Electrifying the Heating & Cooling Sector in Washington, D.C.

Heat Pump Rebate Program Design

Prepared for DC Department of Energy and Environment
Building Electrification Initiative

October 2018

Department of Energy & Environment

CADMUS

Contents

Introduction | Washington DC Heat Pump Program Design

- *This report, prepared for the Washington DC Department of Energy and Environment (DOEE), summarizes key considerations for implementing an air source heat pump (ASHP) rebate program in the District. The report is intended to inform the review and potential revision of the DC Sustainable Energy Utility's (DCSEU) existing rebate. The report includes:*
  - ***Context on DC's heat pump market and program design goals****, including City climate reduction targets, program goals, heat pump market opportunities within the District, and market barriers addressed by a rebate program*
  - *Summary of research findings regarding* ***key components for heat pump rebate program design to support market development*** *in the District, including: rebate delivery method, quality assurance and control activities, market education and outreach activities, technology requirements, and rebate amount*

Introduction | Methodology and resources for program design

Interviews

- 12 interviews were conducted with 19 different interviewees, including program administrators, DC-area contractors, DC-area distributors, and technology manufacturers

Literature review

- Multiple documents summarizing program design best practices were reviewed
- Key documents are referenced throughout the report and/or included as additional resources

DC-specific data and documents

- District datasets and reports were reviewed to establish DC-specific market context and to develop market segmentation and rebate adoption models
- Key resources are referenced throughout the report

Interviewee Type	Name	Organization
Program Administrators	Kerry Hogan	NYSERDA
	Jim Frank	CLEAResult
	Lisa Boba; Jesus Pernia	Energize CT
	Andy Meyer	Efficiency Maine
DC-Area Contractors	Eric Lewis	Reliable Air and Duct
	Clayton Brault; Robert Hopkins; Randy Greer; Jerry Kackley	WL Gary
	Trevor Dodge	Dodge Mechanical
	Tim Capps	Capps Mechanical
DC-Area Distributors	Bethany Ferguson	Ferguson/Lyon, Conklin & Co. Inc.
	Tim O'Donnell	AireCo
Heat Pump Manufacturers	Rick Nortz; Joe Tompkins	Mitsubishi Electric US
	Charlie McCrudden, Mark Trzyna; Mark Utz	Daikin Comfort

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Key Resources

- VEIC. *2017 Regional Cold Climate Air Source Heat Pump Market Transformation Workshop* (link)
- ACEEE. *Swimming to Midstream: New Residential HVAC Program Models and Tools* (link)
- VEIC. *Driving the Market for Heat Pumps in the Northeast* (link)
- Online review of program websites: NYSERDA, Energize CT, Efficiency Vermont, Efficiency Maine, EmPower Maryland

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Key Datasets and Documents

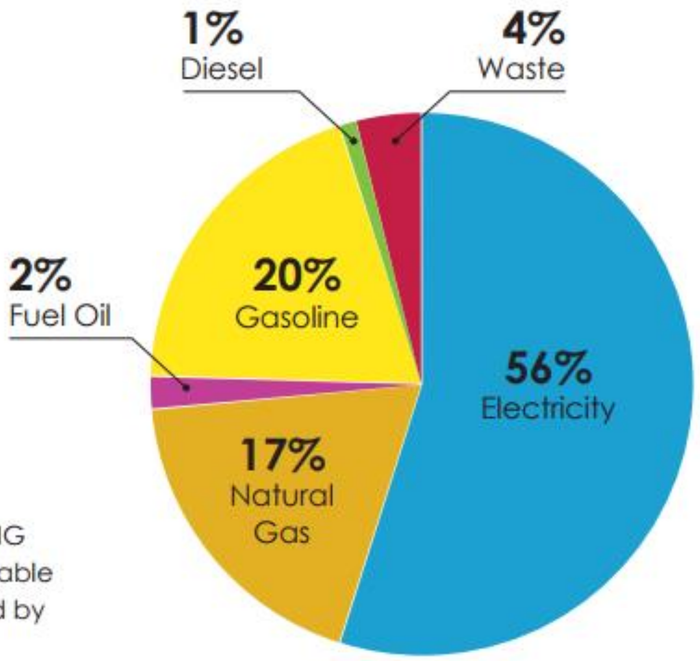
- DC Tax Assessors Database
- NOAA National Center for Environmental Information: DC (Reagan Washington International Airport) annual climate data
- Climate Ready DC (2016)
- American Communities Survey (2015)
- EIA fuel prices and projections data for Mid-Atlantic region
- Bureau of Labor Statistics Average Energy Prices

