Technical Description and Impact

This proposal has numerous components involving multiple project partners. This proposal combines technical, social, and financial aspects of energy efficiency and weatherization. The technical aspect focuses on the appropriate air-source heat pump technology to install in a dwelling unit, proper sizing of heating/cooling systems as well as electrical systems, and appropriate weatherization testing and installation of weatherization materials. The social aspect focuses on proper client selection and subsequent communication and client education throughout the entire project. The financial aspect addresses the management and allocation of funds from different funding pools that will leverage the impact of the project for the income-eligible clients served.

Feasibility:

Air-source heat pumps:

Energy staff at our partner Subgrantee WAP agencies have been involved with installing air-source heat pumps more over the past 1-2 years than in the past. As the trend continues to transform the heating/cooling market towards electric stratification, agencies are becoming more experienced with these types of installations compared to standard fossil fuel systems.

It is important to note that each air-source heat pump installation is a customized project based on both the dwelling's characteristics and the client's needs. There is no "one-size fits all" process for installing air-source heat pumps. When an Energy Auditor conducts a design walk-through of a residence, she/he should start with the intentions of a trying to achieve a full house displacement. It doesn't always end up that way, but that is typically the main goal. The Energy Auditor will then look at all options for each heated space according to accesses for line-sets and head/duct placements. Some situations can only have one option with no place for duct work, so there is not much thought needed in those situations. In cases where there are multiple options, individual heads, ducted, or combinations of both, it would be a client and dwelling specific design. The benefit of individually placed heads is the ability to control areas to different levels of heating and cooling (in a case where there are three bedrooms with different kids wanting different temperatures) and they usually are more efficient as long as they are designed properly. The disadvantages of the heads are sometimes in small private areas they might be oversized a bit as they only come in certain sizes (BTUs), and most of the time the smallest head is big enough to power multiple small bedrooms without a great way to travel to and from the separated rooms. That is when the Energy Auditor would need to see if a small ducted midsize air handler or ducted unit would be better, especially in a case where there is an elderly person only using one (1) of three (3) bedrooms and we can give all bedrooms the same temperature via ducts. Ducted units are less efficient because of duct work heat loss, and obviously they lose the ability to control those connected rooms individually. There also needs to be access/space for placement of duct work and air handlers. In these cases, an Energy Auditor usually prefers basements over attics due to the more extreme conditions in attics causing more heat loss on

ducts etc. Massachusetts also has a large majority of dwellings with finished basements negating the basement option. Additionally, dwellings where attics aren't accessible are a non-option as well, thus limiting it to one (1) option of individual heads. If the basements or attics are fully available, full-ducted air handlers are an option as well, but they might have more duct loss and less individual control as a result. They can, however, heat whole individual floors well enough, but they can get expensive with ductwork. An Energy Auditor might often lean towards individual heads for the efficiency and control, but they also have certain issues and things to design around. Multiport units are really meant for one level multi-room heated areas, and when designing a system, an Energy Auditor needs to be aware of BTUs per head, as well as outdoor unit BTUs, so each head is using a proper load and not performing what is called "a heat dump" in unwanted areas of excess BTUs, as this will cause overheating and short cycling which can damage or even reduce the lifespan of the unit. This is a basic technological description showing why each dwelling unit is unique and must be designed individually.

The air-source heat pump installation work will be funded partially with SERC funds and partially with HEARTWAP leveraged funds through the annual LIHEAP set-aide within DHCD. The typical amount of funding provided by HEARTWAP for a new heating system in a municipal utility service territory is $5,000. Most of the selected dwellings will have no access to utility funds, but if there are dwelling units that are eligible for either municipal utility funds or natural gas utility funds, those funds will be leveraged with SERC and HEARTWAP funds for heating/cooling system services.

Weatherization: The full-scale, whole-house weatherization work that will be done in conjunction with the installation of air-source heat pumps will be similar to any other dwelling weatherized as part of the Massachusetts WAP. The NEAT energy audit will be used on all dwellings as part of this SERC grant. It is anticipated that the NEAT audit will be re-approved by DOE for use by summer/fall 2022. All testing that is normally conducted as part of weatherization (i.e. blower door, CAZ, etc.) will be conducted at each dwelling unit. Since an ultra-efficient heating/cooling system is being installed, it is that much more critical that the dwelling be properly weatherized with significant CFM reduction in air movement. Weatherization measures will focus on insulation, air sealing, weatherstripping, as well as various health & safety measures and energy-related incidental repair measures.

