Leading by Example Council Agenda
July 11th, 2023

- Welcome
- National Climate and Energy News
- LBE Updates
- Technical Potential of Solar
- Embodied Carbon Reduction Policies and Strategies

Massachusetts Department of Energy Resources

World News

World Registers Hottest Day Ever Recorded on July ~~3rd~~ ~~4th~~ 5th

The globe's average temperature reached 62.9F (17.18C) on July 5th, the highest since records began in 1979, beating the record set in August 2021

Source: Reuters, AP News

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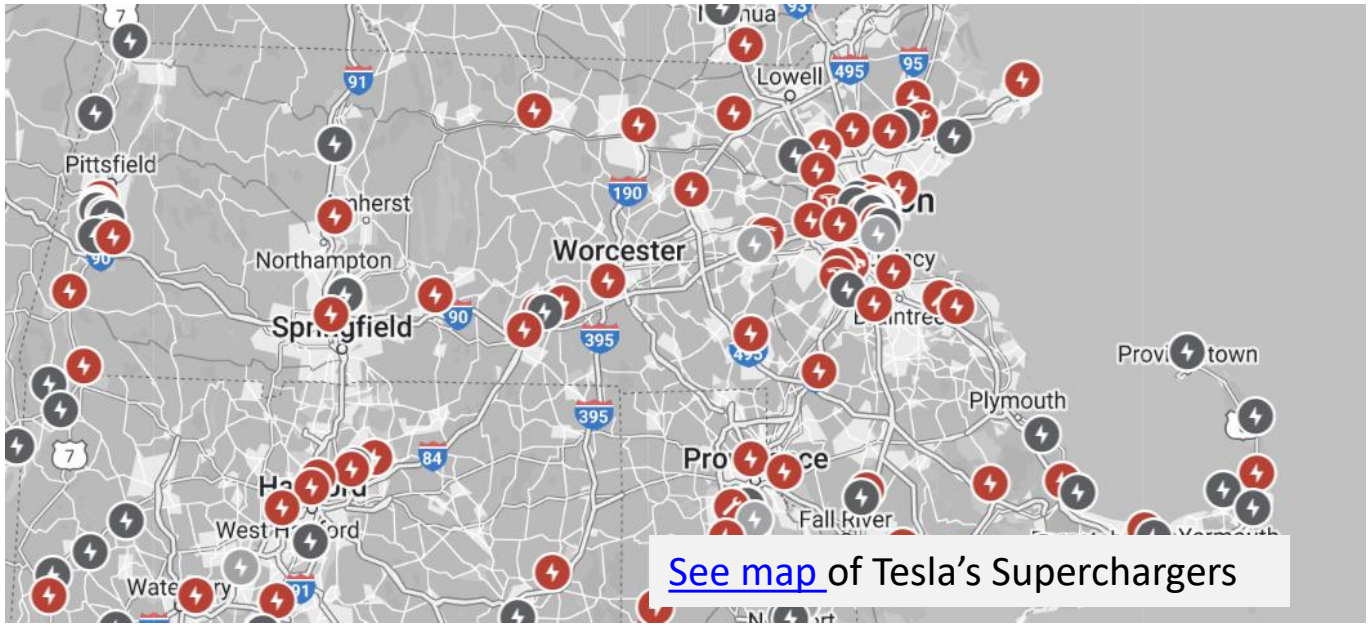
We're workin on it…

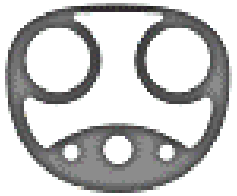
EV Charging: Industry Shift from CCS to NACS?

Starting in 2024-2025, GM, Ford, Volvo, Mercedes Benz, Polestar, and Rivian EVs will come with the **North American Charging Standard (NACS)** connector instead of the current industry-standard CCS

GM and Ford struck deals with Tesla to access Tesla fast chargers across the U.S. and will offer an NACS adapter for their vehicles



CCS Type 1



NACS (e.g., Tesla)

Sources: CNBC, electrek

Clean Vehicle Credits Under the IRA

New Clean Vehicle Credit

- Eligibility: **Individuals** who meet the adjusted gross income thresholds; can also apply for vehicles purchased by individuals for their business
- Vehicle criteria:
  - Battery capacity at least 7 kWh
  - <14,000 pounds
  - Qualified manufacturer and model
- Credit amount: $3,750-$7,500
  - Dependent on meeting battery components and/or battery mineral requirements

VS.

Commercial Clean Vehicle Credit

- Eligibility: **Businesses and tax-exempt organizations**
- Must meet vehicle criteria:
  - Battery capacity
  - Vehicle use
  - Manufacturer
- Credit Amount:
  - $7,500-$40,000
- Eligible for Direct Pay
  - Not eligible for transferability

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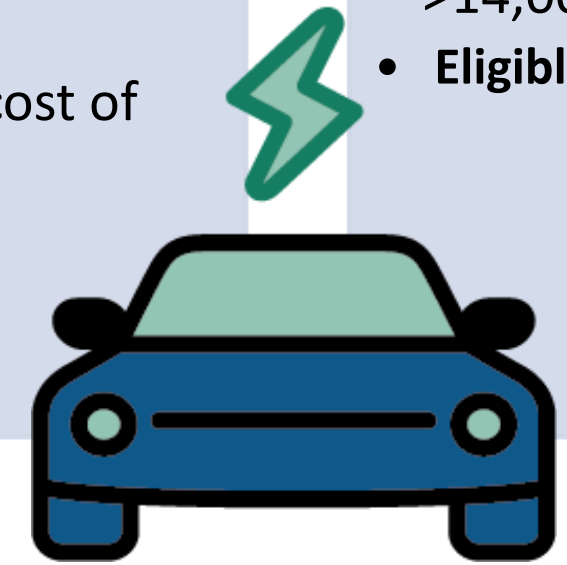
Commercial Clean Vehicle Tax Credit (CCVC)

The credit amount equals the lesser of:

- 30% of the purchase price if the vehicle is not powered by gas or diesel

or

- The incremental cost of the vehicle



Maximum credit allowed:

- $7,500 for vehicles <14,000 pounds
- $40,000 for vehicles >14,000 pounds
- **Eligible for Direct Pay**

Additional criteria:

- Must meet battery requirements
  - 7 kWh or 15 kWh depending on vehicle weight
- Fuel cell motor vehicle requirements
- Must be from a qualified manufacturer
- Must be domestically assembled

More Information

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CCVC Qualified Manufacturers as of July 2023

American Honda Motors*	Audi of America	**Autocar***	Battle Motors	**Blue Bird***
BMW of North America	Daimler Truck of North America	Ecostream RV industries	Envirotech Vehicles	**Ford Motor Company***
General Motors*	Gillig	GreenPower	**Hyundai Motor America***	Jaguar Land Rover
Kia America	Lion Electric Company & Manufacturing	Lordstown EV Corporation	Lucid USA	**Mack Trucks***
Mazda Motor of America	Mercedes-Benz USA	MINI USA	Mitsubishi Motors North America	Motiv Power Systems
Navistar*	Nikola Corporation	**Nissan North America***	Nova Bus (US)	Odyne Systems
PACCAR*	Phoenix Cars	Polestar Automotive	Porsche Cars	Proterra Operating Company
Rivian Automotive	SEA Electric	**Stellantis N.V.***	Subaru of North America	Tesla
Toyota Motor Sales*	VinFast	Volkswagen Group of America	Volvo Car North America	**Volvo Trucks North America***
Xos				

***On statewide contract**

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Market Watch: Current EVs

Light Duty

Make	Model	Year	CCVC Eligible?
Chevrolet	Bolt	2023	Yes
	Bolt EUV	2023	Yes
Ford	E-Transit	2023	Yes
	F-150 Lightning	2023	Yes
	Mustang Mach-E	2023	Yes
Hyundai	Ioniq 5	2023	Yes
	Ioniq 6	2023	Yes
	Kona	2023	Yes
Kia	EV6	2023	Yes
	Niro	2023	Yes
Nissan	Leaf	2023	Yes
	Ariya	2023	Yes
Subaru	Solterra	2023	Yes
Toyota	bZ4X	2023	Yes
Volkswagen	ID.4	2023	Yes

Medium Duty

Make	Model	Year	CCVC Eligible?
Envirotech	Urban Electric Truck	2023	Yes
Greenpower	Star CC	2023	Yes
Motiv	E-450	2023	Yes
Lightning eMotors	Box Truck	2023	No
	Cargo Van	2023	No
	ZEV3	2023	No
	ZEV4	2023	No

Heavy Duty

Make	Model	Year	CCVC Eligible?
Freightliner	eCascadia	2023	Yes
International	eMV	2023	Yes
Volvo	VNR	2023	Yes

Ford E-Transit

Chevy Bolt EUV

And Many More!

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Market Watch: Upcoming EVs

Light Duty

Make	Model	Year	CCVC Eligible?
Chevrolet	Blazer	2024	Yes
	Equinox	2024	Yes
	Silverado	2024	Yes
Honda	Prologue	2024	Yes
Kia	EV9	2024	Yes
Mercedes	eSprinter	2024	Yes
RAM	1500 REV	2024	Yes
Volkswagen	ID.7	2024	Yes
	ID.Buzz	2024-2025	Yes
GMC	Hummer EV	2024	Yes

Medium Duty

Make	Model	Year	CCVC Eligible?
Bollinger	B4	TBD	No
	B5	TBD	No
	B6	TBD	No
Cenntro Logistar	400	TBD	No

Heavy Duty

Make	Model	Year	CCVC Eligible?
Tesla	Semi	TBD	Yes

And More!

Kia EV9

Cenntro Logistar 400

Exciting news!

New Access to Federal Tax Credits through the Inflation Reduction Act

The CCVC is one of multiple tax credits that will become available for nontaxable entities, including **state government agencies**

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Inflation Reduction Act Tax Credit Overview

Certain tax credits are applicable to any eligible projects that have started since January 1, 2023.

Direct Pay (formally known as Elective Pay):

Instead of receiving a reduction in tax liability, entities eligible for direct pay can receive direct payments.

More information

Transferability:

Instead of receiving a reduction in tax liability, those eligible for transferability can monetize the credits by transferring them to another unrelated party for payment in return.

More information

Plus: A proposed special rule in the IRA guidance would further enable the credits to be combined with grants and loans.

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Federal Direct Pay Tax Credits for Non-Taxable Entities

- New pathway for non-taxable entities to access clean energy tax incentives in the Inflation Reduction Act (IRA)
- Applicable for EVs, charging, solar, heat pumps, and more
  - FAQs
  - Federal guidance
  - Transferability info

LBE to focus on providing support for state entities navigating direct pay!

List of tax credits and their eligibility under the Inflation Reduction Act

Electricity	Fuels	Vehicles	Manufacturing		Eligible for direct pay
45, 45Y				Clean electricity production tax credit	✓
48, 48E				Clean electricity investment tax credit	✓
45U				Zero-emission nuclear power production credit	✓
45Q				Credit for carbon oxide sequestration*	✓
	45Z			Clean fuel production credit	✓
	45V			Clean hydrogen production tax credit*	✓
		30C		Alternative fuel vehicle refueling property credit	✓
		45W		Credit for qualified commercial clean vehicles	✓
			48C	Advanced energy project credit	✓
			45X	Advanced manufacturing production credit*	✓

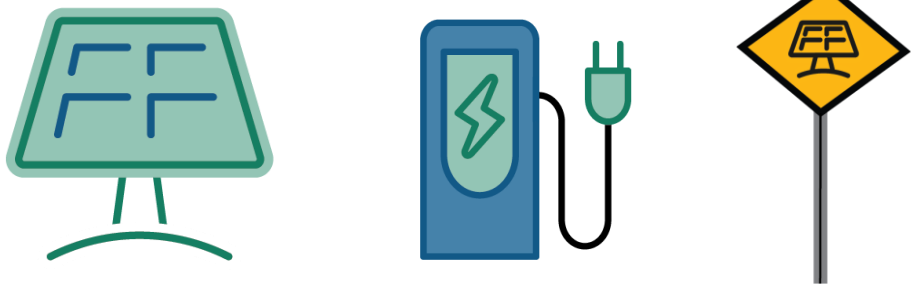
**Direct payments for these credits are available to taxable entities for five years.*
Source: Legal Information Institute, "26 U.S. Code § 6417 - Elective payment of applicable credits"
Table: Center for American Progress

New Tax Credits: How Do They work?

Eligible Projects: multiple solar and wind technologies, municipal solid waste, geothermal (electric generation), tidal, biomass, landfill gas, hydroelectric, marine, hydrokinetic, energy storage technologies, microgrid controllers, fuel cells, geothermal (heat pump and direct use), combined heat & power, microturbines, interconnection costs, and electric vehicle charging stations

Possible Tax Credits: Clean Electricity Production (45, 45Y), Clean Electricity Investment (48,48E), Alternative fuel vehicle refueling property (30D)

- Tax credit starts with a base amount of either 6% (48E, 30D) or $0.003/kWh (45Y).
- If project meets prevailing wage requirements it can receive a 5x multiplier.
- There are also multiple stackable bonus adders:
  - 10% - located in Energy Community (48E, 45Y)
  - 10% - meets domestic content requirements (48E, 45Y)
  - 10% - located in low-income community or on tribal land (48E)*
  - 20% - located in low-income residential buildings or part of low-income economic benefit projects (48E)*
  - Direct Pay and Transferability Options



*the "located in a low-income community or on tribal land" and the " located in a low-income residential building or part of low-income economic benefit project are not able to be stacked together

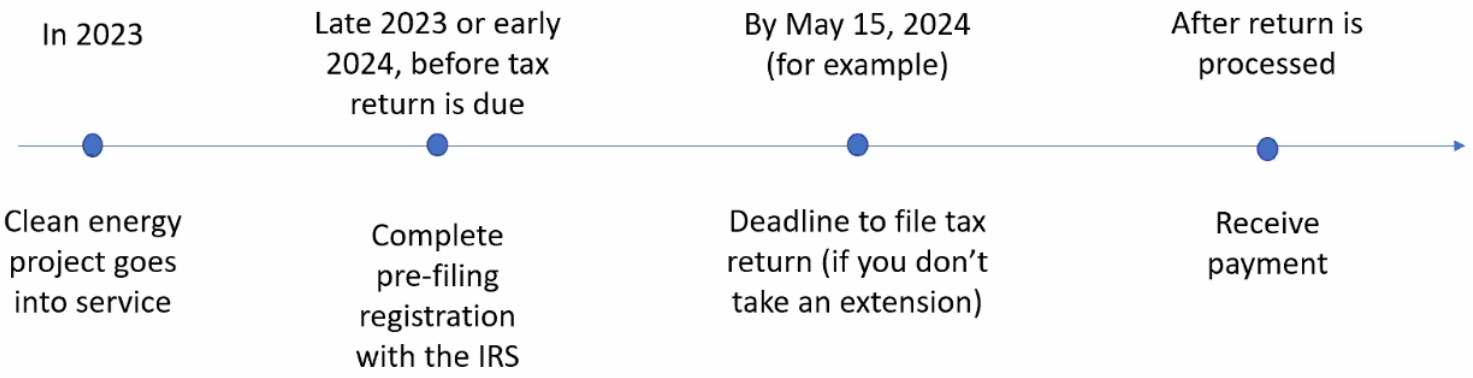
What Will the Process Look Like?

Retroactive tax credits will likely not be available until May 2024

- For example, if a state entity installs rooftop solar in early 2023, they would likely pre-file late 2023 or early 2024 and make the direct pay election on their tax return in the spring

A local government that makes a clean energy investment that qualifies for the investment tax credit can file an annual tax return (via Form 990-T) with the IRS to claim elective pay for the full value of the investment tax credit, as long as it meets all of the requirements, including a pre-filing registration requirement.

As the local government would not owe other federal income tax, the IRS would then make a refund payment in the amount of the credit to the local government.



The e-portal, expected Fall 2023, will enable entities to…

1) complete the required pre-filing registration process &
2) submit for a direct pay credit in Spring 2024

Image source: US Dept. of Treasury webinar on June 29, 2023

More to come…

Questions?

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News and Updates: Massachusetts

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Offshore Wind Development Snapshot: Update

In June, SouthCoast Wind announced they are moving to terminate their contracts, citing increased project costs

	Project	Developer	Size	Current Status	Expected operational date
Round 1	Vineyard Wind 1	Copenhagen Infrastructure Partners, Avangrid	800 MW	Under construction	2023/2024
Round 2	SouthCoast Wind *(formerly Mayflower Wind)*	Shell, Oceans Wind	800 MW	Contract Approved, Under Appeal	2027
Round 3	Commonwealth Wind	Avangrid	1,200 MW	Contract Approved, Under Appeal	Before 2030
	SouthCoast Wind	Shell, Oceans Wind	400 MW	Contract Approved, Under Appeal	Before 2030
Round 4	TBD		Up to 3,600 MW**	Draft RFP under review	*Draft RFP requires before 2032*

Total offshore wind procurement authority: 5,600 MW

***The new Draft RFP seeks to procure at least 400 MW and up to the maximum amount remaining of the statutory requirement of 5,600 MW of offshore wind energy generation under Section 83C, taking into account offshore wind energy generation under contract at the time when proposals are due, in any event not to exceed 3,600 MW.*

Source: Commonwealth Magazine

District Geothermal Pilots Break Ground

- Eversource is the first gas utility in the US to build and run a “networked geothermal system” in its Framingham pilot project
  - Will provide heating and cooling for 37 buildings: apartment complex, homes, fire station, college building, and commercial properties
  - Includes a hundred 600’ wells, a mile of underground pipe, and heat pumps in every building
- National Grid also broke ground for a district geothermal system in Lowell, with UMass Lowell as a participant

Sources: WBUR, National Grid

New England Grid Expected to be More Stable Than Anticipated

- New England's largest fossil fuel power plant, Mystic Generating Station, closing summer 2024
  - Everett Marine Terminal, which sells 80% of its LNG to Mystic, may close
- Everett is one of the only facilities that can accept LNG from tankers; current pipelines cannot deliver same demand
- New models show that New England may face "limited exposure to energy shortfalls" in winter without both Everett and new transmission line in Maine, through 2027
  - Assumes the region becomes *increasingly reliant on oil-fired power plants* to fill in gaps when demand spikes
- Improved outlook for grid reliability is thanks to:
  - Strong growth of solar
  - Certainty around 800 MW Vineyard Wind project
  - Fewer power plant retirements than expected
  - Less growth in energy demand than expected

Upcoming MassDEP MD/HD Grant

- **$7.5 million MassDEP grant opportunity** to support the electrification of medium- and heavy-duty vehicles
- Funded through the Volkswagen Settlement
- Grants will be made available for eligible mitigation actions of the VW Settlement
  - Includes classes 4-8 local freight trucks, buses and waste & dump trucks
  - Covers repowering of diesel engines or replacement of diesel vehicles with EVs
- More details to come!

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LBE Updates

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BPLE Ride and Drive – August 9th

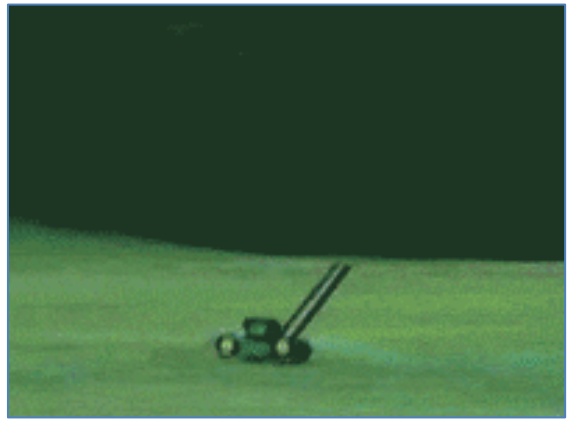
Learn more and experience firsthand the battery-powered landscaping equipment available on statewide contract FAC116!

Hosted by LBE, OSD, and the Taunton Housing Authority

Featured equipment will include…	
Trimmers	Zero-turn mowers
Blowers	Loaders and utility vehicles
Chainsaws	Stand-on mowers
Pole saws	Push mowers

RSVP here or scan:

Wednesday, August 9th
9:30am-12pm
Taunton Housing Authority
Fitzsimmons Arms, 30 Olney St
Taunton, MA 02780



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FY24 Grants: Fleet EVSE Deployment

- The LBE Fleet EVSE Deployment Grant is supporting deployment of 38 charging ports, with another 49 ports in the queue pending application approvals
- Most of the original $800,000 program allocation has been committed…

Total initial allocation	**$800,000**
Grants awarded May 2023: UMA, MIL, DMF	$337,000
Apps pending approval: DFW, DoS, UMCMS	$179,660
Apps in queue: DCR, BSU	$275,000
Remaining FY23 budget	**$8,093**

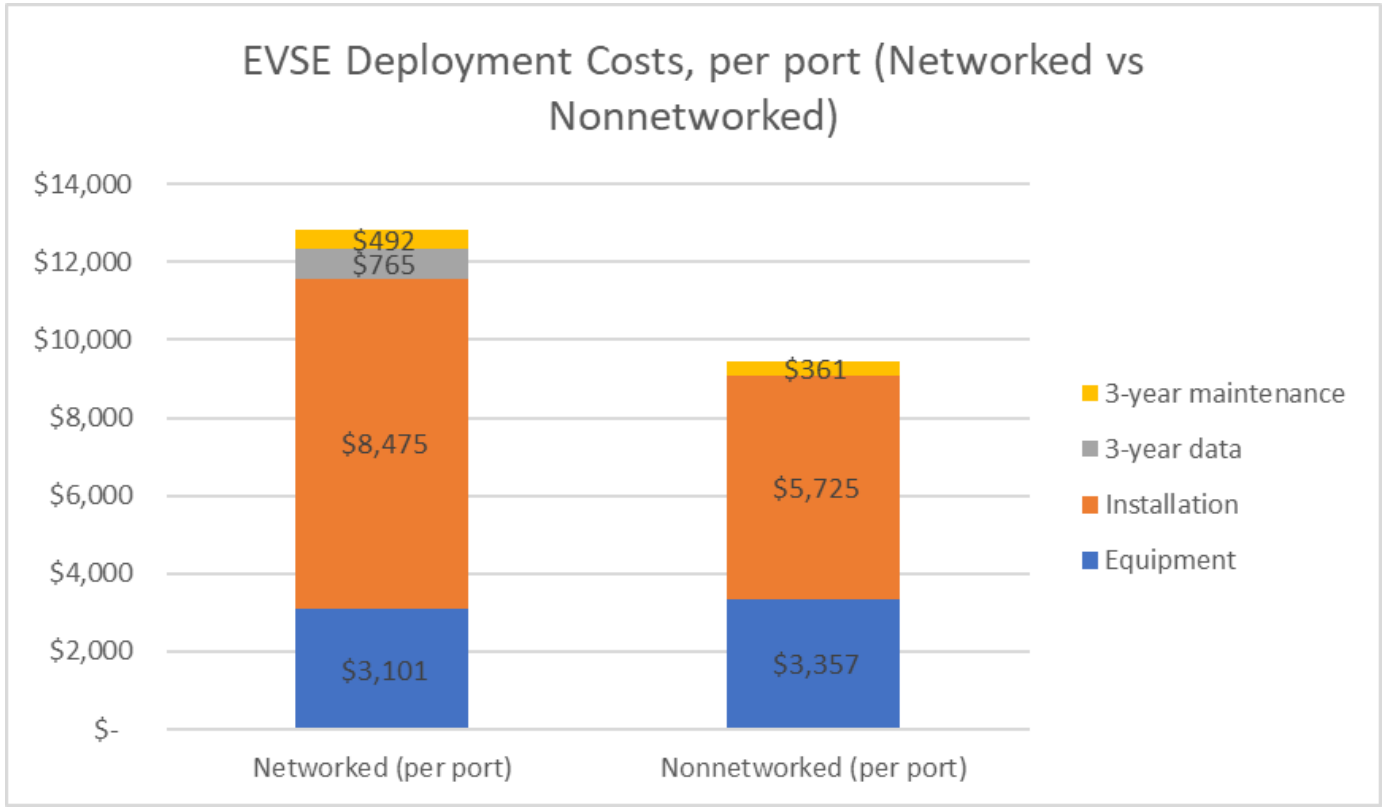
- LBE has been allocated an additional **$600,000** in capital funding to continue this program, and is pursuing other funding sources

FY24 budget (as of 7/1/23)	**$608,093**

Interested in pursuing grant funding? Have questions as you plan your fleet charging needs? Reach out to LBE ASAP!

