories	In new construction/full remodels, new systems with GWP < 150
Incremental Cost Percentage for RMP Compliance	-100%
Incremental Annual Costs for RMP Compliance Per System ($ / year)	-$151 to -$3,100 per system [a]
For Labeling, Recordkeeping and One-time Facility Registration Requirements under the Proposed Amendments	No change from baseline

[a] The range of values represent the average savings for the different system sizes (large, medium and small). For full calculation, see SRIA Appendix.

iv. <u>Total Incremental Costs per New Refrigeration System in New Facilities.</u>

To calculate total incremental costs for systems placed in new facilities, CARB staff first calculate costs for large, medium and small systems under each refrigeration end-use sector. All upfront costs i.e., equipment and installation, were amortized over 15 to 20 years, depending on the average lifetime for different types of systems, using a 5 percent annual real interest rate to reflect end-user financing. Total incremental costs range between 5 and 18 percent above the baseline scenario for most refrigeration systems, while net savings are expected for a few system types. The annual total incremental costs per system ranges between $700 and $17,000 per year and are listed in **Tables 14** to **16**. Savings are expected for large IPR and cold storage systems due to expected reduction in all ongoing costs. Total costs for new systems over the system lifetime range between $15,000 and $249,000 depending on system size and end-use.

Table 14. *Total Incremental Costs per New, Large Refrigeration System with GWP < 150 (2018$)*

Cost Categories	Commercial – Retail Food Facility	Commercial – Other	Industrial Process	Cold Storage
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$192,000	+$134,000	+$182,000	+$225,000
Installation ($)	+$43,100	+$14,400	+$82,100	+$101,000
Total Upfront ($)	+$235,000	+$148,000	+$264,000	+327,000
Amortized Annual Upfront ($ / year)	+$22,600	+$14,300	+$21,200	+$26,200
Ongoing Costs				
Refrigerant Replenishment ($ / year)	– $2,800	– $2,800	– $2,500	– $3,800
Electricity ($ / year)	$0	$0	– $35,000	– $35,000
RMP Compliance ($ / year)	– $3,100	– $3,100	– $3,100	– $3,100
Total Incremental Costs				
Total Annual ($ / year)	+$16,600	+$8,320	-$19,400	-$15,700
Total Lifetime ($)	+$249,000	+$125,000	-$389,000	-$314,000

Table 15. *Total Incremental Costs per New, Medium Refrigeration System with GWP < 150 (2018$)*

Cost Categories	Commercial – Retail Food Facility	Commercial – Other	Industrial Process	Cold Storage
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$43,800	+$30,600	+$58,700	+$49,100
Installation ($)	+$9,850	+$3,280	+$26,400	+$22,100

Cost Categories	**Commercial – Retail Food Facility**	**Commercial – Other**	**Industrial Process**	**Cold Storage**
Total Upfront ($)	+$53,600	+$33,900	+$85,100	+$71,100
Amortized Annual Upfront ($ / year)	+$5,170	+$3,270	+$6,830	+$5,710
Ongoing Costs				
Refrigerant Replenishment ($ / year)	-$548	-$548	-$289	-$199
Electricity ($ / year)	$0	$0	$0	$0
RMP Compliance ($ / year)	-$645	-$645	-$645	-$645
Total Incremental Costs				
Total Annual ($ / year)	+$3,970	+$2,100	+$5,890	+$4,860
Total Lifetime ($)	+$59,600	+$31,100	+$118,00	+$97,300

Table 16. *Total Incremental Costs per New, Small Refrigeration System with GWP < 150 (2018$)*

Cost Categories	**Commercial – Retail Food Facility**	**Commercial – Other**	**Industrial Process**	**Cold Storage**
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$15,300	+$10,700	+$19,800	+$21,500
Installation ($)	+$3,440	+$1,150	+$8,910	+$9,690
Total Upfront ($)	+$18,700	+$11,900	+$28,700	+$31,200
Amortized Annual Upfront ($ / year)	+$1,504	+$952	+$2,300	+$2,500
Ongoing Costs				
Refrigerant Replenishment ($ / year)	-$56	-$56	-$33	-$15
Electricity ($ / year)	$0	$0	$0	$0
RMP Compliance ($ / year)	-$151	-$151	-$151	-$151
Total Incremental Costs				

Cost Categories	Commercial – Retail Food Facility	Commercial – Other	Industrial Process	Cold Storage
Total Annual ($ / year)	+$1,300	+$745	+$2,120	+$2,340
Total Lifetime ($)	+$25,900	+$14,900	+$42,400	+$46,800

3. Costs for Existing Retail Food Facilities to Comply with Company-wide Reduction Targets.

The Proposed Amendments require retail food companies, i.e., primarily supermarkets and grocery stores, to reduce their current banks of high-GWP HFC refrigerants. Instead of implementing this on a per-store basis, CARB staff propose taking a wider approach, where each retail food company will be required to reduce their company-wide average GWP (weighted by the pounds of refrigerant, across all their stores) to below 1,400 by 2030. This is referred to as the "Weighted-average GWP Reduction Program." In effect, this will be a performance standard for the retail food industry and is akin to CARB's vehicular fleet standards whereby retail food companies will be required to reduce HFC emissions from their current "fleet" or portfolio of supermarkets and grocery stores, while being encouraged to transition to low-GWP technologies.

This approach provides flexibility to companies to (1) reduce their GWP using strategies most suitable for them; and (2) to plan and distribute costs over an 8-year period, between 2022 and 2030. Retail food companies will also have an alternative compliance option, under which they can reduce both, the total amount of refrigerant used and GWP of those refrigerants across their stores. This is called the "Greenhouse Gas Potential" or "GHGp" and represents the potential HFC emissions that can result from all the systems a company owns. End-users will have the option to opt-into this compliance pathway by January 1, 2022, and will be required to reduce their company-wide GHGp by 55 percent below their 2019 baseline.

Since there are several ways to comply with the Proposed Amendments and it is speculative to assume which reduction strategies companies will choose, CARB staff estimated the incremental costs for this rule based on the most common-place practice in the industry today, i.e., retrofits to refrigerants with GWP below 1,400. Based on stakeholder input, this will also be the most economical option to achieve minimum compliance. Other options listed in **Section I.F** may cost more but will have the added benefit of being more future-proof in terms of future national and global HFC regulations and could allow companies to leave some stores un-altered (if extra reductions are obtained from some stores, others may be left untouched).

To estimate the incremental costs of refrigerant retrofits, CARB staff sought direct input from supermarket end-users and those are discussed and summarized below. Each cost category is discussed in detail in **Table 17** below.

Table 17. *Average Incremental Costs for Existing Retail Food Systems (i.e., in Supermarkets and Grocery Stores)*

Cost Categories	Average Incremental Costs
Equipment and Installation	+$45 per pound of refrigerant
Refrigerant Replenishment	+50% per pound of refrigerant
Operation and Maintenance	No change from baseline
RMP Compliance	No change from baseline
Electricity	–5% per system

While the F-Gas Inventory tracks emissions on a per-system basis, end-users may plan to carry out retrofits for the entire store or facility at once, instead of one system at a time. To provide a holistic overview, an example of incremental costs for retrofitting a typical supermarket is given below in **Table 18**. For this example, an average supermarket is assumed to use 2,500 pounds of refrigerant across all systems containing more than 50 pounds of refrigerant, and having a facility-wide annual refrigerant leak rate of 23 percent.

Table 18. *Supermarket Refrigeration Cost Example for Retrofit to R-448A/R-449A (2018$)*

Cost Category	Baseline System using R-404A	System retrofitted to R-448A or R-449A	Difference
Upfront Costs ($) (amortized over 10 years with a 5% interest rate)	$0	$14,569	+$14,569
Refrigerant Replenishment ($ / year)	$4,025	$6,038	+$2,013
Electricity ($ / year)	$205,292	$195,027	- $10,265
Total Annual Incremental Costs per Supermarket ($ / year)	$209,000	$216,000	+$6,320

- <u>Upfront Equipment and Installation Costs:</u> For the existing retail food systems, a typical refrigerant retrofit includes the following: recovery/removal of old refrigerant, replacing necessary seals and valves on the display cases and receivers, replacement of lubricant oil and filters, filling in the new refrigerant, re-labeling all equipment, leak and pressure checks before and after changing the refrigerant, and recordkeeping related to the changes. Altogether, along with associated labor costs, the upfront costs of retrofit are on average, $45 per pound of refrigerant in the system. For an average supermarket that uses a total of 2,500 pounds of R-404A type refrigerant, the upfront cost for retrofitting the entire store is estimated to be 2,500 lb. × $45 per lb. = $112,500. For the purposes of this analysis, this upfront cost is amortized over a period of 10 years, roughly half the average lifetime of a new system. The assumption here being that a retrofitted system will at least be used for another 10 years. A full 20-year amortization is not used because systems being retrofitted are going to be of varying ages and may not all last as long. The amortization also includes a 5 percent annual real interest rate to reflect end-user financing. For an average supermarket, this equates to an annualized incremental upfront cost of approximately $14,600 per store.

- Ongoing Refrigerant Replenishment Costs: The ongoing costs may be higher than baseline for refrigerant replenishment; it is estimated that costs for refrigerants with GWP less than 1,400, for example R-448A / R-499A are on average 50 percent higher than R-404A-type refrigerant per pound. For an average supermarket that has a total charge of 2,500 lb. and an annual average refrigerant leak rate of 23 percent, the baseline cost for replenishing leaked refrigerant annually is 2,500 lb. × 23% per year × $7 per lb. = $4,025 per year. After the retrofit, assuming no change in annual leak rates occurs, the annual cost for refrigerant will be = 2,500 lb. × 23% per year × $10.50 per lb. = $6,038 per year. Thus, the incremental cost per year is expected to be $6,038 – $4,025 = $2,013 per year. While it is expected that the cost of the refrigerants like R-448A and R-449A will soon achieve parity with the current commonly used refrigerants, we do not factor in a declining cost curve to be conservative and not understate the costs.

- Ongoing Operation and Maintenance Costs: No incremental costs are expected for maintenance because systems using refrigerants with GWP less than 1,400. These refrigerants are already in use today and do not require any additional maintenance than the baseline higher GWP HFC systems.

- Ongoing RMP Compliance Costs: These systems will continue to be regulated under the RMP unless the GWP of the system falls below 150, so no change in RMP compliance costs is assumed. There are some recordkeeping and reporting requirements associated with compliance with the weighted-average GWP / GHGp reduction requirements. However, those align with the current requirements under the RMP and thus, are not expected to increase the costs to end-users for compliance.

- Electricity: Retrofits are expected to yield energy savings. Laboratory studies of retrofits have demonstrated that R-448A/R-449A have higher coefficients of performance and use less compressor power compared to high-GWP refrigerants like R-404A, which results in lower energy consumption when existing systems are retrofitted to use the former (Mota-Babiloni et al., 2015; Sethi et al., 2016; Fricke et al., 2017).

Additionally, as part of the retrofit process, refrigeration systems receive an overhaul and "tune-up." This tune-up, though not related to the refrigerants' properties, improves the energy efficiency of the system, which results in savings that may not have otherwise occurred. Laboratory studies of retrofits report energy savings of up to 20 percent and supermarket end-users experienced with retrofits have reported a reduction in energy consumption of up to 9 percent after retrofitting from R-404A to R-448A / R-449A. Since, apart from the R-404A / R-507 systems, retrofits will likely be carried out for systems using other refrigerants as well (for example, R-22 and R-407A), as a conservative estimate, CARB staff assume at least an average of 5 percent reduction in electricity costs can be expected from all retrofitted systems. To calculate the savings in dollars, an U.S. EPA estimate of average baseline electricity costs for a typical supermarket was used (U.S.EPA, 2020c), and 5 percent savings were calculated assuming at least 50 percent of the annual cost of electricity borne by a supermarket is due to its refrigeration systems. On average, a supermarket is expected to save at least $10,000 per year due to improved energy efficiency if all systems greater than 50 pounds were retrofitted.

For the cost analysis to be consistent with the F-Gas Inventory which tracks emissions per system and not per facility, the number of systems that would need to be retrofitted (**Table 19**) were multiplied with the incremental annual costs per system (**Table 20**) to estimate total annual costs for retrofits on a statewide level. To comply with the progress step in 2026, some of the existing retail food systems are modeled to retrofit in 2026 while the remaining in 2030 to comply with the overall requirement for the statewide weighted-average GWP to be below 1,400 by 2030. The number of systems affected by this rule decreases from 2026 to 2030 as some of those existing systems reach their end of life and turn over into new equipment which are then required to use refrigerants compliant with the GWP limits for new systems (discussed in the preceding section).

Table 19. *Number of Refrigeration Systems Affected by the Weighted-Average GWP Requirement*

Year	Existing Systems Affected by Weighted-Average GWP Reduction Program (e.g., Retrofits)		
	Large	Medium	Small
2026	70	3,197	8,365
2030	26	1,958	6,730

Table 20. *Total Incremental Costs per Retail Food System for Retrofitting to GWP < 1,400 (2018$)*

Cost Categories	**Large**	**Medium**	**Small**
Upfront Costs (Equipment and Installation)			
Total Upfront ($)	+$151,000	+$30,800	+$4,640
Amortized Annual Upfront ($ / year)	+$19,500	+$3,990	+ $600
Ongoing Costs			
Refrigerant Replenishment ($ / year)	+$2,840	+$548	+ $56
Electricity ($ / year)	- $13,800	- $2,800	- $600
Regulatory Compliance ($ / year)	$0	$0	$0
Total Incremental Costs			
Total Annual ($ / year)	+$8,620	+$1,730	+$56

4. Costs for Existing Industrial Process and Cold Storage Facilities.

Under the Proposed Amendments, new systems being installed in existing industrial process refrigeration and cold storage facilities have to use refrigerants with a GWP below 2,200 and 1,500, respectively. This requirement applies to all facilities except retail food facilities, which are addressed separately above.

To comply with this rule, HFCs like R-448A, R-449A and R-134a can be used. The costs associated with this proposed rule are relatively minor compared to the rules discussed before, since refrigerants compliant with this GWP limit are already required under the current regulations for cold storage and are already used in other refrigeration systems today. Additionally, the rule will apply only to those IPR refrigeration systems that are not chillers.

After discussion with stakeholders, CARB staff estimated a 10 percent incremental equipment cost for the IPR non-chiller systems. Across system sizes (small to large), the lifetime incremental equipment costs per IPR system range between $9,900 and $91,000 (see SRIA Appendix tables for details). No incremental installation costs are assumed because there are no fundamental differences between installation of systems using currently used HFCs like R-404A or R-407A and HFCs with a GWP less than 1,500. Refrigerant costs on an ongoing basis are expected to be higher than baseline, because costs for R-448A/R-499A are on average 50 percent higher than R-404A-type refrigerant per pound. Across system sizes (small to large) and types (commercial, industrial, cold storage), the incremental annual costs ranges between $33 and $2,800 per year.

Since the refrigerants with GWP values just under 1,500 and systems using them do not differ in any significant way from the baseline refrigerants, no other changes are expected relative to the baseline since costs associated with operation and maintenance, electricity, and compliance with RMP and the Proposed Amendments are expected to remain the same as the baseline scenario. For full costs and details, the incremental costs per system type for this rule are given in the SRIA Appendix tables.

5. Total Costs – Refrigeration.

To calculate total costs for the Proposed Amendments for regulated refrigeration systems, the incremental costs per system are multiplied by the number of new or existing systems that are affected by the rule, i.e.,

Annual Total Costs for Refrigeration = (Incremental cost per new system using refrigerant with GWP < 150 or 1,500 x Number of new systems affected by rule per year) + (Incremental cost per existing retail food system x Number of affected retail food systems).

In addition, an 8.5 percent sales tax was added to the equipment costs.[60] System populations affected by the Proposed Amendments for refrigeration are discussed in **Section VIII. A.i**. **Table 21** lists the total direct costs and savings associated with all the proposed rules for regulated refrigeration systems. Between 2022 and 2040, the net annual costs range between $1.98 million and $35.6 million, with an average annual cost of $25.9 million. Across new and existing refrigeration facilities, added compliance costs for refrigeration systems arise mainly due to the higher upfront equipment and installation costs.

Some savings are expected due to reduced RMP compliance costs and lower refrigerant costs for new facilities with GWP less than 150. Some energy savings are also expected for new industrial process facilities and for retail food facilities as they retrofit their systems to comply with the weighted GWP reduction requirement. The total costs for refrigeration increase sharply in 2026 and 2030 as existing retail food facilities comply (by retrofits) and reduce their weighted-average GWP to below 1,400. The costs for retrofits are amortized over 10 years and thus, starting 2036, total costs start to decline and plateau. All values given below are rounded up to three significant figures. For the emissions analysis, systems being retrofitted continue to survive and yield emissions reductions based on the equipment survival curves built into the inventory. At their end of life, retiring systems get replaced by new systems which are governed by GWP limits discussed in the preceding section.

[60] The sales tax varies across the state from a minimum of 7.25% up to 10.25% in some municipalities; a value of 8.5% was used for staff's analysis based on a statewide population weighted average.

Table 21. *Total Costs for the Proposed Amendments for Refrigeration Systems (Millions 2018$)*

Year	Equipment and Installation Costs[a]	Refrigerant Costs[b]	Total Costs[c]	RMP Regulatory Cost-Savings[d]	Electricity Cost-Savings[e]	Total Savings[f]	Net Costs[g]
2022	$1.58	$0.64	$2.22	-$0.13	-$0.10	-$0.24	$1.98
2023	$3.17	$1.28	$4.45	-$0.27	-$0.21	-$0.47	$3.97
2024	$4.77	$1.92	$6.69	-$0.40	-$0.31	-$0.71	$5.98
2025	$6.38	$2.56	$8.94	-$0.53	-$0.42	-$0.95	$7.99
2026	$28.1	$5.60	$33.7	-$0.67	-$15.6	-$16.2	$17.4
2027	$29.7	$6.26	$35.9	-$0.81	-$15.7	-$16.5	$19.5
2028	$31.3	$6.91	$38.2	-$0.94	-$15.8	-$16.8	$21.5
2029	$33.0	$7.57	$40.5	-$1.08	-$16.0	-$17.1	$23.4
2030	$47.0	$9.67	$56.7	-$1.22	-$26.0	-$27.2	$29.4
2031	$48.7	$10.3	$59.0	-$1.36	-$26.1	-$27.5	$31.5
2032	$50.3	$11.0	$61.3	-$1.50	-$26.2	-$27.7	$33.6
2033	$52.0	$11.7	$63.7	-$1.64	-$26.3	-$28.0	$35.7
2034	$53.7	$12.4	$66.0	-$1.78	-$26.5	-$28.2	$37.8
2035	$55.4	$13.0	$68.4	-$1.92	-$26.6	-$28.5	$39.9
2036	$37.0	$11.3	$48.3	-$2.06	-$11.4	-$13.4	$34.9
2037	$38.2	$11.5	$49.7	-$2.13	-$11.5	-$13.6	$36.1
2038	$39.5	$11.6	$51.1	-$2.21	-$11.6	-$13.8	$37.3
2039	$40.7	$11.8	$52.5	-$2.28	-$11.7	-$14.0	$38.5
2040	$29.5	$10.5	$40.1	-$2.36	-$2.1	-$4.46	$35.6
Annual Average	**$33.2**	**$8.3**	**$41.4**	**-$1.3**	**-$14.2**	**-$15.5**	**$25.9**
Cumulative (2022 – 2040)	**$630**	**$158**	**$788**	**-$25**	**-$270**	**-$295**	**$492**

[a] Annual equipment and installation costs above the baseline, for new systems complying with the GWP limits of 150 and 1,500 in new and existing facilities, and the weighted-average GWP requirement for retail food facilities. Equipment costs contain an 8.5 percent sales tax.
[b] Annual costs for replenishing leaked refrigerant across all affected systems (added costs from retail food systems complying with weighted-average GWP requirement and new systems complying with a GWP limit of 1,500 minus savings for new systems complying with a GWP limit of 150).
[c] Total costs = sum of annual equipment, installation and refrigerant costs.
[d] Annual cost savings due to lower regulatory (RMP) costs for new systems in new facilities complying with a GWP limit for 150.
[e] Annual electricity savings for new, large IPR systems complying with the GWP limit of 150 and savings from retrofitted retail food systems.
[f] Total cost-savings = sum of annual regulatory and electricity cost-savings.
[g] Net annual costs = Total Costs + Total Savings.

6. Costs to Typical Businesses – Refrigeration.

Based on user-reported data in CARB's RMP database in 2018, regulated refrigeration systems are most commonly used in retail food facilities such as supermarkets, grocery stores, warehouse clubs, supercenters and discount department stores (mainly NAICS codes 445110, 452910, 452112) followed distantly by merchant wholesalers (NAICS codes starting with 424), food production and manufacturing facilities including wineries and breweries (NAICS codes starting with 311 and 312), refrigerated warehouses and storage facilities (NAICS code 493) and a small number of various types of industrial process facilities. To illustrate the typical costs for companies owning these facilities, the average estimated costs for (1) a retail food company and (2) an industrial process refrigeration and cold storage company are discussed below.

Retail Food Companies: As discussed earlier, under the Proposed Amendments, retail food companies will have to comply with two sets of rules (1) use refrigerants with GWP lower than 150 in newly constructed/fully remodeled facilities starting 2022, and (2) on a company-wide basis, reduce the weighted-average GWP to below 1,400 or GHGp by 55 percent by 2030 across all their stores (with a progress step in 2026).

To illustrate the costs to a typical business, we will consider an average large supermarket company with 141 stores in California.[61] All cost assumptions are the same as discussed in previous sub-sections, for a large commercial retail food system. For newly constructed facilities, equipment and installation will result in incremental costs while savings are expected from the avoided costs of complying with the RMP regulation and for replenishing leaked refrigerant.

It is worth noting that costs of equipment and installation are expected to decline as market adoption of low-GWP systems and relatedly, contractor experience with those systems, to increase. As an example, the European Union also has a similar rule for large refrigeration systems and low-GWP systems are expected to achieve cost parity with the baseline HFC systems by 2022 when the rule goes into effect. While CARB staff expect similar trends in California, to be conservative, we did not factor any experience curves into the analysis. Since the estimated growth rate for supermarkets is 1 percent per year, a typical company with a 141 stores is expected to open one new supermarket per year. The annual incremental costs for a newly constructed supermarket is estimated to be the same as that for a new large commercial system using a refrigerant with GWP below 150, which is $16,600 per year (**Table 14**).

Under the Proposed Amendments, supermarkets (and grocery stores) are also required to reduce their company-wide weighted-average GWP to below 1,400. End-users will also have an alternative compliance pathway under which they will be required to reduce their company-wide GHGp by 55 percent below their 2019 levels,

[61] Average number of stores per retail food company registered under CARB's RMP regulation, based on Dun and Bradstreet database in 2019. Updated from the SRIA, which used an estimated 120 stores per typical retail food company.

by 2030. For a refrigerant retrofit to R-448A / R-449A, the annual average incremental cost per store is estimated to be $6,320 per year (**Table 18**). For an average large company that owns 141 supermarket stores in California, retrofits or other conversions to refrigerants with GWP values less than 1,400 have to occur by 2030. The proposed rules become effective in 2022, which gives each company 8 years to plan and carry out the changes in all their stores. On average, this means a typical company with a 141 stores would retrofit 17.6 stores per year. Thus, the minimum average annual incremental cost for this company is expected to be 17.6 × $6,320 = $111,000 for compliance with the weighted-average GWP reduction requirement. Here, it is important to note that retail food companies are not required to retrofit every system and store under the weighted-average GWP reduction requirement, even though retrofits are expected to be the most economical option on a per-store basis.

Cost-savings can be achieved in the long term if companies choose to invest more upfront capital (to simultaneously reduce GWP along with refrigerant charge) in some stores while leaving some other stores unaltered. The requirements under the weighted-average GWP / GHGp reduction programs are designed to provide this type of flexibility to regulated companies. However, since there can be several ways in which GWP and charge reduction can be accomplished, each with different costs, for this analysis, CARB staff are estimating the costs for the most straightforward, economically conservative approach of retrofits. This is to avoid speculation on both, costs and on the likelihood of companies choosing from the different options.

In all, the annual average incremental costs for a supermarket company with 141 stores in California to comply with the proposed rules is expected to be $128,000 per year – this includes the incremental cost for opening one new store a year and retrofitting nearly 18 existing stores each year. Over the regulatory timeframe, between 2022 and 2040, the average annualized cost for retrofitting all 141 stores (over 10 years) and for opening 1 new / remodeled store per year is $635,000 per company.

<u>Industrial Process Refrigeration and Cold Storage Companies</u>: For IPR and cold storage facilities, the Proposed Amendments will require refrigerants with GWP values less than 150 for new systems in newly constructed/fully remodeled facilities. Large systems containing more than 2,000 pounds typically serve very large warehouses and processing facilities. For the large systems, net annual savings of up to $19,000 are expected, due to reduced ongoing costs related to refrigerant replenishment, electricity and RMP compliance (**Table 14**). For medium and small systems, incremental costs range between $2,000 and $6,000 per system per year (**Table 15**, **Table 16**). Total costs or savings will depend on how many systems are used by a facility.

Some incremental costs for replacing new systems in existing facilities are only expected for industrial process refrigeration facilities, since cold storage warehouses are required to use refrigerants with GWP less than 1,500 in the baseline scenario, under SB 1013. The main source of incremental costs for new systems in existing IPR facilities is the 10 percent premium on equipment. Total annual incremental cost with amortization of 20 years and 5 percent interest is expected to be between $800 and $9,000 for small, medium and large systems, respectively (see SRIA Appendix).

7. Cost to Small Businesses – Refrigeration.

For end-users who will use new systems in newly constructed or remodeled facilities, the per-system costs to small businesses are not expected to be different from the costs experienced by typical businesses. It is important to note that the 50 pound system threshold for the proposed rules automatically exempts most small businesses like convenience and corner stores which generally use smaller refrigeration systems. Independent store owners/operators are not expected to open new facilities at the same rate as the large supermarket chains. Thus, CARB staff assume the costs for new facilities to comply with the GWP limit of 150 will be borne by the large businesses.

For existing retail food outlets such as supermarkets and grocery stores, the additional requirement to reduce the weighted GWP to below 1,400 or achieve a 55 percent reduction in their GHGp by 2030 will place some cost burden on small businesses. Overall, the incremental costs per store are the same as those to a typical business, i.e., an annual incremental cost of $6,320 per supermarket or grocery store.

Approximately 4,000 supermarkets and grocery stores are registered with CARB under RMP, and approximately 23 percent of those are likely owned by small businesses.[62] These companies own an average of two stores. Averaged over the regulatory timeframe of 2022 to 2040, the annualized cost to a small retail food business for retrofitting their two stores is $6,650 per year. To minimize the impact on small businesses, companies with fewer than 20 stores in California that are not a national chain will only be required to comply by 2030, without a progress step at 2026. This will provide small businesses a full 8 years from the regulation's effective date to plan and spread out the costs. Additionally, since the large companies will be complying with a progress step, contractor familiarity with retrofits and other compliant technology solutions will increase, which will likely bring down the installation costs as well as ongoing costs associated with replenishing the refrigerant.

In the future, California and all of the United States may be affected by the global HFC phase-down resulting from the Kigali Amendment to the Montreal Protocol. One reason to have all commercial refrigeration businesses, large and small, reduce their weighted-average GWP is to prepare them for a future domestic HFC phasedown and/or a virgin refrigerant sales or service ban.

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[62] For the purposes of this regulations, a small business in the retail food sector is defined as a company that owns and/or operates fewer than 20 stores in California and is not part of a national chain.

8. Comparison of Cost Impacts to Typical and Small Refrigeration Businesses.

In response to DOF's comments, this section evaluates whether the cost impacts differ for typical and small businesses. To do this, staff compared the compliance costs for typical and small businesses as a percentage of their average business revenue. All data for annual business revenue and employment were obtained from the Dun and Bradstreet database.

CARB's existing Refrigerant Management Program has a database (called the R3 database) that tracks all refrigerated facilities in California that use refrigeration systems containing more than 50 pounds of refrigerant. End-users of regulated refrigeration systems are required to annually register and report their refrigerant purchase, use and leaks into the database. These same refrigeration systems will be subject to the Proposed Amendments, and thus, CARB's R3 database is the main source of information about businesses affected by the proposed rulemaking. Based on the R3 database, there are currently approximately 6,500 refrigerated facilities using regulated refrigeration systems with most of them being used in retail food facilities like supermarkets and grocery stores, and a smaller number of cold storage and industrial process refrigeration facilities.

<u>Retail Food Businesses:</u> This sector is responsible for the majority of HFC emissions out of the three end-uses under refrigeration. Given their large impact on emissions, the Proposed Amendments require retail food businesses to reduce emissions from their existing facilities in addition to the new facilities. For the purposes of this rule, companies with fewer than 20 retail food facilities in California are deemed as small businesses and have a more relaxed compliance period. While all businesses have to comply by 2030, the small businesses do not have an interim progress step giving them a full 8-year period to comply with the company-wide targets starting in 2022. Based on CARB's RMP database, more than 90 percent of all retail food companies in California are small businesses but together, they own just 23 percent of the stores. Thus, setting the threshold for small businesses at 20 stores allows CARB to maximize emissions reductions from the retail food sector while affecting only a small number of businesses.

Table 22 shows the average annual cost of compliance as a percentage of the average annual sales revenues for typical and small retail food businesses. The per-system cost is the same for all end-users but the absolute costs that small businesses will pay is expected to be lower than typical businesses, because they have an extended compliance period for the company-wide reduction targets and are not expected to build new stores like the large companies. On average, the annualized cost of compliance is much less than 0.1 percent of the annual sales revenue in California for both typical and small

businesses. Furthermore, compliance costs as a percentage of sales revenue for small businesses is much lower than that for typical businesses in California.

Table 22. *Cost impacts on retail food businesses*

Characteristics	Companies with 20 or more stores (Typical business)	Companies with fewer than 20 stores (Small business)
Number of retail food companies in CARB's RMP database R3	23	600
Average number of stores per company	141	2
Average number of employees in the U.S.	199,000	1,230
Average number of employees in CA per company	15,000	165
Average annual sales revenue in the U.S. (Millions 2018$)	$55,100	$1,150
Estimated average annual sales revenue in California (Millions 2018$)[a]	$3,890	$170
Average annualized cost of compliance over regulatory lifetime (2022 – 2040) (2018$)[b]	$635,000	$6,650
Annual cost of compliance as a percentage of the average annual U.S. sales revenue[c]	**0.0012%**	**0.0006%**
Annual cost of compliance as a percentage of the average annual California sales revenue[d]	**0.016%**	**0.004%**

[a] California sales revenue for each company was estimated by multiplying the ratio of U.S. revenue per U.S. employee with the number of employees in California. The average values for typical and small businesses are shown here.
[b] Average annualized costs of compliance for typical and small businesses discussed in detail in Sections VIII.A.6 and VIII.A.7.
[c] Average annualized cost of compliance divided by average annual sales revenue in the U.S.
[d] Average annualized cost of compliance divided by average annual sales revenue in California.

Industrial Process Refrigeration and Cold Storage Businesses: The Proposed Amendments place stringent GWP limits on new refrigeration systems in these sectors only when they open new facilities – this includes new construction and major remodels. Here again, the per-system cost is the same for all end-users but the absolute costs that small businesses will pay is expected to be lower than typical businesses, since they are not expected to build as many new facilities as large businesses. Unlike retail food facilities, for IPR and cold storage, there are no company-wide requirements for existing facilities to reduce their emissions, except when they voluntarily replace old systems in the existing facilities. There, the costs for placing new systems in existing facilities are relatively minor as compared to the costs for new facilities, since they do not involve any significant changes in the refrigeration system architecture or refrigerant type.

9. Cost to Individuals – Refrigeration.

There are no direct costs to individuals as a result of the Proposed Amendments as they pertain to refrigeration. As the prevalence of low-GWP refrigeration systems increase, some individuals in the service contractor industry may see benefits through increased sales; those are discussed in the macroeconomic section of the SRIA Appendix.

B. Air Conditioning Costs

For regulated air conditioners, the following GWP limit would apply under the Proposed Amendments:

- New AC Equipment: New equipment will be required to have refrigerants with GWP less than 750.

The Proposed Amendments will require manufacturers to produce and sell AC equipment that use a refrigerant with a GWP value less than 750 GWP. Manufacturers have two main refrigerant options to meet the 750 GWP limit. One option is to use an A2L (lower flammability) refrigerant and the other option is to use an A1 refrigerant (refrigerant with no flame propagation under test conditions). The refrigerant replacement options identified for R-410A are all Class A (nontoxic). AC equipment using A2L refrigerants are widely available in other regions in the world (Japan, China, Europe and Australia). The costs associated with A2L equipment includes mitigation for its lower flammability properties, which includes preventing refrigerant leaks from occurring and appropriate mitigation if leaks do occur. Depending on the A2L refrigerant selected, there may be higher refrigerant costs or cost savings. The other option is to use an A1 refrigerant.

Equipment and component manufacturers are currently conducting product testing to use an A1 refrigerant with a GWP less than 750. The costs associated with this option include product redesign and higher refrigerant costs. The incremental costs in this analysis are meant to be representative averages for the available refrigerant options which could be used to comply with the Proposed Amendments. The assumptions for direct costs are detailed in the following sections.

1. Cost Methodology and Baseline Costs for AC.

The Proposed Amendments will require manufacturers to produce and sell AC equipment that has higher upfront and ongoing costs for maintenance and repair than the baseline. These costs include higher equipment and installation costs (upfront costs) and higher repair and maintenance costs (ongoing costs). Staff first estimate baseline costs and then estimate the costs to comply with the Proposed Amendments, which are expressed as incremental costs above the baseline. **Table 23** shows the types of costs and industries incurring costs to comply with the limits for new AC equipment under the Proposed Amendments. While equipment pricing is complex, and different manufacturers could use different strategies to pass on these costs, CARB staff make a conservative assumption that all costs from deploying compliant equipment for the California market are fully passed on to end users. Further details on the upfront and ongoing costs are provided in the sections below.

Table 23. *Industries Incurring Direct Costs under the Proposal for Stationary AC*

Type of Cost	Industries Affected	Industries or entities with Direct costs
Equipment (upfront cost)	Equipment Manufacturers	AC end-users (e.g., owners of AC equipment in: single and multi-family homes, commercial buildings, and non-residential buildings such as schools and hospitals)
Transport and Storage (ongoing)	Distributors/ Wholesalers	
Installation (upfront) and Maintenance (ongoing)	Technicians	
Refrigerant (ongoing)	Refrigerant and Equipment Manufacturers, and Distributors/ Wholesalers	
Recordkeeping and Labeling	AC Equipment Manufacturers	

i. AC Baseline.

The Proposed Amendments affect all types of ACs. For the purpose of this analysis, CARB is categorizing this equipment into the following general categories consistent with the F-Gas Inventory:

Room ACs: This category consists of small AC units that are factory sealed and used for conditioning one room at a time. This includes window-mounted, through-the-wall, portable units, packaged terminal ACs (PTAC), packaged terminal heat pumps (PTHP) and dehumidifiers. Due to their small size and relatively low cost, these units are used in private residences, apartments, as well as hotels, small offices, and small shops. While other countries refer to ductless split ACs (mini splits) as room ACs, these types of units are classified as central ACs in the United States and are included in the categories described below.

Residential AC/Heat Pump (HP): This category of equipment is sometimes referred to as "central" or "unitary" AC and includes non-ducted split systems and ducted split and single packaged systems used in residences. In California, the most common type of residential AC is a ducted system that uses a refrigerant to condition air in a central location and the air is distributed to and from rooms by one or more fans and ductwork. Ducted systems can be split systems that connect an indoor and outdoor unit via refrigerant piping or packaged systems that are factory sealed.

CARB tracks residential ACs and residential heat pumps as separate categories in the F-Gas Inventory because of the interest heat pumps have received as a potential strategy for reducing emissions from natural gas use related to heating homes. The main difference between residential and commercial units is the size and capacity of the system to condition larger spaces. Units under 65,000 Btu/hr are categorized as residential, consistent with AHRI certification standards and the U.S. DOE energy equipment categories in their energy conservation standards.[63] According to AHRI shipment data, approximately 96 percent of shipments are residential ACs (AHRI, 2020b).

<u>Commercial AC:</u> AHRI certification standards and the U.S. DOE use 65,000 Btu/hr as the size threshold to distinguish between ACs used in residential and commercial and other non-residential settings. For the purpose of this analysis, the commercial AC category includes AC units used in commercial buildings and non-residential uses such as state buildings, schools and hospitals. While commercial ACs make up approximately 4 to 5 percent of AC shipments, CARB distinguishes between two size ranges of commercial equipment because of the difference in baseline cost and the emission profile of these units. This category includes both ACs and heat pumps but they are not disaggregated as separate categories.

- <u>Commercial AC (Small to Medium):</u> Units ≥ 65,000 Btu/hr and < 135,000 Btu/hr are classified as small to medium, consistent with the U.S.DOE equipment categories used in their energy conservation standards.[64]

- <u>Commercial AC (Large):</u> Units ≥ 135,000 Btu/hr are classified as large, consistent with the U.S. DOE equipment categories used in their energy conservation standards.[65]

The majority of ACs sold in California today use the refrigerant R-410A, which has a GWP value of 2,088, with the exception of room ACs, which have already begun to transition to a lower-GWP refrigerant. Room ACs such as portable and window/wall ACs are already available on the California market today with R-32, which has a GWP value of 675. While the baseline refrigerant is predominately R-410A across different AC categories, the average unit lifetimes, charge size and leak rates vary by equipment type. **Table 24** lists these baseline characteristics from CARB's F-Gas Inventory (CARB, 2016). Staff use these factors to estimate emissions on a per unit basis and in the cost impact analysis.

[63] 10 C.F.R. § 430.32 2017; 11 C.F.R. § 431.92 2016.
[64] 11 C.F.R. § 431.92 2016.
[65] *Ibid.*

Table 24. *Baseline characteristics for stationary AC*

System Type	Baseline Refrigerant	Baseline GWP (100-year, AR4)	Lifetime (Years)	Average Charge Size (lbs.)	Average Annual Leak Rate (%)	Average End-of-Life Leak Rate (%)
Room AC – window/wall	R-410A; R-32	1,382	12	1.54	2.0%	98.5%
Room AC – portable	R-410A; R-32	1,382	10	1.54	1.0%	98.5%
Room AC – PTAC/PTHP	R-410A; R-32	1,382	12	1.0	2.0%	98.5%
Room AC – dehumidifiers	R-410A	2,088	5	1.0	1.0%	98.5%
Residential AC	R-410A	2,088	15	8.157	5.3%	80.0%
Residential HP	R-410A	2,088	15	7.5	5.0%	80.0%
Non-residential AC (≥ 65k to <135,000k Btu/hr)	R-410A	2,088	20	25	10.0%	56.0%
Non-residential AC (≥ 135,000k Btu/hr)	R-410A	2,088	20	60	7.0%	20.0%

Projected Populations of Regulated AC Equipment: CARB staff used the F-Gas Inventory to estimate the number of new ACs entering the California market to quantify baseline emission and costs related to this regulation. The number of AC units within California is growing, due to both continued construction of new buildings and because more buildings are installing ACs. CARB estimates AC equipment growth rates based on historical shipment data, housing and population projections growth, and AC saturation trends. The F-Gas Inventory uses data from the following sources to estimate stationary AC equipment populations:

- National shipment data from the AHRI from 1999 to 2018 (AHRI, 2020b).
- California shipment data from Heating, Air-conditioning and Refrigeration Distributors International (HARDI, 2019).
- 2009 California Residential Appliance Saturation Surveys (RASS) (Palmgren et al., 2010).
- U.S. Energy Information Agency (EIA) Residential Energy Consumption Survey (RECS) (EIA, 2009a-d, 2013a-d, and 2018a-d).

- Population and housing demographic information from the California Department of Finance (California DOF, 2019 and 2020).

The number of AC equipment using F-Gases correlate strongly with population (Barletta et al., 2013). However, based on annual AC equipment shipments from 2000 through 2018 tracked by AHRI (AHRI, 2020), AC usage has historically grown faster than population growth in California, and if global warming continues, we expect this trend to continue into the future (AHRI, 2020B). For residential ACs, staff estimates equipment growth at 1.5 times that population growth (1.1 percent annual equipment growth). For residential heat pumps, staff estimates equipment growth as double the annual population growth (1.5 percent annual equipment growth). For all other AC equipment categories staff estimates equipment growth as an equivalent one-to-one correlation with population growth. In 2019, DOF projected annual average population growth rate of 0.7 percent on average for the period between 2020 and 2040 (California DOF, 2019). Recently, DOF released the latest population forecast which lowers the average growth rate to. 0.5 percent for the same time period (California DOF, 2020a). Throughout this document, the updated growth rate published by DOF in 2020 is used to project statewide growth in RAC, and to estimate costs and emissions reductions from those systems. The figure below shows the number of projected new ACs based on these growth rates.

The projected populations of regulated AC equipment through 2040 is given below:

Table 25. *Projected Shipments of Stationary AC Equipment*

Year	New Air-Conditioning Units		
	Commercial	Residential	Small Self-Contained AC
2020	37,492	650,857	658,625
2021	37,662	655,807	677,060
2022	37,846	661,153	696,435
2023	38,041	666,878	716,788
2024	38,249	672,987	738,165
2025	38,471	679,540	750,317
2026	38,685	685,887	762,673
2027	38,894	692,105	775,259
2028	39,097	698,178	788,077
2029	39,295	704,084	801,130
2030	39,486	709,858	814,433
2031	39,671	715,441	823,199
2032	39,852	720,911	832,043
2033	40,027	726,210	840,955
2034	40,195	731,335	849,935
2035	40,357	736,288	858,986
2036	40,512	741,034	865,528
2037	40,660	745,601	872,078

Year	New Air-Conditioning Units		
	Commercial	Residential	Small Self-Contained AC
2038	40,800	749,924	878,624
2039	40,933	754,036	885,173
2040	41,059	757,919	891,723

Baseline Costs: The baseline costs for new residential and commercial AC equipment, listed in **Table 26**, are based on U.S.DOE Technical Support Documents for their energy conservation standards (U.S. DOE, 2015a, 2015b, 2016a and 2016b). CARB staff obtained the baseline costs including manufacture production cost (MPC) and retail cost for equipment, as well as installation, maintenance and repair costs from U.S. DOE shipment-weighted product distribution projected by U.S. DOE for 2020 to 2040 and average cost per product. CARB staff obtained this information for the "hot-dry" southwest region (California, Arizona, New Mexico and Nevada). Therefore the average baseline costs used in this analysis take into account the range of product prices, which vary by energy efficiency rating, type of product and size, and are weighted by the distribution of products shipped to the southwest market. California represents nearly 80 percent of the population in this region, therefore, the product distribution for the southwest region from the U.S. DOE is expected to be a good characterization of the California market, even with some variation in AC usage between states.

CARB staff corroborated product distributions from U.S. DOE analysis (U.S. DOE, 2016a-b) by comparing shipment data submitted to CARB by the Heating, Air-conditioning and Refrigeration Distributors International (HARDI). HARDI provided annual shipments of residential ACs in California for the years 2013 through 2018 by product type and efficiency rating (HARDI, 2019). Both the U.S. DOE and HARDI data show that the majority (80 percent or more) of AC shipments are in the base efficiency ranges. From 2023 onward, the product distribution shifts into higher base efficiency ranges according to U.S. DOE energy efficiency standard compliance dates taking effect. This is taken into account in the costs staff used to characterize the baseline. The baseline upfront costs (equipment retail and installation costs) are amortized using a 5 percent real interest rate, a 15-year life for residential equipment and 20-year life for commercial equipment to reflect end-user financing.

Table 26. *Baseline Costs for AC Equipment in 2023 ($2018)*

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Equipment Retail Costs ($)	$3,300	$4,655	$8,875	$21,120
Installation Costs ($)	$1,790	$2,020	$4,290	$6,600
Amortized Upfront Costs (Equipment Retail + Installation)	$7,356	$9,646	$21,128	$44,486

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Annual Maintenance/Repair Costs ($)	$70	$105	$945	$810
Lifetime Maintenance/Repair Costs ($)	$1,050	$1,575	$18,900	$16,200
Lifetime Unit Costs ($) (Amortized Upfront + Lifetime Maintenance and Repair)	$8,406	$11,221	$40,028	$60,686

The cost of ACs have generally decreased over the last several decades, even with product redesigns and the introduction of new energy conservation standards. Economic literature and historical data (Desroches et al., 2013) suggest that the costs of AC products trend downward over time according to "learning" or "experience" curves, unlike refrigeration where this data is not available for customized large refrigeration systems.[66] CARB incorporates an experience curve[67] to estimate future baseline costs of products as follows:

$$P = P_0(\frac{X}{X_0})^{-b} = P_0\left(\frac{{X_0}^{at}}{X_0}\right)^{-b} = P_0e^{-\alpha t}$$

where,

P = price of the unit

P_0 = price of the first unit of production

X = cumulative production

X_0 = initial cumulative production

b = experience rate parameter

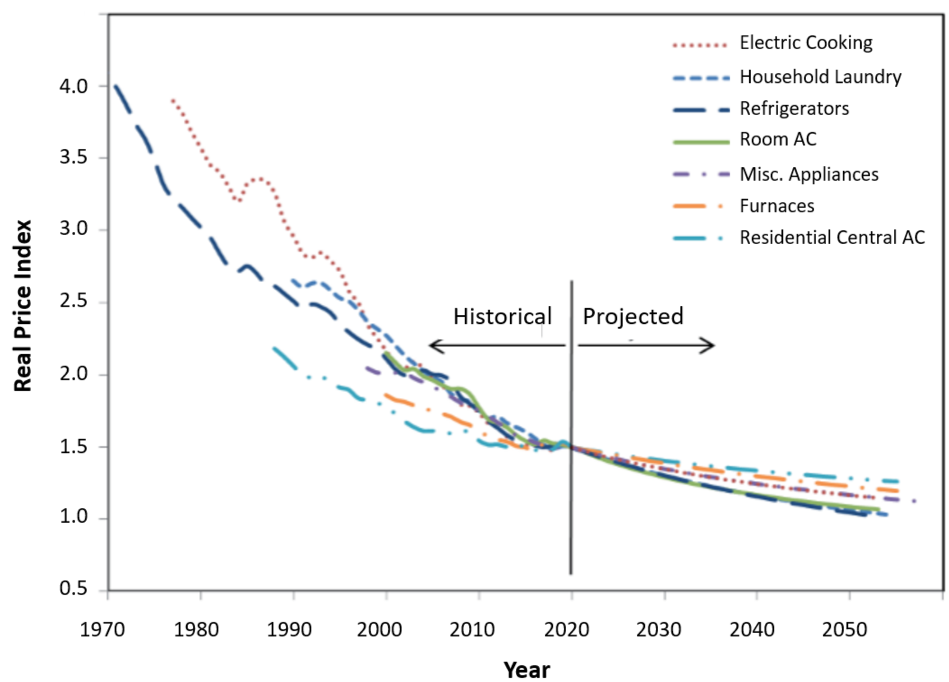
t = time variable, equal to the difference between the base year and any given year

α = exponential parameter of the time variable

[66] Staff estimates the initial cumulative production at 200 million units sold to California from 1978 to 2015 based on CARB's F-Gas Inventory. Staff use 0.163 as the experience rate parameter consistent with the U.S. DOE.

Staff uses a learning rate of 11 percent,[68] which represents the percentage reduction in cost that occurs with each doubling of cumulative production consistent with the U.S. DOE (**Figure 9**). [69]

Figure 9. *Long-Term Decrease in Residential AC Costs*



ii. <u>Incremental Cost Methodology for AC.</u>

CARB staff estimate the incremental cost to comply with the Proposed Amendments as a percentage above baseline. Incremental costs were estimated by seeking input from stakeholders during public working group meetings, stakeholder meetings and surveys as described in **Section XI**. The incremental cost to comply with the Proposed Amendments vary depending on the specific alternative refrigerant selected. Cost impacts for room ACs are not included in this analysis as products are available today at the same or lower cost as equipment using R-410A and a full transition to a refrigerant with a GWP less than 750 is not expected to increase costs (UNEP, 2015; JMS Consulting, 2018). Staff estimated average incremental costs for stationary AC, which takes into account a range of refrigerant options and the associated residential and commercial equipment costs.

[68] The learning rate (LR) is found from the formula $LR = 1 - 2^{-b}$, where *b* is the experience rate parameter of 0.163.
[69] Figure adapted from Desroches et al., 2013.

To obtain incremental costs per system in dollars, the incremental cost percentages were multiplied with the baseline costs for each type of air conditioning system, i.e. *Incremental Cost per System (in 2018$) = Baseline Cost per System (in 2018$) x Incremental Cost as a Percentage above Baseline.* All upfront costs were amortized over 15 to 20 years, depending on the average lifetime for different types of equipment, and using a 5 percent annual interest rate, to reflect end-user financing. Staff applies the learning rate described in the previous section to incremental costs under the Proposed Amendments from 2023 to 2040 and estimates the cumulative sales consistent with the number of new ACs.

<u>Energy Efficiency:</u> Alternative refrigerants either match or have better performance in terms of energy efficiency compared to baseline (Pham and Sachs, 2010). However, it is uncertain what the market penetration of the various alternative refrigerants will be and whether manufacturers will use this efficiency to meet U.S. DOE energy efficiency standards in place of other features for California equipment. Due to these uncertainties, staff did not model energy efficiency savings for end-users.

2. Upfront Equipment and Installation Costs for AC.

<u>Equipment Costs:</u> The majority of AC and refrigeration equipment manufacturers selling equipment to California are international corporations which are transitioning product lines away from high GWP refrigerants and have invested billions to bring next generation refrigerants and equipment to market (JMS Consulting, 2018). Equipment manufacturers can select an A2L or A1 refrigerant to comply with the 750 GWP limit. Regardless of which refrigerant option manufacturers elect to use to comply, changing refrigerants requires system design changes. Even refrigerants that are "near drop in" replacements require design changes to optimize system performance. AC manufacturers incorporate design changes through design cycles to ensure that new equipment meeting all regulatory requirements are available as needed for commercial introduction.

The 2023 compliance date was selected by CARB to allow industry to incorporate a refrigerant change into their ongoing design cycle to meet new U.S. DOE energy conservation standards. CARB had initially proposed a compliance date of 2021. CARB shifted this date to 2023 in order to minimize cost impacts by aligning with the ongoing design cycle, as requested by industry (AHRI et al., 2018). Aligning design cycles significantly reduces the anticipated cost impacts associated with major design cycles, enabling industry to move quickly and efficiently to new equipment designs (JMPS Consulting, 2018).

The cost of a design cycle for equipment manufacturers to redesign product lines traditionally costs $20 to $50 million depending on the timing and complexity of redesign (JMS Consulting, 2018).[70] According to AHRI, equipment manufacturers anticipate spending an average of $21 million per manufacturer to bring AC products to market for California that comply with the Proposed Amendments.[71]

Manufacturers will balance refrigerant cost against other properties of the refrigerant, which can add to design costs. For example, a low-cost refrigerant might require more extensive component redesign while a more expensive refrigerant might offer cost savings or efficiencies elsewhere, or other benefits that are not related to cost. Manufacturers will select a refrigerant that presents a balance of tradeoffs that minimizes product costs and aligns with their strategic priorities to transition refrigerants across different market segments and AC applications.

The AC industry has a history of continually innovating to deliver products with higher efficiency and performance at lower costs while phasing out environmentally harmful refrigerants under the Montreal Protocol. As with past refrigerant transitions and redesigns, added costs are expected, at least initially. Depending on the choice of refrigerant, there may be added costs for design changes to components such as compressors, increases in commodity metal costs, or additional safety features for A2L refrigerants. These costs can be offset by reduced charge sizes, increased efficiency and other benefits of next generation refrigerants. In addition, the cost to transition refrigerants can be minimized through advances in manufacturing and efficiency improvements, which reduce lifecycle costs.

Based on cost analysis provided by equipment manufacturers to CARB, the incremental costs of compliant equipment is estimated to range 5 to 10 percent higher compared to baseline retail costs (see **Table 27**).

The incremental costs of compliant AC equipment is expected to decrease as production increases. CARB incorporates a learning curve as described in earlier in this section under baseline costs, which takes into account diminishing incremental costs relative to baseline as cumulative production increases. CARB staff take a conservative approach that compliant equipment are developed and sold exclusively for the California market. However, as other states commit to taking action on high-GWP HFCs, demand for these products is expected to expand into other market segments.

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70 *Ibid.*

71 The basis of these costs estimates includes a survey of AC equipment manufacture conducted by CARB and cost analysis provided during stakeholder meetings as described in Section XI. Public Process for the Development of the Proposed Action.

Table 27. *Incremental Equipment Costs for New AC Systems*

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Equipment Costs (compared to baseline retail) (%)	+5%	+5%	+10%	+6%
Baseline Retail ($)	$3,300	$4,655	$8,875	$21,120
Total Incremental Equipment Costs ($)	+$165	+$213	+$908	+$1,196

Installation Costs: The installation process will remain largely the same as for baseline R-410A equipment. However, for A2L products, installers would need to be trained to ensure that they are fully equipped to install A2L systems. Training for A2L equipment is expected to be incorporated into existing training programs. Many of the tools used for current R-410A can be used for A2L refrigerants. Technicians will largely be able to replace older tools with ones that are also rated for A2Ls as their older tools are retired at the end of their useful life. The pipework installation is exactly the same as R-410A. While most systems come factory charged, installers transporting refrigerant cylinders will need store them vertically, vehicles must have a flammable gas placard, ($5 to $40) and class B fire extinguishers ($30 to $60). If manufacturers comply with the Proposed Amendments using an A1 refrigerant, there will be no change in installation costs. The cost range for installing AC systems with a refrigerant less than 750 GWP ranges from zero to 6 percent higher. To represent an average scenario, staff estimate installation costs at 3 percent higher for AC systems with the Proposed Amendments in effect (see **Table 28**).

Table 28. *Incremental Installation Costs for New AC Systems*

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Installation Costs	+3%	+3%	+3%	+3%

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
(%)				
Baseline Installation Costs ($)	$1,790	$2,020	$4,290	$6,600
Total Incremental Installation Costs ($)	+$54	+$61	+$129	+$198

3. Ongoing Maintenance and Repair Costs for AC.

CARB anticipates that much of the routine servicing and repairs will be the same as for a baseline system. Many repairs do not involve adding refrigerant, so many of the routine repair items like replacing electronics, motors, etc., are expected to be the same for baseline R-410A systems. In most cases, the cost of labor or equipment components are the majority of the repair cost. In the event a system requires a refrigerant recharge, there may be a change in refrigerant cost. Refrigerant costs may not increase for alternative refrigerants currently in mass production. In fact, there is an opportunity for cost savings for refrigerant that require less charge size for the same capacity system and as systems become more leak tight, there is less potential for leakage. However, new, more complex molecules, such as HFO blends and blends with trifluoroiodide (CF_3I) are expected to be more expensive. Industry has indicated to CARB that new refrigerant blends that would comply with the Proposed Amendments may be two to five times the cost of R-410A at the point of sale to the equipment manufacturer.

The average price of R-410A to the equipment manufacturer today is about $3.00 per pound. It is typical for new refrigerant blends to be more expensive initially and for prices to come down as production increases. While the refrigerants used to comply with the Proposed Amendments are also being deployed around the globe, it is speculative to predict how refrigerant prices may come down in the future. As with current R-410A equipment, refrigerant costs are expected to account for a small portion, less than one percent of the total cost of ownership over the lifetime of the equipment.

Maintenance and repair costs reflect annualized labor and material costs for maintaining and operating of AC equipment and for replacing components that have failed. There is no change in labor time for an A1 alternative. However, for an A2L alternative, there may be an increase in labor time because of additional safe handling processes that will be required with the introduction of A2Ls. For example, in the event that a refrigerant leaks, the technician will have to evacuate and purge the system with dry nitrogen before they can repair the leak. This is a best practice already but will be required for an A2L system. As with the installation, technicians will need to be trained to work on A2L systems and will need to verify that their tools (gauge manifolds, recovery pumps, leak detectors and recovery cylinders etc.) are suitable for use with A2Ls. CARB estimates the incremental cost for servicing and maintenance to be 5 percent. This reflects an extra thirty minutes to an hour of labor time and more expensive replacement parts or the use of a refrigerant that may be more expensive.

Table 29. *Incremental Maintenance and Repair Costs for New AC Systems*

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Maintenance and Repair Costs (%)	+5%	+5%	+5%	+5%
Baseline Lifetime Maintenance and Repair Costs ($)	$1,050	$1,575	$18,900	$16,200
Total Lifetime Incremental Maintenance and Repair Costs ($)	+$53	+$79	+$945	+$810

4. Total Costs – Air Conditioning.

The primary reason for cost increases for AC systems associated with the Proposed Amendments is costs incurred at the manufacturing level. Staff assume all costs are passed on to end-users as higher upfront costs for equipment. A summary of per unit costs are provided in **Table 30**. The total incremental upfront costs is the equipment and installation cost added together and amortized to reflect end-user financing at a 5 percent real interest rate across the lifetime of the equipment—15 year average for residential; 20 year average for commercial. The total incremental ongoing costs per unit come from the added cost of maintenance and repair.

To calculate total costs (**Table 31**) for the Proposed Amendments for regulated AC equipment, the annual incremental costs per system **(Table 30)** are multiplied by the number of new or existing systems that are affected by the rule (**Table 25**). For example, *Annual Total Costs for AC = (Number of new units affected by rule per year) x (Incremental cost per unit).* The total lifetime costs in Table 30 below are represent the annual amortized cost multiplied by the average equipment lifetime (15 years for residential and 20 years for commercial equipment). System populations affected by the Proposed Amendments for refrigeration are discussed in **Section VIII.B.i.** Sales tax is included in the baseline costs.

Table 30. *Total Incremental Costs for Per Unit for New AC Equipment ($2018)*

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Upfront Costs (Equipment + Installation)				
Equipment Retail ($)	+$165	+$213	+$908	+$1,196
Installation ($)	+$54	+$61	+$129	+$198
Total Upfront ($)	+$219	+$274	+$1,037	+$1,394
Amortized Annual Upfront ($/year)	+$21	+$26	+$83	+$112
Ongoing Costs (Maintenance/Repair)				
Lifetime ($)	+$53	+$79	+$945	+$810
Annual ($/year)	+$4	+$5	+$47	+$41
Total Incremental Costs				
Total Lifetime ($)	+$369	+$474	$2,608	$3,048
Total Annual ($)	+$25	+$32	+$130	+$152

Table 31. *Annual Incremental Costs for the Proposed Amendments for New AC Systems (Millions 2018$)*

Year	Equipment and Installation Costs	Service and Maintenance Costs	Total Costs
2022	$0	$0	$0
2023	$18.0	$4.45	$22.4
2024	$36.0	$8.93	$44.9
2025	$54.0	$13.5	$67.5
2026	$72.2	$18.0	$90.2
2027	$90.4	$22.6	$113
2028	$109	$27.2	$136
2029	$127	$31.9	$159

Year	Equipment and Installation Costs	Service and Maintenance Costs	Total Costs
2030	$145	$36.6	$182
2031	$164	$41.3	$205
2032	$182	$46.1	$228
2033	$201	$50.9	$252
2034	$219	$55.7	$275
2035	$238	$60.5	$298
2036	$256	$65.4	$322
2037	$275	$70.3	$345
2038	$279	$72.5	$352
2039	$283	$74.7	$358
2040	$287	$76.8	$364
Annual Average	**$160**	**$41**	**$201**
Cumulative (2022 -2040)	**$3,036**	**$777**	**$3,814**

5. **Cost to Typical Businesses – Air Conditioning.**

Manufacturers are responsible for selling ACs meant to use a refrigerant with less than 750 GWP in California. The Proposed Amendments requires manufacturers to build and sell compliant AC systems and keep records of their sales to California as part of their regulatory requirements. Stationary AC manufacturing is concentrated in relatively few multinational corporations. Seven large manufacturers supply over 95 percent of the U.S. central ACs and heat pumps market, including California (U.S. DOE, 2016a). These businesses have manufacturing facilities in the U.S., but there are no AC manufacturers building systems in California. The majority of room ACs are produced overseas in Asia and imported into the United States. While there are no AC manufacturers building systems in California, this analysis is included to provide further information to stakeholders.

A transition to products that meet the GWP limit under the Proposed Amendments is already underway for room ACs. Room ACs using R-32 (GWP 675) are already available on the market today in California at cost parity with equipment using R-410A. These products are manufactured in Asia where manufacturers have already converted facilities to produce AC equipment using A2L refrigerants. Establishing a 750 GWP limit for room AC products is not expected to increase cost but guarantees emissions reductions from increased sales of lower GWP ACs relative to R 410A.

Residential and commercial central AC/HP manufacturers will comply with the Proposed Amendments by developing new product lines for California. AC manufacturers are producing products for the international market to use refrigerants with a GWP less than 750. Developing products for California does require additional investment to adapt lower-GWP refrigerant technology to the types of systems used most commonly in the U.S. and California, which are ducted systems.

It is typical for companies to invest additional research and development to adapt new technologies to expand into another region with different building designs and regulatory frameworks, such as different codes and standards. The cost to transition products includes research and development, facility retrofits, testing and certifying new products and training employees as well as technicians and contractors. CARB estimates the cost to a typical manufacturer to be approximately $20 million per year, and corroborated by information provided from AHRI. While there are 200 manufacturers of AC equipment in the United States, seven major manufacturers account for over 95 percent of sales. For average costs, CARB considers cost impacts to the seven major manufacturers and assumed equal market share for residential and commercial AC products. Depending on market share, manufacturers may have higher or lower costs.

In response to comments from DOF, CARB conducted an analysis of compliance costs as a proportion of business revenue for typical and small businesses. This includes an analysis for AC manufacturers, who are directly impacted by this regulation. CARB assumes the incremental equipment costs are passed on from AC manufacturers to the end-users but it is also possible that manufacturers will absorb some of the cost to comply. Based on publically traded information, the average sales revenue for an AC manufacturer affected by this regulation ranged from $2 to $24 billion per manufacturer in 2019 with an average of $13 billion per year per manufacturer (MarketWatch, 2020a-f). In comparison, the compliance cost for manufacturers, which is estimated to be $20 million per year on average. This incremental cost, is 0.2 percent on average compared to the sales revenue reported in 2019.

These costs include a premium for California-specific products. However, California is the most populous State in the United States and therefore constitutes a significant fraction of the U.S. appliance market. While manufacturers have indicated that sales of less than 750 GWP ACs will be exclusively for California, the State represents approximately 12 percent of U.S. population and as such, represents a significant portion of the U.S. market. As other states commit to action on HFCs, it is possible that economies of scale may lower the incremental costs provided in this analysis as the market expands (USCA, 2019 and 2020). For example, the Washington State Building Council has adopted ASHRAE 15-2019 and the third edition of UL 60335-2-40, which allows the use of A2L refrigerants in direct systems such as residential and other commercial ACs.

In addition, these costs also includes incremental cost for AC manufacturers to comply with recordkeeping and labeling requirements. The Proposed Amendments add recordkeeping requirements for AC manufacturers. These businesses are required to maintain records and make them available upon a request. In addition, the Proposed Amendments includes requirements for manufacturers to clearly display the date of manufacture, refrigerant and charge size. CARB generally expects that these requirements are consistent with current business practices. However, CARB added cost estimates for additional labor hours in the event that manufacturers make any adjustments to their recordkeeping or inventory practices and to address costs to report to CARB upon request. Staff estimate 100 hours for a software to adjust recordkeeping and labeling practices initially at $73.8 per hour (U.S. BLS, 2019a; U.S. BLS, 2019b). In addition, staff estimates 8 hours a quarter (32 hours a year) thereafter for an office technician at $27.52 per hour (U.S. BLS, 2019a; U.S. BLS, 2019b). The total cost per manufacture is $23,200 by this estimate over the regulatory lifetime. This estimate includes reporting time in the event CARB requests records from manufacturers. While none of the AC manufacturers are located in California, the incremental costs per unit are inclusive of the recordkeeping and labeling costs. Assuming costs related to recordkeeping are passed to California consumers, the incremental cost per AC is $0.01 which is included in the incremental cost for AC equipment which is included in the incremental cost for AC equipment.

The cost impact to manufacturers in this analysis is conservative. Cost estimates for refrigerant transitions and equipment redesigns are typically higher than what is actually experienced (Desroches et al., 2013). Part of the reason for this is that manufacturers have become increasingly efficient at redesigning their products and are constantly working on developments to minimize their own costs by counterbalancing expensive improvements with savings elsewhere (Goetzler et al., 2016; JMS Consulting, 2018; Gloël et al., 2014). In addition, manufacturers build ongoing research and development and redesign costs into product prices. For these reasons, it is possible that the cost impacts may be lower. While equipment pricing is complex and different manufacturers could use different strategies to pass on these costs, staff assume all costs from deploying compliant equipment for the California market are passed on to end-users.

Table 32. *Direct Costs on a Typical Business – AC Manufacturer*

Costs to Typical AC Manufacturer	
Year	**Costs ($Million)**
2022	$0
2023	$20.7
2024	$20.7
2025	$20.7
2026	$20.8
2027	$20.8
2028	$20.8
2029	$20.9
2030	$20.9
2031	$20.9
2032	$20.9
2033	$21.0
2034	$21.0

Costs to Typical AC Manufacturer	
Year	Costs ($Million)
2035	$21.0
2036	$21.0
2037	$21.0
2038	$21.0
2039	$21.0
2040	$21.0

The vast majority of businesses in California across all business sectors use AC. All businesses purchasing and operating an AC after 2023 will be affected by the Proposed Amendments. About 700,000 new commercial ACs will be sold for use in California from 2023 to 2040. Since most commercial facilities will use more than one AC to provide cooling, this represents a maximum number of commercial businesses affected by the Proposed Amendments. The direct costs to typical businesses who purchase a new commercial AC system compliant with the Proposed Amendments are shown in **Table 33** below. On average, compliant equipment is expected to cost owners and operators of commercial systems an average of 5 to 7 percent above the baseline cost over the lifetime of the equipment based on cost analysis provided to CARB by manufacturers. All businesses and non-residential facilities either installing an AC in new construction or replacing an AC are expected to experience higher costs, as shown below, beginning 2023.