The weatherization work will be funded by the weatherization funds provided as part of the annual WAP formula grant. Most of the selected dwellings will have no access to utility funds, but if there are dwelling units that are eligible for either municipal utility funds or natural gas utility funds, those funds will be leveraged with SERC funds for weatherization services.

Electrical upgrades: With a conversion from electric resistance or fossil fuel heating systems, an upgrade to the dwelling's electric panel structure may be necessary. The electric load of the residence will be evaluated as part of the initial assessment of the dwelling unit. The panel will be evaluated from both a capacity and safety perspective. If any alteration, addition, or replacement is warranted, a certified electrician will perform the work.

Given the move towards electric stratification in Massachusetts, it is pragmatic to plan for the future when evaluating and addressing any upgrade to the electric panel structure of a dwelling unit. As part of any upgrade, consideration of future electrical load will be taken into consideration. This will take into account such possibilities as future renewable energy installations (i.e. solar, residential wind, etc.), heat pump water heaters technology, and/or electric vehicle charging at the residence.

The electric panel structure upgrades will be funded entirely with SERC funds.

Target Technical Specifications: Each air-source heat pump unit installed will strive to attain the following target specifications as part of this project.

– Unit will have a variable speed (compressor and fans)
– Heating Season Performance Factor (HSPF) > 10 (>9 ducted or mixed)
– Coefficient of Performance (COP) @ 5 degrees F >1.75 (at maximum capacity operation)
– Seasonal Energy Efficiency Ratio (SEER) > 15
– Include minimum/maximum operating data @ 5, 17, & 47 degrees F
    • Optional low temperature heating, often reported -13 degrees F
    • Also, minimum/maximum cooling at 82 & 95 degrees F

Equity Impacts and Benefits: As mentioned in the Project Overview section of this application, citizens who live in an MLP service territory do not typically receive equal assistance for energy efficiency measure installation that citizens receive who live in an investor-owned service territory. DHCD classifies these MLP service territories as an underserved population in relation to energy efficiency measure installation. Additionally, there are five (5) MLPs that happen to also be classified as a Massachusetts Gateway City. These five (5) cities are: Chicopee, Holyoke, Peabody, Taunton, and Westfield. Under the General Laws of Massachusetts[1], Gateway Cities have a population between 35,000 and 250,000, with an average household income below the state average, and an average educational attainment rate (Bachelor's degree or above) below the state average. Below is Table 1 that shows the four (4) selected Subgrantees for this project and the number of MLP territories and Gateway Cities that they serve:

Table 1:

Subgrantee Agency	MLPs	Gateway Cities
ACTION	10	1
CFC	1	1
SPCA	5	3
WCAC	7	0

[1] General Laws of Massachusetts, Chapter 23A, Section 3A.

This project will select income-eligible clients in MLP service territories based on a hierarchy of specific criteria encompassing energy burden, equity, and inclusion.

From an energy perspective, clients will be chosen who have the highest energy burden. Energy burden, as well as all other priority points, is determined during the client intake process in Massachusetts. Clients who are identified as "high energy burden" will be flagged for priority consideration. Clients who heat their residence with propane will be flagged for consideration as well. Heating oil and propane are currently the most expensive delivered heating fuels in the Commonwealth. Thus, for low-income clients, this represents an added financial energy burden. In addition, most propane tanks are "dealer owned", so consumers cannot shop around with other dealers for better fuel prices. Clients who heat with electric resistance heating will also be flagged for consideration. Electric resistance heat is very costly per square foot of heated space and creates a burden for income-challenged clients. The central goal here is to identify income-challenged clients who are in the greatest need of a heating/cooling system that will reduce their energy costs and increase their comfort in a healthy, safe, and environmentally friendly manner.

According to the White House, "Justice40 is a whole-of-government effort to ensure that Federal agencies work with states and local communities to make good on President Biden's promise to deliver at least 40 percent of the overall benefits from Federal investments in climate and clean energy to disadvantaged communities"[2] As WAP Memorandum 084 notes, "DOE defines underserved communities as populations sharing a particular characteristic, as well as geographic communities that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, as exemplified by the list in the definition of equity". DHCD feels that this project will "triple-attain" the premises of the Justice40 initiative by meeting the following parameters:

1. DHCD considers any income-eligible client residing in an MLP service territory who does not have access to any utility energy efficiency funds to be "disadvantaged".
    a. DHCD plans to serve 100% of income-eligible clients residing in MLP service territories, and over 50% that do not have any access to utility energy efficiency funds…….exceeding the 40% minimum threshold.
2. DHCD will serve a minimum of 40% of income-eligible clients who reside in a Massachusetts Gateway City.
    a. 40%+ of clients served through this project will reside in a combination of the following cities: Chicopee, Holyoke, Peabody, Taunton and Westfield.
3. DHCD will at minimum serve 40% of "minority clients" in MLP service territories. DHCD defines "minority clients" as clients who self-identify as a race other than "Caucasian".
    a. 40%+ of clients served through this project will be a minority client who resides in one of the twenty-three (23) MLP service territories served by the four (4) WAP Subgrantee partners.

[2] The Path to Achieving Justice40, https://www.whitehouse.gov/omb/briefing-room/2021/07/20/the-path-to-achieving-justice40/, July 20, 2021

Cost Savings: The selected contract consultant will be responsible for determining the exact cost savings and the specific payback/return-on-investment formula that will be used for the final study/report. This data will be compiled from each dwelling unit serviced through this grant, tabulated individually, and then combined into overall data for the entire project. The consultant will also determine the formulas for calculating non-energy impacts (NEIs) as part of the project. Several of the Team Member Organizations for this SERC grant have experience working with the Massachusetts Energy Efficiency Advisory Council (EEAC) and developing the metrics for determining these savings and associated benefits that go into the investor-owned utilities' three (3) year energy efficiency plans that are approved by the Massachusetts Department of Public Utilities (DPU). This experience possessed by DOER, LEAN, MMWEC, and ENE will yield a very informative study/report that will be a valuable reference asset going forward for low-income weatherization programs, as well as DOE.

Environmental Benefits: According to the National Academy of Sciences, residential energy use is responsible for approximately twenty percent (20%) of total greenhouse gas (GHG) emissions in the United States. Growing housing stock and continued use of fossil fuels to heat homes is making it more challenging to meet emissions reduction targets set forth by various states. Still, approximately eighty percent (80%) of housing stock is "existing dwellings". In Massachusetts, the goal outlined in the 2050 Decarbonization Roadmap[3] is net zero greenhouse gas emissions by 2050. This project will undertake a study that will quantify the reduction in greenhouse gases attained at each dwelling unit weatherized as part of this project. It is vital to know, as we move forward, the impact that conversion to air-source heat pumps combined with comprehensive weatherization will have on emissions and reductions in greenhouse gases such as carbon dioxide (CO2). The project will use an emissions calculator similar to the EPA's Carbon Footprint Calculator[4] to show the emissions reductions from dwelling's originally heated with fuel oil, propane, natural gas, and electricity.

Associated Technical Best Practices for SERC Project[5]: Below is a list of best practices that, to the best extent possible, will be implemented in conjunction with the installation of air-source heat pumps:

- Multiple condensers recommended when four (4) or more head units are required (Lower Coefficient of Performance on multi-zone systems). Ductless (Coefficient of Performance - ratio of useful heating or cooling provided to work required)

[3] MA Decarbonization Roadmap, https://www.mass.gov/info-details/ma-decarbonization-roadmap
[4] EPA Carbon Footprint Calculator, https://www3.epa.gov/carbon-footprint-calculator/
[5] Massachusetts Low-Income Energy Affordability Network (LEAN), Air Source Heat Pumps: Network Guidance and Delivery, 2021

- Refrigerant line branch boxes should always be avoided. Again, lower Coefficient of Performance and overall efficiency
- Minimize exterior mounted line-sets where possible
- Wall-mounted thermostats used when serving larger rooms with single indoor unit (temperature sensor located at thermostat)
- Handheld controls are appropriate for smaller rooms such as bedrooms, offices, etc. (temperature sensor located at return on air handler)
- Wall and floor units both appropriate; selection based on the room layout and ceiling height
- Condensers should be located strategically at the back or side of home, if possible
- Snow shields and wind screens used, when applicable
- Condenser must be a minimum of 18" off the ground. Wall brackets only appropriate when mounted to solid foundation (vibration issues with wood construction)
- Heat pump system requires annual service, at minimum (HEARTWAP can likely contribute $250 for a Clean/Tune once per year)
- Turn off head unit temperature display (MFG. specific)

In conclusion, DHCD believes this SERC grant will be an important part of our work going forward to assist traditionally under-served clients with limited access to energy efficiency funds reduce both their energy burden and energy inefficiency while improving their household's environmental impact.