FY24 Grants: Average EVSE Deployment Costs

- Data collected from Fleet EVSE grant applications and vendor proposals
- Per-port cost of equipment is fairly consistent
  - Networked: $1,800-$4,200
  - Non-networked: $2,800-$3,500
- Per-port cost of installation varies depending on infrastructure needs (e.g., trenching, panel upgrades, etc)
  - Networked: $3,000-$32,000
  - Non-networked: $2,400-$12,000



slido

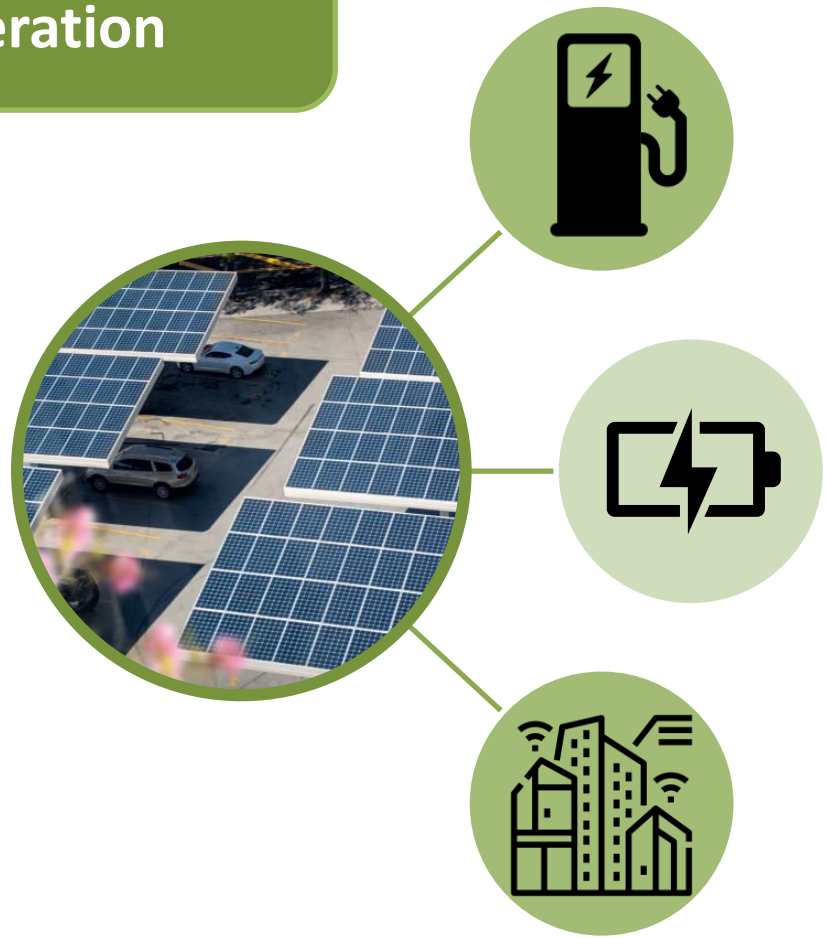
What word comes to mind when we say, "integrated solar"?

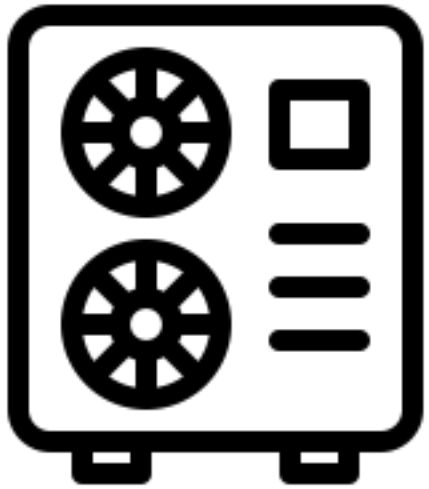
ⓘ Start presenting to display the poll results on this slide.

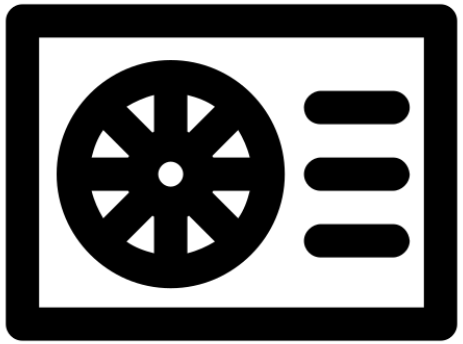
FY24 LBE Grants: Integrated Solar

Integrated solar = solar installations that advance broader statewide and LBE goals beyond electricity generation

- New solar canopy grant program will provide funding projects that…
  - ✓ Expand EV charging infrastructure
  - ✓ Result in grid benefits such as demand reduction (e.g., battery energy storage)
  - ✓ Support facility electrification
- $750,000 allocation in first program year







FY24 LBE Grants: Public Entity Decarbonization

- Addresses financial gaps for small to medium renewable thermal and equipment electrification projects
    - State facilities outside DCAMM purview and regional school districts
- Focuses on the preemptive avoidance of in-kind **replacement of fossil-fuel-based heating and cooling** systems
- Funding priority given to eligible projects located in disadvantaged communities
- ~$4.5M from DOE State Energy Program funding

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Updates to LBE Conversions/GHG Calculator

Tool calculates emissions for:

- Building energy use
- Vehicle energy use

Tool translates energy use & renewable generation into social math, such as:

- MA homes powered/heated
- Vehicles off the road

Check out this calculator on the LBE website under Tools & Resources here

Building Fuel Calculations			GHG Emissions*				Equivalencies				
Select Year (CY or FY)	Fuel	Enter Fuel Amount (Native units)	GHG Emissions Factor (lbs CO2e/unit)	GHG Emissions Factor (metric tonnes CO2e/unit)	Total GHG Emissions (lbs)	Total GHG Emissions (metric tonnes)	MA Homes powered by Electricity (kWh)	MA Homes heated by Natural Gas (therms)	MA Homes heated by Oil (gallons)	MA Homes total energy use	Passenger Vehicles equivalent GHG Emissions
FY_2022	Grid Electricity (kWh)		0.561	0.000255	-	-	-			-	
all	Natural Gas (therms)		11.729	0.005319	-	-		-		-	
all	Natural Gas (CCF)		1					-		-	
all	Oil #2/ Diesel for Buildings (gallons)		2						-	-	
all	Oil #4 (gallons)								-	-	
all	Oil #6 (gallons)		2						-	-	
all	On-Site Co-Gen Electricity (kWh)						-				
all	On-Site Hydro (kWh)						-				
all	On-Site Solar PV Electricity (kWh)						-				
all	On-Site Wind Electricity (kWh)						-				
all	Propane (gallons)		12.7	0.00	-	-					
all	Purchased Steam (mlbs)		207.822	0.094250	-	-					
all	Coal (tons)		4,192.165	1.901209	-	-					
all	Wood Pellets (tons)		-	-	-	-					
all	Cord Wood (chord)		-	-	-	-					
	Totals:				-	-	-	-	-	-	

Enter fuel amount in native units to auto-populate emissions & equivalencies

COMING SOON!

LBE Quarterly Survey

We need your help in tracking progress towards our goals so we can stay up-to-date and report progress in more real time!

- 5-minute survey to provide updates on new:
  - EVs
  - EVSE
  - BPLE
  - Renewable Thermal
  - Renewable Energy
  - Other Sustainable Efforts

- Updates will automatically be added to entity tracking form
- Survey will be available on LBE website and included in quarterly emails

Changes to Mass. LEED Plus 2.0 Standard (MLP 2.0)

- All state new construction and major renovation projects that initiate a study on or after **July 1, 2023**, must adhere to the Commercial Specialized Opt-in Code to comply with the Standard's energy performance requirements

- Nexus of Specialized Opt-in Code and MLP 2.0 Standard:
  - Meet thermal efficiency thresholds by building type
  - Primarily electric heating and cooling (further guidance to come)
  - Other EO 594 requirements still apply

- DOER and DCAMM working on updates to MLP 2.0 guideline accordingly

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Technical Feasibility of Solar

Creating A Clean, Affordable, Equitable and Resilient Energy Future For the Commonwealth

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENERGY RESOURCES
Elizabeth Mahony, Commissioner

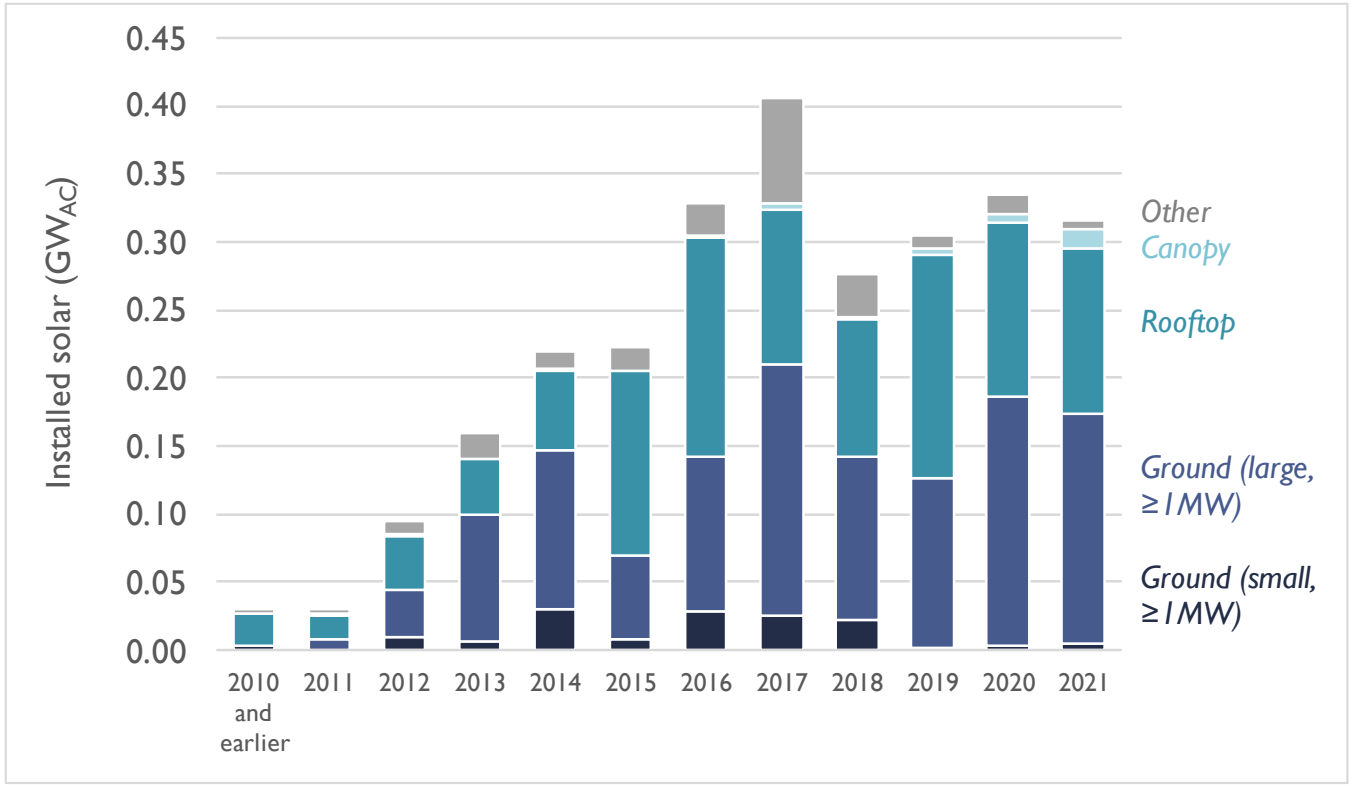
Technical Potential of Solar Study

July 11, 2023

Purpose

1. Determine total technical solar potential to achieve CECP emissions limits
   - Approximately 27 – 34 GW of solar, or 0.3 GW per year
   - Current installed solar = approximately 3 GW (as of August 2022)
     - 0.6 GW being developed under SMART program
2. Develop methodology to quantify potential for solar installations in most preferred to least preferred locations

Figure 1. Solar installations in Massachusetts by year



Study Overview

Stakeholder Engagement

Technical Advisory Committee Convened
- 6 meetings between July 2022 and March 2023

Public Survey
- Posted for 2 months in fall 2022
- Over 3,000 responses received

Public Stakeholder Meetings
- 5 meetings in fall 2022
- 3 virtual, 2 in-person (Barnstable and Berkshire county)

Suitability Categories
- Agriculture
- Biodiversity
- Carbon Sequestration
- Other Ecosystem Services
- Grid Infrastructure
- Slope & Aspect

Geospatial Analysis

Categorization
- Rooftop
- Canopy
- Ground-mounted

Permissibility and Feasibility
- Setbacks and smoothing
- Wetlands / surface water
- Protected open space
- Biomap
- Roads

Total Technical Potential
- Estimated for each type of solar in every parcel

Suitability Analysis
- Each parcel scored (A, B, or C) for each type of solar potential in that parcel

Results

Report and interactive Story Map showing estimated total solar potential and relative suitability of different types of solar across all parcels in Massachusetts.

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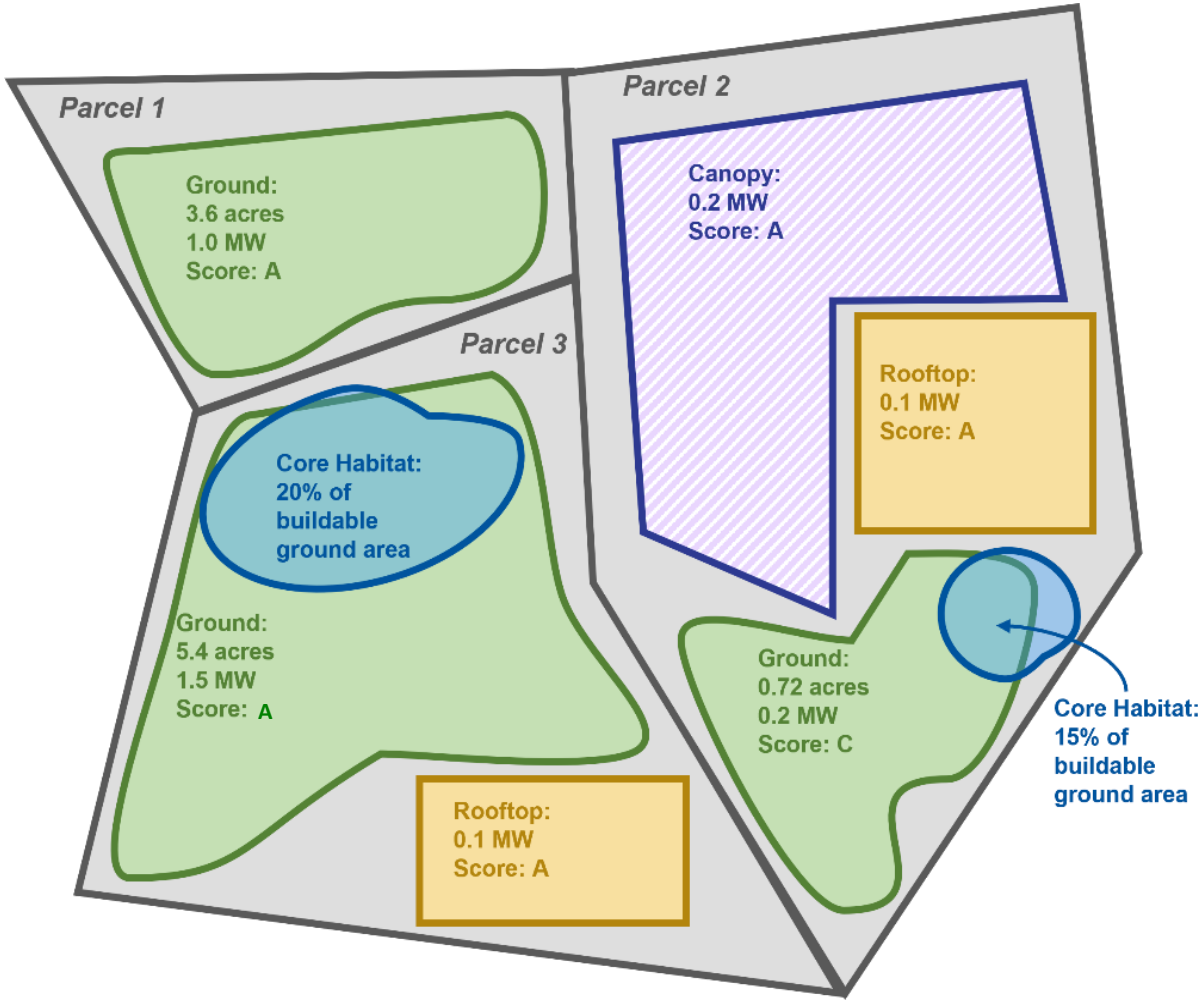
Suitability Categories

Table 1. Suitability Categories and Criteria

Category	Criteria
Agriculture	Does the parcel contain agricultural soils and/or is it designated as farmland?
Biodiversity	Does the parcel overlap with Biomap area?
Other Ecosystem Services	Does the parcel overlap with a Wellhead Protection Area, and/or Areas of Critical Environmental Concern?
Embedded CO_{2e}	How much embedded and foregone CO_{2e} does the parcel contain?
Grid Infrastructure	How far is the parcel from a substation?
Slope and Aspect	What is the parcel's grade and what direction does it face?