Table 33. *Commercial AC/HP Costs ($2018)*

End-Use	Baseline Costs[a] (Annual)	Baseline Lifetime Costs (Total)	Incremental Costs (Annual Amortized)	Lifetime Incremental Costs (Total)
Commercial AC/HP (Small – Medium)	$2,001	$40,028	+$130 (+7%)	+$2,608 (+7%)
Commercial AC/HP (Large)	$3,034	$60,686	+$152 (+5%)	+$3,048 (+5%)

[a] Baseline costs are for year 2023.

In response to comments from DOF, CARB utilized data from the California Buildings Energy Consumption Survey (CBECS) (EIA, 2016a-b) and U.S Census data (U.S. Census 2020a and b) to analyze average revenue and employment by business type and size, including an estimate of AC costs per square footage. The baseline cost for AC is $7 per sq ft and the incremental cost is on average $0.02 per sq ft. Staff calculated this estimate using the baseline cost for both a small to medium AC and large AC and using an assumption used in industry of 1 ton of cooling for every 500 sq ft of commercial floor space: *$Cost per sq ft = (tons of cooling) x (sq ft/ton) x ($ cost).* For example, a large AC on average provides 20 tons of cooling capacity: $*Incremental cost per sq ft = (20 tons) X (500 sq ft/ton) / ($152 incremental cost per year) = $0.015 per sq ft per year*. A small to medium AC on average provides 10 tons of cooling capacity: $*Incremental cost per sq ft = (10 tons X 500 sq ft/ton) / ($130 incremental cost per year) =$0.0026.* On average, the incremental cost is $0.02 sq ft per year for commercial floor space. Baseline costs per sq foot follow the same calculation and use the baseline costs listed in **Table 33**.

CARB found that for businesses with more than 100 employees, the average floor space per establishment is approximately 100,000 square feet (sq ft). Generally buildings larger than 100,000 sq ft will use a chiller. The average building size using commercial ACs with an incremental cost are about 50,000 sq ft. The average incremental cost for a low-GWP AC for a building of this size is about $1,000 per year *($0.02/sq ft x 50,000 sq ft)*. It is common for commercial buildings to use multiple AC systems to accomplish their cooling needs and a building of this size would likely require multiple small to medium ACs or fewer very large commercial ACs. The baseline cost for AC equipment for a building of this size could be $350,000 or more. The baseline cost per AC unit ranges from $7 per sq ft on average *($7 per sq ft x 50,000 sq ft = $352,000).*

CARB staff compared the incremental cost to a range of average revenue from major business sectors. The average revenue ranges from about $70 to $200 million a year for a typical business and $1 to $6 million for a small business (US Census, 2012 and 2018). The incremental cost for a low-GWP AC ranges is an average of $1,000 a year is to less than 0.0001 percent of the annual revenue from a typical business in California.

6. Cost to Small Businesses – Air Conditioning.

None of the AC manufacturers qualify as small businesses. For end-users who will use new ACs, the costs per AC are not expected to be different for small businesses compared to the costs experienced by typical businesses. However, staff completed an analysis to confirm this assumption. The average small business establishment is 6,600 sq ft. This means lower impacts because less cooling power is needed and that translates to either fewer AC units and/or smaller ACs compared to a typical business with 50,000 sq ft.

For example, at 500 sq feet per ton of cooling, a 6,600 sq ft commercial building requires 14 tons of cooling capacity to provide air conditioning to this space. Cooling this 6,600 sq ft of a commercial floor space would require an AC with a baseline cost of $50,000 *($7 per sq ft x 6,600 sq ft)* and an incremental cost of about $140 per year *($0.02 per sq ft per year x 6,600 sq ft)*. Staff compared this to a range of average revenue from major business sectors and the average revenue ranges from about $1 to $6 million for a small business (US Census, 2012 and 2018). The incremental cost for a lower-GWP AC is an average of $141 a year ranges which is 0.01 percent to less than 0.002 percent of the annual revenue from a typical small business in California.

7. Cost to Individuals – Air Conditioning.

Individuals who purchase new AC systems will incur incremental costs beginning in 2023. This includes homeowners, and landlords who purchase and operate residential AC/HP manufactured after 2023. The cost of the most affordable type of AC equipment, room ACs, will not change. For residential AC/HP, the total incremental cost, including equipment, installation and maintenance/repair, is estimated to increase by $369 to $474 ($422 on average) (see Table 29) which is equivalent to a 4 percent higher cost for the end-user over the lifetime of the equipment compared to baseline (see Table 33). On average this is an incremental cost of $28.50 per year ($25 for an AC and $32 for a heat pump). Approximately half a million new residential AC/HPs are sold for use in California each year, and the majority are replacements for old units in existing housing units which have reached end-of-life. California DOF estimates approximately 100,000 construction permits issued for single and multi-family housing in 2019 (California DOF, 2020b). This can be used for approximation for the number of ACs which are installed in new housing units each year.

Table 34. *Residential AC/HP Cost ($2018)*

End-Use	Baseline Costs[a] (Annual)	Baseline Lifetime Costs (Total)	Incremental Costs (Annual Amortized)	Lifetime Incremental Costs (Total)
Residential AC	$560	$8,406	+$25 (+4%)	+$369 (+4%)
Residential HP	$748	$11,221	+$32 (+4%)	+$474 (+4%)

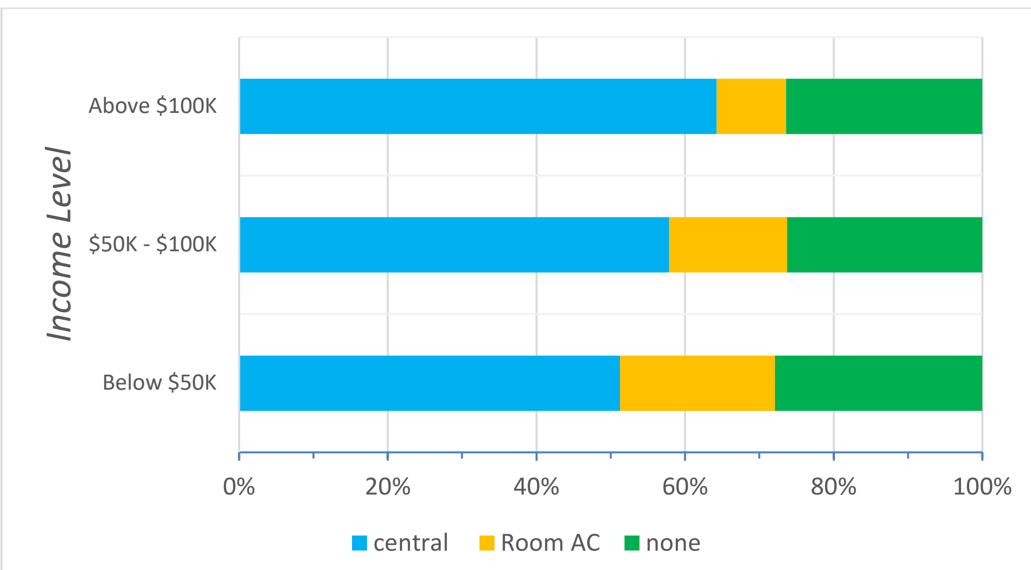
[a]Baseline costs are for year 2023.

In California, 55 percent of occupied housing units are occupied by owners and 45 percent are renter-occupied (U.S. Census 2020a and b). Therefore, it is assumed that about 55 percent of the incremental cost for compliant residential AC/HP will be incurred by homeowners and 45 percent by landlords. In response to comments from DOF, CARB conducted an analysis of cost impacts to individuals in different income brackets using data from the U.S. Census American Housing Survey and American Community Survey (U.S. Census 2020a-b). CARB found that housing units are more likely to be owner-occupied at higher income levels. The average household income for owner-occupied housing is $100,000 a year while the average household income for renter-occupied housing is $52,000. Therefore, the cost of complaint AC are more likely to be incurred by Californian's in higher income brackets who own their homes while landlords incur the incremental residential AC/HPs used by individuals in lower income brackets.

As an example, and based on costs shown in **Table 34** above, if a homeowner making the average income in California of $75,000 needed to purchase a new residential AC system, it would cost an average of $8,406 (**Table 34**) which would be $560 per year assuming the AC was financed. The incremental cost for a lower-GWP AC would be $369 over the lifetime of the equipment which comes out to an extra $25 per year. The annual incremental cost represents 0.03 percent of the average income for homeowners in California ($75,000).

About 40 percent of Californian's earn less than $50,000 a year. The midpoint of the income range in this bracket is $25,000 per year. The annual incremental cost of $25 per year for a residential AC represents 0.1 percent of this level of income. At this income level, central ACs are still the most common type of AC to own. However it is more common to use a room ACs in this income bracket than in higher income brackets (see **Figure 10**). These ACs are lower cost options, which are more suitable for cooling single rooms or smaller spaces than multiple rooms or large homes.

Figure 10. *AC Ownership by Income Level*[72]



In 2018, the median value of a home in California in 2018 was $546,800 (U.S. Census 2020a and b). The incremental costs relative to home values represents a change in housing costs of less than 0.1 percent. The cost of energy will continue to be the larger portion of AC ownership after the initial equipment and install cost. The average household electricity use for an AC system is about 2,177 kWh/house per year in the mixed-dry/hot-dry region, which includes California (EIA, 2018e). At a $0.19 per kWh (EIA, 2019), which is the average cost in California for 2018, a homeowner can expect to spend approximately $6,205 on average on energy over the lifetime of their system. The new U.S. DOE standards taking effect are expected to reduce the energy

[72] *Ibid.*

use associated with residential systems by about 4 percent (U.S. DOE, 2016a). While energy use is not expected to change as a result of this regulation, the net effect of the Proposed Amendments and new U.S. DOE regulations will be higher upfront cost for equipment and lower energy costs than the units sold today.[73]

While not included in this analysis, there are a variety of incentives offered by utilities for the purchase of new more efficient units. These incentives will continue to assist home and building owners to offset upfront costs of new systems which are more energy efficient than older equipment. The cost impacts to end-users who own and operate commercial ACs are discussed in the preceding section.

C. Macroeconomic Impacts

1. Methods for Determining Economic Impacts.

This section describes the estimated total impact of the Proposed Amendments on the California economy. The Proposed Amendments will result in incremental cost and cost-savings for businesses to comply with the regulation. These costs result in direct changes in expenditures in the economy as these cost are passed on to business and individual end-users. These changes in expenditures by end-users will indirectly affect employment, output, and investment in sectors that supply goods and provide services to affected businesses.

These direct and indirect effects lead to induced effects, such as changes in personal income that affect consumer expenditures across other spending categories. The total economic impact is the sum of these effects and are presented in this section. The total economic impacts of the Proposed Amendments are simulated relative to the baseline scenario using the cost estimates described in Section C. The analysis focuses on the changes in major macroeconomic indicators from 2020 to 2040 including employment, output, personal income, and gross state product (GSP). The years of the analysis are used to simulate the Proposed Amendments through more than 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.4 is used to estimate the macroeconomic impacts of the Proposed Amendments on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.[74] REMI Policy Insight Plus provides year-by-year estimates of the total economic impacts of the Proposed Amendments, pursuant to the requirements of SB 617 and the California DOF.[75] CARB uses the REMI single-region,

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[73] The higher upfront equipment costs due to new U.S. DOE requirements are included in the baseline.
[74] For further information and model documentation see: https://www.remi.com/model/pi/.
[75] Senate Bill 617 (Calderon, Stats. of 2011, Ch. 496; amending Gov. Code §§ 11346.2, 11346.3, 11346.5, 11346.9, 11347.3, 1139.1, 13401, 13402, 13403, 13404, 13405, 13406, 13407 and adding Gov.

160-sector model. Several adjustments were made to the model reference case to reflect the impacts of COVID-19 and to reflect the DOF conforming forecasts.

First, the REMI model's National Control was updated with a short-term national forecast based on the U.S. Economic Outlook for 2020-2022 from the University of Michigan's Research Seminar in Quantitative Economics (RSQE)[76] release on April 9, 2020, which was made available in the latest REMI model. Second, the National and Regional Controls in REMI were updated to reflect the most recent Department of Finance conforming forecasts which include population projections dated January 2020 and U.S. real GDP forecasts, and California civilian employment growth numbers Dated May 2020. Because the DOF forecasts only extended to 2023, CARB staff assumed that post-2023, U.S. income and employment would continue to grow at the same rate as projected in the RSQE forecast, while California civilian employment would continue to recover at the rate forecasted by the DOF, until it returned to baseline levels.

2. Inputs of the Assessment.

The estimated economic impact of the Proposed Amendments are sensitive to modeling assumptions. This section provides a summary of the assumptions and inputs used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Amendments. The direct costs and savings estimated in Section C are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[77]

The requirements for low GWP refrigerants in AC systems are estimated to add an incremental cost to the AC equipment, installation, and maintenance for both residential and commercial equipment, as described in **Section VIII.C**. These costs are expected to be passed through to end-users of these systems (i.e. businesses and households).

The costs incurred by businesses that use AC are input into the model as an increase in production costs for the affected industry. The share of costs incurred across different sectors are assumed to be distributed according to their share of capital expenditures on structures as shown in (U.S. Census, 2019).

Code §§ 11342.548, 11346.36, 11349.1.5); Department of Finance Standardized Regulatory Impact Assessment For Major Regulations, Cal. Code Regs., tit. 1, §§ 2000 et seq.

[76] This update assumes that the economic contraction is sever but that aggressive federal response to the pandemic maintains the possibility of a vigorous recovery: https://lsa.umich.edu/econ/rsqe.html.

[77] Refer to Section G: Macroeconomic Appendix for a full list of REMI inputs for this analysis.

3. Results of the Assessment.

The results from the REMI model provide estimates of the impact of the Proposed Amendments on the California economy. These results represent the annual incremental change from the implementation of the Proposed Amendments relative to the baseline scenario. The California economy is forecasted to grow through 2040, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an acceleration of growth resulting from the Proposed Amendments. The results are reported here in five year intervals from 2020 through 2040.

i. <u>California Employment Impacts.</u>

Table 35 presents the impact of the Proposed Amendments on total employment in California across all private industries and the public sector. Employment comprises estimates of the number of jobs, full-time plus part-time, by place of work for all industries. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included. The employment impacts represent the net change in employment across the economy, which is composed of positive impacts for some industries and negative impacts for others. These impacts are derived from simulation results from the REMI model and represent an approximation of changes to projected baseline economic conditions. The Proposed Amendments are estimated to result in an initial slight increase in employment growth through 2025, followed by a decrease in employment growth through 2040. These changes in employment represent 0.01 percent of baseline California employment.

Table 35. *California Employment Impacts*

Impact	2020	2025	2030	2035	2040
California Employment	20,946,451	23,781,456	24,751,250	25,011,315	25,693,353
% Change	0.00%	0.00%	0.00%	-0.01%	0.00%
Change in Total Jobs	0	277	-668	-1,274	-1,158

The total employment impacts presented above are net of changes at the industry level. The overall trend in employment changes by major sector are illustrated in **Figure 11.** **Table 36** shows the changes in employment by industries that are directly impacted by the Proposed Amendments. As the requirements of the Proposed Amendments go into effect there is initially a slight acceleration of job growth due to expenditures on installation and maintenance activities directed at the contractor industries. Over time the increased production costs for business end-users of commercial refrigeration and chillers and AC equipment and the increase in consumer prices for AC equipment result in a slight decrease in job growth, primarily in the major sectors of Retail and Wholesale and Services.

Figure 11. *Job Impacts by Major Sector*

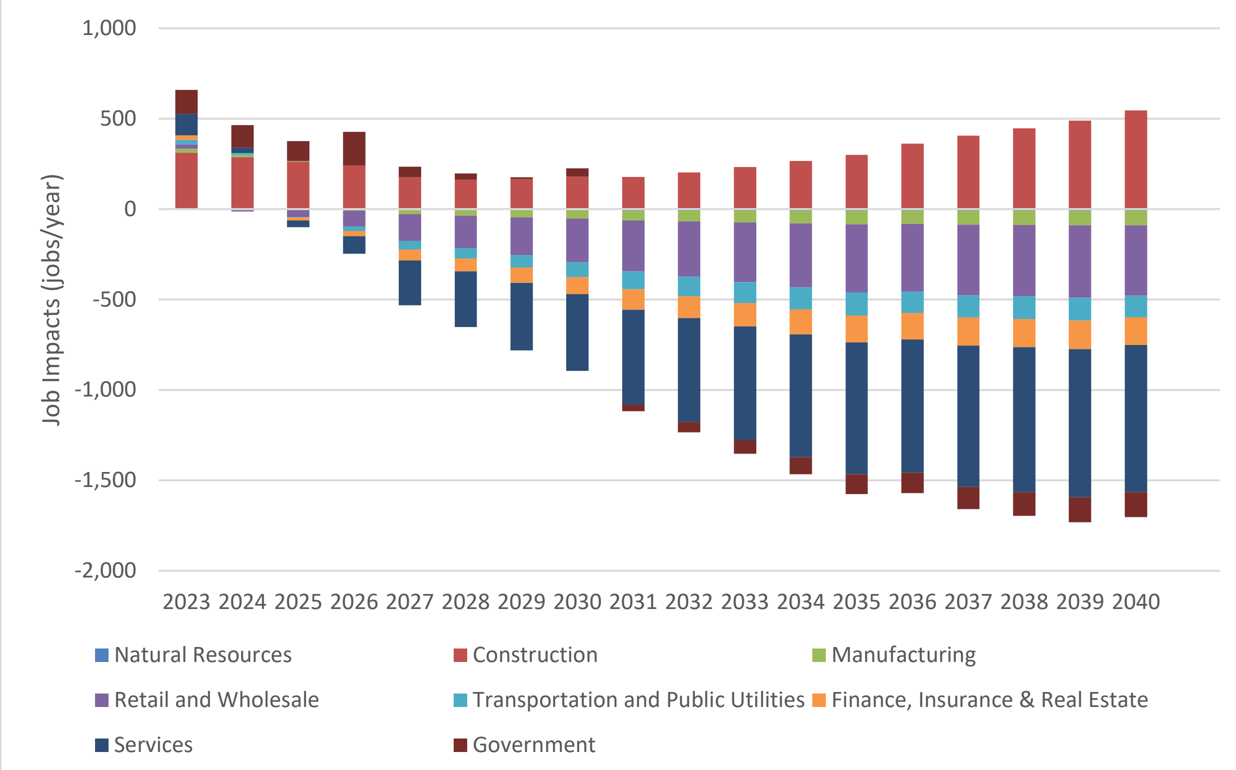


Table 36. *Job Impacts by Primary and Secondary Industries*

Industry	Impact	2020	2025	2030	2035	2040
Electric power generation, transmission and distribution (2211)	% Change	0.00%	0.00%	-0.06%	-0.06%	-0.02%
	Change in Jobs	0	-1	-22	-22	-6
Construction (23)	% Change	0.00%	0.02%	0.01%	0.02%	0.04%
	Change in Jobs	0	262	180	300	545
Other food manufacturing (3119)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.02%
	Change in Jobs	0	-1	-3	-6	-7
Beverage manufacturing (3121)	% Change	0.00%	0.00%	0.00%	0.00%	-0.01%
	Change in Jobs	0	0	-2	-4	-4
Basic chemical manufacturing (3251)	% Change	0.00%	0.01%	0.02%	0.02%	0.01%
	Change in Jobs	0	0	1	1	1
Ventilation, heating, air-conditioning,	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change in Jobs	0	0	-1	-1	-1

Industry	Impact	2020	2025	2030	2035	2040
and commercial refrigeration equipment manufacturing (3334)						
Household appliance manufacturing (3352)	% Change	0.00%	-0.03%	-0.06%	-0.08%	-0.08%
	Change in Jobs	0	-1	-1	-2	-2
Wholesale trade (42)	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change in Jobs	0	-2	-37	-58	-56
Retail trade (44-45)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change in Jobs	0	-43	-204	-319	-334
Warehousing and storage (493)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change in Jobs	0	-1	-13	-21	-23
State & Local Government	% Change	0.00%	0.00%	0.00%	0.00%	-0.01%
	Change in Jobs	0	111	46	-108	-137

ii. The Creation or Elimination of Businesses in California.

The REMI model cannot directly estimate the creation or elimination of businesses. Changes in jobs and output for the California economy described above can be used to understand some potential impacts. The overall jobs and output impacts of the Proposed Amendments are very small relative to the total California economy, representing changes of less than 0.01 percent. Impacts to directly affected industries are also very small relative to the baseline, with only one industry exceeding 0.04 percent. Reductions in output could indicate elimination of businesses.

Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demand. There is no threshold that identifies the creation or elimination of a business. The industry with largest absolute decrease in employment and output is retail trade, this is a large and varied sector consisting of many different types of businesses; it is unlikely that a slowing of growth of 0.02 percent indicates the elimination of any particular existing business. The industry with largest absolute increase in employment and output is construction sector, with an acceleration of growth of about 0.04 percent in the high cost scenario, this could lead to an expansion or creation of businesses over time.

iii. California Business Impacts.

Gross output is used as a measure for business impacts because as it represents an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output is the sum of the amount of production, including all intermediate goods purchased as well as value added (compensation and profit), across all private industries and the public sector, and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth.

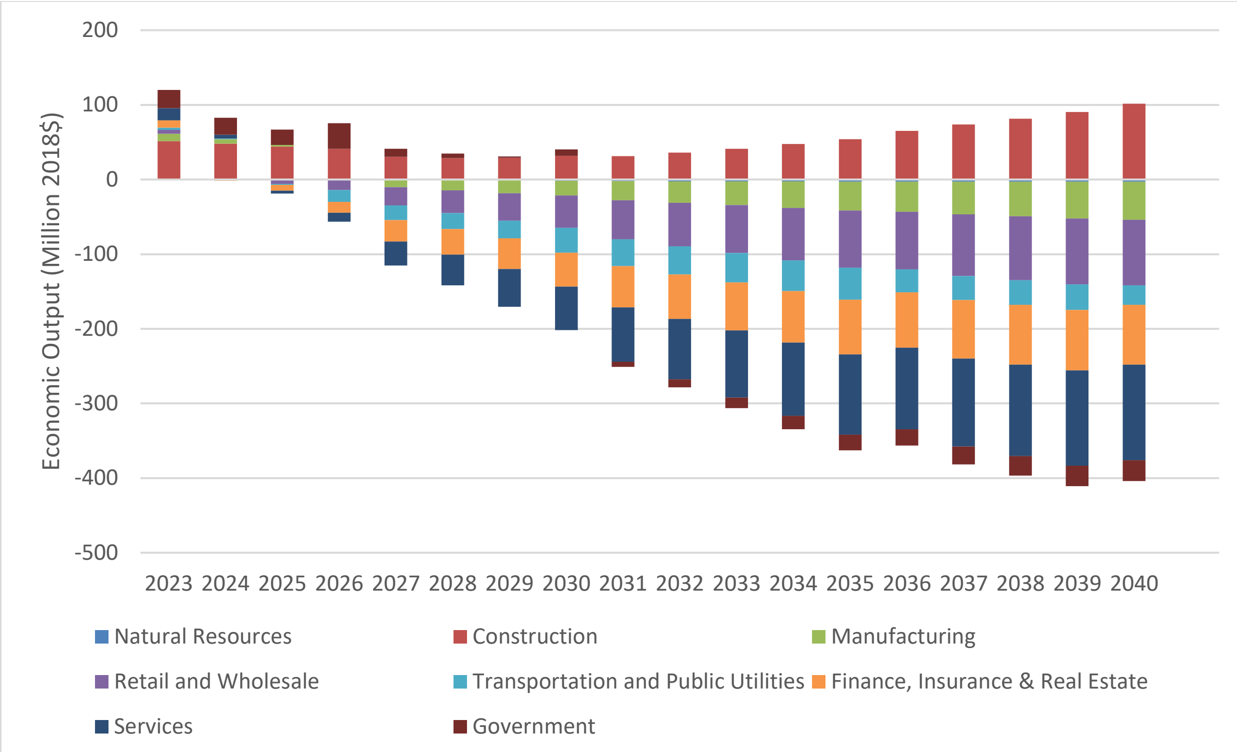
The results of the Proposed Amendments show a decrease in output of $162 million in 2030 and a decrease of $302 million in 2040 as shown in **Table 37**, representing a change of about 0.01 percent of baseline output. The trend in output changes is illustrated by major sector in **Figure 12**. Similar to the employment impacts, there is an initial positive impact, primarily comprised of the construction sector, followed by a decrease primarily comprised of the Retail and Wholesale and Services major sectors.

Table 37. *Change in California Output Growth by Industry*

Industry	Impact	2020	2025	2030	2035	2040
California economy	Output (2018M$)	4,218,064	5,150,812	5,647,130	6,124,655	6,853,532
	% Change	0.00%	0.00%	0.00%	-0.01%	0.00%
	Change (2018M$)	0	48	-162	-309	-302
State & local government	% Change	0.00%	0.00%	0.00%	0.00%	-0.01%
	Change (2018M$)	0	20	9	-21	-28
Electric power generation, transmission and distribution (2211)	% Change	0.00%	0.00%	-0.06%	-0.06%	-0.02%
	Change (2018M$)	0	-1	-24	-27	-8
Construction (23)	% Change	0.00%	0.02%	0.01%	0.02%	0.04%
	Change (2018M$)	0	44	32	54	101
Other food manufacturing (3119)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.02%
	Change (2018M$)	0	0	-1	-2	-3
Beverage manufacturing	% Change	0.00%	0.00%	0.00%	0.00%	-0.01%

Industry	Impact	2020	2025	2030	2035	2040
(3121)	Change (2018M$)	0	0	-1	-2	-2
Basic chemical manufacturing (3251)	% Change	0.00%	0.01%	0.02%	0.02%	0.01%
	Change (2018M$)	0	2	6	8	6
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing (3334)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change (2018M$)	0	0	0	-1	-1
Household appliance manufacturing (3352)	% Change	0.00%	-0.03%	-0.06%	-0.08%	-0.08%
	Change (2018M$)	0	0	0	-1	-1
Wholesale trade (42)	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change (2018M$)	0	-1	-16	-28	-31
Retail trade (44-45)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change (2018M$)	0	-5	-28	-48	-57
Warehousing and storage (493)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change (2018M$)	0	0	-1	-2	-2

Figure 12. *Change in Output in California by Major Sector*



iv. <u>Significant Statewide Adverse Economic Impact Directly Affecting Business, Including Ability to Compete.</u>

Based on CARB staff analysis, the Executive Officer has made an initial determination that proposed regulatory action would not have a significant statewide adverse economic impact on directly affected businesses. In addition, the Executive Officer has made an initial determination that the proposed regulatory action would not have a significant statewide economic impact directly affecting representative private persons.

v. <u>Competitive Advantages Doing Business within the State.</u>

The AC equipment manufacturers that must comply with requirements of the Proposed Amendments are based outside of California and therefore do not present any competiveness impacts for this industry inside California. The incremental costs are anticipated to be incurred generally across business end-users and are not anticipated to result in any competitive advantages or disadvantages within industries.

The refrigeration equipment manufacturers that must comply with requirements of the Proposed Amendments are based outside of California and therefore do not present any competiveness impacts for this industry inside California. The incremental costs of compliance with the AC requirements are assumed to be passed on to end-users in California, primarily in the sectors of retail and wholesale trade. The incremental costs are anticipated to be incurred generally across business end-users and are not anticipated to result in any competitive advantages or disadvantages within industries.

vi. Impacts on Investment in California.

Private domestic investment consists of purchases of residential and nonresidential structures and of equipment and software by private businesses and nonprofit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy.

The relative changes to growth in private investment for the Proposed Amendments are shown in **Table 38** and show a decrease of private investment of about $90 million in 2030 and $66 million in 2040, or less than 0.01 percent of baseline investment.

Table 38. *Change in Gross Domestic Private Investment Growth*

Gross Domestic	2020	2025	2030	2035	2040
Private Investment (2018M$)	302,678	445,127	482,687	530,331	598,826
% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2018M$)	0	-24	-90	-105	-66

vii. The Incentives for Innovation.

The Proposed Amendments sets performance standards for achieving the requirements across both AC and refrigeration sectors. This standard provides an incentive for manufacturers to find innovative methods to achieve these standard in a low cost manner in order to mitigate compliance costs. Staff anticipates that these requirements will result in a growing market for new low-GWP refrigerants and technologies such as CO_2 transcritical and cascade systems, micro-distributed hydrocarbon systems as well low-GWP HFO systems. Manufacturers who invest and gain experience in these technologies will benefit as the market expands. Not only is the demand for air conditioning and refrigeration increasing, but the demand for climate friendly technologies is also increasing. Other U.S. states have committed to taking action on lowering emissions of high-GWP HFCs. In addition, both chemical manufacturers who produce refrigerants and manufacturers of refrigeration and AC equipment are global corporations. The manufacturers producing compliant refrigerants and equipment for California also participate in global markets which include markets where existing policies are already driving adoption of next generation technologies, markets where new measures are driving near-term transformation, as well the worldwide transition that is occurring over a longer-term because of the Kigali Agreement. There is an incentive to commercially deploy and gain experience with these technologies which is bolstered by the Proposed Amendments.

D. The Benefits of the Regulation

CARB's SRIA includes an analysis of the benefits of the Proposed Amendments. The primary benefits of the Proposed Amendments are emissions reductions. The Proposed Amendments have been designed to support growth in technologies that lower HFC emissions. It is anticipated that the Proposed Amendments will reduce HFC emissions from the refrigeration and AC sectors by nearly 40 and 50 percent below baseline by 2040, respectively. Cumulatively, from 2022 through 2040, the Proposed Amendments are expected to yield 72 $MMTCO_2e$ in GHG reductions. Using 20-year GWP values, the Proposed Amendments are expected to yield cumulative GHG emissions reductions of nearly 140 $MMTCO_2e$ by 2040. The total benefits in avoided harms range between $1.7 billion to $7.2 billion through 2040, depending on the discount rate, and are underestimated because of the lack of official social costs of HFCs.

CARB used its F-Gas Inventory to analyze the economic and emissions impacts and benefits for the baseline (or BAU) and alternative scenarios. CARB staff begins this section with a brief description of the F-Gas inventory methodology.

1. Emissions Benefits Methodology.

CARB maintains a California specific F-Gas Inventory as a part of the statewide GHG Emission Inventory, which is used for establishing historical emission trends and tracking California's progress in reducing greenhouse gases. The F-Gas Inventory estimates annual emissions of F-gases, including HFCs, from sources including refrigeration, air conditioning, aerosol propellants, foams, solvents and fire protection end-uses. The F-Gas Inventory is based on the U.S. EPA's Vintaging Model that tracks the use and emissions of annual "vintages" of equipment that are produced each year.

To estimate emissions, CARB maintains emissions profiles for each distinct end-use category of equipment of product that emits an F-Gas. The emissions profile includes the number of units[78], amount of F-Gas required by each unit also called the "charge size," as well as annual and end-of-life leak rates. Since it was initially developed in 2007, CARB steadily refined initial F-Gas emission estimates by replacing scaled down national estimates from the U.S. EPA Vintaging Model with California state-specific estimates based on comprehensive research completed by CARB staff and studies completed by CARB contractors. The F-Gas Inventory is updated periodically as emissions profiles are further refined by incorporating the latest activity data, research and monitoring. The full methodology is available in the latest Emission Inventory Methodology and Technical Support Document for the Greenhouse Gas Inventory and is also the subject of a peer-reviewed scientific paper by CARB staff Gallagher, et al., 2014, published in the journal Environmental Science and Technology (CARB, 2016; Gallagher 2014).

[78] "Units" is generally interchangeable with the term "equipment" or "system" and for Inventory purposes refers to a single system connected through a refrigerant circuit.

CARB staff assume that without regulatory drivers, the use of HFCs will continue to grow rapidly as ODS are phased out of new production. There are a few exceptions. The following non-refrigerant end-use sectors have voluntarily transitioned away from using HFCs:

- Foam expansion agents have replaced HFCs with less costly hydrocarbons for many foam end-use sectors.

- Aerosol propellants have replaced HFCs with hydrocarbons in many consumer products.

- HFC solvents have been replaced by non-fluorinated solvents, including water-based solvents.

- HFC fire suppressants have been replaced by non-fluorinated alternatives and low-GWP fluorocarbons.

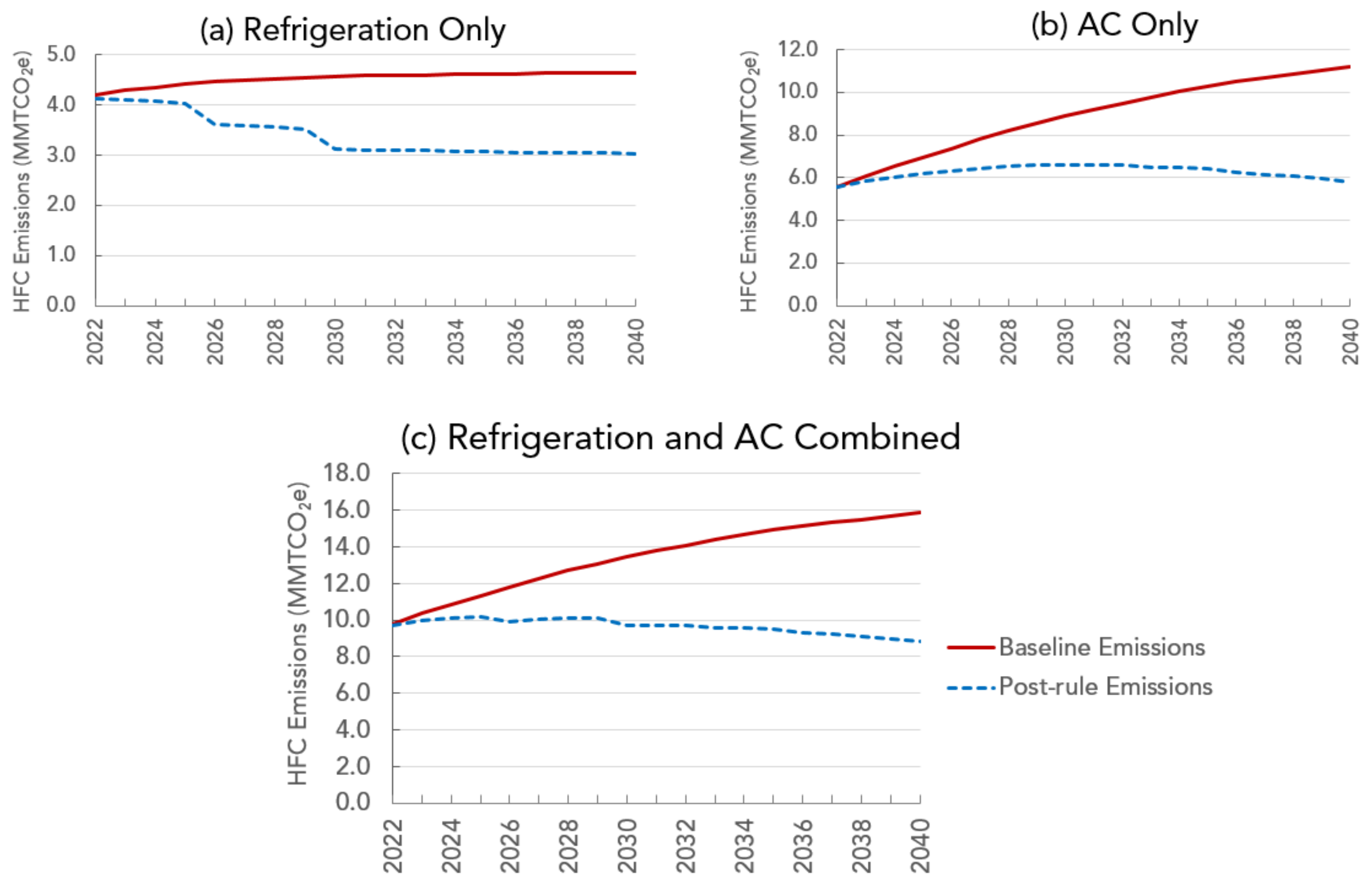
The BAU does not include speculative future changes in equipment average charge sizes, annual leak rates, or end-of-life loss rates. Charge sizes, annual leak rates and equipment end-of-life loss rates remain the same as current years, unless acted upon by exterior forces such as regulations that have been adopted at the state or national level. New units are assumed to use the same amount and type of F-Gas as used in current and previous years, until adopted regulations prohibit the use of specific F-Gases for that end-use. The BAU characteristics for refrigeration and AC units from the F-gas inventory are given in **Table 6** and **Table 24**, respectively and were used to estimate baseline emissions and costs.

The BAU does not include speculative future changes in equipment average charge sizes, annual leak rates, or end-of-life loss rates. Charge sizes, annual leak rates and equipment end-of-life loss rates remain the same as current years, unless acted upon by exterior forces such as regulations that have been adopted at the state or national level. New units are assumed to use the same amount and type of F-Gas as used in current and previous years, until adopted regulations prohibit the use of specific F-Gases for that end-use.

2. **Emission Benefits.**

CARB's 2017 Short Lived Climate Pollutant Reduction Strategy identifies prohibitions of high-GWP refrigerants in new equipment as one of the key measures to reduce HFC emissions in the State, as mandated by the State legislature (CARB, 2017a). **Figure 13** below identifies the projected annual baseline HFC emissions and expected reductions from the Proposed Amendments as they pertain to refrigeration equipment, AC equipment, and both sectors combined.

Figure 13. *Projected Annual Baseline HFC Emissions and Expected Reductions*



For refrigeration, existing SB 1013 requirements prevent a rapid increase in the projected baseline GHG emissions from those systems, but the high-GWP refrigerants currently contained in the existing systems continue to be the greatest source of emissions from the sector. Under the Proposed Amendments, most of the existing refrigerated facilities (i.e., retail food facilities) will be required to reduce their weighted-average GWP of their banked refrigerants to below 1,400 by 2030, with a progress step in 2026, which is reflected in **Figure 13 (a)** above. In addition, new systems that will be installed in newly constructed or remodeled facilities will be required to use refrigerants with GWP less than 150. From these measures combined, HFC emissions from the refrigeration sector are expected to decline by nearly 40 percent below baseline by 2040.

In contrast to the refrigeration equipment, HFC use and emissions from the air-conditioning sector are projected to grow rapidly. This is due to a combination of factors: use of HFCs in the sector is not currently regulated by SB 1013 and AC use is expected to grow in an increasingly warming climate.

Another factor driving the large increase of HFC use and emissions in both, air-conditioning and refrigeration sectors is that new equipment using HFC refrigerants are replacing older equipment using ozone-depleting substance (ODS) refrigerants. Because ODS emissions are intentionally not included in California's GHG Inventory (by design of the Kyoto Protocol and AB 32), the growth of HFC emissions reflects not only simple growth in the number of new equipment used each year, but also the replacement of ODS equipment with HFC equipment. Reducing the GWP of new AC equipment to below 750 is expected to reduce emissions from this sector by nearly 50 percent below baseline by 2040 (**Figure 13 (b)**).

Combined, the annual average reduction in HFC emissions from the refrigeration and AC sectors is estimated to 3.8 MMTCO_2e, from the stationary refrigeration and AC sectors combined between 2022 and 2040 (**Figure 13 (c)**). This is equivalent to removing GHG emissions from 810,000 passenger vehicles driven per year (U.S. EPA, 2019). Cumulatively, from 2022 through 2040, the Proposed Amendments are expected to yield 72 MMTCO_2e in GHG reductions from the two sectors. The annual and cumulative reductions are given in table below.

Table 39. *Annual and Cumulative Emissions Reductions from the Proposed Amendments (using 100-year GWP values)*

Year	Refrigeration + AC	
	Annual Reductions (MMTCO_2e)	Cumulative Reductions (MMTCO_2e)
2022	0.1	0.1
2023	0.4	0.5
2024	0.8	1.3
2025	1.1	2.4
2026	1.9	4.3
2027	2.2	6.5
2028	2.6	9.1
2029	3.0	12
2030	3.7	16
2031	4.1	20
2032	4.4	24
2033	4.8	29
2034	5.1	34
2035	5.4	40
2036	5.8	46
2037	6.1	52
2038	6.4	58
2039	6.7	65
2040	7.0	72
Annual Average	**3.8**	**NA**

It is important to note that the emissions benefits discussed above are calculated using the 100-year GWP values of the HFC refrigerants. A 100–year GWP value is reflective of the warming impact of an HFC relative to CO_2 over that time period. In reality, most HFCs used as refrigerants or as part of refrigerant blends have atmospheric lifetimes shorter than 100 years and thus, their warming impact is even worse in the shorter term. To estimate more near term impacts, HFC emissions can be calculated using their 20-year GWP values. For the HFCs used in refrigeration and AC equipment, the average 20-year GWP is approximately double the 100-year average GWP. Thus, using 20-year GWP values, the Proposed Amendments are expected to yield cumulative GHG emissions reductions of more than 140 $MMTCO_2e$ by 2040. While we use 100-year GWP values throughout this document and for the purposes of the rulemaking, it is important to highlight the potential near-term impacts of these short-lived climate pollutants and the extent of damage HFCs can cause within just a few decades.

The benefit of these GHG reductions can be estimated using the Social Cost of Carbon (SC-CO_2), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future. **Table 40** presents the range of IWG SC-CO_2 values used in regulatory assessments, including the 2017 Scoping Plan (CARB, 2017b).

Table 40. *Social Cost of Carbon, 2015 – 2040 (2007$ Per Metric Ton)*

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2020	$12	$42	$62
2025	$14	$46	$68
2030	$16	$50	$73
2035	$18	$55	$78
2040	$21	$60	$84
2045	$23	$64	$89

If all of the expected emissions reductions projected under the Proposed Amendment are achieved and assumed to be equivalent to CO_2 reductions, the avoided SC-CO_2 in a given year is the total emissions reductions (in $MTCO_2e$) multiplied by the SC-CO_2 (in $/$MTCO_2e$) for that year. The annual emissions reductions from the Proposed Amendments and the estimated benefits are shown in

Table 41 below. The total benefits range between \$1.7 billion to \$7.2 billion through 2040, depending on the discount rate.

Table 41. *Avoided Social Cost of CO_2 (Million 2018\$)*

Year	Annual GHG Emissions Reductions ($MMTCO_2e$)	5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2022	0.10	\$1.63	\$5.38	\$8.01
2023	0.42	\$7.15	\$24.2	\$35.7
2024	0.77	\$12.9	\$44.7	\$65.6
2025	1.12	\$20.4	\$66.9	\$98.9
2026	1.88	\$34.0	\$114	\$168
2027	2.24	\$43.5	\$139	\$203
2028	2.61	\$50.8	\$166	\$241
2029	3.00	\$58.3	\$190	\$280
2030	3.74	\$77.6	\$243	\$354
2031	4.07	\$84.5	\$269	\$391
2032	4.41	\$97.1	\$297	\$429
2033	4.80	\$106	\$330	\$473
2034	5.13	\$120	\$359	\$512
2035	5.43	\$127	\$387	\$549
2036	5.80	\$143	\$421	\$594
2037	6.11	\$150	\$451	\$641
2038	6.38	\$165	\$480	\$678
2039	6.71	\$174	\$513	\$722
2040	7.01	\$191	\$546	\$764
Total	**71.7**	**\$1,664**	**\$5,047**	**\$7,206**

It is also worth noting that the SC-CO_2 estimates discussed above were calculated using the social cost of atmospheric release of CO_2 and likely represent a lower bound for the damages caused by releasing HFCs. This is because HFCs are hundreds to thousands of times more potent at trapping heat in the near term than the longer-lived climate pollutants like CO_2. Unlike CO_2, methane and nitrous oxide, there are no official government estimates for HFCs, though one study estimates of social cost of atmospheric release of HFC-134a to be at least thousand-fold higher than CO_2 (Shindell, 2015).

3. Cost-savings for Refrigeration Systems.

The Proposed Amendments for refrigeration systems are expected to yield some cost-savings for the end-users of low-GWP systems in new facilities, as well existing retail food facilities on an ongoing basis. These savings are discussed in detail in **Section VIII.A** and summarized below.

- New Facilities: Since all new facilities will be required to use refrigerants with a GWP less than 150, they will be exempt from the RMP regulation. Briefly, the RMP regulation requires all refrigerated facilities using refrigerants with a GWP of 150 or more to register with CARB and annually report their refrigerant purchase and use. All RMP facilities pay an annual implementation fee to CARB based on the amount of refrigerant they use and incur costs related to recordkeeping and reporting. The annual costs related to RMP compliance are estimated to be $150 and $3,100 depending on the size of their largest refrigeration system. A new facility using low-GWP refrigerants starting 2022 will experience cost-savings for the same amounts. Additionally, compliance with the GWP limit of 150 is also expected to result in some savings related to higher energy efficiency because some low-GWP refrigerants like ammonia are more energy efficient than the current HFC refrigerants. Based on available information, large systems (2,000 pounds of refrigerants or more) in an industrial process or cold storage facility will experience at least a 10 percent reduction in electricity-related costs per year.

- Existing Retail Food Facilities: Retail food companies will be required to reduce their average emissions by approximately 55 percent by 2030, across their facilities (via either the weighted-average GWP reduction or GHGp reduction pathways). The most economical option will be to retrofit the current systems with refrigerants having a GWP value just under 1,400 e.g., R-448A or R-449A. Refrigerant retrofits are expected to result in improved energy efficiency of the systems for the following reasons: (1) the retrofit refrigerants are estimated to be slightly more energy efficient than the current refrigerants, and (2) as part of the retrofits, the systems will receive maintenance and tune-ups, which generally result in improved energy efficiency. CARB staff estimated that existing facilities will see at least a 5 percent reduction in annual electricity-related costs.

Together for new and existing facilities, the cumulative cost-savings resulting from the refrigeration-related rules are estimated to be $295 million between 2022 and 2040 (**Table 21**).

E. Fiscal Impacts

1. Local Government.

i. Incremental Cost.

Local governments that utilize AC and refrigeration systems may incur incremental costs when they purchase and install new low GWP equipment. Some facilities owned by local school districts are registered in the RMP database as users of the regulated refrigeration systems. Together, they make up less than 1 percent of all registered refrigerated facilities and therefore affected by proposed amendments. In this analysis, we assume the same portion of the overall incremental costs are passed on the local governments. AC systems are generally used in state and local government buildings throughout California. Staff assumes the incremental cost of these systems for state and local government is proportional to the share of state and local government demand in California, being 2.0 percent and 6.7 percent, respectively.[79]

ii. Sales Tax Revenue.

Sales taxes are levied in California to fund a variety of programs at the state and local level. These Proposed Amendments will result in the sale of more expensive AC and refrigeration systems in California, which will result in higher sales tax collected by local governments. Overall, state sales tax revenue may increase less than the direct increase from equipment sales if overall business and consumer spending does not increase.

iii. Utility User Fee.

Many cities and counties in California levy a Utility User Fee on electricity usage. This fee varies from city to city and ranges from no tax to 11 percent. A value of 3.53 percent was used in this analysis representing a population-weighted average (SCO, 2018). By decreasing the amount of electricity used, there will be a decrease in the amount of the utility user fee revenue collected by cities and counties.

iv. Fiscal Impacts on Local Governments.

Over the regulatory lifetime, Local Governments are estimated to incur incremental costs of about $66 million resulting from AC and refrigeration systems used by local government facilities. Local Governments are also estimated to see a direct increase in sales tax revenue of $154 million and a decrease in revenue from the Utility User Fee of $9.2 million. On net, the total fiscal impact (revenues – costs) is estimated to be $15 million over the first three years and $81 million through 2040 (**Table 42**).

Table 42. *Fiscal Impacts on Local Governments (Million 2018$)*

Year	Incremental Costs	Sales Tax Revenue	Utility User Fee Revenue	Total Fiscal Impact*
2022	$0.0	$0.8	$0.0	$0.8
2023	$0.4	$7.8	$0.0	$7.4
2024	$0.7	$7.8	$0.0	$7.1

[79] Based on REMI Policy Insight Plus (v 2.3), state and local governments' share of demand in California is 8.7 percent, which is then disaggregated to state government and local government based on employment share.

Year	Incremental Costs	Sales Tax Revenue	Utility User Fee Revenue	Total Fiscal Impact*
2025	$1.1	$7.8	$0.0	$6.7
2026	$1.5	$14.5	-$0.5	$12.5
2027	$1.9	$7.9	-$0.5	$5.5
2028	$2.2	$7.9	-$0.5	$5.1
2029	$2.6	$7.9	-$0.5	$4.7
2030	$3.0	$12.0	-$0.9	$8.1
2031	$3.4	$7.9	-$0.9	$3.7
2032	$3.7	$7.9	-$0.9	$3.3
2033	$4.1	$8.0	-$0.9	$2.9
2034	$4.5	$8.0	-$0.9	$2.6
2035	$4.9	$8.0	-$0.9	$2.2
2036	$5.2	$8.0	-$0.4	$2.3
2037	$5.6	$8.0	-$0.4	$2.0
2038	$6.0	$8.0	-$0.4	$1.6
2039	$6.4	$8.0	-$0.4	$1.2
2040	$6.7	$8.0	-$0.1	$1.2
Total	**$64.1**	**$154.3**	**-$9.2**	**$81.0**

*The Total Fiscal Impact is calculated as the change in revenue minus costs.

2. State Government.

i. Incremental Cost.

Some California state government facilities use regulated refrigeration systems and may incur incremental costs when they purchase new equipment. These facilities include but are not limited to state prisons, correctional and rehabilitation facilities, and the state universities. Based on the RMP database, in 2018, 1 percent of all registered refrigerated facilities were owned by the state government. For this analysis, we assume the same percentage of costs are passed on to state government. AC systems are generally used in state and local government buildings throughout California. Staff assumes the incremental cost of these systems for state and local government is proportional to the share of state and local government demand in California, being 2.0 percent and 6.7 percent, respectively.[80]

[80] Based on REMI Policy Insight Plus (v 2.3), state and local governments' share of demand in California is 8.7 percent, which is then disaggregated to state government and local government based on employment share.

ii. Sales Tax Revenue.

Sales taxes are levied in California to fund a variety of programs at the state and local level. The Proposed Amendments will result in the sale of more expensive AC and refrigeration systems in California, which will result in higher sales tax collected by the state government. Overall, state sales tax revenue may increase less than the direct increase from equipment sales if overall business spending does not increase.

iii. CARB Staffing.

The Proposed Amendments will have an impact on CARB's staffing requirements. Existing staff will support implementation of the requirements in the Proposed Amendments. However, existing staff cannot be fully devoted to tasks related to implementation because of the need for further rulemakings to implement additional strategies to reduce HFC emissions. CARB will require four additional Air Pollution Specialist (APS) positions for implementing and enforcing the requirements for existing supermarkets and grocery stores. The additional personnel would be responsible for data analysis, annual review of company's emissions reductions, assisting stakeholders with inquiries, supporting enforcement by going on site visits and carrying out audits of stakeholder reports, and other general implementation duties. Any additional work related to implementation of rules for new equipment will be distributed among the existing resources. Each position will place an annual cost burden of $180,000 per year on CARB, starting fiscal year 2022-23.

iv. Energy Resource Fee Revenue.

The Energy Resource Fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities. The revenue collected is deposited into the Energy Resources Programs Account of the General Fund which is used for ongoing energy programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the CEC.

v. Fiscal Impacts on State Government.

Over the regulatory lifetime, the State government is estimated to incur incremental costs of about $23 million resulting from AC and refrigeration systems used by State government facilities and $13 million for CARB staffing and resources. The State government is also estimated to see a direct increase in sales tax revenue of $131 million and a decrease in revenue from the Energy Resource Fee of $1 million. On net, the total fiscal impact (revenues – costs) is estimated to be $12 million over the first three years and $94 million through 2040 (**Table 43**).

Table 43. *Fiscal Impacts on State Government (Million 2018$)*

Year	Incremental Costs	CARB Staffing & Resources Costs	Sales Tax Revenue	Energy Resource Fee Revenue	Total Fiscal Impact*
2022	$0.0	$0.0	$0.7	$0.0	$0.7
2023	$0.1	$0.7	$6.6	$0.0	$5.7
2024	$0.3	$0.7	$6.6	$0.0	$5.6
2025	$0.4	$0.7	$6.6	$0.0	$5.5
2026	$0.6	$0.7	$12.4	$0.0	$11.1
2027	$0.7	$0.7	$6.7	$0.0	$5.2
2028	$0.8	$0.7	$6.7	$0.0	$5.1
2029	$1.0	$0.7	$6.7	$0.0	$5.0
2030	$1.1	$0.7	$10.3	-$0.1	$8.3
2031	$1.3	$0.7	$6.7	-$0.1	$4.7
2032	$1.4	$0.7	$6.7	-$0.1	$4.5
2033	$1.5	$0.7	$6.7	-$0.1	$4.4
2034	$1.7	$0.7	$6.7	-$0.1	$4.3
2035	$1.8	$0.7	$6.7	-$0.1	$4.2
2036	$1.9	$0.7	$6.8	$0.0	$4.1
2037	$2.0	$0.7	$6.8	$0.0	$4.0
2038	$2.1	$0.7	$6.8	$0.0	$3.9
2039	$2.2	$0.7	$6.8	$0.0	$3.8
2040	$2.3	$0.7	$6.8	$0.0	$3.7
Total	**$23.3**	**$12.9**	**$130.7**	**-$0.6**	**$93.8**

*The Total Fiscal Impact is calculated as the change in revenue minus costs

IX. Evaluation of Regulatory Alternatives

Government Code section 11346.2, subdivision (b)(4) requires CARB to consider and evaluate reasonable alternatives to the proposed regulatory action and provide reasons for rejecting those alternatives. This section discusses alternatives evaluated and provides reasons why these alternatives were not included in the proposal. As explained below, no alternative proposal was found to be less burdensome and equally effective in achieving the purposes of the regulation in a manner than ensures full compliance with the authorizing law.

A. Alternative 1.

Alternative 1 is a more stringent requirement for both stationary refrigeration systems containing more than 50 pounds of refrigerant and stationary AC systems. **Table 44** summarizes the requirements of Alternative 1. Under this alternative, every new refrigeration system would be required to have a refrigerant with a GWP value below 10. Only natural refrigerants (CO_2, NH_3 and hydrocarbons) would currently be able to comply with this limit; HFO/HFC blends such as R-454C with GWP values between 11 and 150 would be prohibited under this scenario. Additionally, this would apply to all facilities, new and existing. For AC equipment, room ACs would be required to have a refrigerant with a GWP value less than 10 and residential and commercial AC equipment would be required to use a refrigerant with a GWP value less than 500. The compliance options for stationary AC systems would be more limited than with a 750 limit, and the compliance options would all have some degree of flammability properties. These GWP limits align with proposals from stakeholders advocating for the most stringent GWP limits technologically feasible today.

Table 44. *Alternative 1 GWP Limits for Stationary Refrigeration and AC*

End-Use Sector	Refrigerant GWPs Prohibited(100-year GWP Value)	Prohibition Date
Stationary Refrigeration (new systems with over 50 lb. refrigerant in new and existing facilities)	10 or greater	January 1, 2022
Stationary Room AC (new)	10 or greater	January 1, 2023
Stationary AC (new)(Commercial)	500 or greater	January 1, 2023
Stationary AC (new) (Residential)	500 or greater	January 1, 2023

Emissions Reductions and Cost

For refrigeration and AC, Alternative 1 is expected to result in additional emissions reductions compared to the Proposed Amendments. CARB estimates annual emissions reductions for Alternative 1 of approximately 5.3 $MMTCO_2e$ annually in 2030 and 101 $MMTCO_2e$ cumulatively by 2040 from the refrigeration and AC sectors. This alternative provides over 40 percent more emissions reductions than the Proposed Amendments. The cost for Alternative 1 is more than twice the cost of the Proposed Amendments at an average of $568 million per year with a total cost of $11 billion by 2040. The cost effectiveness of Alternative 1 is approximately $110 per $MTCO_2e$ emissions reductions compared to approximately $60 per $MTCO_2e$ for the Proposed Amendments.

Table 45. *Costs, Benefits and Emissions Reductions of Alternative 1*

Year	Total Costs (Millions 2018$)	Total Savings (Millions 2018$)	Net Costs (Millions 2018$)	Emissions Reductions ($MMTCO_2e$)
2022	$34.7	-2.5	32.2	0.2
2023	$97	-5.1	92.0	0.7
2024	$160	-7.6	152.1	1.3
2025	$223	-10.2	212.5	1.8

2026	$286	-12.8	273.2	2.4
2027	$350	-15.4	334.2	3.0
2028	$413	-18.0	395.5	3.6
2029	$478	-20.6	457.1	4.2
2030	$542	-23.2	518.9	4.8
2031	$607	-25.9	580.9	5.4
2032	$672	-28.6	643.2	6.0
2033	$737	-31.2	705.7	6.6
2034	$802	-33.9	768.5	7.2
2035	$868	-36.6	831.4	7.7
2036	$934	-39.3	894.6	8.3
2037	$981	-40.6	940.1	8.8
2038	$1,006	-41.9	964.2	9.3
2039	$1,031	-43.2	988.3	9.8
2040	$1,057	-44.5	1,012	10
Annual Average	**$594**	**-$25.3**	**$568**	**5.3**
Cumulative (2022-2040)	**$11,278**	**-$481**	**$10,797**	**101**

Cost-Savings

The cost-savings associated with new facilities discussed in Section C.3 also expected under Regulatory Alternative 1, where all new refrigeration systems would be required to comply with the GWP limit of 150. This includes savings due to improved energy efficiency of some refrigeration systems, and lower costs of compliance with the RMP regulation. Since Alternative 1 would require a much larger number of systems to use low-GWP (GWP < 150) refrigerants, greater savings are expected from this alternative than the main proposal. From 2022 to 2040, the cumulative cost-savings resulting from the refrigeration-related rules for alternative 1 are estimated to be $481 million.

Reasons for Rejection

Although Alternative 1 would result in more emissions reductions than the Proposed Amendments, CARB is rejecting this proposal because of the higher cost and infeasibility.

Refrigeration

Alternative 1 for refrigeration is similar to CARB's original proposal for the Proposed Amendments, although the GWP limit was 150, not 10. This GWP limit would have applied to all new equipment, irrespective of whether it is installed in new facilities or replaces retiring equipment in existing facilities. As the details of the proposal were discussed during stakeholder engagements and the economic impacts analyzed, it became increasingly clear that the direct costs associated with this alternative are very high. The main reason is the incompatibility of equipment using refrigerants with GWP less than 150 (or less than 10) with the currently installed equipment suitable for HFCs. This poses a significant systems integration problem which currently can only be resolved with a 100 percent replacement of equipment. Additionally, if a facility owner were to carry out a full system replacement, doing so is logistically onerous without shutting the facility down. Facility owners avoid store closures for any length of time to prevent losses in customer loyalty and revenue. While estimated emissions reductions from this alternative are significantly higher than the main proposal, this alternative proposal could result in a shift in the behavior of the owners/operators - fewer system replacements would occur and as a result, old leaky systems that are in dire need of replacement and upgrades would likely not be updated, especially in facilities owned by small businesses. Due to high associated costs associated with this alternative and to avoid potential shifts in end-user behavior that could lead to higher emissions, CARB has rejected this alternative.

Air Conditioning

CARB is rejecting this alternative for AC for two main reasons. First, a GWP less than 10 for room AC is not feasible in the near term. This GWP limit would require the use of either an HFO or an A3 (higher flammability) refrigerant such as R-290 (propane). Using an HFO refrigerant to achieve a GWP of less than 10 for room ACs would likely need substantial redesign to achieve the same level of energy efficiency. Alternative 1 would increase cost for room AC products, which are the lowest cost option for end-users. As for using an A3 refrigerant in room ACs, there is no proposal currently to revise product standards to allow for their use in the U.S., which is a precursor to even considering adopting new building codes which allow for their use.

B. Alternative 2.

Alternative 2 comprises less stringent requirements for both refrigeration and AC than the Proposed Amendments (**Table 46**). Under this alternative, new refrigeration systems would have a less stringent requirement to use a refrigerant with GWP less than 1,500. Some stakeholder have suggested this as part of an alternative and recommend that CARB propose additional measures which lower the leak rates from refrigeration and AC equipment. For commercial refrigeration systems above 50 pounds, CARB already has an existing program to this very purpose – CARB's Refrigerant Management Program (RMP) has now been in effect for 9 years. For AC equipment, there is an existing program implemented by South Coast AQMD under Rule 1415 that is similar to RMP but applies to commercial AC systems with more than 50 pounds of refrigerant. South Coast AQMD Rule 1415 covers 40 percent of the state's population within its jurisdiction and requires commercial facilities with ACs to register their facility, conduct annual leak inspections, repair leaks within 14 days and keep records on site. This is business as usual for the 40 percent of the state population within the jurisdiction of South Coast AQMD. Alternative 2, expands South Coast AQMD Rule 1415 requirements to commercial AC equipment with more than 50 pounds of refrigerant across the rest of the state. Alternative 2 does not set GWP limits for stationary AC and does not address emissions from residential AC.

Alternative 2 is aligned with stakeholder request for less stringent requirements for these sectors and instead relying on external market forces to propel the transition to low-GWP refrigerants while imposing additional government oversight of refrigerant management from commercial equipment.

Table 46. *Alternative 2 Requirements for Stationary Refrigeration and AC*

End-Use Sector	Requirement	Prohibition Date
Stationary Refrigeration (new systems with over 50 pounds of refrigerant in new and existing facilities)	Prohibition on new equipment with a 100-year GWP of 1,500 or greater	January 1, 2022
Stationary Commercial AC (over 50 pounds)	Refrigerant Management Program for AC: end-user reporting and leak management requirements	January 1, 2023

Emissions Reduction and Cost

For refrigeration and AC, Alternative 2 is expected to result in significantly less emissions reductions compared to the Proposed Amendments. Alternative 2 results in annual reductions of less than 1 $MMTCO_2e$ in 2030 and cumulative reductions equaling 17 $MMTCO_2e$ by 2040 from the refrigeration and AC sectors, which is less than 25 percent of the emissions reductions estimated for the Proposed Amendments. The cost for Alternative 2 is an average of $56 million per year with a total cost of $1.1 billion by 2040. Alternative 2 has a poorer cost-effectiveness of approximately $70 per $MTCO_2e$ compared to approximately $60 per $MTCO_2e$ offered by the Proposed Amendments.

The following table shows the annual costs and emissions reductions for Alternative 2. No direct savings are expected in this scenario.

Table 47. *Costs, Benefits and Emissions Reductions of Alternative 2*

Year	Total Costs[a] (Millions 2018$)	Emissions Reductions ($MMTCO_2e$)
2022	$1.34	0.08
2023	$45.0	0.27
2024	$45.0	0.35
2025	$46.8	0.44

2026	$48.7	0.52
2027	$50.6	0.61
2028	$52.4	0.69
2029	$54.3	0.77
2030	$56.2	0.85
2031	$58.1	0.92
2032	$60.1	0.99
2033	$62.0	1.06
2034	$64.0	1.12
2035	$65.9	1.19
2036	$67.9	1.24
2037	$69.1	1.30
2038	$70.4	1.35
2039	$71.7	1.39
2040	$73.0	1.43
Annual Average	**$55.9**	**0.87**
Cumulative (2022-2040)	**$1,063**	**17**

[a] Annual costs include the upfront and ongoing costs for new refrigeration systems to comply with the 1500 GWP limit and for all users of commercial AC systems to comply with an RMP-like program.

<u>Reasons for Rejection</u>

CARB is rejecting this proposal because it would yield significantly less emissions reductions and is less cost-effective than the Proposed Amendments.

For refrigeration, Alternative 2 would require the use mid-GWP (i.e., GWP < 1,500) refrigerants like R448A and R-449A in new systems, irrespective of whether the systems are installed in newly constructed, remodeled or existing facilities. This would not require a transition to low-GWP refrigerants like CO_2, NH_3, hydrocarbons or the low-GWP fluorocarbon refrigerants. In this scenario, we would not maximize the emissions reductions that can be obtained from this sector because we do not utilize truly sustainable, low-GWP refrigerant options that are readily available and widely used across the world in similar applications. Additionally and perhaps of greatest concern to industry, a proposal like this will leave the refrigeration sector exposed to even more refrigerant transitions and associated costs in the immediate future due to the impending global HFC phasedown as well as need for more state regulations to meet California's HFC reduction and overall carbon neutrality goals.

CARB is rejecting Alternative 2 for AC because there is less potential to reduce emissions and refrigerant management programs are more effective for commercial refrigeration systems than for commercial AC. This is because there are fewer commercial refrigeration systems and these systems have higher per unit charge sizes and leak rates. Fugitive emissions from commercial AC sector are substantial because of the sheer number of ACs, which also presents a greater implementation challenge. Additionally, CARB is rejecting Alternative 2 because it does not address residential AC.

C. Small Business Alternative.

The Board has not identified any reasonable alternatives that would lessen any adverse impact on small business.

For refrigeration, CARB staff considered exempting the small businesses from the weighted-average GWP reduction requirements for retail food facilities altogether. However, in the future, California and all of the United States may be affected by the global HFC phase-down resulting from the Kigali Amendment to the Montreal Protocol (UNIDO, 2017). The European Union has already started experiencing the impact of the phase-down, where end-users of HFCs have reportedly experienced drastic refrigerant price volatility and refrigerant shortages (*Cooling Post*, 2017a-b; Battesti, 2018). The main reason to have all commercial refrigeration businesses, large and small, reduce their use of high-GWP refrigerants is to prepare them for a future domestic HFC phasedown and to reduce their exposure to sudden market upheavals and related negative economic impacts if and when the phasedown is implemented domestically.