Contents

Climate Targets & Strategic Electrification | Achieving DC's ambitious climate reduction target will require strategically electrifying building sector heating and cooling

- The District has **committed to reduce citywide greenhouse gas (GHG) emissions by 100% from 2006 levels by 2050**, with an interim target of 50% by 2032.
  - **Close to 75% of citywide GHG emissions** currently come from the energy used in buildings
  - **Nearly 20% of citywide emissions** come from natural gas and oil burned onsite in buildings
- Clean Energy DC estimates that **achieving GHG interim reduction goals will require a "transition to heat pump based systems** and high-performance [building] envelopes."

Figure 7: Proportion of GHG emissions by source, 2012



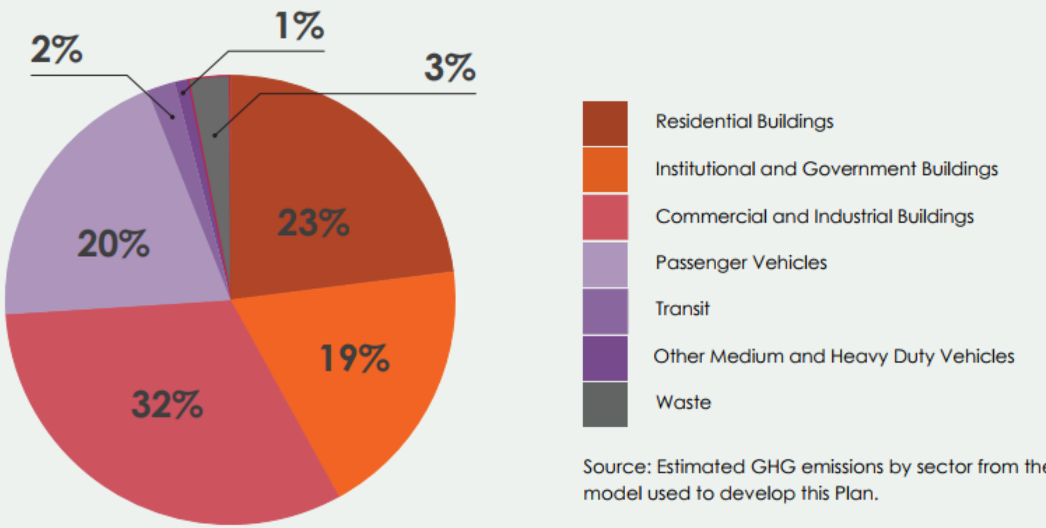
Source: GHG Summary Table maintained by DOEE.

Source: Clean Energy DC (2016)

Residential Sector Building Electrification | The small residential sector presents near-term, high-impact opportunities for strategic building electrification

- 1-4 family homes are **nearly half of residential buildings** in the District (numbering more than 145,000)
- **23% of citywide GHG emissions come from residential buildings,** which includes on-site combustion of fossil fuels for thermal energy
- **38% of 1-4 family homes do not have central AC,** which supports adoption of ASHPs because they provide efficient home cooling

Figure 4: Modeled proportion of GHG emissions by sector, 2015



Source: Estimated GHG emissions by sector from the model used to develop this Plan.

Sources: Clean Energy DC (2016); analysis of DC tax assessor data; American Communities Survey 2015 5-year estimates