Figure 2. Suitability scoring example – biodiversity category



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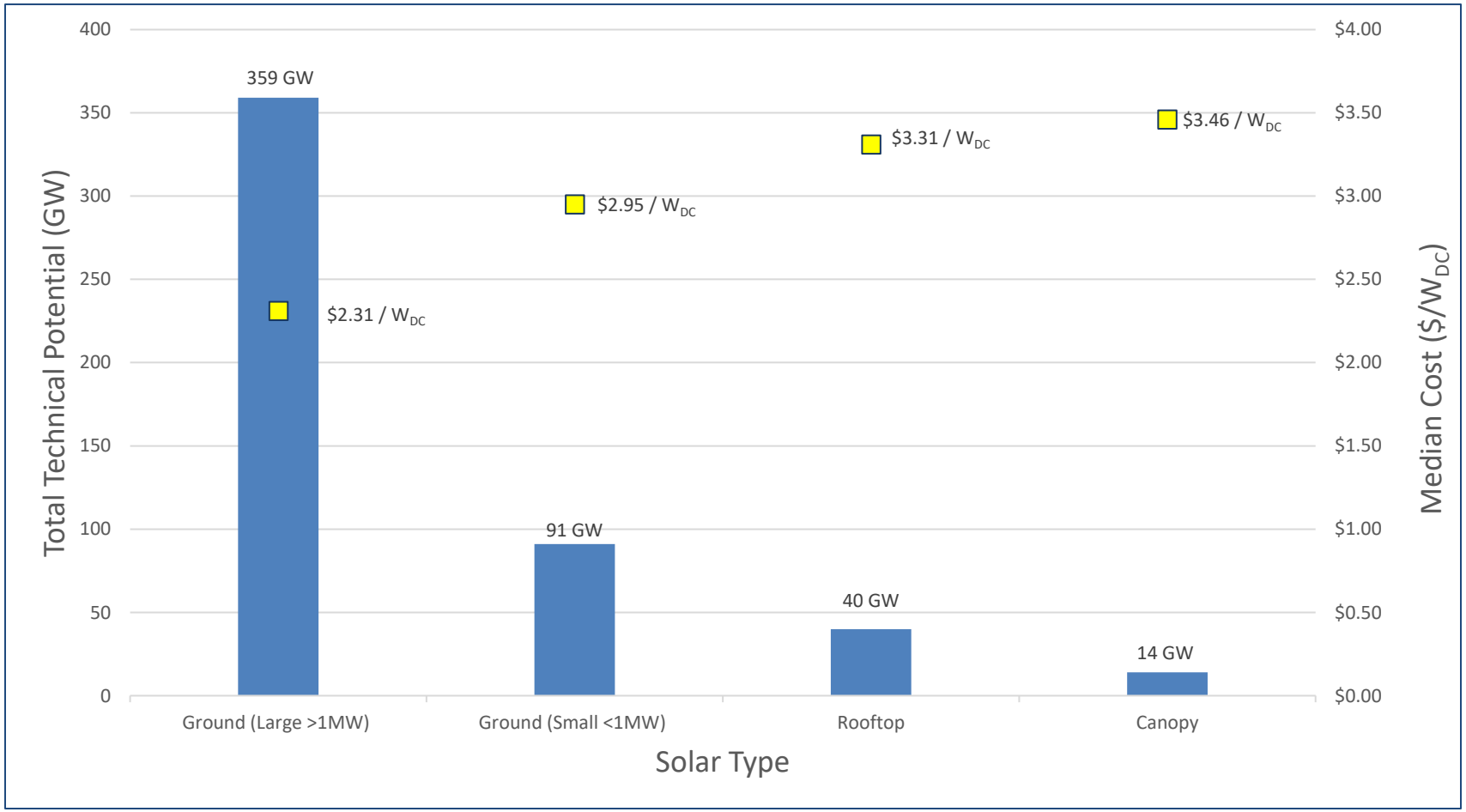
Total Technical Potential

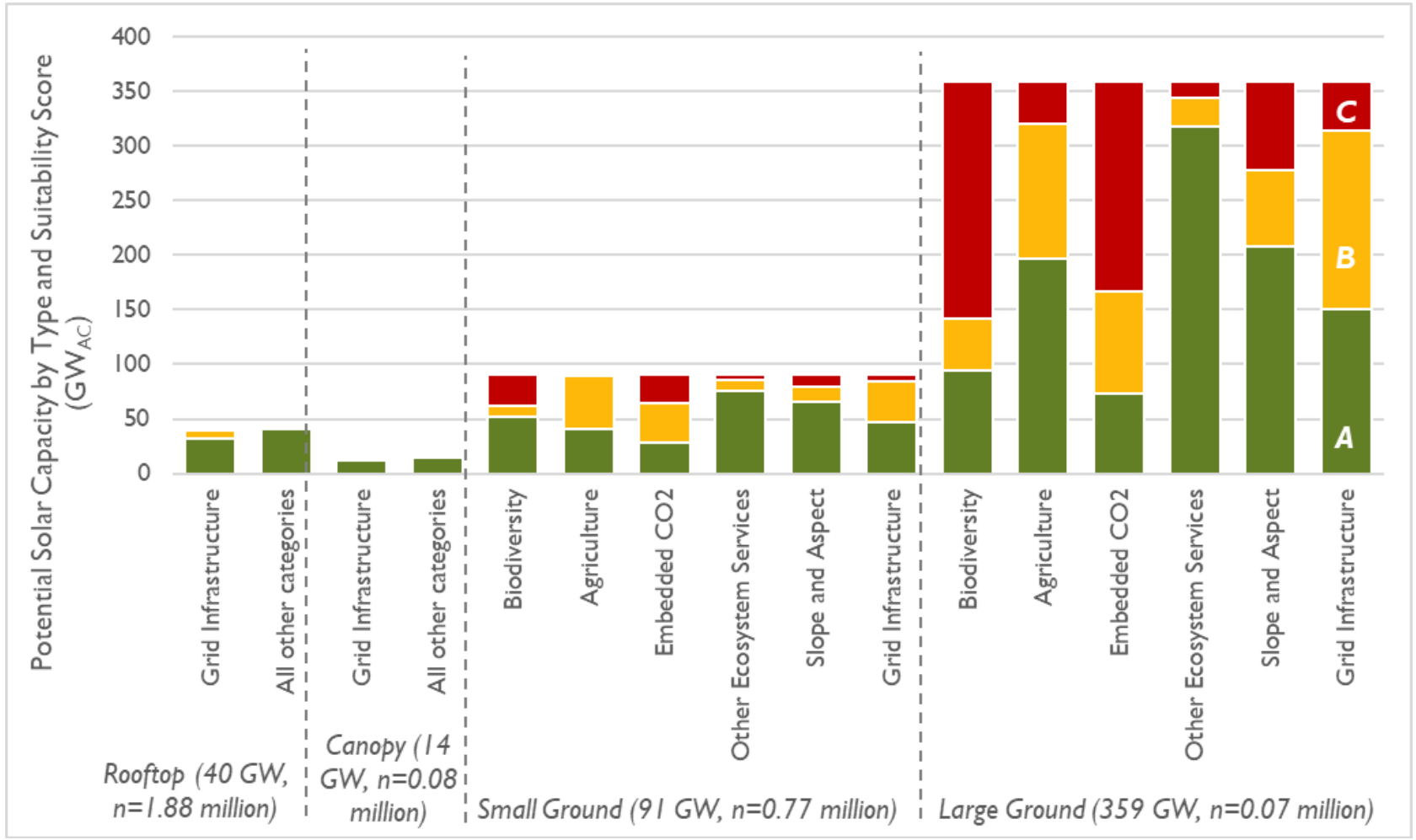
Key Take Away: Massachusetts has **506 GW** of solar potential

Figure 3. Total technical solar potential and cost/watt of type of solar



Suitability Results

Figure 4. Share of technical potential by solar type and suitability score



Key Take Aways:

- **152 GW_{AC}** receives a Highly Suitable score (A or B in every category)
- **52 GW_{AC}** receives an A in every category
- *We can site solar **strategically** to balance land use priorities while meeting solar deployment needs*

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Results – Suitable Potential

Figure 6. Solar potential by combined suitability score, all types, no "C" grades

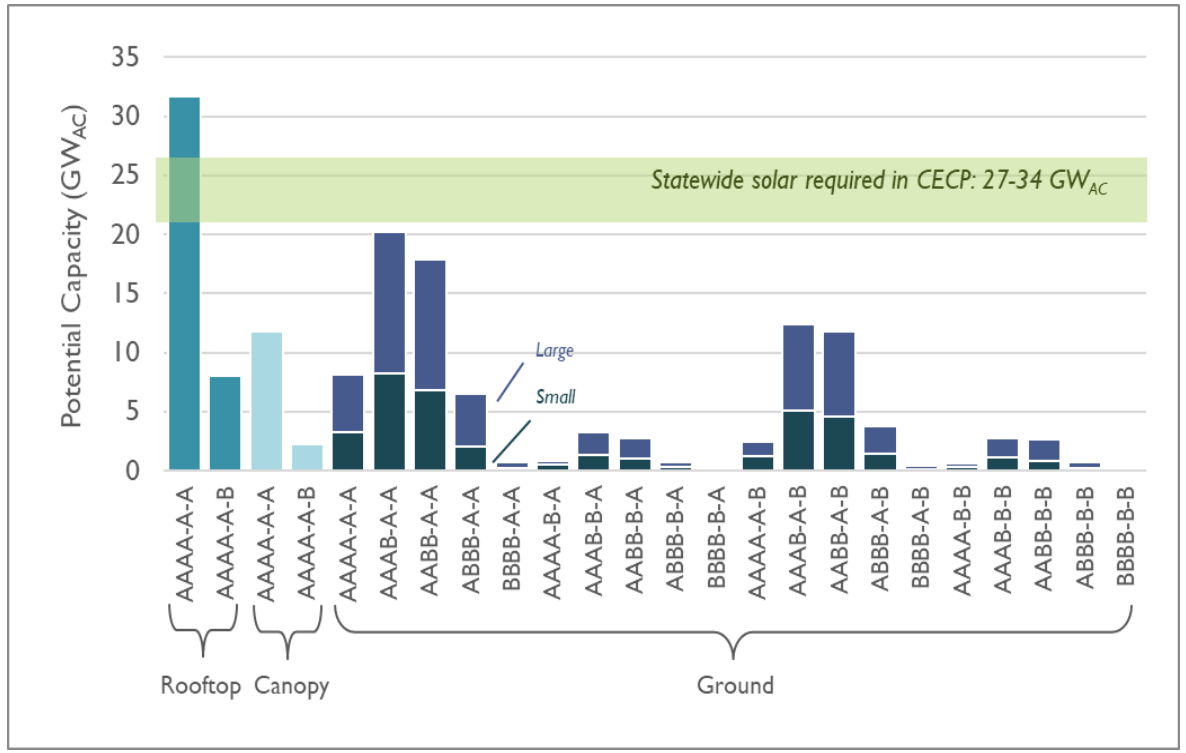
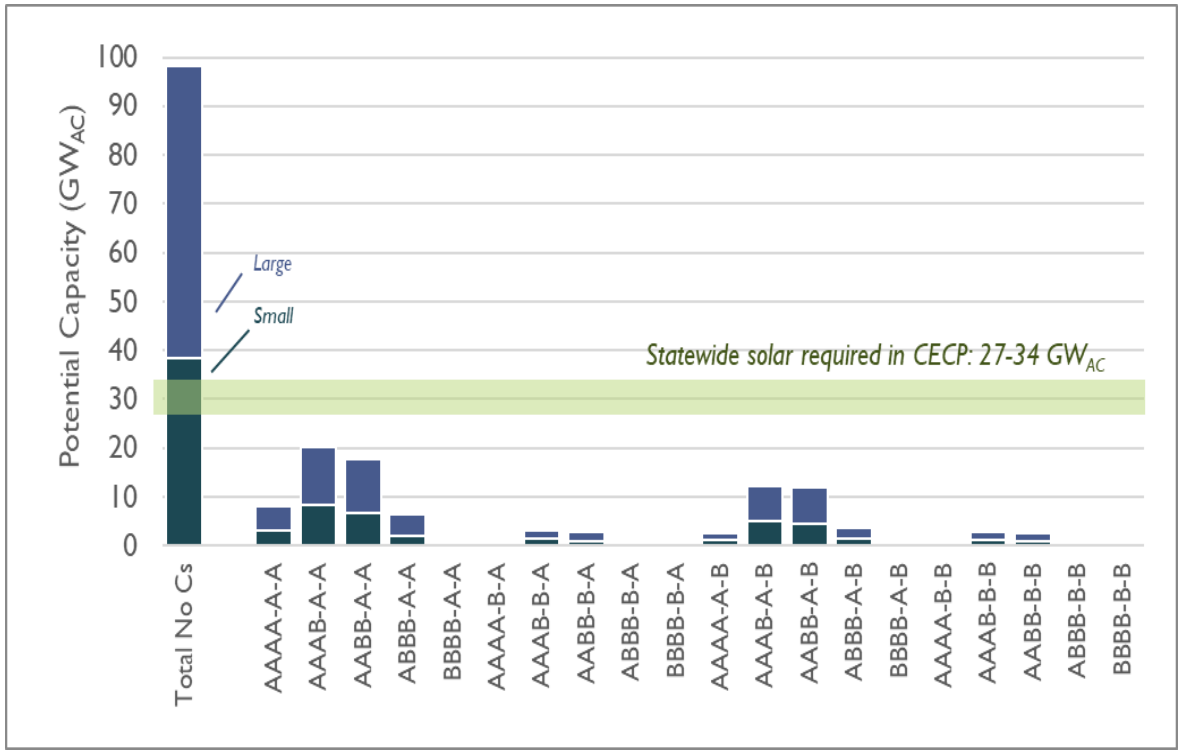


Figure 7. Solar potential by combined suitability score, ground-mounted solar only, no "C" grades



Policy Considerations

- We do not assume we will max out solar deployment in all Highly Suitable locations
  - Competition for roof space as building electrification increases need for other rooftop equipment
  - Roof age, condition, and structural ability
  - Disincentives for commercial property owners to install solar (split incentives)
  - Competition from other types of development (housing, etc.)
  - Some potentially suitable locations may have been screened out with our methodology – ex. Certain wellhead protection zones.
- Grid infrastructure is a major barrier to solar deployment
  - Analysis does not account for current hosting capacity
- Environmental justice is a nuanced topic that cannot be analyzed quantitatively
  - Solar siting decisions in EJ communities require community planning and engagement
  - Story Map is a tool to facilitate engagement with EJ communities about priority locations for solar

Story Map

- https://technicalpotentialofsolar-ma-synapse.hub.arcgis.com/

Next Steps

- Additional analysis using related spatial data
  - Overlay with Environmental Justice map
  - Overlay with hosting capacity maps
- Findings may inform future policies to achieve CECP limits
  - Grid Modernization Advisory Council
  - DOE Solar for All grant application
  - Next generation solar programs

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Massachusetts Department of Energy Resources

THANK YOU!

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Massachusetts Department of Energy Resources

Embodied Carbon Reduction Policies and Strategies

Embodied Carbon Agenda

Why are we talking about embodied carbon?

What exactly is embodied carbon? Where does it come from and how do we track it?

How can we reduce embodied carbon in state projects?

Massachusetts Department of Energy Resources

The Why: Embodied Carbon Policies in MA and Beyond

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Massachusetts Department of Energy Resources

KEY TERMS

- **Embodied Carbon:** The greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials (CLF)
- **Environmental Product Declaration (EPD):** A report that provides third-party verified data about a product's lifecycle environmental performance, including global warming potential (International EPD System)
- **Global warming potential (GWP):** A measure of how much energy the emissions of 1 ton of gas will absorb over a given period of time, relative to 1 ton of CO_2. The larger the GWP, the more that a given gas warms the Earth compared to CO_2. (EPA)
- **Whole-Building Life Cycle Assessment (LCA):** An evaluation of a building's environmental impacts throughout its life cycle, including material production, construction, usage, end-of-life, and externalized impacts (CLF)

EXECUTIVE ORDER 594

- Section 3: Mass LEED Plus 2.0 Standard for New Construction
  - To maximize the potential GHG emissions reductions, all new construction and substantial renovations, where possible and cost-effective, shall…**Evaluate and implement strategies to reduce embodied carbon contained in building materials.**
- Section 8: Guidance, Guidelines and Studies
  - LBE, in collaboration with other agencies, will lead efforts to develop guidance, guidelines or studies to support agency implementation of strategies and programs designed to meet the goals of this order. Including but not limited to…**recommendations on whether and how agencies may incorporate embodied carbon into their emissions calculations and programs**

EMBODIED CARBON POLICIES IN MA

State Policies

- **2050 CECP**: "Following the completion of the (EO594 Section 8), research the Commonwealth will explore incorporating embodied carbon standards into the evaluation of new state facilities."
- **Commission on Clean Heat**: Recommended Research and Development - *Embodied carbon of new construction and best practices for mitigating associated emissions*

Proposed Legislation

- (HD.1033/SD.840) Act Incorporating Embodied Carbon into State Climate Policy (*Private Sector*)
- (HD.2668 / SD.817) Act requiring state procurement of low-carbon building materials (*State Projects*)
- (SD.820) Act relative to the use of low-embodied carbon concrete in state projects (*State Projects & Infrastructure*)

Municipal Policies

- Boston: Mass Timber Accelerator; Article 37 and Zero Carbon Building Zoning; Zero Waste Boston Deconstruction Initiative
- Brookline: Resolution for EC reduction in concrete, for municipal projects and infrastructure
- Cambridge: Net Zero Action Plan recommends addressing embodied carbon through updated green building requirements
- Newton: Sustainability ordinance; measurement requirements in progress
- Somerville: Zero Carbon pathway for Net-Zero Ready Buildings requires analysis of embodied carbon and proof of offset

EMBODIED CARBON POLICIES ACROSS THE U.S.

States

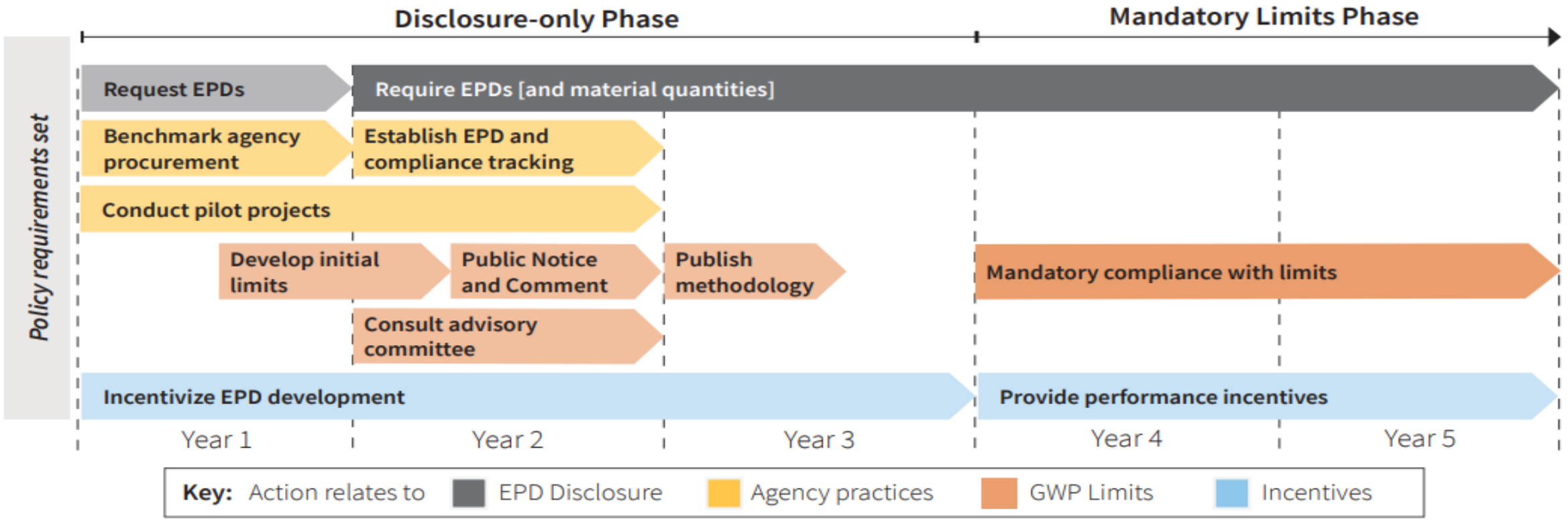
- 2017: **Buy Clean CA** set GWP limits for steel, glass, and wool for buildings and DOT. 2022 law added concrete and new limits.
- 2021: **Buy Clean WA** pilot will set GWP limits for Concrete, Steel, Wood for buildings
- 2021: **NY Low-Embodied-Carbon Concrete Leadership Act** will set GWP limits on concrete for buildings and DOT projects
- 2021: **Buy Clean CO** will set GWP limits on concrete, Steel, Wool, Asphalt, Cements, and Glass
- 2022: **Oregon pilot** targeting low-embodied carbon concrete and steel for DOT projects

Federal

- Buy Clean EO commits federal government to purchasing lower carbon steel, concrete, asphalt, and flat glass
- In spring 2022, GSA set embodied carbon standards for concrete, asphalt, and whole-buildings
- U.S. DOE currently developing tools for whole-building EC lifecycle cost assessments
- U.S. EPA grant program will support EPD development, data collection, and labeling

PHASING-IN OF EMBODIED CARBON POLICIES

State and federal policies follow similar phased approaches to collect data, set emissions limits, and eventually enforce emission limits



Source: Carbon Leadership Forum

Massachusetts Department of Energy Resources

The What: Defining and Measuring Embodied Carbon


A building project causes environmental impacts far beyond its building site.

global CO_2 emissions by sector

buildings generate nearly ***40%*** *of annual global greenhouse gas (GHG) emissions*

DECARBONIZING BUILDINGS

source: Architecture 2030

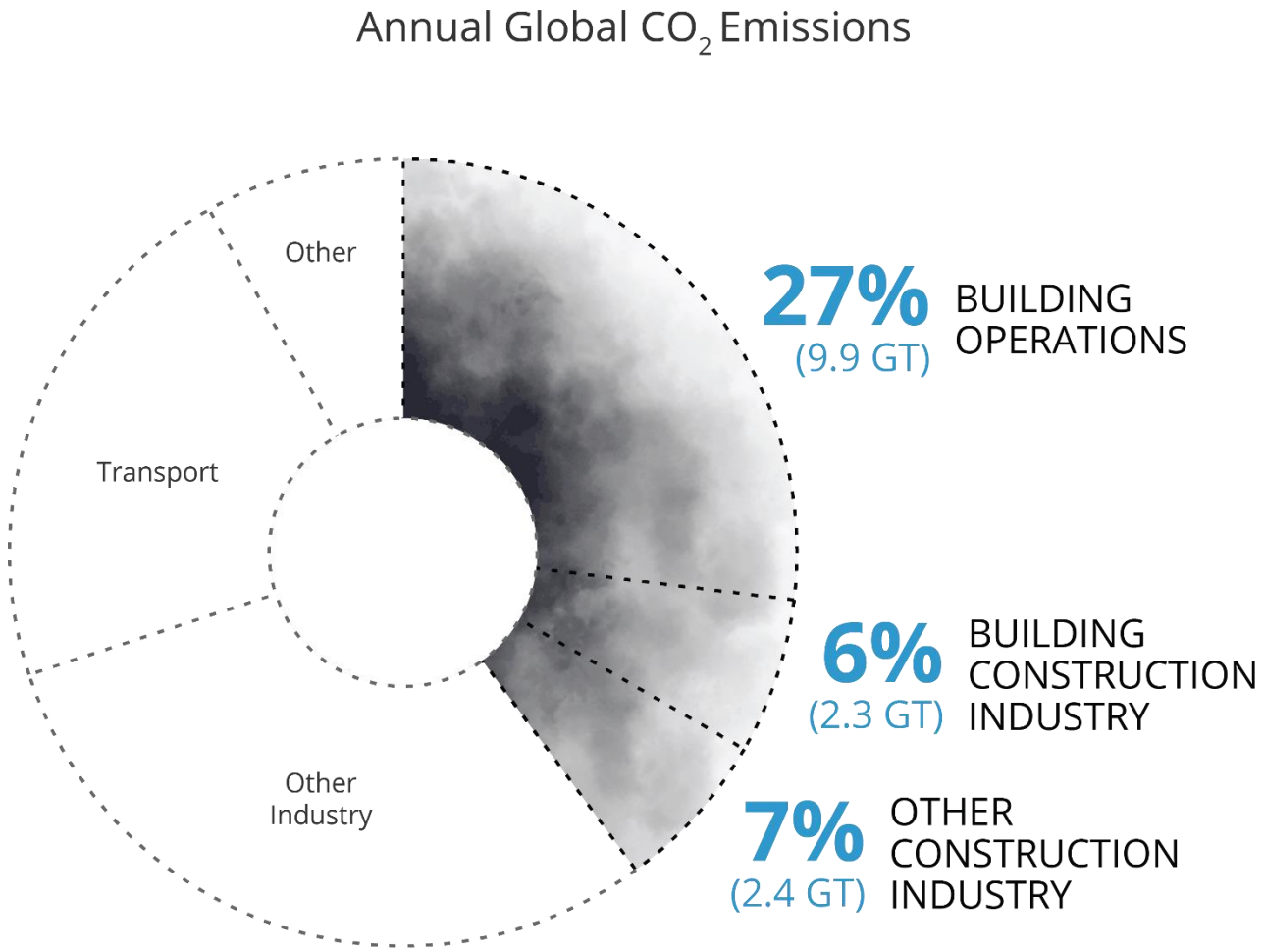
embodied energy

the energy consumed by all of the processes associated with the production of a building - such as mining natural resources, manufacturing, transporting, & construction

operational energy

the energy consumed by running a building - such as heating, cooling, lighting, & power