For AC, there are no small business manufacturers that have been identified as affected by the Proposed Amendments. However, all small businesses in California that purchase a new AC system from 2023 onward are affected by the Proposed Amendments. CARB has not identified any reasonable alternatives to the requirements pertaining to stationary AC that would lessen any adverse impact on small business.

Health and Safety Code section 57005 Major Regulation Alternatives

CARB estimates the proposed regulation will have an economic impact on the state's business enterprises of more than $10 million in one or more years of implementation. CARB will evaluate alternatives submitted to CARB and consider whether there is a less costly alternative or combination of alternatives that would be equally as effective in achieving increments of environmental protection in full compliance with statutory mandates within the same amount of time as the proposed regulatory requirements, as required by Health and Safety Code section 57005.

D. Future Considerations.

1. Sales prohibition of new refrigerant above a threshold GWP: Require reclaimed refrigerant used for servicing existing equipment. Using reclaimed refrigerant instead of new refrigerant should decrease the amount of new refrigerant necessary, and incentivize greater recovery of existing refrigerant available at the time of equipment retirement.

2. <u>HFC phasedown:</u> Track ratification of global phasedown in U.S. phasedown of total CO_2-equivalents of HFC refrigerant produced and brought into California. The global phasedown of HFC production and consumption, known as "The Kigali Amendment" (to the Montreal Protocol) has not been ratified by the United States as of September 2020, nor has an equivalent measure yet been brought into law in the U.S. The SB 1383 HFC reduction goals for California cannot be met without an HFC phasedown, which should occur at the national level due to the difficulty in enforcing a California-only HFC phasedown at the state level.

3. <u>Low-GWP requirements for additional end-uses</u>: Refrigeration equipment containing less than 50 pounds of refrigerant charge, water heater heat pumps, clothes dryer heat pumps, and swimming pool heat pumps. CARB estimates that non-residential refrigeration equipment containing less than 50 pounds of refrigerant will still contribute to 30 percent of stationary refrigeration HFC emissions by 2030, even with currently proposed regulations in place. Heat pumps used for water heaters, clothes dryers, and swimming pools currently represent negligible HFC emissions, but these emissions are expected to increase significantly as California moves to replace fossil fuel heating with electricity powering heat pumps for heating.

4. <u>Carbon neutrality efforts:</u> Executive Order B-55-18 directs California to achieve a carbon neutral economy by 2045. Through rigorous scientific research and analysis, state agencies have determined that building electrification is the lowest-cost pathway to achieve carbon neutrality in California. The combination of an electrical grid that is 100 percent powered by renewable sources and highly energy efficient equipment are cornerstones of building electrification, which is already underway in California. Refrigerant-containing heat pump appliances are highly efficient and can achieve a significant reduction in GHG emissions, and thus, are an integral building electrification strategy. Current heat pump products, not covered by the Proposed Amendments, such as heat pump water heaters, clothes dryers and pool heaters, predominantly utilize traditional high-GWP refrigerants. While they displace natural gas emissions and have significant environmental and health benefits, emissions of HFC refrigerants can potentially increase with the rapid and wide uptake of these appliances. CARB may consider regulations to limit the GWP of refrigerants used in these heat pumps to avoid a potential increase in HFC emissions and leapfrog to low-GWP alternatives to avoid locking in HFC-containing equipment over another equipment lifecycle of 10-20 years.

X. Justification for Adoption of Regulations Different from Federal Regulations Contained in the Code of Federal Regulations

Currently, there are no federal regulations that limit the global warming impacts of refrigerants used in stationary air conditioning. Some prohibitions for the stationary refrigeration sector were present in the U.S. EPA's SNAP Rules 20 and 21. However, as indicated above these were partially vacated. Currently there are proposed national bills that would phasedown HFCs nationwide. The proposals are S.2754 (American Innovation and Manufacturing Act of 2019); HR.5544 (American Innovation and Manufacturing Leadership Act of 2020); and more recent proposals such as H.R.4447 (Clean Economy Jobs and Innovation Act), amongst others. These proposals require a phasedown in consumption and production of HFCs. However, as of this time, these are just proposals.

XI. Public Process for Development of the Proposed Action (Pre-Regulatory Information)

Consistent with Government Code sections 11346, subdivision (b), and 11346.45, subdivision (a), and with the Board's long-standing practice, CARB staff held public workshops and had other meetings with interested persons during the development of the proposed regulation. These informal pre-rulemaking discussions provided staff with useful information that was considered during development of the regulation that is now being proposed for formal public comment.

The Proposed Amendments have been developed through an extensive process of engagement with the public and industry stakeholders. In 2017, 2018, 2019, and 2020, CARB staff conducted four public workshops, which were webcast and made available by teleconference, on the Proposed Amendments. Information regarding these workshops and any associated materials are posted on the CARB website and distributed through several public listservs that include over 30,000 recipients. The workshops and meetings allowed CARB staff to consider stakeholder feedback and to incorporate it into the Proposed Amendments, as appropriate. CARB staff will continue to consider stakeholder feedback throughout the regulatory adoption process, including up to the adoption of the final regulation.

CARB staff worked closely with many of the stationary refrigeration stakeholders over the last decade, many of whom are subject to *California's Refrigerant Management Program* that was approved by the Board in December 2009 as well as the "*Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration and Foam End-Uses*" (CA SNAP) adopted in March 2018. The public outreach process for RMP (CARB, 2009) and the CA SNAP (CARB, 2018b) are described in the Initial Statement of Reasons (ISOR) for each of the rulemakings.

The low-GWP refrigerant requirements for both refrigeration and AC equipment were recommended by CARB and made publicly available as early as December 2008 in the first Climate Change Scoping Plan (CARB, 2008a-b). The low-GWP requirements proposed in this rulemaking were reiterated and described in three additional CARB documents: First Update to the Climate Change Scoping Plan (CARB, 2014); California's 2017 Climate Change Scoping Plan (CARB, 2017b); and the Short-Lived Climate Pollutant Reduction (SLCP) Strategy (CARB, 2017a). The specific GWP limits were first proposed as 150 GWP for stationary refrigeration and 750 for stationary AC in the Draft SLCP Strategy (CARB, 2015), which was released in September 2015 and included in the final draft approved by the Board in 2017. Since then, equipment manufacturers, trade organizations, nonprofits and others have been in close contact with CARB, providing information regarding the status of commercialization and market adoption of technologies that can meet these limits and input on the Proposed Amendments.

Recently, the outreach has focused on gathering stakeholder input on the technical feasibility, cost and enforceability of the proposal. Public outreach in support of developing the regulatory proposal includes but is not limited to the following activities:

CARB Public Workshops: Since 2017, CARB has held six public workshops and technical working group meetings regarding this regulatory proposal (October 2017; October 2018; March 2019; August 2019; January 2020 and July 2020). CARB staff posted information regarding these workshops and associated materials on the HFC Reduction Measures website and distributed notices through four public list serves maintained by CARB that include over 30,000 recipients who have identified the following as their topics of interest: "climate change"; "commercial refrigeration specifications;" "HFC reduction measures;" and" stationary equipment refrigerant management program." At the meetings, which were available by webinar and by teleconference, CARB solicited stakeholder feedback on the regulation. CARB staff worked closely with stakeholders, reviewing their comments from both the workshop along with several follow-up meetings to discuss their comments and recommendations.

External Public Presentations: In addition to public workshops and meetings hosted by CARB, staff presented details of the regulatory proposal and sought input through the following: presentation through Greenchill, a U.S. EPA web series supporting food retailers in reducing refrigerant emission and decreasing their impact on the ozone layer and climate in April 2019; staff presentation at the UC Davis Energy Affiliates Forum in April 2019; conference presentation at ATMO America in June 2019; staff presentation at a Western Heating Ventilation and Air Conditioning Performance Alliance (WHPA) meeting in May 2019 and a staff presentation at workshops organized by the North American Sustainable Refrigeration Council in July 2019 and January 2020 (CARB, 2019c).

CARB Surveys: CARB staff circulated surveys to equipment manufacturers, refrigerant manufacturers, distributors/wholesalers, reclaimers, and trade groups from December 2018 to March 2019 to better understand cost impacts associated with the regulatory proposal.

Stakeholder Meetings: CARB staff held frequent in-person meetings and conference calls with multiple stakeholders interested in providing input to CARB throughout the period from October 2017 to January 2020. In addition to in-person meetings, CARB staff also held teleconferences to develop the proposed rule, exchange feedback, identify plausible solutions to any implementation challenges, and ultimately ensure the development of feasible compliance pathways for the end-users, one of which was suggested directly by them. CARB staff have worked closely with more than 150 separate stakeholders, in the development of the Proposed Amendments, who can be generally described as representing the following groups:

- Original equipment manufacturers (OEMs) of refrigeration and AC equipment.
- Components manufacturers of refrigeration and AC equipment.
- Groups of supermarket companies and the North American Sustainable Refrigeration Council (NASRC).
- Industry trade groups representing OEMs and end-users.
- End-users, including but not limited to: supermarket and grocery store owners and managers; wine, beer, and beverage makers; refrigerated warehouse, cold storage, and refrigerated distributing facilities.
- Design, engineering and consulting firms.
- Refrigerant manufacturers.
- Refrigerant distributors and distributor trade groups.
- Federal government agencies, including the U.S. EPA and the U.S. DOE.
- California state agencies, including local air districts, the CEC, CPUC, and the Office of the State Fire Marshal.
- Utility company representatives.
- Labor groups representing HVACR contractors and technicians.
- Non-profit environmental organizations.

CARB specifically requested data and input regarding alternatives from those who would be subject to or affected by the regulations the public workshops held in March and August 2018.

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XIII. Appendices

Appendix A. Proposed Regulation Order

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State of California
AIR RESOURCES BOARD

Proposed Amendments to the Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols, Propellants, and Foam End-Uses Regulation

Standardized Regulatory Impact Assessment (SRIA)

DATE OF RELEASE: March 19, 2020

Air Resources Board

1001 I Street

Sacramento, California 95814

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A. INTRODUCTION

Hydrofluorocarbons (HFCs) are synthetic gases used in refrigeration and air conditioning (AC) equipment, insulating foams, solvents, aerosol products, and fire protection. They are primarily produced for use as substitutes for ozone-depleting substances (ODS), including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which are being phased out under the Montreal Protocol. HFCs are short-lived climate pollutants (SLCPs) with global warming potentials (GWPs) hundreds to thousands of times greater than carbon dioxide.[1] GWP values provide a common unit of measure, which allows for comparison of greenhouse gas (GHG) emissions across different sectors. The larger the GWP value, the more that a given gas warms the Earth compared to carbon dioxide (CO_2) over a given time period. The mix of all HFCs in current use in California, weighted by usage (tonnage), has an average 100-year GWP of 1,700, and an average 20-year GWP of 3,800.[2]

Atmospheric observations show that the volume of HFCs in the atmosphere is increasing rapidly, at 7 to 15 percent annually.[3] If no measures are taken, it is estimated that HFCs will amount to 9 to 19 percent of total greenhouse gas emissions globally by 2050.[4] Studies indicate that replacing high-GWP HFCs with low-GWP alternatives worldwide could avoid 0.1 degree Celsius (°C) of global warming by 2050 and warming of up to 0.5°C by 2100, offering one of the most cost-effective climate mitigation strategies available.[5] In California, HFCs currently comprise 5 percent of greenhouse gas emissions in California, but they are the fastest growing source of GHG emissions, primarily driven by the increased demand for refrigeration and AC and the replacement of Ozone-Depleting Substances (ODS) with HFCs.[6] Even with preliminary HFC

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[1] The Intergovernmental Panel on Climate Change (IPCC) developed the concept of GWP as an index to evaluate the climate impacts of different GHGs, including SLCPs. This metric provides a comparison of the ability of each GHG to trap heat in the atmosphere relative to CO_2 over a specified time horizon. GWP accounts for the lifetime of different GHGs in the atmosphere, and the amount of energy they absorb on a per-kilogram basis, relative to CO_2, to represent the relative climate forcing of a kilogram of emissions when averaged over a time period of interest (for example, 20 years or 100 years). Current practice in most of the world for developing GHG emission inventories, including California's inventory, is to use GWP values from the 4th Assessment Report of the IPCC (AR4), which was released in 2007 (IPCC 2007). This proposed rulemaking and SRIA uses 100-yr GWP values from AR4 to be consistent with current industry practices.

[2] The GWP limits being proposed in this rulemaking are in terms of 100-year GWP values to be consistent with the State's official GHG inventory and for accounting for emissions in programs adopted under Assembly Bill (AB) 32. However, CARB also considers the 20-year GWP values as a part of this analysis which better reflect how damaging SLCPs can be over the short-term.

[3] Carpenter, et al. (2014), Ozone-Depleting Substances (ODSs) and Other Gases of Interest to the Montreal Protocol (web link: https://orbi.uliege.be/handle/2268/175647, Last accessed February 2020). See also Doherty, et al. (2014), Global emissions of HFC-143a (CH3CF3) and HFC-32 (CH2F2) from in situ and air archive atmospheric observations (web link: https://www.atmos-chem-phys.net/14/9249/2014/acp-14-9249-2014.pdf, Last accessed February 2020).

[4] *Ibid*.

[5] Xu Y., et al. (2013), The role of HFCs in mitigating 21st century climate change (web link: https://www.atmos-chem-phys.net/13/6083/2013/acp-13-6083-2013.pdf, Last accessed February 2020).

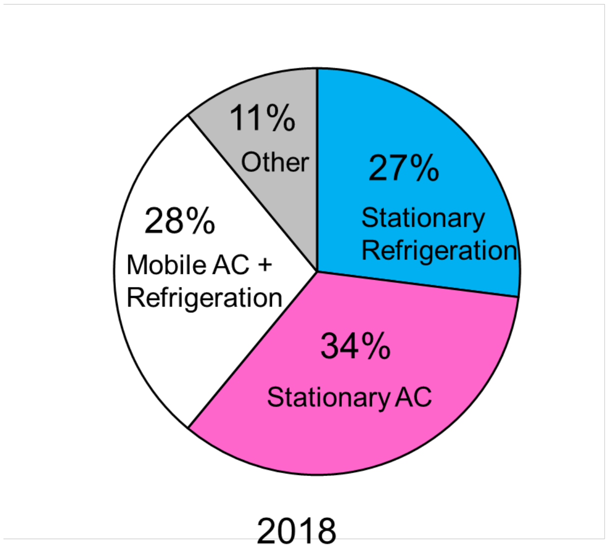
[6] California Air Resources Board, California Greenhouse Gas Emissions for 2000 to 2017 - Trends of Emissions and Other Indicators, released in 2019 (web link: https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf, Last accessed February 2020); See also United Nations Environment Programme (UNEP) (2011), HFCs: A Critical Link in Protecting Climate and the Ozone Layer - A UNEP Synthesis Report (web link: https://www.ccacoalition.org/en/resources/hfcs-critical-link-protecting-climate-and-ozone-layer-synthesis-report, Last accessed February 2020).

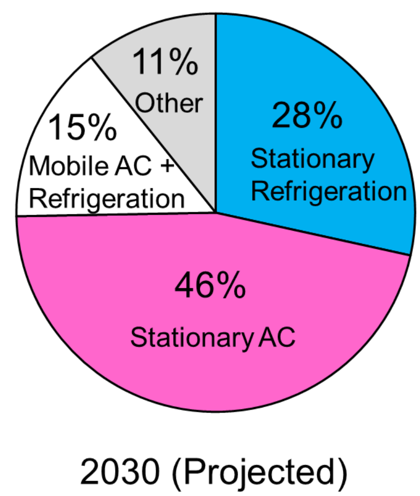
emissions reductions measures already in place as a part of early action for AB 32, HFC emissions are still expected to increase in California by approximately 15 percent from 2019 to 2030.[7]

Figure 1 shows HFC emissions in California by end-use sector based on emission estimates conducted by CARB. [8] In 2018, the total HFC emissions in California are estimate to be approximately 19 million metric tons in CO_2-equivalents ($MMTCO_2e$). [9] HFC emissions in 2018 are almost equal amounts from stationary refrigeration, stationary AC, and mobile vehicle AC and transport refrigeration (Mobile R/AC). The remaining 11 percent of HFC emissions are from aerosol propellants, foams, and other sources including solvents, and fire suppressants. By 2030, HFC emissions will have grown approximately 5 percent to 20 $MMTCO_2e$.[10] Although total estimated HFC emissions are not significantly different in 2030 compared to 2018, the sources of HFC emissions are expected to change significantly from 2018 to 2030. HFC emissions from the mobile R/AC sector are expected to decrease significantly due to the increasing use of low-GWP AC refrigerants in new passenger vehicles.[11] HFC emissions from stationary AC are expected to increase, without further HFC measures, as AC equipment[12] built before 2010 using HCFC-22, an ODS refrigerant, continue to be replaced with new equipment using R-410A, a blend of HFC refrigerants. Additionally, residential AC use is increasing, from 63 percent of all households in California in 2011, to 73 percent by 2017.[13]

[7] California Air Resources Board, Short-Lived Climate Pollutant Reduction Strategy, March 2017. Appendix C: California SLCP Emissions. web link https://ww2.arb.ca.gov/resources/documents/final-short-lived-climate-pollutant-reduction-strategy-march-2017, Last accessed February 2020. See also California Air Resources Board, 2019. Analysis conducted by CARB Research Division to estimate growth of HFC emissions under business as usual (BAU) conditions, October 2019.
[8] California Air Resources Board, California Greenhouse Gas Emissions for 2000 to 2017 - Trends of Emissions and Other Indicators, released in 2019 (web link: https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf, Last accessed
[9] *Ibid.*
[10] *Ibid.*
[11] United States Environmental Protection Agency (U.S. EPA). The 2018 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975. U.S. EPA Report PA-420-R-19-002, March 2019. Web link at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100W5C2.PDF?Dockey=P100W5C2.PDF (accessed February 2020).
[12] Generally, the terms "equipment" and "systems" are interchangeable. For the purpose of this analysis, CARB refers to AC "equipment" to exclude components of heating ventilation and AC (HVAC) systems such as ductwork which are part of the system but not directly impacted by this regulation.
[13] U.S. Energy Information Administration (U.S. EIA). Residential Energy Consumption Survey (RECS), 2009. Table HC7.11, Air Conditioning in Homes in West Region, Divisions, and States, 2009. web link https://www.eia.gov/consumption/residential/data/2009/#ac (accessed February 2020); See also U.S. Census Bureau, American Housing Survey, 2017. web link https://www.census.gov/programs-surveys/ahs.html (accessed February 2020).

Figure 1. California sources of HFC emissions by sector in 2018 (total of 19 million metric tonnes of carbon dioxide equivalents [MMTCO2E) and projected for 2030 (total of 20 MMTCO2E). Source: California's F Gas Inventory, 2017. IPCC AR4 100-year GWP values used.





Refrigeration and AC equipment also contribute to global warming through indirect emissions due to the electricity consumed in operating the equipment. (Note that "systems" "equipment" and "units" are often used interchangeably in the cooling industry). The relative importance of the direct and indirect contributions depends on the type of system, the refrigerant used, the leak rates, the electricity consumption and the "carbon intensity" of the electricity, which refers to the GHG emissions associated with producing electricity. Globally, indirect emissions from electricity generation account for approximately 74 percent of total emissions from stationary AC systems with the remaining 26 percent from refrigerants.[14] In California, the refrigerant emissions represent an even more significant portion of total emissions because of the lower carbon intensity of electricity in California and the significant improvements in energy efficiency levels.

To further reduce HFC emissions in California, CARB is proposing to amend the regulation: "Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols, Propellants, and Foam End-Uses Regulation" or "CA Significant New Alternatives Policy (SNAP) Regulation," hereafter referred to as the "Proposed Amendments". The Proposed Amendments have four main elements:

- Prohibits the use of high GWP of refrigerants in new refrigeration systems containing more than 50 pounds of refrigerant beginning January 1, 2022

- Requires existing retail food facilities to reduce their company-wide, weighted-average GWP for all refrigeration systems containing more than 50 pounds of refrigerant to less than 1,400 by 2030, with a progress step in 2026 for large companies. An optional

[14] W. Goetzler, M. Guernsey, et. al., 2016. *The Future of Air Conditioning in Buildings* https://www.energy.gov/sites/prod/files/2016/07/f33/The%20Future%20of%20AC%20Report%20-%20Full%20Report_0.pdf (Last accessed February 2020).

compliance pathway for achieving similar emissions reductions by reducing refrigerant amounts (full charge of system) and/or GWP will also be available.

- Prohibits the use of high GWP of refrigerants in all new stationary AC systems beginning January 1, 2023.
- Clarifies requirements of the existing CA SNAP regulation and the "California Cooling Act" (Senate Bill 1013, Lara, Stats. of 2018, Ch. 375; Health & Safety Code § 39734).

The Proposed Amendments will help meet several HFC reduction objectives and recommendations included in California Senate Bill 32 (SB 32),[15] which enhanced "The Global Warming Solutions Act of 2006"also known as Assembly Bill 32 (AB 32),[16] "The Short-lived Climate Pollutants Act," also known as Senate Bill 1383 (SB 1383);[17] and the most recent "California Cooling Act;"[18] the 2008 Climate Change Scoping Plan; the 2014 First Update to the Climate Change Scoping Plan;[19] California's 2017 Climate Change Scoping Plan;[20] and the 2017 Short-Lived Climate Pollutant Reduction Strategy.[21]

1. Regulatory History

Federal

In 1987, the United States signed the Montreal Protocol, an international treaty that requires signatory nations to regulate the production and use of ODS. In 1990, Congress implemented its treaty obligations by amending the Clean Air Act to add Title VI, which addresses stratospheric ozone protection by phasing out the use of ozone-depleting chemicals. Section 612 of the Clean Air Act authorizes U.S. EPA to require direct replacement of these compounds. Listed substances have a specific phase-out schedule. U.S. EPA created the Significant New Alternatives Policy (SNAP) program (42 U.S.C. § 7671k(a)) to require manufacturers to stop using listed chemicals and replace them with listed safe substitute substances. U.S. EPA added HFCs to the list of prohibited substances in 2015 and 2016 but in August 2017 and April 2019, following an industry challenge to U.S. EPA's authority to add HFCs to the prohibited list, the court partially vacated the two rules (known as the *Mexichem I* [22] and *Mexichem II*[23] decisions).

[15] Senate Bill 32 (Pavely, Stats. of 2016, Ch. 249, Health & Saf. Code § 38566).
[16] Global Warming Solutions Act of 2006, Assembly Bill 32 (Nunez, Stats. of 2006, Ch. 488, Health & Saf. Code §§ 38500 et seq).
[17] Short Lived Climate Pollutants, Senate Bill 1383 (Lara, Stats. of 2016, Ch. 395, Health & Saf. Code § 39730.5).
[18] California Cooling Act, Senate Bill 1013 (Lara, Stats. of 2018, Ch. 375, Health & Saf. Code § 39764).
[19] California Air Resources Board, First Update to the Climate Change Scoping Plan, released in May 2014 (web link: https://ww3.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf, Last accessed February 2020).
[20] California Air Resources Board, California's 2017 Climate Change Scoping Plan, released in November 2017 (web link: https://ww3.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf, Last accessed February 2020).
[21] California Air Resources Board, Short-Lived Climate Pollutant Reduction Strategy, released in March 2017 (web link: https://ww3.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf, Last accessed February 2020).
[22] *Mexichem Fluor, Inc. v. Environmental Protection Agency* (D.C. Cir. 2017) 866 F. 3d 451 (Mexichem I).
[23] *Mexichem Fluor, Inc. v. Environmental Protection Agency* (D.C. Cir. 2019) 760 Fed.Appx. 6 (Mexichem II).

Historically, U.S. EPA regulated[24] HFCs under two separate sections of the Clean Air Act. The existing federal regulations on HFCs include the following provisions:

- *U.S. EPA Rule 612 (40 Code of Federal Regulations, Part 82, Subpart G, Appendices U and V):* U.S. EPA implements the SNAP Program under Section 612 of the Clean Air Act (42 U.S.C. § 7671k, et seq.) to identify and evaluate substitutes for ODS.

- *U.S. EPA Rule 608 (40 Code of Federal Regulations, Part 82, Subpart F):* Section 608 of the Clean Air Act (42 U.S.C. § 7671g, et seq.) prohibits the knowing release of refrigerant during the maintenance, service, repair, or disposal of air-conditioning and refrigeration equipment. The U.S. EPA requires proper refrigerant management practices by owners and operators of refrigeration and air-conditioning systems, technicians, and others.[25]

State

The State of California is required to reduce Greenhouse Gas (GHG) emissions under various laws identified above. AB 32 specifically includes HFCs as one of the classes of GHG emissions and mandates their reduction. Under AB 32, GHG emissions in California must be reduced to 1990 levels by the year 2020. SB 32 builds upon AB 32 to require all GHG emissions be reduced 40 percent below 1990 levels by the year 2030. SB 1383 further requires annual HFC emissions to be reduced to 40 percent below 2013 levels by the year 2030. Additionally, SB 1013 prohibits the use of specific high-GWP HFCs in a wide range of end-use categories, including stationary refrigeration, insulating foam, aerosol propellants, and chillers.

CARB currently implements several regulatory programs to reduce HFC emissions from these sectors:

- *Refrigerant Management Program (RMP):*[26] RMP is modeled after the U.S. Environmental Protection Agency (U.S. EPA) Clean Air Act, Section 608 program to protect the stratospheric ozone layer by reducing usage and emissions of ozone-depleting substances. In addition to ozone-depleting substances, CARB also included non-ozone-depleting substance HFC refrigerants with a 100-year GWP of 150 or greater (considered "high-GWP").

- *California Prohibitions on High-GWP HFCs:*[27] In 2018, California backstopped key U.S. EPA SNAP Program prohibitions on high-GWP HFCs through two avenues. First, by adopting a new CARB HFC regulation ("Prohibitions on Use of Certain Hydrofluorocarbons in

[24] Due to the *Mexichem* decisions, HFCs are no longer prohibited under the SNAP program but U.S. EPA does continue to approve safe substitutes for CFCs and HCFCs.
[25] U.S. EPA released a proposed rule that would remove HFCs from the 608 requirements. See Protection of Stratospheric Ozone: Revisions to the Refrigerant Management Program's Extension to Substitutes, 83 Fed. Reg. 49332 (Oct. 1, 2018). As of February 10, 2020, U.S. EPA has not finalized the proposed rule.
[26] Cal. Code of Regs., tit. 17, §§ 95380, et seq.
[27] Cal. Code Regs., tit. 17, §§ 95371, et seq.

Stationary Refrigeration, Chillers, Aerosols, Propellants, and Foam End-Uses Regulation"), and secondly, through new legislation—SB 1013.

- *Additional HFC Measures:* California also implements regulations to reduce HFC emissions from consumer product aerosol propellants, semiconductor manufacturing, and small cans of HFC-134a used by at-home "DIYer" mechanics.[28]

Local

The South Coast Air Quality Management District (SCAQMD) regulates stationary commercial AC systems with over 50 pounds of ODS or high-GWP refrigerants:

- *District Rule 1415*: Affected entities must register, conduct leak inspections and keep records on site. Rule 1415 also contains requirements for any person who installs, repairs, maintains, services, relocates, or disposes of any AC system, and for any person who recycles, recovers, reclaims, distributes or sells high-GWP refrigerants. SCAQMD also implements Rule 1415.1, which is equivalents to the statewide RMP.

International

The importance of reducing HFC emissions to alleviate the worst impacts of global warming has also been recognized by the global community. In 2016, representatives from 197 nations signed "The Kigali Amendment" to amend the existing Montreal Protocol (to reduce ODS production and consumption) to include a gradual phase-down in the production of HFCs beginning 2019. The Kigali Amendments were ratified and entered into force on January 1, 2019. As of February 2020, 85 nations have ratified the Kigali Amendment.

Non-Article 5 Parties,[29] including Japan, Australia, Canada and the European Union (EU) have committed to reducing HFCs by 85 percent below 2012-2013 average annual usage baseline levels by the year 2036. Most Article 5 Parties have committed to reducing HFCs 80 percent by the year 2040, as compared to future average annual baseline usage of HFCs in years 2020, 2021, and 2022. Although the U.S. was a signatory, the U.S. has not ratified the Kigali Amendment as of February 2020. The majority of AC and refrigeration equipment manufacturers selling equipment to California are international corporations transitioning product lines away from high-GWP HFC refrigerants and have invested billions to bring next generation refrigerants and equipment to market.[30]

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[28] Contained in various sections, commencing with Cal. Code of Regs., tit. 13, §§ 1900 et seq.

[29] The Montreal Protocol separates countries into two different classifications based on the special situation of developing countries. Pursuant to the Montreal Protocol, Non-Article 5 Parties are developed countries and Article 5 Parties are developing countries whose annual calculated level of consumption of the controlled substance is less than 0.3 kilograms per capita on the date of the entry into force of the Protocol or any time thereafter within ten years of the date of entry into force. Article 5 Parties are entitled to a delay in compliance with certain control measures under the Montreal Protocol.

[30] AHRI & ARAP, Letter to United States Senate and House of Representatives (Oct. 8, 2019), available at: https://images.magnetmail.net/images/clients/AHRI/attach/FINALCEOLetterwithSignaturesFinal.pdf.

Energy Efficiency

The energy efficiency performance of most heating and cooling equipment is regulated by the National Appliance Efficiency Conservation Act (NAECA) and California Appliance Efficiency Regulations (Title 20) which are administered by the U.S. Department of Energy (U.S. DOE) and the California Energy Commission (CEC), respectively. Requirements promulgated under these regulations as well as voluntary labeling and incentive programs have resulted in significant emissions reductions and cost savings for end-users. While energy conservation standards can place upward pressure on equipment prices, the incremental price for efficient products has dropped rapidly along with a long-term decline in baseline prices.[31] In the Proposed Amendments, staff proposes to set the effective date for the 750 GWP limit for new ACs in 2023 in order to align with new efficiency standards taking effect and leverage the existing equipment redesign cycle for energy efficiency standards to reduce costs associated with transitioning refrigerants.

Building Codes and Industry Voluntary Standards

The American National Standards Institute (ANSI) is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. Both the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) and Underwriters Laboratory (UL) are ANSI-accredited standard setting bodies. UL develops and publishes product safety standards, which contain design criteria for appliances. Manufacturers build products in accordance with these safety standards and submit them to UL for testing. UL provides certification for these products if they meet the safety standards design criteria. ASHRAE develops and publishes application safety standards that describe equipment design and safe installation, often referred to as application safety standards. ASHRAE and UL have representative consensus guidelines for committees that develop standards to engage a diverse set of stakeholders. UL and ASHRAE standards are designed to complement one another and work in conjunction. Provisions from these standards are adopted in into building codes, whereby they become law. [32] In order for a refrigerant to be used in California, it must be allowed for use by these standard and code setting bodies.

2. Proposed Amendments

The Proposed Amendments would prohibit the use of high-GWP refrigerants in two sectors that contribute the most to statewide HFC emissions, namely, stationary refrigeration and AC equipment as well as one equipment type that falls into both stationary and AC sectors (chillers). The Proposed Amendments also includes adding in recordkeeping, reporting, and labeling requirements, and clarifying edits to the regulation. The Proposed Amendments are summarized below.

[31] Van Buskirk, et al. (2014), A Retrospective investigation of energy efficiency standards: policies may have accelerated long term declines in appliance costs (web link: https://iopscience.iop.org/article/10.1088/1748-9326/9/11/114010/pdf, Last accessed February 2020).
[32] California Mechanical Code, Cal. Code Regs., tit. 24, Part 4.

a. GWP Limits for New Equipment

The proposed requirements for new equipment are summarized in Table 1.

Table 1. Summary of Proposed Amendments for New Equipment

General End-Use	Specific End-Use	Prohibited Substances	Effective Date
Stationary Refrigeration	New refrigeration systems containing more than 50 pounds of refrigerant (non-residential) in newly constructed / remodeled facilities	Refrigerants with GWP greater than or equal to 150	January 1, 2022
Stationary AC	All new AC equipment, residential and non-residential	Refrigerants with GWP greater than or equal to 750	January 1, 2023
Chillers	All new chillers	Refrigerants with GWP greater than or equal to 750	January 1, 2024

For new equipment, there are two sectors impacted and one equipment type falling into both sectors (chillers):

- Refrigeration: Refers to the process of cooling products and/or processes, and storing chilled and/or frozen products at the appropriate temperatures. The Proposed Amendments will be applicable only to refrigeration systems containing more than 50 pounds of refrigerant. Facilities that use stationary refrigeration systems above that size threshold typically include, but are not limited to retail food facilities, for example, supermarkets and grocery stores; cold storage warehouses, food preparation and processing facilities; hotels and recreational facilities; facilities with other types of industrial process refrigeration (IPR) equipment. The rationale for the proposed GWP limit in new refrigeration equipment is to reduce the global warming impact of refrigerants inadvertently leaked from the equipment as a part of the equipment wear and fittings fatigue from normal use; average leak rates for even well-maintained refrigeration systems are between 10 and 20 percent of its entire refrigerant charge each year. SB 1013 HFC prohibitions in new refrigeration equipment still allow refrigerants up to 2,100 times more global warming than carbon dioxide. Continuing to use high-GWP refrigerants in new equipment is counter-productive to achieving the HFC emissions goal required by SB 1383.

- Air Conditioning: Refers to the use of a refrigerant to cool, heat or dehumidify air. An AC that uses a refrigerant to provide heating in addition to cooling is referred to as a heat pump and these types of systems are included in the Proposed Amendments. Stationary AC includes room ACs meant to condition air in a single room as well as central ACs used in residential, commercial and other non-residential settings. This includes all types of AC systems including those that use a refrigerant to provide heating in addition to cooling (heat pump), room ACs and dehumidifiers as well as ductless split and ducted split and packaged ACs used in residential, commercial and non-residential settings.[33] The rationale for the proposed GWP limit in new AC equipment is to reduce the significant and growing source of greenhouse gas emissions from AC end-uses. These end-uses represents the fastest growing source of HFC emissions in California; if left unchecked will reach 46 percent of emissions by 2030. Transitioning refrigerants in new equipment, which predominately use R-410A (GWP 2,088) is one of the most effective ways to mitigate the growing bank of high-GWP refrigerants in this sector.

- Chillers: Refers to equipment that uses water or heat transfer fluid to chill. They can be used for AC or refrigeration applications. For refrigeration, they are most commonly used in industrial processing refrigeration (IPR) facilities and sometimes in commercial facilities. The primary refrigerant used in a 'refrigeration chiller' is chosen based on the temperature needs of the facility (i.e., how cold the process and/or products need to be) and is usually coupled with a secondary fluid like glycol that circulates through the facility. Based on RMP data, an estimated 50 percent of the systems registered under IPR facilities are chillers. Larger buildings are often cooled by a central chiller that pumps chilled water to heat exchangers in air handling or fan-coil units that deliver conditioned air. Chillers are typically located in a machinery room or outdoors. Chillers can also be used to provide AC to multiple building by using a centralized plant to deliver chilled water via underground insulated pipes to multiple buildings in a process referred to as district cooling.[34]

The rationale for including chillers in the proposed regulation is to provide additional clarity to existing regulations used to implement SB 1013. The existing regulation contains a list of 24 specific refrigerants banned in new equipment beginning January 1, 2024. The proposed regulation eliminates any mention of specific refrigerants and replaces them with a single GWP limit of 750 in new equipment, which was the de facto previous GWP limit of the existing regulation, although no GWP limit was directly expressed. Using a single GWP limit instead of a list of refrigerants that may be subject to change will add clarity to the regulated community, and the flexibility to be used in the future without numerous changes to list additional prohibited refrigerants as they become available.

b. GWP Limits for Existing Facilities Using Refrigeration Systems

Apart from rules for new refrigeration systems in newly constructed and remodeled facilities, the Proposed Amendments will also require existing facilities to reduce their emissions in the following ways:

[33] In the rest of this document, the term AC is used for ACs and heat pumps that directly cool or heat air.
[34] SB 1013 banned specific refrigerants with high GWP values and the compliant refrigerant options for AC chillers are below the 750 GWP limit. Manufacturers of chillers have already commercialized equipment using next generation refrigerants in accordance with SB 1013's requirement prohibiting high-GWP refrigerants from being used in new chillers starting 2024.

- Due to their high emissions impact, retail food facilities such as supermarkets and grocery stores will be required to reduce their weighted-average GWP[35] to below 1,400 or reduce their Greenhouse Gas Emissions Potential or GHGp[36] (i.e., refrigerant amount multiplied by GWP, summed over all refrigerants used by the company across all their stores) from their existing systems by 55 percent by 2030.
- Across all non-retail food facilities, any new systems being installed in existing facilities must use refrigerants with GWP values less than 1,500. This is a preventative measure to disallow high-GWP refrigerants from being used in any refrigerated facility. For most refrigerated facilities, new systems with high-GWP refrigerants are already prohibited from use. This rule will help cover any remaining facilities.

Table 2. Summary of Proposed Rules for Refrigeration Equipment in Existing Facilities

Regulated Entity	Compliance Requirements	Compliance Date
Refrigerated Facilities excluding Retail Food Facilities	Prohibition on refrigerants with GWP greater than or equal to 1,500 in new systems containing more than 50 pounds of refrigerant	January 1, 2022
Retail Food Companies with greater than or equal to 20 Retail Food Facilities	Attain a company-wide weighted-average GWP below 2,500 or 25% reduction in GHGp below 2018 levels	January 1, 2026
	Attain a company-wide weighted-average GWP below 1,400 or 55% reduction in GHGp below 2018 levels	January 1, 2030
Retail Food Companies with fewer than 20 Retail Food Facilities	Attain a company-wide weighted-average GWP below 1,400 or 55% reduction in GHGp below 2018 levels	January 1, 2030

c. Recordkeeping, Reporting, and Labeling

The Proposed Amendments include labeling and recordkeeping requirements for refrigeration, AC, chillers, as well as some reporting requirements retail food facilities. Existing labels meeting the requirements may be used. For retail food facilities, existing reporting and recordkeeping requirements under the Refrigerant Management Program regulation will help end-users comply with the reporting requirements under the Proposed Amendments. For AC manufacturers, the

[35] Weighted-average GWP is defined as the average GWP of all refrigerants used by a retail food company across all their stores and systems with more than 50 pounds of refrigerant each, weighted by the pounds of each refrigerant. For more information, see Section C.
[36] Greenhouse Gas Emissions Potential (GHGp) is defined as the pounds of each refrigerant multiplied by its GWP, summed over all refrigerants used across all stores owned by a company in systems containing more than 50 pounds of refrigerant. For more information, see Section C.

recordkeeping requirements are not expected to be additional to the standard business practices.

3. Statement of the Need of the Proposed Regulation

Climate scientists agree that global warming and other shifts in the climate system observed over the past century are caused by human activities and that these recorded changes are occurring at an unprecedented rate.[37] California is already feeling the impacts of climate change, and projections show that these effects will continue and worsen. The impacts of climate change on California have been documented by the Office of Environmental Health Hazard Assessment (OEHHA) in the *Indicators of Climate Change Report*.[38]

Californians are experiencing hot days and nights more frequently while California has become drier and more susceptible to drought. Statewide precipitation has become increasingly variable and changes in snowpack have led to less reliable water supply. Extreme weather events such as coastal storm surges, drought, wildfires, floods, and heat waves, are expected to become more frequent and more severe. As GHG emissions continue to accumulate and climate disruption grows, destructive weather events will become more frequent. Climate change is making events like these more frequent, more catastrophic, and costlier. The total statewide economic cost of the 2013–2014 drought was estimated at $2.2 billion, with a total loss of 17,100 jobs.[39] In the Central Valley, the drought cost California agriculture about $2.7 billion and more than 20,000 jobs in 2015.[40] It is imperative that California continue to work to reduce GHG emissions in order to decrease the impacts. California has instituted specific legal mandates to reduce GHG and more specifically, SLCPs, including HFC emissions.

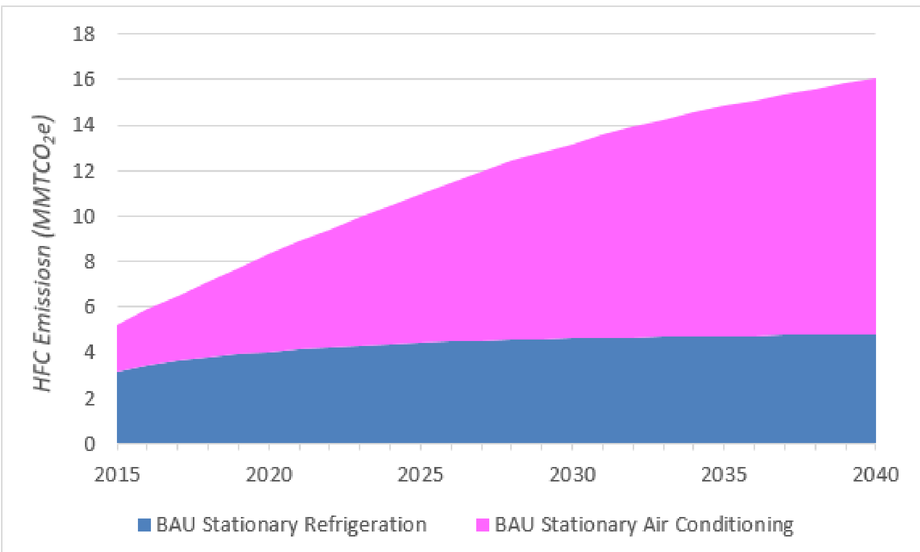
HFCs are powerful climate forcers. While they remain in the atmosphere for a much shorter time than carbon dioxide, their relative global warming potentials can be thousands of times greater than CO_2. The mix of HFCs in current use, weighted by usage (tonnage), has an average atmospheric lifetime of 15 years. The warming impact of any GHG depends on how long the gases stay in the atmosphere. Since the average lifetime of HFCs is 15 years, their warming impact or their GWP values, are higher when considered over a 20-year timeframe compared to a 100-year timeframe. For example, the average 100-year GWP of the current mix of HFCs being used as refrigerants is less than half the average 20-year GWP. This highlights the fact the damage caused HFCs is significantly worse when considered in the near term. Additionally, not only are HFCs thousands of times more potent than CO_2 but they also represent the fastest growing source of greenhouse gas emissions in California, the U.S., and globally.[41] The primary

[37] Cook, et al., 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. (web link: https://advances.sciencemag.org/content/advances/1/1/e1400082.full.pdf, Last accessed February 2020).
[38] Office of Environmental Health Hazard Assessment, 2018. Indicators of Climate Change in California. (web link: https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf, Last accessed February 2020).
[39] Howitt, et al., 2014 Economic Impacts of 2014 Drought on California Agriculture. July 23, 2014. (web link: https://watershed.ucdavis.edu/files/biblio/DroughtReport_23July2014_0.pdf, Last accessed February 2020).
[40] Williams, et al., 2015. Contribution of anthropogenic warming to California drought during 2012–2014. (web link: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015GL064924, Last accessed February 2020).
[41] Intergovernmental Panel on Climate Change, 2014. Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the

factor driving the large increase of HFC use and emissions in the air-conditioning and refrigeration sectors is that new equipment using HFC refrigerants are replacing older equipment using ozone-depleting substance (ODS) refrigerants. Because ODS emissions are intentionally not included in California's GHG Inventory (by design of the Kyoto Protocol and AB 32), the growth of HFC emissions reflects not only simple growth in the number of new equipment used each year, but also the replacement of ODS equipment with HFC equipment.

As shown in Figure 2., HFC emissions from stationary refrigeration and stationary AC are expected to increase more than 50 percent by 2030 if left unchecked. This growth in HFC emissions would greatly undermine efforts to address climate change.

Figure 2. Business-As-Usual HFC Emissions in California from 2010 to 2040



The first goal of the Proposed Amendments is to take steps towards addressing climate change. Acting now to reduce HFC emissions can have an immediate beneficial impact on climate change. The most recent 2018 IPCC report analyzed the impacts associated with a warming of 1.5°C. The IPCC report indicates that significant changes will need to be made to avoid the most devastating impacts of a 2°C temperature increase.[42]

The second goal of the Proposed Amendments is to meet California's statutory mandates. Recognizing the importance of mitigating climate change, the California Legislature enacted several laws aimed to reduce both GHG and HFC emissions. In 2006, the California Legislature adopted AB 32 requiring a reduction of GHG emissions to 1990 levels by 2020. In 2016, the Legislature adopted SB 32, further strengthening the mandate by requiring GHG reductions to 40 percent below 1990 levels by 2030. That same year, the Legislature adopted SB 1383

Intergovernmental Panel on Climate Change. (web link: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf, Last accessed February 2020).

[42] Intergovernmental Panel on Climate Change, Special Report: Global Warming of 1.5°C, 2018. (web link: https://www.ipcc.ch/sr15/, Last accessed February 2020).

requiring a 40 percent reduction in HFC emissions below 2013 baseline levels by the year 2030. CARB adopted several plans and regulations already to meet these mandates.

California Health and Safety Code sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, and 41511 grant CARB authority to adopt regulations that reduce emissions of GHGs and HFCs and to "do that which is necessary" to carry out CARB's purpose. California Health and Safety Code sections 39730, 39730.5, and 39734 specifically grant CARB authority to regulate HFCs. Under these laws, CARB is authorized to regulate stationary refrigeration and AC as emissions sources.

Despite several HFC emissions reductions programs in place, CARB analysis estimates that the 2030 HFC emissions goal cannot be reached using only current measures. Based on CARB's 2017 F-gas Inventory (published in 2019), with existing regulations in place, annual HFC emissions in California are projected to be approximately 20 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 2030.[43] The SB 1383 emissions reduction goal of 40 percent below 2013 emissions by 2030 equates to annual emissions of 10 $MMTCO_2e$ or less by 2030. Thus, on annual basis, by 2030, annual emissions reductions of at least 10 $MMTCO_2e$ are needed from additional regulatory measures and/or incentive programs. New system GWP limits are needed to restrict the banks of high GWP refrigerants in California in both refrigeration and AC equipment. As shown in **Figure *2*.**, together, refrigeration and AC end-uses contributed 34 percent of all HFC emissions in California in 2018. Stationary AC is the fastest growing of all sectors that use HFCs as refrigerants and is projected to contribute 46 percent of all HFC emissions in 2030—the largest of any individual sector contribution. Apart from fire suppressants, it is also the only HFC emission sector that is not yet regulated by CARB.

On average, depending on system type and size, the regulated refrigeration systems survive between 15 to 20 years. It is worth noting that some facilities like supermarkets use their systems well past this average lifetime, and by some industry accounts, for up to 30 years. Thus, once a product using HFCs is installed or otherwise placed into use in California, it is difficult to require removal, and "locks in" those HFC emissions over the lifetime of the product. Based on user-reported data from the Refrigerant Management Program in 2018, 30 to 40 percent of all regulated refrigeration systems in the State today use R-404A or R-507; which are HFC refrigerants with very high GWP values of nearly 4,000. Additionally, more than 30 percent of the systems continue to use R-22, an ozone depleting HCFC refrigerant being phased out under the Montreal Protocol. The R-22 systems in particular are aging and nearing their retirement. Under business-as-usual over the next 10 years, they will be replaced by refrigerants like R-407A, which has a GWP of 2,100, higher than that of R-22.

Similarly, AC equipment survives between 15 and 20 years, depending on equipment type. More than half of AC equipment currently uses HCFC-22, an ODS which is scheduled for a complete production and import phase-out in the United States by 2020. The HCFC-22 refrigerant is being replaced with HFCs that have higher GWPs, thus increasing the GHG impact of refrigerants. In anticipation of the HCFC-22 phase-out by 2020, most owners of equipment using HCFC-22 will

[43] California Air Resources Board, 2017. California High GWP Gases Inventory for 2000-2017 – by Sector and Activity. Available at: https://ww3.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_sector_sum_2000-17hgwp.pdf, Last accessed February 2020).

either replace the equipment by 2020, or at a minimum replace the HCFC-22 refrigerant in the same equipment (retrofit) with a high-GWP HFC refrigerant.

A window of opportunity exists in the next five years to accelerate the transition of refrigeration and air-conditioning equipment to lower-GWP refrigerants, before another generation of equipment is locked into using higher-GWP refrigerants. In addition to taking action during a critical time period for preventing the worst impacts of climate change, industry has stressed the importance of regulatory certainty to signify that the time to transition the market to more climate friendly refrigerants is now.

In September 2018, nine chemical and equipment manufacturing companies, the Air-Conditioning, Heating, and Refrigeration Institute (AHRI), which represents companies that produce over 90 percent of equipment in North America, and the Natural Resources Defense Council (NRDC) sent a letter to CARB urging CARB to adopt a regulation prohibiting refrigerants with a GWP of 750 or greater in new stationary AC equipment beginning January 1, 2023.[44] The signatories to the letter identified this date to balance environmental benefit while minimizing cost impacts on consumers, and to provide adequate time for manufacturers, distributors, and contractors to prepare for a safe and efficient transition to lower-GWP technologies. CARB responded immediately to the industry's request for certainty as to the date of the transition to more climate friendly AC in California.

Additional goals are to provide regulatory certainty to businesses in California, clarify the existing regulations, and help advance more sustainable cooling technologies in the State.

4. Major Regulation Determination

CARB staff determined that the Proposed Amendments is a major regulation as the analysis shows a greater than $50 million economic impact over a 12-month period after full implementation. The first equipment prohibitions under the Proposed Amendments will become effective January 1, 2022 and will be fully implemented the following year for new equipment and in 2030 for the existing retail food facilities. This SRIA analyzes the costs from the first compliance date out to one average equipment lifetime for regulated refrigeration and AC equipment i.e., 2022 to 2040. Please see Section D, Macroeconomic Impacts for the analysis.

5. Baseline Information

To estimate the economic impacts of the Proposed Amendments, CARB evaluated the economic and emissions impacts of the proposal relative to the business-as-usual (BAU) or "baseline" scenario each year for the analysis period from 2020 to 2040. CARB maintains a California specific Fluorinated Gas (F-Gas) Inventory as a part of the statewide GHG Emission Inventory that is used for establishing historical emission trends and tracking California's progress in reducing greenhouse gases. To determine the baseline scenario for the economic and emissions analysis,

[44] AHRI, NRDC, Carrier Corporation, Daikin Applied Americas, Inc., Goodman Manufacturing Company, L.P., Lennox International, Nortek Global HVAC LLC, Trane Inc., The Chemours Company, Honeywell International Inc., Letter to Chair Nichols. 14 September 2018. (web link: http://www.ahrinet.org/Portals/_Appleseed/documents/news/AHRI_NRDC_CARB_Letter_regarding_SLCP_HFC_measures.pdf, Last accessed February 2020).

CARB used its F-Gas Inventory and the DOF population forecasts as a basis for the analysis. The regulatory proposal and alternative scenarios result in economic and emissions changes relative to the baseline scenario and those are discussed throughout the document.

For the SRIA, the F-Gas Inventory is used to estimate emissions under BAU and alternative scenarios and to forecast the number of AC and refrigeration units each year through 2040 for which there are direct costs or benefits associated with the Proposed Amendments. For additional information regarding the F-Gas Inventory methodology, see referenced publicly available documents.[45] Unit populations, such as AC and refrigeration units, are assumed to increase proportionally to population, unless data indicate otherwise. CARB staff uses the California Department of Finance (DOF) population projections for estimating growth rates.[46]

Under the BAU scenario, as modeled in the F-Gas Inventory, it is assumed that all entities are in full compliance with current regulations governing the use of fluorinated refrigerants in the state. A description of how policies affecting refrigeration and or air conditioning systems are taken into account in the BAU scenario is provided below:

- *California SNAP*: This includes CARB's HFC Regulation, "Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning, Chillers, Aerosols, Propellants, and Foam End-Uses" which incorporates SB 1013. California SNAP adopted key federal prohibitions on the use of very high-GWP refrigerants originally issued under the U.S. EPA SNAP Rules 20 and 21 as they read in January 2017 prior to being partially vacated. The BAU GWP utilized in this analysis reflects the use of compliant refrigerants in new and retrofit systems.

- *California Refrigerant Management Program:* The RMP regulation is aimed at minimizing leaks of refrigerants from refrigeration systems containing more than 50 pounds of refrigerants with GWP values greater than 150. RMP data on average refrigerant amount used per system, or "charge size", and annual leak rates are used to update the F-Gas Inventory inputs that are used in this analysis.

- *U.S. DOE Energy Conservation Standards:* U.S. DOE sets minimum energy conservation standards under the NAECA for appliances and equipment used in homes, businesses, and other applications, including small self-contained, commercial and residential AC. The baseline for this analysis incorporates equipment, installation, maintenance and repair costs from the U.S. DOE's Technical Support Documents[47] for the efficiency standards in effect today, some of which have future compliance dates.

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[45] California Air Resources Board, California's High Global Warming Potential Gases Emission Inventory, 15th Ed., 2016. (web link: https://ww3.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf, Last accessed February 2020).

[46] California Department of Finance, 2019. Population Projections. http://www.dof.ca.gov/Forecasting/Demographics/Projections/, Last accessed December 2019).

[47] Energy Conservation Program: Energy Conservation Standards for Residential Central Air Conditioners and Heat Pumps, 82 Fed. Reg. 1786 (Jan. 6, 2017); See Technical Support Documents submitted as part of rulemaking available here: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0048-0102; Energy Conservation Standards for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment, 81 Fed.

Additional information on these policies can be found in **Section *1***, Regulatory History of this document. The information used in this to develop the baseline emissions on populations for regulated refrigeration and AC systems is discussed below.

a. Stationary Refrigeration Systems

The baseline emissions from this category depend on the projected populations of and the sizes of the systems. The following sections describe the characteristics and population projects of the regulated refrigeration systems that make up the baseline. For the purposes of this analysis, CARB categorizes stationary refrigeration systems containing more than 50 pounds of refrigerant into the three end-use sectors listed below.

- *Commercial Refrigeration:* This end-use sector comprises mainly retail food facilities designed to store and display chilled or frozen goods for commercial sale, for example, in supermarkets and grocery stores. In addition, some commercial systems are used in merchant wholesale facilities, hotels, amusement parks, etc.

- *Industrial Process Refrigeration:* This sector includes systems that cool process streams in industrial applications. This includes, but is not limited to, food and non-food production and manufacturing, respectively. The choice of refrigerant for specific applications depends on ambient and required operating temperatures and pressures.[48]

- *Cold Storage Warehouses:* This sector includes systems in facilities that "store meat, produce, dairy products, and other perishable goods. The majority of cold storage warehouses in the United States use ammonia as the refrigerant in a vapor compression cycle, although some rely on other refrigerants."[49]

This system classification broadly aligns with the U.S.EPA's SNAP end-uses of retail food refrigeration, industrial process refrigeration and cold storage warehouses. These systems are currently subject to CARB's Refrigerant Management Program (RMP) under which they have to provide annual reports on their refrigerant purchase and use and follow best leak management practices.[50] The RMP has three size classes for the refrigeration systems, which are as follows:

Table 3. Refrigeration system size classes in CARB's Refrigerant Management Program

System Size	Full charge of system (amount of high-GWP refrigerant contained)
Large	2,000 pounds and above
Medium	200 to under 2,000 pounds
Small	Over 50 to under 200 pounds

Reg. 2420 (Jan. 15, 2016); See Technical Support Documents submitted s part of rulemaking available here: https://www.regulations.gov/docket?D=EERE-2013-BT-STD-0007 (Hereinafter collectively "U.S. DOE Technical Support Documents").

[48] United States Environmental Protection Agency definitions, (web link: https://www.epa.gov/snap/substitutes-refrigeration-and-air-conditioning, Last accessed February 2020).

[49] *Ibid.*

[50] California Air Resources Board, Refrigerant Management Program, (web link: https://ww2.arb.ca.gov/our-work/programs/refrigerant-management-program, Last accessed February 2020).

The same size classes are used for this analysis. This helps align the implementation of the Proposed Amendments with the already established RMP. Here on, stationary refrigeration systems containing more than 50 pounds of refrigerant are referred to as "regulated refrigeration systems" in this document. Baseline characteristics for regulated refrigeration systems are based on CARB's F-Gas Inventory and the RMP database, and are given in Table 4.

Table 4. Baseline Characteristics for New Stationary Refrigeration Systems

System Type	Baseline Refrigerant for New Systems	Baseline GWP (100-year, AR4[51])	Lifetime (Years)	Average Full Charge (lb.)	Average Annual Leak Rate (%)
Commercial Refrigeration					
Large	R-407A	2,107	15	3,352	24.2%
Medium			15	684	22.9%
Small			20	103	15.6%
Industrial Process Refrigeration					
Large	R-404A, R-507, R-134a	3,066	20	5,873	12.3%
Medium			20	660	12.5%
Small			20	104	9.1%
Cold Storage					
Large	R-448A / R-449A	1,391	20	7,252	14.8%
Medium			20	552	10.3%
Small			20	113	3.7%

For all refrigeration systems, the average end-of-life leak rate is 20 percent.

For commercial refrigeration and cold storage, the baseline GWP for new systems in new construction is the maximum allowable GWP value under the current California SNAP regulation and SB 1013. Industrial process refrigeration systems are not currently included in the original California SNAP regulation or SB 1013; the baseline GWP for new systems in that sector is based on the F-Gas Inventory and is the weighted-average GWP of all the refrigerants used in the sector. The average system lifetimes and refrigerant charge sizes are from the F-Gas Inventory.[52] To reflect the current state of emissions, the average annual leak rates used in this analysis are based on refrigerant leak data reported by end-users to CARB's RMP in 2018. The average end-of-life leak rates are from CARB's F-Gas Inventory and align with the U.S. EPA's estimates.[53]

Based on the F-Gas Inventory, commercial refrigeration systems, most of which are used in supermarkets and grocery stores comprise 74 percent of all high-GWP refrigeration systems, followed by industrial process refrigeration and cold storage, which account for 22 percent and 4 percent of the high-GWP refrigeration systems, respectively. Since the majority of the regulated

[51] AR4: Fourth Assessment Report issued in 2007 by the United Nations Intergovernmental Panel on Climate Change.
[52] California Air Resources Board, 2016, California's High Global Warming Potential Gases Emission Inventory: Emission Inventory Methodology and Technical Support Document, *2015 Edition* (web link: https://ww3.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf, Last accessed February 2020).
[53] Accounting Tool to Support Federal Reporting of Hydrofluorocarbon Emissions: Supporting Documentation, September 2, 2014. Prepared for the Stratospheric Protection Division, Office of Air and Radiation, U.S. EPA by ICF International. Available at https://www.epa.gov/snap/accounting-tool-support-federal-reporting-hydrofluorocarbon-emissions (accessed 7 February 2020).

refrigeration systems are used in retail food industry, that is to say in supermarkets and grocery stores, the Proposed Amendments include additional requirements for existing supermarkets and grocery stores, as outlined in section A.2.

I. Projected Populations of Regulated Refrigeration Systems

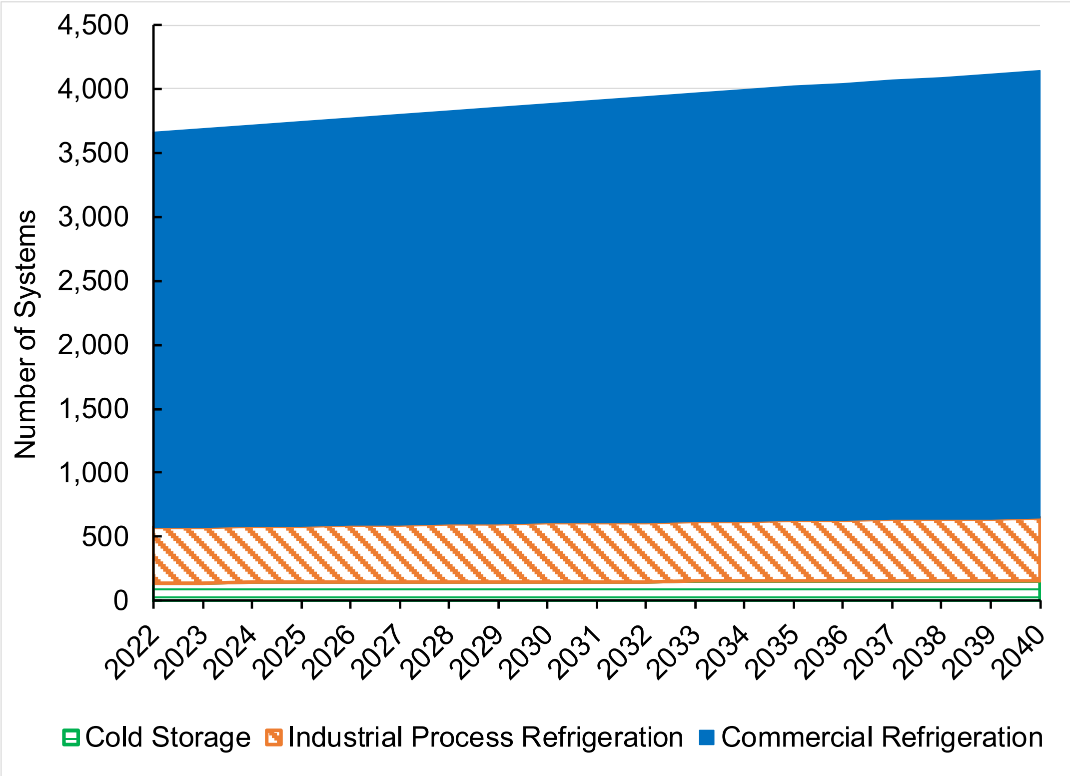
CARB staff used the F-Gas Inventory to estimate the number of new systems entering the California market to quantify baseline emissions and costs related to the Proposed Amendments. The F-Gas Inventory uses data from the following sources to estimate stationary refrigeration system populations:

- Research report by Armines, "Inventory of Direct and Indirect GHG Emissions from Stationary Air conditioning and Refrigeration Sources" for CARB, 2009.[54]
- 2012 Report on Greenhouse Gas Performance Analysis by ICF International.[55]
- Data from CARB's Refrigerant Management Database—Refrigerant Registration and Reporting System or R3.[56]
- Projected population growth from the California Department of Finance.[57]

The number of refrigeration systems within California is growing due to (1) new construction of refrigerated facilities, and (2) due to replacement of retiring equipment in existing facilities. On average, the annual growth in regulated refrigeration equipment correlates with population growth in the state. This is based on the assumption that as population increases, facilities like supermarkets and cold storage warehouses will increase proportionally to serve the additional population. In 2019, DOF projected annual average population growth rates between 0.80 and 0.58 percent between 2020 and 2040. ***Figure* 3.** shows the projected number of new regulated refrigeration systems based on DOF-projected growth rates by end-use sector:

[54] Armines et al., 2009. Inventory of Direct and Indirect GHG Emissions from Stationary Air conditioning and Refrigeration Sources, with Special Emphasis on Retail Food Refrigeration and Unitary Air Conditioning, Final Report, March 2009. CARB research contract 06-325. (web link: https://ww3.arb.ca.gov/research/apr/past/06-325.pdf, Last accessed February 2020).
[55] ICF International, 2012. Greenhouse Gas Performance Analysis for Commercial Buildings with Large Refrigeration and Air Conditioning Systems, Final Report, May 2012. CARB research contract 09-306. (web link: https://ww3.arb.ca.gov/research/apr/past/09-306.pdf, Last accessed February 2020).
[56] California Air Resources Board, 2019. Refrigerant Management Program database, R3. (web link: https://ssl.arb.ca.gov/rmp-r3/, Last accessed February 2020).
[57] California Department of Finance, 2019. Population Projections. (web link: http://www.dof.ca.gov/Forecasting/Demographics/Projections/, Last accessed February 2020).

Figure 3. New refrigeration systems between 2022 and 2040



As mentioned earlier, most refrigeration systems containing more than 50 pounds of HFC refrigerants are used in commercial refrigeration, followed by industrial process refrigeration and cold storage. Annually, new refrigeration systems can either be installed in newly constructed or fully remodeled facilities or they can be used to replace equipment reaching end of their useful life in existing facilities. Based on CARB's F-Gas Inventory, majority of new systems in any given year are used to replace retiring equipment in existing facilities. For example, even though the figure above shows more than 3,500 new regulated refrigeration systems being added in 2020, most of the new units annually are used to replace systems reaching end of life and approximately only 10 to 13 percent of those are used in new construction.[58] In the baseline scenario, the new systems use refrigerants with GWP values between 2,000 and 4,000 depending on the end-use sector. Under the Proposed Amendments, new systems in new facilities will be required to use refrigerants with a GWP less than 150, while existing facilities will be required to use refrigerants with a GWP less than 1,500 across all end-use sectors.

According to the F-Gas Inventory and CARB's RMP program, retail food refrigeration is the largest sub-set of commercial refrigeration. Retail food refrigeration encompasses supermarkets and grocery stores which use 70 percent of the regulated refrigeration systems in California and

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[58] Since new construction is assumed to correlate with population growth, in any given year, an average of 0.76 percent of the operational systems are assumed to be added in newly constructed facilities. Depending on average system lifetime, 0.76 percent of operational units equates to 10 to 13 percent of all new systems per year installed in new construction. For this analysis, a similar percentage is assumed to be used in remodeled facilities. See Appendix

Table 63 for more detail.

have the largest amounts of high-GWP refrigerants *banked* inside them. Additionally, systems used for retail food refrigeration have the highest average annual leak rates compared to any other sector.

Table 5 below shows that in 2022, less than 1 percent of the operational systems are expected to be used in new facilities while 99 percent of the systems will be used in existing facilities. Thus, existing facilities hold the highest potential for emissions reductions. Under the baseline scenario, these existing systems would continue to use refrigerants with GWP values between 2,000 and 4,000. Under the Proposed Amendments, new systems in new facilities will be subject to a GWP limit of 150, while existing facilities will be required to reduce their emissions by more than 50 percent. Together, the proposed rules will result in significant emissions reductions while ensuring a greater market adoption of truly sustainable, low-GWP (i.e., GWP < 150) technologies in this sector.