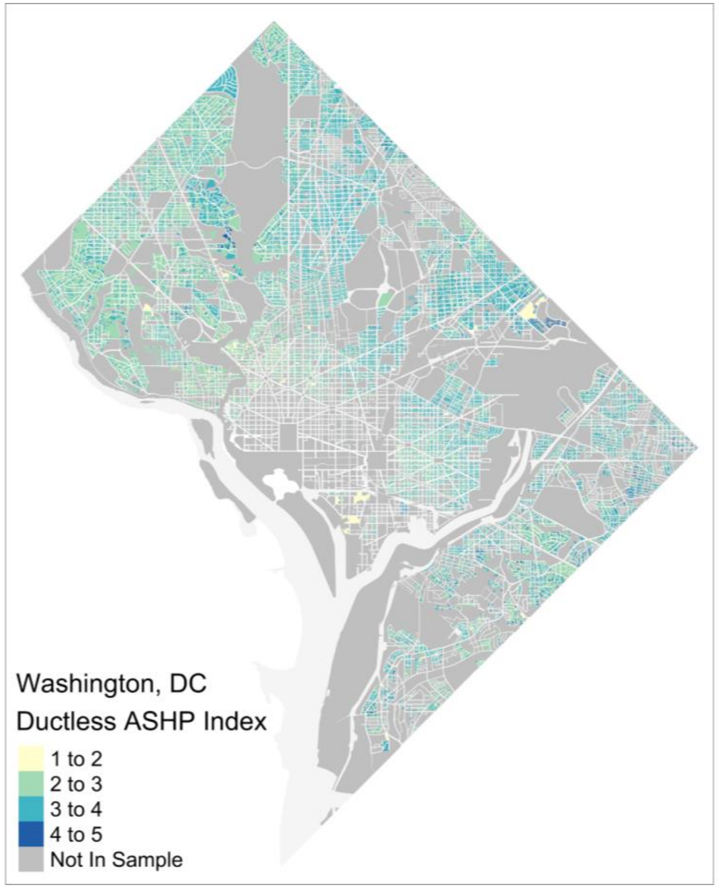
Market Opportunity | Market segmentation analysis identifies thousands of ASHP installation opportunities for residents without central AC and residents that heat with non-gas fuels

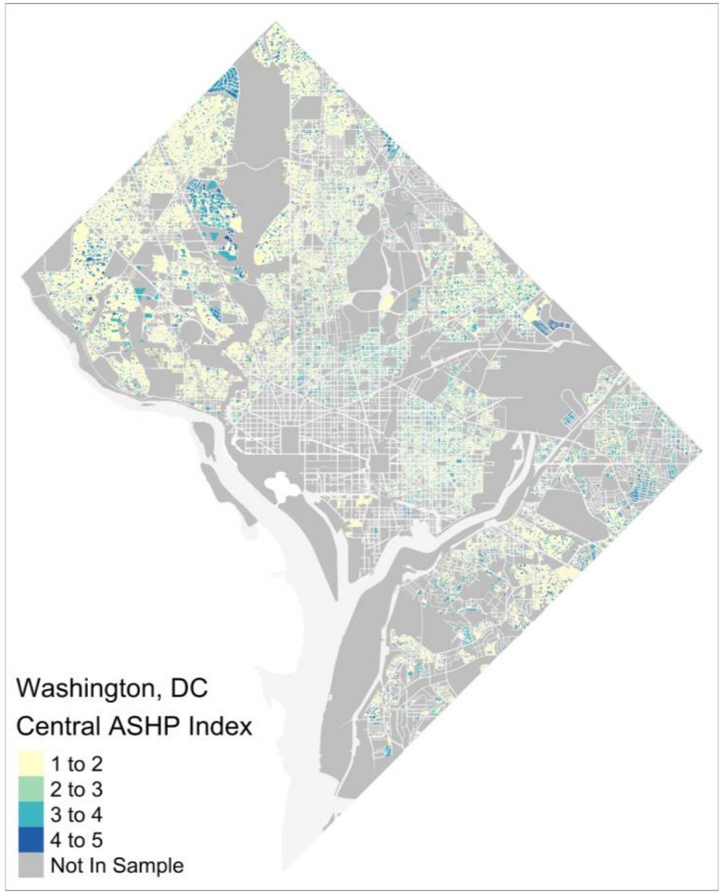
Ductless ASHP: 4,000 high-potential homes identified

Highest market potential homes are those that i) do not have ducted or central AC and/or ii) heat with fuel oil, propane, and electric resistance (non-gas fuels).

Central ASHP: 5,500 high-potential homes identified

Highest market potential homes are those that i) have ducted heating systems but do not have central AC and/or ii) heat with fuel oil, propane, and electric resistance (non-gas fuels).