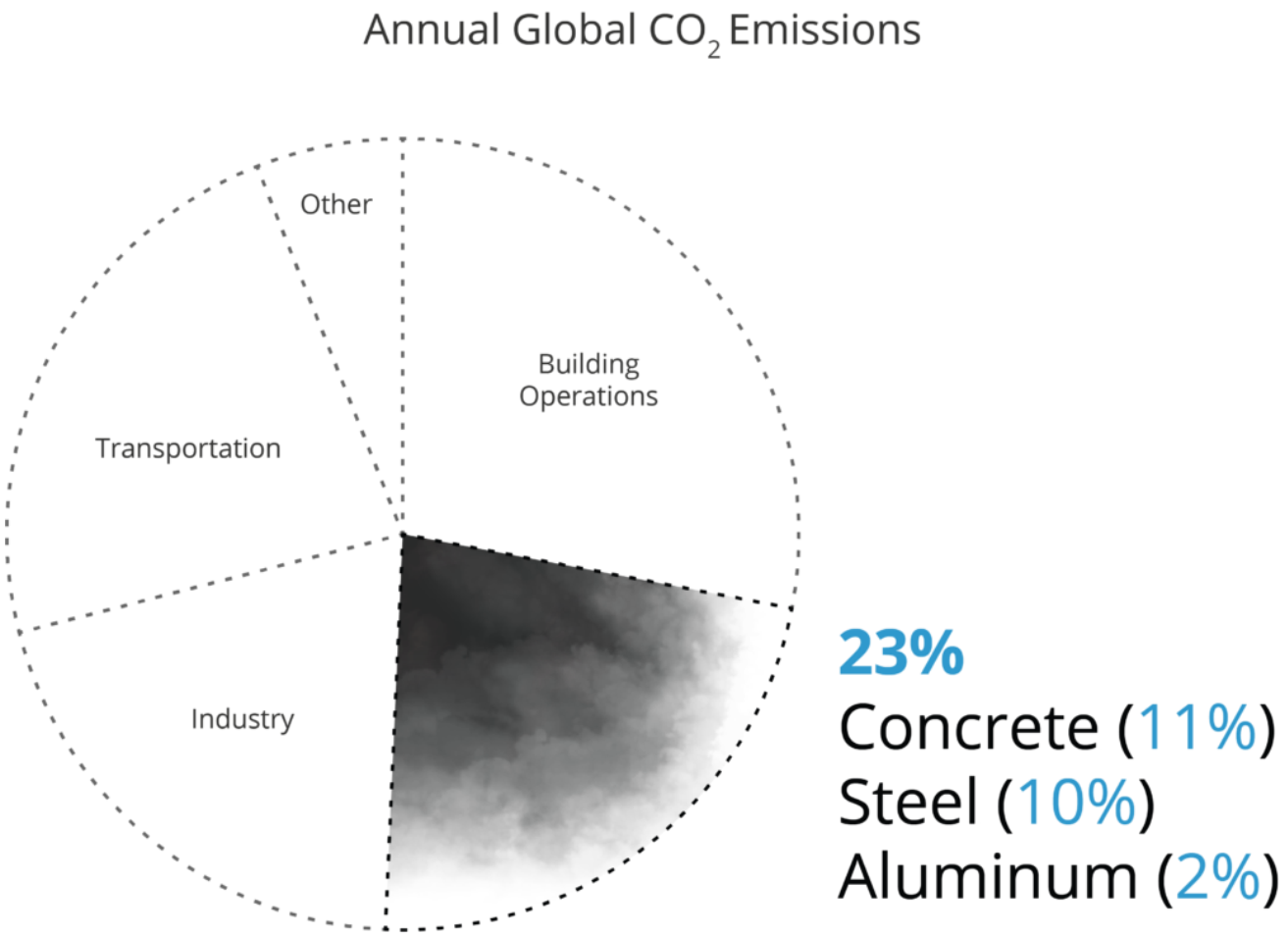
DECARBONIZING BUILDINGS



 Data Source: IEA (2022), Buildings, IEA, Paris

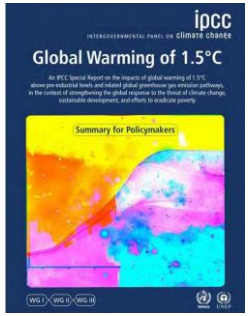
Building Construction Industry and Other Construction Industry represent emissions from concrete, steel, and aluminum for buildings and infrastructure respectively.

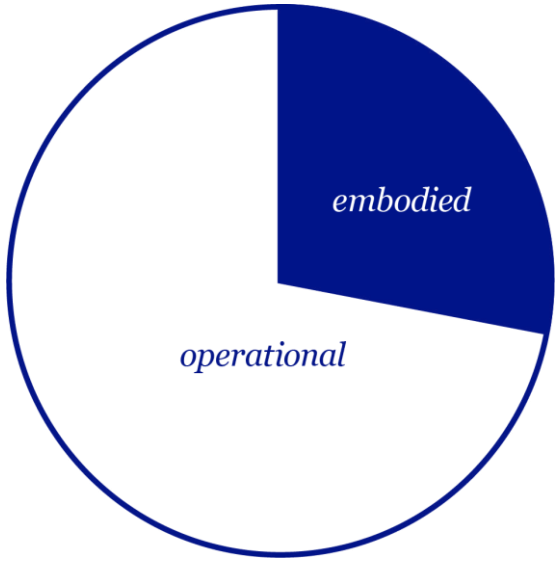
DECARBONIZING BUILDINGS



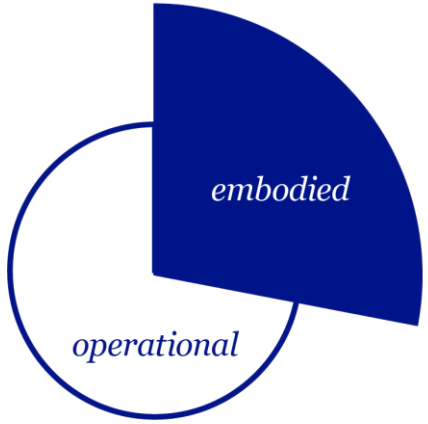
Data Sources: Global ABC Global Status Report 2018, EIA

EMBODIED & OPERATIONAL ENERGY

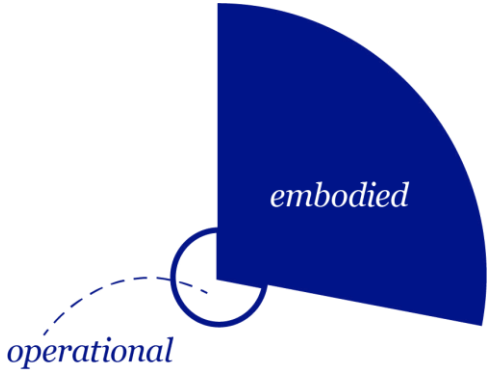




60 year lifespan
code building



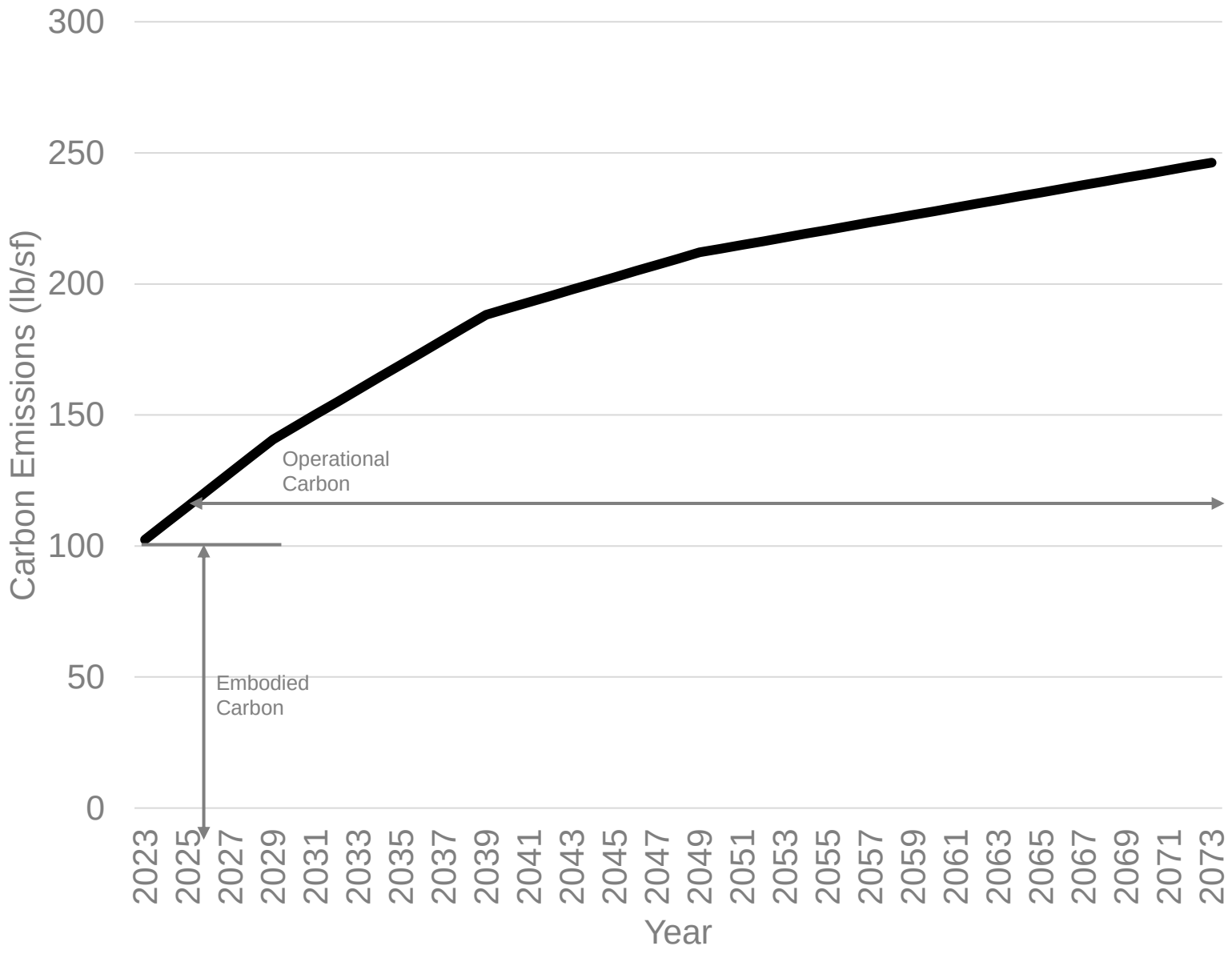
60 year lifespan
high performance building

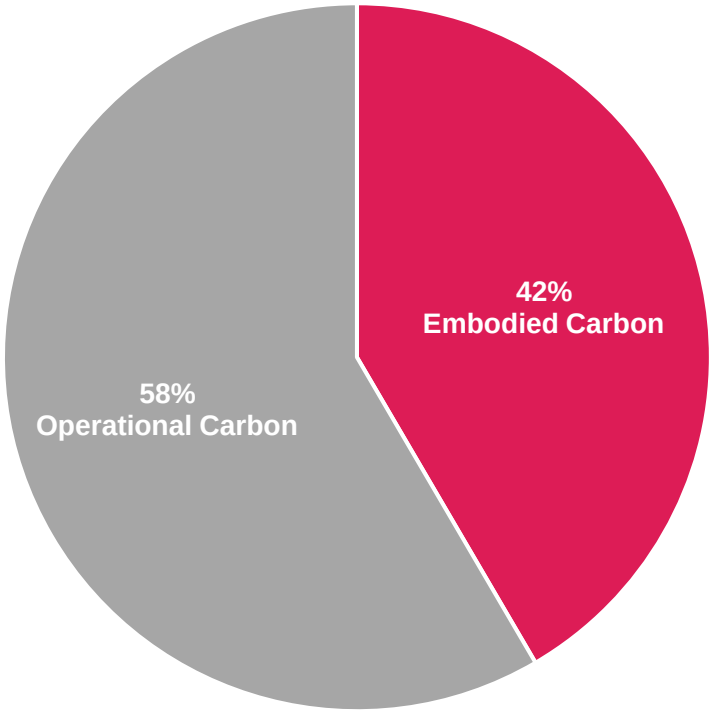


10 year lifespan
high performance building

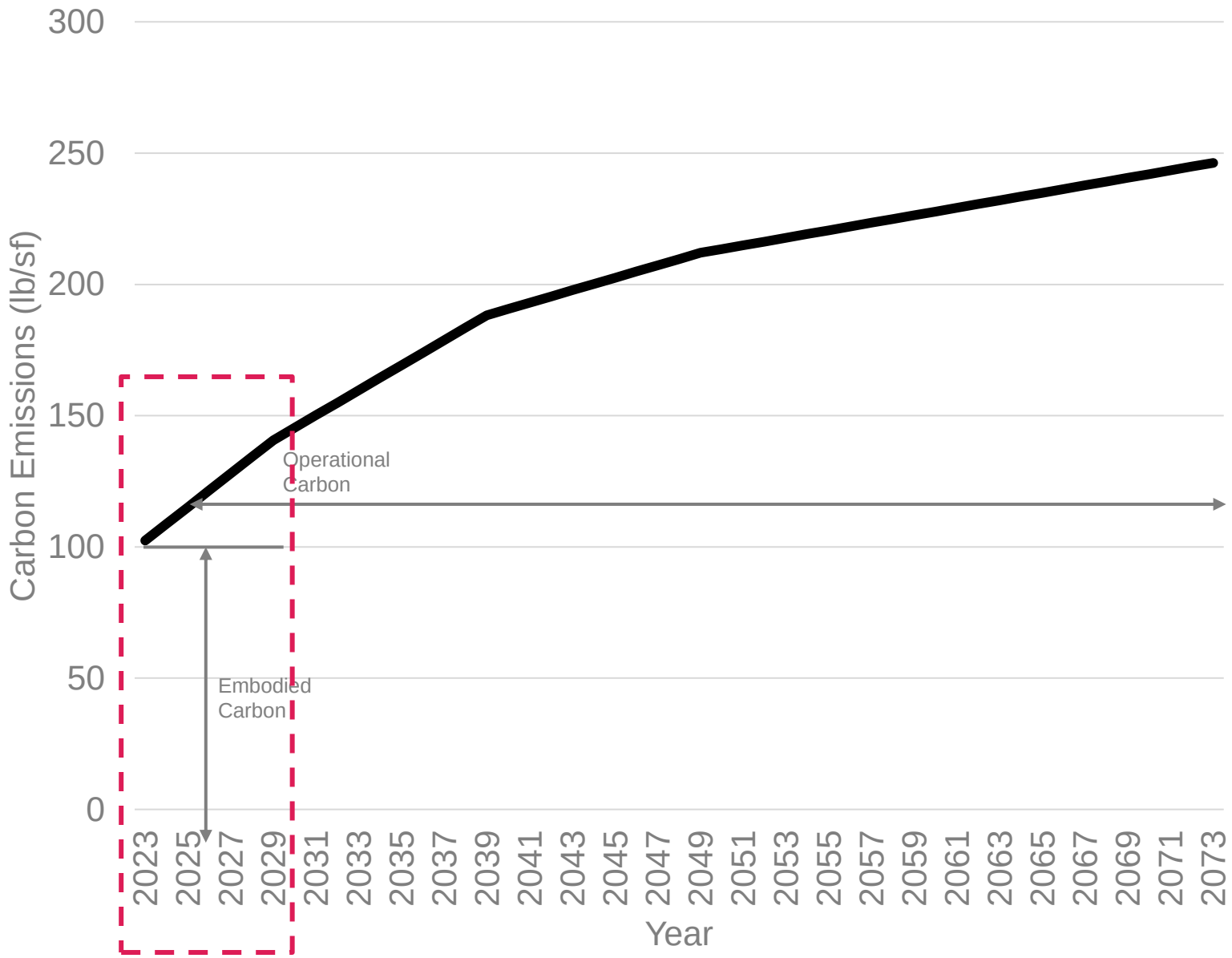
sources: K. Simonen, Life Cycle Assessment, Routledge, 2014