Table 5. Post-Rule Projected Populations of Retail Food Refrigeration Systems

Year	New Systems in New Facilities [a]	Existing Facilities New Systems Replacing Retiring Systems [b]	Existing Facilities Existing Systems (not yet reached end-of-life) [c]	Total Projected Population of Retail Food Systems [d]
2022	256	1,884	34,651	36,791
2023	514	3,783	32,835	37,132
2024	773	5,693	31,001	37,467
2025	1,032	7,598	29,167	37,798
2026	1,290	9,491	27,344	38,124
2027	1,545	11,364	25,540	38,449
2028	1,796	13,206	23,767	38,770
2029	2,041	15,008	22,036	39,086
2030	2,282	16,772	20,345	39,400
2031	2,517	18,495	18,700	39,712
2032	2,745	20,152	17,127	40,023
2033	2,965	21,760	15,608	40,333
2034	3,180	23,324	14,137	40,641
2035	3,382	24,790	12,773	40,946
2036	3,573	26,174	11,500	41,247
2037	3,758	27,511	10,278	41,547
2038	3,934	28,779	9,132	41,844
2039	4,097	29,951	8,091	42,139
2040	4,247	31,021	7,164	42,431

[a] New systems in newly constructed facilities – required to use refrigerants with GWP less than 150, starting 2022 under the Proposed Amendments.
[b] New systems replacing retiring equipment in existing facilities -– required to have an average GWP less than 1,400 under the Proposed Amendments on a company-wide basis.
[c] Existing systems that have not reached their end of life – required to have an average GWP less than 1,400 under the Proposed Amendments on a company-wide basis.
[d] Total population of retail food systems = new systems + existing systems (i.e., footnotes *a* + *b* + *c*).
Projected populations of other regulated refrigeration systems (i.e., cold storage and industrial process refrigeration) are given in Table 63 of the Appendix.

b. Stationary AC

The Proposed Amendments affects all types of ACs. For the purpose of this analysis, CARB is categorizing this equipment into the following general categories consistent with the F-Gas Inventory:

Room ACs: This category consists of small AC units that are factory sealed and used for conditioning one room at a time. This includes window-mounted, through-the-wall, portable units, packaged terminal ACs (PTAC), packaged terminal heat pumps (PTHP) typically used in hotels, and dehumidifiers. Due to their small size and relatively low cost, these units are used in private residences, apartments, as well as hotels, small offices, and small shops. While other countries refer to ductless split ACs (mini splits) as room ACs, these types of units are classified as central ACs in the United States and are included in the categories described below.

Residential AC/Heat Pump (HP): This category of equipment is sometimes referred to as "central" or "unitary" AC and includes non-ducted split systems and ducted split and single packaged systems used in residences. In California, the most common type of residential AC is a ducted system that uses a refrigerant to condition air in a central location and the air is distributed to and from rooms by one or more fans and ductwork. Ducted systems can be split systems that connect an indoor and outdoor unit via refrigerant piping or packaged systems that are factory sealed.

CARB tracks residential ACs and residential heat pumps as separate categories in the F-Gas Inventory because of the interest heat pumps have received as a potential strategy for reducing emissions from natural gas use related to heating homes. The main difference between residential and commercial units is the size and capacity of the system to condition larger spaces. Units under 65,000 Btu/hr are categorized as residential, consistent with AHRI certification standards and the U.S. DOE energy equipment categories in their energy conservation standards.[59] According to AHRI shipment data, approximately 96 percent of shipments are residential ACs.[60]

Commercial AC: AHRI certification standards and the U.S. DOE use 65,000 Btu/hr as the size threshold to distinguish between ACs used in residential and commercial and other non-residential settings. For the purpose of this analysis, the commercial AC category includes AC units used in commercial buildings and non-residential uses such as state buildings, schools and hospitals. While commercial ACs make up approximately 4 to 5 percent of AC shipments, CARB distinguishes between two size ranges of commercial equipment because of the difference in baseline cost and the emission profile of these units. This category includes both ACs and heat pumps but they are not disaggregated as separate categories.

[59] 10 C.F.R. § 430.32 2017; 11 C.F.R. § 431.92 2016.

[60] Air-Conditioning, Heating, and Refrigeration Institute (AHRI) monthly shipment data reports. Web link at: http://www.ahrinet.org/statistics (accessed February 2020).

- *Commercial AC (Small to Medium):* Units ≥ 65,000 Btu/hr and < 135,000 Btu/hr are classified as small to medium, consistent with the U.S. DOE equipment categories used in their energy conservation standards. [61]
- *Commercial AC (Large):* Units ≥ 135,000 Btu/hr are classified as large, consistent with the U.S. DOE equipment categories used in their energy conservation standards.[62]

The majority of ACs sold in California today use the refrigerant R-410A, which has a GWP value of 2,088, with the exception of room ACs, which have already begun to transition to a lower-GWP refrigerant. Room ACs such as portable and window/wall ACs are already available on the California market today with R-32, which has a GWP value of 675. While the baseline refrigerant is predominately R-410A across different AC categories, the average unit lifetimes, charge size and leak rates vary by equipment type. ***Table 6*** lists these baseline characteristics from CARB's F-Gas Inventory.[63] Staff use these factors to estimate emissions on a per unit basis and in the cost impact analysis.

Table 6. Baseline characteristics for stationary AC

System Type	Baseline Refrigerant	Baseline GWP (100-year, AR4)	Lifetime (Years)	Average Charge Size (lbs.)	Average Annual Leak Rate (%)	Average End-of-Life Leak Rate (%)
Room AC – window/wall	R-410A; R-32	1,382	12	1.54	2.0%	98.5%
Room AC – portable	R-410A; R-32	1,382	10	1.54	1.0%	98.5%
Room AC – PTAC/PTHP	R-410A; R-32	1,382	12	1.0	2.0%	98.5%
Room AC – dehumidifiers	R-410A	2,088	5	1.0	1.0%	98.5%
Residential AC	R-410A	2,088	15	8.157	5.3%	80.0%
Residential HP	R-410A	2,088	15	7.5	5.0%	80.0%
Non-residential AC (≥ 65k to <135,000k BTUH)	R-410A	2,088	20	25	10.0%	56.0%
Non-residential AC (≥ 135,000k BTUH)	R-410A	2,088	20	60	7.0%	20.0%

[61] 11 C.F.R. § 431.92 2016.
[62] Ibid.
[63] California Air Resources Board, 2016, California's High Global Warming Potential Gases Emission Inventory: Emission Inventory Methodology and Technical Support Document, 2015 Edition (web link: https://ww3.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf, Last accessed February 2020).

II. Projected Populations of Regulated AC Equipment

CARB staff used the F-Gas Inventory to estimate the number of new ACs entering the California market to quantify baseline emission and costs related to this regulation. The number of AC units within California is growing, due to both continued construction of new buildings and because more and more buildings are installing ACs. CARB estimates AC equipment growth rates based on historical shipment data, housing and population projections growth, and AC saturation trends. The F-Gas Inventory uses data from the following sources for to estimate stationary AC equipment populations:

- National shipment data from the AHRI from 1999 to 2018.[64]
- California shipment data from Heating, Air-conditioning and Refrigeration Distributors International (HARDI).
- 2009 California Residential Appliance Saturation Surveys (RASS).[65]
- U.S. Energy Information Agency (EIA) Residential Energy Consumption Survey (RECS).[66]
- Population and housing demographic information from the California Department of Finance.[67]

The number of AC equipment using F-Gases correlate strongly with population.[68] DOF projects annual average population growth rates between 0.8 and 0.6 percent between 2020 and 2040 with an average of 0.7 percent. However, based on annual AC equipment shipments from 2000 through 2018 tracked by AHRI, we know that AC usage has historically grown faster than population growth in California, and if global warming continues, we expect this trend to continue into the future.[69] For residential ACs, staff estimates equipment growth at 1.5 times that population growth (1.1 percent annual equipment growth). For residential heat pumps, staff estimates equipment growth as double the annual population growth (1.5 percent annual equipment growth). For all other AC equipment categories staff estimates equipment growth as an equivalent one-to-one correlation with population growth. The figure below shows the number of projected new ACs based on these growth rates.

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[64] Air Conditioning, Heating, & Refrigeration Institute, 2019. Central Air Conditioners and Air-Source Heat Pumps" U.S. Manufacturers' Shipments of Central Air Conditioners and Air-Source Heat Pumps, 1999-2018. (web link: http://www.ahrinet.org/Resources/Statistics/Historical-Data/Central-Air-Conditioners-and-Air-Source-Heat-Pumps, Last accessed February 2020).

[65] California Energy Commission, 2010. California 2009 Residential Appliance Saturation Study (RASS). *https://ww2.energy.ca.gov/appliances/rass/previous_rass.html*, Last accessed February 2020).

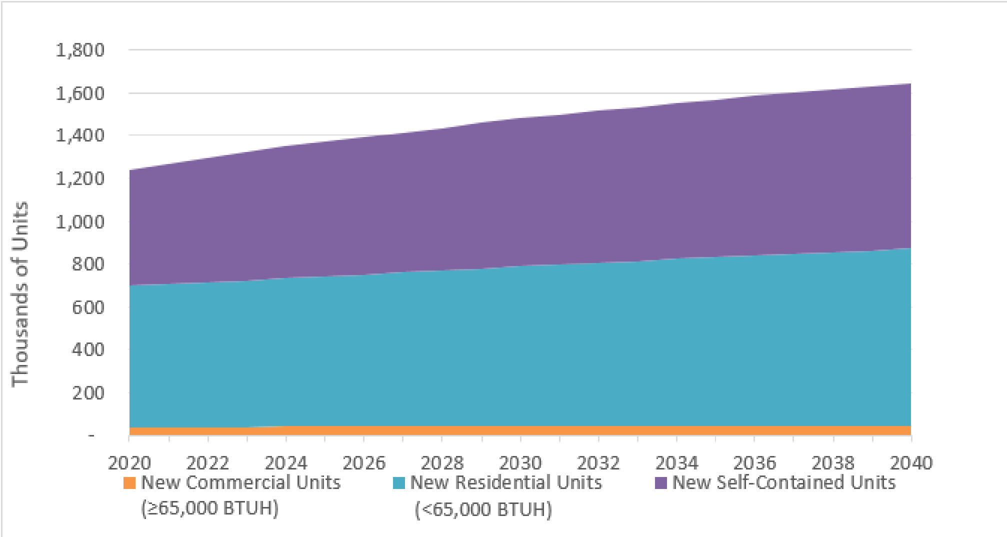
[66] California Energy Commission, 2010. California 2009 Residential Appliance Saturation Study (RASS). (web link: https://ww2.energy.ca.gov/appliances/rass/previous_rass.html, Last accessed February 2020). See also Energy Information Administration, Residential Energy Consumption Survey (RECS), 2003, 2009 and 2015 Survey Years. (web link: https://www.eia.gov/consumption/residential/data/2015/, Last accessed February 2020).

[67] California Department of Finance, 2019. Population Projections. http://www.dof.ca.gov/Forecasting/Demographics/Projections/, Last accessed February 2020).

[68] Barletta, et al., 2013. Emission estimates of HCFCs and HFCs in California from the 2010 CalNex study. (web link: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/jgrd.50209, Last accessed February 2020).

[69] Air Conditioning, Heating, & Refrigeration Institute, 2019. Central Air Conditioners and Air-Source Heat Pumps" U.S. Manufacturers' Shipments of Central Air Conditioners and Air-Source Heat Pumps, 1999-2018. (web link: http://www.ahrinet.org/Resources/Statistics/Historical-Data/Central-Air-Conditioners-and-Air-Source-Heat-Pumps, Last accessed February 2020).

Figure 4. Projected New AC Shipments to California (2020 to 2040)



The projected populations of regulated AC equipment through 2040 is given below:

Table 7. Projected Shipments of Stationary AC Equipment

Year	New Air-Conditioning Units		
	Non-residential	Residential	Small Self-Contained AC
2020	37,797	659,713	539,390
2021	38,096	668,456	557,842
2022	38,393	677,215	577,154
2023	38,689	685,949	597,367
2024	38,982	694,689	618,526
2025	39,274	703,416	630,372
2026	39,566	712,192	642,486
2027	39,857	720,991	654,877
2028	40,145	729,737	667,549
2029	40,432	738,501	680,511
2030	40,718	747,262	693,769
2031	41,000	755,963	702,550
2032	41,277	764,565	711,450
2033	41,550	773,053	720,471
2034	41,820	781,495	729,616
2035	42,080	789,685	738,885
2036	42,337	797,801	745,705
2037	42,589	805,792	752,589
2038	42,836	813,657	759,538
2039	43,077	821,349	766,552
2040	43,311	828,870	773,632

6. Public Outreach and Input

The Proposed Amendments have been developed through an extensive process of engagement with the public and industry stakeholders. In 2017, 2018, 2019, and 2020, CARB conducted four public workshops, which were webcast and made available by teleconference, on the Proposed Amendments. Information regarding these workshops and any associated materials are posted on the CARB website and distributed through several public listserves that include over 30,000 recipients. The workshops and meetings allowed CARB staff to consider stakeholder feedback and to incorporate it into the Proposed Amendments, as appropriate. CARB staff will continue to consider stakeholder feedback throughout the regulatory adoption process, including up to the adoption of the final regulation.

CARB staff worked closely with many of the stationary refrigeration stakeholders over the last decade, many of whom are subject to *California's Refrigerant Management Program* that was approved by the Board in December 2009 as well as the "*Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration and Foam End-Uses*" (CA SNAP) adopted in March 2018. The public outreach process for RMP[70] and the CA SNAP[71] are described in the Initial Statement of Reasons (ISOR) for each of the rulemakings.

The low-GWP refrigerant requirements for both refrigeration and AC equipment were recommended by CARB and made publicly available as early as December 2008 in the first Climate Change Scoping Plan.[72] The low-GWP requirements proposed in this rulemaking were reiterated and described in three additional CARB documents: First Update to the Climate Change Scoping Plan (2014);[73] California's 2017 Climate Change Scoping Plan;[74] and the Short-Lived Climate Pollutant Reduction (SLCP) Strategy (2017).[75] The specific GWP limits were first proposed as 150 GWP for stationary refrigeration and 750 for stationary AC in the Draft SLCP

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[70] California Air Resources Board, Initial Statement of Reasons: Refrigerant Management Program, 2009. (web link: https://ww3.arb.ca.gov/regact/2009/gwprmp09/isorref.pdf, Last accessed February 2020).

[71] California Air Resources Board, Initial Statement of Reasons: Public Hearing to Consider the Proposed Regulation for Prohibitions on use of Certain Hydrofluorocarbons in Stationary Refrigeration and Foam End Uses, 2018. (web link: https://ww3.arb.ca.gov/regact/2018/casnap/isor.pdf?_ga=2.97926559.1258857852.1573774546-109732520.1501863071, Last accessed February 2020).

[72] California Air Resources Board, 2008. Climate Change Scoping Plan - a framework for change - pursuant to AB 32, The California Global Warming Solutions Act of 2006, and Climate Change Scoping Plan Appendices Volume 1: Supporting Documents and Measure Detail (web link: https://ww3.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf and https://ww3.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf, Last accessed February 2020).

[73] California Air Resources Board, 2014. First Update to the Climate Change Scoping Plan - Building on the Framework - pursuant to AB 32, The California Global Warming Solutions Act of 2006 (web link: https://ww3.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf, Last accessed February 2020).

[74] California Air Resources Board, 2017. California's 2017 Climate Change Scoping Plan - The strategy for achieving California's 2030 greenhouse gas target (web link: https://ww3.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf, Last accessed February 2020).

[75] California Air Resources Board, 2017. Short-Lived Climate Pollutant Reduction Strategy (web link: https://ww3.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf, Last accessed February 2020).

Strategy,[76] which was released in September 2015 and included in the final draft approved by the Board in 2017. Since then, equipment manufacturers, trade organizations, nonprofits and others have been in close contact with CARB, providing information regarding the status of commercialization and market adoption of technologies that can meet these limits and input on the Proposed Amendments.

Recently, the outreach has focused on gathering stakeholder input on the technical feasibility, cost and enforceability of the proposal. Public outreach in support of developing the regulatory proposal includes but is not limited to the following activities:

CARB Public Workshops: Since 2017, CARB has held four public workshops regarding this regulatory proposal (October 2017; [77] October 2018; [78] March 2019; [79] and August 2019.[80]). Staff posted information regarding these workshops and associated materials on the HFC Reduction Measures website[81] and distributed notices through four public list serves maintained by CARB that include over 30,000 recipients who have identified the following as their topics of interest: "climate change"; "commercial refrigeration specifications"; "HFC reduction measures"; and" stationary equipment refrigerant management program." At the meetings, which were available by webinar and by teleconference, CARB solicited stakeholder feedback on the regulation. CARB staff worked closely with stakeholders, reviewing their comments from both the workshop along with several follow-up meetings to discuss their comments and recommendations.

External Public Presentations: In addition to public workshops and meetings hosted by CARB, staff presented details of the regulatory proposal and sought input through the following: presentation through Greenchill, a U.S. EPA web series supporting food retailers in reducing refrigerant emission and decreasing their impact on the ozone layer and climate in April 2019;[82] staff presentation at the UC Davis Energy Affiliates Forum in April 2019; conference presentation

[76] California Air Resources Board, 2015. California Air Resources Board (CARB) "Draft Short-Lived Climate Pollutant Reduction Strategy. "(web link: https://ww3.arb.ca.gov/cc/shortlived/2015draft.pdf, Last accessed February 2020).
[77] California Air Resources Board, 2017. Meeting Notice for Rulemaking Proposal: High-Global Warming Potential Refrigerant Emissions Reductions. (web link: https://ww3.arb.ca.gov/cc/shortlived/meetings/10242017/2017-10-5-workshop-notice-hfc-rulemaking.pdf?_ga=2.156768955.1258857852.1573774546-109732520.1501863071, Last accessed February 2020).
[78] California Air Resources Board, 2018. Workshop on Upcoming Hydrofluorocarbon Emission Reduction Measures. (web link: https://ww2.arb.ca.gov/resources/documents/hfc-reduction-measures-workshop-october-24-2018., Last accessed November 2019).
[79] California Air Resources Board, 2019. Technical Working Group Meeting on Upcoming Stationary Air Conditioning Regulation. (web link: https://ww2.arb.ca.gov/sites/default/files/2019-02/Email%20Invite%20-%20Technical%20Working%20Group_2019_03_06_1.pdf, Last accessed February 2020).
[80] California Air Resources Board, 2019. Technical Working Group Meeting on Upcoming HFC Regulations for Stationary Refrigeration and AC Equipment (web link: https://ww2.arb.ca.gov/sites/default/files/2019-07/Technical%20Working%20Group%20Notice%20-%20August%202019.pdf, Last accessed February 2020).
[81] California Air Resources Board, Stationary Hydrofluorocarbon Reduction Measures Website (web link: https://ww2.arb.ca.gov/our-work/programs/stationary-hydrofluorocarbon-reduction-measures, Last accessed February 2020).
[82] California Air Resources Board, 2019. California Cooling Act and Proposed High-Global Warming Potential Refrigerant Prohibitions. (web link: https://www.epa.gov/greenchill/events-and-webinars, Last accessed February 2020).

at ATMO America in June 2019;[83] staff presentation at a Western Heating Ventilation and Air Conditioning Performance Alliance (WHPA) meeting in May 2019 and a staff presentation at workshops organized by the North American Sustainable Refrigeration Council in July 2019 and January 2020.[84]

CARB Surveys: Staff circulated surveys to equipment manufacturers, refrigerant manufacturers, distributors/wholesalers, reclaimers, and trade groups from December 2018 to March 2019 to better understand cost impacts associated with the regulatory proposal.

Stakeholder Meetings: Staff held frequent in-person meetings and conference calls with multiple stakeholders interested in providing input to CARB throughout the period from October 2017 to January 2020. In addition to in-person meetings, CARB also held teleconferences to develop the proposed rule, exchange feedback, identify plausible solutions to any implementation challenges, and ultimately ensure the development of feasible compliance pathways for the end-users, one of which was suggested directly by them. CARB staff have worked closely with more than 150 separate stakeholders, in the development of the Proposed Amendments, who can be generally described as representing the following groups:

- Original equipment manufacturers (OEMs) of refrigeration and AC equipment.
- Components manufacturers of refrigeration and AC equipment.
- Groups of supermarket companies and the North American Sustainable Refrigeration Council (NASRC).
- Industry trade groups representing OEMs and end-users.
- End-users, including but not limited to: supermarket and grocery store owners and managers; wine, beer, and beverage makers; refrigerated warehouse, cold storage, and refrigerated distributing facilities.
- Design, engineering and consulting firms.
- Refrigerant manufacturers.
- Refrigerant distributors and distributor trade groups.
- Federal government agencies, including the U.S. EPA and the U.S. DOE.
- California state agencies, including local air districts, the CEC, California Public Utilities Commission (CPUC), and the Office of the State Fire Marshal.

[83] California Air Resources Board, 2019. HFC Refrigerant Regulations in California –New and Proposed. (web link: https://www.slideshare.net/ATMO/glenn-gallagher-california-air-resources-board-carb, Last accessed February 2020).
[84] California Air Resources Board, 2019. NASRC Refrigerants Workshop Seeks to Align Climate and Energy Goals in California. (web link: http://nasrc.org/articles1/2019/5/29/nasrc-refrigerants-workshop-seeks-to-align-climate-and-energy-goals-in-california, Last accessed February 2020).

- Utility company representatives.
- Labor groups representing HVACR contractors and technicians.
- Non-profit environmental organizations.

CARB continues to consider public and stakeholder feedback and specifically requested data and input regarding alternatives from those who would be subject to or affected by the regulations (including other state agencies and local agencies, where appropriate) at the public workshops held in March and August 2018.

B. BENEFITS

The Proposed Amendments have been designed to support growth in technologies that lower HFC emissions. It is anticipated that the Proposed Amendments will reduce HFC emissions from the refrigeration sector by nearly 50 percent below baseline by 2040 and 56 percent below baseline by 2040 in the AC sector. Cumulatively, from 2022 through 2040, the Proposed Amendments are expected to yield 75 $MMTCO_2e$ in GHG reductions. Using 20-year GWP values, the Proposed Amendments are expected to yield cumulative GHG emissions reductions of nearly 150 $MMTCO_2e$ by 2040. The total benefits in avoided harms range between $1.69 billion to $7.32 billion through 2040, depending on the discount rate. \

CARB used its F-Gas Inventory to analyze the economic and emissions impacts and benefits for the baseline (or BAU) and alternative scenarios. We begin this section with a brief description of the F-Gas inventory methodology.

1. Inventory Methodology

CARB maintains a California specific F-Gas Inventory as a part of the statewide GHG Emission Inventory, which is used for establishing historical emission trends and tracking California's progress in reducing greenhouse gases. The F-Gas Inventory estimates annual emissions of F-gases, including HFCs, from sources including refrigeration, air conditioning, aerosol propellants, foams, solvents and fire protection end-uses. The F-Gas Inventory is based on the U.S. EPA's Vintaging Model that tracks the use and emissions of annual "vintages" of equipment that are produced each year.

To estimate emissions, CARB maintains emissions profiles for each distinct end-use category of equipment of product that emits an F-Gas. The emissions profile includes the number of units[85], amount of F-Gas required by each unit also called the "charge size," as well as annual and end-of-life leak rates. Since it was initially developed in 2007, CARB steadily refined initial F-Gas emission estimates by replacing scaled down national estimates from the U.S. EPA Vintaging Model with California state-specific estimates based on comprehensive research completed by CARB staff and studies completed by CARB contractors. The F-Gas Inventory is updated periodically as emissions profiles are further refined by incorporating the latest activity data, research and monitoring. The full methodology is available in the latest *Emission Inventory Methodology and Technical Support Document* for the Greenhouse Gas Inventory[86] and is also the subject of a peer-reviewed scientific paper by CARB staff Gallagher, et al., 2014, published in the journal Environmental Science and Technology.[87]

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[85] "Units" is generally interchangeable with the term "equipment" or "system" and for Inventory purposes refers to a single system connected through a refrigerant circuit.

[86] California Air Resources Board, 2016, California's High Global Warming Potential Gases Emission Inventory: Emission Inventory Methodology and Technical Support Document, *2015 Edition* (web link: https://ww3.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf, Last accessed February 2020).

[87] Gallagher, G. et al., (2014), High-global Warming Potential F-Gas Emissions in California: Comparison of Ambient-based versus Inventory-based Emission Estimates, and Implications of Estimate Refinements (web link: https://pubs.acs.org/doi/pdf/10.1021/es403447v, Last accessed February 2020).

Staff assume that without regulatory drivers, the use of HFCs will continue to grow rapidly as ODS are phased out of new production. There are a few exceptions. The following non-refrigerant end-use sectors have voluntarily transitioned away from using HFCs:

- Foam expansion agents have replaced HFCs with less costly hydrocarbons for many foam end-use sectors.

- Aerosol propellants have replaced HFCs with hydrocarbons in many consumer products.

- HFC solvents have been replaced by non-fluorinated solvents, including water-based solvents.

- HFC fire suppressants have been replaced by non-fluorinated alternatives and low-GWP fluorocarbons.

The BAU does not include speculative future changes in equipment average charge sizes, annual leak rates, or end-of-life loss rates. Charge sizes, annual leak rates and equipment end-of-life loss rates remain the same as current years, unless acted upon by exterior forces such as regulations that have been adopted at the state or national level. New units are assumed to use the same amount and type of F-Gas as used in current and previous years, until adopted regulations prohibit the use of specific F-Gases for that end-use.

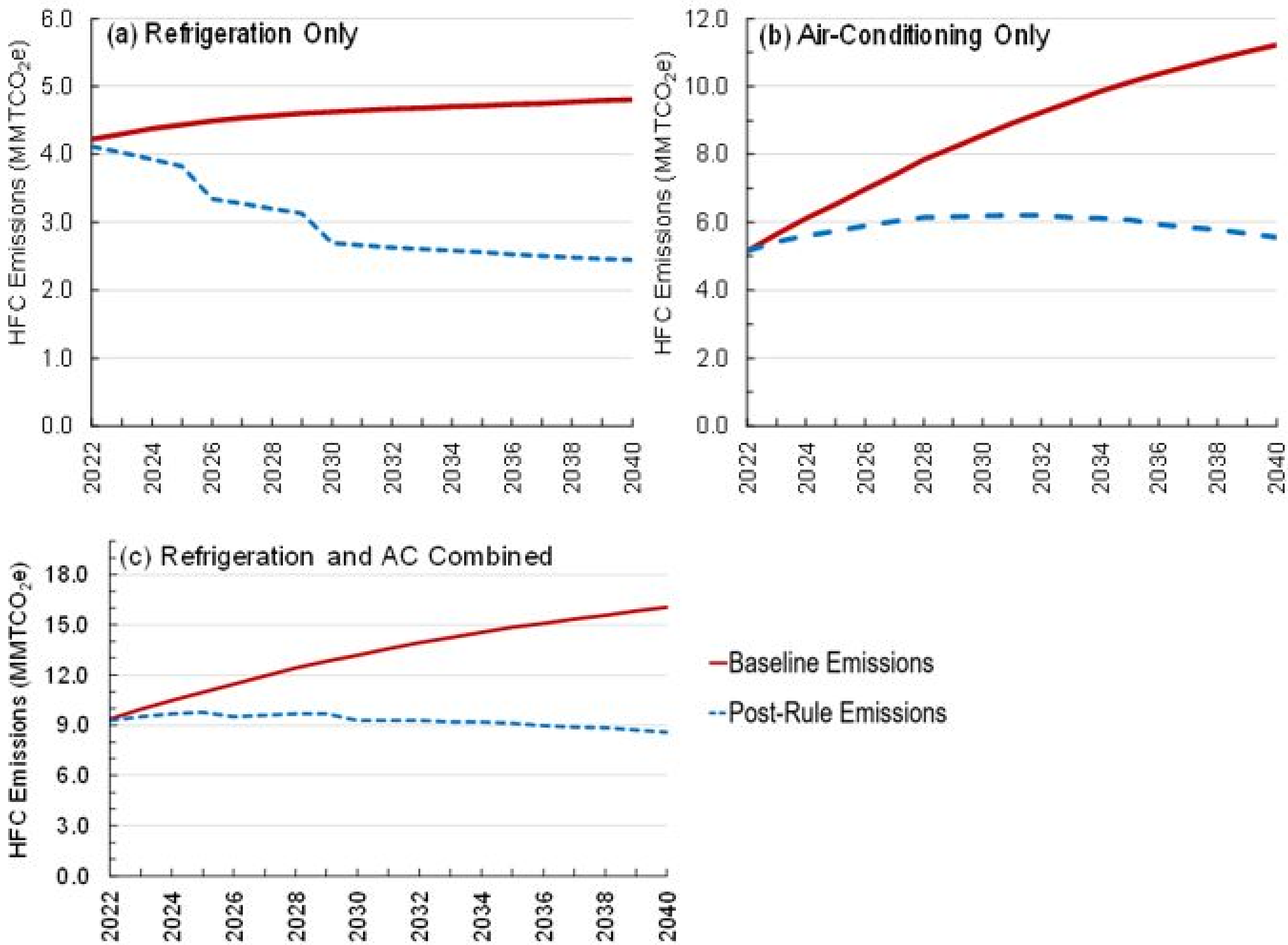
2. Emission Benefits

CARB's 2017 Short Lived Climate Pollutant Reduction Strategy identifies prohibitions of high-GWP refrigerants in new equipment as one of the key measures to reduce HFC emissions in the State, as mandated by the State legislature.[88] Figure 5 below identifies the projected annual baseline HFC emissions and expected reductions from the Proposed Amendments as they pertain to refrigeration equipment, AC equipment, and both sectors combined.

[88] California Air Resources Board, 2017. Short Lived Climate Pollutant Reduction Strategy. (web link: https://ww2.arb.ca.gov/sites/default/files/2018-12/final_slcp_report%20Final%202017.pdf, Last accessed February 2020).

[88] California Air Resources Board, 2017. Short Lived Climate Pollutant Reduction Strategy. (web link: https://ww2.arb.ca.gov/sites/default/files/2018-12/final_slcp_report%20Final%202017.pdf, Last accessed February 2020).

Figure 5. Projected Annual Baseline HFC Emissions and Expected Reductions from the Proposed Amendments as they pertain to (a) refrigeration equipment only, (b) air-conditioning equipment only, and (c) refrigeration and AC equipment combined



For refrigeration, existing SB 1013 requirements prevent a rapid increase in the projected baseline GHG emissions from those systems, but the high-GWP refrigerants currently contained in the existing systems continue to be the greatest source of emissions from the sector. Under the Proposed Amendments, most of the existing refrigerated facilities (i.e., retail food facilities) will be required to reduce their weighted-average GWP of their banked refrigerants to below 1,400 by 2030, with a progress step in 2026, which is reflected in Figure 5 (a) above. In addition, new systems that will be installed in newly constructed or remodeled facilities will be required to use refrigerants with GWP less than 150. From these measures combined, HFC emissions from the refrigeration sector are expected to decline by nearly 50 percent below baseline by 2040.

In contrast to the refrigeration equipment, HFC use and emissions from the air-conditioning sector are projected to grow rapidly. This is due to a combination of factors: use of HFCs in the sector is not currently regulated by SB 1013 and AC use is expected to grow in an increasingly warming climate. The primary factor driving the large increase of HFC use and emissions in the air-conditioning and refrigeration sectors is that new equipment using HFC refrigerants are replacing older equipment using ozone-depleting substance (ODS) refrigerants. Because ODS emissions are intentionally not included in California's GHG Inventory (by design of the Kyoto Protocol and AB 32), the growth of HFC emissions reflects not only simple growth in the number of new equipment used each year, but also the replacement of ODS equipment with HFC equipment. Reducing the GWP of new AC equipment to below 750 is expected to reduce emissions from this sector by 56 percent below baseline by 2040 (Figure 5. (b)).

Combined, the annual average reduction in HFC emissions from the refrigeration and AC sectors is estimated to 4.0 $MMTCO_2e$, from the stationary refrigeration and AC sectors combined between 2022 and 2040 (Figure 5. (c)). This is equivalent to removing GHG emissions from 850,000 passenger vehicles driven per year.[89] Cumulatively, from 2022 through 2040, the Proposed Amendments are expected to yield 75 $MMTCO_2e$ in GHG reductions from the two sectors. The annual and cumulative reductions are given in Table 8.

Table 8. Annual and Cumulative Emissions Reductions from the Proposed Amendments (using 100-year GWP values)

Year	Refrigeration + AC	
	Annual Reductions ($MMTCO_2e$)	Cumulative Reductions ($MMTCO_2e$)
2022	0.1	0.1
2023	0.4	0.5
2024	0.8	1.3
2025	1.2	2.5
2026	1.9	4.5
2027	2.3	6.8
2028	2.7	9.5
2029	3.1	12.6
2030	3.9	16.5
2031	4.3	20.8
2032	4.6	25.4
2033	5.0	30.4
2034	5.4	35.8
2035	5.7	41.5
2036	6.1	47.6
2037	6.5	54.1
2038	6.8	60.8
2039	7.1	67.9
2040	7.5	75.4

It is important to note that the emissions benefits discussed above are calculated using the 100-year GWP values of the HFC refrigerants. A 100–year GWP value is reflective of the warming

[89]United States Environmental Protection Agency, 2019. Greenhouse Gas Equivalencies Calculator. (web link: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator, Last accessed, January 2020).

impact of an HFC relative to CO_2 over that time period. In reality, most HFCs used as refrigerants or as part of refrigerant blends have atmospheric lifetimes shorter than 100 years and thus, their warming impact is even worse in the shorter term. To estimate more near term impacts, HFC emissions can be calculated using their 20-year GWP values. For the HFCs used in refrigeration and AC equipment, the average 20-year GWP is approximately double the 100-year average GWP. Thus, using 20-year GWP values, the Proposed Amendments are expected to yield cumulative GHG emissions reductions of more than 150 $MMTCO_2e$ by 2040. While we use 100-year GWP values throughout this document and for the purposes of the rulemaking, it is important to highlight the potential near-term impacts of these "super-pollutants" and the extent of damage HFCs can cause within just a few decades.

3. Benefits to Typical Businesses

a. Stationary Refrigeration

The economic analysis for refrigeration systems discusses all costs directly from an end-users perspective. End-users of regulated refrigeration systems include both typical and small businesses, such as independent owners / operators of grocery stores, cold storage warehouses and small industrial process refrigeration facilities. Benefits experienced by small businesses will be the same as those experienced by typical businesses discussed above.

Typical businesses (e.g., supermarkets, grocery stores, food production and other manufacturing facilities, and cold storage warehouses) are expected to benefit from early implementation of lower-GWP technologies. Equipment manufacturers providing compliant solutions will also benefit from increased market adoption of low-GWP technologies and will have the opportunity to establish themselves as market leaders in California. From an end-user standpoint, under the Proposed Amendments for refrigeration systems, facilities that replace their existing systems with low-GWP systems and start using non-synthetic or "natural" refrigerants (e.g., CO_2, ammonia or propane) will have much lower ongoing cost for replenishing leaked refrigerant. Additionally, any facility that only contains systems greater than 50 pounds using refrigerants with GWP values less than 150 will be exempt from the RMP regulation. This will reduce current costs associated with compliance. Furthermore, using low-GWP technologies will reduce the exposure of end-users to future regulations and the global HFC phase-down. Facilities that retrofit refrigeration equipment can also expect to realize electricity cost-savings due to two main factors: 1) energy efficiencies of compliant refrigerants like R-448A/R-449A are higher compared to current, commonly used refrigerants like R-404A and, 2) as part of the refrigerant retrofit, refrigeration systems will get a "tune up" that may not have otherwise occurred and generally results in greater energy efficiency. These cost-savings a fully quantified in the Direct Costs section.

b. Stationary AC

For AC, the typical business affected by the Proposed Amendments are AC manufacturers. There are no quantifiable benefits to AC manufacturers. However, AC manufacturers bringing new technologies to market will benefit economically in the long-term as other adoption of these technologies expands beyond California because of market pressures from the Kigali Amendment and other drivers to transition away from high-GWP refrigerants. There is no single typical business using commercial AC equipment. All businesses using commercial ACs that purchase a new AC after 2023 will be affected and there are no direct benefits to these businesses other than the avoided impacts of climate change.

c. Other California Businesses

The Proposed Amendments are estimated to result in increased expenditures for contractors who install and maintain the regulated equipment. This will benefit businesses who provide these services through increased sales. These indirect effects are accounted for in the Macroeconomic Analysis (Section E).

4. Benefits to Small Businesses

a. Stationary Refrigeration

The economic analysis for refrigeration systems discusses all costs directly from an end-users perspective. End-users of regulated refrigeration systems include both typical and small businesses, such as independent owners / operators of grocery stores, cold storage warehouses and small industrial process refrigeration facilities. Benefits experienced by small businesses will be the same as those experienced by typical businesses discussed above.

b. Stationary AC

There are no small business AC manufacturers that have been identified as affected by the Proposed Amendments. All small businesses in California that purchase a new AC system from 2023 onward are affected by the Proposed Amendments. There are no direct benefits to these businesses other than avoided impacts from climate change.

c. Other California Businesses

The Proposed Amendments for refrigeration equipment used in existing retail food outlets may result in benefits to both typical and small businesses – the proposed rule requires supermarkets and grocery stores in California to reduce their current average GWP and/or emissions potential by more than 50 percent by 2030. This can be accomplished through several options, all of which require technical skills and experiences likely to create a higher demand for refrigerant service and recovery contractors and technicians. The service industry jobs are local and located in California, and thus likely to benefit the local economy.

The Proposed Amendments are estimated to result in increased expenditures for contractors who install and maintain the regulated equipment. This will benefit small businesses who provide these services through increased sales. These indirect effects are accounted for in the Macroeconomic Analysis (Section E).

5. Benefits to Individuals

Other than the social cost of carbon discussed below, there are no direct health benefits to individuals as a result of the Proposed Amendments. Any indirect or induced impacts are discussed in the Macroeconomic Impact section.

a. *Social Cost of Carbon*

The benefit of these GHG reductions can be estimated using the Social Cost of Carbon (SC-CO_2), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future.

In this analysis, CARB utilizes the current Interagency Working Group (IWG) supported SC-CO_2 values to consider the social costs of actions taken to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan [90] and is in line with Executive Orders including 12866 and the OMB Circular A-4 of September 17, 2003, and reflects the best available science in the estimation of the socio-economic impacts of carbon.[91]

The IWG describes SC-CO_2 as follows:

The social cost of carbon (SC-CO_2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO_2 emissions by the same amount in that year. The SC-CO_2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts – from global climate change that result from an additional ton of CO_2.

These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO_2 emissions today will affect economic outcomes throughout the next several centuries.[92]

Table 9 presents the range of IWG SC-CO_2 values used in regulatory assessments, including the 2017 Scoping Plan.

Table 9. Social Cost of Carbon, 2015 – 2040 (2007$ Per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2020	$12	$42	$62
2025	$14	$46	$68
2030	$16	$50	$73
2035	$18	$55	$78
2040	$21	$60	$84
2045	$23	$64	$89

[90] California Air Resources Board, California's 2017 Climate Change Scoping Plan, released in November 2017 (web link: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf, Last accessed June 2019).
[91] Office of Management and Budgets, Circular A-4 (web link: https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf, Last accessed February 2020).

[92] National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, 2017, (web link: www.nap.edu/24651, Last accessed February 2020).

The SC-CO_2 is year specific; that is, environmental damages are estimated for a given year in the future and the value of the damages is discounted back to the present. The SC-CO_2 increases over time as systems become stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. The SC-CO_2 is highly sensitive to the discount rate. Higher discount rates decrease the value today of future environmental damages. The IWG estimates the SC-CO_2 across a range of discount rates that encompass a variety of assumptions regarding the correlation between climate damages and consumption of goods and is consistent with OMB's Circular A-4 guidance. CARB utilizes the IWG standardized range of discount rates, from 2.5 to 5 percent to represent varying valuation of future damages and adjusts them for inflation using California Consumer Price Index (CPI).[93] An inflation adjustment, using the California Consumer Product Index (CPI), is applied to the values to convert them 2018 dollars, consistent with the rest of this analysis.[94]

If all of the expected emissions reductions projected under the Proposed Amendment are achieved and assumed to be equivalent to CO_2 reductions, the avoided SC-CO_2 in a given year is the total emissions reductions (in $MTCO_2e$) multiplied by the SC-CO_2 (in \$/$MTCO_2e$) for that year. The annual emissions reductions from the Proposed Amendments and the estimated benefits are shown in **Table 10** below. The total benefits range between $1.69 billion to $7.32 billion through 2040, depending on the discount rate.

Table 10. Avoided Social Cost of CO_2 (Million 2018$)

Year	GHG Emissions Reductions ($MMTCO_2e$)	5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2022	0.1	$1.70	$5.60	$8.30
2023	0.4	$7.20	$24.4	$36.1
2024	0.8	$13.0	$45.1	$66.1
2025	1.2	$20.5	$67.4	$99.7
2026	1.9	$34.1	$115	$168
2027	2.3	$43.7	$140	$204
2028	2.7	$51.1	$167	$242
2029	3.1	$58.7	$192	$282
2030	3.9	$78.2	$244	$357
2031	4.3	$85.3	$272	$395
2032	4.6	$98.2	$301	$433
2033	5.0	$107	$334	$479
2034	5.4	$122	$364	$520

[93] National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, 2017, (web link: www.nap.edu/24651, Last accessed February 2020). As noted in the 2017 Scoping Plan, CARB is aware that the current federal administration has recently withdrawn certain social cost of carbon reports as no longer representative of federal governmental policy. However, this determination does not call into question the validity and scientific integrity of federal social cost of carbon work, or the merit of independent scientific work. Indeed, the IWG's work remains relevant, valid, reliable, and appropriate for use for these purposes.

[94] California Department of Finance. California Consumer Product Index (CPI-U), (web link: http://dof.ca.gov/Forecasting/Economics/Indicators/Inflation/, Last accessed February 2020).

Year	GHG Emissions Reductions ($MMTCO_2e$)	5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2035	5.7	$129	$394	$558
2036	6.1	$146	$429	$605
2037	6.5	$154	$461	$655
2038	6.8	$169	$491	$694
2039	7.1	$178	$526	$740
2040	7.5	$196	$560	$784
Total	75	$1,690	$5,130	$7,320

There is an active discussion within government and academia about the role of SC-CO_2 in assessing regulations, quantifying avoided climate damages, and the values themselves. In January 2017, the National Academies of Sciences, Engineering, and Medicine (NAS) released a report examining potential approaches for a comprehensive update to the SC-CO_2 methodology to ensure resulting cost estimates reflect the best-available science. The NAS review did not modify the estimated values of the SC-CO_2, but evaluated the models, assumptions, handling of uncertainty, and discounting used in the estimating of the SC-CO_2. The report titled, "Valuating Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide," recommends near-term improvements to the existing IWG SC-CO_2 as well as a long-term comprehensive updates. The State will continue to follow updates to the IWG SC-CO2, outlined in the NAS report, and incorporate appropriate peer-reviewed modifications to estimates based on the latest available data and science.[95]

It is important to note that the SC-CO_2, while intended to be a comprehensive estimate of the damages caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO_2, including costs associated with changes in co-pollutants, the social cost of other GHGs including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The IPCC has stated that the IWG SC-CO_2 estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.[96] CARB will continue engaging with experts to evaluate the comprehensive California-specific impacts of climate change and air pollution.

It is also worth noting that the SC-CO_2 estimates discussed above were calculated using the social cost of atmospheric release of CO_2 and likely represent a lower bound for the damages caused by releasing HFCs. This is so because HFCs are hundreds to thousands of times more potent at trapping heat in the near term than the longer-lived climate pollutants like CO_2. Unlike CO_2, methane and nitrous oxide, there are no official government estimates for HFCs, though

[95] National Academy of Sciences, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, web link: http://www.nap.edu/24651, Last accessed February 2020)

[96] Intergovernmental Panel on Climate Change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate change, web link: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg3_full_report-1.pdf, Last accessed February 2020.

one study estimates of social cost of atmospheric release of HFC-134a to be at least thousand-fold higher than CO_2.[97]

b. Health Benefits

While there are no direct health benefits that can be quantified using present methodologies, there are co-benefits of controlling global warming by removing GHG emissions. There is mounting scientific evidence that an increase in average temperatures is linked to the increase in number and intensity of wildfires, exacerbation of drought conditions in the State and prolonged, more intense heat waves, which have a disproportionate impact on the sensitive age groups as well as disadvantaged communities.[98] The Social Cost of Carbon discussion in the preceding section provides monetary estimates of the damages that would be avoided by reducing GHG emissions under this Proposed Amendments.

c. Other Benefits

The Proposed Amendments pertaining to refrigeration equipment are expected to result in improved energy efficiency for existing supermarket systems that reduce the weighted average GWP to below 1,400. The most common strategy for achieving the necessary emissions reductions will be to do a "refrigerant retrofit." This means replacing the high-GWP refrigerant in an existing system with a lower-GWP refrigerant. Retrofits are commonly accompanied by changes in seals, valves and lubricants. Systems retrofitted from R-404A to R-448A/R-449A have shown improved energy efficiency.[99] This is likely due to a combination of two factors – the replacement refrigerants are more efficient (see Section C, Direct Costs for more details) and as part of the retrofit, the systems receive a "tune-up" (new seals, valves etc.) which improves the overall energy efficiency of systems that otherwise would not have received these upgrades.

Many of the alternative refrigerants which may be used to comply with the Proposed Amendments pertaining to AC equipment have better energy efficiency or refrigerant performance characteristics. Manufacturers may elect to use more efficient refrigerants to comply with the Proposed Amendments. It is speculative to predict the market share of these refrigerants and refrigerant choice is only one factor for how manufacturer's choose to meet minimum efficiency requirements set by the U.S. DOE.

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[97] Shindell, D. T. (2015). The social cost of atmospheric release. (web link: https://link.springer.com/article/10.1007/s10584-015-1343-0, Last accessed February 2020).

[98] State of California (2018) *California's Fourth Climate Change Assessment*, http://climateassessment.ca.gov/, Last accessed February 2020); See also U.S. EPA (2018) *Climate Change in the United States: Benefits of Global Action*, https://www.epa.gov/cira/downloads-cira-report, Last accessed February 2020).

[99] U.S. Department of Energy (DOE). Working Fluids: Low Global Warming Potential Refrigerants - 2014 Building Technologies Office Peer Review. Omar Abdelaziz, Oak Ridge National Laboratory (web link: https://www.energy.gov/sites/prod/files/2014/10/f18/emt13_abdelaziz_042414.pdf, Last accessed February 2020).

C. DIRECT COSTS

The Proposed Amendments cover the following categories of businesses that use AC and refrigeration systems and have a total cost as outlined in table below.

Table 11. Regulated Businesses and Overview of Costs

General End Use	Specific End Use	Entities Affected	Average Annual Direct Costs, 2022-2040 (million 2018$ / year)
Air Conditioning	Air conditioning equipment (new) residential and commercial	Air conditioning equipment manufacturers	*$210*
Refrigeration	Systems containing more than 50 pounds of refrigerant (typically used in commercial refrigeration, cold storage and industrial process refrigeration)	Supermarkets and grocery stores (i.e., retail food facilities); cold storage warehouses; industrial processes including, but not limited to, food production and manufacturing, wineries, breweries, chemical manufacturing etc. for full six-digit codes and description , see ***Table*** 69 in the Appendix	*$29.6*

The average annual direct costs between 2022 and 2040 are $29.6 million for the refrigeration end-use sectors and $210 million for the AC end-use sectors. The direct costs comprise costs related to equipment, installation, maintenance, refrigerant replenishment, electricity, retrofit of manufacturing facilities, and in case of refrigeration, the costs associated with compliance with the weighted-average GWP reduction requirements for retail food facilities.

Refrigeration and AC costs are discussed separately below.

1. Direct Cost Inputs

a. Direct Cost Inputs – Refrigeration

For regulated refrigeration systems, two distinct rules will apply, depending on whether the systems are used in new or existing facilities:

- **In Newly Constructed and Remodeled Facilities:** New systems will be required to have refrigerants with a GWP less than 150, starting January 1, 2022.

- **In Existing Facilities:** Systems in existing retail food facilities will be required to reduce their weighted-average GWP to below 1,400 by 2030 (with a progress step in 2026 for large businesses). New systems in other facilities (for example, cold storage and industrial process refrigeration) will be required to use refrigerants with GWP below 1,500.

Below is a brief overview of the compliance options available to end-users of regulated refrigeration systems and the methodology used to assess costs to end-users for compliance with the Proposed Amendments.

To comply with the GWP limit of 150 in new facilities, the currently available refrigerant options include carbon dioxide (CO_2), ammonia (NH_3), which have GWP values of 1 and 0, respectively, and hydrocarbons e.g., propane, which typically have GWP values below 10. All three are historical refrigerants and were in use in the late 19th and early 20th century, before the first generation of synthetic fluorinated refrigerants, i.e., chlorofluorocarbons or CFCs were invented. They are commonly dubbed "natural refrigerants" because unlike HFCs, these are naturally occurring gases. Their thermodynamic properties make them ideal refrigerants. However, they do present some risks and occupational safety challenges due to their toxicity (for NH_3), flammability (for NH_3 and hydrocarbons) and high operating pressures (for CO_2). Over the last few decades, extreme health- and climate-damaging impacts of fluorinated refrigerants have come to light, due to which the so-called "natural refrigerants" are now re-gaining popularity. Unlike the current fluorinated refrigerants, natural refrigerants are deemed environmentally benign, given that they are not ozone depleting substances and have very low to zero global warming potentials. Additionally, over the last few decades, advances in technology coupled with rigorous safety regulations have made it possible to manage the risks associated with NH_3, CO_2 and hydrocarbons, and use them safely in refrigeration systems.

Apart from these options, refrigerant manufacturers are already actively working towards developing and optimizing the next generation of synthetic fluorinated refrigerants with GWP values below 150. Field trials of low-GWP hydrofluoroolefin (HFO) systems are already underway in Europe.[100] For the purposes of this regulation, CARB remains technology neutral, and will allow the use of all refrigerants with GWP values below 150.

Table 12 summarizes the refrigerant / system options with GWP values less than 150.

[100] Cooling Post, Co-op store trials A2L refrigerant R-454C (web link: https://www.coolingpost.com/uk-news/co-op-store-trials-a2l-refrigerant-r454c/, Last accessed February 2020).

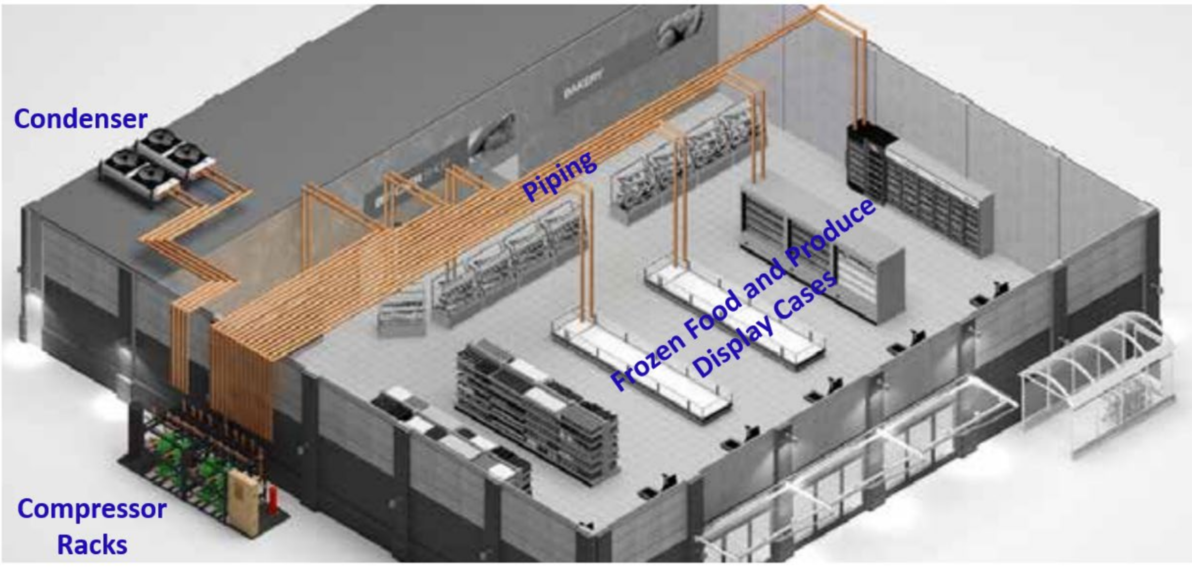
Table 12. Currently Available Refrigerants / Refrigeration System Types with GWP values less than 150

Refrigeration End-Use Sector	Compliant Options
Commercial refrigeration	Transcritical CO_2 Ammonia/CO_2 cascade Propane/CO_2 cascade Micro-distributed propane systems HFOs-based systems (under development)
Industrial process refrigeration; Cold storage	Low-charge ammonia Transcritical CO_2 Ammonia/CO_2 cascade HFO-based systems (under development)

CARB's original proposal included a GWP limit of 150 even for new systems in existing facilities. For cost and logistical reasons, it is difficult for existing facilities to switch from systems currently using HFC refrigerants to new ones using refrigerants with GWP less than 150.

The schematic below shows the typical layout of the refrigeration equipment in a supermarket – broadly, it consists of the following (1) compressors (often located in a machine room, mezzanine level or at the back of the facility , (2) condenser often located on the rooftop, (3) fixtures like display cases for storing and showcasing produce and frozen foods inside the supermarket, (4) expansion valves or metering devices (not labeled), and (5) refrigerant piping or lines connecting the display cases to the compressors and condensers. The refrigerant piping carries cold, mostly liquid refrigerant to the display cases for chilling the products. Inside the display cases, the cold refrigerant absorbs heat and vaporizes, cooling the products. After this, refrigerant piping carries the hot, vaporized refrigerant from the cases back to the compressor and eventually the condenser, to reject heat.

Figure 6. Example of a Centralized Refrigeration System[101]



The differences in thermodynamic properties and safety-related requirements for the currently available low-GWP refrigerants make them incompatible with equipment designed for HFC refrigerants. For example, CO_2 has higher operating pressures and a higher volumetric capacity than HFCs – this results in CO_2 systems having smaller compressors, and CO_2 systems require thicker refrigerant piping with a smaller diameter. Thus, the existing equipment in a supermarket that uses HFC refrigerants today cannot function with the currently available low-GWP refrigerants. However, systems installed in existing facilities account for a majority of the emissions from this sector, and reducing those emission is vitally important to meeting California's HFC reduction mandates.

Thus, to get meaningful emissions reductions and promote a transition to lower-GWP technologies in the existing facilities, the Proposed Amendments will require all retail food facilities to reduce the weighted-average GWP of all the refrigerants used across each company to below 1,400. Additionally, new systems being installed in all remaining refrigeration facilities, including industrial process refrigeration and cold storage will be required to have a GWP value less than 1,500. These GWP limits can be met by several HFC/HFO refrigerants available in the market today, some of which are given in Table 13.

[101] Adapted from original image in Kysor Warren, Parallel Compression Refrigeration, Installation and Operation Manual, web link: http://www.kysorwarren.com/files/literature/merchandisers/service/i/KW-IOM-HFC.pdf, Last acessed February 2020.

Table 13. Currently available refrigerants with GWP values less than 1,400

Refrigeration End-Use Sector	Currently Available Compliant Options
Commercial refrigeration; Industrial process refrigeration; Cold storage	R-448A R-449A R-513A R-450A

I. Cost Methodology and Baseline Upfront Costs for New Refrigeration Systems

Compliance with the Proposed Amendments are expected to result in costs higher than the baseline scenario, due to higher upfront costs for equipment and installation. In some cases, savings are expected on an ongoing basis from reductions in costs for refrigerant replenishment and electricity. Changes in regulatory costs associated with both, CARB's RMP regulation and the Proposed Amendments are also discussed.

Table 14 shows the types of costs and entities that will incur the costs associated with the Proposed Amendments as they pertain to refrigeration equipment. All costs are expected to be passed on to the end-users and thus, for this analysis, all costs are estimated from an end-user's standpoint for refrigeration systems.

Table 14. Industries Incurring Compliance Costs for Refrigeration Systems

Type of Cost	Industries incurring costs (assumed to be passed-on)	Industries or entities with passed-on costs
Equipment (initial)	OEMs	Refrigeration end-users (e.g., supermarkets, grocery stores, cold storage warehouses, process refrigeration facilities)
Installation (initial) Maintenance (ongoing)	Technicians (costs of training for low-GWP)	
Refrigerant (ongoing)	Distributors/ Wholesalers	
Electricity (related to Energy Efficiency) (ongoing)	End-user	
Regulatory Cost (ongoing)	End-user	

To quantify costs resulting from the Proposed Amendments above the baseline scenario, we first estimate baseline costs and then the incremental costs above the baseline.

Baseline Costs: In almost all cases, regulated refrigeration systems are designed to serve large cooling needs and are built and installed per the needs and specifications of the facility. Unlike smaller systems like residential refrigerators and ACs, estimates of baseline system costs are not available directly online. End-users like supermarkets use the services of design / engineering firms and equipment manufacturers to receive competitive bids for purchase and installation of all equipment needed for the facility, which may not necessarily be on a per-system basis. Since the F-Gas inventory tracks emissions on a per-system basis, we estimated costs per system for this analysis. To estimate upfront costs per system, CARB staff first estimated the baseline equipment costs on a per-facility basis using past stakeholder input and a few publicly available estimates.[102] The baseline cost estimates were shared and discussed with stakeholders during a public technical working group meeting[103] and through individual phone meetings.[104] Baseline facility-level costs were apportioned to systems based on the average amount of refrigerants they contain (i.e., average system full charge). The conversion of baseline facility equipment and installation costs to system costs are given in Table 62 in the Appendix. Baseline costs per refrigeration system size (large, medium, and small) and type (commercial, industrial process, and cold storage) are given below in Table 16.

Table 15. Baseline Upfront Costs for New Refrigeration Systems (2018$)

End-Use Sector	System Size	Baseline Upfront Costs (HFC DX system)	
		Equipment	Installation
Retail Food Refrigeration	Large	$958,000	$431,000
	Medium	$219,000	$98,500
	Small	$76,500	$34,400
Other Commercial Refrigeration	Large	$670,000	$144,000
	Medium	$153,000	$32,800
	Small	$53,600	$11,500
Industrial Process Cooling	Large	$912,000	$411,000
	Medium	$293,000	$132,000
	Small	$99,000	$44,600
Cold Storage	Large	$1,130,000	$507,000
	Medium	$245,000	$110,000
	Small	$108,000	$48,400

Incremental Costs: To assess the incremental costs resulting from the proposed rules, incremental costs as a percentage above baseline were estimated by seeking direct input from stakeholders during the public technical working group meetings and phone meetings referenced above, and are discussed in detail below. To obtain incremental costs per system in dollars, the incremental cost percentages were multiplied with the baseline costs for each type of

[102] HillPhoenix, DeCO$_2$ded: Understanding ROI on CO2 Refrigeration Systems (web link: http://www.r744.com/files/Hillphoenix_CO2_ROI_WhitePaper_v10_Oct24_2014.pdf, Last accessed February 2020); See also CTA Architects Engineers, 2014. Energy & Store Development Conference Presentation (web link: https://www.fmi.org/docs/default-source/energy/supermarket-refrigeration-system-design-process---a-consultant's-view.pdf?sfvrsn=2).

[103] CARB, 2019. Agenda for CARB Technical Working Group, Refrigeration Session (web link: https://ww2.arb.ca.gov/sites/default/files/2019-08/Refrigeration%20Hand-Out%20%28Final%2008-01-19%29.pdf)

[104] Direct communications with stakeholders between August 2019 and December 2019.

refrigeration system, i.e. *Incremental Cost per System (in 2018$) = Baseline Cost per System (in 2018$) x Incremental Cost as a Percentage above Baseline.*

II. Incremental Costs for New Refrigeration Systems in Newly Constructed / Remodeled Facilities

Because there are several options available to end-users for compliance, the baseline and incremental costs in this analysis are meant to be representative averages for the available options. The assumptions for direct costs are detailed in the following sections.

Equipment Cost: Currently, equipment using low-GWP refrigerants is more expensive than the baseline HFC systems and is the main source of added costs for compliance with the Proposed Amendments. Since these are custom-built systems, information about incremental costs are not easily available. Based on direct input from stakeholders and a few publicly available estimates,[105] for low-GWP equipment in newly constructed or fully remodeled facilities, staff assumes the incremental cost to be between 15 and 25 percent, and on average, 20 percent above baseline. Factors contributing to the higher equipment costs for compliant systems are primarily the differences in the design of the low-GWP systems compared to the baseline HFC systems. Since it is speculative to quantitatively parse out incremental costs due to the different design factors, here we describe them qualitatively: Different compliant refrigerants have differing thermodynamic, physical or chemical properties that may require specialized system architecture. For example, for CO_2, the systems are built to withstand higher pressures than baseline systems and may require some additional features like adiabatic condensers to achieve energy efficiencies in hot ambient climates; in micro-distributed propane systems, very small quantities of propane (< 150 grams per system) are used to cool/freeze products in display cases directly and the heat is rejected through a water loop running through the facility; in low-charge ammonia systems used primarily in IPR and cold storage, small completely sealed units containing ammonia may be placed on rooftops – this helps mitigate the costs associated with managing very large quantities of ammonia and the associated safety risks. In addition, the refrigerant lines or piping, which can be very extensive and runs all through the facility is different for each of the low-GWP refrigerants and different from the current baseline system piping.

Installation Cost: For commercial refrigeration systems, CARB staff assumes that the cost of installation, mainly tied to labor, could be higher on average by 10 percent, due to the fact that service technicians familiar with the low-GWP systems are not as easily available as those for traditional systems. The currently available technicians familiar with the low-GWP systems may have to work extra hours to meet the initial demand or may charge higher rates. It is important to note that availability of technicians is directly linked to market adoption of the technologies. As low-GWP systems become more common, the technician base servicing those systems will grow bringing parity in installations costs. Additionally, the added installation cost is offset to some extent by a few factors. Based on stakeholder input, costs of electrical installation of the low-

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[105] HillPhoenix, DeCO$_2$ded: Understanding ROI on CO2 Refrigeration Systems (web link: http://www.r744.com/files/Hillphoenix_CO2_ROI_WhitePaper_v10_Oct24_2014.pdf, Last accessed February 2020); See also CTA Architects Engineers, 2014. Energy & Store Development Conference Presentation (web link: https://www.fmi.org/docs/default-source/energy/supermarket-refrigeration-system-design-process---a-consultant's-view.pdf?sfvrsn=2, Last accessed February 2020).

GWP systems, e.g., transcritical CO_2 can be lower since it requires less after-market electrical installation because the wiring for the case controllers and electronic expansion valves come factory installed.[106] In contrast, baseline HFC refrigerant cases need to have additional after-market electrical installation of temperature sensors.

Ammonia is already widely used in the industrial refrigeration and cold storage sectors, and there is no shortage of a trained and experienced technician base servicing ammonia systems. However, there is a lack of technicians familiar with the system architecture of the newer types of ammonia systems. Based on stakeholder input, some electrical upgrades may be needed in IPR and cold storage facilities for the low-GWP systems and that can contribute to higher installation costs. Thus, for IPR and cold storage, CARB assumes a 20 percent incremental cost for installation, mainly to incorporate the potentially higher electrical costs associated with the installation of low-charge NH_3 and NH_3/CO_2 cascade systems. Tables below show the baseline and incremental costs per system. Incremental costs were calculated by multiplying the baseline costs with the incremental cost percentages discussed above. All values are rounded up to three significant figures.

Table 16. Incremental Upfront Costs for New, GWP < 150 Refrigeration Systems (2018$)

End-Use Sector	System Size	Incremental Upfront Costs (%)[a]		Incremental Upfront Costs[b] (2018$)	
		Equipment	Installation	Equipment	Installation
Retail Food Refrigeration	Large	20%	10%	+$192,000	+$43,100
	Medium			+$43,800	+$9,800
	Small			+$15,300	+$3,400
Other Commercial Refrigeration	Large			+$134,000	+$14,400
	Medium			+$30,600	+$3,280
	Small			+$10,700	+$1,150
Industrial Process Cooling	Large		20%	+$182,000	+$82,100
	Medium			+$58,700	+$26,400
	Small			+$19,800	+$8,910
Cold Storage	Large			+$225,000	+$101,000
	Medium			+$49,100	+$22,100
	Small			+$21,500	+$9,690

[a] Incremental costs above baseline for compliant systems in percentages.
[b] Incremental costs are calculated by multiplying baseline upfront costs (given in ***Table 15***) with incremental costs in percentages.

[106] HillPhoenix, DeCO_2ded: Understanding ROI on CO2 Refrigeration Systems (web link: http://www.r744.com/files/Hillphoenix_CO2_ROI_WhitePaper_v10_Oct24_2014.pdf, Last accessed February 2020).

In contrast to the upfront costs discussed above, some savings are expected on an ongoing basis for new refrigeration systems. These savings are associated with replenishment of leaked refrigerant, electricity costs and compliance costs associated with CARB's RMP regulation. Each of these are discussed below.