Note: See Appendix for summary of market segmentation methodology

Program Design Context | Building electrification stakeholders in the District

- Energy efficiency programs within the District are implemented by the DC Sustainable Energy Utility (DCSEU). DCSEU has a performance-based contract to pursue cost-effective measures that deliver energy savings to DC residents and businesses.
  - Due to DCSEU's current regulatory structure, the organization cannot claim energy savings for fuel-switching heat pump installations, which limits the rebate amount that it can provide[1]
- Although DCSEU would be the ultimate implementer of the rebate program, **it may be possible for DOEE to support components of program design**, such as education and outreach.
- As DCSEU reviews its existing heat pump program, **this report will provide insight into program design options and key considerations that may improve existing program results**. Because DCSEU will make final decisions regarding program implementation, this report will not provide formal recommendations for program design.

Note: [1] See Rebate Amount section for more information

Program Design Context | DC's existing residential heat pump rebate program

DC SUSTAINABLE ENERGY UTILITY
YOUR GUIDE TO GREEN

Program Design

- The current program **delivers a $300 or $500 rebate to the end-customer/homeowner following installation** (rebate amount depends on technology installed)
- DCSEU maintains a **list of qualified contractors that are eligible to offer the rebate**
- The program **includes limited additional supporting activity** (e.g. marketing and outreach, contractor training requirements, quality control etc.)

Outcomes

- DCSEU's **existing residential heat pump rebate program has received lower-than-expected adoption** over the past few years

Source: Interviews with DCSEU, DCSEU home heating (link)

Program Design Goals | Priorities for heat pump program design

DOEE and DCSEU collaboratively established the following goals to be pursued during rebate program design:

Energy Savings

- Drive installations to achieve energy savings within the District

Contractor Development

- Increase the number of contractors offering heat pumps
- Improve the quality of installations

Awareness Building

- Raise local technology awareness among distributors, installers, and consumers

Note: Program goals were established during a March 2018 workshop facilitated by Cadmus that included DOEE, DCSEU, and Mitsubishi

Market Barriers and Program Design | The District's heat pump market is impacted by a range of barriers

Regulatory & Policy Barriers

- Fuel switching regulations
- Fossil fuel subsidies
- Lack of economy-wide carbon pricing

Technical & Building Barriers

- Low rates of refurbishment
- Limited performance data
- High central AC penetration

Economic Barriers

- Higher installed costs
- Inadequate financing and ROI
- Capital constraints

Awareness Barriers

- Lack of consumer and contractor awareness
- Policy & consumer awareness of thermal energy impacts

Decision-Making Barriers

- Ownership priorities
- Split incentives/ high rate of renting
- Lack of confidence in technology

Supply Chain Barriers

- Insufficient contractor base and training
- Staff training for O&M
- Supply chain inefficiencies

Market Barriers and Program Design | A multifaceted rebate program can address a subset of barriers impacting the District's heat pump market

Market Barriers	Description	Relevant Rebate Program Components
Economic Barriers	• Higher heat pump installation costs compared to alternative technologies • Long payback periods for heat pump adoption	• **Heat Pump Rebate**
Supply Chain Barriers	• Contractors not sufficiently trained to install heat pumps • Contractors not sufficiently trained to offer heat pumps in DC market specifically	• **Quality Assurance & Control** • **Rebate Recipient**
Awareness Barriers	• Lack of consumer heat pump awareness • Lack of contractor heat pump awareness • Lack of awareness of DCSEU's rebate program	• **Market Education & Outreach** • **Rebate Recipient**

Targeted Barriers | Economic and supply chain barriers targeted by a rebate program

Economic Barriers

- **Higher installation costs compared to alternative technologies.** Heat pumps have higher installed costs than most conventional fossil fuel systems.
- **Long or non-existent payback for heat pump adoption.** In current market conditions, the payback period for installing a heat pump for some customers is either 10-15 years or not within the technology's operating lifetime.

Supply Chain Barriers

- **Contractors not sufficiently trained to install heat pumps.** This lack of training results in either low-quality installations that harm market development and/or contractor hesitancy to offer heat pumps as a solution to homeowners.
- **Contractors not sufficiently trained to offer heat pumps in DC market specifically.** Even contractors that are aware of heat pumps as an option for the region may not offer them in DC due to building stock complications, including: DC duct spaces are too small for cooling, poor weatherization in DC homes, limited space to place condensers in dense multifamily housing, and need for protection of refrigerant lines.