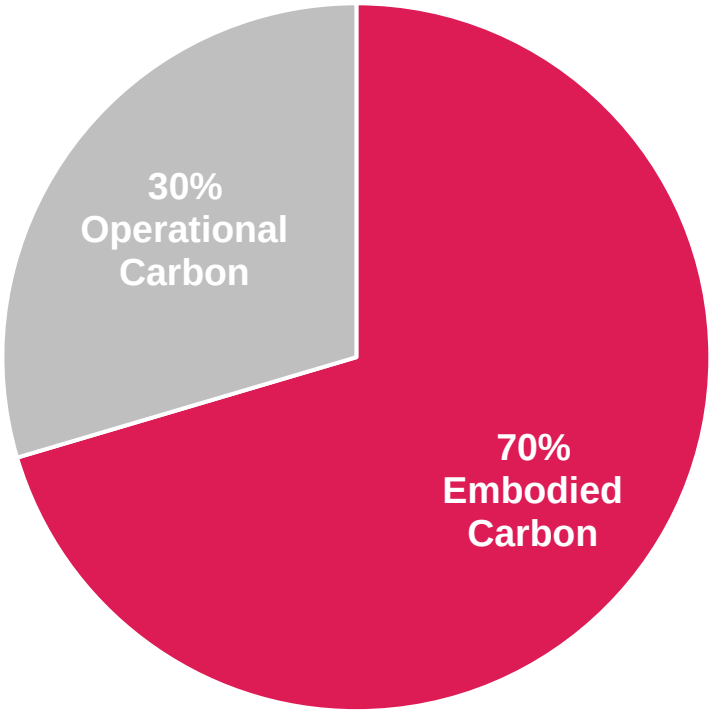
CARBON OVER THE LIFE OF A TYPICAL NEW BUILDING IN MASSACHUSETTS





TIME VALUE OF CARBON





LIFE CYCLE ASSESSMENT

LIFE CYCLE ASSESSMENT

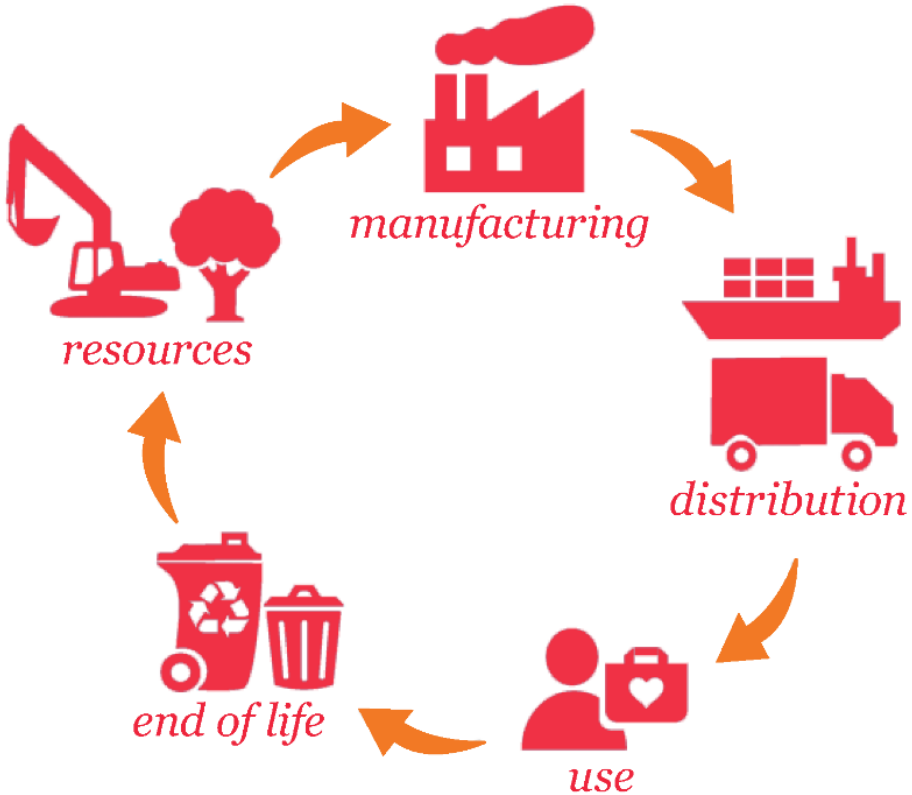


image source: Eco Enterprises Quebec

GWP

ODP

Acidification

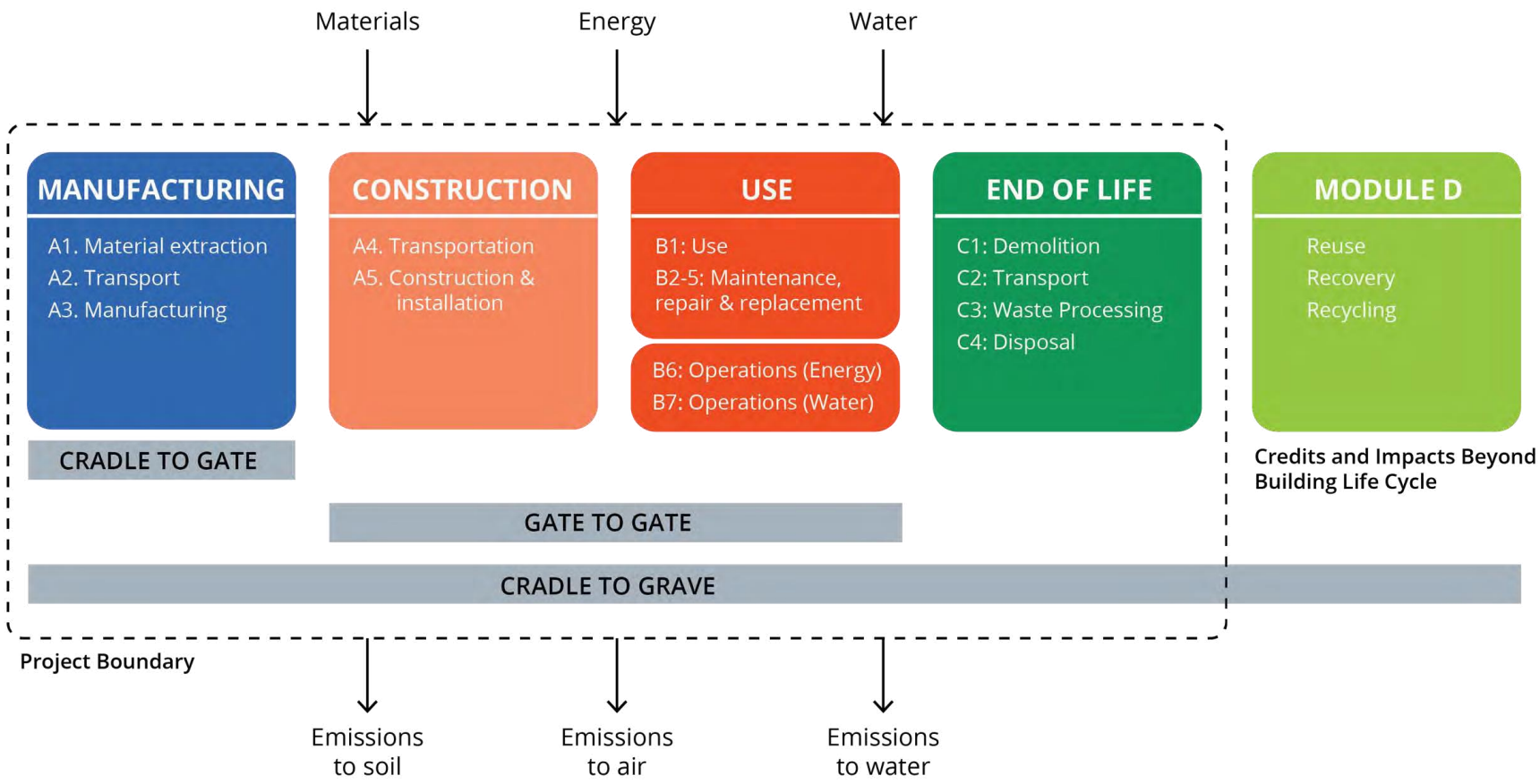
Eutrophication

Smog

Energy Use

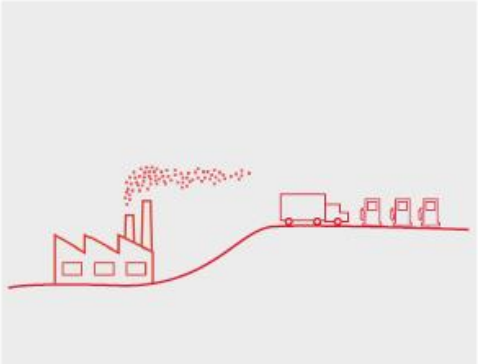
LCA

SYSTEM BOUNDARY



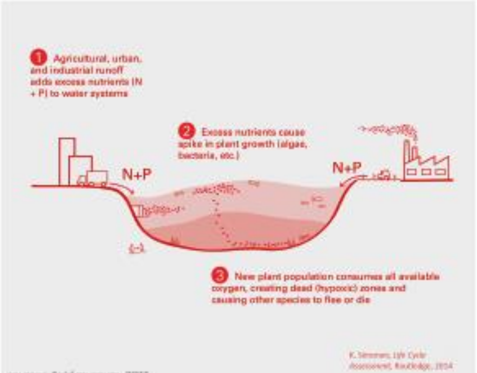
HOW TO MEASURE LIFE CYCLE IMPACTS

non-renewable energy [MJ]



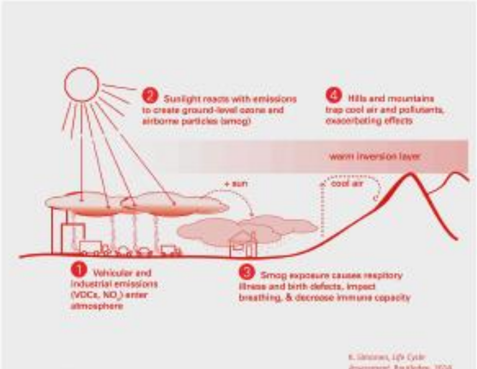
sources: iStock

eutrophication potential [kg N-eq]



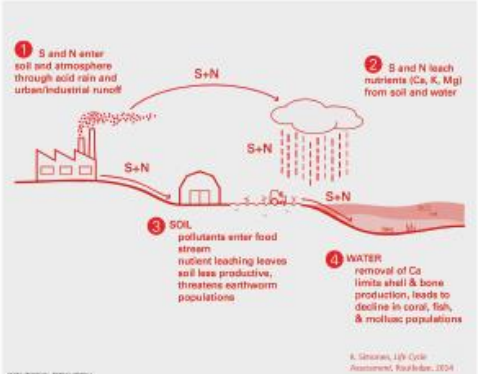
sources: field museum, 2017

smog formation potential [kg O_3-eq]



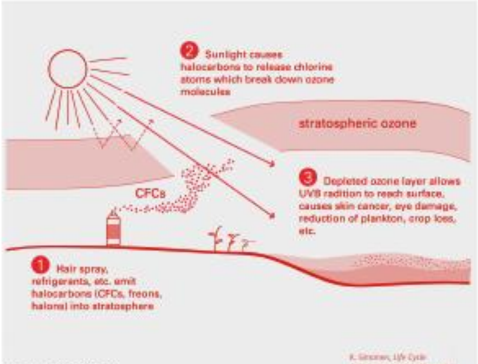
sources: getty images

acidification potential [kg SO_2-eq]



sources: nps.gov

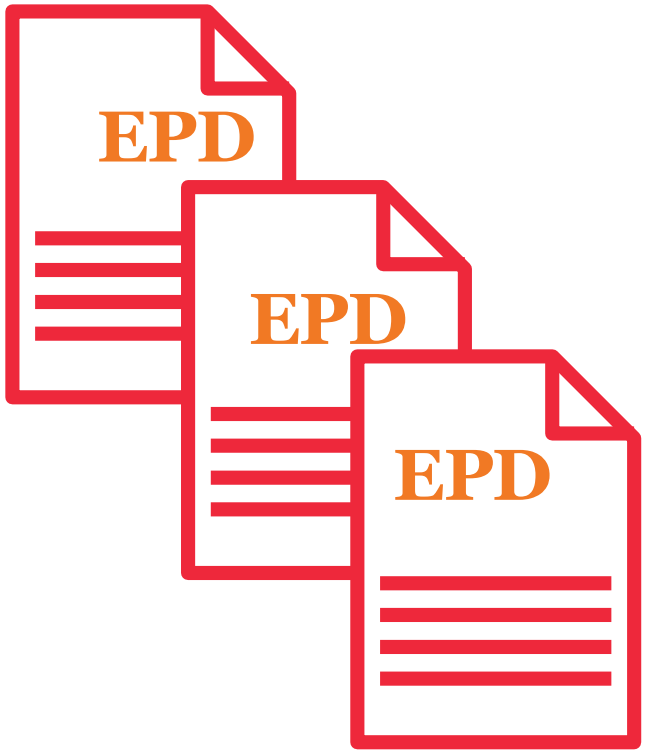
ozone depletion potential [kg CFC 11-eq]



sources: recondoil.com

LIFE CYCLE ASSESSMENT TOOLS

MANUAL vs. COMPUTED



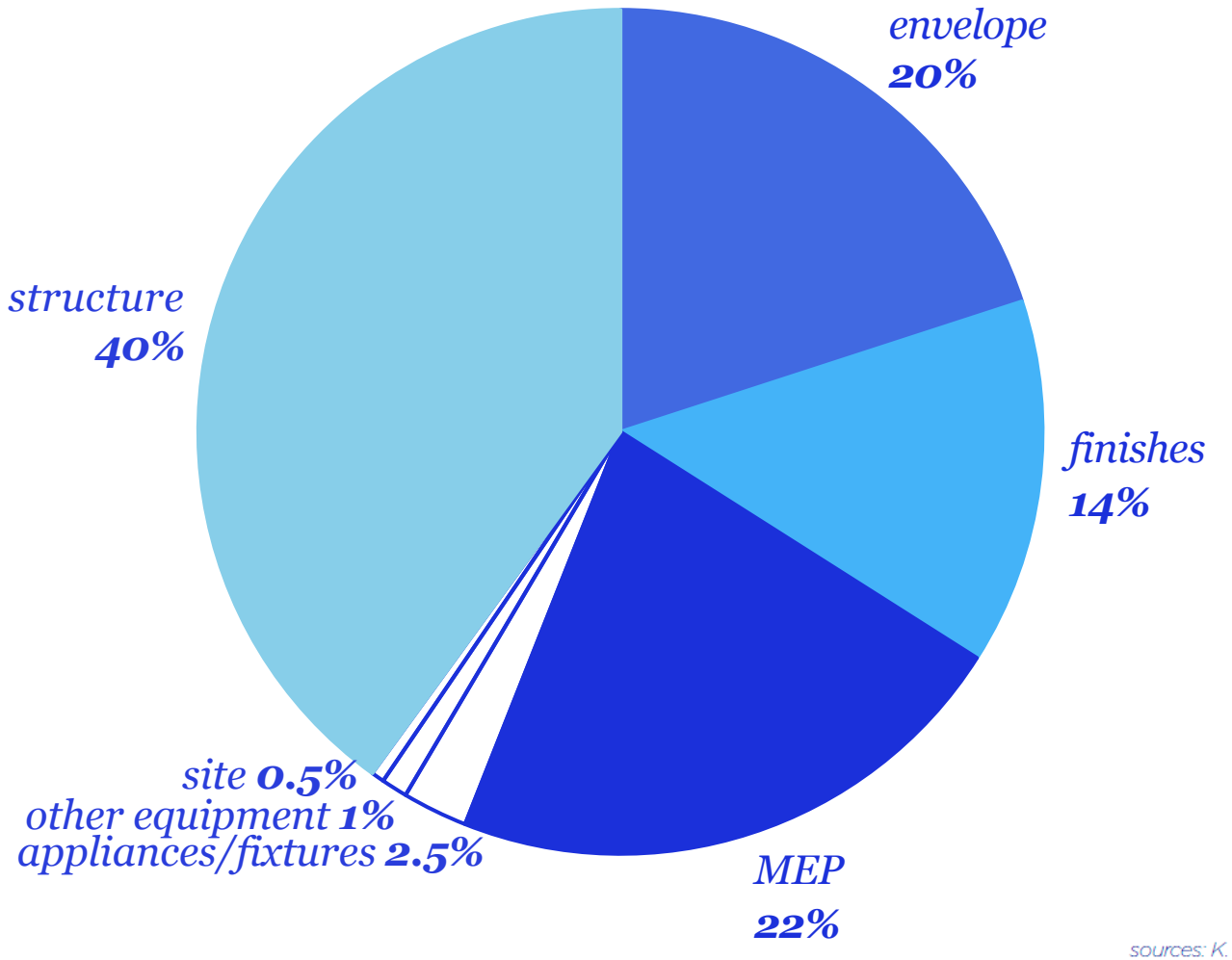
tally®

Athena Impact Estimator for Buildings

One Click LCA

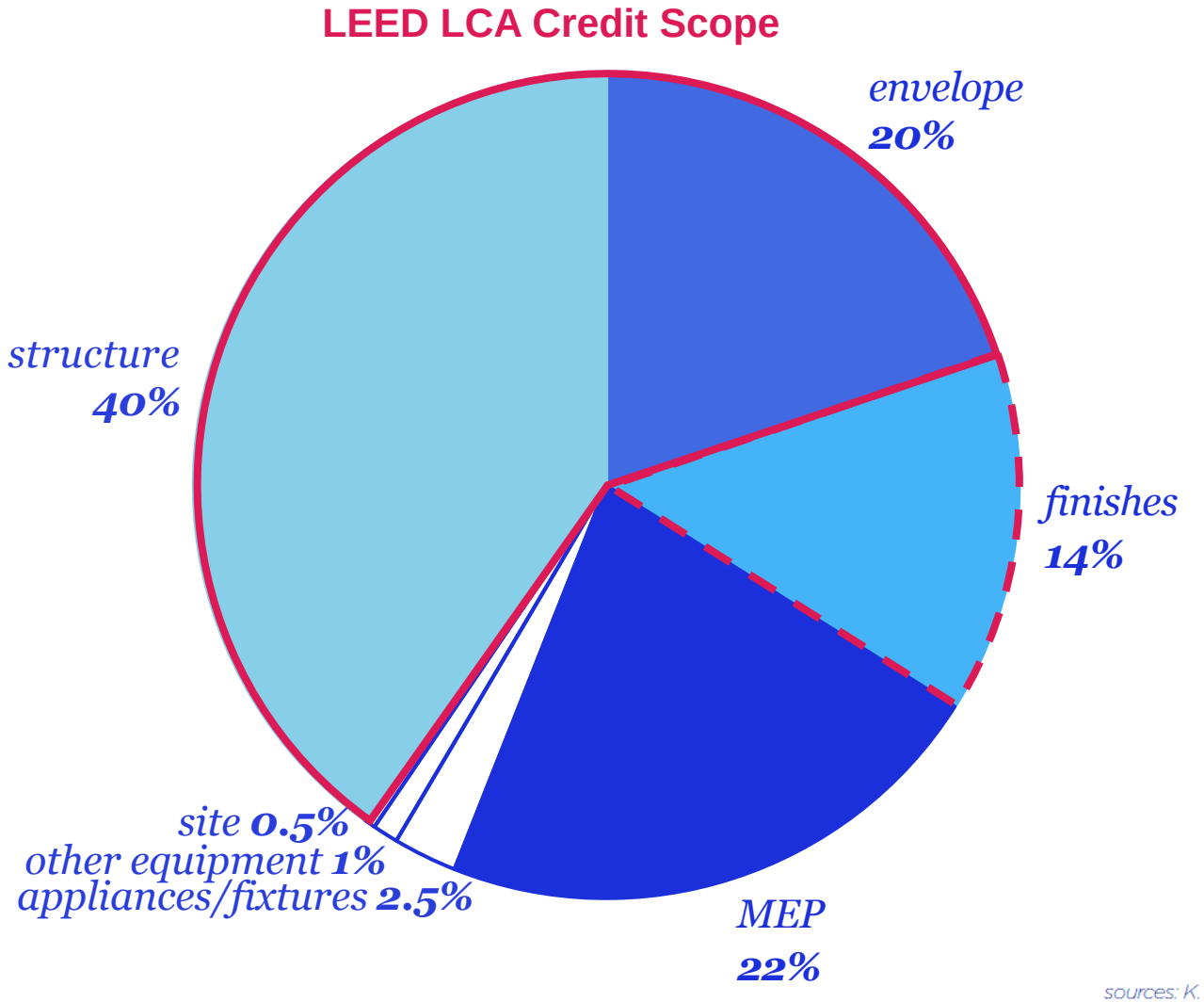
EC3
Embodied Carbon Calculator for Construction

EMBODIED CARBON IN BUILDINGS



sources: K. Simonen, Testing Whole Building LCA: Research and Practice, 2015

EMBODIED CARBON IN BUILDINGS



sources: K. Simonen, Testing Whole Building LCA: Research and Practice, 2015

LEED V4.1 CREDITS

Materials & Resources: Building Life-Cycle Impact Reduction

Option 2: Whole Building Life-Cycle Assessment (1-4 points):

For new construction (buildings or portions of buildings), conduct a cradle-to-grave LCA of the project's structure and enclosure and follow one of the paths below to earn up to 4 points:

- *Path 1 (1 point):* Conduct LCA of structure and enclosure
- *Path 2 (2 points):* Conduct LCA of structure and enclosure that demonstrates a minimum of 5% reduction, compared with baseline building in at least 3 of the 6 impact categories listed below, one of which must be GWP*
- *Path 3 (3 points):* Conduct LCA of structure and enclosure that demonstrates a minimum of 10% reduction, compared with baseline building in at least 3 of the 6 impact categories listed below, one of which must be GWP*
- *Path 4 (4 points):* Meet requirements of Path 3 and incorporate reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared to baseline building of at least 20% reduction for GWP, and at least 10% reduction in 2 additional impact categories*

* no impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building

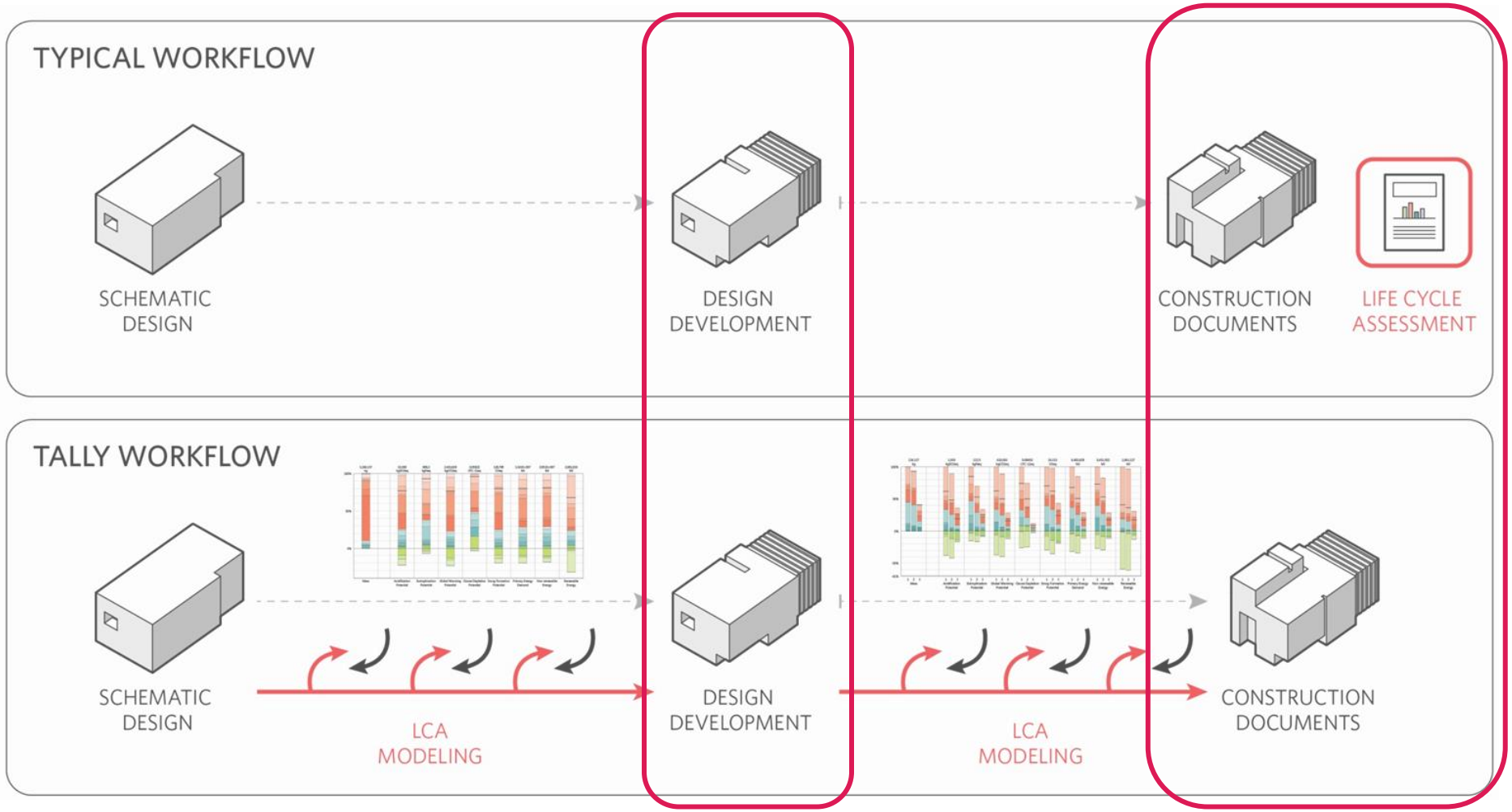
BASELINE VS DESIGN MODEL

Baseline building

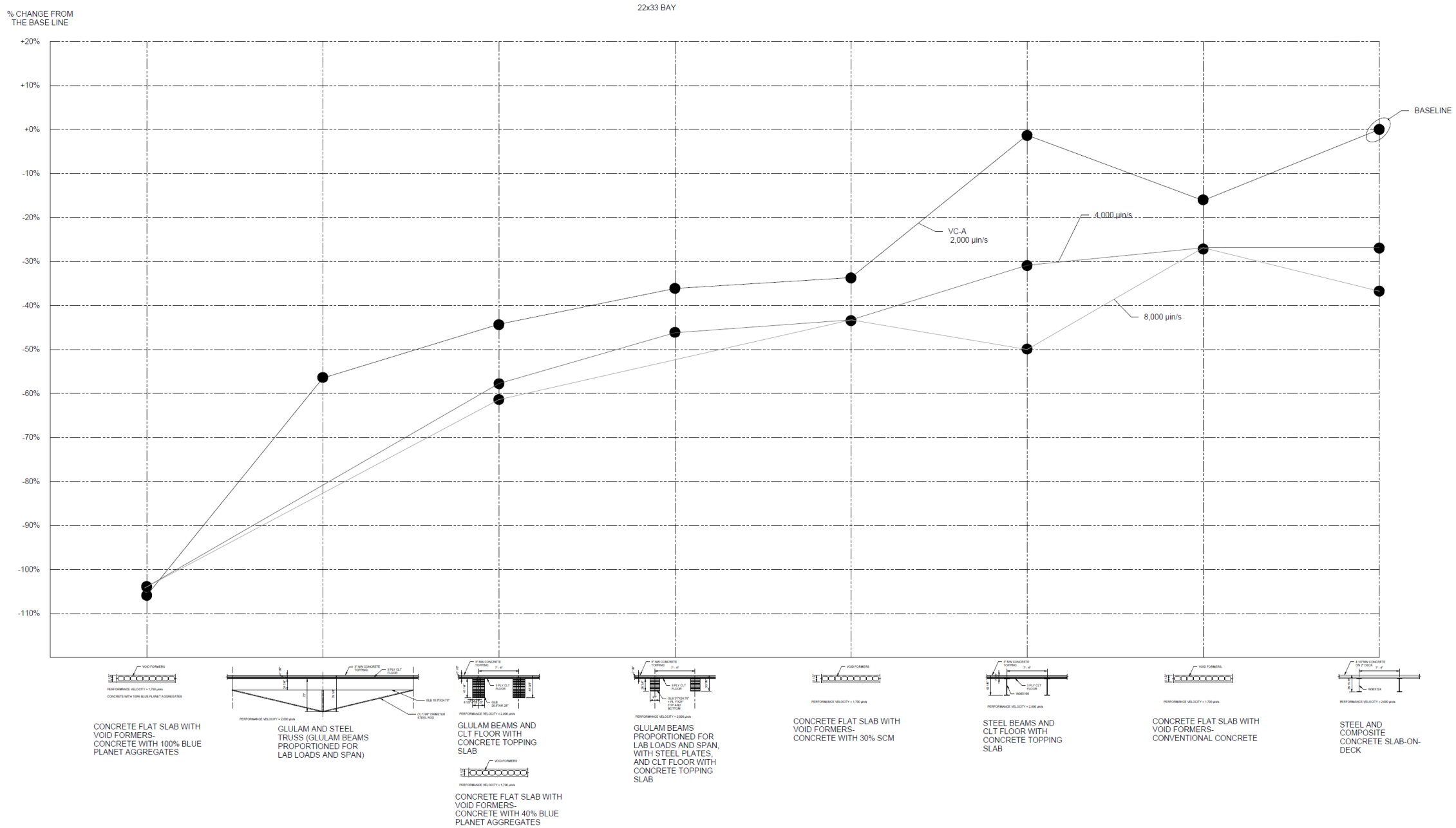
Reflect typical construction practices for location, be equivalent to design building in function, gross floor area, orientation, approx. operational energy