Refrigerant Replenishment: Annually, regulated refrigeration systems leak on average, between 4 to 24 percent of the total refrigerant amount they contain (see Table 4 for baseline leak rates). For example, a large retail food system containing 3,352 pounds of refrigerant, with an annual average leak rate of 24.2% leaks an average of 810 pounds of refrigerant per year. Multiplied by an average annual refrigerant cost of $7 per pound gives an annual cost of replenishing leak refrigerant of approximately $5,700 per year. Across different system sizes and types, annual baseline costs for refrigerant replenishment per system can range widely, and depending on the full charge and leak rate, are estimated to between $29 and $7,500 per year per system (see Appendix ***Table 73*** for details). The current, market-ready low-GWP refrigerants like CO_2 and NH_3 are naturally-occurring gases which are cheaper than synthetic on- and off-patent HFC refrigerants. On average, CO_2 and NH_3 cost between $2 and $4 per pound, at least 50 percent lower than the baseline HFC refrigerant costs, which can range between $5 and $10 per pound (average: $7 per pound).

Table 17. Incremental Refrigerant Costs for New Refrigeration Systems with GWP < 150

Description	In new construction/full remodels, new systems with GWP < 150
Average Incremental Cost Percentage	–50%
Incremental Annual Cost Per Commercial Refrigeration System ($ / year)	- $56 to -$2,800 [a]
Incremental Annual Cost Per Industrial Process Refrigeration System ($ / year)	- $33 to -$2,500 [a]
Incremental Annual Cost Per Cold Storage System ($ / year)	- $15 to -$3,800 [a]

[a] The range of values represent the average savings for the different system sizes (large, medium and small) for each type of refrigeration system (i.e., commercial refrigeration, industrial process refrigeration and cold storage). See Appendix Table 66 for full calculations.

Electricity: Energy usage and thus, electricity costs vary widely by facility type. For example, the electricity costs for a cold storage warehouse can be very different from that of a supermarket. In addition, for some low-GWP refrigerants like CO_2, energy usage by the refrigeration system is heavily influenced by the climate zone. Despite the evidence that currently available low-GWP refrigeration systems can be at energy parity or in some cases, be more energy efficient than baseline HFC systems, the performance of commercial systems e.g., those in supermarkets can still vary due to a number of factors, like operation and maintenance. Due to lack of overarching U.S. DOE energy efficiency requirements on the systems themselves and lack of adequate benchmarking of baseline energy performance of commercial refrigeration systems in the field, CARB staff did not include energy-related costs or savings for the new low-GWP systems in newly constructed / fully remodeled commercial refrigeration facilities.

On the other hand, for industrial process refrigeration and cold storage, because the industry is already well-acquainted with the use of low-GWP refrigerants like ammonia, there are studies and real-world examples of energy cost-savings associated with their use. There are several accounts of end-users installing low-charge ammonia systems and experiencing significant energy savings over HFC systems in cold storage and IPR facilities, reportedly up to 30 percent savings in some cases.[107] In addition to ammonia, CO_2 is emerging as an industrial refrigerant, whether used alone or in combination with NH_3. Ammonia and CO_2 used together in cascade systems minimizes the amount of NH_3 thus lowering the associated risks, and removes any energy penalty issues that can arise from purely CO_2 systems in hot climates, while maximizing the use of environmentally benign, low-cost refrigerants. Using a NH_3/CO_2 cascade system, energy savings of 10 to 25 percent have been measured relative to an HFC baseline system by a California utility company.[108]

As a conservative estimate and based on the data discussed above, CARB staff assumes a10 percent savings in energy for large IPR and cold storage systems being installed in new or remodeled facilities. For the small and medium systems, due to lack of studies comparing the use of low-GWP refrigerants with high-GWP HFC systems. Thus, no savings are assumed for this analysis for the small and medium IPR and cold storage systems (although energy parity with baseline systems and even savings in some cases are likely). On the whole, for IPR and cold storage, a 10 percent energy savings estimate for large systems only is likely an underestimate. Based on available reports, on average, the baseline annual cost of electricity for a large cold storage or IPR system used to serve the needs of a whole facility is estimated to be $350,000 per year (see Appendix ***Table 74*** for details). Thus, a 10 percent annual savings equates to savings of $35,000 per year per large IPR and cold storage system.

[107] Process Cooling, Electrification: Providing Efficiencies Through the Cold Chain (web link: https://www.process-cooling.com/articles/89403-electrification-providing-efficiencies-throughout-the-cold-chain, Last accessed February, 2020); Accelerate America, 2016. Baker Cold Storage. (web link: https://issuu.com/shecco/docs/aa1609/46, Last accessed February 2020); Accelerate America, 2016. Lineage Logistics (web link: https://issuu.com/shecco/docs/aa1609/46, Last accessed February 2020); Accelerate America, 2018. KPAC Cold Storage, (web link: https://issuu.com/shecco/docs/aa1803/36, Last accessed February 2020).

[108] Southern California Edison Company, 2017. *Ammonia/CO_2 Refrigeration System Evaluation at a Food Processing Facility*. (web link: https://www.etcc-ca.com/reports/ammoniaco2-refrigeration-system-evaluation-food-processing-facility, Last accessed February 2020).

Table 18. Incremental Electricity Costs for New Refrigeration Systems with GWP < 150

Description	In new construction/full remodels, new systems with GWP < 150
Average Incremental Cost Percentage	–10% for large IPR and cold storage systems; no change for others
Average Annual Incremental Costs for Large IPR and Cold Storage Systems ($ / year)	- $35,000

Regulatory Cost: Currently, CARB's RMP regulation affects all facilities using refrigeration systems containing more than 50 pounds of a high-GWP refrigerant, where "high-GWP" means a GWP value of 150 or greater. Cost of compliance with the RMP rule includes paying an annual implementation fee (based on facility size) and costs associated with record-keeping and reporting. Baseline annual costs for RMP compliance per system are estimated to be $151, $645 and $3,100 for small, medium and large systems, respectively (see Appendix *Table 75* for details). These baseline costs do not include savings expected under the RMP due to avoided leaks.

The Proposed Amendments will require systems with more than 50 pounds of refrigerant in all newly constructed and fully remodeled facilities to use refrigerants with GWP less than 150, and thus will be exempt from RMP's annual implementation fee, recordkeeping and reporting requirements. This will result in cost-savings for those facilities and the implementation costs borne by the State.

Under the Proposed Amendments, newly constructed or remodeled facilities will have to complete a one-time free registration in CARB's online refrigerant management database, R3. Since most companies that own these facilities already register their existing facilities in R3 under the RMP regulation, this requirement is not expected to add any costs. In addition, equipment manufacturers will be required to add labels and keep records of sales. The current California SNAP regulation requires recordkeeping and a disclosure statement. Here, a labeling requirement is being proposed in lieu of the disclosure. Some labels are required under the current product standards for various components of built-up refrigeration systems and, if sufficient, those existing labels may be used to comply with the proposed rules. Thus, the Proposed Amendments are not expected to add any regulatory costs on any entities.

Table 19 summarizes the change in regulatory costs relative to the baseline scenario.

Table 19. Incremental Regulatory Costs for New Refrigeration Systems with GWP < 150

Cost Categories	In new construction/full remodels, new systems with GWP < 150
Incremental Cost Percentage For RMP Compliance	-100%
Incremental Annual Costs for RMP Compliance Per System ($ / year)	-$151 to -$3,100 per system [a]
For Labeling, Recordkeeping and One-time Facility Registration Requirements under the Proposed Amendments	No change from baseline

[a] The range of values represent the average savings for the different system sizes (large, medium and small). For full calculation, see Appendix Table 68.

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III. Total Incremental Costs per New Refrigeration System with GWP < 150

To illustrate total incremental costs from this proposed rule, we will discuss costs for large systems under each refrigeration sub-sector.

All upfront costs i.e., equipment and installation, were amortized over 15 to 20 years, depending on the average lifetime for different types of systems, using a 5 percent annual real interest rate to reflect end-user financing.

Total incremental costs range between 5 and 18 percent above the baseline scenario for most refrigeration systems, while net savings are expected for a few. The annual total incremental costs per large system ranges up to $17,000 per year and are given in Table 20 through 22 below. Net savings are expected for large IPR and cold storage systems due to expected reduction in all ongoing costs. For medium systems, incremental annual costs range between $2,000 and $6,000 per year.

Table 20. Total Incremental Costs per New, Large Refrigeration System with GWP < 150 (2018$)

Cost Categories	Commercial – Retail Food	Commercial – Other	Industrial Process	Cold Storage
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$192,000	+$134,000	+$182,000	+$225,000
Installation ($)	+$43,100	+$14,400	+$82,100	+$101,000
Total Upfront ($)	+$235,000	+$148,000	+$264,000	+327,000
Amortized Annual Upfront ($ / year)	+ $22,600	+$14,300	+ $21,200	+$26,200
Ongoing Costs				
Refrigerant Replenishment ($ / year)	– $2,800	– $2,800	– $2,500	-$3,800
Electricity ($ / year)	$0	$0	– $35,000	– $35,000
RMP Compliance ($ / year)	– $3,100	– $3,100	– $3,100	– $3,100
Total Incremental Costs				
Total Annual ($ / year)	+$16,600	+$8,320	-$19,400	-$15,700
Total Lifetime ($)	+$249,000	+$125,000	-$389,000	-$314,000

Table 21. Total Incremental Costs per New, Medium Refrigeration System with GWP < 150 (2018$)

Cost Categories	Commercial – Retail Food	Commercial – Other	Industrial Process	Cold Storage
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$43,800	+$30,600	+$58,700	+$49,100
Installation ($)	+$9,850	+$3,280	+$26,400	+$22,100
Total Upfront ($)	+$53,600	+$33,900	+$85,100	+$71,100
Amortized Annual Upfront ($ / year)	+$5,170	+$3,270	+$6,830	+$5,710

Cost Categories	Commercial – Retail Food	Commercial – Other	Industrial Process	Cold Storage
Ongoing Costs				
Refrigerant Replenishment ($ / year)	-$548	-$548	-$289	-$199
Electricity ($ / year)	$0	$0	$0	$0
RMP Compliance ($ / year)	-$645	-$645	-$645	-$645
Total Incremental Costs				
Total Annual ($ / year)	+$3,970	+$2,100	+$5,890	+$4,860
Total Lifetime ($)	+$59,600	+$31,100	+$118,00	+$97,300

Table 22. Total Incremental Costs per New, Small Refrigeration System with GWP < 150 (2018$)

Cost Categories	Commercial – Retail Food	Commercial – Other	Industrial Process	Cold Storage
Upfront Costs (Equipment and Installation)				
Equipment ($)	+$15,300	+$10,700	+$19,800	+$21,500
Installation ($)	+$3,440	+$1,150	+$8,910	+$9,690
Total Upfront ($)	+$18,700	+$11,900	+$28,700	+$31,200
Amortized Annual Upfront ($ / year)	+$1,504	+$952	+$2,300	+$2,500
Ongoing Costs				
Refrigerant Replenishment ($ / year)	-$56	-$56	-$33	-$15
Electricity ($ / year)	$0	$0	$0	$0
RMP Compliance ($ / year)	-$151	-$151	-$151	-$151
Total Incremental Costs				
Total Annual ($ / year)	+$1,300	+$745	+$2,120	+$2,340
Total Lifetime ($)	+$25,900	+$14,900	+$42,400	+$46,800

IV. Incremental Costs for Refrigeration Systems in Existing Facilities

i. Retail Food Facilities

The Proposed Amendments require retail food companies, i.e., supermarkets and grocery stores, to reduce their current banks of high-GWP HFC refrigerants. Instead of implementing this on a per-store basis, CARB staff proposes taking a wider approach, where each retail food company will be required to reduce their company-wide average GWP (weighted by the pounds of refrigerant, across all their stores) to below 1,400 by 2030. Hereafter, this is referred to as the "Weighted-average GWP Reduction Program." In effect, this will be a performance standard for the retail food industry and is akin to CARB's vehicular fleet standards whereby retail food companies will be required to reduce HFC emissions from their current "fleet" of supermarkets and grocery stores, while being encouraged to transition to low-GWP technologies.

This approach provides flexibility to companies to (1) reduce their GWP using strategies most suitable for them; and (2) to plan and distribute costs over an 8-year period, between 2022 and 2030. Retail food companies will also have an alternative compliance option, under which they can reduce both, the total amount of refrigerant used and GWP of those refrigerants across their stores. This is called the "Greenhouse Gas Potential" or "GHGp" and represents the potential HFC emissions that can result from all the systems a company owns. End-users will have the option to opt-into this compliance pathway by January 1, 2022, and will be required to reduce their company-wide GHGp by 55 percent below their 2018 baseline.

The following are some options for meeting the weighted-average GWP or the GHGp reduction targets:

- Reduce GWP by
    - Retrofits to refrigerants with GWP below 1,400.
    - Partial system conversions to low-GWP (GWP < 150) refrigerants in the store.
- Reduce refrigerant amount (or charge) and GWP by
    - Replace a current system with distributed and micro-distributed HFC systems using refrigerants with GWP < 1,400. These systems use smaller amounts of refrigerants than the current systems.
    - Replace a current system with an indirect system, i.e., systems which use smaller quantities of HFC refrigerants as the primary refrigerants and a secondary heat transfer fluid or low-GWP refrigerant to cool products e.g., cascades.
    - Replace a current system with stand-alone systems (much smaller quantities of refrigerants and lower GWPs).

Since there are several ways to comply with the Proposed Amendments, CARB staff estimated the incremental costs for this rule based on the most common-place practice in the industry today, i.e., retrofits to refrigerants with GWP below 1,400. Based on stakeholder input, this will also likely be the most economical option to achieve compliance. Other options listed above may cost more but will have the added benefit of being more future-proof in terms of future national and global HFC regulations and could allow companies to leave some stores un-altered (if extra reductions are obtained from some stores, others may be left untouched).

To estimate the incremental costs of refrigerant retrofits, CARB staff sought direct input from supermarket end-users[109] and those are discussed below and summarized in Table 23. Each cost category is discussed in detail below.

Table 23. Average Incremental Costs for Existing Retail Food Systems (i.e., in Supermarkets and Grocery Stores)

Cost Categories	Average Incremental Costs
Equipment and Installation	+$45 per pound of refrigerant
Refrigerant Replenishment	+50% per pound of refrigerant
Operation and Maintenance	No change from baseline
RMP Compliance	No change from baseline
Electricity	–5% per system

While the F-Gas Inventory tracks emissions on a per-system basis, end-users may plan to carry out retrofits for the entire store or facility at once, instead of one system at a time. To provide a holistic look, an example of incremental costs for retrofitting a typical supermarket is given below in Table 24. For this example, an average supermarket is assumed to use 2,500 pounds of refrigerant across all systems containing more than 50 pounds of refrigerant, and having a facility-wide annual refrigerant leak rate of 23 percent.

Table 24. Supermarket Refrigeration Cost Example for Retrofit (2018$)

Cost Category	Baseline System using R-404A	System retrofitted to R-448A / R-449A	Difference
Upfront Costs (amortized over 10 years with a 5% interest rate)	$0	$14,569	+$14,569
Refrigerant Replenishment	$4,025	$6,038	+$2,013
Electricity	$205,292	$195,027	- $10,265
Total Annual Costs per Supermarket ($ / year)	$209,317	$215,634	+$6,320

Upfront Equipment and Installation Costs: For the existing retail food systems, a typical refrigerant retrofit includes the following: recovery/removal of old refrigerant, replacing necessary seals and valves on the display cases and receivers, replacement of lubricant oil and filters, filling in the new refrigerant, re-labeling all equipment, leak and pressure checks before

[109] Direct communications with stakeholders between August 2019 and December 2019.

and after changing the refrigerant, and recordkeeping related to the changes. Altogether, along with associated labor costs, the upfront costs of retrofit are on average, $45 per pound of refrigerant in the system. For an average supermarket that uses a total of 2,500 pounds of R-404A type refrigerant, the upfront cost for retrofitting the entire store is estimated to be 2,500 lb. × $45 per lb. = $112,500. For the purposes of this analysis, this upfront cost is amortized over a period of 10 years, roughly half the average lifetime of a new system. The assumption here being that a retrofitted system will at least be used for another 10 years. A full 20-year amortization is not used because systems being retrofitted are going to be of varying ages and may not all last as long. The amortization also includes a 5 percent annual real interest rate to reflect end-user financing. For an average supermarket, the annualized incremental upfront cost is approximately $14,600 per store.

Refrigerant Replenishment: The ongoing costs may be higher for refrigerant replenishment; based on stakeholder input, it is estimated that costs for refrigerants with GWP less than 1,400, for example, R-448A / R-499A are on average 50 percent higher than R-404A-type refrigerant per pound. For an average supermarket that has a total charge of 2,500 lb. and an annual average refrigerant leak rate of 23 percent, the baseline cost for replenishing leaked refrigerant annually is 2,500 lb. × 23% per year × $7 per lb. = $4,025 per year. After the retrofit, assuming no change in annual leak rates occurs, the annual cost for refrigerant will be = 2,500 lb. × 23% per year × $10.50 per lb. = $6,038 per year. Thus, the incremental cost per year is expected to be $6,038 – $4,025 = $2,013 per year. While it is expected that the cost of the refrigerants like R-448A and R-449A will soon achieve parity with the current commonly used refrigerants, we do not factor in a declining cost curve to be conservative and not understate the costs.

Operation and Maintenance: No incremental costs are expected for maintenance because systems using refrigerants with GWP less than 1,400 are already in use today and do not require any additional maintenance than the baseline high-GWP HFC systems.

RMP Compliance: These systems will continue to be regulated under the RMP unless the GWP of the system falls below 150, so no change in RMP compliance costs is assumed. There are some recordkeeping and reporting requirements associated with compliance with the weighted-average GWP / GHGp reduction requirements. However, those align with the current requirements under the RMP and thus, are not expected to increase the costs to end-users for compliance.

Electricity: Retrofits are expected to yield energy savings. Laboratory studies of retrofits have demonstrated that R-448A/R-449A have higher coefficients of performance and use less compressor power compared to high-GWP refrigerants like R-404A, which results in lower energy consumption when existing systems are retrofitted to use the former.[110] Additionally, as part of

[110] Mota-Babiloni, et al., (2015). Experimental evaluation of R448A as R404A lower-GWP alternative in refrigeration systems. (web link: https://www.tib.eu/en/search/id/tema%3ATEMA20150916080/Experimental-evaluation-of-R448A-as-R404A-lower/, Last accessed February 2020); Sethi, et al., (2016). Experimental evaluation and field trial of low global warming potential R404A replacements for commercial refrigeration. (web link: https://www.tandfonline.com/doi/abs/10.1080/23744731.2016.1209032, Last accessed February 2020); Fricke, B. A., Sharma, V., & Abdelaziz, O. (2017). Low Global Warming Potential Refrigerants for Commercial Refrigeration Systems. (web link: https://info.ornl.gov/sites/publications/Files/Pub75272.pdf, Last accessed February 2020).

the retrofit process, refrigeration systems receive an overhaul and “tune-up” – this tune-up, though not related to the refrigerants’ properties, improves the energy efficiency of the system, which results in savings that may not have otherwise occurred. Laboratory studies of retrofits report energy savings of up to 20 percent[111] and supermarket end-users experienced with retrofits have reported a reduction in energy consumption of up to 9 percent after retrofitting from R-404A to R-448A / R-449A.[112] Since, apart from the R-404A / R-507 systems, retrofits will likely be carried out for systems using other refrigerants as well (for example, R-22 and R-407A), as a conservative estimate, CARB staff assume at least an average of 5 percent reduction in electricity costs can be expected from all retrofitted systems.

To calculate the savings in dollars, an U.S. EPA estimate of average baseline electricity costs for a typical supermarket was used,[113] and 5 percent savings were calculated assuming at least 50 percent of the annual cost of electricity borne by a supermarket is due to its refrigeration systems. On average, a supermarket is expected to save at least $10,000 per year due to improved energy efficiency if all systems greater than 50 pounds were retrofitted.

For the cost analysis to be consistent with the F-Gas Inventory which tracks emissions per system and not per facility, we multiplied the number of systems that would need to be retrofitted (Table 25) with the incremental annual costs per system (Table 26) to estimate total annual costs for retrofits on a statewide level. To comply with the progress step in 2026, some of the existing retail food systems are modeled to retrofit in 2026 while the remaining in 2030 to comply with the overall requirement for the statewide weighted-average GWP to be below 1,400 by 2030. The number of systems affected by this rule decreases from 2026 to 2030 as some of those existing systems reach their end of life and turn over into new equipment which are then required to use refrigerants compliant with the GWP limits for new systems (discussed in the preceding section).

Table 25. Number of Refrigeration Systems Affected by the Weighted-Average GWP Requirement

Year	Existing Systems Affected by Weighted-Average GWP Reduction Program (e.g., Retrofits)		
	Large	Medium	Small
2026	70	3,197	8,365
2030	26	1,958	6,730

111 *Ibid.*

112 Direct communications with stakeholders between August 2019 and December 2019.

113 U.S.EPA. Supermarkets: An Overview of Energy Use and Energy Efficiency Opportunities (web link: https://www.energystar.gov/sites/default/files/buildings/tools/SPP%20Sales%20Flyer%20for%20Supermarkets%20and%20Grocery%20Stores.pdf), Last Accessed: February 2020.

Table 26. Total Incremental Costs per Retail Food System for Retrofitting to GWP < 1,400 (2018$)

Cost Categories	Large	Medium	Small
Upfront Costs (Equipment and Installation)			
Total Upfront ($)	+$151,000	+$30,800	+$4,640
Amortized Annual Upfront ($ / year)	+$19,500	+$3,990	+ $600
Ongoing Costs			
Refrigerant Replenishment ($ / year)	+$2,840	+$548	+ $56
Electricity ($ / year)	- $13,800	- $$2,800	- $600
Regulatory Compliance ($ / year)	$0	$0	$0
Total Incremental Costs			
Total Annual ($ / year)	+$8,620	+$1,730	+$56

ii. Other Refrigerated Facilities

Under the Proposed Amendments, new systems being installed in all existing facilities have to use refrigerants with a GWP below 1,500. This requirement applies to all facilities except retail food facilities, which are addressed separately above.

To comply with this rule, HFCs like R-448A, R-449A and R-134a can be used. The costs associated with this proposed rule are relatively minor compared to the rules discussed before, since refrigerants compliant with this GWP limit are already required under the current regulations for cold storage and are already used in commercial refrigeration. Thus, of the three refrigeration end-use sectors, this proposed rule mainly affects only industrial process refrigeration (IPR). Additionally, the rule will apply only to those IPR refrigeration systems that are not chillers.[114]

After discussion with stakeholders, CARB staff estimated a 10 percent incremental equipment cost for the IPR non-chiller systems. Across system sizes (small to large), the lifetime incremental equipment costs per IPR system range between $9,900 and $91,000 (see Table 65). No incremental installation costs are assumed because there are no fundamental differences between installation of systems using currently used HFCs like R-404A or R-407A and HFCs with a GWP less than 1,500. Refrigerant costs on an ongoing basis are expected to be higher than baseline, because costs for R-448A/R-499A are on average 50 percent higher than R-404A-type refrigerant per pound. Across system sizes (small to large) and types (commercial, industrial, cold storage), the incremental annual costs ranges between $33 and $2,800 per year (see

[114] Chillers have a separate GWP limit of 750, which is discussed in Section A.

Table ***66***). Since the refrigerants with GWP values just under 1,500 and systems using them do not differ in any significant way from the baseline refrigerants, no other changes are expected relative to the baseline since costs associated with operation and maintenance, electricity, and compliance with RMP and the Proposed Amendments are expected to remain the same as the baseline scenario. For full costs and details, the incremental costs per system type for this rule are given in the Appendix tables.

V. Total Costs – Refrigeration

To calculate total costs for the Proposed Amendments for regulated refrigeration systems, the incremental costs per system are multiplied by the number of new or existing systems that are affected by the rule, i.e., *Annual Total Costs for Refrigeration = (Incremental cost per new system using refrigerant with GWP < 150 or 1,500 x Number of new systems affected by rule per year) + (Incremental cost per existing retail food system x Number of affected retail food systems).* In addition, an 8.5 percent sales tax was added to the equipment costs.[115] System populations affected by the Proposed Amendments for refrigeration are discussed in Section A, Baseline Information.

Table 27 shows the total direct costs and savings associated with all the proposed rules for regulated refrigeration equipment. Between 2022 and 2040, the total annual costs range between $2.18 million and $41.7 million, with an average annual cost of $27.4 million. Across new and existing refrigeration facilities, added compliance costs for refrigeration systems arise mainly due to the higher upfront equipment and installation costs. Some savings are expected due to reduced RMP compliance costs and lower refrigerant costs for new facilities with GWP less than 150. Some energy savings are also expected for new industrial process facilities and for retail food facilities as they make system upgrades to comply with the weighted GWP reduction requirement. The total costs for refrigeration increase sharply in 2026 and 2030 as existing retail food facilities comply (by retrofits) and reduce their weighted-average GWP to below 1,400. The costs for retrofits are amortized over 10 years and thus, starting 2036, total costs start to decline and plateau. All values are rounded up to three significant figures. For the emissions analysis, systems being retrofitted continue to survive and yield emissions reductions based on the equipment survival curves built into the inventory. At their end of life, retiring systems get replaced by new systems which are governed by GWP limits discussed above.

Table 27. Total Costs for the Proposed Amendments for Refrigeration Systems (Millions 2018$)

Year	Equipment and Installation Cost[a]	Refrigerant Cost[b]	Regulatory Cost[c]	Electricity Cost[d]	Total Cost[e]
2022	$2.07	$0.57	-$0.19	-$0.15	$2.30
2023	$4.15	$1.15	-$0.39	-$0.30	$4.61
2024	$6.25	$1.73	-$0.58	-$0.46	$6.95
2025	$8.37	$2.32	-$0.78	-$0.61	$9.30

[115] The sales tax varies across the state from a minimum of 7.25% up to 10.25% in some municipalities; a value of 8.5% was used for staff's analysis based on a statewide population weighted average.[115]

Year	Equipment and Installation Cost[a]	Refrigerant Cost[b]	Regulatory Cost[c]	Electricity Cost[d]	Total Cost[e]
2026	$30.8	$5.33	-$0.98	-$16.0	$19.2
2027	$33.0	$5.93	-$1.18	-$16.1	$21.6
2028	$35.1	$6.53	-$1.38	-$16.3	$23.9
2029	$37.3	$7.13	-$1.58	-$16.6	$26.2
2030	$52.6	$9.27	-$1.78	-$27.1	$33.0
2031	$54.8	$9.88	-$1.99	-$27.3	$35.4
2032	$57.1	$10.5	-$2.20	-$27.5	$37.9
2033	$59.3	$11.1	-$2.41	-$27.6	$40.4
2034	$61.6	$11.7	-$2.62	-$27.8	$42.9
2035	$63.8	$12.4	-$2.83	-$28.0	$45.4
2036	$45.8	$10.6	-$3.04	-$12.7	$40.7
2037	$47.4	$10.7	-$3.16	-$12.8	$42.2
2038	$49.0	$10.9	-$3.27	-$13.0	$43.7
2039	$50.7	$11.1	-$3.39	-$13.2	$45.1
2040	$39.2	$9.7	-$3.51	-$3.1	$42.2

[a] Total annual added equipment and installation cost above the baseline, for new systems complying with the GWP limits of 150 and 1,500 in new and existing facilities, and the weighted-average GWP requirement for retail food facilities. Equipment costs contain an 8.5 percent sales tax.
[b] Total annual cost for replenishing leaked refrigerant across all affected systems (added costs from retail food systems complying with weighted-average GWP requirement and new systems complying with a GWP limit of 1,500 minus savings for new systems complying with a GWP limit of 150).
[c] Total annual cost savings due to lower regulatory (RMP) costs for new systems in newly constructed facilities complying with a GWP limit for 150.
[d] Total annual electricity savings for new, large IPR systems complying with the GWP limit of 150 and savings from retrofitted retail food systems.
[e] Total annual costs are the sum of all annual costs and savings per year.

b. Direct Cost Inputs – Air Conditioning

For regulated air conditioners, the following GWP limit would apply under the Proposed Amendments:

- **New AC Equipment:** New equipment will be required to have refrigerants with GWP less than 750.

Manufacturers have two main refrigerant options to meet the 750 GWP limit. One option is to use an A2L (lower flammability) refrigerant and the other option is to use an A1 (non-flammable) refrigerant.[116] The refrigerant replacement options identified for R-410A are all Class A (nontoxic). AC equipment using A2L refrigerants are widely available in other countries (Japan, China, Europe and Australia). The costs associated with A2L equipment includes mitigation for its lower flammability properties, which includes preventing refrigerant leaks from occurring and

[116] These refrigerant designations are set by the nationally accredited standard setting body, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

appropriate mitigation if leaks do occur. Depending on the A2L refrigerant selected, there may be higher refrigerant costs or cost savings. The other option is to use an A1 (non-flammable) refrigerant. Equipment and component manufacturers are currently conducting product testing to use an A1 refrigerant with a GWP less than 750. The costs associated with this option include product redesign and higher refrigerant costs. The incremental costs in this analysis are meant to be representative averages for the available refrigerant options which could be used to comply with the Proposed Amendments. The assumptions for direct costs are detailed in the following sections.

I. Cost Methodology for Air Conditioning Costs

The Proposed Amendments will require manufacturers to produce and sell AC equipment that has higher upfront and ongoing costs for maintenance and repair than in the baseline. These costs included higher equipment and installation costs (upfront costs) and higher repair and maintenance costs (ongoing costs). Staff first estimate baseline costs and then estimate the costs to comply with the Proposed Amendments, which are expressed as incremental costs above the baseline. Table 28 shows the types of costs and industries incurring costs to comply with the limits for new AC equipment under the Proposed Amendments. While equipment pricing is complex, and different manufacturers could use different strategies to pass on these costs, staff make a conservative assumption that all costs from deploying compliant equipment for the California market are fully passed on to end-users. Further details on the upfront and ongoing costs are provided in the sections below.

Table 28. Industries Incurring Direct Costs under the Proposal for Stationary AC

Type of Cost	Industries incurring costs and NAICS costs	Industries or entities with passed-on costs
Equipment (upfront cost)	Equipment Manufacturers	AC end-users (e.g., owners of AC equipment in: single and multi-family homes, commercial buildings, and non-residential buildings such as schools and hospitals)
Transport and Storage (ongoing)	Distributors/ Wholesalers	
Installation (upfront) and Maintenance (ongoing)	Technicians	
Refrigerant (ongoing)	Refrigerant and Equipment Manufacturers, and Distributors/ Wholesalers	

Baseline Costs: The baseline costs for new residential and commercial AC equipment are based on U.S. DOE Technical Support Documents for their energy conservation standards.[117] Staff

[117] Energy Conservation Program: Energy Conservation Standards for Residential Central Air Conditioners and Heat Pumps, 82 Fed. Reg. 1786 (Jan. 6, 2017); See Technical Support Documents submitted as part of rulemaking available here: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0048-0102; Energy Conservation

obtained the baseline costs including manufacture production cost (MPC) and retail cost for equipment, as well as installation, maintenance and repair costs from U.S. DOE shipment-weighted product distribution projected by U.S. DOE for 2020 to 2040 and average cost per product. Staff obtained this information for the "hot-dry" southwest region (California, Arizona, New Mexico and Nevada). Therefore the average baseline costs used in this analysis take into account the range of product prices, which vary by energy efficiency rating, type of product and size, and are weighted by the distribution of products shipped to the southwest market (see Table 29). California represents nearly 80 percent of the population in this region, therefore, the product distribution for the southwest region from the U.S. DOE is expected to be a good characterization of the California market, even with some variation in AC usage between states. Staff corroborated product distributions from U.S. DOE analysis[118] by comparing shipment data submitted to CARB by the Heating, Air-conditioning and Refrigeration Distributors International (HARDI). HARDI provided annual shipments of residential ACs in California for the years 2013 through 2018 by product type and efficiency rating. Both the U.S. DOE and HARDI data show that the majority (80 percent or more) of AC shipments are in the base efficiency ranges. From 2023 onward, the product distribution shifts into higher base efficiency ranges according to U.S. DOE standard compliance dates taking effect. This is taken into account in the costs staff used to characterize the baseline. The baseline upfront costs (equipment retail + installation costs) are amortized using a 5 percent real interest rate, a 15-year life for residential equipment and 20-year life for commercial equipment to reflect end-user financing.

Table 29. Baseline Costs for AC Equipment in 2023 ($2018)

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Equipment Retail Costs ($)	$3,300	$4,655	$8,875	$21,120
Installation Cost ($)	$1,790	$2,020	$4,290	$6,600
Amortized Upfront Costs (Equipment Retail + Installation)	$7,356	$9,646	$21,128	$44,486
Annual Maintenance/Repair Cost ($)	$70	$105	$945	$810
Lifetime Maintenance/Repair Costs ($)	$1,050	$1,575	$18,900	$16,200
Lifetime Unit Costs ($) (Amortized Upfront + Lifetime Maintenance and Repair)	$8,406	$11,221	$40,028	$60,686

Standards for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment, 81 Fed. Reg. 2420 (Jan. 15, 2016); See Technical Support Documents submitted s part of rulemaking available here: https://www.regulations.gov/docket?D=EERE-2013-BT-STD-0007 (Hereinafter collectively "U.S. DOE Technical Support Documents").
[118] *Ibid.*

The cost of ACs have generally decreased over the last several decades, even with product redesigns and the introduction of new energy conservation standards. Economic literature and historical data[119] suggest that the costs of AC products trend downward over time according to "learning" or "experience" curves.[120] CARB incorporates an experience curve[121] to estimate future baseline costs of products as follows:

$$P = P_0(\frac{X}{X_0})^{-b} = P_0\left(\frac{X_0{}^{at}}{X_0}\right)^{-b} = P_0e^{-\alpha t}$$

where,

P = price of the unit

P_0 = price of the first unit of production

X = cumulative production

X_0 = initial cumulative production

b = experience rate parameter

t = time variable, equal to the difference between the base year and any given year

α = exponential parameter of the time variable

Staff uses a learning rate of 11 percent,[122] which represents the percentage reduction in cost that occurs with each doubling of cumulative production consistent with the U.S. DOE.[123]

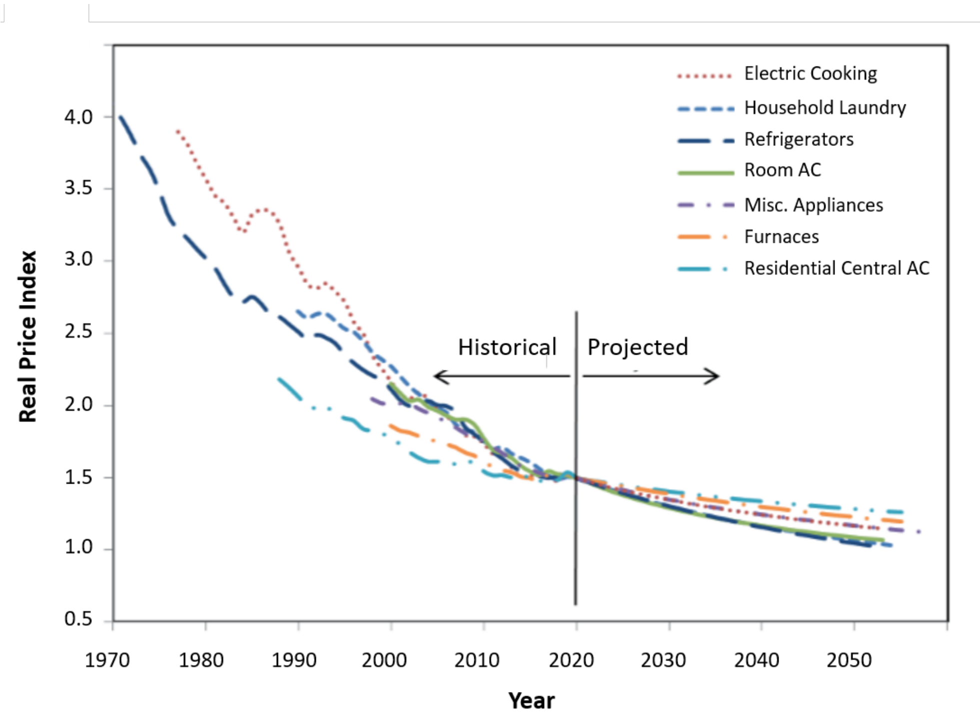
[119] Descroches, L., et al., (2013). Incorporating experience curves in appliance standards analysis. (web link: https://www.sciencedirect.com/science/article/pii/S0301421512008488, Last accessed February 2020); See also U.S. DOE Technical Support Documents.

[120] Staff estimates the initial cumulative production at 200 million units sold to California from 1978 to 2015 based on CARB's F-Gas Inventory. Staff use 0.163 as the experience rate parameter consistent with the U.S. DOE.

[122] The learning rate (LR) is found from the formula $LR = 1 - 2^{-b}$, where *b* is the experience rate parameter of 0.163.

[123] *Ibid.*

Figure 7. Long-Term Decrease in Residential AC Costs[124]



Incremental Costs: Staff estimate the incremental cost to comply with the Proposed Amendments as a percentage above baseline. Incremental costs were estimated by seeking input from stakeholders during public working group meetings, stakeholder meetings and surveys as described in Section A.6., Public Outreach and Input. The incremental cost to comply with the Proposed Amendments vary depending on the specific alternative refrigerant selected. Cost impacts for room ACs are not included in this analysis as products are available today at the same or lower cost as equipment using R-410A and a full transition to a refrigerant with a GWP less than 750 is not expected to increase costs.[125] Staff estimated average incremental costs for stationary AC residential and commercial equipment, which takes into account a range of refrigerant options and the associated costs. To obtain incremental costs per system in dollars, the incremental cost percentages were multiplied with the baseline costs for each type of air conditioning system, i.e. *Incremental Cost per System (in 2018$) = Baseline Cost per System (in 2018$) x Incremental Cost as a Percentage above Baseline.*

All upfront costs were amortized over 15 to 20 years, depending on the average lifetime for different types of equipment, and using a 5 percent annual interest rate, to reflect end-user financing. Staff applies the learning rate described in the previous section to incremental costs

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[124] Figure adapted from Desroches et al., 2013.
[125] UNEP, *Fact Sheet 7: Small Self Contained Air-Conditioning*, Last visited February 2020); See also JMS Consulting, *Consumer Cost Impacts of U.S. Ratification of the Kigali Amendment*. (web link: http://www.ahrinet.org/App_Content/ahri/files/RESOURCES/Consumer_Costs_Inforum.pdf, Last accessed February 2020).

under the Proposed Amendments from 2023 to 2040 and estimates the cumulative sales consistent with the number of new ACs described in Section A.5., Baseline Information.

Energy Efficiency: Alternative refrigerants either match or have better performance in terms of energy efficiency compared to baseline.[126] However, it is uncertain what the market penetration of the various alternative refrigerants will be and whether manufacturers will use this efficiency to meet U.S. DOE energy efficiency standards in place of other features for California equipment. Due to these uncertainties, staff did not model energy efficiency savings for end-users.

II. Upfront Equipment and Installation Costs

Equipment Costs: The majority of AC and refrigeration equipment manufacturers selling equipment to California are international corporations which are transitioning product lines away from high-GWP refrigerants and have invested billions to bring next generation refrigerants and equipment to market. [127] Equipment manufacturers can select an A2L or A1 refrigerant to comply with the 750 GWP limit. Regardless of which refrigerant option manufacturers elect to use to comply, changing refrigerants requires system design changes. Even refrigerants that are "near drop-in" replacements require design changes to optimize system performance.
AC manufacturers incorporate design changes through design cycles to ensure that new equipment meeting all regulatory requirements are available as needed for commercial introduction. The 2023 compliance date was selected by CARB to allow industry to incorporate a refrigerant change into their ongoing design cycle to meet new U.S. DOE energy conservation standards. CARB had initially proposed a compliance date of 2021. CARB shifted this date to 2023 in order to minimize cost impacts by aligning with the ongoing design cycle, as requested by industry.[128] Aligning design cycles significantly reduces the anticipated cost impacts associated with major design cycles, enabling industry to move quickly and efficiently to new equipment designs.[129]

The cost of a design cycle for equipment manufacturers to redesign product lines traditionally costs $20 to $50 million depending on the timing and complexity of redesign.[130] According to AHRI, equipment manufacturers anticipate spending an average of $21 million per manufacturer to bring AC products to market for California that comply with the Proposed Amendments.[131] Manufacturers will balance refrigerant cost against other properties of the refrigerant, which can

[126] https://aceee.org/files/proceedings/2010/data/papers/1933.pdf
[127] AHRI & ARAP, Letter to United States Senate and House of Representatives (Oct. 8, 2019). (web link: https://images.magnetmail.net/images/clients/AHRI/attach/FINALCEOLetterwithSignaturesFinal.pdf, Last accessed February 2020).
[128] AHRI, NRDC, Carrier Corporation, Daikin Applied Americas, Inc., Goodman Manufacturing Company, L.P., Lennox International, Nortek Global HVAC LLC, Trane Inc., The Chemours Company, Honeywell International Inc., Letter to Chair Nichols. 14 September AHRI et al., Joint Voluntary Commitment Letter to CARB (Sept. 14, 2018). (web link: http://www.ahrinet.org/Portals/_Appleseed/documents/news/AHRI_NRDC_CARB_Letter_regarding_SLCP_HFC_measures.pdf., Last accessed February 2020).
[129] JMS Consulting, Consumer Cost Impacts of U.S. Ratification of the Kigali Amendment (web link: http://www.ahrinet.org/App_Content/ahri/files/RESOURCES/Consumer_Costs_Inforum.pdf, Last accessed February 2020)
[130] *Ibid.*
[131] The basis of these costs estimates includes a survey of AC equipment manufacture conducted by CARB and cost analysis provided during stakeholder meetings as described in Section A. 6. Public Outreach.

add to design costs. For example, a low-cost refrigerant might require more extensive component redesign while a more expensive refrigerant might offer cost savings or efficiencies elsewhere, or other benefits that are not related to cost. Manufacturers will select a refrigerant that presents a balance of tradeoffs that minimizes product costs and aligns with their strategic priorities to transition refrigerants across different market segments and AC applications.

The AC industry has a history of continually innovating to deliver products with higher efficiency and performance at lower costs while phasing out environmentally harmful refrigerants under the Montreal Protocol. As with past refrigerant transitions and redesigns, added costs are expected, at least initially. Depending on the choice of refrigerant, there may be added costs for design changes to components such as compressors, increases in commodity metal costs, or additional safety features for A2L refrigerants. These costs can be offset by reduced charge sizes, increased efficiency and other benefits of next generation refrigerants. In addition, the cost to transition refrigerants can be minimized through advances in manufacturing and efficiency improvements, which reduce lifecycle costs.

Based on cost analysis provided by equipment manufacturers to CARB, the incremental costs of compliant equipment is estimated to range 5 to 10 percent higher compared to baseline retail costs (see ***Table 30***). The incremental costs of compliant AC equipment is expected to decrease as production increases. CARB incorporates a learning curve as described in Section B, under Subsection I, Cost Methodology for Air Conditioning, which takes into account diminishing incremental costs relative to baseline as cumulative production increases. Staff take a conservative approach that compliant equipment are developed and sold exclusively for the California market. However, as other states commit to taking action on high-GWP HFCs, demand for these products is expected to expand into other market segments.

Table 30. Incremental Equipment Costs for New AC Systems

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Equipment Costs (compared to baseline retail) (%)	+5%	+5%	+10%	+6%
Baseline Retail ($)	$3,300	$4,655	$8,875	$21,120
Total Incremental Equipment Costs ($)	+$165	+$213	+$908	+$1,196

Installation Cost: The installation process will remain largely the same as for baseline R-410A equipment. However, for A2L products, installers would need to be trained to ensure that they are fully equipped to install A2L systems. Training for A2L equipment is expected to be incorporated into existing training programs. Many of the tools used for current R-410A can be used for A2L refrigerants. Technicians will largely be able to replace older tools with ones that are also rated for A2Ls as their older tools are retired at the end of their useful life. The pipework installation is exactly the same as R-410A. While most systems come factory charged, installers transporting refrigerant cylinders will need store them vertically, vehicles must have a flammable gas placard, ($5 to $40) and class B fire extinguishers ($30 to $60). If manufacturers comply with the Proposed Amendments using an A1 refrigerant, there will be no change in installation costs. The cost range for installing AC systems with a refrigerant less than 750 GWP ranges from zero to 6 percent higher. To represent an average scenario, staff estimate installation costs at 3 percent higher for AC systems with the Proposed Amendments in effect (see ***Table 31***).

Table 31. Incremental Installation Costs for New AC Systems

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Installation Costs (%)	+3%	+3%	+3%	+3%
Baseline Installation Cost ($)	$1,790	$2,020	$4,290	$6,600
Total Incremental Installation Costs ($)	+$54	+$61	+$129	+$198

III. Ongoing Maintenance and Repair Costs

CARB anticipates that much of the routine servicing and repairs will be the same as for a baseline system. Many repairs do not involve adding refrigerant, so many of the routine repair items like replacing electronics, motors, etc., are expected to be the same for baseline R-410A systems. In most cases, the cost of labor is the majority of the repair cost. In the event a system requires a refrigerant recharge, there may be a change in refrigerant cost. Refrigerant costs may not increase for alternative refrigerants currently in mass production. In fact, there is an opportunity for cost savings for refrigerant that require less charge size for the same capacity system and as systems become more leak tight. However, new, more complex molecules, such as HFO blends and blends with trifluoroiodide (CF_3I) are expected to be more expensive. Industry has indicated to CARB that new refrigerant blends that would comply with the Proposed Amendments may be two to five times the cost of R-410A at the point of sale to the equipment manufacturer. The average price of R-410A to the equipment manufacturer today is about $3.00 per pound. It is typical for new refrigerant blends to be more expensive initially and for prices to come down as production increases. While the refrigerants used to comply with the Proposed Amendments are also being deployed around the globe, it is speculative to predict how refrigerant prices may come down in the future. As with current R-410A equipment, refrigerant costs are expected to account for a small portion, less than one percent of the total cost of ownership over the lifetime of the equipment.

Maintenance and repair costs reflect annualized labor and material costs for maintaining and operating of AC equipment and for replacing components that have failed. There is no change in labor time for an A1 alternative. However, for an A2L alternative, there may be an increase in labor time because of additional safe handling processes that will be required with the introduction of A2Ls. For example, in the event that a refrigerant leaks, the technician will have to evacuate and purge the system with dry nitrogen before they can repair the leak. This is a best practice already but will be required for an A2L system. As with the installation, technicians will need to be trained to work on A2L systems and will need to verify that their tools (gauge manifolds, recovery pumps, leak detectors and recovery cylinders etc.) are suitable for use with A2Ls. CARB estimates the incremental cost for servicing and maintenance to be 5 percent. This reflects an extra thirty minutes to an hour of labor time and more expensive replacement parts or the use of a refrigerant that may be more expensive.

Table 32. Incremental Maintenance and Repair Costs for New AC Systems

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Total Incremental Maintenance and Repair Costs (%)	+5%	+5%	+5%	+5%
Baseline Lifetime Maintenance and Repair Costs ($)	$1,050	$1,575	$18,900	$16,200
Total Lifetime Incremental Maintenance and Repair Costs ($)	+$53	+$79	+$945	+$810

IV. Total Costs – Air-Conditioning

The primary reason for cost increases for AC systems associated with the Proposed Amendments is costs incurred at the manufacturing level. Staff assume all costs are passed on to end-users as higher upfront costs for equipment and a summary of per unit costs are provided in Table 33. The total incremental upfront costs is the equipment and installation cost added together and amortized to reflect end user financing at a 5 percent real interest rate across the lifetime of the equipment—15 year average for residential; 20 year average for commercial. The total incremental ongoing costs per unit come from the added cost of maintenance and repair.

To calculate total costs (Table 34) for the Proposed Amendments for regulated AC equipment, the annual incremental costs per system are multiplied by the number of new or existing systems that are affected by the rule, i.e., *Annual Total Costs for AC = (Incremental cost per new system* *using refrigerant with GWP < 750 (in 2018$) x Number of new units affected by rule per year) + (Incremental cost per unit (in 2018$)*. System populations affected by the Proposed Amendments for refrigeration are discussed in Section A, Baseline Information. Sales tax is included in the baseline costs.

Table 33. Total Incremental Costs for Per Unit for New AC Equipment ($2018)

Cost Categories	Residential Central AC	Residential Central HP	Commercial AC/HP (Small – Medium)	Commercial AC/HP (Large)
Upfront Costs (Equipment + Installation)				
Equipment Retail ($)	+$165	+$213	+$908	+$1,196
Installation ($)	+$54	+$61	+$129	+$198
Total Upfront ($)	+$219	+$274	+$1,037	+$1,394
Amortized Annual Upfront ($/year)	+$21	+$26	+$83	+$112
Ongoing Costs (Maintenance/Repair)				
Lifetime ($)	+$53	+$79	+$945	+$810
Annual ($/year)	+$4	+$5	+$47	+$41
Total Incremental Costs				
Total Lifetime ($)	+$369	+$474	$2,192	$2,488
Total Annual ($)	+$25	+$32	+$110	+$124

Table 34. Annual Incremental Costs for the Proposed Amendments for New AC Systems (Millions 2018$)

Year	Equipment and Installation Costs	Service and Maintenance Costs	Total Costs
2023	$18.4	$4.60	$23.0
2024	$37.0	$9.20	$46.2
2025	$55.7	$13.8	$69.5
2026	$74.4	$18.5	$93.0
2027	$93.3	$23.3	$117
2028	$112	$28.1	$140
2029	$132	$33.0	$164
2030	$151	$37.9	$189
2031	$170	$42.8	$213
2032	$190	$47.8	$237
2033	$209	$52.9	$262
2034	$229	$58.0	$287
2035	$249	$63.1	$312
2036	$269	$68.3	$337

Year	Equipment and Installation Costs	Service and Maintenance Costs	Total Costs
2037	$289	$73.6	$362
2038	$294	$76.0	$370
2039	$299	$78.5	$378
2040	$304	$81.0	$385

c. *Total Costs for the Proposed Amendments*

The total net direct costs inputs of the Proposed Amendments are summarized in Table 35. These include all upfront and ongoing costs incurred. All values are rounded up to three significant figures.

Table 35. Total Annual Costs for the Proposed Amendments (millions of 2018$)

Year	Refrigeration		Air-Conditioning		Total Costs for Refrigeration and AC Equipment ($ / Year)
	Upfront[a]	Ongoing[b]	Upfront[c]	Ongoing[d]	
2022	$2.07	$0.23	$0	$0	$2.30
2023	$4.15	$0.46	$18.4	$4.60	$27.6
2024	$6.25	$0.70	$37.0	$9.20	$53.1
2025	$8.37	$0.93	$55.7	$13.8	$79
2026	$30.8	-$11.63	$74.4	$18.5	$112
2027	$33.0	-$11.38	$93.3	$23.3	$138
2028	$35.1	-$11.19	$112	$28.1	$164
2029	$37.3	-$11.08	$132	$33.0	$191
2030	$52.6	-$19.66	$151	$37.9	$222
2031	$54.8	-$19.42	$170	$42.8	$248
2032	$57.1	-$19.17	$190	$47.8	$276
2033	$59.3	-$18.93	$209	$52.9	$302
2034	$61.6	-$18.68	$229	$58.0	$330
2035	$63.8	-$18.43	$249	$63.1	$357
2036	$45.8	-$5.11	$269	$68.3	$378
2037	$47.4	-$5.24	$289	$73.6	$405
2038	$49.0	-$5.37	$294	$76.0	$414
2039	$50.7	-$5.50	$299	$78.5	$423
2040	$39.2	$3.07	$304	$81.0	$427

[a] Refrigeration upfront costs include equipment and installation cost increments above the baseline, for new systems complying with GWP limits of 150 and 1,500 in new and existing facilities, respectively, and for compliance with the weighted-average GWP requirement for retail food facilities.
[b] Refrigeration ongoing costs include cost increments and savings for refrigerant replenishment, electricity and RMP compliance above the baseline, for new systems complying with GWP limits of 150 and 1,500 in new and existing facilities, respectively, and for compliance with the weighted-average GWP requirement for retail food facilities.
[c] AC upfront costs include equipment and installation cost increments above the baseline for new equipment.
[d] AC ongoing costs include repair and maintenance cost increments about the baseline for new equipment.

2. Direct Costs on Typical Businesses

a. Stationary Refrigeration

Based on user-reported data in CARB's RMP database in 2018, regulated refrigeration systems are most commonly used in retail food facilities such as supermarkets, grocery stores, warehouse clubs, supercenters and discount department stores (NAICS code 445110, 452910, 452112) and followed distantly by merchant wholesalers (NAICS codes starting with 424), food production and manufacturing facilities including wineries and breweries (NAICS codes starting with 311 and 312), refrigerated warehouses and storage facilities (NAICS code 493) and a small number of various types of industrial process facilities. To illustrate the typical costs for companies owning these facilities, the average estimated costs for (1) a supermarket company and (2) a cold storage / food processing company are discussed below.

I. Retail Food Facilities (Supermarkets and Grocery Stores)

As discussed earlier, under the Proposed Amendments, retail food companies will have to comply with two sets of rules (1) use refrigerants with GWP lower than 150 in newly constructed/fully remodeled facilities starting 2022, and (2) on a company-wide basis, reduce the weighted-average GWP to 1,400 or emissions potential by 55 percent by 2030 across all their stores (with a progress step in 2026).

To illustrate the costs to a typical business, we will consider an average large supermarket company with 120 stores in California.[132] All cost assumptions are the same as discussed in previous sub-sections, for a large commercial retail food system. For newly constructed facilities, equipment and installation will result in incremental costs while savings are expected from the avoided costs of complying with the RMP regulation and for replenishing leaked refrigerant.

It is worth noting that costs of equipment and installation are expected to decline as market adoption of low-GWP systems and relatedly, contractor experience with those systems, to increase. As an example, the European Union also has a similar rule for large refrigeration systems and low-GWP systems are expected to achieve cost parity with the baseline HFC systems by 2022 when the rule goes into effect.[133] While CARB staff expect similar trends in California, to be conservative, we did not factor any experience curves into the analysis. Since the estimated growth rate for supermarkets is 1 percent per year, the incremental annual cost for a company with 120 supermarkets, for opening 1 new supermarket per year. The annual incremental costs for a newly constructed supermarket are given in Table 20. Overall, the added annual costs are expected to be $16,600 per year,[134] which is on average, 10 percent higher than the baseline scenario.

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[132] Based on CARB's RMP database. The average number of supermarkets owned by companies with 20 or more stores is 120.

[133] The European Commission, 2017. Report from the Commission Assessing the 2022 Requirement to Avoid Highly Global Warming Hydrofluorocarbons in Some Commercial Refrigeration Systems.

[134] Using the incremental annual cost for one, large system containing 3,300 pounds of refrigerant as a proxy for a single centralized system serving the entire supermarket.

Under the Proposed Amendments, supermarkets (and grocery stores) are also required to reduce their company-wide weighted-average GWP to below 1,400. End-users will also have an alternative compliance pathway under which they will be required to reduce their company-wide GHGp by 55 percent below their 2018 levels, by 2030. Table 24 shows the expected incremental costs associated with refrigerant retrofits in an average supermarket, the most common and economical option to comply. The annual average incremental cost per store is estimated to be $6,320 per year. For an average large company that owns 120 supermarket stores in California, retrofits or other conversions to refrigerants with GWP values less than 1,400 have to occur by 2030. The proposed rules, become effective in 2022, which gives each company 8 years to plan and carry out the changes in all their stores. On average, this means a typical company with a 120 stores would retrofit 15 stores per year. Thus, the average annual incremental cost for this company is expected to be 15 × $6,320 = $94,800, for compliance with the weighted-average GWP reduction requirement.

Here, it is important to note that retail food companies are not required to retrofit every system and store under the weighted-average GWP reduction requirement, even though retrofits are expected to be the most economical option on a per-store basis. Additional costs savings can be achieved if companies choose to invest more upfront capital (to simultaneously reduce GWP along with refrigerant charge) in some stores while leaving some other stores unaltered. The requirements under the weighted-average GWP / GHGp reduction programs are designed to provide this type of flexibility to regulated companies. However, since there can be several ways in which GWP and charge reduction can be accomplished, each with different costs, for this analysis, CARB staff are estimating the costs for the most straightforward, economically conservative approach of retrofits. This is to avoid speculation on both, costs and on the likelihood of companies choosing from the different options.

Including one newly constructed store per year, the annual average incremental costs for a supermarket company with 120 stores in California to comply with the proposed rules is expected to be $111,000 per year. Between 2022 and 2030, for retrofitting all 120 stores[135] and for opening 1 new / remodeled store per year, the cumulative annual costs to the company by 2030 are $111,000 x 8 = $888,000. Past 2030, incremental costs will only be borne for opening new / remodeled stores since all existing stores would have already made the changes necessary to the comply with the requirements.

II. Industrial Process Refrigeration and Cold Storage Warehouses

For industrial process and cold storage facilities, the Proposed Amendments will require refrigerants with GWP values less than 150 for new systems in newly constructed/fully remodeled facilities. For large systems containing more than 5,000 pounds of refrigerant – systems like these typically serve very large warehouses and processing facilities, net annual savings of up to $19,000 are expected, due to reduced ongoing costs related to refrigerant replenishment, electricity and RMP compliance. For medium and small systems, incremental costs range between $2,000 and $6,000 per system per year. Total costs or savings will depend on how many systems are used by a facility.

[135] Only if a company chooses to retrofit all their stores.

Some incremental costs for replacing new systems in existing facilities are only expected for industrial process refrigeration facilities, since cold storage warehouses are required to use refrigerants with GWP less than 1,500 in the baseline scenario, under SB 1013. The main source of incremental costs for new systems in existing IPR facilities is the 10 percent premium on equipment. Total annual incremental cost with amortization of 20 years and 5 real percent interest is expected to be between $800 and $9,000 for small, medium and large systems, respectively (see Appendix tables).

b. *Stationary AC*

Manufacturers are responsible for selling ACs meant to use a refrigerant with less than 750 GWP in California. The Proposed Amendments requires manufacturers to build and sell compliant AC systems and keep records of their sales to California as part of their regulatory requirements. Stationary AC manufacturing is concentrated in relatively few multinational corporations. Seven large manufacturers supplying over 95 percent of the U.S. central ACs and heat pumps market, including California.[136] These businesses have manufacturing facilities in the U.S., but there are no AC manufacturers building systems in California. The majority of room ACs are produced overseas in Asia and imported into the United States. While there are no AC manufacturers building systems in California, this analysis is included to provide further information to stakeholders.

Most room ACs are manufactured in Asia and a transition to products that would be compliant with the Proposed Amendments is already underway. Residential and commercial central AC/HP manufacturers will comply with the Proposed Amendments by developing new product lines for California. AC manufacturers are producing products for the international market to use refrigerants with a GWP less than 750. Developing products for California does require additional investment to adapt lower-GWP refrigerant technology to the types of systems used most commonly in the U.S. and California, which are ducted systems.

It is typical for companies to invest additional research and development to adapt new technologies to expand into another region with different building designs and regulatory frameworks, such as different codes and standards. The cost to transition products includes research and development, facility retrofits, testing and certifying new products and training employees as well as technicians and contractors. CARB estimates the cost to a typical manufacturer to be approximately $20 million per year assuming the seven major manufacturers have equal market share for residential and commercial AC products. Depending on market share, manufacturers may have higher or lower costs.

These costs include a premium for California-specific products. However, California is the most populous State in the United States and therefore constitutes a significant fraction of the U.S. appliance market. While manufacturers have indicated that sales of less than 750 GWP ACs will be exclusively for California, the State represents approximately 12 percent of U.S. population and as such, represents a significant portion of the U.S. market. As other states commit to action on HFCs, it is possible that economies of scale may lower the incremental costs provided in this

[136] See U.S. DOE Technical Support Documents.

analysis as the market expands.[137] For example, the Washington State Building Council has adopted ASHRAE 15-2019 and the third edition of UL 60335-2-40, which allows the use of A2L refrigerants in direct systems such as residential and other commercial ACs.

The cost impact to manufacturers in this analysis is conservative. Cost estimates for refrigerant transitions and equipment redesigns are typically higher than what is actually experienced.[138] Part of the reason for this is that manufacturers have become increasingly efficient at redesigning their products and are constantly working on developments to minimize their own costs by counterbalance expensive improvements with savings elsewhere.[139] In addition, manufacturers build ongoing research and development and redesign costs into product prices. For these reasons, it is possible that the cost impacts may be lower. While equipment pricing is complex and different manufacturers could use different strategies to pass on these costs, staff assume all costs from deploying compliant equipment for the California market are passed on to end-users.

Table 36. Direct Costs on a Typical Business – AC Manufacturer

Costs to Typical AC Manufacturer	
Year	Costs ($Million)
2023	$22.0
2024	$22.1
2025	$22.2
2026	$22.3
2027	$22.4
2028	$22.5
2029	$22.6
2030	$22.7
2031	$22.8
2032	$22.9
2033	$23.0
2034	$23.1
2035	$23.2

[137] United States Climate Alliance, 2019 Annual Report: Strength in Numbers: American Leadership on Climate, available at http://www.usclimatealliance.org/annual-report; See also United States Climate Alliance, Short-Lived Climate Pollutant Challenge. (web link: http://www.usclimatealliance.org/slcpchallenge, Last accessed February 2020).
[138] Descroches, L., et al., (2013). Low Global Warming Potential Refrigerants for Commercial Refrigeration Systems. (web link: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2013/6-appliances-product-policy-and-ict/trends-in-the-cost-of-efficiency-for-appliances-and-consumer-electronics/, Last accessed February 2020); See also U.S. DOE Technical Support Documents.
[139] United States Department of Energy, The Future of Air Conditioning for Buildings (web link: https://www.energy.gov/sites/prod/files/2016/07/f33/The%20Future%20of%20AC%20Report%20-%20Full%20Report_0.pdf, Last accessed February 2020); See also JMS Consulting, Consumer Cost Impacts of U.S. Ratification of the Kigali Amendment (web link: http://www.ahrinet.org/App_Content/ahri/files/RESOURCES/Consumer_Costs_Inforum.pdf, Last accessed February 2020); Deutsche Gesellschaft für Internationale Zusammenarbeit, Green Cooling Initiative (web link: https://www.green-cooling-initiative.org/data/user_upload/Downloads/Publications/EN_Green_Cooling_Technologies_-_Market_trends_in_selected_refrigeration_and_air_conditioning_subsectors.pdf, Last accessed February 2020).

Costs to Typical AC Manufacturer	
Year	Costs ($Million)
2036	$23.3
2037	$23.4
2038	$23.4
2039	$23.5

The direct costs to typical businesses who purchase a new commercial AC systems compliant with the Proposed Amendments are shown in Table 37 below. On average, compliant equipment is expected to cost owners and operators of commercial systems an average of 5 to 7 percent above the baseline cost over the lifetime of the equipment based on cost analysis provided to CARB by manufacturers. Since AC is used across all types of businesses, there is no average typical business that is reflective of commercial AC end-users. All businesses and non-residential facilities either installing an AC in new construction or replacing an AC will experience higher costs as shown below, beginning 2023.

Table 37. Commercial AC/HP Cost ($2018)

End-Use	Baseline Costs[a] (Annual)	Baseline Lifetime Costs (Total)	Incremental Costs (Annual Amortized)	Lifetime Incremental Costs (Total)
Commercial AC/HP (Small – Medium)	$2,001	$40,028	+$130 (+7%)	+$2,608 (+7%)
Commercial AC/HP (Large)	$3,034	$60,686	+$152 (+5%)	+$3,048 (+5%)

[a] Baseline costs are for year 2023.

3. Direct Costs on Small Businesses

a. Stationary Refrigeration

Like AC, manufacturing of commercial and industrial refrigeration systems is concentrated under a few companies, and none of these are small businesses. Compliant, low-GWP systems for newly constructed facilities and remodeled facilities are already in production today, and used widely around the world. Any costs associated with increasing production is assumed to be passed onto the end-users.

For end-users who will use new systems in newly constructed or remodeled facilities, the costs to small businesses are not expected to be different from the costs experienced by typical businesses. The proposed rules requires new refrigeration systems in these facilities to have a GWP below 150, whenever they are constructed or remodeled. Businesses are expected to take the added costs into account when planning to open a new facility or fully remodel an existing one. The 50 pound system threshold for the proposed rules automatically exempts most small businesses like convenience and corner stores which generally use smaller refrigeration systems.

For existing retail food outlets such as supermarkets and grocery stores, the additional requirement to reduce the weighted GWP to below 1,400 or achieve a 55 percent reduction in their GHGp by 2030 will place some cost burden on small businesses. Overall, the incremental costs per store are the same as those to a typical business, i.e., an annual incremental cost of $6,320 per supermarket or grocery store (Table 24).

Approximately 4,000 supermarkets and grocery stores are registered with CARB under RMP, and less than 20 percent of those are likely owned by small businesses. Based on employment[140] and RMP data, companies with less than a 100 employees own fewer than 20 stores in California and are considered to be small businesses for this analysis. These companies own an average of 2 stores. Thus, an average small company will incur an incremental cost of $6,320 x 2 = $12,600 per year for compliance with the Proposed Amendments. However, to minimize the impact on small businesses, companies with fewer than 20 stores in California that are not a national chain will only be required to comply by 2030, without a progress step at 2026. This will provide small businesses a full 8 years from the regulation's effective date to plan and spread out the costs. Additionally, since the large companies will be complying with a progress step, contractor familiarity with retrofits and other compliant technology solutions will increase, which will likely bring down the installation costs as well as ongoing costs associated with replenishing the refrigerant.

In the future, California and all of the United States may be affected by the global HFC phase-down resulting from the Kigali Amendment to the Montreal Protocol.[141] The European Union has already started experiencing the impact of the phase-down, where end-users of HFCs have reportedly experienced drastic refrigerant price volatility and refrigerant shortages.[142] One reason to have all commercial refrigeration businesses, large and small, reduce their weighted-average GWP is to prepare them for a future domestic HFC phasedown and to reduce their exposure to similar market upheavals if and when the phasedown is implemented domestically.

b. *Stationary AC*

None of the AC manufacturers qualify as small businesses. For end-users who will use new systems, the costs to small businesses are not expected to be different from the costs experienced by typical businesses (see Section C.2.b).