Targeted Barriers | Market awareness barriers targeted by a rebate program

Customer Awareness Barriers

- **Customers lack awareness of heat pumps generally.** Customer do not know that heat pumps are a viable home heating and cooling solution.
- **Customers lack awareness of cold climate and ductless heat pumps specifically.** Some customers are aware of earlier heat pump models, but are not aware that the technology has improved significantly in terms of efficiency, cold-climate performance, and aesthetics. Contractors report that most customers requesting central ASHPs are replacing existing systems. Few customers are converting to central ASHPs from central AC or alternative heating systems, and few are installing ductless systems.
- **Customers lack awareness of heat pump operations and maintenance best practices.** Consumers do not know how to operate and maintain heat pumps to ensure long-term energy efficiency and prevent damage to the technology.

Contractor Awareness Barriers

- **Contractors lack awareness of ductless heat pumps.** Interviews indicate that more contractors are aware of centrally ducted ASHPs than ductless ASHPs.
- **Contractors lack awareness of DCSEU rebate.** Several contractors that do work in the DC area are not aware that DCSEU offers a residential heat pump incentive or are not certain which products qualify for the program.

Contents

Program Design | Summary of program components

Successful rebate programs support market development through multifaceted approaches that engage all parts of the heat pump supply chain. Components evaluated for this program include:

Component	Description
Contractor vs. Distributor Rebate Delivery	• The supply chain entity that receives and processes the rebate
Quality Assurance & Control	• Activities to promote high-quality ASHP installations and proper customer operations and maintenance
Market Education & Outreach	• Activities to promote ASHPs and rebate program to distributors, contractors, and customers
Technology Requirements	• ASHP performance requirements to qualify for rebates (e.g. HSPF and SEER rating requirements)
Rebate Amount	• Rebate amounts provided for each installation to reduce ASHP upfront costs

Program Design Components

Contractor vs. Distributor Rebate Delivery

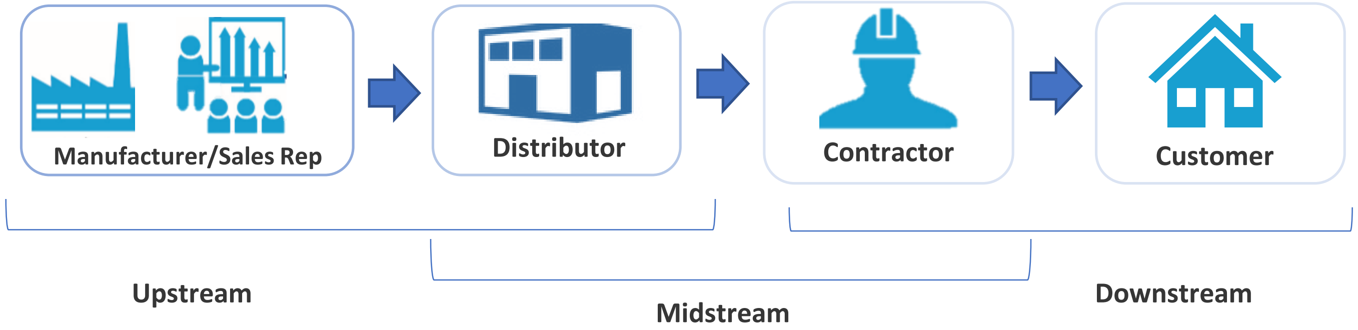
Quality Assurance & Control

Market Education & Outreach

Technology Requirements

Rebate Amount

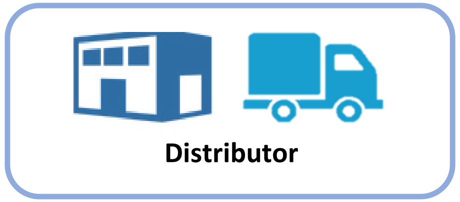
Contractor vs. Distributor Rebate Delivery | Various terminology is used to describe rebate program recipient and delivery options