Design building

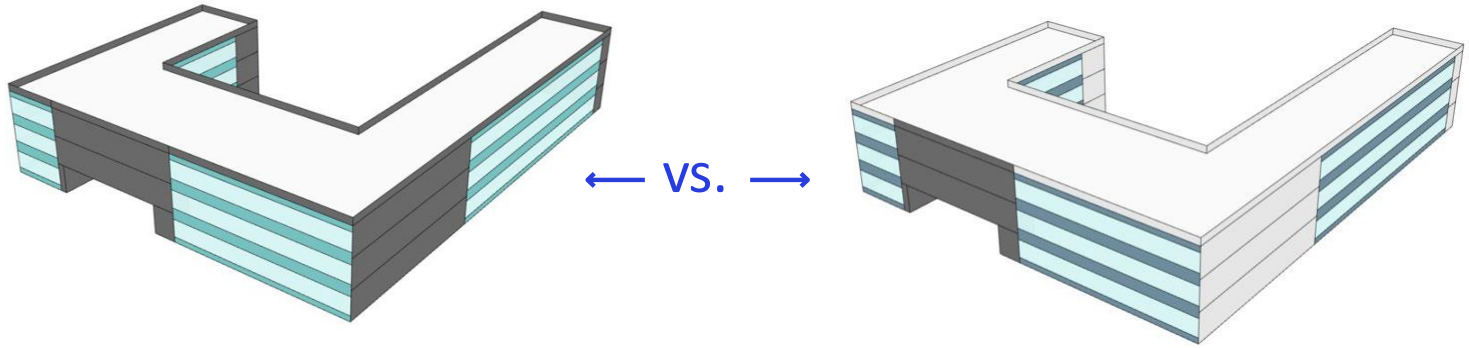
Final project design



EMBODIED CARBON REDUCTIONS - STRUCTURES



EMBODIED CARBON REDUCTIONS - ENVELOPE



ENVELOPE CALCULATOR

◉ Initial Carbon (only Module A) ○ 60 Year (with Module D) ○ 60 Year (no Module D)

Option 1

Type	Square Feet	GWP
MV - Granite	15470	286968.50
CW - Spandrel (Alum w/ Backpan)	8665	123822.85
	24,135 ft²	410,791.35 kgCO₂eq

Option 3

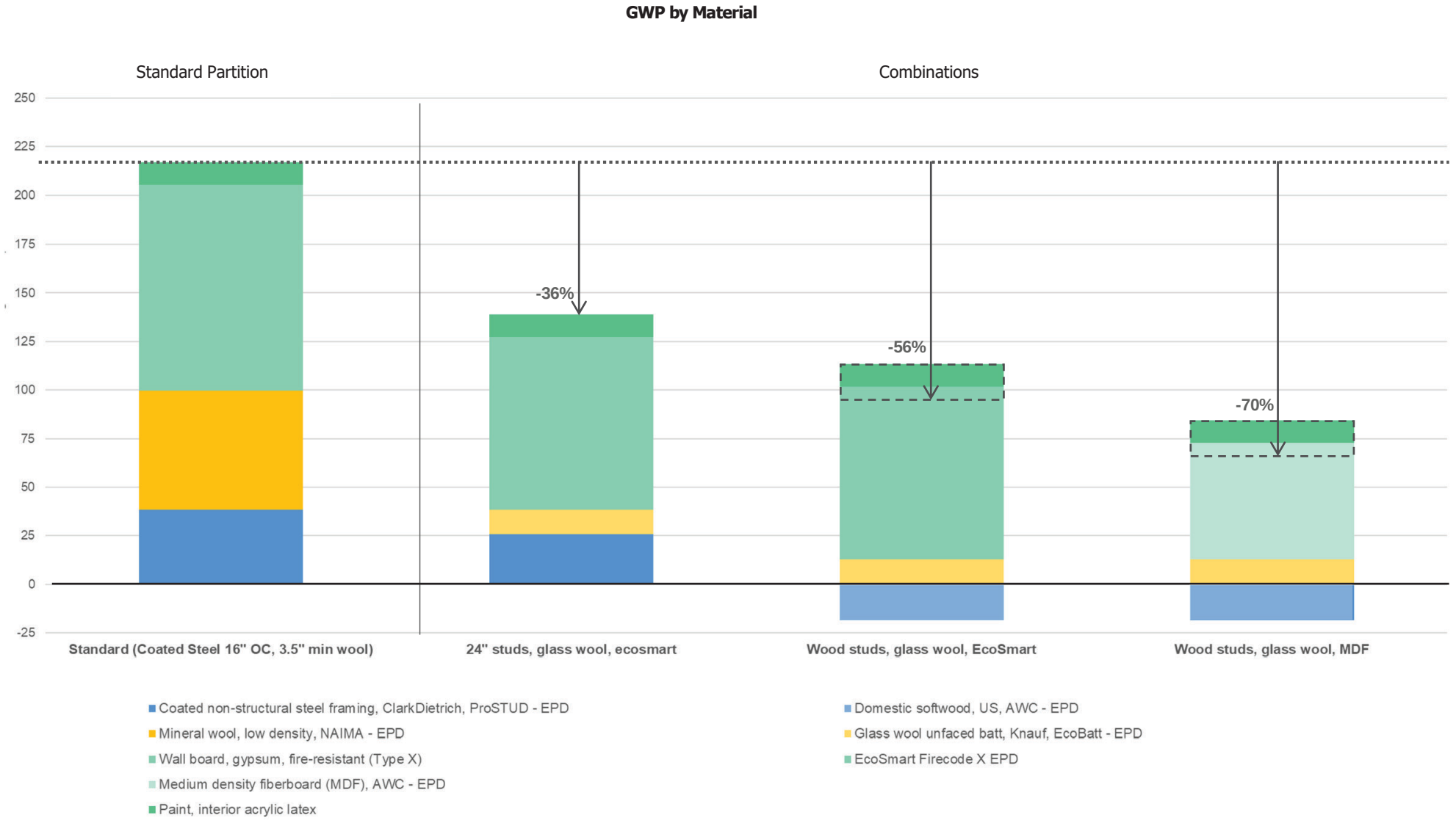
Type	Square Feet	GWP
MV - Granite	2659	49324.45
RS - Granite	12811	82502.84
RS - Formed Zinc Panel	8665	[illegible]
	24,135 ft²	189,449.54 kgCO₂eq

54% reduction in embodied carbon!

EMBODIED CARBON REDUCTIONS - PARTITIONS

EMBODIED CARBON OF PARTITIONS

Study Module: 12’6” floor-to-floor, 10’ long, 1 year lifespan

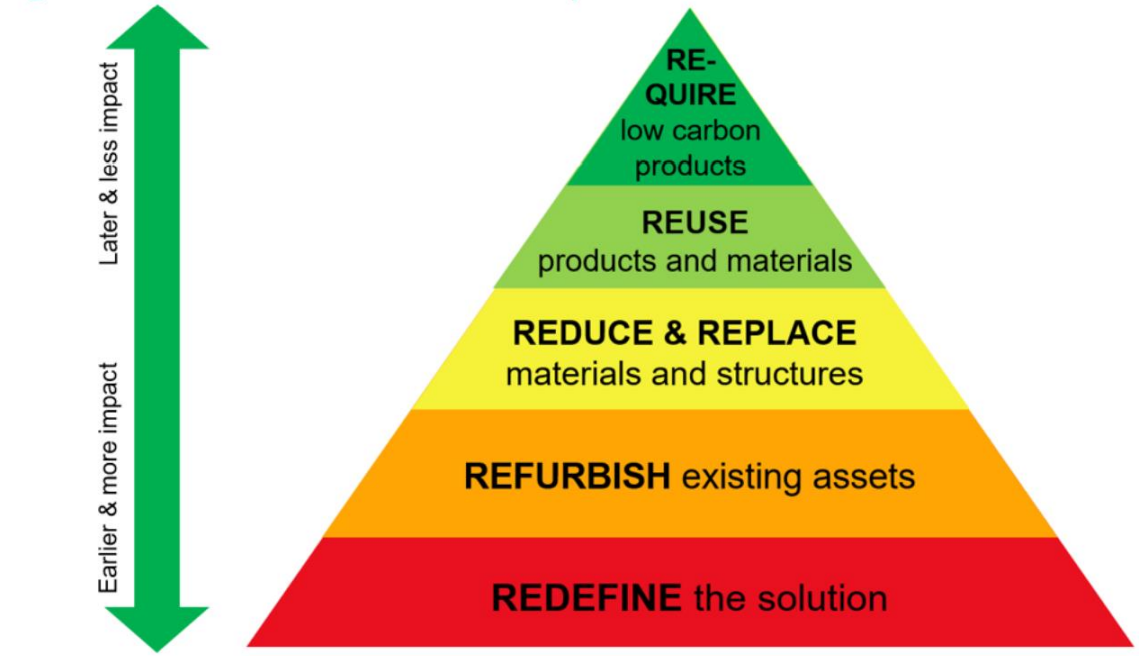


Partition Analysis

REDUCING EMBODIED CARBON

- Select materials that have lower global warming potential
- Use biobased materials
- Reuse buildings and materials
- Use less materials
- Look at the holistic carbon impacts of material choices

Figure 2 Embodied Carbon Reduction Pyramid

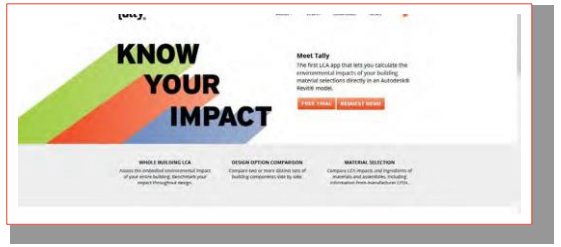


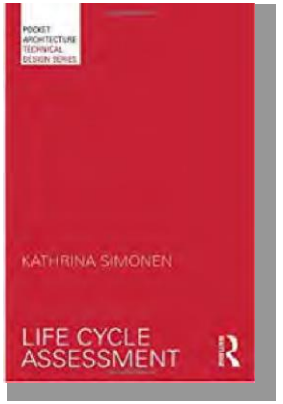
City Policy Framework for Dramatically Reducing Embodied Carbon

Source: Carbon Neutral Cities Alliance, City Policy Framework for Dramatically Reducing Embodied Carbon, 2021

RESOURCES

- *Carbon Leadership Forum*
- *Architecture 2030*
- *BSA Embodied Carbon 101*
- *choosetally.com*
- *EC3*
- *Athena Sustainable Materials Institute*
- *oneclicklca.com*
- *payette.com/kaleidoscope-tool/*
- *Carbon Smart Palette*
- Pocket Architecture Technical Design Series: *Life Cycle Assessment* - Kathrina Simonen





Massachusetts Department of Energy Resources

The How: Strategies to Reduce Embodied Carbon in Massachusetts Projects

Concrete EPD Kickstarter: Environmental Product Declarations

- $3,000 grant for each Massachusetts ready-mix concrete plant
- To partially offset costs for third-party verified site specific instant EPDs
- All state construction and transportation projects can ask for good, better, best GHG mixes on projects now
- www.macapa.org/epd-grant-program/ or email Craig hq@macapa.org

MASSACHUSETTS CLEAN ENERGY CENTER®

Jayne Lino, MassCEC

MASSACHUSETTS CLEAN ENERGY CENTER

EMBODIED CARBON REDUCTION CHALLENGE

THE CHALLENGE: REDUCE UPFRONT CARBON OF BUILDINGS

ENTRIES DUE MARCH 31, 2024 | 5:00 PM

EMBODIED CARBON REDUCTION CHALLENGE

2 TOOLS

ONE CLICK or TALLY

Available at no cost. Express interest on BE+ website

TRAINING

No cost embodied carbon educational offerings

11

PRIZES

$30,000 - $50,000

- Tips and Tricks: Tally LCA – June 27, 2023
- Tips and Tricks: One Click LCA – June 29, 2023
- Embodied Carbon Case Studies – July 23, 2023
- Embodied Carbon Tools Overview – June 14, 2023
- Tally Office Hours – October 5th, 2023
- One Click LCA Office Hours – Nov. 15th 2023
- Case Studies of Winning Submissions – July 2024

STEP 1: EXPRESS INTEREST

More resources: https://builtenvironmentplus.org/embodied-carbon-challenge/

CONCRETE

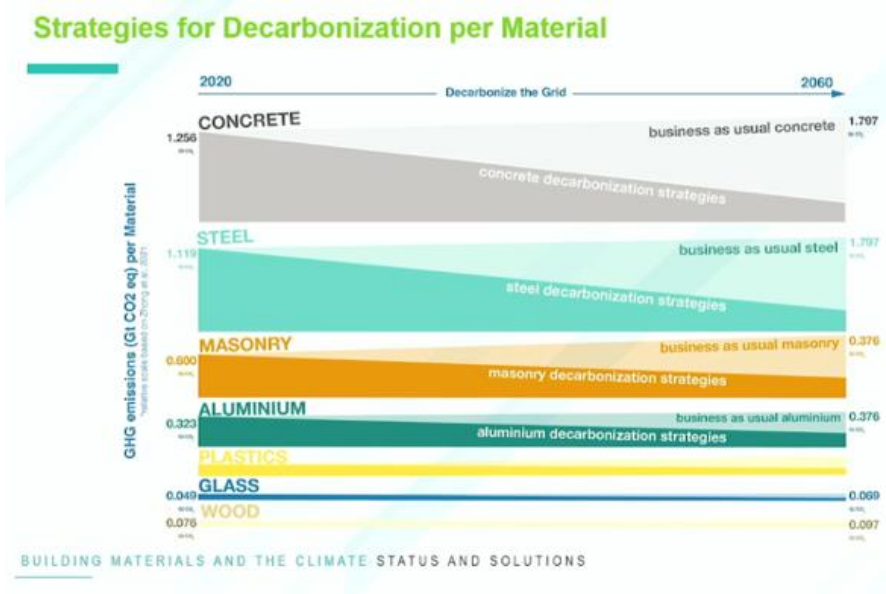
Best Practice Decarbonization Strategies

Frank Mruk, FAIA

The Top 10 List

1. Communicate Carbon Reduction Goals
2. Ensure Good Quality Control and Assurance
3. Optimize Concrete Volume
4. Use Alternative Cements
5. Use Supplementary Cementitious Materials
6. Use Admixtures
7. Don’t Limit Ingredients
8. Set Targets for Carbon Footprint
9. Sequester Carbon Dioxide in Concrete
10. Encourage Innovation

BUILD WITH STRENGTH MASSACHUSETTS



To comply with the Paris climate accord, cement emissions must fall by at least 16 percent by the end of the decade.

Zhong, X., Hu, M., Deetman, S. et al. Global greenhouse gas emissions from residential and commercial building materials and mitigation strategies to 2060. Nat Commun 12, 6126 (2021

No. 1:

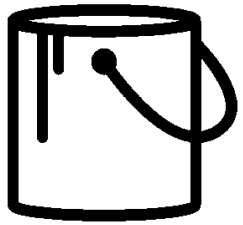
Communication Top Categories for Reducing Embodied Carbon

CONCRETE

14-33% Reduction

1.

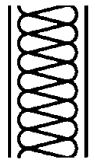
FINISHES



4-10% Reduction

4.

INSULATION



16% Reduction

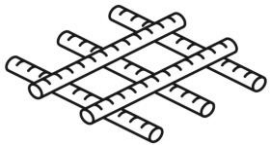
2.

GLAZING

3% Reduction

5.

REBAR



5% Reduction

3.

All at none to low-cost premium.

No. 1:

Communication Top Categories for Reducing Embodied Carbon

RMI Report, Reducing Embodied Carbon in Buildings Low-Cost, High-Value Opportunities July 2021

No. 1:

Communicate Carbon Reduction Goals

GSA's low embodied carbon concrete standard, a 20% reduction in the amount of "embodied carbon"

NJ: Bill S-287 New Jersey Law Provides Tax Credits to Low-Carbon Concrete Manufacturers

NY: Low-Embodied-Carbon Concrete Leadership Act.

Coming: MA, PA, CT

No. 2:

Ensure Good Quality Control and Assurance

Manufacturer Qualifications:

- NRMCA Certified Concrete Production Facility
- NRMCA Concrete Technologist Level 2

Installer Qualifications:

- ACI Flatwork Finisher

Testing Agency Qualifications:

- Meets ASTM C1077
- ACI Concrete Field Testing Technician Grade I
- ACI Concrete Laboratory Testing Technician Level I
- Results certified by a registered design professional

No. 2:

Ensure Good Quality Control and Quality Assurance

No. 3:

Optimize Concrete Design

If a structural element such as a column or beam is designed larger than required, then excessive concrete is being used which increases embodied carbon.

ASTM C595		
Type	**Description**	**Notes**
Type IL (X)	Portland-Limestone Cement	Where X can be between 5 and 15% limestone
Type IS (X)	Portland-Slag Cement	Where X can be up to 70% slag cement
Type IP (X)	Portland-Pozzolan Cement	Where X can be up to 40% pozzolan (fly ash is the most common)
Type IT (AX)(BX)	Ternary Blended Cement	Where X can be up to 70% of pozzolan + limestone + slag, with pozzolan being no more than 40% and limestone no more than 15%

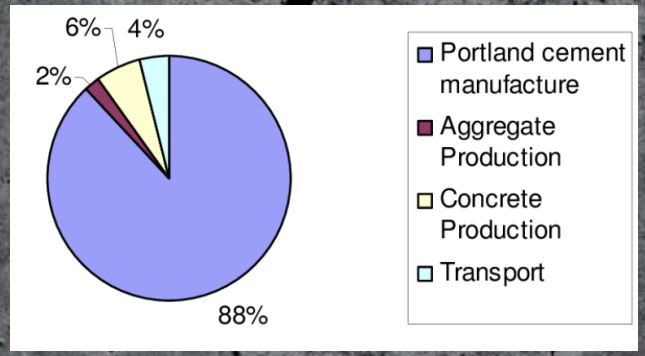
No. 4:

Use Alternative Cements

Portland-limestone cement is intended to fully replace ordinary Portland cement, 10% reduction in carbon footprint.

No. 5:

Use Supplementary Cementitious Materials



Summary of CO2 emissions derived from concrete

Concrete Materials:

1. Fly Ash or Natural Pozzolan: ASTM C618
2. Slag Cement: ASTM C989
3. Silica Fume: ASTM C1240
4. Glass Pozzolan: ASTM C1866
5. Etc.