4. Direct Costs on Individuals

a. *Stationary Refrigeration*

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[140] Dun and Bradstreet Database, 2018. Employment data for RMP companies.

[141] United Nations Industrial Development Organization. (web link: https://www.unido.org/our-focus/safeguarding-environment/implementation-multilateral-environmental-agreements/montreal-protocol/montreal-protocol-evolves-fight-climate-change, Last accessed February 2020).

[142] Cooling Post, R404A price rises 62% in a month, (web link: https://www.coolingpost.com/world-news/r404a-price-rises-62-in-a-month/, Last accessed February 2020); See also Cooling Post, 2017 ends with a 60% price rise. (web link: https://www.coolingpost.com/uk-news/2017-ends-60-price-rise/, Last accessed February 2020); R744, EU's HFC price skyrocketing since start of F-Gas Regulation, (web link: http://r744.com/articles/8339/eu_s_hfc_prices_skyrocketing_since_start_of_f_gas_regulation, Last accessed February 2020).

There are no direct costs to individuals as a result of the Proposed Amendments as they pertain to refrigeration. As the prevalence of low-GWP refrigeration systems increase, some individuals in the service contractor industry may see benefits through increased sales; those are discussed in the macroeconomic section.

b. Stationary AC

Individuals who purchase new AC systems will incur incremental costs beginning in 2023. This includes homeowners, multi-family housing, commercial and other non-residential facility owners who purchase and operate AC systems. The cost of the most affordable type of AC equipment, room ACs, will not change. For residential central AC/HP, the total incremental cost, including equipment, installation and maintenance/repair, is estimated to increase by $360 to $474 which is equivalent to a 4 percent higher cost for the end-user over the lifetime of the equipment (see

***Table* 38** below).

Table 38. Residential AC/HP Cost ($2018)

End-Use	Baseline Cost[a] (Annual)	Baseline Lifetime Cost (Total)	Incremental Cost (Annual Amortized)	Lifetime Incremental Costs (Total)
Residential AC	$560	$8,406	+$25 (+4%)	+$369 (+4%)
Residential HP	$748	$11,221	+$32 (+4%)	+$474 (+4%)

[a]Baseline costs are for year 2023.

In 2018, the median value of a home in California in 2018 was $546,800.[143] The incremental costs relative to home values represents a change in housing costs of less than 0.1 percent. The cost of energy will continue to be the larger portion of AC ownership after the initial equipment and install cost. The average household electricity use for an AC system is about 2,177 kWh/house per year in the mixed-dry/hot-dry region, which includes California.[144] At a $0.19 per kWh, which is the average cost in California for 2018, a homeowner can expect to spend approximately $6,205 on average on energy over the lifetime of their system.[145] The new U.S. DOE standards taking effect are expected to reduce the energy use associated with residential systems by about 4 percent. While energy use is not expected to change as a result of this regulation, the net effect of the Proposed Amendments and new U.S. DOE regulations will be higher upfront cost for equipment and lower energy costs than the units sold today.[146]

[143] United States Census, Selected Housing Characteristics (web link: https://data.census.gov/cedsci/table?q=housing%20value&hidePreview=true&table=DP04&tid=ACSDP1Y2018.DP04&t=Housing%20Value%20and%20Purchase%20Price&lastDisplayedRow=25&moe=false&g=0400000US06, Last accessed February 2020).
[144] U.S. Energy Information Administration, Residential Energy Consumption Survey (RECS) (web link: (https://www.eia.gov/consumption/residential/data/2015/index.php?view=consumption#undefined Last accessed February 2020).
[145] U.S. Energy Information Administration, Electric Power Monthly (web link: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a, Last accessed: February, 2020).
[146] The higher upfront equipment costs due to new U.S. DOE requirements are included in the baseline.

While not included in this analysis, there are a variety of incentives offered by utilities for the purchase of new more efficient units. These incentives will continue to assist home and building owners to offset upfront costs of new systems which are more energy efficient than older equipment. The cost impacts to end-users who own and operate commercial systems is discussed under section "C. Direct Costs" under "Direct Cost on Typical Businesses."

D. FISCAL IMPACTS

1. Local Government

a. Incremental Cost

Local governments that utilize AC and refrigeration systems may incur incremental costs when they purchase and install new low GWP equipment. Some facilities owned by local school districts are registered in the RMP database as users of the regulated refrigeration systems. Together, they make up less than 1 percent of all registered refrigerated facilities and therefore affected by proposed amendments. In this analysis, we assume the same portion of the overall incremental costs are passed on the local governments. AC systems are generally used in state and local government buildings throughout California. Staff assumes the incremental cost of these systems for state and local government is proportional to the share of state and local government demand in California, being 2.0 percent and 6.7 percent, respectively.[147]

b. Sales Tax Revenue

Sales taxes are levied in California to fund a variety of programs at the state and local level. These Proposed Amendments will result in the sale of more expensive AC and refrigeration systems in California, which will result in higher sales tax collected by local governments. Overall, state sales tax revenue may increase less than the direct increase from equipment sales if overall business and consumer spending does not increase.

c. Utility User Fee

Many cities and counties in California levy a Utility User Fee on electricity usage. This fee varies from city to city and ranges from no tax to 11 percent. A value of 3.53 percent was used in this analysis representing a population-weighted average.[148] By decreasing the amount of electricity used, there will be a decrease in the amount of the utility user fee revenue collected by cities and counties.

d. Fiscal Impacts on Local Governments

Over the regulatory lifetime, Local Governments are estimated to incur incremental costs of about $66 million resulting from AC and refrigeration systems used by local government facilities. Local Governments are also estimated to see a direct increase in sales tax revenue of $166 million and a decrease in revenue from the Utility User Fee of $8.5 million. On net, the total fiscal impact (revenues – costs) is estimated to be $17 million over the first three years and $91 million through 2040 (Table 39).

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[147] Based on REMI Policy Insight Plus (v 2.3), state and local governments' share of demand in California is 8.7 percent, which is then disaggregated to state government and local government based on employment share.

[148] California State Controller's Office, User Utility Tax Revenue and Rates (web link: https://sco.ca.gov/Files-ARD-Local/LocRep/2016-17 Cities UUT.pdf, Last accessed February 2020).

Table 39. Fiscal Impacts on Local Governments (Million 2018$)

Year	Incremental Costs	Sales Tax Revenue	Utility User Fee Revenue	Total Fiscal Impact*
2022	$0.0	$1.1	$0.0	$1.1
2023	$0.4	$8.3	$0.0	$7.9
2024	$0.8	$8.3	$0.0	$7.5
2025	$1.1	$8.3	$0.0	$7.2
2026	$1.5	$15.3	-$0.5	$13.2
2027	$1.9	$8.4	-$0.5	$6.0
2028	$2.3	$8.5	-$0.6	$5.6
2029	$2.7	$8.5	-$0.6	$5.3
2030	$3.1	$11.4	-$0.8	$7.5
2031	$3.5	$8.6	-$0.8	$4.3
2032	$3.9	$8.6	-$0.8	$4.0
2033	$4.2	$8.7	-$0.8	$3.6
2034	$4.6	$8.7	-$0.8	$3.2
2035	$5.0	$8.8	-$0.8	$2.9
2036	$5.4	$8.8	-$0.3	$3.1
2037	$5.8	$8.8	-$0.3	$2.7
2038	$6.2	$8.9	-$0.3	$2.3
2039	$6.6	$8.9	-$0.3	$2.0
2040	$7.0	$8.9	-$0.1	$1.8
Total	$66.1	$165.8	-$8.5	$91.1

*The Total Fiscal Impact is calculated as the change in revenue minus costs.

2. State Government

a. Incremental Cost

Some California state government facilities use regulated refrigeration systems and may incur incremental costs when they purchase new equipment. These facilities include but are not limited to state prisons, correctional and rehabilitation facilities, and the state universities. Based on the RMP database, in 2018, 1 percent of all registered refrigerated facilities were owned by the state government. For this analysis, we assume the same percentage of costs are passed on to state government. AC systems are generally used in state and local government buildings throughout California. Staff assumes the incremental cost of these systems for state and local government is proportional to the share of state and local government demand in California, being 2.0 percent and 6.7 percent, respectively.[149]

[149] Based on REMI Policy Insight Plus (v 2.3), state and local governments' share of demand in California is 8.7 percent, which is then disaggregated to state government and local government based on employment share.

b. Sales Tax Revenue

Sales taxes are levied in California to fund a variety of programs at the state and local level. The Proposed Amendments will result in the sale of more expensive AC and refrigeration systems in California, which will result in higher sales tax collected by the state government. Overall, state sales tax revenue may increase less than the direct increase from equipment sales if overall business spending does not increase.

c. CARB Staffing

The Proposed Amendments will have an impact on CARB's staffing requirements. Existing staff will support implementation of the requirements in the Proposed Amendments. However, existing staff cannot be fully devoted to tasks related to implementation because of the need for further rulemakings to implement additional strategies to reduce HFC emissions. CARB will require four additional Air Pollution Specialist (APS) positions for implementing and enforcing the requirements for existing supermarkets and grocery stores. The additional personnel would be responsible for data analysis, annual review of company's emissions reductions, assisting stakeholders with inquiries, supporting enforcement by going on site visits and carrying out audits of stakeholder reports, and other general implementation duties. Any additional work related to implementation of rules for new equipment will be distributed among the existing resources. Each position will place an annual cost burden of $180,000 per year on CARB, starting fiscal year 2022-23.

d. Energy Resource Fee Revenue

The Energy Resource Fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities. The revenue collected is deposited into the Energy Resources Programs Account of the General Fund which is used for ongoing energy programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the California Energy Commission.

e. Fiscal Impacts on State Government

Over the regulatory lifetime, the State government is estimated to incur incremental costs of about $25 million resulting from AC and refrigeration systems used by State government facilities and $20 million for CARB staffing and resources. The State government is also estimated to see a direct increase in sales tax revenue of $140 million and a decrease in revenue from the Energy Resource Fee of $1 million. On net, the total fiscal impact (revenues – costs) is estimated to be $12 million over the first three years and $94 million through 2040 (Table 39).

Table 40. Fiscal Impacts on State Government (Million 2018$)

Year	Incremental Costs	CARB Staffing & Resources Costs	Sales Tax Revenue	Energy Resource Fee Revenue	Total Fiscal Impact*
2022	$0.0	$0.4	$0.9	$0.0	$0.5
2023	$0.2	$1.1	$7.0	$0.0	$5.7
2024	$0.3	$1.1	$7.0	$0.0	$5.6
2025	$0.4	$1.1	$7.0	$0.0	$5.5
2026	$0.6	$1.1	$12.9	$0.0	$11.1
2027	$0.8	$1.1	$7.1	$0.0	$5.2
2028	$0.9	$1.1	$7.1	$0.0	$5.1
2029	$1.1	$1.1	$7.2	$0.0	$5.0
2030	$1.2	$1.1	$9.6	-$0.1	$7.2
2031	$1.4	$1.1	$7.2	-$0.1	$4.7
2032	$1.5	$1.1	$7.3	-$0.1	$4.6
2033	$1.6	$1.1	$7.3	-$0.1	$4.5
2034	$1.8	$1.1	$7.4	-$0.1	$4.4
2035	$1.9	$1.1	$7.4	-$0.1	$4.3
2036	$2.0	$1.1	$7.4	$0.0	$4.3
2037	$2.1	$1.1	$7.4	$0.0	$4.2
2038	$2.3	$1.1	$7.5	$0.0	$4.1
2039	$2.4	$1.1	$7.5	$0.0	$4.0
2040	$2.5	$1.1	$7.5	$0.0	$3.9
Total	$25.1	$20.4	$139.8	-$0.6	$93.8

*The Total Fiscal Impact is calculated as the change in revenue minus costs.

E. MACROECONOMIC IMPACTS

1. Methods for Determining Economic Impacts

This section describes the estimated total impact of the Proposed Amendments on the California economy. The Proposed Amendments will result in incremental cost and cost-savings for businesses to comply with the regulation. These costs result in direct changes in expenditures in the economy as these cost are passed on to business and individual end-users. These changes in expenditures by end-users will indirectly affect employment, output, and investment in sectors that supply goods and provide services to affected businesses.

These direct and indirect effects lead to induced effects, such as changes in personal income that affect consumer expenditures across other spending categories. The total economic impact is the sum of these effects and are presented in this section. The total economic impacts of the Proposed Amendments are simulated relative to the baseline scenario using the cost estimates described in Section C. The analysis focuses on the changes in major macroeconomic indicators from 2020 to 2040 including employment, output, personal income, and gross state product (GSP). The years of the analysis are used to simulate the Proposed Amendments through more than 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.3 is used to estimate the macroeconomic impacts of the Proposed Amendments on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.[150] REMI Policy Insight Plus provides year-by-year estimates of the total economic impacts of the Proposed Amendments, pursuant to the requirements of SB 617 and the California Department of Finance.[151] CARB uses the REMI single-region, 160-sector model with the model reference case adjusted to reflect the Department of Finance conforming forecasts. These forecasts include California population figures dated May 2019, U.S. real GDP forecast, and civilian employment growth numbers dated April 2019.

2. Inputs of the Assessment

The estimated economic impact of the Proposed Amendments are sensitive to modeling assumptions. This section provides a summary of the assumptions and inputs used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Amendments. The direct costs and savings estimated in Section C are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[152]

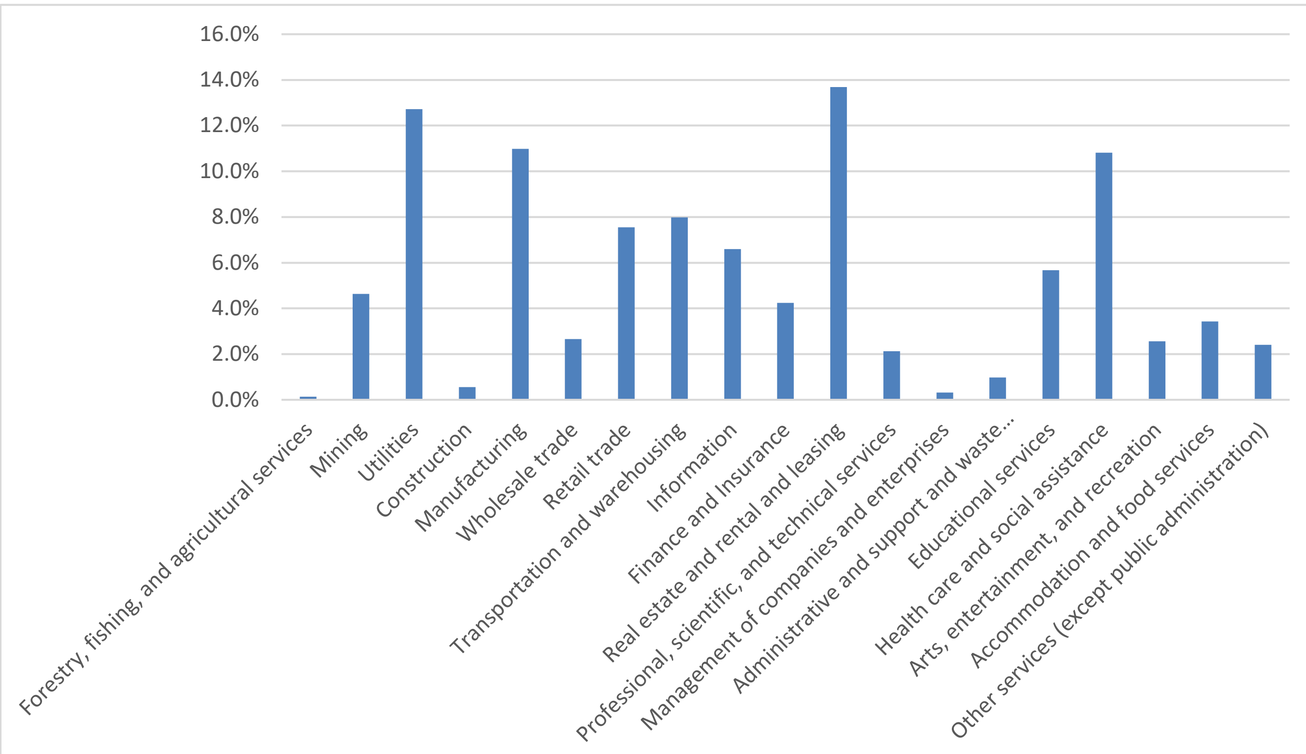
The requirements for low GWP refrigerants in AC systems are estimated to add an incremental cost to the AC equipment, installation, and maintenance for both residential and commercial

[150] For further information and model documentation see: https://www.remi.com/model/pi/.
[151] Senate Bill 617 (Calderon, Stats. of 2011, Ch. 496; amending Gov. Code §§ 11346.2, 11346.3, 11346.5, 11346.9, 11347.3, 1139.1, 13401, 13402, 13403, 13404, 13405, 13406, 13407 and adding Gov. Code §§ 11342.548, 11346.36, 11349.1.5); Department of Finance Standardized Regulatory Impact Assessment For Major Regulations, Cal. Code Regs., tit. 1, §§ 2000 et seq.
[152] Refer to Section G: Macroeconomic Appendix for a full list of REMI inputs for this analysis.

equipment, as described in Section C. These costs are expected to be passed through to end-users of these systems (i.e. businesses and households).

The costs incurred by businesses that use AC are input into the model as an increase in production costs for the affected industry. The share of costs incurred across different sectors are assumed to be distributed according to their share of capital expenditures on structures as shown in Figure 8.[153]

Figure 8. Share of Capital Expenditures on Structures by Sector



The costs incurred by residential AC end-users are separated into those for replacement systems in existing structures and those for systems in new structures, as described in Section C. The cost incurred for replacement systems are input into the model as an increase in the consumer price for Household Appliances.[154] The consumer price policy variable affects the economy through changes in expenditures on goods and services based on consumers' response to a price increase for this consumption category. The model assumes that the consumer demand for the good is inelastic,[155] which implies that a price increase, increases total expenditures on this

[153] Annual Capital Expenditures Survey 2017. U.S. Census Bureau. (web link: https://www.census.gov/library/publications/2019/econ/2017-aces-summary.html). Expenditures on mining structures are excluded here.
[154] Household appliances are a component Personal Consumption Expenditures as described by BEA https://www.bea.gov/media/5711. This PCE category within REMI best represents the types of equipment affected under this proposed regulation.
[155] This refers to the technical definition of inelastic in economics, where a percent change in quantity demanded is less than the percent change in price, for a given good. This implies that a price increase, increases total expenditures on this good.

category, corresponding with an equivalent reduction in expenditures on all other goods and services. This input reflects the logic of a behavioral response to an increase in the price of AC systems, as illustrated in Section C.4. The cost incurred for AC systems for new housing are input into the model as an increase in consumer spending on Household Appliances, with an equivalent reduction in consumer spending on all other consumption categories and savings.

These costs incurred by AC and heat pump end-users results in corresponding changes in final demand for industries supplying those particular goods or services as shown in Table 41. As the direct costs on AC equipment manufacturers are incurred out of state, it is assumed here that the changes in demand for the HVAC supply chain also occur out state. This increase in demand is therefore omitted from evaluation in the economic model. All other changes in demand related to AC equipment are included in this analysis. The increased installation costs corresponds to an increase in demand for the general contractors (NAICS 23) that provide this service. The increased maintenance costs corresponds to an increase in demand for the mechanical contractors (NAICS 23) that provide this service.

Table 41: Sources of Changes in Production Costs or Prices and Final Demand by Industry

Source of Cost or Savings	Industries or Individuals with Change in Production Cost or Prices (NAICS)	Industries with Changes in Final Demand (NAICS)
AC - Equipment cost	All Industries and Individuals that use stationary AC equipment	None (out of state)
AC - Installation cost		General contractors (23)
AC - Maintenance cost		Mechanical contractors (23)
Refrigeration – Equipment cost	All Industries that use commercial stationary refrigeration. Primarily: Retail trade (44-45), Wholesale trade (42), Food mfg. (311), Beverage mfg. (3121), Pharmaceutical and medicine mfg. (3254).*	None (out of state)
Refrigeration – Installation cost		Contractors (23)
Refrigeration – Electricity cost-savings		Electric power generation, transmission, and distribution (2211)
Refrigeration – Refrigerant cost		Basic chemical mfg. (3251)
Refrigeration – RMP reporting cost-savings		None (changes firms' labor productivity)

The direct costs of the requirements of low GWP systems for commercial refrigeration and chillers are also expected to be passed on to end-users of the equipment, as described in Section C. The end-users of the equipment will incur an incremental cost related to changes in the equipment and installation cost and the cost of refrigerants. The energy-efficiency gains from the retrofit requirement results in cost-savings to end-users. The net change in the costs is input into the model as a change in production costs for the affected industries. Additionally, facilities that move to low GWP systems will no longer be required to report as part of CARB's RMP, resulting cost-savings, which is input in the model as increase in firms' labor productivity. The share of cost borne by each industry is assumed to be distributed proportionally to the number of systems by industry as reported to the CARB's RMP. This is primarily retail trade (44-45), wholesale trade (42), food manufacturing (311), beverage manufacturing (3121), and pharmaceutical and medicine manufacturing (3254).

These costs incurred by refrigeration and chiller end-users correspond with changes in final demand for industries supplying those particular goods or services as shown in Table 41. As the direct costs on refrigeration and chiller system equipment manufacturers are incurred out of state, it is assumed here that the changes in demand for the supply chain also occur out state. This change in demand is therefore omitted from evaluation in the economic model. All other changes in demand related to refrigeration and chillers equipment is included in this analysis. The increased installation costs corresponds to an increase in demand for contractors (NAICS 23) that provide this service. The increased refrigerant costs corresponds to an increase in demand for the basic chemical manufacturing industry (NAICS 3251), which produces these refrigerants. The cost-savings from energy efficiency gains, correspond with a decrease in demand for Electric power generation, transmission, and distribution (2211) industry.

In addition to these changes in production costs or prices and final demand, there will also be economic impacts as a result of the fiscal effects, primarily from passed-through compliance costs on AC and refrigeration equipment and changes in sales tax revenue. These changes in costs along with changes in government revenue are modeled as a change in state and local government spending, assuming these revenue increases are not offset elsewhere. Additional CARB staff and resources in support of this regulation are modeled as changes in state government employment and spending.

3. Results of the Assessment

The results from the REMI model provide estimates of the impact of the Proposed Amendments on the California economy. These results represent the annual incremental change from the implementation of the Proposed Amendments relative to the baseline scenario. The California economy is forecasted to grow through 2040, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an acceleration of growth resulting from the Proposed Amendments. The results are reported here in five year intervals from 2020 through 2040.

a. California Employment Impacts

Table 42 presents the impact of the Proposed Amendments on total employment in California across all private industries and the public sector. Employment comprises estimates of the number of jobs, full-time plus part-time, by place of work for all industries. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included. The employment impacts represent the net change in employment across the economy, which is composed of positive impacts for some industries and negative impacts for others. The Proposed Amendments are estimated to result in an initial slight increase in employment growth through 2025, followed by a decrease in employment growth through 2040. These changes in employment represent 0.01 percent of baseline California employment.

Table 42: California Employment Impacts

Impact	2020	2025	2030	2035	2040
California Employment	24,321,773	24,825,743	25,207,076	25,874,320	26,713,095
% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
Change in Total Jobs	0	92	-1,198	-1,934	-1,966

The total employment impacts presented above are net of changes at the industry level. The overall trend in employment changes by major sector are illustrated in ***Figure 9***. ***Table 43*** shows the changes in employment by industries that are directly impacted by the Proposed Amendments. As the requirements of the Proposed Amendments go into effect there is initially a slight acceleration of job growth due to expenditures on installation and maintenance activities direct at the contractor industries. Over time the increased production costs for business end-users of commercial refrigeration and chillers and AC equipment and the increase in consumer prices for AC equipment result in a slight decrease in job growth, primarily in the major sectors of Retail and Wholesale and Services.

Figure 9: Job Impacts by Major Sector

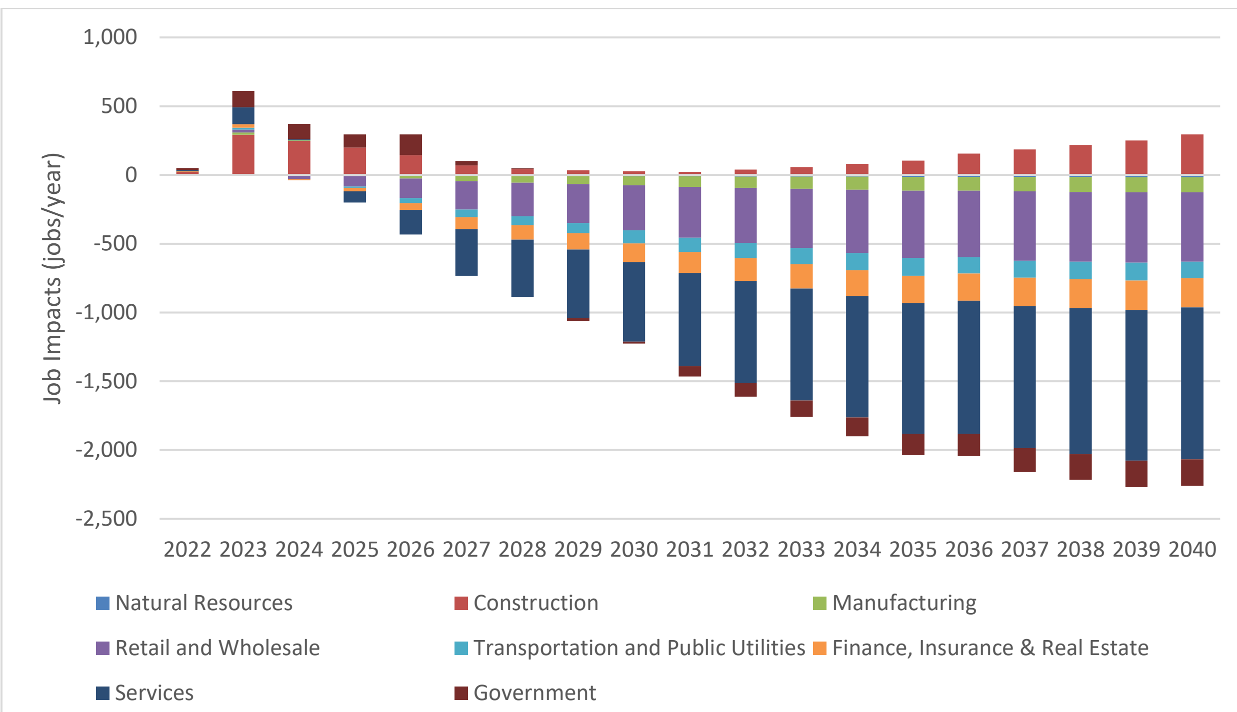


Table 43: Job Impacts by Primary and Secondary Industries

Industry	Impact	2020	2025	2030	2035	2040
Electric power generation, transmission and distribution (2211)	% Change	0.00%	0.00%	-0.06%	-0.07%	-0.02%
	Change in Jobs	0	-1	-30	-31	-10
Construction (23)	% Change	0.00%	0.02%	0.00%	0.01%	0.02%
	Change in Jobs	0	200	27	103	295
Other food manufacturing (3119)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change in Jobs	0	-1	-5	-8	-10
Beverage manufacturing (3121)	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change in Jobs	0	-1	-3	-5	-6
Basic chemical manufacturing (3251)	% Change	0.00%	0.00%	0.02%	0.02%	0.01%
	Change in Jobs	0	0	1	1	1
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing (3334)	% Change	0.00%	-0.01%	-0.03%	-0.04%	-0.04%
	Change in Jobs	0	0	-1	-2	-2
Household appliance manufacturing (3352)	% Change	0.00%	-0.03%	-0.07%	-0.10%	-0.10%
	Change in Jobs	0	-1	-2	-2	-2
Wholesale trade (42)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change in Jobs	0	-6	-49	-73	-74
Retail trade (44-45)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change in Jobs	0	-69	-279	-415	-429
Warehousing and storage (493)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change in Jobs	0	-3	-15	-24	-27
State & Local Government	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change in Jobs	0	94	-14	-156	-195

b. California Business Impacts

Gross output is used as a measure for business impacts because as it represents an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output is the sum of the amount of production, including all intermediate goods purchased as well as value added (compensation and profit), across all private industries and the public sector, and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth.

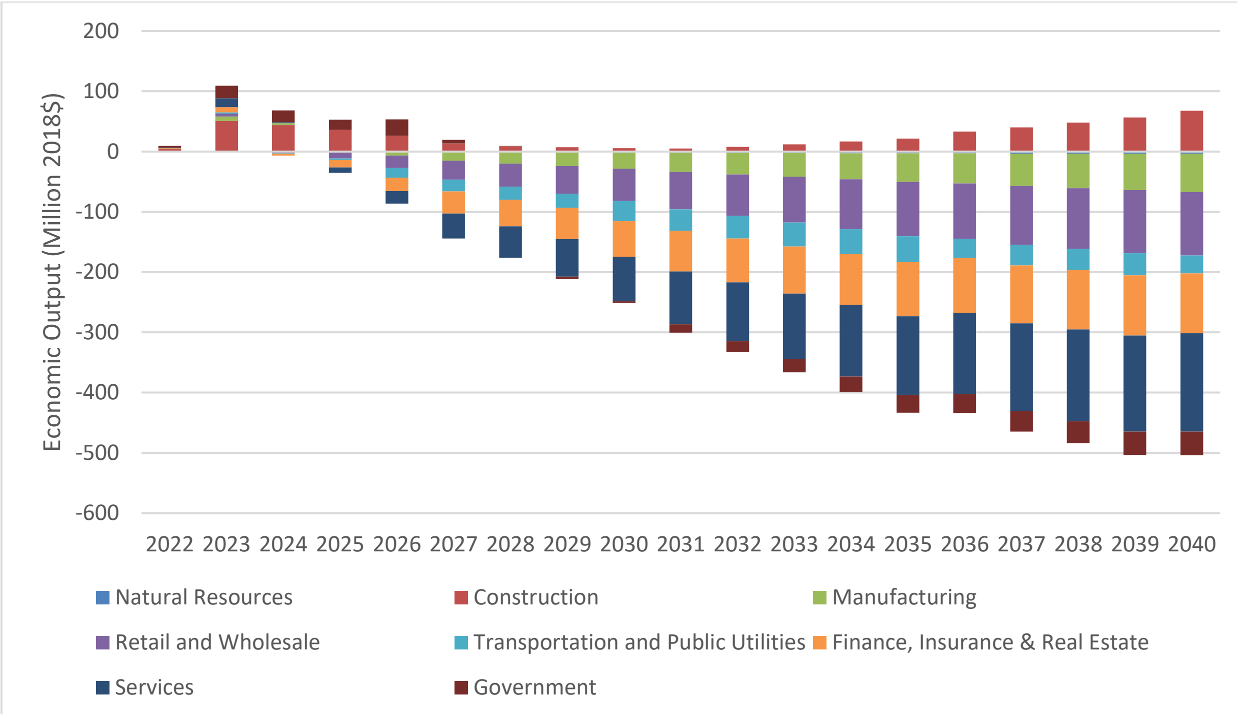
The results of the Proposed Amendments show a decrease in output of $245 million in 2030 and a decrease of $436 million in 2040 as shown in ***Table*** 44, representing a change of about 0.01 percent of baseline output. The trend in output changes is illustrated by major sector in ***Figure 10***. Similar to the employment impacts, there is an initial positive impact, primarily comprised of the construction sector, followed by a decrease primarily comprised of the Retail and Wholesale and Services major sectors.

Table 44: Change in California Output Growth by Industry

Industry	Impact	2020	2025	2030	2035	2040
California economy	Output (2018M$)	4,485,291	4,888,434	5,293,094	5,854,565	6,585,520
	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change (2018M$)	0	18	-245	-412	-436
State & local government	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change (2018M$)	0	17	-3	-30	-39
Electric power generation, transmission and distribution (2211)	% Change	0.00%	0.00%	-0.07%	-0.07%	-0.02%
	Change (2018M$)	0	-1	-23	-26	-9
Construction (23)	% Change	0.00%	0.02%	0.00%	0.01%	0.03%
	Change (2018M$)	0	36	6	22	68
Other food manufacturing (3119)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change (2018M$)	0	0	-2	-3	-4
Beverage manufacturing	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%

Industry	Impact	2020	2025	2030	2035	2040
(3121)	Change (2018M$)	0	0	-1	-2	-3
Basic chemical manufacturing (3251)	% Change	0.00%	0.00%	0.02%	0.02%	0.01%
	Change (2018M$)	0	2	6	7	5
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing (3334)	% Change	0.00%	-0.01%	-0.03%	-0.04%	-0.04%
	Change (2018M$)	0	0	-1	-1	-1
Household appliance manufacturing (3352)	% Change	0.00%	-0.03%	-0.07%	-0.10%	-0.10%
	Change (2018M$)	0	0	-1	-1	-1
Wholesale trade (42)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change (2018M$)	0	-2	-17	-28	-32
Retail trade (44-45)	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change (2018M$)	0	-8	-37	-62	-73
Warehousing and storage (493)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
	Change (2018M$)	0	0	-1	-2	-2

Figure 10: Change in Output in California by Major Sector



c. Impacts on Investments in California

Private domestic investment consists of purchases of residential and nonresidential structures and of equipment and software by private businesses and nonprofit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy.

The relative changes to growth in private investment for the Proposed Amendments are shown in Table 45 and show a decrease of private investment of about $120 million in 2030 and $102 million in 2040, or less than 0.01 percent of baseline investment.

Table 45: Change in Gross Domestic Private Investment Growth

Gross Domestic	2020	2025	2030	2035	2040
Private Investment (2018M$)	401,332	436,725	471,989	531,538	600,769
% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2018M$)	0	-31	-120	-141	-102

d. Impacts on Individuals in California

The Proposed Amendments result in impacts to individuals as the incremental costs of AC equipment is passed on to residential end-users. Additionally, the costs incurred by affected businesses and the public sector will cascade through the economy and impact individuals. One measure of this impact is the change in real personal income, which includes worker compensation and government and business transfer payments, adjusted for inflation.

Table 46 shows the annual change in real personal income across all individuals in California. Total personal income growth decreases by about $426 million in 2030 and $823 million in 2040 as a result of the Proposed Amendments, or less than 0.03 percent of the baseline. The change in personal income estimated here can also be divided by the California population to show the average or per capita impact on personal income. The decrease in personal income growth is estimated to be about $6 per person in 2030 and $7 per person in 2040.

Table 46: Change in Personal Income Growth

Description	2020	2025	2030	2035	2040
Personal Income (2018M$)	2,473,892	2,764,513	3,074,439	3,411,855	3,810,321
% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
Change (2018M$)	0	-115	-426	-706	-823
Personal Income per capita (2018$)	61,133	65,717	70,464	75,603	81,969
% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%
Change (2018$)	0	-3	-6	-8	-7

e. Impacts on Gross State Product (GSP)

Gross State Product (GSP) is the market value of all goods and services produced in California and is one of the primary indicators used to gauge the health of an economy. Under the Proposed Amendments, GSP growth is anticipated to decrease by about $209 million in 2030 and decrease by $326 million in 2040 as shown in Table 47. These changes represent less than 0.01 percent of baseline GSP.

Table 47: Changes in Gross State Product (GSP) Growth

Description	2020	2025	2030	2035	2040
GSP (2018M$)	2,775,611	3,026,419	3,282,868	3,602,543	3,984,281
% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2018M$)	0	-40	-209	-312	-326

f. Creation or Elimination of Businesses

The REMI model cannot directly estimate the creation or elimination of businesses. Changes in jobs and output for the California economy described above can be used to understand some potential impacts. The overall jobs and output impacts of the Proposed Amendments are very small relative to the total California economy, representing changes of less than 0.01 percent.

Impacts to directly affected industries are also very small relative to the baseline, with only one industry exceeding 0.04 percent. Reductions in output could indicate elimination of businesses.

Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demand. There is no threshold that identifies the creation or elimination of a business. The industry with largest absolute decrease in employment and output is retail trade, this is a large and varied sector consisting of many different types of businesses; it is unlikely that a slowing of growth of 0.02 percent in the high cost scenario indicates the elimination of any particular existing business. The industry with largest absolute increase in employment and output is construction sector, with an acceleration of growth of about 0.04 percent in the high cost scenario, this could lead to an expansion or creation of businesses over time.

g. Incentives for Innovation

The Proposed Amendments sets performance standards for achieving the requirements across both AC and refrigeration sectors. This standard provides an incentive for manufacturers to find innovative methods to achieve these standard in a low cost manner in order to mitigate compliance costs. Staff anticipates that these requirements will result in a growing market for new low-GWP refrigerants and technologies such as CO_2 transcritical and cascade systems, micro-distributed hydrocarbon systems as well low-GWP HFO systems. Manufacturers who invest and gain experience in these technologies will benefit as the market expands. Not only is the demand for air conditioning and refrigeration increasing, but the demand for climate friendly technologies is also increasing. Other U.S. states have committed to taking action on lowering emissions of high-GWP HFCs. In addition, both chemical manufacturers who produce refrigerants and manufacturers of refrigeration and AC equipment are global corporations. The manufacturers producing compliant refrigerants and equipment for California also participate in global markets which include markets where existing policies are already driving adoption of next generation technologies, markets where new measures are driving near-term transformation, as well the worldwide transition that is occurring over a longer-term because of the Kigali Agreement. There is an incentive to commercially deploy and gain experience with these technologies which is bolstered by the Proposed Amendments.

h. Competitive Advantage or Disadvantage

The AC equipment manufacturers that must comply with requirements of the Proposed Amendments are based outside of California and therefore do not present any competiveness impacts for this industry inside California. The incremental costs are anticipated to be incurred generally across business end-users and are not anticipated to result in any competitive advantages or disadvantages within industries.

The refrigeration equipment manufacturers that must comply with requirements of the Proposed Amendments are based outside of California and therefore do not present any competiveness impacts for this industry inside California. The incremental costs of compliance with the AC requirements are assumed to be passed on to end-users in California, primarily in the sectors of retail and wholesale trade. The incremental costs are anticipated to be incurred generally across business end-users and are not anticipated to result in any competitive advantages or disadvantages within industries.

4. Summary and Agency Interpretation of the Assessment Results

The results of the macroeconomic analysis of the Proposed Amendments are summarized in Table 48. As analyzed here, CARB estimates the Proposed Amendments is unlikely to have a significant impact on the California economy. Overall, Proposed Amendments are estimated to result in a change in the growth of jobs, State GDP, and output that is projected to not exceed 0.01 percent of the baseline, while achieving a significant cumulative reduction in GHG emissions. This change is small compared the average annual growth rate of 1.8 percent projected for this time horizon. The Proposed Amendments will result in a small decrease in growth in the Retail and Wholesale trade sectors due to incremental cost incurred by businesses and increased consumer prices for household appliances. The Proposed Amendments will also result in a small increase in growth in the construction sector resulting from increased expenditures on contractors who install and maintain equipment AC and refrigeration equipment.

Table 48: Summary of the Macroeconomic Impacts of the Proposed Amendments

Description	Impact	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-40	-209	-312	-326
Personal Income	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.02%
	Change (2019M$)	0	-115	-426	-706	-823
Employment	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change in Jobs	0	92	-1,198	-1,934	-1,966
Output	% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%
	Change (2019M$)	0	18	-245	-412	-436
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-31	-120	-141	-102

F. ALTERNATIVES

1. Alternative 1

Alternative 1 is a more stringent requirement for both stationary refrigeration systems containing more than 50 pounds of refrigerant and stationary AC systems. Under this alternative, every new refrigeration system would be required to have a refrigerant with a GWP value below 10. Only natural refrigerants (CO_2, NH_3 and hydrocarbons) would currently be able to comply with this limit; HFO/HFC blends such as R-454C with GWP values between 11 and 150 would be prohibited under this scenario. For AC equipment, room ACs would be required to have a refrigerant with a GWP value less than 10 and residential and commercial AC equipment would be required to use a refrigerant with a GWP value less than 500. Currently, there is only one A1 refrigerant that industry has identified as a refrigerant alternative to R-410A with a GWP under 750. A GWP limit of 500 would exclude this option. A GWP limit of 500 would also exclude multiple A2L options which manufacturers are either selling in the market today or are in the process of commercializing. Options for room ACs would include propane and HFOs. There compliance options for stationary AC systems would be more limited, and would have some degree of flammability properties. These GWP limits align with proposals from stakeholders advocating for the most stringent GWP limits technologically feasible today.

Table 49 summarizes the requirements of Alternative 1.

Table 49. Alternative 1 GWP Limits for Stationary Refrigeration and AC

Stationary Refrigeration or AC Sector	Refrigerant GWPs Prohibited (100-year GWP Value)	Prohibition Date
Stationary Refrigeration (new systems with over 50 lb. refrigerant in new, remodeled and existing facilities)	10 or greater	January 1, 2022
Stationary Room AC (new)	10 or greater	January 1, 2023
Stationary AC (new) (Commercial)	500 or greater	January 1, 2023
Stationary AC (new) (residential)	500 or greater	January 1, 2023

a. Costs

Based on CARB's F-Gas inventory, refrigeration systems used in supermarkets, grocery stores, cold storage and industrial process cooling have an average lifetime of 15 – 20 years. At that time, one or more motor-bearing parts (e.g., compressors, condensers, evaporators) typically need to be replaced. In existing facilities, a system would be considered "new" if the repair/replacement costs of the components being replaced exceed 50 percent of the cost of replacing the whole system. In that case, the facility owners/operators would then be required to swap out all of the remaining equipment to make the whole facility run using a refrigerant with a

GWP value less than 10. Because the current refrigerants with GWP less than 10 are not compatible with any of the HFC equipment currently in use, the upfront costs related to equipment and installation would be high. Table 50 shows the direct cost inputs for the refrigeration equipment for Alternative 1.

Table 50. Alternative 1 Incremental Costs for New Refrigeration Systems

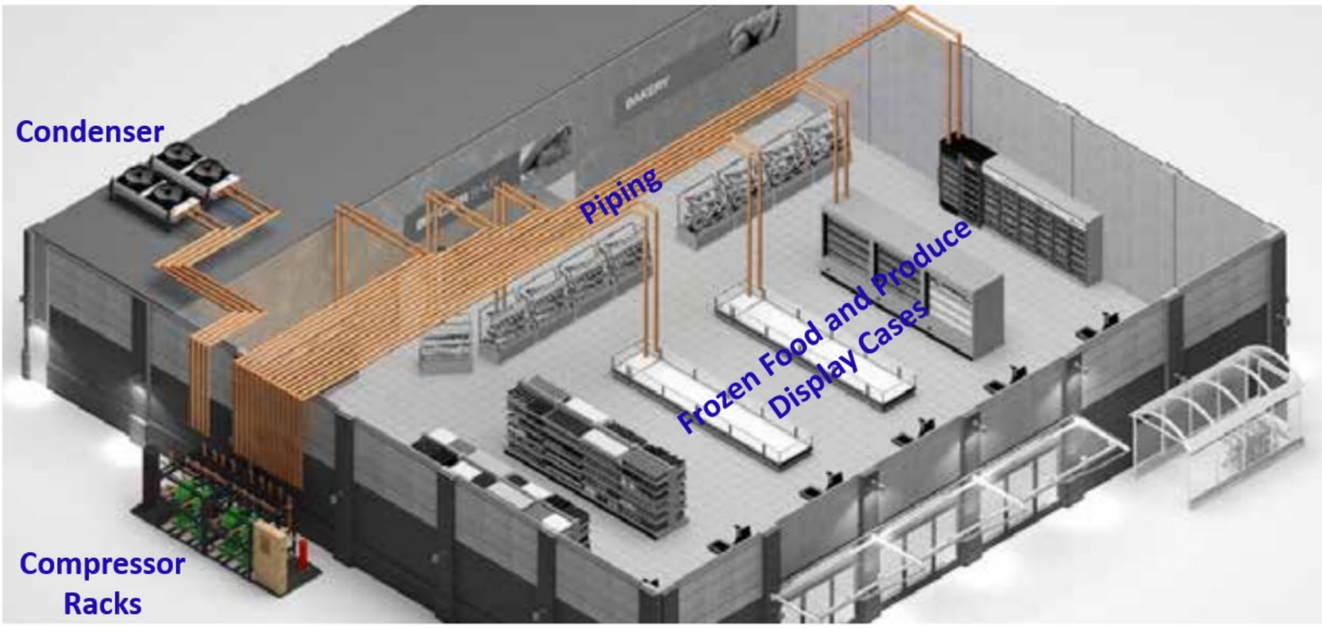
Cost Categories	New systems in existing facilities, GWP < 10	Incremental Annual Costs for New Systems Existing Facilities ($ / year)[a]
Equipment and Installation (Upfront)	Equipment: + 80%; Installation: +20% for commercial refrigeration, +40% for IPR and cold storage	+$3,620 to +$82,100 [b]
Refrigerant Replenishment (ongoing)	– 50%	+$15 to +$2,840
Maintenance (ongoing)	No change from baseline	+$0
Electricity (ongoing)	–10% for large IPR and cold storage systems; no change for others	-$35,000 to +$0
RMP Compliance (ongoing)	– 100%	-$151 to -$3,100
Total Annual Costs ($ / year)		+$3,410 to +$75,900

[a] The range of values represents the different incremental costs based on system sizes (i.e., small, medium, large) and system types (i.e., commercial, industrial process and cold storage).
[b] Amortized annual incremental upfront costs, including a 5 percent rate to reflect end-user financing.

The key difference between the main proposal and Alternative 1 are the higher incremental costs for placing new systems in existing facilities. As discussed earlier, if in an existing facility, a refrigeration system undergoes partial component replacement but that replacement exceeds a capital cost threshold, then the systems is deemed "new." In this case, the facility would be required to use a refrigerant with a GWP value below 10. All the equipment from that facility previously in use for HFC refrigerants would need to be replaced to make it compatible for a refrigerant with GWP less than 10 (none of the HFC equipment is compatible for use with refrigerants with GWP < 10 that are currently available).

The schematic below shows the typical layout of the refrigeration equipment in a supermarket – broadly, it consists of the following (1) compressors (often located in a machine room, mezzanine level or at the back of the facility , (2) condenser often located on the rooftop, (3) fixtures like display cases for storing and showcasing produce and frozen foods inside the supermarket, (4) expansion valves or metering devices (not labeled), and (5) refrigerant piping or lines connecting the display cases to the compressors and condensers. The refrigerant piping carries cold, mostly liquid refrigerant to the display cases for chilling the products. Inside the display cases, the cold refrigerant absorbs heat and vaporizes, cooling the products. After this, refrigerant piping carries the hot, vaporized refrigerant from the cases back to the compressor and eventually the condenser, to reject heat.

Figure 11. Example of a Centralized Refrigeration System[156]



The differences in thermodynamic properties and safety-related requirements for the currently available low-GWP refrigerants make them incompatible with equipment designed for HFC refrigerants. For example, CO_2 has higher operating pressures and a higher volumetric capacity than HFCs – this results in CO_2 systems having smaller compressors, and CO_2 systems require thicker refrigerant piping with a smaller diameter. Thus, any existing equipment in a supermarket that uses HFC refrigerants today cannot simply be "retrofitted" with the currently available low-GWP refrigerants. To use low-GWP refrigerants, all existing equipment will need to be completely replaced. For this analysis, based on stakeholder input, CARB staff assume an 80 percent average incremental cost for compliant new equipment in existing facilities. Even though a full replacement will occur, the incremental costs are not assumed to be 100 percent because some components would have to be replaced as part of the baseline, for example, some display cases and other components would be replaced upon which the capital cost threshold of 50 percent is triggered and, as a result of which, a full replacement is triggered. In addition, the installation costs would double relative to the main proposal, because labor would be required to uninstall the existing HFC-compatible equipment and then install the compliant new equipment. Because the currently available compliant refrigerant options for the main proposal will be the same if the GWP limit is 10 instead of 150 (i.e., CO_2, ammonia and propane), ongoing costs such

[156] Adapted from original image in Kysor Warren, Parallel Compression Refrigeration, Installation and Operation Manual. (web link: http://www.kysorwarren.com/files/literature/merchandisers/service/i/KW-IOM-HFC.pdf, Last acessed February 2020).

as refrigerant replenishment, electricity and RMP compliance are all expected to be the same as those for the main proposal and yield some savings to the end-user.

As discussed in Section A.5.a, only 20 to 26 percent of new systems in any given year are installed in newly constructed or remodeled facilities, and the remaining 74 to 80 percent are used to replace retiring equipment in existing facilities. Since Alternative 1 would require all of the new systems to use refrigerants with GWP values below 10, all existing facilities would face very high incremental upfront costs.

For Stationary AC, the key difference between the main proposal and Alternative 1 is the potential for higher cost as the compliance options are more limited to newer A2L refrigerants. Staff estimate higher upfront costs if all manufacturers were to transition to an A2L with a GWP limit less than 500 by 2023. Under this scenario, manufacturers may not be able to leverage their investments in refrigerant options below 750 but above 500.

When provided with different refrigerant options for compliance, equipment manufacturers have the ability to select a compliance pathway, which minimizes their cost. In addition, the compliance options that exist today are newer refrigerant HFO blends, which comes with higher costs, especially initially, and the higher costs for installation, service and maintenance of an A2L system would also apply. Room ACs using R-290 (propane) are being introduced to the market in Asia, however codes and standards are farther behind in allowing this technology in California. Recently, a new window AC design was introduced using an HFO with a GWP below 10, which would not require any codes or standards changes and the manufacturer has indicated it will be at cost parity with R-410A when commercially available. However, major manufacturers have not begun a redesign or testing products to release a comprehensive line of room ACs using HFOs, likely because other refrigerants provide more cost-effective options. In addition, other refrigerants such as R-290 offer energy efficiency gains without additional design changes for energy efficiency. Without any codes and standards changes proposed to allow for the use of propane, a 2023 compliance date for room ACs would likely be infeasible.

Table 51. Alternative 1 Incremental Costs for New AC Equipment

Cost Categories	Room AC/HP	Residential Central AC/HP	Commercial AC/HP
Equipment Retail (Upfront)	No change from baseline	+ $250	+ $1,400
Installation (Upfront)	No change from baseline	+$50	+$140
Servicing and Maintenance (ongoing)	No change from baseline	+$90	+$950

The overall costs associated with Alternative 1 for the refrigeration systems is given in ***Table 52***. For both refrigeration and AC, the upfront costs are estimated to be much higher than the main proposal, ranging between $28 million and over $850 million per year, from 2022 to 2040, with an average cost of $566 million per year.

Table 52. Total Costs for Alternative 1 (million 2018$)

Year	Refrigeration		AC		Total Costs ($ / year)
	Upfront[a]	Ongoing[b]	Upfront[c]	Ongoing[d]	Refrigeration + AC
2022	32.2	-$2.6	$0	$0.0	29.6
2023	64.6	-$5.1	$234	$5.5	299
2024	97.3	-$7.8	$235	$11.1	336
2025	130	-$10.4	$236	$16.8	373
2026	163	-$13.0	$238	$22.5	410
2027	197	-$15.7	$239	$28.3	448
2028	230	-$18.4	$240	$34.2	487
2029	264	-$21.1	$242	$40.1	525
2030	298	-$23.8	$243	$46.1	564
2031	333	-$26.5	$244	$52.1	603
2032	367	-$29.3	$246	$58.2	642
2033	402	-$32.1	$247	$64.4	682
2034	437	-$34.9	$248	$70.6	721
2035	473	-$37.7	$250	$76.9	761
2036	508	-$40.5	$251	$83.2	802
2037	526	-$41.9	$252	$89.6	826
2038	544	-$43.4	$253	$92.2	846
2039	562	-$44.8	$254	$94.8	867
2040	581	-$46.2	$255	$97.4	887

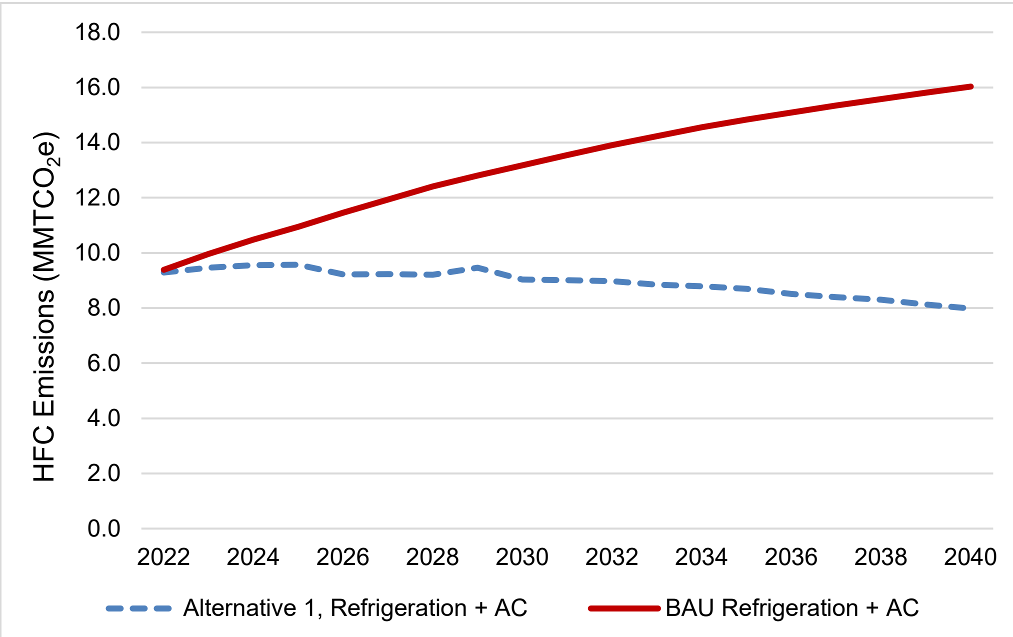
[a]Annualized equipment and installation costs for refrigeration systems.
[b]Annual ongoing savings for refrigeration systems for refrigerant replenishment, electricity and RMP compliance.
[c]Annualized equipment and installation costs for AC.
[d]Annual maintenance and repair costs for AC.

b. Benefits

For refrigeration systems, Alternative 1 is expected to get the highest expected emissions reductions, since it would use the natural turn-over of refrigeration equipment to transition the industry towards the lowest-GWP refrigerants available today. This means that all new systems, including those being installed in existing facilities would have to use refrigerants with GWP values less than 10 (i.e., all new systems shown in Figure 3 would be required to use ultra-low GWP refrigerants). This alternative is the quickest way to achieve emissions reductions and transitioning this sector to refrigerants with the lowest warming potentials possible within the next two decades. While two decades seems long, it is worth noting that commercial and industrial refrigeration systems are large, complex, and designed to last for a long time. For AC equipment, Alternative 1 is expected to get the highest expected emissions reductions because it would require the lowest GWP technologically possible at this time.

Between 2022 and 2040, Alternative 1 results in average annual emissions reductions of 6.2 $MMTCO_2e$ and cumulative reductions equaling 117 $MMTCO_2e$ combined from the refrigeration and AC sectors (***Table 53***).

Figure 12. Projected Annual Baseline Emissions and Expected Reductions from Alternative 1



The annual GHG emission reductions multiplied by the SC-CO_2 values shown in ***Table 53***, summed across the regulatory lifetime and adjusted for inflation gives a monetary estimate of the benefit of GHG emission reductions from this alternative. These benefits range from about $2.6 billion to $11.3 billion through 2040, depending on the chosen discount rate.

Table 53. Projected Emissions Benefits from Alternative 1

Year	GHG Emissions Reductions ($MMTCO_2e$)	Avoided Social Cost of Carbon (Million 2018$)		
		5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2022	0.9	$15.0	$49.7	$74.0
2023	1.4	$23.6	$79.9	$118
2024	2.0	$32.7	$113	$166
2025	2.6	$45.4	$149	$220
2026	3.2	$55.9	$188	$276
2027	3.8	$71.3	$228	$333
2028	4.4	$83.1	$271	$393
2029	5.1	$95.0	$310	$456
2030	5.7	$114	$356	$519
2031	6.3	$126	$402	$583
2032	6.9	$147	$449	$648
2033	7.5	$161	$502	$719
2034	8.1	$184	$551	$785

Year	GHG Emissions Reductions ($MMTCO_2e$)	Avoided Social Cost of Carbon (Million 2018$)		
		5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2035	8.7	$196	$598	$848
2036	9.3	$221	$652	$920
2037	9.8	$234	$702	$998
2038	9.9	$249	$723	$1,022
2039	10.5	$264	$778	$1,094
2040	11.0	$291	$831	$1,163
Total	117	$2,610	$7,930	$11,340

c. Economic Impacts

Alternative 1 is more stringent compared to the Proposed Amendments, requiring AC equipment to achieve a lower GWP standard and requiring commercial refrigeration system to all achieve less than 150 GWP. This results in higher incremental cost as passed-through to end-users, relative to the Proposed Amendments. The macroeconomic impact analysis results are qualitatively similar to the results of the Proposed Amendments, but of a larger magnitude as shown in **Table** 54. Figure 13 and Figure 14 show the job and economic impact changes of Alternative 1, respectively.

Table 54. Change in Growth of Economic Indicators for Alternative 1

Description	Impact	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-123	-455	-790	-1,020
Personal Income	% Change	0.00%	-0.01%	-0.03%	-0.04%	-0.05%
	Change (2019M$)	0	-289	-814	-1,367	-1,740
Employment	% Change	0.00%	0.00%	-0.02%	-0.02%	-0.03%
	Change in Jobs	0	-1,136	-3,852	-6,275	-7,566
Output	% Change	0.00%	0.00%	-0.01%	-0.02%	-0.03%
	Change (2019M$)	0	-206	-746	-1,303	-1,711
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-93	-215	-271	-272

Figure 13. Job Impacts of Alternative 1 by Major Sector

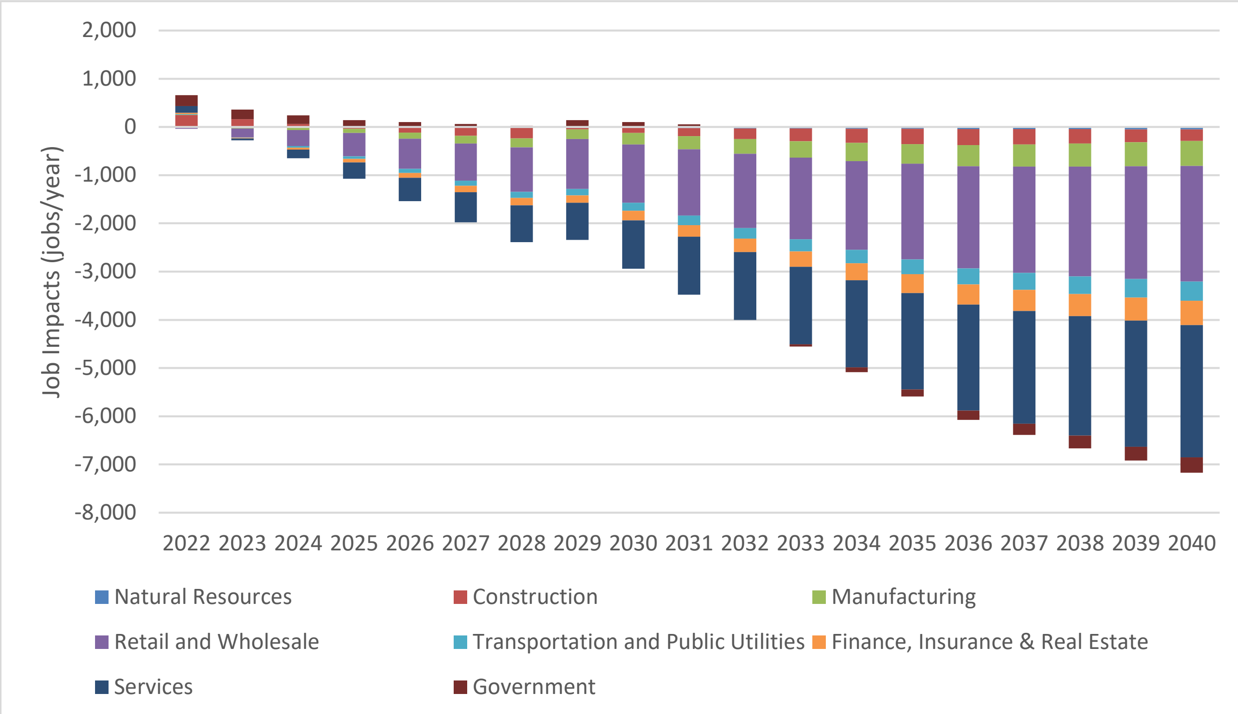
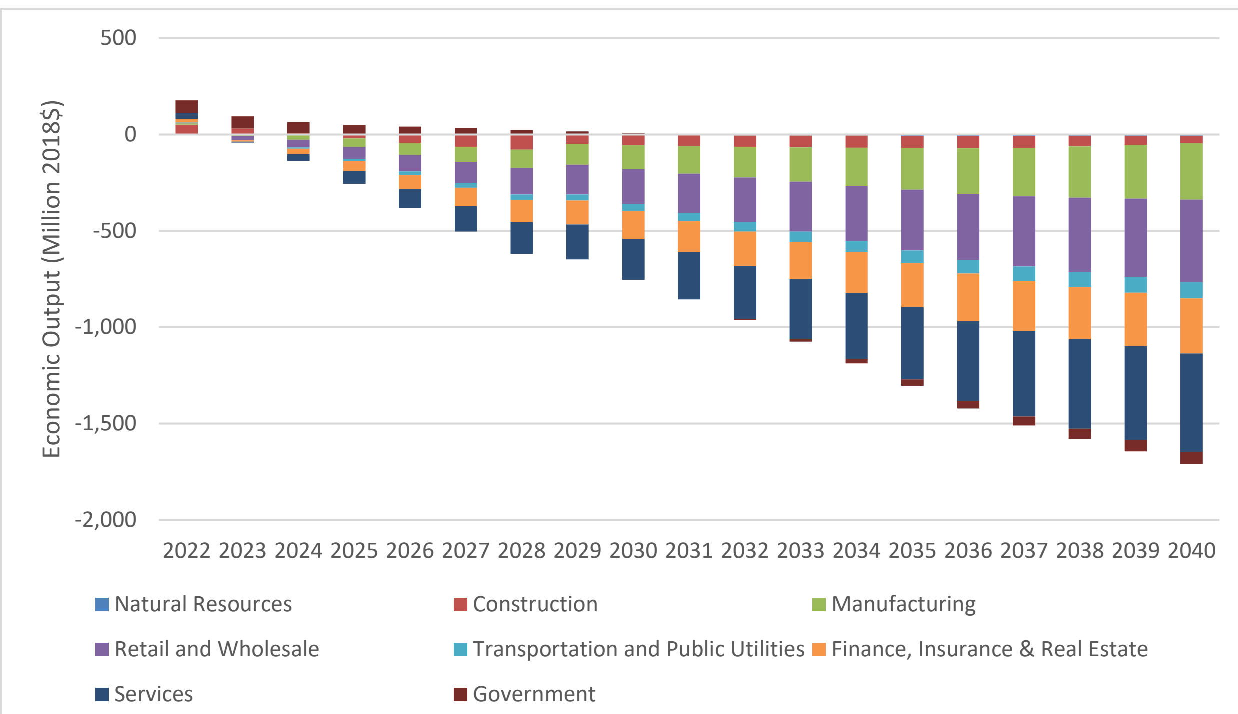


Figure 14. Economic Impacts of Alternative 1 by Major Sector



d. Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emissions reduction. There are multiple approaches to calculating cost-effectiveness. For the Proposed Amendment, staff calculated the cost-effectiveness (in $/MTCO$_2$e) by dividing the net direct cost of the regulation from 2022 to 2040 by the expected GWP-weighted emissions reductions over that time-period. Cost-effectiveness for the Proposed Amendments and Alternative 1 is summarized in Table 55. Staff estimated that Alternative 1 would be less cost-effective than the Proposed Amendments due to the higher upfront and ongoing costs.

Table 55. Cost Effectiveness of the Proposed Amendments and Alternative 1

Proposal	Cost-Effectiveness ($/MTCO2e)
Proposed Amendments	$58
Alternative 1	$82
Difference in Cost-Effectiveness	$24

e. Reason for Rejecting

For refrigeration, as the details of the proposal were discussed during stakeholder engagements and the economic impacts analyzed, it became increasingly clear that the direct costs associated with this alternative are very high. The main reason is the incompatibility of equipment using refrigerants with GWP < 10 with the currently installed equipment suitable for HFCs. This poses a significant systems integration problem which currently can only be resolved with a 100 percent replacement of equipment. Additionally, if a facility owner were to carry out a full system replacement, doing so is logistically onerous without shutting the facility down. Facility owners avoid store closures for any length of time to prevent losses in customer loyalty and revenue. While estimated emissions reductions from this alternative are significantly higher than the main proposal, this alternative proposal could result in a shift in the behavior of the owners/operators - fewer system replacements would occur and as a result, old leaky systems that are in dire need of replacement and upgrades would likely not be updated, especially in facilities owned by small businesses. Due to high associated costs associated with this alternative and to avoid shifts in consumer behavior that could lead to higher emissions, CARB has rejected this alternative.

CARB is rejecting this alternative for AC for two main reasons. First, a GWP less than 10 for room AC is not feasible in the near-term. This GWP limit would require the use of either an HFO or an A3 (highly flammable) refrigerant such as R-290. Using an HFO refrigerant to achieve a GWP of less than 10 for room ACs would likely need substantial redesign to achieve the same level of energy efficiency. Transitioning room AC product lines to an HFO with a GWP under 10 would be more costly and without the added benefit to manufacturers of increased energy efficiency. As for using an A3 refrigerant in room ACs, there is no proposal currently to revise product standards to allow for their use in the U.S., which is a precursor to adopting new building codes which allow for their use. CARB rejected this proposal for a GWP less than 10 for room ACs because of the infeasibility of using an A3 refrigerant and the cost of an HFO alternative for this category of equipment.