Concrete Materials:

Chemical Admixtures:

1. Air-Entraining Admixture: ASTM C 260/C 260M
2. Water-Reducing Admixture ASTM C 494/C 494M Type A
3. High-Range Water-Reducing Admixture: ASTM C 494/C 494M Type F or G
4. Accelerating Admixture: ASTM C 494/C 494M Type C or E
5. Retarding Admixture: ASTM C 494/ C 494M Type B or D
6. Hydration Control Admixture: ASTM C 494/C 494M Type B or D

No. 7:

Don’t Limit Ingredients

- Performance Specifications

- ~~Maximum w/cm ratio~~
- ~~Air content of 6% for all concrete~~
- ~~Maximum cement content~~
- ~~Minimum cement content~~
- ~~Maximum fly ash content~~
- ~~Minimum fly ash content~~
- ~~Water: Potable~~

Concrete Strengths

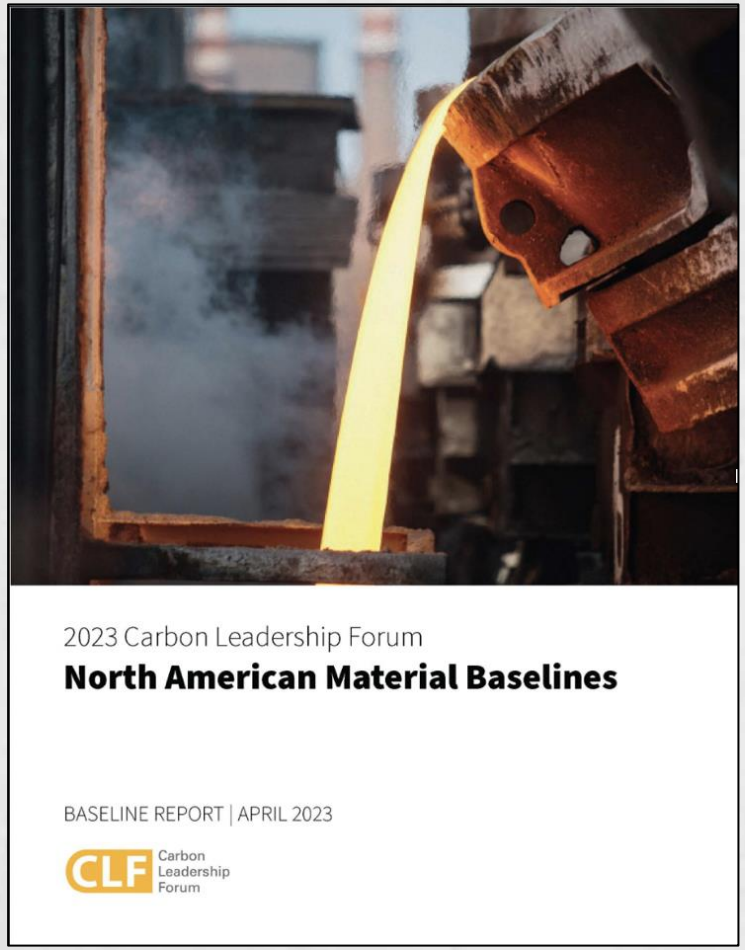
- **Shear Walls: 6,000 psi**
- **Columns: 8,000 psi**
- **Floors 2-18: 5,000 psi**
- **Floors B2-1: 5,000 psi**
- **Basement Walls: 5,000 psi**
- **Mat Foundation: 6,000 psi**

No. 8:

Set a Carbon Budget

- Resist the temptation to set carbon footprint limits for individual classes of concrete.

NRMCA & Industry Wide/Average EPD



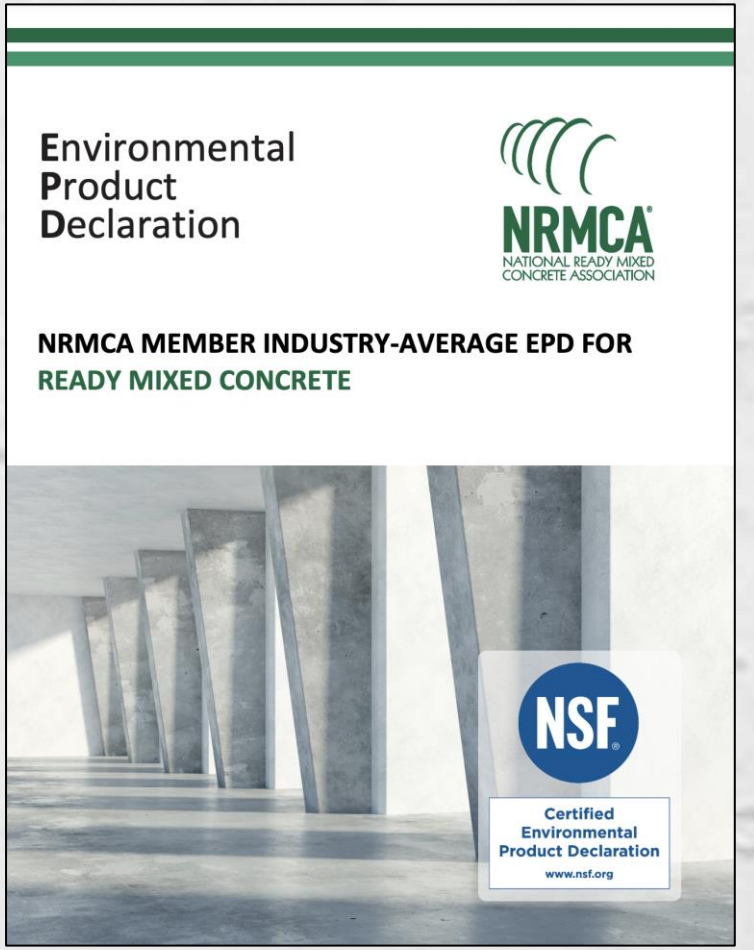


Table 1: Declared Product Range Classification

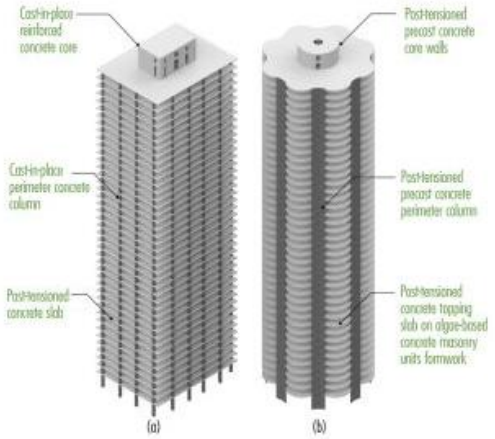
Specified Compressive Strength range (Column 1)	SCM range (%) (Column 2)	Product Name (Column 3)
0-2500 psi (0-17.24 MPa)	0-19% Fly Ash and/or Slag	2500-00-FA/SL
	20-29% Fly Ash	2500-20-FA
	30-39% Fly Ash	2500-30-FA
	40-49% Fly Ash	2500-40-FA
	30-39% Slag	2500-30-SL
	40-49% Slag	2500-40-SL
	≥ 50% Slag	2500-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	2500-50-FA/SL
2501-3000 psi (17.25-20.68 MPa)	0-19% Fly Ash and/or Slag	3000-00-FA/SL
	20-29% Fly Ash	3000-20-FA
	30-39% Fly Ash	3000-30-FA
	40-49% Fly Ash	3000-40-FA
	30-39% Slag	3000-30-SL
	40-49% Slag	3000-40-SL
	≥ 50% Slag	3000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	3000-50-FA/SL
3001-4000 psi (20.69-27.58 MPa)	0-19% Fly Ash and/or Slag	4000-00-FA/SL
	20-29% Fly Ash	4000-20-FA
	30-39% Fly Ash	4000-30-FA
	40-49% Fly Ash	4000-40-FA
	30-39% Slag	4000-30-SL
	40-49% Slag	4000-40-SL
	≥ 50% Slag	4000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	4000-50-FA/SL

No. 9:

Sequester Carbon Dioxide

Concrete Materials:

A. Normal-weight Aggregate: ASTM C33
B. Lightweight Aggregate: ASTM C330
C. Recycled concrete aggregate (crushed concrete) meeting the requirements of ASTM C33 or ASTM C330 may be used in structural concrete up to 10% of the total aggregate.
D. Artificial limestone aggregate meeting the requirements of ASTM C33 or ASTM C330 is permitted.
E. Carbon mineralization by injecting CO2 into concrete during manufacturing or curing in CO2 atmosphere shall be permitted.



URBAN SEQUOIA

SOM

PROMETHEUS MATERIALS

COP27 SHARM EL-SHEIKH EGYPT 2022

Sublime Systems

ecocem

KLAW INDUSTRIES

CemVision

Carbfix

CARBON CURE™

chement

ECOMATERIAL TECHNOLOGIES

FOSKOR

DB Group

POSREGEN

No. 10:

Encourage Innovation

- Ground Glass Pozzolan
- Carbon Storing Aggregate
- Carbon Negative Cement
- Carbon Dioxide infused fly ash
- Biochar
- Limestone Calcined Clay Cement
- Biogenic Limestone Cement
- Geopolymer Cement
- Metamaterial Cement

No. 10: Encourage Innovation

Search PitchBook...

Collapse

Screeners
- Companies & Deals
- Public Companies
- Investors & Funds
- Limited Partners
- People
- Debt & Lenders
- Service Providers

Library
- Research Center
- Corporate Events
- News

LCD Credit Analysis
- Credit News
- Credit Research

Market Analysis
- Analyst Workspaces
- Analyst-Curated Verticals
- Emerging Spaces
- Market Size Estimates
- Market Maps

Funds Analysis
- Funds Overview
- Benchmarks
- Portfolio Forecasting

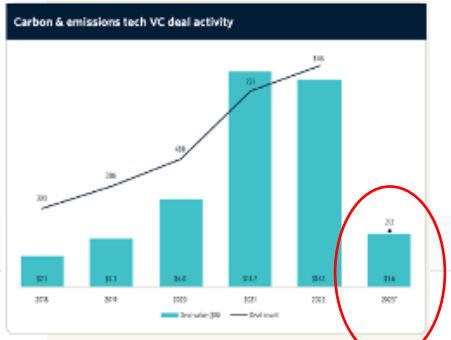
My PitchBook
- Workspaces
- Saved Searches & Lists
- My Fields & Notes

Companies in ready-mix concrete | 1,447 Companies

Modify All Criteria (1)

Keywords: ready-mix concrete ×

Overview | Companies | Deals | Investors | People | Pivot Table | Charts



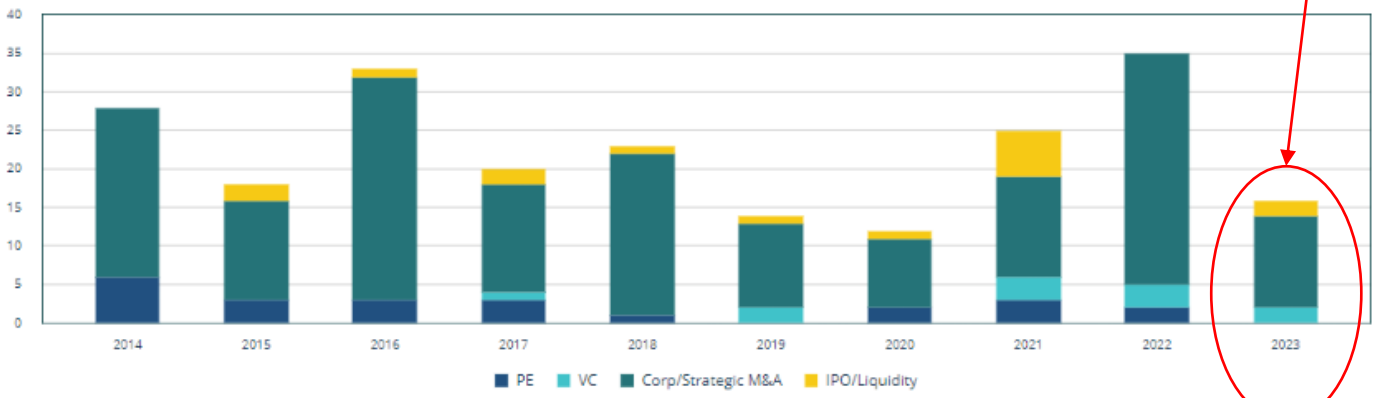
Share | Save

Quick Stats

1,447	893	329	499	$7.70B	$65.63B	$70.02M
Companies	Deals	Investors	Exits	Largest Deal	Capital Invested	Med Post Val

Investments Over Time

Deal Count | Capital Raised | Download



View All Data

FIRST QUARTER 2023

Market Map Preview

Companies to Watch

New Entrants | Most Capital Raised | Most Likely Fundraising

Cementos Portland Val...	CEMEX LatAm Holdings ...	AfriSam
Total Raised $1.39B	Total Raised $1.15B	Total Raised $1.14B
Last Deal Type Debt Refin.	Last Deal Type 2ndary - Open	Last Deal Type 2ndary - Private

Summit Materials (Buil...	Cementbouw	New Enterprise Stone &...
Total Raised $906.19M	Total Raised $760.51M	Total Raised $576.90M
Last Deal Type 2ndary - Open	Last Deal Type M&A	Last Deal Type Debt Refin.

View All Data

Top Players

Investors | Acquirers | Public Companies | Private Companies

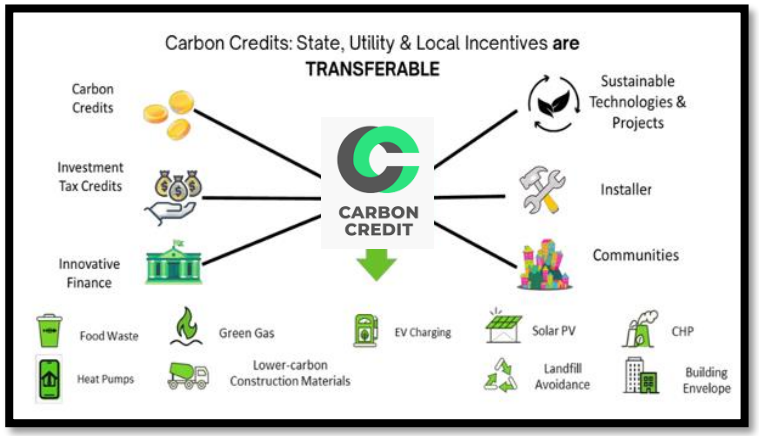
U.S. Concrete	CRH (LON: CRH)	Summit Materials (Buil...

Carbon Credit Pricing by Type

Project Type:	Volume Sold (MtCO2e):	Average Price:	Price Range:
Wind	12.8	$1.9	$0.3 - $18
REDD+	11	$3.3	$0.8 - $20+
Landfill methane	7.9	$2	$0.2 - $19
Tree planting	3	$7.5	$2.2 - $20+
Clean cookstoves	3	$4.9	$2 - $20+
Run-of-river hydro	1.5	$1.4	$0.2 - $8
Water/purification	1.2	$3.8	$1.7 - $9
Improved forest management	0.8	$9.6	$2 - $17.5
Biomass/biochar	0.7	$3	$0.9 - $20+
Energy efficiency - industrial-focused	0.7	$4.1	$0.1 - $20
Biogas	0.6	$5.9	$1 - $20+
Energy efficiency - community-focused	0.6	$9.4	$3.3 - $20+
Transportation	0.5	$2.9	$2.2 - $6.8
Fuel switching	0.5	$11.4	$3.5 - $20+
Solar	0.3	$4.1	$1 - $9.8
Livestock methane	0.2	$7	$4 - $20+
Geothermal	0.1	$4	$2.5 - $8
Agro-forestry	0.1	$9.9	$9 - $11

8 Billion Trees .com

FROM: PLANTING TREES



What is carbon credit tokenization?

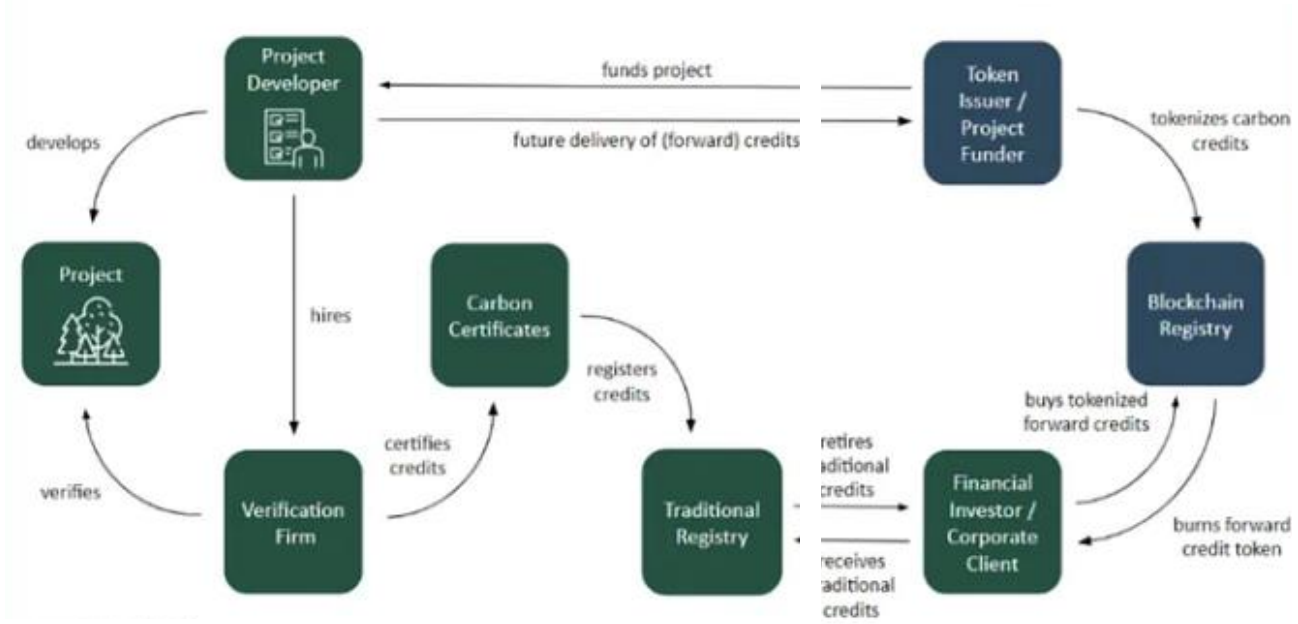
Carbon credit tokenization is the process of creating digital tokens representing real carbon credits with the help of blockchain technology. These credits can be bought, sold, & traded like any other digital assets.

CARBON CREDIT

No. 10:

Encourage Innovation

TO: Tokenized Forward Credits



Decarbonization – Strategies Now

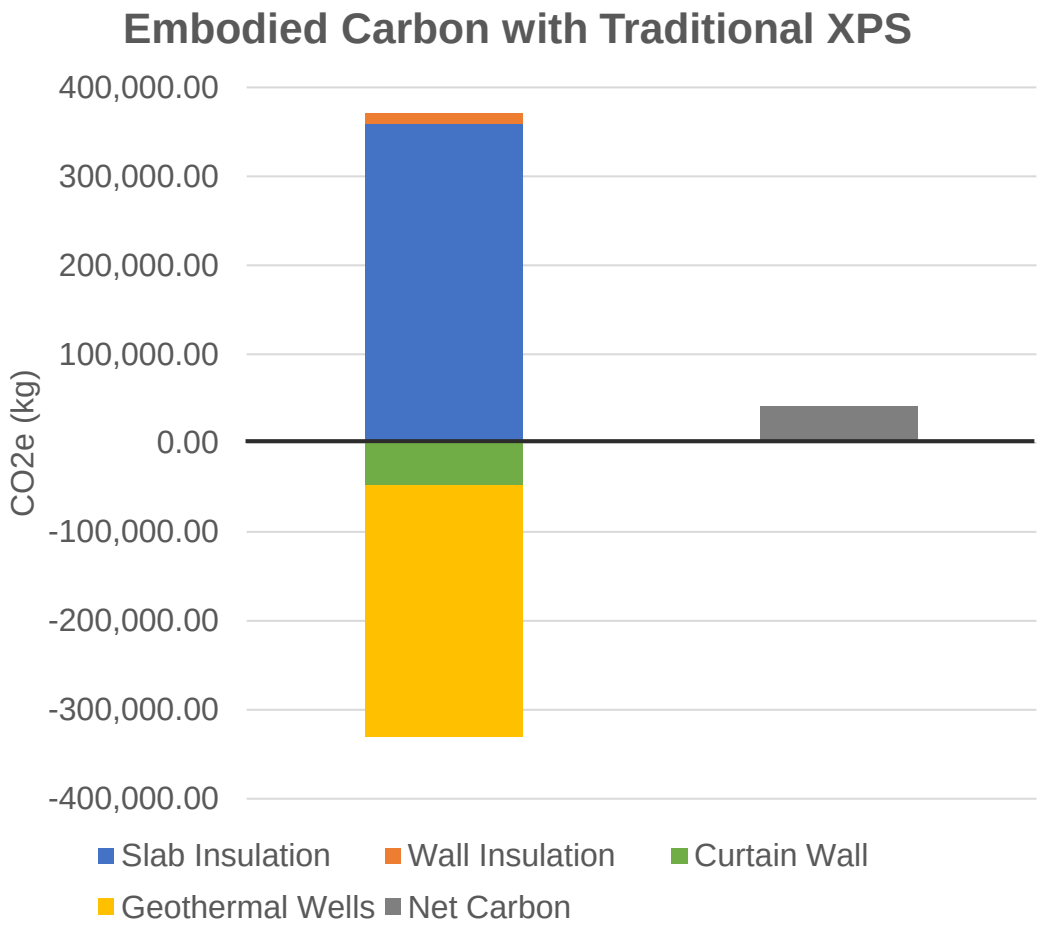
Frank Mruk, FAIA, LEED AP, FStratPS
fmruk@nrmca.org
401-585-7756

NRMCA
NATIONAL READY MIXED CONCRETE ASSOCIATION

BUILD WITH STRENGTH MASSACHUSETTS

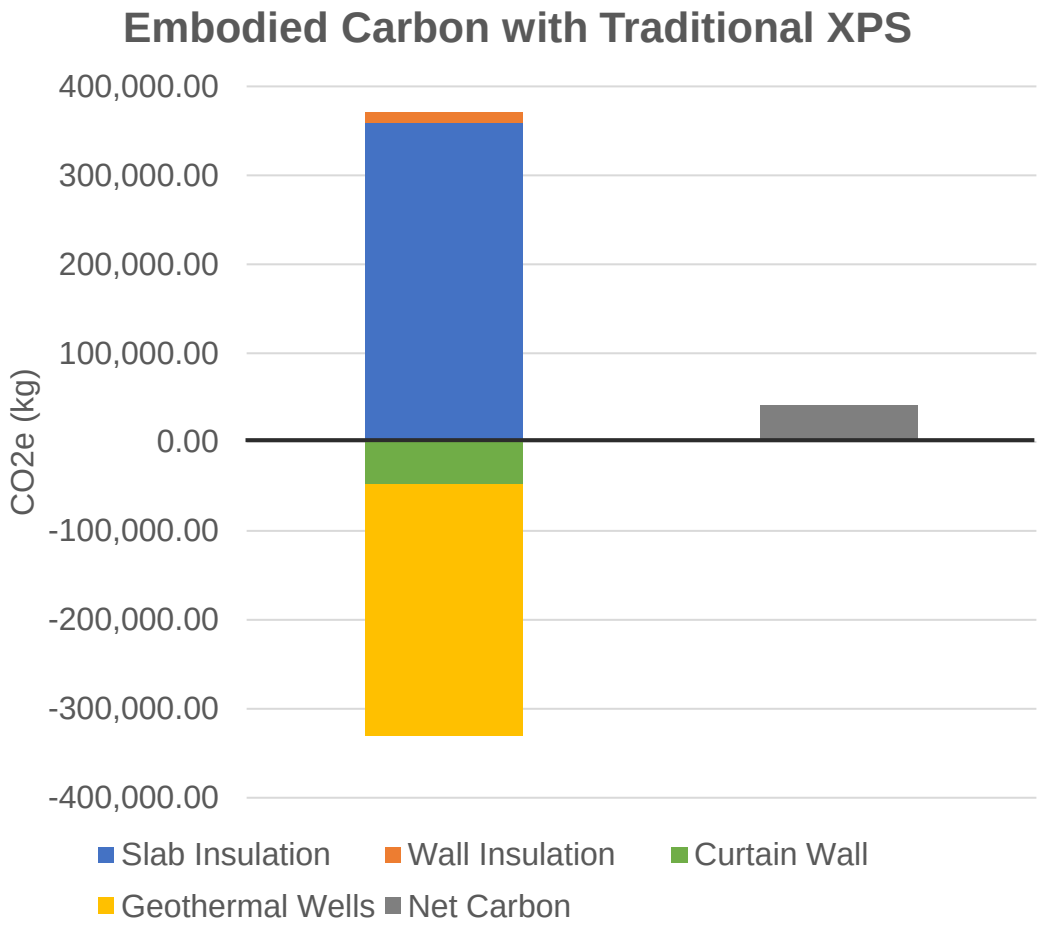
REDUCING EMBODIED CARBON – UPGRADED ENVELOPE PERFORMANCE

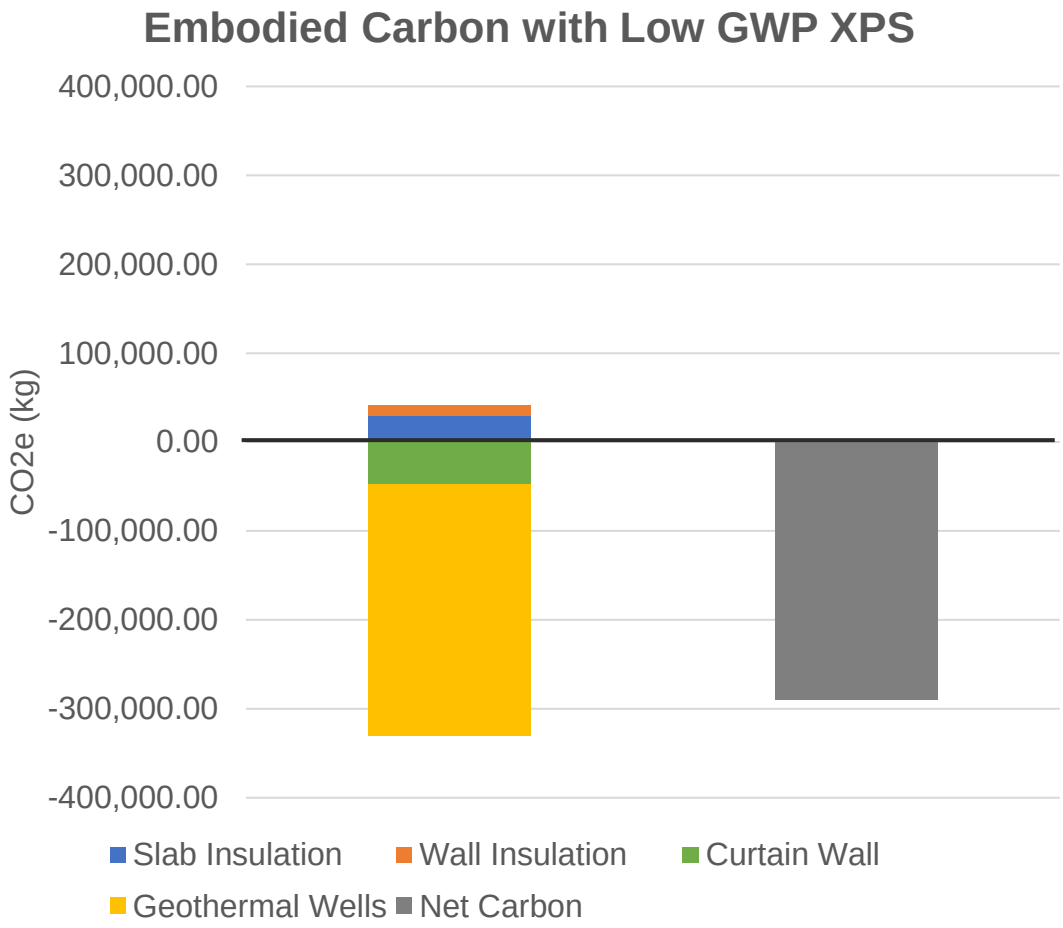
REDUCING EMBODIED CARBON – UPGRADED ENVELOPE PERFORMANCE



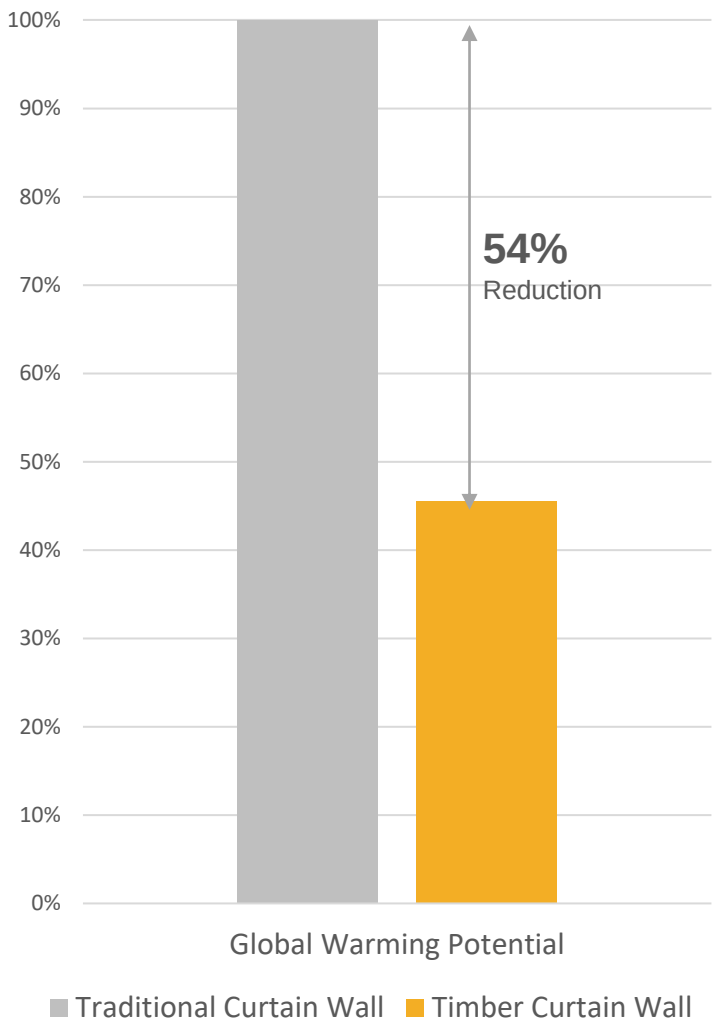
- Increase wall insulation by 1” (mineral wool)
- Increase slab insulation by 2” (XPS)
- Switch to timber curtain wall
- Reduction in heating load reduces geothermal wells by 72

REDUCING EMBODIED CARBON – UPGRADED ENVELOPE PERFORMANCE





SMALL CHANGES, BIG IMPACTS



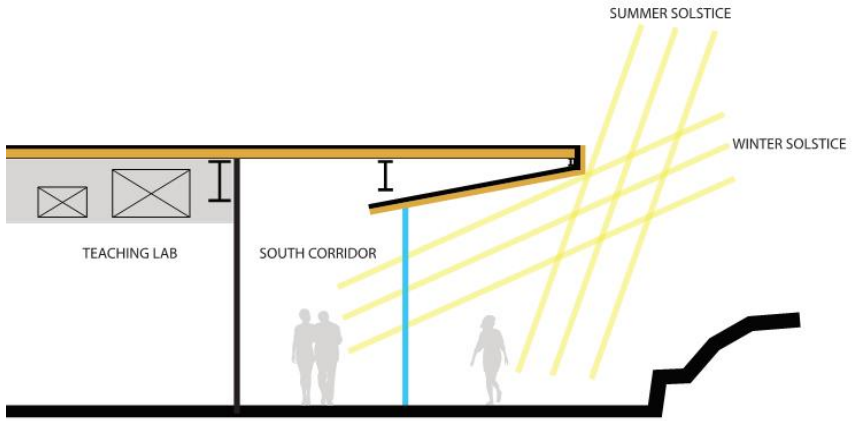
= 116,600 $kgCO_2eq$ **reduction**

Equivalent to the GHG emissions from

14.5 homes for one year

CAPE COD COMMUNITY COLLEGE

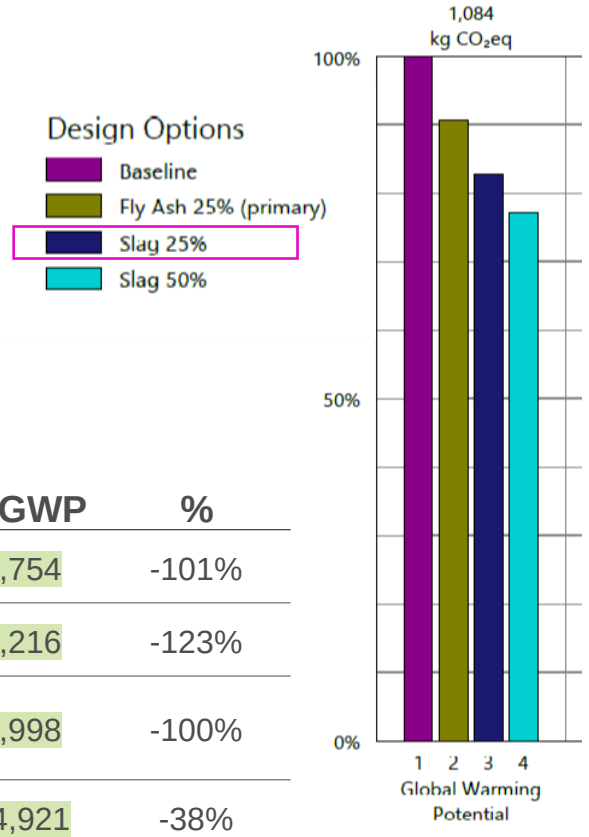
HIGH PERFORMANCE BUILDING



- Rainscreen System
- Triple-Glazed Curtain Wall
- Wood Punched Windows (Operable in Offices)
- 50% Traditional Window-to-Wall Ratio
- 19% Window-to-total Building Envelope Ratio

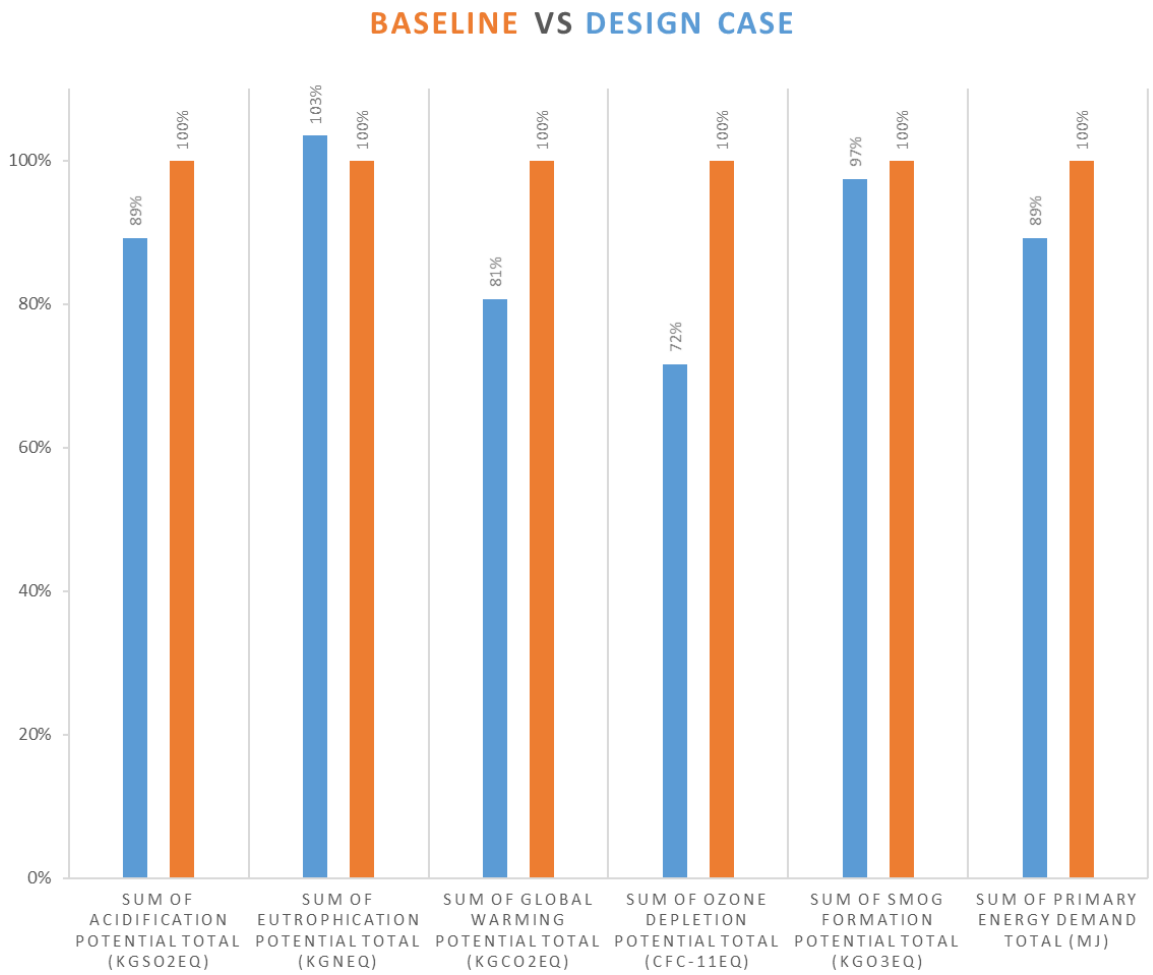
THERMALLY MODIFIED WOOD CLADDING

IDENTIFY CHANGES



SD (Baseline)			100% CD			
	GWP			GWP	Net GWP	%
Cementitious panel	13,587	>	Thermally-modified wood	(167)	-13,754	-101%
Cementitious panel soffit	8,288	>	Marine-grade plywood	(1,928)	-10,216	-123%
Cementitious panel inside ceiling	15,998	>	Omitted	-	-15,998	-100%
Concrete (no admixture)	816,781	>	Concrete with 25% slag	511,860	-304,921	-38%
Steel	270,095	>	Sloping steel	188,393	-81,702	-30%
Tapered insulation	1,234,191	>	Flat insulation with crickets	1,046,552	-187,639	-15%
Concrete + metal roof deck	27,603	>	CLT	(17,978)	-45,581	-165%
Aluminum windows	10,892	>	Aluminum-clad wood windows	4,178	-6,713	-39%

CAPE COD COMMUNITY COLLEGE WHOLE BUILDING LCA

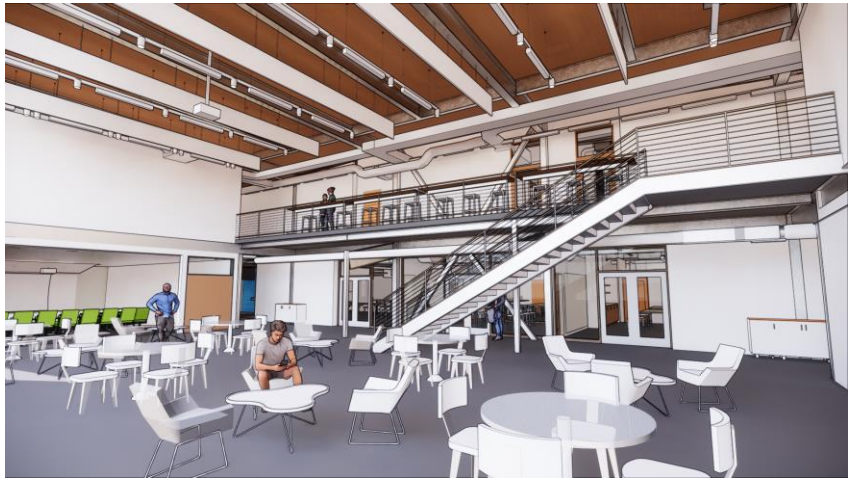


Description of change		Explanation of equivalency in function and performance, including replacement rates
Baseline	**Proposed**	
0-19% Fly Ash or Slag Concrete	20-29% Fly Ash	Fly ash ratio was increased for cast-in-place concrete mixture.
Total tonnage of steel	Total tonnage of steel	Oversized steel was reduced per engineering and sloped roof
Interior soffit with CFMF and fiber cement board panels	Exposed roof deck on interior	Interior soffit omitted with change to CLT roof deck, visible from interior
Fiber cement board panel exterior soffit	Marine-grade plywood soffit	Equivalent assembly for exterior soffit material
Fiber cement board siding	Thermally-modified wood siding	Exterior rainscreen cladding
TPO roofing	PVC roofing	Exterior roofing material
Concrete slab on metal deck roof	CLT structural roof deck	Roof deck
XPS Insulation in exterior walls and soffits	Mineral wool insulation	Equivalent exterior insulation values
XPS tapered insulation on roof	Flat insulation on sloped steel and metal deck	Equivalent exterior insulation value for optimization of material waste
Triple-glazed aluminum curtainwall system	Reduced overall exterior glazing	Less glazed area per exterior aesthetic
Rooftop mechanical screen	Omitted screen	Leaving mechanical equipment visible on roof
Aluminum windows	Painted aluminum-clad wood windows	Punched glazed openings

TOTAL EMBODIED REDUCTION

-19.2%

total embodied
carbon reduction



Next LBE Council Meeting

Save the Date!

Tuesday, Sept 12th

10am-12pm

Upcoming Tentative Meeting Dates:
Nov 14th
Jan 9th, 2024

"Yes, I did say I wanted a 'green' home. But not in the literal sense."

Extra slides

Crustacean-Based Batteries

- Researchers at the University of Maryland developed a process to combine chitin from crab shells with zinc to create batteries
- Test batteries were 99.7% efficient after 1,000 cycles (~400 hours)
- These batteries are not flammable, and the chitosan material breaks down in soil after 5 months leaving only recyclable zinc

Source: Guardian

Embodied Carbon Policy Approaches

Optimize **Project**	Optimize **System**	Optimize **Procurement**
• Build less, reuse more • Design to reduce EC and increase material/structural efficiency	• Choose low-carbon systems and assemblies • Use alternate, low-carbon materials	• Select the lowest carbon version of the selected product • Clean manufacturing (efficiency, fuel switching)
Early Design Calculators, Rules of Thumb	Whole Building Life Cycle Assessment (WBLCA)	Environmental Product Declarations (EPDs) / EC3

Reuse & Deconstruction

Zoning & City Incentive Programs

Procurement (Buy Clean)

Building Codes & Regulations

Climate Action Plans

Image Source: *Carbon Leadership Forum, 2020*

Current and Upcoming EVs

Nissan Leaf*

Available

- Class: Hatchback
- Engine: BEV
- Range: 149 miles
- Battery: 40 kWh
- HP: 147
- Base MSRP: $28,040
- On SWC
- Learn More ...

VW ID.7

2024

- Class: Sedan
- Engine: BEV
- Range: TBD
- Battery: 77 or 86 kWh
- HP: 282
- Base MSRP: TBD
- Learn More ...

*Nissan Leaf S model specs

DOER
Massachusetts Department of Energy Resources

Current and Upcoming EVs

Kia EV6

Available

- Class: CUV
- Engine: BEV
- Range: 206-310 miles*
- Battery: 77.4 kWh
- HP: 225-576
- Passengers: 5
- MSRP: $42,600 - $61,600*
- Learn More ...

Kia EV9

2024

- Class: CUV
- Engine: BEV
- Range: 250 miles
- Battery: 76.1 or 99.8 kWh
- HP: TBD
- Passengers: 7
- MSRP: TBD
- Learn More ...

*Dependent on trim

Current and Upcoming EVs

Ford F-150 Lightning Pro

Available

- Class: Pickup
- Engine: BEV
- Range: 240 miles
- Battery: 98 kWh
- HP: 462
- Towing Capacity: 5,000lbs
- MSRP: $59,974
- On SWC
- Learn More ...

Ram 1500 REV

2024

- Class: Pickup
- Engine: BEV
- Range: 240 miles
- Battery: 168 or 229 kWh
- HP: 654
- Towing Capacity: 14,000lbs
- MSRP: TBD
- On SWC
- Learn More ...

Current and Upcoming EVs

Ford e-Transit

Available

- Class: Cargo Van
- Engine: BEV
- Range: 108/116/126 miles
- Battery: 68 kWh
- HP: 266
- Interior Space: 246.7 – 536.4 cu ft
- MSRP: $51,495
- Cab and Chassis options
- On SWC
- Learn More ...

Mercedes eSprinter

Late 2023

- Class: Cargo Van
- Engine: BEV
- Range: 248 miles
- Battery: 113 kWh
- HP: 134
- Interior Space: 488 cu ft
- MSRP: TBD
- Learn More ...

Current and Upcoming EVs

Chrysler Pacifica

Available

- Class: Van
- Engine: PHEV
- Range: 500+ miles
- Battery: 16 kWh
- HP: 282
- Passengers: 7
- MSRP: TBD
- On SWC
- Learn More ...

VW ID.Buzz

Summer 2024

- Class: Minibus
- Engine: BEV
- Range: 240v miles
- Battery: 91 kWh
- HP: 282
- Passengers: 7
- MSRP: TBD
- Learn More ...