CARB rejected the proposal of 500 GWP by 2023 for all residential and commercial ACs because it would limit the compliance options significantly and would result in higher cost impacts. This

GWP limit would exclude an A1 alternative, effectively limiting the options to newer A2L refrigerant blends. In addition, this limit further excludes A2L options with GWP values less than 750 but above 500 which are either being sold in the market today or are in the process of being commercialized. This could increase costs of the Proposed Amendments for manufacturers which have selected this refrigerant to pivot to another option and be ready with compliant equipment by 2023. A range of compliance options allows manufacturers to minimize cost impacts by leveraging their investments in refrigerant technology less than 750 to transition products for California and other markets by 2023.

2. Alternative 2

Alternative 2 comprises less stringent requirements for both refrigeration and AC than the Proposed Amendments. Under this alternative, all of the new regulated refrigeration systems would have to use mid-GWP (i.e., GWP < 1,500) refrigerants like R-448A and R-449A, irrespective of whether the systems are installed in newly constructed, remodeled or existing facilities. This would not require a transition to low-GWP refrigerants like CO_2, NH_3, hydrocarbons or the low-GWP fluorocarbon refrigerants in newly constructed and remodeled facilities. This is aligned with stakeholders advocating for the least stringent requirements for these sectors and instead rely on external market forces to propel the transition to low-GWP refrigerants. Alternative 2 does not set a GWP limit for AC systems and instead expands leak management and reporting requirements under South Coast AQMD Rule 1415 to AC equipment across the rest of the state.

Some stakeholders have suggested tightening the leaks of refrigerants from this equipment instead of applying restrictions on refrigerant GWP values in new equipment. For regulated refrigeration systems, CARB's Refrigerant Management Program has now been in effect since 2011. In Alternative 2, CARB also considers a statewide program similar to South Coast AQMD Rule 1415 for Stationary AC equipment. Rule 1415 expands RMP requirements to AC equipment over 50 pounds. Facilities with AC equipment with a full charge capacity of greater than 50 pounds of refrigerant are required to register their facility, conduct annual leak inspections, repair leaks within 14 days and keep records on site. This is business as usual for the 40 percent of the state population within the jurisdiction of South Coast AQAMD. This proposal would expand these requirements statewide, which is aligned with stakeholder request for more government oversight of the management of high-GWP refrigerants in commercial equipment. More specifically, this proposal includes an annual report and filing fee, and quarterly leak inspections. However, even if this program cut leak rates 30 percent, this is a less effective strategy for AC than for refrigeration systems because commercial AC is less leaky and charge sizes are smaller than refrigeration systems affected by RMP. While these ACs contribute significantly to HFC emissions, there is less potential to reduce emission per unit through improved management and a greater implementation challenge because of the sheer number of ACs. Additionally, this would not cover residential AC.

a. Costs

Incremental costs associated with Alternative 2 are summarized in tables below. For refrigeration, there are small increases expected for equipment used in industrial refrigeration and the ongoing costs of refrigerant replenishment for all systems. Regarding AC, the costs predominately affects existing systems, unlike the main proposal which only affects new equipment. The costs for

Alternative 2 include an annual leak inspection for large commercial AC equipment, and recordkeeping and reporting consistent with the requirements set in South Coast AQMD Rule 1415 adopted as a statewide regulation. The requirements would be consistent with South Coast AQMD, and as such, neither costs nor are emissions reductions from equipment within this region included in the analysis for Alternative 2.

Table 56. Alternative 2 Incremental Costs for Regulated Refrigeration Systems

Cost Categories	Incremental Cost Percentages	Incremental Annual Costs ($ / year)
Equipment (Upfront)	No change from baseline for commercial refrigeration and cold storage; +10% for IPR	+$795 to +$7,320 [a]
Installation (Upfront)	No change from baseline	+$0
Refrigerant Replenishment (ongoing)	+ 50% for commercial refrigeration and IPR; no change for cold storage	+$33 to +$2,800 [b]
Maintenance (ongoing)	No change from baseline	+$0
Electricity (ongoing)	No change from baseline	+$0
RMP Compliance (ongoing)	No change from baseline	+$0
Total Annual Cost ($ / year)		+$830 to +$9,850 [c]

[a] Annual amortized upfront incremental cost for IPR systems, including a 5 percent rate reflecting end-user financing. See Cost Appendix tables for more details.)

[b] Annual incremental costs for replenishing leaked refrigerant. The range of values represents the different incremental costs based on system size (i.e., small, medium, large) and system type (i.e., commercial, industrial process, cold storage). See

Table 66 in the Appendix for more details.
[c] Total annual incremental costs for Alternative 2. The range of values represents the different incremental costs based on system size (i.e., small, medium, large) and system type (i.e., commercial, industrial process, cold storage).

Table 57. Alternative 2 Incremental Costs for Regulated AC Equipment

Cost Category	Commercial AC Systems > 50 lb.
AC Leak Management Program (ongoing)	+$267 per system

The overall costs associated with Alternative 2 for the refrigeration systems is given in Table 58. The annual average costs associated with alternative 2 are estimated to be $118 million, between 2022 and 2040. The main source of the costs for this alternative are the high implementation costs associated with a refrigerant management program for reducing refrigerant leaks from commercial AC equipment.

Table 58. Total Costs for Alternative 2 (million 2018$)

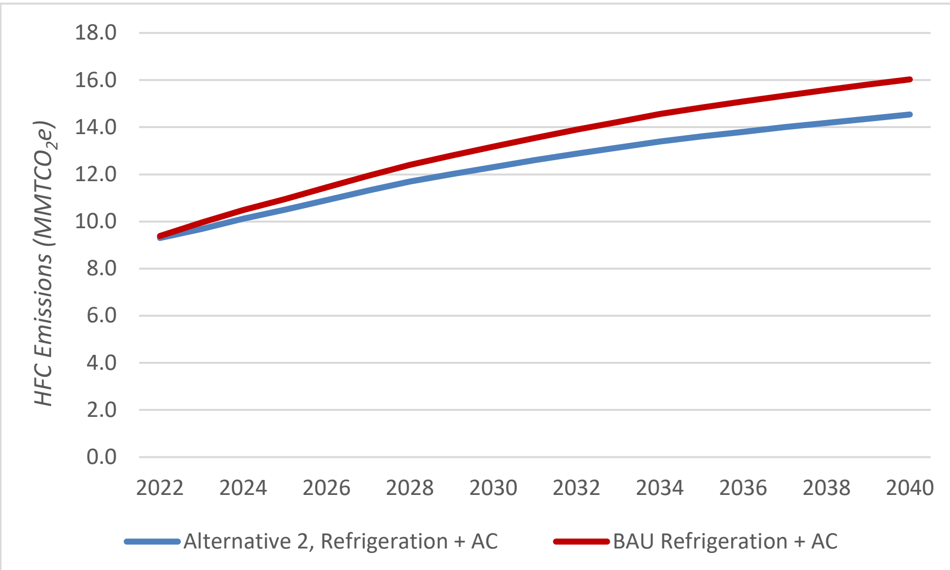
Year	Refrigeration		AC	Total Costs ($ / year)
	Upfront[a]	Ongoing[b]	Ongoing[c]	Refrigeration + AC
2022	0.53	0.81	0.0	1.34
2023	1.07	1.6	101	103
2024	1.61	2.5	102	106
2025	2.15	3.3	103	108
2026	2.70	4.1	104	111
2027	3.26	5.0	105	113
2028	3.81	5.8	106	116
2029	4.37	6.7	108	119
2030	4.94	7.5	109	121
2031	5.51	8.4	110	124
2032	6.08	9.3	111	127
2033	6.66	10.2	113	129
2034	7.24	11.0	114	132
2035	7.82	11.9	115	135
2036	8.41	12.8	116	137
2037	9.0	13.1	117	139
2038	9.6	13.3	118	141
2039	10.2	13.6	120	143
2040	10.8	13.9	121	145

[a]Annualized equipment and installation costs for refrigeration systems.
[b] Annual ongoing costs for refrigerant replenishment for refrigeration systems.
[c] Annual recordkeeping, reporting, leak inspection and filing costs for commercial AC.

b. *Benefits*

For refrigeration and AC, Alternative 2 is expected to get the lowest expected emissions reductions. Between 2022 and 2040, Alternative 2 results in average annual emissions reductions of less than 1 $MMTCO_2e$ and cumulative reductions equaling 17 $MMTCO_2e$ from the refrigeration and AC sectors.

Figure 15. Projected Annual Baseline Expected Reductions from Alternative 2



The annual GHG emission reductions multiplied by the SC-CO_2 values shown in Table 59 summed across the regulatory lifetime and adjusted for inflation gives a monetary estimate of the benefit of GHG emission reductions from this alternative. The benefits range from about 0.3 billion to $1.6 billion through 2040, depending on the chosen discount rate.

Table 59. Projected Emissions Benefits from Alternative 2

Year	GHG Emissions Reductions ($MMTCO_2e$)	Avoided Social Cost of Carbon (millions 2018$)		
		5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2022	0.1	$1.40	$4.50	$6.80
2023	0.3	$4.50	$15.4	$22.7
2024	0.4	$6.00	$20.6	$30.3
2025	0.5	$8.00	$26.1	$38.6
2026	0.5	$9.50	$31.8	$46.7
2027	0.6	$11.8	$37.6	$54.9
2028	0.7	$13.3	$43.6	$63.1
2029	0.8	$14.9	$48.6	$71.4
2030	0.9	$17.5	$54.6	$79.7
2031	0.9	$19.0	$60.6	$87.9
2032	1.0	$21.8	$66.7	$96.2
2033	1.1	$23.3	$73	$104

Year	GHG Emissions Reductions ($MMTCO_2e$)	Avoided Social Cost of Carbon (millions 2018$)		
		5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2034	1.2	$26.2	$79	$112
2035	1.2	$27.7	$85	$120
2036	1.3	$30.6	$90	$127
2037	1.3	$32.0	$96	$136
2038	1.4	$35.0	$101	$143
2039	1.4	$36.2	$107	$150
2040	1.5	$39.2	$112	$157
Total	17	$378	$1,150	$1,650

c. Economic Impacts

Alternative 2 imposes less stringent requirements compared to the Proposed Amendments. This results in lower incremental cost passed-through to end-users, but also achieves less emission reductions. The macroeconomic impact analysis results are qualitatively similar to the results of the Proposed Amendments, but of a smaller magnitude as shown in Table 60. Figure 16 and Figure 17 show the job and economic impact changes of Alternative 2, respectively.

Table 60. Change in Growth of Economic Indicators for Alternative 2

Description	Impact	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-21	-37	-50	-60
Personal Income	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-35	-57	-77	-93
Employment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	0	-87	-211	-296	-351
Output	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-31	-55	-75	-94
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2019M$)	0	-11	-13	-13	-13

Figure 16. Job Impacts of Alternative 2 by Major Sector

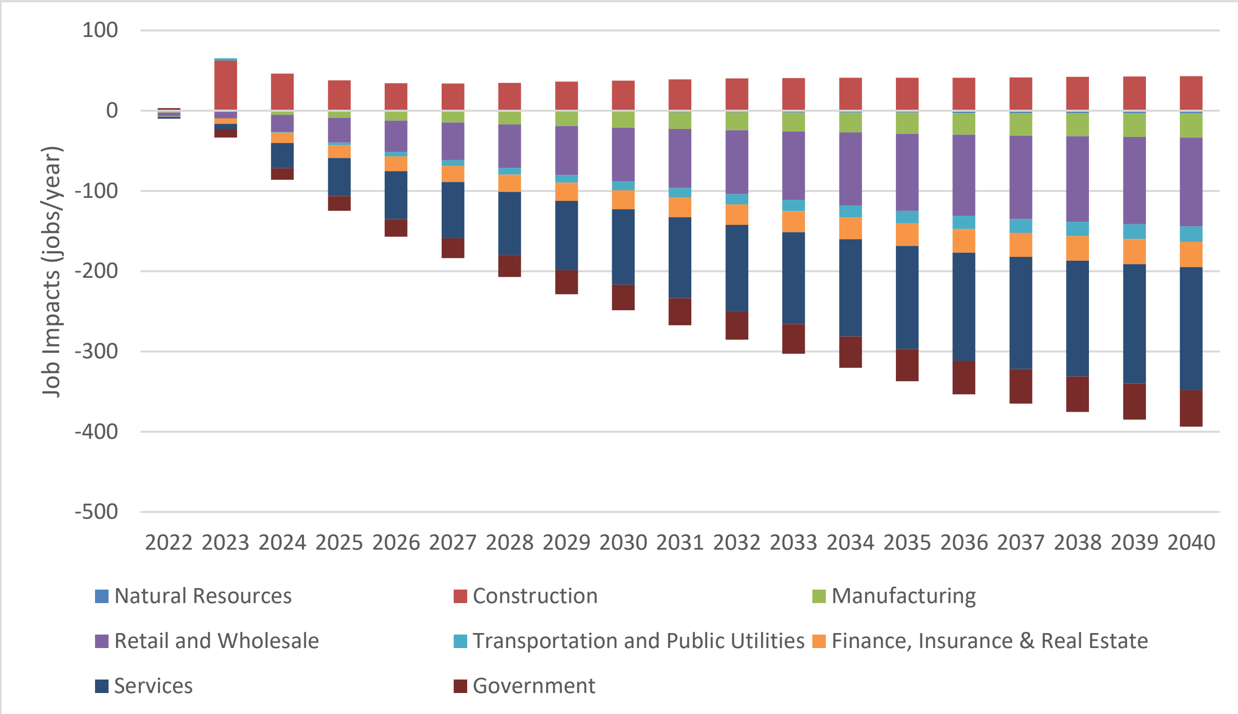
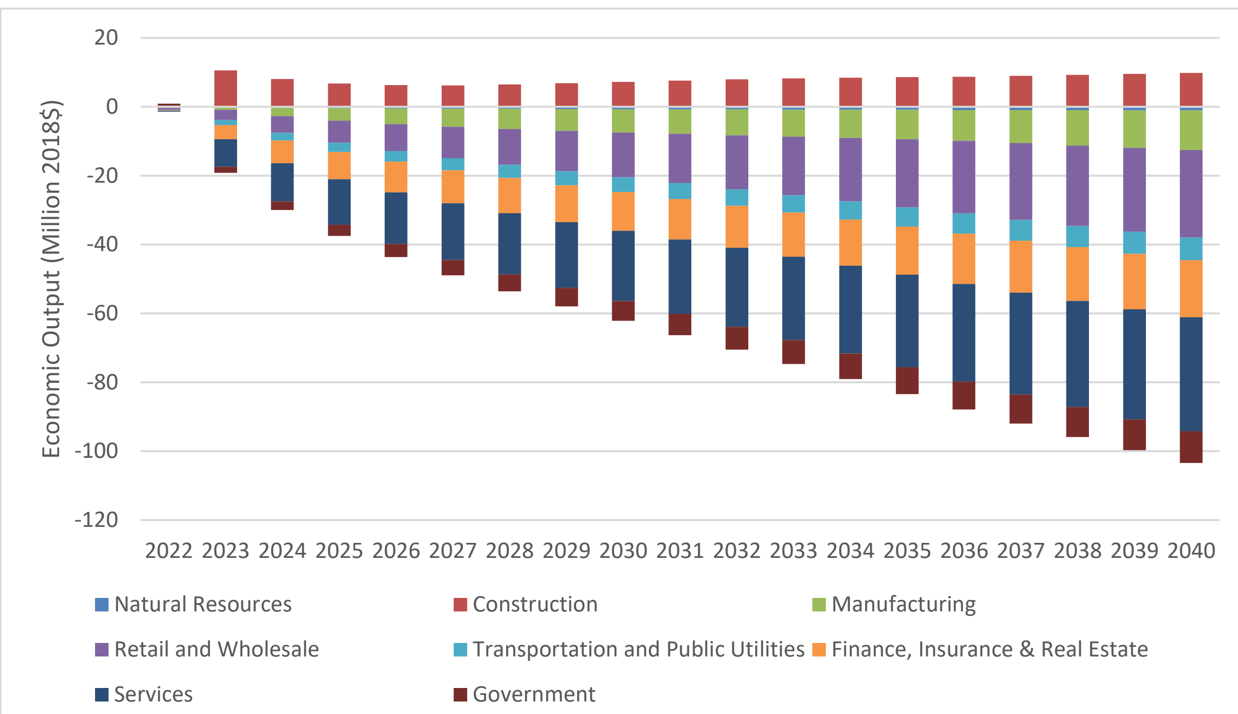


Figure 17. Economic Impacts of Alternative 2 by Major Sector



d. Cost-Effectiveness

Cost-effectiveness values for the Proposed Amendments and Alternative 2 were calculated as described in this section and are summarized in Table 61 below. Staff estimated that Alternative 2 would be less cost-effective than the Proposed Amendments because it achieves fewer emissions reductions relative to the cost.

Table 61. Cost-Effectiveness of the Proposed Amendments and Alternative 2, 2022 – 2040

Proposal	Cost-Effectiveness ($/MMT$CO_2$e)
Proposed Amendments	$58
Alternative 2	$276
Difference in Cost-Effectiveness	$218

e. Reason for Rejecting

The requirements under Alternative 2 are expected to yield significantly lower emissions reductions than the main proposal. Just from the refrigeration sector, the annual emissions reductions are, on average 50 percent lower than the main proposal and cumulative reductions until 2040 and lower by nearly 40 percent. For the AC sector, both the annual emissions and cumulative reduction are 90 percent lower on average compared to the main proposal.

In addition, some stakeholder have suggested that CARB propose measures, which lower the leak rate from refrigeration and AC equipment. To address leaks from refrigeration systems, CARB already has an existing program (RMP) which is more stringent that any current federal rules. There is an existing program, South Coast AQMD Rule 1415 which applies to the nearly 40 percent of large commercial equipment in the state which are in this district. In this Alternative, CARB analyzed the costs and benefits of expanding South Coast AQMD Rule 1415 to cover the remaining 60 percent of the state. The costs of implementing this program include conduction of leak inspections, recordkeeping and submitting reports. Since the leak rates from commercial ACs are already much lower than for residential ACs, there is less room for improving leak rates in existing AC systems as for refrigeration systems, which generally have higher leak rates and substantially higher charge sizes (hundreds to thousands of pounds). Even if the leak rates for large commercial ACs were minimized, the cost would be relatively high compared to the emissions reductions achieved and the implementation challenge would be large considering there are about 200,000 ACs that would need to report compared to the approximately 30,000 regulated refrigeration systems registered in RMP. In addition, Alternative 2 does not address the most significant source of emission from the AC sector, which is residential equipment. Thus, it is more feasible and cost-effective to reduce refrigerant emissions by lowering the GWP of the refrigerant type across all categories of AC equipment.

G. APPENDIX TABLES

1. Cost Appendix

Table 62. Facility-to-system cost conversion for baseline equipment and installation costs

Facility	Average Total Charge at Facility (lb.)[a]	Average Baseline Equipment Cost at Facility[b]	Average $/lb. for Facility[c]	System Size[d]	Inventory System Average Charge (lb.)[e]	Average Baseline Equipment Cost per system[f]	Average Baseline Installation Cost per System[g]
Retail Food	3,500	1,000,000	$286	Large	3,352	$958,000	$431,000
Retail Food	2,500	800,000	$320	Medium	684	$219,000	$98,500
Retail Food	350	260,000	$743	Small	103	$76,500	$34,400
IPR and Cold Storage	10,300	$1,600,000	$155	Large	5,873	$912,000	$411,000
IPR and Cold Storage	1,800	$800,000	$444	Medium	660	$293,000	$132,000
IPR and Cold Storage	420	$400,000	$952	Small	104	$99,000	$44,600
IPR and Cold Storage	10,300	$1,600,000	$155	Large	7,252	$1,130,000	$507,000
IPR and Cold Storage	1,800	$800,000	$444	Medium	552	$245,000	$110,000
IPR and Cold Storage	420	$400,000	$952	Small	113	$108,000	$48,400

[a] Average total refrigerant charge used at the facility across all systems containing more than 50 pounds of refrigerant.
[b] Average baseline costs for equipment per facility type and size, estimated by staff using publicly available estimates and discussed with stakeholders in public meetings.

[c] Average cost per pound of refrigerant at each type of facility, calculated by dividing column *b* (average baseline equipment cost per facility) by column *a* (average refrigerant charge at facility in pounds).
[d] Corresponding system size in the RMP database, if one system were to serve the cooling needs of the whole facility.
[e] Average system refrigerant charge by system type and size, based on RMP database in 2018.
[f] Average baseline cost per system, calculated by multiplying column *c* (average cost per pound at facility) and column *e (average system charge in pounds).*
[g] Average baseline installation charge per system, calculated as 45% x baseline equipment charge per system (based on stakeholder input).

Table 63. New refrigeration systems in new construction per year

Sub-sector	Number of operational units in 2018[a]	Average Lifetime (years)[b]	New units in existing facilities in 2018[c]	New units in new construction in 2018[d]	Total new units in 2018[e]	% new units in new construction[f]
CR Retail Large	204	15	14	2	15	10%
CR Retail Medium	10,927	15	728	83	811	10%
CR Retail Small	27,065	20	1353	206	1559	13%
CR Other Large	87	15	6	1	6	10%
CR Other Medium	4,683	15	312	36	348	10%
CR Other Small	11,599	20	580	88	668	13%
IPR Large	366	20	18	3	21	13%
IPR Medium	2,408	20	120	18	139	13%
IPR Small	13,943	20	697	106	803	13%
Cold Storage Large	69	20	3	1	4	13%
Cold Storage Medium	2,230	20	112	17	128	13%
Cold Storage Small	2,247	20	112	17	129	13%

[a] Number of operational refrigeration systems by type in 2018 (source: CARB F-Gas Inventory).
[b] Average system lifetime (source: CARB F-Gas Inventory).
[c] Calculated by dividing Operational units in 2018 by the average lifetime. This is the number of new units needed annually to replace retiring equipment in existing facilities.
[d] Calculated as 0.76% of the operational units in 2018 (correlated with annual average population growth in California).
[e] Total new units = 'new units replacing retiring equipment' (footnote c) + 'new units in new construction' (footnote d).
[f] Calculated by dividing 'new units in new construction' (footnote c) by 'total new units' (footnote e).

Table 64. Projected Populations of Regulated Refrigeration Systems - Refrigeration systems containing more than 50 pounds of high-GWP ‡ refrigerant

Year	Commercial Retail Food Systems	Commercial Other (Excluding Retail Food Systems)	Industrial Process	Cold Storage
2022	36,791	15,768	15,804	2,550
2023	37,132	15,914	15,967	2,576
2024	37,467	16,058	16,127	2,602
2025	37,798	16,199	16,284	2,628
2026	38,124	16,340	16,438	2,653
2027	38,449	16,478	16,591	2,677
2028	38,770	16,615	16,741	2,702
2029	39,086	16,751	16,888	2,725
2030	39,400	16,885	17,034	2,749
2031	39,712	17,020	17,178	2,772
2032	40,023	17,153	17,321	2,795
2033	40,333	17,286	17,462	2,818
2034	40,641	17,417	17,601	2,841
2035	40,946	17,547	17,739	2,863
2036	41,247	17,678	17,875	2,885
2037	41,547	17,806	18,010	2,907
2038	41,844	17,933	18,142	2,928
2039	42,139	18,060	18,274	2,949
2040	42,431	18,185	18,404	2,970

Table 65. Baseline and Incremental Upfront Costs for New GWP < 1,500 Refrigeration Systems used in Industrial Process Refrigeration and Cold Storage (2018$)

End-Use Sector	System Size	Baseline Costs (HFC DX system)[a]		Incremental Costs (GWP < 1,500 system)[b]	
		Equipment	Installation	Equipment	Installation
Commercial Refrigeration	Large	$958,000	$431,000	$0	$0
	Medium	$219,000	$98,500	$0	$0
	Small	$76,500	$34,400	$0	$0
Industrial Process Cooling	Large	$912,000	$411,000	+$91,200	$0
	Medium	$293,000	$132,000	+$29,300	$0
	Small	$99,000	$44,600	+$9,900	$0
Cold Storage	Large	$1,130,000	$507,000	$0	$0
	Medium	$245,000	$110,000	$0	$0
	Small	$108,000	$48,400	$0	$0

[a] Baseline equipment and installation costs per system discussed in Table 62 above.
[b] Incremental costs above baseline, calculated as baseline cost x incremental cost percentage. For commercial refrigeration no incremental costs are expected because there are no fundamental equipment- or installation-related differences between systems using refrigerants like R448A/R449A and those using baseline refrigerants like R-407A. For IPR, 10% incremental equipment costs above baseline are assumed. For cold storage, refrigerants with GWP greater than 1,500 are prohibited under SB1013 starting 2023, and thus no incremental cost is assumed.

Table 66. Baseline and Incremental Refrigerant Replenishment Costs for New Refrigeration Systems over the Baseline Scenario (2018$)

System Type	Average Full Charge[a] (lb.)	Average Annual Leak Rate[b] (%)	Baseline Refrigerant Costs[c] ($ / year)	Incremental Costs, GWP < 150[d] ($ / year)	Incremental Costs, GWP < 1,500[e] ($ / year)
Commercial, Retail Food – Large	3,352	24.2%	$5,700	– $2,800	+ $2,800
Commercial, Retail Food – Medium	684	22.9%	$1,100	– $550	+ $550
Commercial, Retail Food – Small	103	15.6%	$110	– $56	+ $56
Commercial, Other – Large	3,352	24.2%	$5,700	– $2,800	+ $2,800
Commercial, Other – Medium	684	22.9%	$1,100	– $550	+ $550
Commercial, Other – Small	103	15.6%	$110	– $56	+ $56
Industrial Process Refrigeration – Large	5,873	12.3%	$5,100	– $2,500	+ $2,500
Industrial Process Refrigeration – Medium	660	12.5%	$580	– $290	+ $290
Industrial Process Refrigeration – Small	104	9.1%	$70	– $33	+ $33
Cold Storage – Large	7,252	14.8%	$7,500	–$3,750	$0

System Type	Average Full Charge[a] (lb.)	Average Annual Leak Rate[b] (%)	Baseline Refrigerant Costs[c] ($ / year)	Incremental Costs, GWP < 150[d] ($ / year)	Incremental Costs, GWP < 1,500[e] ($ / year)
Cold Storage – Medium	552	10.3%	$400	– $200	$0
Cold Storage – Small	113	3.7%	$29	– $15	$0

[a] Average full charge per system (also given in Baseline section, Table 4).
[b] Average annual leak rate per system in 2018 (also given in Baseline section, Table 4).
[c] Baseline cost for refrigerant replenishment per year = Average full charge of system (in pounds) x Average Annual Leak Rate x Average baseline cost of refrigerant (i.e., $7 / pound). This is the estimated amount of money spent each year for replenishing leaked refrigerant from each system (rounded to two significant figures).
[d] For systems with refrigerant GWP less than 150, the cost per pound of refrigerant are assumed to be 50% lower than the baseline cost (for e.g., CO_2 is 50% cheaper than R-407A on a per-pound basis). Thus, annual costs for refrigerant replenishment are 50% lower than baseline.
[e] For systems with refrigerant GWP less than 150, the cost per pound of refrigerant is assumed to be 50% lower than the baseline cost (for e.g., R-448A/R-449A is 50% more expensive than R-407A on a per-pound basis). Thus, annual costs for refrigerant replenishment are 50% higher than baseline.

Table 67. Average Incremental Electricity Costs for New Refrigeration Systems over the Baseline Scenario (2018$)

System Type	Baseline Costs [a] ($ / year)	Incremental Costs, GWP < 150[b] ($ / year)	Incremental Costs, GWP < 1,500[c] ($ / year)
Cold Storage and Industrial Process Refrigeration Large (excluding chillers)	$350,000	– $35,000	$0

[a] Baseline electricity costs estimated as follows: Annual energy consumption for large cold storage warehouses varies between 2.0 and 3.3 million kWh per year,[157] with an average value of 2.7 million kWh per year. The 12-month annual average price of electricity for the industrial sector in California from June 2018 to May 2019 was $0.13 per kWh.[158] Thus, the average baseline electricity cost for a large cold storage facility is estimated to be 2.7 million kWh/year x $0.13/kWh = $350,000 per year (rounded to two significant digits). Due to lack of separate data sources, a similar baseline cost is assumed for large IPR systems.

[b] For new IPR and cold storage systems with refrigerant GWP less than 150 (required in newly constructed / remodeled facilities), an estimated 10% energy savings are expected due to more energy-efficient refrigerants like NH_3 and due to the superior build quality of the low-GWP systems. Thus, annual costs for electricity are estimated to be 10% lower than baseline. For more details, see Section C.

[c] For new IPR and cold storage systems with refrigerant GWP less than 1,500 (required in existing facilities), no changes are expected in electricity costs relative to the baseline, since energy performance of baseline, high-GWP HFCs is expected to be the same as HFC refrigerants with GWP just under 1,500 in new systems.

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[157] Specific energy consumption for cold storage warehouses ranges between 0.8 and 1.4 kWh per cubic feet per year (Becker Engineering Company, 2013. Greenguide For Sustainable Energy Efficient Refrigerated Storage Facilities. web link https://ww2.energy.ca.gov/2013publications/CEC-500-2013-145/CEC-500-2013-145.pdf, Last accessed: February 2020). Average size of cold storage facility is 2.4 million cubic feet (U.S. Department of Agriculture, 2016. Capacity of Refrigerated Warehouses 2015 Summary. web link https://downloads.usda.library.cornell.edu/usdaesmis/files/x059c7329/db78tf70f/9306t216s/CapaRefrWa-01-25-2016.pdf, Last accessed: February 2020). Thus, the energy consumption per facility ranges between 2.0 and 3.3 million kWh per year, with an average value of 2.7 million kWh per year.

[158] United States Energy Information Administration, 2019. (web link: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a, Last accessed February 2020).

Table 68. Incremental RMP Compliance Costs for New Refrigeration Systems over the Baseline Scenario (2018$)

System Type	Baseline Costs[a] ($ / year)	Incremental Costs, GWP < 150[b] ($ / year)	Incremental Costs, GWP < 1,500[c] ($ / year)
Commercial, Retail Food – Large	$3,100	– $3,100	$0
Commercial, Retail Food – Medium	$650	– $650	
Commercial, Retail Food – Small	$150	– $150	
Commercial, Other – Large	$3,100	– $3,100	
Commercial, Other – Medium	$650	– $650	
Commercial, Other – Small	$150	– $150	
Industrial Process Refrigeration – Large	$3,100	– $3,100	
Industrial Process Refrigeration – Medium	$650	– $650	

[a] Baseline costs for RMP compliance are based on original estimates in the Initial Statements of Reason for CARB's RMP regulation,[159] converted to 2018 dollars. The original cost estimates were on a per-facility basis. These were converted to system costs based on the following assumptions: "small facilities with approximately 5 systems in the small refrigerant charge size category, medium facilities with approximately 5 systems in the medium refrigerant charge size category, and large facilities with approximately 2 systems in the large refrigerant charge size category".[160] NOTE: RMP-based costs are gross costs estimated in 2009. The RMP regulation is estimated to save end-users due to avoided refrigerant leakage costs. However, only the gross costs are used for this analysis.
[b] Compliant refrigeration systems in newly constructed and remodeled stores (i.e., GWP < 150) will be exempt from RMP regulation and thus will see a decline in compliance costs.
[c] Compliant refrigeration systems in existing facilities (i.e., GWP < 1,500) will remain subject to RMP. No changes in RMP-related compliance costs are expected.

[159] CARB, 2009. Appendix C, Economic Impact Estimates – High-Global Warming Potential Stationary Source Refrigerant Management Program. Table 10.(web link: https://ww3.arb.ca.gov/regact/2009/gwprmp09/refappc.pdf, Last accessed February 2020).
[160] Ibid.

Table 69. NAICS Codes Using Refrigeration Systems Affected by CARB's RMP Regulation and the Proposed Amendments (based on RMP registration data in 2018)

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
445110;Supermarkets and Other Grocery (except Convenience) Stores	3,243	59%
452910;Warehouse Clubs and Supercenters	440	5%
424480;Fresh Fruit and Vegetable Merchant Wholesalers	137	2%
452112;Discount Department Stores	272	2%
493120;Refrigerated Warehousing and Storage	148	2%
311999;All Other Miscellaneous Food Manufacturing	134	2%
312130;Wineries	267	2%
325412;Pharmaceutical Preparation Manufacturing	34	1.0%
424410;General Line Grocery Merchant Wholesalers	57	0.9%
115114;Postharvest Crop Activities (except Cotton Ginning)	67	0.8%
311991;Perishable Prepared Food Manufacturing	40	0.8%
541712;Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	33	0.7%
922140;Correctional Institutions	30	0.7%
424420;Packaged Frozen Food Merchant Wholesalers	43	0.6%
311812;Commercial Bakeries	42	0.6%
424470;Meat and Meat Product Merchant Wholesalers	44	0.6%
424810;Beer and Ale Merchant Wholesalers	45	0.6%
721110;Hotels (except Casino Hotels) and Motels	4	0.5%
334413;Semiconductor and Related Device Manufacturing	33	0.5%
622110;General Medical and Surgical Hospitals	39	0.4%
311412;Frozen Specialty Food Manufacturing	27	0.4%

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
325414;Biological Product (except Diagnostic) Manufacturing	10	0.4%
541711;Research and Development in Biotechnology	17	0.4%
493110;General Warehousing and Storage	23	0.4%
311612;Meat Processed from Carcasses	24	0.4%
325413;In-Vitro Diagnostic Substance Manufacturing	20	0.3%
713110;Amusement and Theme Parks	6	0.3%
424460;Fish and Seafood Merchant Wholesalers	29	0.3%
453998;All Other Miscellaneous Store Retailers (except Tobacco Stores)	44	0.3%
312120;Breweries	26	0.3%
722310;Food Service Contractors	17	0.3%
611310;Colleges Universities and Professional Schools	11	0.3%
424490;Other Grocery and Related Products Merchant Wholesalers	28	0.2%
311830;Tortilla Manufacturing	11	0.2%
221112;Fossil Fuel Electric Power Generation	30	0.2%
311511;Fluid Milk Manufacturing	10	0.2%
115116;Farm Management Services	5	0.2%
311411;Frozen Fruit Juice and Vegetable Manufacturing	13	0.2%
311421;Fruit and Vegetable Canning	15	0.2%
493190;Other Warehousing and Storage	13	0.2%
493130;Farm Product Warehousing and Storage	20	0.2%
311919;Other Snack Food Manufacturing	15	0.2%
928110;National Security	16	0.2%
311513;Cheese Manufacturing	13	0.2%
336411;Aircraft Manufacturing	9	0.2%

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
311911;Roasted Nuts and Peanut Butter Manufacturing	8	0.2%
326199;All Other Plastics Product Manufacturing	18	0.2%
326160;Plastics Bottle Manufacturing	16	0.2%
311712;Fresh and Frozen Seafood Processing	15	0.2%
311520;Ice Cream and Frozen Dessert Manufacturing	18	0.2%
517212;Cellular and Other Wireless Telecommunications	3	0.2%
311423;Dried and Dehydrated Food Manufacturing	12	0.2%
333295;Semiconductor Machinery Manufacturing	8	0.2%
311813;Frozen Cakes Pies and Other Pastries Manufacturing	8	0.1%
447110;Gasoline Stations with Convenience Stores	34	0.1%
325120;Industrial Gas Manufacturing	33	0.1%
311615;Poultry Processing	13	0.1%
312111;Soft Drink Manufacturing	18	0.1%
445299;All Other Specialty Food Stores	12	0.1%
111219;Other Vegetable (except Potato) and Melon Farming	12	0.1%
624210;Community Food Services	7	0.1%
111411;Mushroom Production	8	0.1%
424430;Dairy Product (except Dried or Canned) Merchant Wholesalers	14	0.1%
445230;Fruit and Vegetable Markets	9	0.1%
111422;Floriculture Production	3	0.1%
325411;Medicinal and Botanical Manufacturing	7	0.1%
541614;Process Physical Distribution and Logistics Consulting Services	6	0.1%
336415;Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	1	0.1%
111998;All Other Miscellaneous Crop Farming	14	0.1%

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
424820;Wine and Distilled Alcoholic Beverage Merchant Wholesalers	7	0.1%
722110;Full-Service Restaurants	28	0.1%
221310;Water Supply and Irrigation Systems	6	0.1%
333415;Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	5	0.1%
336414;Guided Missile and Space Vehicle Manufacturing	4	0.1%
323110;Commercial Lithographic Printing	11	0.1%
324110;Petroleum Refineries	8	0.1%
713940;Fitness and Recreational Sports Centers	18	0.1%
334516;Analytical Laboratory Instrument Manufacturing	6	0.1%
311611;Animal (except Poultry) Slaughtering	3	0.1%
112120;Dairy Cattle and Milk Production	12	0.1%
333294;Food Product Machinery Manufacturing	7	0.1%
327910;Abrasive Product Manufacturing	6	0.1%
312112;Bottled Water Manufacturing	4	0.1%
325211;Plastics Material and Resin Manufacturing	7	0.1%
445210;Meat Markets	7	0.1%
336413;Other Aircraft Parts and Auxiliary Equipment Manufacturing	11	0.1%
339999;All Other Miscellaneous Manufacturing	8	0.1%
221119;Other Electric Power Generation	10	0.1%
111336;Fruit and Tree Nut Combination Farming	9	0.1%
312113;Ice Manufacturing	8	0.1%
311941;Mayonnaise Dressing and Other Prepared Sauce Manufacturing	4	0.1%

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
334112;Computer Storage Device Manufacturing	1	0.1%
339112;Surgical and Medical Instrument Manufacturing	8	0.1%
112990;All Other Animal Production	4	0.1%
541990;All Other Professional Scientific and Technical Services	2	0.1%
211111;Crude Petroleum and Natural Gas Extraction	16	0.1%
332813;Electroplating Plating Polishing Anodizing and Coloring	7	0.1%
325320;Pesticide and Other Agricultural Chemical Manufacturing	3	0.1%
541512;Computer Systems Design Services	1	0.1%
311822;Flour Mixes and Dough Manufacturing from Purchased Flour	5	0.1%
334419;Other Electronic Component Manufacturing	5	0.1%
221330;Steam and Air-Conditioning Supply	4	0.1%
611710;Educational Support Services	3	0.1%
325998;All Other Miscellaneous Chemical Product and Preparation Manufacturing	5	0.1%
424990;Other Miscellaneous Nondurable Goods Merchant Wholesalers	2	0.1%
336111;Automobile Manufacturing	1	0.1%
221320;Sewage Treatment Facilities	7	0.1%
111421;Nursery and Tree Production	2	0.1%
561910;Packaging and Labeling Services	7	0.1%
326111;Plastics Bag Manufacturing	5	0.1%
541380;Testing Laboratories	5	0.1%
311111;Dog and Cat Food Manufacturing	3	0.1%

NAICS Codes 6-Digit and Descriptors	Number of Facilities Registered in R3 in 2018	Percent Refrigeration Systems under each NAICS in 2018 in R3[a]
221122;Electric Power Distribution	3	0.1%
311613;Rendering and Meat Byproduct Processing	3	0.1%

[a] NAICS codes using fewer than 0.1% of the total registered systems are not shown here. In total, 97% of all NAICS codes using refrigeration systems and registered with CARB are given in this table. Note: NAICS codes are reported by end-users into the R3 database and not checked for accuracy by CARB.

2. Macroeconomic Appendix

Table 70. REMI Inputs for the Main Proposal (Million 2017$)

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Consumer Spending	Reallocate Consumption: Household appliances	-	5.92	11.90	17.92	24.00	30.14	36.32	42.57	48.86	55.21	61.61	68.06	74.57	81.12	87.73	94.38	95.16	95.93	96.70
Consumer Price	Household appliances	-	12.75	25.60	38.55	51.61	64.77	78.03	91.40	104.87	118.44	132.12	145.90	159.78	173.75	187.82	201.99	203.49	204.99	206.47
Production Cost	Forestry, fishing, and agricultural services	-	0.01	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09	0.10	0.10	0.11	0.12	0.12
Production Cost	Mining	-	0.23	0.46	0.69	0.92	1.15	1.39	1.62	1.85	2.09	2.32	2.56	2.80	3.04	3.28	3.52	3.76	4.00	4.24
Production Cost	Utilities	-	0.63	1.26	1.89	2.53	3.17	3.81	4.45	5.09	5.74	6.39	7.04	7.69	8.34	9.00	9.66	10.32	10.98	11.65
Production Cost	Manufacturing	-	0.54	1.09	1.63	2.18	2.73	3.29	3.84	4.40	4.95	5.51	6.08	6.64	7.21	7.77	8.34	8.91	9.48	10.06
Production Cost	Transportation and warehousing	-	0.39	0.79	1.19	1.59	1.99	2.39	2.79	3.20	3.60	4.01	4.42	4.83	5.24	5.65	6.06	6.48	6.89	7.31
Production Cost	Information	-	0.33	0.65	0.98	1.31	1.64	1.97	2.31	2.64	2.97	3.31	3.65	3.99	4.33	4.67	5.01	5.35	5.69	6.04
Production Cost	Finance and Insurance	-	0.21	0.42	0.63	0.84	1.05	1.27	1.48	1.70	1.91	2.13	2.34	2.56	2.78	3.00	3.22	3.44	3.66	3.88
Production Cost	Real estate and rental and leasing	-	0.68	1.36	2.04	2.72	3.41	4.10	4.79	5.48	6.17	6.87	7.57	8.27	8.98	9.69	10.40	11.11	11.82	12.53
Production Cost	Professional, scientific, and technical services	-	0.11	0.21	0.32	0.42	0.53	0.64	0.74	0.85	0.96	1.07	1.17	1.28	1.39	1.50	1.61	1.72	1.83	1.94
Production Cost	Management of companies and enterprises	-	0.02	0.03	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.16	0.17	0.19	0.21	0.22	0.24	0.26	0.27	0.29
Production Cost	Administrative and support and waste management	-	0.05	0.10	0.15	0.19	0.24	0.29	0.34	0.39	0.44	0.49	0.54	0.59	0.64	0.69	0.74	0.79	0.84	0.90
Production Cost	Educational services	-	0.28	0.56	0.84	1.13	1.41	1.69	1.98	2.27	2.56	2.84	3.13	3.42	3.72	4.01	4.30	4.60	4.89	5.19
Production Cost	Health care and social assistance	-	0.53	1.07	1.61	2.15	2.69	3.24	3.78	4.33	4.88	5.43	5.98	6.54	7.09	7.65	8.21	8.77	9.34	9.90

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Arts, entertainment, and recreation	-	0.13	0.25	0.38	0.51	0.64	0.76	0.89	1.02	1.15	1.28	1.41	1.55	1.68	1.81	1.94	2.07	2.21	2.34
Production Cost	Accommodation and food services	-	0.17	0.34	0.51	0.68	0.85	1.03	1.20	1.37	1.55	1.72	1.90	2.07	2.25	2.43	2.60	2.78	2.96	3.14
Production Cost	Other services (except public administration)	-	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.09	1.21	1.33	1.45	1.58	1.70	1.83	1.95	2.08	2.20
Exogenous Final Demand	Electric power generation, transmission and distribution (2211)	(0.15)	(0.29)	(0.44)	(0.59)	(15.41)	(15.55)	(15.76)	(16.03)	(26.17)	(26.33)	(26.49)	(26.65)	(26.82)	(26.98)	(12.21)	(12.37)	(12.54)	(12.71)	(3.00)
Exogenous Final Demand	Construction (23)	3.66	51.00	55.99	61.04	66.12	71.26	76.45	81.69	86.97	92.30	97.67	103.08	108.52	114.01	119.52	125.08	127.94	130.80	133.65
Exogenous Final Demand	Basic chemical manufacturing (3251)	0.55	1.11	1.67	2.24	5.14	5.72	6.29	6.88	8.94	9.53	10.12	10.72	11.32	11.93	10.20	10.36	10.51	10.66	9.35
State and Local Government Spending	State Government	0.49	5.49	5.41	5.30	10.71	5.01	4.89	4.79	6.98	4.54	4.44	4.34	4.23	4.13	4.11	4.01	3.91	3.81	3.76
State and Local Government Spending	Local Government	1.03	7.60	7.27	6.93	12.74	5.74	5.41	5.06	7.15	4.04	3.71	3.36	3.02	2.66	2.83	2.49	2.13	1.78	1.77
State and Local Government Employment	State Government	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Production Cost	Forestry; Fishing, hunting, trapping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Support activities for agriculture and forestry	0.03	0.06	0.08	0.11	0.23	0.26	0.28	0.31	0.37	0.40	0.43	0.46	0.49	0.52	0.47	0.48	0.50	0.52	0.50
Production Cost	Oil and gas extraction	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Nonmetallic mineral mining and quarrying	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Production Cost	Support activities for mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Electric power generation, transmission, and distribution	0.01	0.02	0.03	0.04	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.17	0.18	0.16	0.17	0.17	0.18	0.17
Production Cost	Natural gas distribution	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Water, sewage, and other systems	0.01	0.01	0.02	0.02	0.04	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.09	0.10	0.09	0.09	0.10	0.10	0.10
Production Cost	Construction	0.00	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.28	0.30	0.33	0.36	0.39	0.42	0.45	0.48	0.50
Production Cost	Other wood product manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Glass and glass product manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Lime, gypsum and other nonmetallic mineral product manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04
Production Cost	Foundries	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Cutlery and handtool manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Boiler, tank, and shipping container manufacturing	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Machine shops; turned product; and screw, nut, and bolt manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Coating, engraving, heat treating, and allied activities	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04
Production Cost	Other fabricated metal product manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Industrial machinery manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Commercial and service industry machinery manufacturing, including digital camera manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04
Production Cost	Engine, turbine, power transmission equipment manufacturing	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Computer and peripheral equipment manufacturing, excluding digital camera manufacturing	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Production Cost	Semiconductor and other electronic component manufacturing	0.02	0.03	0.05	0.06	0.13	0.15	0.16	0.18	0.21	0.23	0.25	0.26	0.28	0.30	0.27	0.28	0.29	0.30	0.29
Production Cost	Navigational, measuring, electromedical, and control instruments manufacturing	0.00	0.01	0.01	0.01	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.06	0.06	0.07	0.07	0.07
Production Cost	Manufacturing and reproducing magnetic and optical media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Other electrical equipment and component manufacturing	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Motor vehicle manufacturing	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03
Production Cost	Motor vehicle body and trailer manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Aerospace product and parts manufacturing	0.01	0.03	0.04	0.05	0.10	0.12	0.13	0.14	0.17	0.18	0.20	0.21	0.22	0.24	0.21	0.22	0.23	0.24	0.23
Production Cost	Medical equipment and supplies manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04
Production Cost	Other miscellaneous manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Production Cost	Animal food manufacturing	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Grain and oilseed milling	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Production Cost	Sugar and confectionery product manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Production Cost	Fruit and vegetable preserving and specialty food manufacturing	0.03	0.05	0.08	0.10	0.21	0.24	0.26	0.29	0.35	0.37	0.40	0.43	0.46	0.48	0.43	0.45	0.47	0.48	0.47
Production Cost	Dairy product manufacturing	0.02	0.03	0.05	0.06	0.12	0.14	0.16	0.17	0.20	0.22	0.24	0.25	0.27	0.29	0.26	0.27	0.28	0.28	0.28
Production Cost	Animal slaughtering and processing	0.02	0.03	0.05	0.06	0.13	0.15	0.16	0.18	0.22	0.23	0.25	0.27	0.29	0.30	0.27	0.28	0.29	0.30	0.29
Production Cost	Seafood product preparation and packaging	0.00	0.01	0.01	0.02	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08
Production Cost	Bakeries and tortilla manufacturing	0.03	0.06	0.09	0.12	0.24	0.27	0.30	0.33	0.39	0.42	0.45	0.48	0.51	0.54	0.49	0.51	0.52	0.54	0.53
Production Cost	Other food manufacturing	0.08	0.16	0.24	0.33	0.66	0.75	0.83	0.91	1.09	1.18	1.26	1.35	1.44	1.53	1.37	1.42	1.47	1.52	1.48
Production Cost	Beverage manufacturing	0.06	0.12	0.18	0.25	0.50	0.57	0.63	0.69	0.83	0.89	0.96	1.02	1.09	1.16	1.04	1.08	1.11	1.15	1.12
Production Cost	Textile mills and textile product mills	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Pulp, paper, and paperboard mills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Converted paper product manufacturing	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
Production Cost	Printing and related support activities	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Production Cost	Petroleum and coal products manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04
Production Cost	Basic chemical manufacturing	0.00	0.01	0.01	0.02	0.04	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.07	0.08	0.08	0.08	0.08
Production Cost	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04
Production Cost	Pesticide, fertilizer, and other agricultural chemical manufacturing	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Pharmaceutical and medicine manufacturing	0.05	0.09	0.14	0.19	0.38	0.43	0.48	0.53	0.63	0.68	0.73	0.78	0.83	0.88	0.79	0.82	0.85	0.88	0.86
Production Cost	Paint, coating, and adhesive manufacturing	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
Production Cost	Soap, cleaning compound, and toilet preparation manufacturing	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Production Cost	Other chemical product and preparation manufacturing	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Plastics product manufacturing	0.01	0.03	0.04	0.06	0.12	0.13	0.15	0.16	0.19	0.21	0.22	0.24	0.26	0.27	0.24	0.25	0.26	0.27	0.26
Production Cost	Rubber product manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Wholesale trade	0.15	0.44	0.73	1.02	1.80	2.09	2.38	2.68	3.15	3.45	3.75	4.05	4.36	4.66	4.50	4.74	4.98	5.21	5.26

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Retail trade	1.69	3.76	5.85	7.94	15.40	17.54	19.65	21.72	25.81	27.99	30.19	32.40	34.62	36.86	33.95	35.41	36.88	38.36	37.84
Production Cost	Air transportation	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Rail transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Truck transportation	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Transit and ground passenger transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Pipeline transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Scenic and sightseeing transportation and support activities for transportation	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02
Production Cost	Warehousing and storage	0.07	0.15	0.22	0.29	0.60	0.67	0.75	0.82	0.98	1.06	1.14	1.21	1.29	1.37	1.23	1.28	1.32	1.37	1.33
Production Cost	Software publishers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Data processing, hosting, related services, and other information services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Telecommunications	0.00	0.01	0.01	0.02	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08
Production Cost	Monetary authorities, credit intermediation, and related activities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Real estate	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02
Production Cost	Consumer goods rental and general rental centers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Architectural, engineering, and related services	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Computer systems design and related services	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Production Cost	Management, scientific, and technical consulting services	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Production Cost	Scientific research and development services	0.03	0.06	0.08	0.11	0.23	0.26	0.29	0.31	0.38	0.41	0.44	0.47	0.50	0.53	0.47	0.49	0.51	0.53	0.51
Production Cost	Other professional, scientific, and technical services	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Office administrative services; Facilities support services	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Production Cost	Business support services; Investigation and security services; Other support services	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04
Production Cost	Travel arrangement and reservation services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Waste management and remediation services	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Educational services; private	0.01	0.02	0.03	0.04	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.17	0.18	0.16	0.16	0.17	0.18	0.17
Production Cost	Outpatient, laboratory, and other ambulatory care services	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Production Cost	Hospitals; private	0.01	0.02	0.04	0.05	0.10	0.12	0.13	0.14	0.17	0.18	0.19	0.21	0.22	0.23	0.21	0.22	0.23	0.23	0.23
Production Cost	Nursing and residential care facilities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Individual and family services; Community and vocational rehabilitation services	0.00	0.01	0.01	0.01	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Production Cost	Performing arts companies; Promoters of events, and agents and managers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Spectator sports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Production Cost	Museums, historical sites, and similar institutions	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Production Cost	Amusement, gambling, and recreation industries	0.01	0.02	0.03	0.05	0.09	0.11	0.12	0.13	0.16	0.17	0.18	0.19	0.21	0.22	0.20	0.20	0.21	0.22	0.21
Production Cost	Accommodation	0.01	0.03	0.04	0.05	0.11	0.13	0.14	0.15	0.18	0.20	0.21	0.23	0.24	0.26	0.23	0.24	0.25	0.25	0.25
Production Cost	Food services and drinking places	0.01	0.02	0.03	0.04	0.08	0.09	0.10	0.12	0.14	0.15	0.16	0.17	0.18	0.19	0.17	0.18	0.19	0.19	0.19
Production Cost	Electronic and precision equipment repair and maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Modifications to the Proposed Regulation Order

Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning, ~~Chillers, Aerosols-Propellants,~~ and ~~Foam~~ Other End-Uses

California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4

[Note: The amendments to existing regulatory language are shown in ~~strikethrough~~ to indicate deletions and underline to indicate additions. New deletions and additions to the proposed language that are made public with this notice are shown in ~~double strikethrough~~ and double underline format, respectively]

Amend sections 95371, 95372, 95373, 95374, 95375, 95376, and 95377, 95378, and add section 95379, Article 4, Subarticle 5, Chapter 1, Division 3, Title 17, California Code of Regulations to read as follows:

Subarticle 5. Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning, ~~Chillers,~~ ~~Aerosols-Propellants,~~ and ~~Foam~~ Other End-Uses

§ 95371. Purpose.

The purpose of this subarticle is to reduce hydrofluorocarbon (HFC) emissions by adopting specific prohibitions for certain substances in refrigeration, air-conditioning, chillers, ice rinks, cold storage, aerosols-propellants, and foam end-uses to support California's ~~progress toward the 2030~~ greenhouse gas emission reduction goals ~~and hydrofluorocarbon emissions reduction targets as well as the Short Lived Climate Pollutant Strategy~~.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734 and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734 and 41511, Health and Safety Code.

§ 95372. Applicability.

This subarticle applies to any person who sells, leases, rents, installs, uses, or otherwise enters into commerce, in the State of California, any product, equipment, material, or substance in end-uses listed in Table 1, section 95374(a); Table 2, section 95374(b); Table 3, section 95374(c); or Table 4, section 95374(d) of this subarticle.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 95373. Definitions.

(a) For the purposes of this subarticle, ~~excepting sections 95374(b) and 95376,~~ the following definitions shall apply:

“Aerosols” or *“Aerosol”* means an aerosol product with a pressurized spray system that dispenses product ingredients by means of a propellant contained in a product or a product's container, or by means of a mechanically induced force.

“Air-conditioning (AC) Equipment” or *“Air-conditioning System”* means equipment that cools, heats or dehumidifies spaces in residential or non-residential settings, for comfort cooling and other purposes, including but not limited to room air conditioning such as window units, packaged terminal air conditioners (PTAC), packaged terminal heat pumps (PTHP), and portable air conditioners; central air conditioners and heat pumps (i.e., ducted); non-ducted air conditioners and heat pumps~~systems~~ (both mini and multi splits); packaged rooftop units; water-source and ground-source heat pumps; and dehumidifiers. Air-conditioning also includes computer room and data center cooling and remote condensing units for comfort cooling applications. Chillers are defined separately from “air-conditioning equipment.” For the purposes of this regulation, “air-conditioning equipment” applies to stationary air-conditioning equipment and does not apply to mobile air-conditioning, including those used in vehicles, rail and trains, buses, aircraft, watercraft, recreational vehicles, recreational trailers, and campers.

“Air District” means an air quality management district or air pollution control district created or continued in existence under Health and Safety Code sections 40000-41357.

“Air Pollution Control Officer” or *“APCO"* means the appointed head of a local air quality management district or air pollution control district whose appointment and duties are set forth in Health and Safety Code sections 40750-40753.

“Applicant” means, for purposes of this regulation, any person who sells, leases, rents, installs, uses, or otherwise enters into commerce, in the State of California, any substance in end-uses listed in Table 1, section 95374(a); Table 2, section 95374(b); Table 3, section 95374(c); or Table 4, section 95374(d) of this subarticle who applies for a variance under section 95377 of this subarticle. For purposes of this definition, trade groups are not applicants.

"*Baseline Greenhouse Gas Potential*" or "*Baseline GHGp*" means the greenhouse gas potential (GHGp) of a company's retail food facilities at the end of calendar year 2019. The baseline GHGp will be revised when any of the following occur:

(1) Retail food facilities that are sold or transferred will be removed from the baseline GHGp.

(2) Acquired retail food facilities will be added to the baseline GHGp using their 2019 GHGp levels, and the current GHGp of acquired stores will be used to calculate the current GHGp.

"Bear Spray" means a specific aerosol bear deterrent that has active ingredients of capsaicin and related capsaicinoids and is used to deter aggressive or charging bears.

"Blowing Agent" or *"Foam Blowing Agent"* or *"Foam Expansion Agent"* or *"Foaming Agent"* ~~is~~ means a substance that functions as a source of gas to generate bubbles or cells in the mixture during the formation of foam~~which is capable of producing a cellular structure via a foaming process in a variety of materials that undergo hardening or phase transition, such as polymers and plastics. Blowing agents are typically applied when the blown material is in a liquid stage~~.

"Capital Cost" means an expense incurred in the production of goods or in rendering services, including but not limited to the cost of engineering, purchase, and installation of components or systems, and instrumentation, and contractor and construction fees.

"Certified Reclaimed Refrigerant" means used (recovered) refrigerant from a previously operational appliance that has been reclaimed by a U.S. EPA-certified refrigerant reclaimer and meets all of the following conditions:

(1) Meets all specifications in 40 C.F.R. Part 82, Subpart F, Appendix A (Specifications for Refrigerants) (January 1, 2017), which is incorporated herein by reference;

(2) Must have results of the analysis conducted to verify that reclaimed refrigerant meets the necessary specifications as required in (1) above; and

(3) Contains no greater than fifteen percent (15%) new (virgin) refrigerant by weight to meet AHRI 700 standard refrigerant specifications. The certified reclaimer must have documentation that supports it has not exceeded the maximum allowable virgin refrigerant content.

"*Change in Ownership*" means a transfer of the title of a facility subject to this subarticle.

"*Charge*" or "*Refrigerant Charge*" means the amount of refrigerant by mass contained in a refrigeration system. Charge is generally measured by grams, ounces, pounds, or kilograms.

"*Charge Reduction*" means to reduce the refrigerant full charge amount through a mechanical system change in the refrigeration circuit and not simply through a nominal full charge change.

"*Chiller*" means a water or heat transfer fluid chilling equipment package custom built in place, or a factory-made and prefabricated assembly of one (1) or more compressors, condensers and evaporators, with interconnections and accessories including controls, designed for the purpose of cooling or heating water or a heat transfer fluid. A chiller is a machine specifically designed to make use of a vapor compression refrigeration cycle or absorption refrigeration cycle to transfer heat from a cold water or heat transfer fluid circulating system to the air, a heat transfer fluid, or other heat exchange media. Chillers can be water-cooled, air-cooled, or evaporatively cooled. Chillers include but are not limited to rotary chillers, centrifugal chillers, and positive displacement chillers, including reciprocating, scroll, and screw chillers. For the purpose of this regulation, "chiller" includes those used for comfort cooling, space and area cooling, or industrial process cooling. A chiller used for refrigeration in a retail food facility is considered an indirect type of "supermarket system."

"*Class I Substance*" means any ozone-depleting compound defined in the Clean Air Act, as amended, 42 U.S.C. ~~§~~section 7671(3) (effective November 15, 1990).

"*Class II Substance*" means any ozone-depleting compound defined in the Clean Air Act, as amended, 42 U.S.C. ~~§~~section 7671(4) (effective November 15, 1990).

"*Cold Storage*" means a refrigerated facility or warehouse used for the storage of temperature-controlled substances. For the purposes of this regulation, cold storage is regulated as "refrigeration equipment (new), containing more than 50 pounds refrigerant" in section 95374(c).

"*Commercial Ice Machine*" means a non-residential ice machine and/or ice maker used in a commercial establishment to produce ice artificially for consumer use, including but not limited to, a hotel, restaurant, or convenience store.

"*Company*" means all businesses, affiliates, brands, or subsidiaries or franchises, owned or operated by the same parent company.

"*Component*" means a part of a refrigeration system, including but not limited to condensing units, compressors, condensers, evaporators, and receivers; and all of its connections and subassemblies, without which the refrigeration system will not properly function or will be subject to failures.

"*Cumulative Replacement*" means the addition of or change in multiple components within a three-year period.

"Date of Manufacture" means:

(1) For foam imported into the state, the date the foam was initially manufactured;

(2) For foam systems imported into the state, the date the polyurethane blend and isocyanate were packaged or labeled; or

(3) For chillers, air-conditioning and refrigeration equipment, the date that the manufacturer affixed an equipment label indicating the equipment's date of manufacture.

(4) For refrigeration and air-conditioning equipment built-up and completed on site, the date that the refrigerant circuit was completed and initially filled with refrigerant.

''End-use'' means processes or classes of specific applications within industry sectors, such as those listed in Table 1, Table 2, Table 3, and Table 4, section 95374 of this subarticle.

"*Executive Officer*" means the Executive Officer of the California Air Resources Board or his or her delegate.

"Executive Order" means, for purposes of this regulation, an order issued by the Executive Officer of CARB that specifies the variance duration with enforceable conditions and requirements necessary to support the variance.

"Flexible Polyurethane" means a non-rigid polyurethane foam including but not limited to that used in furniture, bedding, chair cushions, and shoe soles.

"Foam" means a product with a cellular structure formed via a foaming process in a variety of materials that undergo hardening via a chemical reaction or phase transition.

"Foam System" means a multipart liquid material that expands when mixed to form a solid or flexible substance in which thin films of material separate pockets of gas.

"Force Majeure" means, for purposes of this regulation, a sudden and unforeseeable event involving a clear danger, demanding action to prevent or mitigate the loss of, or damage to, life, health, property, or essential public services, arising from causes beyond the control of the Applicant, which delays or prevents the performance of any obligation under this regulation, despite the Applicant's best efforts to fulfill the obligation. This includes events where the local government, State of California, or federal government issues a declaration of emergency, which can include war, wildfires, floods, hurricanes, tornadoes, earthquakes, volcanic eruptions, and pandemics. This does not include negligent acts or the Applicant's financial inability to perform which is unrelated to the event as described in this section.

"*Full Charge*", "*Optimal Charge*", or "*Critical Charge*" means the amount of refrigerant required in the refrigerant circuit for normal operating characteristics and conditions of a refrigeration system or appliance, as determined by using one or a combination of the following four methods:

(1) Use of the equipment manufacturer's specifications of the full charge;

(2) Use of appropriate calculations based on component sizes, density of refrigerant, volume of piping, seasonal variances, and other relevant considerations; ~~or~~

(3) Use of actual measurements of the amount of refrigerant added to or evacuated from the appliance, including for seasonal variances; and/or

~~(3)~~(4) The midpoint of an established range for full charge based on the best available data regarding the normal operating characteristics and conditions for the system.

"Global Warming Potential", "GWP", "Global Warming Potential Value" or *"GWP Value"* means the 100-year GWP value first published by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Working Group 1 Report (AR4) (IPCC, 2007); and if not contained in AR4, then the GWP Value means the 100-year GWP value published by the IPCC in its Fifth Assessment Working Group 1 Report (AR5) (IPCC 2013).

“*Greenhouse Gas*” or “*GHG*” means carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen trifluoride (NF_3) sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated gases.

“Greenhouse Gas Potential”, or “*GHGp*” means:

GHGp = Σ(Charge × GWP)

Where:

∑ is the sum of the products of charge multiplied by the GWP for each separate type of refrigerant.

“Heat Transfer Fluid” means any gas or liquid used for the purpose of transmitting heat from one place to another.

“Household Refrigerators and Freezers” means appliances used to keep food and drink cool, and includes refrigerators, refrigerator-freezers, freezers, and miscellaneous household refrigeration appliances intended for residential use.

“Household Refrigerators and Freezers - Built-in” means any any appliance used for cooling, including but not limited to refrigerator, refrigerator-freezer or freezer that is intended for residential use and meets all of the following:

(1) 7.75 cubic feet or greater total volume and 24 inches or less depth not including doors, handles, and custom front panels;

(2) Sides that are not finished and not designed to be visible after installation;

(3) Designed, intended, and marketed exclusively to be installed totally encased by cabinetry or panels that are attached during installation; securely fastened to adjacent cabinetry, walls, or floor; and

(4) Equipped with an integral factory-finished face or accept a custom front panel.

“Household Refrigerators and Freezers - Compact” means any appliance used for cooling, including but not limited to refrigerator, refrigerator-freezer or freezer intended for residential use with a total refrigerated volume of less than 7.75 cubic feet (220 liters).

“*Hydrofluorocarbon*” or “*HFC*” means a class of GHGs which are ~~saturated~~ organic compounds containing hydrogen, fluorine, and carbon; primarily used as refrigerants, foam blowing agents, aerosols propellants, solvents, and fire suppressants.

"Ice Rink" means a frozen body of water and/or hardened chemicals, including, but not limited to professional ice skating rinks and those used by the general public for recreational purposes.

"Impossibility" means, for purposes of this regulation, the Applicant exercised best efforts but still was unable to comply with the regulatory requirements for reasons beyond his or her control despite exercising foresight to prevent the non-compliance.

"Industrial Process Refrigeration" means to cool process streams at a specific location in manufacturing and other forms of industrial processes and applications, and are complex, customized systems that are directly linked to the industrial process. Where one appliance is used for both industrial process refrigeration and other applications, it will be considered an industrial process refrigeration system if 50 percent or more of its operating capacity is used for industrial process refrigeration. Industrial process refrigeration or cooling using a chiller is regulated as a chiller. Industrial process refrigeration not using a chiller is regulated as industrial process refrigeration equipment.

"Integral Skin Polyurethane" means a self-skinning polyurethane foam, including but not limited to that used in car steering wheels and~~,~~ dashboards~~, and shoe soles~~.

"Low Temperature Refrigeration System" means a commercial or industrial process refrigeration system that maintains food, beverages, or other items at temperatures at or below 32 degrees Fahrenheit (0 degrees Cel~~e~~sius).

"Medium Temperature Refrigeration System" means a commercial or industrial process refrigeration system that maintains food, beverages, or other items at temperatures above 32 degrees Fahrenheit (0 degrees Ce~~nc~~lsius).

"Metered Dose Inhaler" or *"Medical Dose Inhaler"* or *"MDI"* means a device that delivers a measured amount of medication as a mist that a patient can inhale and consists of a pressurized canister of medication in a case with a mouthpiece.

"Motor-bearing" means refrigeration equipment containing motorized parts. This includes compressors, condensers, and evaporators.

"*National Supermarket Chain"* means a retail food chain, brand name, or business operating more than 100 retail food facilities in the United States.

"New Air-conditioning Equipment" means any air-conditioning equipment or system that is one of the following:

(1) F~~f~~irst installed using new components, ~~or~~ used components, or a combination of new or used components;~~,~~ or

(2) An~~a~~ existing system with a single ~~new exterior~~ condenser and single evaporator that has a new exterior condenser, condensing unit, or remote condensing unit;~~,~~ or

(3) ~~a new complete refrigeration circuit in an existing system.~~An existing system having more than one condenser and/or more than one evaporator that is modified such that the system has experienced cumulative replacements, within any three-year time period, of 75 percent or more of indoor evaporator units (by number), and 100 percent of air source or water source condensing units.

"*New Chiller" or "New Chiller Equipment"* means any chiller equipment or chiller system end-use sectors listed in Table 3, section 95374(c) that is:

(1) First installed using new or used components, or a combination of new or used components; or

(2) Modified such that:

(A) The capacity is increased through the addition of motor-bearing components, including evaporators, compressors, or condensers~~,~~; or

(B) The system has experienced cumulative replacements, within any three-year time period, of motor-bearing components in full or exceeding 50 percent of the capital cost of replacing all the motor-bearing components in the entire chiller system.

"*New Facility"* means, for any refrigeration end-uses listed in Table 3, section 95374(c); and refrigeration end-uses listed in Table 4, section 95374(d), any of the following:

(1) New construction;

(2) An existing facility not previously used for cold storage, retail food refrigeration, commercial refrigeration, industrial process refrigeration, or ice rinks; or

(3) An existing facility used for cold storage, retail food refrigeration, commercial refrigeration, or industrial process refrigeration; with a replacement of 75 percent or more of evaporators (by number) and, 100 percent of compressors racks, and 100 percent of condensers.

"*New Refrigeration Equipment"* means either of the following:

(1) Any refrigeration equipment ~~that is first installed using new or used components; or~~ listed in Table 1 or Table 2, sections 95374(a) and (b) that is:

(A) First installed using new or used components, or a combination of new or used components; or

(B)~~(2) Any refrigeration equipment that is m~~Modified such that~~ it is~~:

1.~~(i)~~ The nominal compressor capacity is increased~~Expanded after the date at which this subarticle becomes effective, to handle an expanded cooling load by the addition of components in which the capacity of the system is increased, including refrigerant lines, evaporators, compressors, condensers, and other components~~; or

2.~~(ii)~~ The system has experienced cumulative replacements, within any three-year time period, of components in full or exceeding 50 percent of the capital cost of replacing the entire refrigeration system, excluding the cost of refrigerated display cases. ~~Replaced or cumulatively replaced after the date at which this subarticle becomes effective, such that the capital cost of replacing or cumulatively replacing components exceeds 50 percent of the capital cost of replacing the entire refrigeration system.~~

(2) Any refrigeration equipment in a new facility, that is first installed using new or used components, or a combination of new or used components, applicable to refrigeration end-use sectors listed in Table 3 and Table 4, sections 95374(c) and (d), in the following:

(A) New construction;

(B) An existing facility not previously used for cold storage, retail food refrigeration, commercial refrigeration, ~~or~~ industrial process refrigeration, or ice rinks; or

(C) An existing facility used for cold storage, retail food refrigeration, commercial refrigeration, or industrial process refrigeration; with a replacement of 75 percent or more of evaporators (by number) and, 100 percent of compressors racks, and 100 percent of condensers, and connected evaporator loads.

"*Operate*" means to have operational control of the facility.

"*Operator*" means the person or entity having operational control of the facility.

“Other Air-conditioning” or “Other Air-conditioning Equipment” means any residential or non-residential air-conditioning equipment or air-conditioning system not otherwise defined as room air conditioner, wall air conditioner, window air conditioner, packaged terminal air conditioner (PTAC), packaged terminal heat pump (PTHP), portable air-conditioner, residential dehumidifier, or variable refrigerant flow (VRF) system.

“Other Refrigeration” means any stationary, non-residential refrigeration equipment that is used for an application other than retail food, cold storage, ice rinks, industrial process refrigeration, or air-conditioning; or is used for two or more applications including retail food, cold storage, ice rinks, industrial process refrigeration, commercial refrigeration, or air-conditioning.

“*Own*” means to have legal title to the facility that is subject to this subarticle.

“*Owner*” means the person having legal title to the facility that is subject to this subarticle.

“Packaged Terminal Air Conditioner” or *“PTAC”* means a wall sleeve and a separate unencased combination of heating and cooling assemblies specified by the builder and intended for mounting through the wall. It includes a prime source of refrigeration, separable outdoor louvers, forced ventilation, and heating availability energy.

“Packaged Terminal Heat Pump” or *“PTHP”* means a packaged terminal air conditioner that utilizes reverse cycle refrigeration as its prime heat source and can have supplementary heating availability by builder's choice of energy.

“*Person*” means any individual, firm, association, organization, manufacturer, distributor, partnership, business trust, corporation, limited liability company, company, state, or local governmental agency or public district.

“*Phenolic Insulation Board and Bunstock*” means phenolic insulation manufactured by a process in which a plastic foam forms an insulating core between two flexible tissue faced layers, or produced by mixing high solids and phenolic resin with a surface acting agent, including but not limited to that used for roofing and wall~~s~~ insulation. Bunstock or bun stock is a large solid box-like structure formed during the production of polystyrene insulation.

“Polyolefin” means foam sheets and tubes made of polyolefin, a macromolecule formed by the polymerization of olefin monomer units.

“Polystyrene Extruded Boardstock and Billet (XPS)” means a foam formed from polymers of styrene and produced on extruding machines in the form of foam slabs that can be cut and shaped into panels used for, but not limited to, roofing, walls, flooring, and pipes.

“*Polystyrene Extruded Sheet*” means polystyrene foam including that used for packaging. ~~and buoyancy or floatation.~~ It includes but is not limited to products~~is also~~ made into food-service items, including hinged polystyrene containers (for "take-out" from restaurants); food trays (meat and poultry) plates, bowls, and retail egg containers.

“Polyurethane” means a polymer formed principally by the reaction of an isocyanate and a polyol and which would include polyisocyanurate (‘polyiso’).

“Portable Air Conditioner” means a portable encased assembly, other than a “packaged terminal air conditioner,” “room air conditioner,” or “dehumidifier,” that delivers cooled, conditioned air to an enclosed space, and is powered by single-phase electric current. It includes a source of refrigeration and may include additional means for air circulation and heating.

“Propellant” means a liquefied or compressed gas that is used in whole or in part, such as a cosolvent, to expel a liquid or any other material from the same self-pressurized container or from a separate container.

“Refrigerant” or *“Refrigerant Gas”* means any substance, including blends and mixtures, which is a compound or gas used in vapor compression cycle refrigeration that is used for heat transfer purposes and provides a cooling or warming effect.

“Refrigerant Blend” is a mixture or combination of two or more single-component refrigerants.

“Refrigerated Food Processing and Dispensing Equipment” means equipment that dispenses and/or processes a variety of food and beverage products by either combining ingredients, mixing or preparing them at the proper temperature, or by function as a holding tank to deliver the product at the desired temperature or to deliver chilled ingredients for the processing, mixing and preparation. Some may use a refrigerant in a heat pump, or utilize waste heat from the cooling system to provide hot beverages. Some may also provide heating functions to melt or dislodge ice or for sanitation purposes. This equipment can be self-contained or connected by piping to a dedicated condensing unit located elsewhere. Equipment within this end-use category include but are not limited to: chilled and frozen beverages (carbonated and non-

carbonated, alcoholic and nonalcoholic); frozen custards, gelato, ice cream, Italian ice, sorbets and yogurts; milkshakes, ‘‘slushies’’ and smoothies, and whipped cream.

“*Refrigeration*” means the use of a refrigerant gas to mechanically move heat from one region to another to create a cooled region via a vapor compression cycle.

“*Refrigeration Equipment*” or *“Refrigeration System”* means any stationary device that is designed to contain and use refrigerant gas, including any device listed in Section 95374(a), Table 1 under the general end-use “refrigeration,” listed in section 95374(b), Table 2 under the general end-use “Household Refrigerators and Freezers” or listed in section 95374(c), Table 3 under the general end-use “Cold Storage Warehouses,” “Industrial Process Refrigeration,” and “Ice Rinks”, or listed in section 95374(d), Table 4 under the general end-use “Retail Food Refrigeration”. For a device with multiple independent circuits, each ~~independent~~ circuit is considered a separate article of equipment. Refrigeration equipment includes refrigeration equipment used in retail food, cold storage, industrial process refrigeration and cooling (not using a chiller), ice rinks, and other refrigeration applications.

“*Refrigerant Registration and Reporting System*” or “*R3 Database*” means a web based tool for implementing the registration, reporting, and fee payment provision for facilities using at least one refrigeration system containing greater than 50 pounds of refrigerant.

“*Remote Condensing Units*” means refrigeration equipment or units that have a central condensing portion and may consist of one (and sometimes two) compressor(s), one condenser, and one receiver assembled into a single unit, which is normally located external to the sales area. The condensing portion (and often other parts of the system) is located outside the space or area cooled by the evaporator. Remote condensing units are commonly installed in, but not limited to, convenience stores, specialty shops (e.g., bakeries, butcher shops), supermarkets, restaurants, and other locations where food is stored, served, or sold.

“*Residential Consumer Refrigeration Products*” means “Household Refrigerators and Freezers”, or “Household Refrigerators and Freezers Compact”, or “Household Refrigerators and Freezers - Built-in”. “Residential Consumer Refrigeration Products”, “Household Refrigerators and Freezers”, “Household Refrigerators and Freezers Compact”, and “Household Refrigerators and Freezers - Built-in”. It does not include refrigerators and freezers used in aircraft, watercraft, passenger vehicles, trucks for personal use, recreational vehicles, recreational trailers, and campers; and do not include refrigerators and freezers used in hospitals, medical facilities, pharmacies, research facilities, and laboratories for the storage of non-food or non-potable drink items.

"Residential Dehumidifier" means a residential air-conditioning product, other than a portable air conditioner, room air conditioner, or packaged terminal air conditioner, that is a self-contained, electrically operated, and mechanically encased assembly consisting of:

(1) A refrigerated surface (evaporator) that condenses moisture from the atmosphere;

(2) A refrigerating system, including an electric motor;

(3) An air-circulating fan; and

(4) A means for collecting or disposing of the condensate.

"Responsible Official" means, for purposes of this regulation, one of the following representatives with authority to bind and make decisions:

(1) For a corporation, a president, secretary, treasurer, or vice president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation, or a duly authorized representative of such person;

(2) For a partnership or sole proprietorship, a general partner or the proprietor, respectively; or

(3) For a municipal, state, federal, or other public agency, either a principal executive officer or a ranking elected official.

"*Retail Food Refrigeration"* or "*Commercial Refrigeration*" means equipment designed to store and display chilled or frozen goods for commercial sale or use. This end-use includes but is not limited to the following categories of equipment: stand-alone units (equipment), refrigerated food processing and dispensing units (equipment), remote condensing units, and supermarket systems.

"*Retail Food Facility*" means a facility that sells food and uses at least one retail food refrigeration equipment or refrigeration system with more than 50 pounds of a refrigerant with a GWP value of 150 or greater. Retail food facility includes supermarkets, grocery stores, and any other food merchandising stores.

"*Retire*" means the permanent removal from service of a refrigeration system, or component, rendering it unfit for use by the current or any future owner or operator.

"*Retrofit*", or "*Refrigerant Retrofit"* means the replacement of the refrigerant used in refrigeration equipment with a different refrigerant, and any related changes to the refrigeration equipment required to maintain its operation and reliability following refrigerant replacement.

"Rigid Polyurethane" means a rigid closed-cell foam containing urethane polymers produced by the reaction of an isocyanate and a polyol.

"Rigid Polyurethane Appliance Foam" means polyurethane foam in domestic appliances used for insulation.

"Rigid Polyurethane Commercial Refrigeration and Sandwich Panels" means polyurethane foam used to provide insulation in walls and doors, including that used for commercial refrigeration equipment, refrigerated transport trailers, and doors, including garage doors.

"Rigid Polyurethane High-pressure Two-component Spray Foam" means a liquid polyurethane foam system sold as two parts (i.e., A-side and B-side) in non-pressurized containers that is field or factory applied in situ using high-pressure proportioning pumps at 800-1600 pounds per square inch (psi) and an application gun to mix and dispense the chemical components.

"*Rigid Polyurethane Laminated Boardstock and Polyisocyanurate Laminated Boardstock*" means laminated board insulation made with polyurethane or polyisocyanurate foam, including but not limited to that used for roofing and walls. ~~This does not include the following end-use categories: rigid polyurethane appliance foam, rigid polyurethane commercial refrigeration and sandwich panels, rigid polyurethane marine flotation foam, rigid polyurethane spray foam, and rigid polyurethane one-component foam sealants.~~

"Rigid Polyurethane Low-pressure Two-component Spray Foam" means a liquid polyurethane foam system sold as two parts (i.e., A-side and B-side) in containers that are pressurized to less than 250 psi during manufacture of the system for application without pumps that are typically applied in situ relying upon a liquid blowing agent and/or gaseous foam blowing agent that also serves as a propellant.

"Rigid Polyurethane Marine Flotation Foam" means a buoyancy or flotation polyurethane foam used in boat and ship manufacturing for both structural and flotation purposes.

"Rigid Polyurethane One-component Foam Sealants" means a polyurethane foam generally packaged in aerosol cans that is applied in situ using a gaseous foam blowing agent that is also the propellant for the aerosol formulation.

“Rigid Polyurethane Slabstock and Other” means a rigid closed-cell polyurethane foam formed into slabstock insulation for panels and fabricated shapes for pipes and vessels.

“Room Air Conditioner,” or *“Wall Air Conditioner,”* or *“Window Air Conditioner”* means a consumer product, other than a “packaged terminal air conditioner,” which is powered by a single phase electric current and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.

“Stand-alone Units or Equipment” means refrigerators, freezers, and reach-in coolers (either open or with doors) where all refrigeration components are integrated and, for the smallest types, the refrigeration circuit is entirely brazed or welded. These systems are fully charged with refrigerant at the factory and typically require only an electricity supply to begin operation. Stand-alone Units or Equipment does not include commercial ice machines.

“*Stationary*” means the system ~~is:~~ meets at least one of the following conditions:

(1) ~~(i) i~~Installed in a building, structure, or facility;

(2) ~~(ii)a~~Attached to a foundation, or if not attached, will reside at the same ~~location~~ building, structure, or facility for more than twelve consecutive months; or

(3) ~~(iii) l~~Located ~~intermittently~~ permanently at the same facility for at least two consecutive years and operates at that facility a total of at least 90 days each year.

“*Substance*” means any chemical, product substitute, or alternative manufacturing process, whether new or retrofit, intended for use in the end-uses listed in Table 1, section 95374(a); Table 2, section 95374(b);Table 3, section 95374(c); or Table 4, section 95374(d) of this subarticle.

“Supermarket Systems” means multiplex or centralized systems designed to cool or refrigerate, which operate with rack(s) of compressors installed in a machinery room. Two main design classifications are used: direct and indirect systems.

(1) *“Direct Systems”* means the refrigerant circulates from the machinery room to the sales area, where it evaporates in display-case heat exchangers, and then returns in vapor phase to the suction headers of the compressor racks. Another direct supermarket design, often referred to as a distributed refrigeration system,

uses an array of separate compressor racks located near the display cases rather than having a central compressor rack system.

(2) *"Indirect Systems*" means the system uses a central refrigeration system to cool a secondary fluid that is then circulated throughout the store to the cases. This includes secondary loop systems and cascade refrigeration. A chiller used in retail food facilities to cool a secondary fluid subsequently used to cool food, beverage, and displayed products is considered a central refrigeration system.

"*Use*" means any utilization of a compound or any substance, including but not limited to utilization in a~~ manufacturing process or~~ product in California, consumption by the end-user in the State of California, or in intermediate applications in the State of California, such as formulation or packaging for other subsequent applications.

"Variable Refrigerant Flow (VRF)" system means an engineered direct expansion (DX) multi-split system incorporating the following: A split system air-conditioner or heat pump incorporating a single refrigerant circuit that is a common piping network to two or more indoor evaporator each capable of independent control, or compressor units. VRFs contain a single module outdoor unit or combined module outdoor units with at least one variable capacity compressor that has three or more stages, with air or water as the heat source. This includes *"Variable Refrigerant Volume (VRV)" systems.*

"Vending Machine~~s~~" means a self-contained unit~~s~~ that dispenses goods that must be kept cold or frozen.

"Very Low Temperature Refrigeration or Cooling" means a refrigeration or cooling system that maintains temperatures below -58 degrees Fahrenheit (-50 degrees Celsius), including but not limited to, medical and laboratory freezers, specialized industrial process cooling applications, and extreme temperature environmental testing.

"Weighted-average GWP" means ∑ (charge x GWP)/ ∑ charge

Where:

Charge equals the pounds of each separate type of refrigerant, refrigerant blend, or heat transfer fluid used in refrigeration equipment and systems. Refrigeration equipment with more than 50 pounds of refrigerant will be included in the calculation.

GWP is the 100-year GWP value of the refrigerant, refrigerant blend, or heat transfer fluid.

Refrigerant is a specific type of refrigerant, refrigerant blend, or heat transfer fluid, including but not limited to hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs), hydrofluorocarbons (HCFCs), hydrofluoroolefins (HFOs), carbon dioxide (CO_2), ammonia, water, glycol, and other heat transfer fluids.

∑ in the numerator is the sum of the products of charge multiplied by the GWP for each separate type of refrigerant.

∑ in the denominator is the sum of all pounds of refrigerant charge in all refrigeration equipment with more than 50 pounds of refrigerant.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 95374. List of Prohibited Substances.

(a) The following table lists prohibited substances as of their relevant dates:

Table 1: End-~~U~~use and Prohibited Substances.

General End-Use	Specific End-Use	Prohibited Substances	Effective Date
Refrigeration			
Retail food refrigeration equipment	Supermarket systems (new)[a]	HFC-227ea, R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, R-434A, R-507A	Prohibited as of January 1, 2019
Retail food refrigeration equipment	Supermarket systems (refrigerant retrofit)	R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, R-434A, R-507A	Prohibited as of January 1, 2019
Retail food refrigeration equipment	Remote condensing units (new)[a]	HFC-227ea, R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, R-434A, R-507A	Prohibited as of January 1, 2019

Retail food refrigeration equipment	Remote condensing units (refrigerant retrofit)	R-404A, R-407B, R-421B, R-422A, R-422C, R-422D, R-428A, R-434A, R-507A	Prohibited as of January 1, 2019
Retail food refrigeration equipment	Stand-alone medium-temperature units with a compressor capacity below 2,200 Btu/hr and not containing a flooded evaporator (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, THR-03	Prohibited as of January 1, 2019
Retail food refrigeration equipment	Stand-alone medium-temperature units with a compressor capacity below 2,200 Btu/hr and containing a flooded evaporator (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, THR-03	Prohibited as of January 1, 2020

Retail food refrigeration equipment	Stand-alone medium-temperature units with a compressor capacity equal to or greater than 2,200 Btu/hr (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, THR-03	Prohibited as of January 1, 2020
Retail food refrigeration equipment	Stand-alone low-temperature units (new)	HFC-227ea, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-44 (2003 formulation)	Prohibited as of January 1, 2020
Retail food refrigeration equipment	Stand-alone units (refrigerant retrofit)	R-404A, R-507A	Prohibited as of January 1, 2019

Retail food refrigeration equipment	Refrigerated food processing and dispensing equipment (new)	HFC-227ea, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-44 (2003 formulation)	Prohibited as of January 1, 2021
Vending machines	Vending machines (new)	FOR12A, FOR12B, HFC-134a, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-426A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), SP34E	Prohibited as of January 1, 2019
Vending machines	Vending machines (refrigerant retrofit)	R-404A, R-507A	Prohibited as of January 1, 2019
~~**General End-Use**~~	~~**Specific End-Use**~~	~~**Prohibited Substances**~~	~~**Effective Date**~~
Foam~~s~~ Systems Used to Manufacture			
Foams	Rigid polyurethane laminated boardstock and polyisocyanurate laminated boardstock	HFC-134a, HFC-245fa, HFC-365mfc and blends thereof	Prohibited as of January 1, 2019
	Flexible polyurethane	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof	

	Integral skin polyurethane	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	
	Polystyrene extruded sheet	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	
	Phenolic insulation board and bunstock	HFC-143a, HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof	

[a] For refrigeration equipment containing more than 50 pounds of refrigerant under these end-uses, see Table 4 for additional requirements.

(b) The following table lists prohibited substances as of their relevant dates:

Table 2: End-~~U~~use and Prohibited Substances.

General End-Use	**Specific End-Use**	**Prohibited Substances**	**Effective Date**
Refrigeration			
Cold storage warehouses ~~(new)~~	Cold storage warehouses (new)[a]	HFC-227ea, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407A, R-407B, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-423A, R-424A, R-428A, R-434A, R-438A, R-507A, and RS-44 (2003 composition)	Prohibited as of January 1, 2023
Household refrigerators and freezers (new)	Compact residential consumer refrigeration products	FOR12A, FOR12B, HFC-134a, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, and THR-03	Prohibited as of January 1, 2021

Household refrigerators and freezers (new)	Residential consumer refrigeration products	FOR12A, FOR12B, HFC-134a, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, and THR-03	Prohibited as of January 1, 2022
Household refrigerators and freezers (new)	Built-in residential consumer refrigeration products	FOR12A, FOR12B, HFC-134a, KDD6, R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-407F, R-410A, R-410B, R-417A, R-421A, R-421B, R-422A, R-422B, R-422C, R-422D, R-424A, R-426A, R-428A, R-434A, R-437A, R-438A, R-507A, RS-24 (2002 formulation), RS-44 (2003 formulation), SP34E, and THR-03	Prohibited as of January 1, 2023
~~Chillers~~			

~~Chillers~~	~~Centrifugal chillers (new)~~	~~FOR12A, FOR12B, HFC-134a, HFC-227ea, HFC-236fa, HFC-245fa, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-423A, R-424A, R-434A, R-438A, R-507A, RS-44 (2003 composition), and THR-03~~	~~Prohibited as of January 1, 2024~~
~~Chillers~~	~~Positive displacement chillers (new)~~	~~FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-424A, R-434A, R-437A, R-438A, R-507A, RS-44 (2003 composition), SP34E, and THR-03~~	~~Prohibited as of January 1, 2024~~
Foam~~s~~ Systems Used to Manufacture			
Foams	Rigid polyurethane: slabstock and other	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	Prohibited as of January 1, 2019
Foams	Rigid polyurethane: appliance foam	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	Prohibited as of January 1, 2020

Foams	Rigid polyurethane: commercial refrigeration and sandwich panels	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	Prohibited as of January 1, 2020
Foams	Polyolefin	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	Prohibited as of January 1, 2020
Foams	Rigid polyurethane: marine flo~~a~~tation foam	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, and Formacel Z-6	Prohibited as of January 1, 2020
Foams	Rigid polyurethane (PU): ~~spray foam~~ high-pressure two-component spray foam	HFC-134a, HFC-245fa, and blends thereof; blends of HFC-365mfc with at least four percent HFC-245fa, and commercial blends of HFC-365mfc with 7 to 13 percent HFC-227ea and the remainder HFC-365mfc; and Formacel TI	Prohibited as of January 1, 2020
Foams	Rigid polyurethane (PU)~~:spray foam -~~ one-component foam sealants	HFC-134a, HFC-245fa, and blends thereof; blends of HFC-365mfc with at least four percent HFC-245fa, and commercial blends of HFC-365mfc with 7 to 13 percent HFC-227ea and the remainder HFC-365mfc; and Formacel TI	Prohibited as of January 1, 2020

Foams	Polystyrene: extruded boardstock and billet (XPS)	HFC-134a, HFC-245fa, HFC-365mfc, and blends thereof; Formacel TI, Formacel B, and Formacel Z-6	Prohibited as of January 1, 2021
Foams	Rigid polyurethane (PU): ~~spray foam -~~ low-pressure two-component spray foam	HFC-134a, HFC-245fa, and blends thereof; blends of HFC-365mfc with at least four percent HFC-245fa, and commercial blends of HFC-365mfc with 7 to 13 percent HFC-227ea and the remainder HFC-365mfc; and Formacel TI	Prohibited as of January 1, 2021
Aerosols – Propellants			
Aer~~s~~osols - Propellants	Aer~~s~~osols - propellants	HFC-125, HFC-134a, HFC-227ea, and blends of HFC-227ea and HFC-134a	Prohibited as of January 1, 2019

[a] For the purposes of refrigeration equipment under this end-use containing more than 50 pounds of refrigerant, see Table 3 for additional requirements.

(c) The following table lists prohibited substances as of their relevant dates:

Table 3: End-use and-Prohibited Substances.

General End-Use	**Specific End-Use**	**Prohibited Substances**	**Effective Date**
Air-conditioning Equipment, Stationary			
Air-conditioning Equipment	Room/wall/window air-conditioning equipment, PTACs, PTHPs, portable air-conditioning equipment, and residential dehumidifiers (new)	Refrigerants with a GWP of 750 or greater	Prohibited as of January 1, 2023

Air-conditioning Equipment	Other ~~A~~air-conditioning (new) equipment, residential and non-residential	Refrigerants with a GWP of 750 or greater	Prohibited as of January 1, ~~2023~~2025
Air-conditioning Equipment	Variable Refrigerant Flow (VRF) system (new)	Refrigerants with a GWP of 750 or greater	Prohibited as of January 1, 2026
Chillers - Air-conditioning, Industrial Process Refrigeration			
Chillers	Chillers (new) designed for ~~minimum~~ a chilled fluid leaving the evaporator at temperatures > +35 °F (2 °C)	Refrigerants with a GWP of 750 or greater	Prohibited as of January 1, 2024
Chillers - Industrial Process Refrigeration			
Chillers	Chillers (new) designed for ~~minimum~~ a chilled fluid leaving the evaporator at temperatures ≤ +35 °F (2 °C) and > -10 °F (-26 °C)	Refrigerants with a GWP of 1,500 or greater	Prohibited as of January 1, 2024
Chillers	Chillers (new) designed for ~~minimum~~ a chilled fluid leaving the evaporator at temperatures ≤ -10 °F (-26 °C) and > -58 °F (-50 °C)	Refrigerants with a GWP of 2,200 or greater	Prohibited as of January 1, 2024
Refrigeration Equipment, Stationary (in New Facilities)			
Cold Storage Warehouses	Refrigeration equipment (new), containing more than 50 pounds refrigerant	Refrigerants with a GWP of 150 or greater	Prohibited as of January 1, 2022
Ice Rinks	Refrigeration Equipment (new), containing more than 50 pounds refrigerant and Chillers (new)	Refrigerants with a GWP of 150 or greater	Prohibited as of January 1, 2024

Industrial Process Refrigeration excluding Chillers	Refrigeration equipment (new), containing more than 50 pounds refrigerant	Refrigerants with a GWP of 150 or greater	Prohibited as of January 1, 2022
Other Refrigeration	Refrigeration equipment (new), containing more than 50 pounds refrigerant	Refrigerants with a GWP of 150 or greater	Prohibited as of January 1, 2022
Refrigeration Equipment, Stationary (in Existing Facilities)			
Ice Rinks	Refrigeration Equipment (new), containing more than 50 pounds refrigerant and Chillers (new)	Refrigerants with a GWP of 750 or greater	Prohibited as of January 1, 2024
Industrial Process Refrigeration excluding Chillers	Refrigeration equipment (new), containing more than 50 pounds refrigerant	Refrigerants with a GWP of 2,200 or greater	Prohibited as of January 1, 2022

(d) The following table lists prohibited substances or requirements as of their relevant dates:

Table 4: End-use and-Prohibited Substances or Requirements.

General End-Use	**Specific End-Use**	**Prohibited Substances / Requirement**	**Effective Date**
Refrigeration Equipment, Stationary (in New Facilities)			
Retail Food Refrigeration	Refrigeration equipment (new), containing more than 50 pounds refrigerant	Refrigerants with a GWP of 150 or greater	Prohibited as of January 1, 2022

Refrigeration Equipment, Stationary (in Existing Facilities)			
Companies owning or operating 20 or more retail food facilities in California, and national supermarket chains operating in California	Refrigeration equipment containing more than 50 pounds refrigerant	Attain a company-wide weighted-average GWP of less than 2,500 or a 25% or greater reduction in GHGp below 2019 levels	~~January 1,~~ December 31, 2026
		Attain a company-wide weighted-average GWP of less than 1,400 or a 55% or greater reduction in GHGp below 2019 levels	January 1, 2030
Companies owning or operating fewer than 20 retail food facilities in California	Refrigeration equipment containing more than 50 pounds refrigerant	Attain a company-wide weighted-average GWP of less than 1,400 or a 55% or greater reduction in GHGp below 2019 levels	January 1, 2030

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 95375. Requirements ~~Applicable to Table 1 of Section 95374(a)~~.

(a) ~~*Prohibitions*~~ *Requirements Applicable to Table 1 of Section 95374(a)*.

(1) *Prohibitions*. No person ~~may~~shall sell, lease, rent, install, use, or otherwise enter into commerce, in the State of California, any refrigeration equipment or foam system manufactured after the effective date, that does not comply with Table 1, section 95374(a) of this subarticle.

~~(b)~~(2) *Exceptions*. The following exceptions apply to the list of prohibited substances or the effective dates for prohibited substances for ~~foam~~ end-uses identified in Table 1 of section 95374(a) of this subarticle:

~~(1)~~(A) *Foam End-Uses*. The effective date for all foam end-uses identified in Table 1 of section 95374(a) of this subarticle are extended to January 1, 2022, for military end-uses and January 1, 2025, for space- and aeronautics-related end-uses where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements. For rigid polyurethane and polyisocyanurate laminated boardstock, polystyrene extruded sheet, and phenolic insulation board and bunstock, these same extensions include closed cell foam products and products containing closed cell foams manufactured with the applicable prohibited substances on or before these dates.

(B) *Very Low Temperature Refrigeration or Cooling Uses*. The prohibitions for refrigeration end-uses identified in Table 1 of section 95374(a) do not apply to refrigeration equipment used for Very Low Temperature Refrigeration or Cooling.

(C) *Refrigeration End-Uses*. Replacement of a refrigeration component in refrigeration equipment or system in an existing facility as part of the normal maintenance of refrigeration equipment; if the cumulative replacement of components within any three-year period does not exceed 50 percent of the capital cost of replacing the entire refrigeration equipment or system, excluding the cost of refrigerated display cases.

~~(c)~~(3) *Disclosure and Recordkeeping for Refrigeration End-Use Categories.* ~~The disclosure and recordkeeping requirements of this subarticle do not apply to any end-use category listed in Table 2 of section 95374(b) of this subarticle.~~

~~(1)~~(A) *Disclosure Statement*. As of the effective date of this subarticle, any person who manufactures motor-bearing new refrigeration equipment for sale or entry into commerce in the State of California, must provide a written disclosure to the buyer ~~as part of the sales transaction and invoice~~. The required written disclosure must state: "This equipment meets the regulatory requirements for hydrofluorocarbons as of the manufacturing date. Only those refrigerants ~~approved~~ allowable in the state for specific end uses may be used."~~is prohibited from use in California with any refrigerants on the "List of Prohibited Substances" for that specific end-use, in accordance with California Code of Regulations, title 17, section 95374. This disclosure statement has been reviewed and approved by [THE COMPANY] and [THE COMPANY] attests, under penalty of perjury, that these statements are true and accurate."~~

~~(2)~~(B) *Recordkeeping*. As of the effective date of this subarticle, any person who manufactures motor-bearing new refrigeration equipment for sale or entry into commerce in the State of California, must maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer, a copy of the following records:

1.~~(A)~~ Name and address of the person purchasing the equipment at the time of purchase.

2.~~(B)~~ Telephone number and email address of the person purchasing the equipment at the time of purchase, if provided to the manufacturer.

3.~~(C)~~ Model and serial number of the equipment. When the affected equipment is part of an assembly without an individual serial number, the serial number of each component must be recorded. If a component or equipment does not have an individual serial number or the serial number is inaccessible after assembly the physical description must be recorded in enough detail for positive identification.

4.~~(D)~~ Date of manufacture of the equipment.

5.~~(E)~~ Date of sale of the equipment.

6.~~(F)~~ The refrigerant type(s) the equipment is designed to use.

7.~~(G)~~ The refrigerant and full charge capacity of the equipment, where available.

8.~~(H)~~ A copy of the disclosure statement ~~issued~~made available to the ~~buyer~~person purchasing the equipment or recipient of the new refrigeration equipment.

(4~~d~~) *Recordkeeping for Foam End-Use Categories.*

(A) The recordkeeping requirements of this subarticle do not apply to any end-use category listed in Table 2 of section 95374(b) of this subarticle.~~(1)~~ ~~*Recordkeeping.*~~ As of the effective date of this subarticle, any person who manufactures a foam system in any end-use category listed in Table 1 of section 95374(a) of this subarticle for sale or entry into commerce in the State of California, must maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer, a copy of the following records:

1.~~(A)~~ Name and address of the person purchasing the foam system at the time of purchase.

2.~~(B)~~ Telephone number and email address of the person purchasing the foam system at the time of purchase, if provided to the manufacturer.

3.~~(C)~~ The type of foam end-use category.

4.~~(D)~~ Date of manufacture of the foam system.

5.~~(E)~~ Date of sale of the foam system.

6.~~(F)~~ The blowing agent used in the foam system.

(B) Foam end-uses that no longer use any prohibited substance listed in section 95374(a) may provide the California Air Resources Board with an attestation under penalty of perjury that the end-use does not use a prohibited substance and this shall serve as compliance with section 95375(a)(4). All attestations shall be sent in accordance with section 953788~~7~~(c)~~(3)~~.

~~NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39607, 39730.5, 39734 and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734 and 41511, Health and Safety Code.~~

~~§ 95376. Requirements Applicable to Table 2 of Section 95374(b).~~

~~(a)~~(b) ~~*Prohibitions*~~*Requirements Applicable to Table 2 of Section 95374(b)*.

(1) *Prohibitions*. No person ~~may~~ shall ~~offer any equipment or product for sale~~,sell, lease, rent, install, use, or otherwise ~~cause any equipment or product manufactured after the effective date, to~~ enter into commerce in the State of California, ~~if that equipment or product uses or will use a substitute in a manner inconsistent with~~ any ~~substitute in~~ end-use equipment or product manufactured after the effective date, ~~s~~ that does not comply with the requirements of ~~listed in~~ Table 2 of section 95374(b) of this subarticle.

~~(b)~~(2) *Exceptions*. The following exceptions apply to the list of prohibited substances or the effective dates for prohibited substances for end-uses identified in Table 2 of section 95374(b) of this subarticle:

~~(1)~~(A) *Foam End-Uses*. Except where specified below, the effective date for foam end-uses identified in Table 2 of section 95374(b) of this subarticle are extended to January 1, 2022, for military applications and January 1, 2025, for space- and aeronautics-related applications, where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements, including closed cell foam products and products containing closed cell foams manufactured with the applicable prohibited substances on or before these dates.

1.~~(A)~~ *Polystyrene: Extruded Boardstock and Billet*: The prohibited substances for polystyrene extruded boardstock and billet are acceptable for use in this specific end-use from January 1, 2021, until January 1, 2022, in military applications and until January 1, 2025, for space- and aeronautics-related applications where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements. Closed cell foam products and products containing closed cell foams manufactured with the prohibited substances for polystyrene extruded boardstock and billet on or before January 1, 2022, for military applications or on or before January 1, 2025, in space- and aeronautics-related applications, may be used after those dates.

2.~~(B)~~ Rigid Polyurethane: Spray Foam - High-Pressure Two-Component ("High-Pressure RP"): The prohibited substances for High-Pressure RP are acceptable for use in High-Pressure RP from January 1, 2020, until January 1, 2025, only in military or space- and aeronautics-related applications where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements. Closed cell foam products and products containing closed cell foams manufactured with the prohibited substances for High-Pressure RP on or before January 1, 2025, may be used after that date.

3.~~(C)~~ *Rigid Polyurethane: Spray Foam - Low-Pressure Two-Component ("Low-Pressure RP")*: The prohibited substances for Low-Pressure RP are acceptable for use in Low Pressure RP from January 1, 2021, until January 1, 2025, only in military or space- and aeronautics-related applications where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements. Low pressure two-component spray foam kits manufactured with the prohibited substances for Low-Pressure RP on or before January 1, 2025, for military or space– and aeronautics-related applications may be used after that date.

~~*(2) Chillers End-Uses*. New centrifugal chillers and new positive displacement chillers are allowed to use HFC-134a for military marine vessels and allowed to use R-404A and HFC-134a for human-rated spacecraft and related support equipment where reasonable efforts have been made to ascertain that other~~

~~alternatives are not technically feasible due to performance or safety requirements.~~

~~(3)~~(B) *Aerosols - Propellants End-Uses*. Unless otherwise prohibited by State regulation, HFC-134a is allowed in the following aerosol propellant specific uses:

1.~~(A)~~ Cleaning products for removal of grease, flux and other soils from electrical equipment or electronics;

2.~~(B)~~ Refrigerant flushes;

3.~~(C)~~ Products for sensitivity testing of smoke detectors;

4.~~(D)~~ Sprays containing corrosion preventive compounds used in the maintenance of aircraft, electrical equipment or electronics, or military equipment;

5.~~(E)~~ Duster sprays specifically for removal of dust from photographic negatives, semiconductor chips, and specimens under electron microscopes, and energized electrical equipment;

6.~~(F)~~ Adhesives and sealants in large canisters;

7.~~(G)~~ Lubricants and freeze sprays for electrical equipment or electronics;

8.~~(H)~~ Sprays for aircraft maintenance;

9.~~(I)~~ Pesticides for use near electrical wires or in aircraft, in total release insecticide foggers, or in certified organic use pesticides for which the U.S. EPA has specifically disallowed all other lower-global warming potential (GWP) propellants;

10.~~(J)~~ Mold release agents and mold cleaners;

11.~~(K)~~ Lubricants and cleaners for spinnerettes for synthetic fabrics;

12.~~(L)~~ Document preservation sprays;

13.~~(M)~~ Metered dose inhalers (MDIs) approved by the U.S. Food and Drug Administration (FDA) for medical purposes;

14.~~(N)~~ Wound care sprays;

15.~~(O)~~ Topical coolant sprays for pain relief; ~~and~~

16.~~(P)~~ Products for removing bandage adhesives from skin~~.~~; and

17. Bear spray.

(C) *Aerosols - Propellants End-Uses*. HFC-227ea and blends of HFC-227ea and HFC-134a are allowed in metered dose inhalers (MDIs) approved by the U.S. Food and Drug Administration (FDA) for medical purposes.

~~NOTE: Authority cited: Section 39734, Health and Safety Code. Reference: Section 39734, Health and Safety Code.~~

(c) *Requirements Applicable to Table 3 of Section 95374(c)*.

(1) *Prohibitions*. No person shall sell, lease, rent, install, use, or enter into commerce in the State of California, any end-use equipment or product manufactured after the effective date, that does not comply with Table 3 of section 95374(c) of this subarticle.

(2) *Exceptions*. The following exceptions apply to the list of prohibited substances or the effective dates for prohibited substances for end-uses identified in Table 3 of section 95374(c) of this subarticle:

(A) *Chillers End-Uses*. New centrifugal chillers and new positive displacement chillers are allowed to use HFC-134a for military marine vessels and allowed to use R-404A and HFC-134a for human-rated spacecraft and related support equipment where reasonable efforts have been made to ascertain that other alternatives are not technically feasible due to performance or safety requirements.

(B) *Refrigeration equipment with 50 Pounds or Less of Refrigerant*. The prohibitions in Table 3, section 95374(c), do not apply to any refrigeration, cold storage, industrial process refrigeration, and all non-residential refrigeration not otherwise categorized as retail food, cold storage, or industrial process refrigeration that contain 50 pounds or less of refrigerant.

(C) *Very Low Temperature Refrigeration or Cooling*: The prohibitions in Table 3, section 95374(c), do not apply to any end-uses used for Very Low Temperature Refrigeration or Cooling.

(D) *Approved Building Permits*: The prohibitions in Table 3, section 95374(c), do not apply to any facility with new refrigeration equipment that received an approved building permit before the effective date.

(3) *Reclaimed Refrigerant Use Requirements.* Manufacturers of AC and VRF equipment subject to effective dates of January 1, 2025 and January 1, 2026 respectively, in Table 3 shall comply with requirements listed under section 95376.

(4) Labeling *and Recordkeeping.*

(A) *Labeling*. As of the effective date of this subarticle, any person who manufactures any end-use category identified in Table 3 of section 95374(c) shall display a label on the equipment that clearly and visibly indicates:

1. The type of refrigerant;

2. Where available, the refrigerant charge size in ounces, pounds, or kilograms;

3. The date of manufacture, indicating at a minimum, the four digit year of manufacture in standard format; and

4. Existing labels meeting the above requirements may be used. For built-up systems, existing equipment component labels may be used.

(B) *Recordkeeping for Manufacturers*. As of the effective date of this subarticle, any person who manufactures any equipment listed in Table 3 of section 95374 (c) of this subarticle, for sale or entry into commerce in the State of California, shall maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer or a local Air Pollution Control Officer, a copy of the following records:

1. Name and address of the person purchasing the equipment at the time of purchase;

2. Telephone number and email address of the person purchasing the equipment at the time of purchase, if provided to the manufacturer;

3. Model and serial number of the equipment. When the affected equipment is part of an assembly without an individual serial number, the serial number of each component must be recorded. If a component or equipment does not have an individual serial number or the serial number is inaccessible after assembly, the physical description must be recorded in enough detail for positive identification;

4. Date of manufacture of the equipment;

5. Date of sale of the equipment;

6. The refrigerant type(s) the equipment is designed to use; and

7. The refrigerant and full charge capacity of the equipment, where available.

(d) *Requirements Applicable to Table 4 of Section 95374(d).*

(1) *Prohibitions for Refrigeration Equipment, Stationary (in New Facilities)*. No person shall sell, lease, rent, install, use, or enter into commerce in the State of California, any end-use equipment or product manufactured after the effective date, that does not comply with Table 4 of section 95374(d) of this subarticle.

(2) *Labeling and Recordkeeping Requirements for Manufacturers.*

(A) *Labeling for Manufacturers*. As of the effective date of this subarticle, any person who manufactures any equipment in end-use category identified in Table 4 of section 95374(d) shall display a label on the equipment that clearly and visibly indicates:

1. The type of refrigerant;

2. Where available, the refrigerant charge size in ounces, pounds, or kilograms;

3. The date of manufacture, indicating at a minimum, the four digit year of manufacture in standard format; and

4. Existing labels meeting the above requirements may be used. For built-up systems, existing equipment component labels may be used.

(B) *Recordkeeping for Manufacturers*. As of the effective date of this subarticle, any person who manufactures any equipment listed in Table 4 of section 95374 (d) of this subarticle, for sale or entry into commerce in the State of California, shall maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer or a local Air Pollution Control Officer, a copy of the following records:

1. Name and address of the person purchasing the equipment at the time of purchase;

2. Telephone number and email address of the person purchasing the equipment at the time of purchase, if provided to the manufacturer;

3. Model and serial number of the equipment. When the affected equipment is part of an assembly without an individual serial number, the serial number of each component must be recorded. If a component or equipment does not have an individual serial number or the serial number is inaccessible after assembly, the physical description must be recorded in enough detail for positive identification;

4. Date of manufacture of the equipment;

5. Date of sale of the equipment;

6. The refrigerant type(s) the equipment is designed to use; and

7. The refrigerant and full charge capacity of the equipment, where available.

(3) *Exceptions*. The following exceptions apply to the effective dates for prohibited substances for end-uses identified in Table 4 of section 95374(d) of this subarticle:

(A) Facilities with new refrigeration equipment with approved building permit applications before the effective date.

(B) *Refrigeration equipment with 50 Pounds or Less of Refrigerant*. The prohibitions in Table 4, section 95374(d), do not apply to any refrigeration equipment that contain 50 pounds or less of refrigerant.

(4) *Requirements for Refrigeration Equipment, Stationary (in Existing Facilities).* The following requirement shall apply:

(A) ~~*January 1*~~*December 31, 2026 Requirements*. Companies that own or operate 20 or more retail food facilities in California and companies that are defined in this regulation as "national supermarket chains" shall comply with one of the following requirements by ~~January 1~~December 31, 2026:

1. The weighted-average GWP shall be less than 2,500 for the aggregated total of all refrigerant in all refrigeration systems greater than 50 pounds; or

2. GHGp of all refrigerant in all refrigeration systems greater than 50 pounds shall be reduced by 25 percent or more of their 2019 baseline GHGp.

(B) *January 1, 2030 Requirements*. Companies that own or operate one or more retail food facilities in California shall comply with one of the following requirements by January 1, 2030:

1. The weighted-average GWP shall be less than 1,400 for the aggregated total of all refrigeration systems greater than 50 pounds; or

2. The GHGp of all refrigerant in all refrigeration systems greater than 50 pounds shall be reduced by 55 percent or more of their 2019 baseline GHGp.

(5) *Registration Requirements for Companies with Retail Food Facilities.* On or before January 1, 2022, retail food facilities shall register the following information in the R3 database:

(A) Refrigeration systems containing more than 50 pounds of refrigerant that use a GWP less than 150, including:

1. System identification number (assigned by the facility owner or operator);

2. System type;

3. System manufacturer;

4. System model or description;

5. System model year;

6. System serial number. The serial number(s) of the affected system or component must be recorded when present and accessible. When the affected system or component is part of an assembly without a serial number or does not have an individual serial number or is not accessible after assembly, the physical location of the affected system must be recorded in enough detail to permit positive identification;

7. Physical location of the refrigeration system through schematic or floor plan with system locations clearly noted;

8. Temperature classification – The refrigeration system must be identified as a low temperature system, a medium temperature system, or other;

9. Full charge of the refrigeration system; and

10. Type of refrigerant(s) used.

(B) When a refrigeration system full charge size decreases to 50 pounds or less after a refrigerant retrofit or charge reduction, the exact amount of charge reduced must be reported.

(C) All retail food facilities owned by the company that are located in California.

(D) All registered information required in sections 95375(3) shall be updated by January 1 of the year after the information has changed.

(6) *Reporting Requirements for Companies with Retail Food Facilities.* On or before March 1, 2022, and each year thereafter by March 1, all companies with a retail food facility shall report into the R3 database for the prior calendar year with the following information:

(A) Name of Company;

(B) Company Federal Tax Identification Number;

(C) Company mailing address including a street address, city, state, and zip code;

(D) Company location address including a street address, city, state, and zip code;

(E) Company contact person;

(F) Company contact person phone number;

(G) Company contact person e-mail address; and

(H) Compliance Information:

1. The company's weighted-average GWP; and

2. The company's GHGp.

(7) *Recordkeeping Requirements for Companies with Retail Food Facilities.* As of the effective date of this subarticle, any person who owns or operates a retail food facility shall maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer or a local Air Pollution Control Officer, the following records or documentation that shows the following information:

(A) The means by which the full charge was determined, both before and after either a refrigerant retrofit or charge reduction;

(B) Each refrigeration system refrigerant retrofit, including the full charge and type of refrigerant used in the system before a retrofit and after a retrofit;

(C) Each refrigeration system charge reduction, including the full charge size before a refrigerant charge reduction and after a refrigerant charge reduction;

(D) Refrigeration system retirement, including date of removal of the refrigeration system from the facility;

(E) Amount and type of refrigerant removed from the refrigeration system and where the refrigerant was stored and/or sent afterwards, either after a system retirement, system refrigerant retrofit, or a system charge reduction;

(F) The calculations and spreadsheets used to create the reported information under section 95375(d)(4); and

(G)The recordkeeping requirements of section 95375(d)(7) shall include documentation including but not limited to, invoices, receipts, records of shipments, plans, or work details, that are generated or supported by information from a third party, such as a service technician or refrigerant reclaimer.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39607, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 95376. *Refrigerant Recovery, Reclaim, and Reuse Requirements (R4 Program).*

(a) *Reclaimed Refrigerant Use Requirements for Manufacturers of AC Equipment Subject to Effective Date of January 1, 2025 in Table 3*. Equipment manufacturers shall determine the number of pounds of certified reclaimed R-410A refrigerant use required as follows:

(1) Use the following equation to determine baseline average pounds per year:

Baseline Average Pounds of Refrigerant in 2018 and 2019 = [(pounds in AC equipment entered into California in 2018 + pounds in AC equipment entered into California in 2019) ÷ 2].

(2) Applying the calculated baseline average pounds, determine the number of pounds of certified reclaimed R-410A refrigerant use required annually, using the following equation:

Annual Reclaim Use Requirement for 2023 = [(10% × baseline average pounds calculated in (a)(1)) × 1.04 (a one-time growth factor of 4%)].

Annual Reclaim Use Requirement for 2024 = [(10% × baseline average pounds calculated in (a)(1)) × 1.04 (a one-time growth factor of 4%)].

(3) For AC manufacturers with no shipments into California in 2018 and 2019, the baseline years shall be 2023 and 2024. Projected shipments into California shall be used to calculate the certified reclaimed refrigerant requirements for the initial baseline report and first annual report, while actual shipments into California will be used for the final annual report. The following equation shall be used to determine the number of pounds of certified reclaimed R-410A refrigerant use requirement:

Annual Reclaim Use Requirement for 2023 and 2024: (10% × pounds in AC equipment entered into California per year).

(4) The requirement shall be met by AC manufacturers by any or all of the following:

(A) Certified reclaimed R-410A refrigerant purchased and used in new equipment.

(B) Certified reclaimed R-410A refrigerant purchased and used in the servicing of existing equipment.

(C) Optional Early Action Credit: Refrigerant with a GWP less than 750 used in new equipment entered into commerce in California prior to January 1, 2025.

(5) The requirement to purchase and use certified reclaimed R-410A refrigerant shall be met before July 1, 2025.

(b) *Reclaimed Refrigerant Use Requirements for Manufacturers of VRF Equipment Subject to Effective Date of January 1, 2026 in Table 3*. VRF manufacturers shall determine the number of pounds of certified reclaimed R-410A refrigerant use required as follows:

(1) Use the following equation to determine baseline average pounds per year:

[(pounds in VRF equipment entered into California in 2018 + pounds in VRF equipment entered into California in 2019) ÷ 2].

(2) Applying the calculated baseline average pounds per year, determine the number of pounds of certified reclaimed R-410A refrigerant use required annually, using the following equations:

Annual Reclaim Use Requirement for 2023: [(15% × average pounds per year calculated in (b)(1)) × 1.10 (a one-time growth factor of 10%)].

Annual Reclaim Use Requirement for 2024: [(15% × average pounds per year calculated in (b)(1)) × 1.10 (a one-time growth factor of 10%)].

Annual Reclaim Use Requirement for 2025: [(25% × average pounds per year calculated in (b)(1)) × 1.10 (a one-time growth factor of 10%)].

(3) For VRF manufacturers with no shipments into California in 2018 and 2019, the baseline years shall be 2023, 2024, and 2025. Projected shipments into California shall be used to calculate the certified reclaimed refrigerant requirements for the initial baseline report and first annual report, while actual shipments into California will be used for the subsequent annual reports. The following equation shall be used to determine the number of pounds of certified reclaimed R-410A refrigerant requirement:

Annual Reclaim Use Requirement for 2023 and 2024: (15% × pounds in VRF equipment entered into California per year).

Annual Reclaim Use Requirement for 2025: (25% × pounds in VRF equipment entered into California in 2025).

(4) The requirement shall be met by VRF manufacturers by any or all of the following:

(A) Certified reclaimed R-410A refrigerant purchased and used in new equipment.

(B) Certified reclaimed R-410A refrigerant purchased by the VRF manufacturer and used in the servicing of existing equipment.

(C) *Optional Early Action Credit*: Refrigerant with a GWP less than 750 used in new VRF equipment entered into commerce in California prior to January 1, 2026.

(5) The requirement to purchase and use certified reclaimed R-410A refrigerant shall be met before July 1, 2026.

(c) *Reporting Requirements for AC and VRF Manufacturers*.

(1) *Initial Baseline Report*. An Initial Baseline Report with self-certification shall be submitted by July 1, 2023 and must include:

(A) For AC Manufacturers:

(i) With AC shipments into California in 2018 and 2019: The type and quantity (pounds) of refrigerant used with a GWP of 750 or greater for equipment manufactured in 2018 and 2019 for use in California; and the quantity (pounds) of certified reclaimed R-410A refrigerant required, as calculated using the equations in section 95376(a)(1) and 95376(a)(2).

(ii) With no AC shipments equipment into California in 2018 and 2019: The projected type and quantity (pounds) of refrigerant used with a GWP of 750 or greater for equipment manufactured in 2023 and 2024 for use in California; and the quantity (pounds) of certified reclaimed R-410A refrigerant required, as calculated using the equation in section 95376(a)(3).

(B) For VRF Manufacturers:

(i) With VRF shipments into California in 2018 and 2019: The type and quantity (pounds) of refrigerant used with a GWP of 750 or greater for equipment manufactured in 2018 and 2019 for use in California; and the quantity (pounds) of certified reclaimed R-410A refrigerant required, as calculated using the equations in section 95376(b)(1) and 95376(b)(2).

(ii) With no VRF shipments into California in 2018 and 2019: The projected type and quantity (pounds) of refrigerant used with a GWP of 750 or greater for equipment manufactured in 2023, 2024 and 2025 for use in California; and the quantity (pounds) of certified reclaimed R-410A refrigerant required, as calculated using the equations in section 95376(b)(3).

(2) *Annual and Final Reports*. AC and VRF manufacturers shall submit annual reports with self-certification as follows:

(A) For AC manufacturers, an annual report is due July 1, 2024, and a final annual report is due July 1, 2025.

(B) For VRF manufacturers, annual reports are due July 1, 2024 and July 1, 2025. A final annual report is due July 1, 2026.

(C) For AC and VRF manufacturers, annual and final reports must include the following:

1. Type and quantity (pounds) of certified reclaimed R-410A refrigerant used in factory for new equipment manufactured;

2. Type and quantity (pounds) of certified reclaimed R-410A refrigerant used in field for charging new equipment or servicing existing equipment;

3. Type and quantity (pounds) of refrigerant with a GWP less than 750 used in new AC equipment and/or new VRF equipment entered into commerce in California;

4. Number and types of equipment entered into commerce in California containing refrigerant with a GWP less than 750 prior to January 1, 2025 for ACs, and prior to January 1, 2026 for VRFs;

5. Names and addresses of U.S. EPA-certified reclaimers and the quantity (pounds) of certified reclaimed R-410A refrigerant purchased and used from each entity; and

6. An attestation, certifying under penalty of perjury, signed and dated by a responsible official with authority, that under the R4 Program, the certified reclaimed refrigerant is not being purchased, used, or counted to comply with any other government requirement(s), private or voluntary program(s), or any other credit(s) or incentive(s).

(3) All required reports must be submitted electronically.

(d) *Record-keeping Requirements For AC and VRF Manufacturers*. As of the effective date of this subarticle, any person who manufactures equipment subject to the R4 Program requirements for sale or entry into commerce in the State of California, must maintain for five years and make available, upon request by the California Air Resources Board's Executive Officer, a copy of the following records:

(1) All reportable information required by section 95376(c);

(2) Number and types of equipment distributed containing certified reclaimed R-410A refrigerant;

(3) Name and addresses (where available) of distributors or servicing companies to which equipment manufacturers sold or distributed reclaimed refrigerant; and

(4) Additional substantiating documentation such as receipts, purchase orders, contracts or agreements.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39607, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 9537*7*~~7~~6. Enforcement.

(a) Failure to comply with any ~~applicable~~ requirement of this subarticle constitutes a separate violation of this subarticle, including but not limited to failure to retain or produce any records.

(b) Submitting or producing inaccurate information or record(s) that are required to be submitted or retained by this subarticle constitutes a separate violation of this subarticle.

(c) Falsifying any information or record required to be submitted or retained by this subarticle constitutes a separate violation of this subarticle.

(d) ~~Excepting sections 95374(b) and 95376, v~~Violations of this subarticle, including violations of any condition imposed pursuant to section 95378~~7~~, are subject to penalties under the Health and Safety Code section 38580.

~~(e) Violations of sections 95374(b) and 95376 are subject to penalties set forth in Article 3 (commencing with Section 42400) of Chapter 4 of Part 4 of the Health and Safety Code.~~

(~~f~~e) Any violation of this subarticle may be enjoined pursuant to the Health and Safety Code section 41513.

(f) Enforcement of this subarticle may be carried out by authorized representatives of the Executive Officer or a local Air Pollution Control Officer.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.

§ 95378~~7~~. Variance.

(a) *Applicability*. An Applicant may submit a request to the Executive Officer for a variance from the requirements of section 95374 and 95375. The Executive Officer may grant a variance if the Executive Officer determines that the Applicant has proven by clear and convincing evidence that the criteria for each variance type in section 95378~~7~~(b) has been met and that the Applicant has complied with all application requirements specified in subsection 95378~~7~~(c).

(b) *Variance Types*. The Executive Officer may issue the following variances:

(1) *Impossibility*. The Applicant cannot comply with the regulatory requirements, and the Applicant can demonstrate all of the following criteria:

(A) A lower risk substitute is not currently or potentially available;

(B) An exemption will not increase the overall risk to human health or the environment; and

(C) The Applicant has used best efforts to anticipate and address the impossibility and any potential noncompliance.

(2) *Force Majeure*. The Applicant cannot comply with the regulatory requirements, and the Applicant can demonstrate all of the following criteria:

(A) Non-compliance is due to a Force Majeure event; and

(B) The Applicant has used best efforts to anticipate and address any force majeure event and any potential noncompliance, including minimizing any adverse effects of the noncompliance.

(c) *Application for Variance*. To apply for a variance the Applicant shall submit an Application in accordance with the following requirements:

(1) The Application shall include:

(A) Applicant name, ownership status, address, telephone number, and email address;

(B) Description of business activity or product description;

(C) Relationship to the product;

(D) The specific section(s) from which a variance is being requested;

(E) An explanation and description of the reasons for seeking a variance;

(F) Identify whether the variance requested is pursuant to section 95378~~7~~ (b)(1), 95378~~7~~ (b)(2), or both; and provide the following:

1. Clear and convincing evidence demonstrating how the variance criteria specified in section 95378~~7~~ (b) has been met; and

2. Rationale with supporting documentation for attributing non-compliance to Impossibility or a Force Majeure;

(G) A description of all efforts made to expeditiously fulfill the requirements of the section(s) from which a variance is being requested;

(H) Length of variance requested as well as the earliest date when compliance will be achieved;

(I) A compliance plan which describes in detail how, if a variance is granted, compliance will be achieved as expeditiously as possible including (i) the method by which compliance will be achieved, (ii) milestone dates, and (iii) milestone achievements;

(J) A description of the damage or harm that will result to the Applicant from immediate compliance with the regulatory requirements, including if compliance would result in an extraordinary economic hardship, such as closure of the entire facility or loss of a large portion of the revenue.

(K) Excepting section 95378~~7~~ (b)(2), quantification of current GHG emissions resulting from normal business-as-usual operations as it directly relates to the continued use of any substance in end-uses listed in Table 1, section 95374(a); Table 2, section 95374(b); Table 3, section 95374(c); or Table 4, section 95374(d). This includes quantification of the direct GHG emissions resulting from refrigerant leaks or HFC emissions and indirect GHG emissions resulting from energy use (where applicable), with all calculations, based on the average lifetime of the equipment or product that will continue to use prohibited substances. Applicant must include all calculations used to calculate GHG emissions estimates and use CARB approved emission factors;

(L) A description of any negative impacts to human health or the environment that may result from the granting of a variance;

(M) A mitigation plan that demonstrates how the Applicant will reduce excess GHG emissions to a level equal to or below what would have been emitted had the Applicant been in compliance and how the applicant will mitigate any negative impacts to human health or the environment. Applicant must include all calculations used to calculate GHG emission estimates and use CARB approved emissions factors. This may include an analysis of options to minimize usage of prohibited substances, efforts to reduce leaks or venting of prohibited substances, and options to recycle or destroy high-GWP refrigerant(s); and

(N) A detailed explanation of efforts that may be implemented to curtail noncompliance in lieu of obtaining a variance.

(2) The Applicant shall certify under penalty of perjury that they are a Responsible Official with full authority to submit the application, implement any provision of an Executive Order, and all information provided is true and accurate to the best of the Applicant’s knowledge, after conducting due diligence. Applications without this certification will be automatically denied.

(3) All applications and documentation relating to the variance shall be submitted to CARB at the following email address:

HFCREDUCTION@ARB.CA.GOV

(4) Applications may be submitted to the following address:

CALIFORNIA AIR RESOURCES BOARD

CHIEF, RESEARCH DIVISION

1001 I STREET

SACRAMENTO, CA 95814

(5) Verbal submissions do not constitute acceptable application formats.

(6) Applications and supporting documents shall be written in the English language.

(7) Any Applicant submitting information to the Executive Officer pursuant to this subarticle may claim such information as “confidential” by clearly identifying such information as “confidential.” Any claim of confidentiality by an Applicant submitting information must be based on the Applicant’s belief that the information marked as confidential is either trade secret or otherwise exempt from public disclosure under the California Public Records Act (Government Code, section 6250 et seq.). All such requests for confidentiality shall be handled in accordance with the procedures specified in California Code of Regulations, title 17, sections 91000 to 91022.

(d) Approval and Disapproval Process.

(1) The Executive Officer will determine whether the application is complete and will notify the Applicant of this determination within 30 days of receipt of an application. If the application is determined to be incomplete, the Executive Officer will notify the Applicant and specify the information needed to make the application complete. To be complete, the Applicant must provide all information identified in section 95378~~7~~, subsections (b) and (c). The application will not be deemed complete until all information in section 95378~~7~~ subsections (b) and (c) is submitted. Any application not providing all required information within 90 calendar days, is automatically denied.

(2) Within 30 calendar days after the application is deemed completed, the Executive Officer will publicly post notice of receipt of the application, and the requested variance, and invite public comment for 30 calendar days from the date the notice is posted.

> (A) Public comments that are received within 30 calendar days of the date such information is made available shall be considered by the Executive Officer in making the final decision on the application. The Applicant may also on his or her own initiative submit additional supporting documentation before a decision has been reached.
>
> (B) The Executive Officer will determine if the variance application is approved or disapproved within 60 calendar days after close of the public comment period.

(3) The Executive Officer will notify the Applicant of the decision in writing, and if approved, will specify any and all terms and conditions of the variance in the form of an Executive Order.

(4) An approved variance, including the terms and conditions of the Executive Order, are granted solely to the Applicant of the variance and are non-transferrable.

(5) The variance shall not be retroactively applied to any date before the Applicant submits a complete application.

(6) The Executive Officer may expeditiously approve a variance application for a force majeure event meeting the criteria specified in section 95378~~7~~ (b)(2) prior to the close of a public comment period if the Executive Officer determines the urgency of the force majeure event necessitates an immediate variance to protect human health or the environment.

(e) Failure to Comply with Terms or Conditions of the Executive Order.

(1) The Applicant shall comply with all terms of the Executive Order.

(2) The variance shall cease to be effective immediately upon the failure of the Applicant, to whom the variance was granted, to comply with any term or condition of the Executive Order.

(f) Revocation or Modification of Variance.

(1) If the Executive Officer determines that the Applicant no longer meets the variance criteria specified in subsection (b) of this section, the Executive Officer may revoke or modify the Executive Order.

(2) If the Executive Officer determines that the Applicant violates any requirement of the Executive Order, the Executive Officer may revoke or modify the Executive Order.

(g) Review of Agency Decision.

(1) An Applicant may petition for review of the Executive Officer's decision by requesting an administrative hearing in accordance with the procedures specified in title 17, California Code of Regulations, Division 3, Chapter 1, Subchapter 1.25, Article 2 (commencing with section 60055.1).

(2) An Applicant adversely affected by the final decision of the administrative hearing may seek judicial review by filing a petition for writ of mandate in accordance with section 1094.5 of the California Code of Civil Procedure within 30 days after the order or decision becomes final.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 38597, 39515, 39516, 39600, 39601, 39605, 39730.5, 39734 and 41511, Health and Safety Code; Section 1094.5 of the California Code of Civil Procedure. Reference: Sections

38510, 38598, 38560, 38562, 38566, 38580, 38597, 39515, 39516, 39600, 39601, 39605, 39730, 39730.5, 39734 and 41511, Health and Safety Code; Section 1094.5 of the California Code of Civil Procedure; Mathews v. Eldridge (1976) 424 U.S. 319.

§ 95379~~8~~. Severability.

Each part of this subarticle shall be deemed severable, and in the event that any provision of this subarticle is held to be invalid, the remainder of this subarticle shall continue in full force and effect.

NOTE: Authority cited: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730.5, 39734, and 41511, Health and Safety Code. Reference: Sections 38510, 38598, 38560, 38562, 38566, 38580, 39600, 39601, 39730, 39730.5, 39734, and 41511, Health and Safety Code.