- » Heat pump rebates can target **four primary points of the technology's supply chain**: the manufacturer, the distributor, the contractor, and the homeowner.
- » The terms **"upstream," "midstream," and "downstream,"** are also applied to rebates targeted at different points in the supply chain.
- » To simplify terminology, **this report refers to program-types by the supply chain actor that receives the rebate** (e.g. distributor, contractor, customer)

Contractor vs. Distributor Rebate Delivery | DCSEU's existing rebate structure versus alternative options evaluated for program design

- DCSEU's **current rebate is delivered to the end-customer/homeowner** following a heat pump installation
- Alternative options evaluated for this program design include rebates delivered to:



- **Distributor.** The distributor provides an instant rebate to the contractor at the point of sale and submits sale information to the DCSEU for review and payment.

- **Contractor.** Following an installation, the contractor submits required installation documentation to DCSEU review and payment.

- A detailed description of both a contractor and distributor rebate delivery model is available in Appendix B

Distributor Program | Case Study: Energize CT distributor program has supported increased program participation and reduced contractor participation requirements

energize CONNECTICUT CT

In 2017, Energize CT moved their ductless heat pump rebate from the customer to the distributor

Program Design

- The program design **assumes that the contractor will pass incentive down to the customer** via a line item on the heat pump bill and the program is marketed directly to the customer
- Previous contractor requirements (e.g. training) were **removed by Energize CT due to difficulty of verification through distributor**; contractor insurance is the only remaining quality control requirement, but Energize CT relies upon the distributor for verification
- Energize CT **inspects 5% of installed systems** to ensure that they are installed properly

Outcomes

- The rebate delivery adjustment **resulted in a 115% increase in units sold** from 2016 to 2017

Source: Interviews with Energize CT program administrators

Distributor Program | Most effective for reducing upfront barriers to program participation but may pose challenges for improving installation quality

Strengths	Challenges
• **Increases program convenience for contractor and customer.** Contractor and customer receive the rebate upfront, removing administrative barriers (e.g. paperwork submission) to program participation. • **May encourage distributors to stock more qualifying, high-efficiency heat pumps.** Distributors may stock more higher-quality equipment due to the rebate because they earn higher profits on this technology.[1] • **May increase program participation.** Instant rebates have been shown to increase rebated systems in other programs. (See Energize CT case study). • **Leverages distributor's existing administrative capacity.** Most distributors already have administrative staff to support rebate processing. • **May increase end-rebate delivered to customer.** Contractors place a percentage markup on heat pump purchases, meaning an distributor rebate may increase the price reduction for the end-customer. For example, a $4,000 system that is marked up 20% will cost the customer $4,800. If the same system receives a $500 upfront rebate, the $3,500 upfront price with a 20% markup would cost the customer $4,200. Thus, a $500 rebate results in a $600 price decrease.[2]	• **Ensuring installation quality.** Compared to contractor and customer rebates, interviews suggest that distributor programs have more difficulties promoting high-quality installations than other options because the rebate is furthest from point of installation. This distance from the point of sale makes it difficult to implement installation requirements (e.g. installation checklists or pictures). Additionally, interviews suggest that it is more difficult to verify and enforce contractor credentials such as insurance or training requirements. • **Collecting installation data.** Interviews with program administrators suggest that it may be difficult to collect data beyond the installation address (e.g. previous heating system, customer motivation for purchasing a heat pump, etc.). • **Administrative fees.** Distributor administrative fees of $15-$75 per unit will increase total measure cost DCSEU. The fees will need to be sufficient to gain distributor interest in assuming administrative responsibilities of program. • **Marketing the program to customers.** Interviews with technology manufacturers suggest it can be difficult to promote distributor rebates to the customer because customer does not receive rebate directly.

Sources: [1] VEIC. *2017 Regional Cold Climate Air Source Heat Pump Market Transformation Workshop* (link); [2] Interviews with DC-area contractors; General: interviews with program administrators, heat pump manufacturers, DC-area distributors, and DC-area manufacturers

Distributor Program | Implementation steps

Identify & Recruit Distributors	Establish Program Specifics	Develop Rebate Submission Channel	Collaborate on Program Support
• Evaluate the supply chain to identify the distribution companies and individual sites that supply the majority of the DC market. • Meet with targeted distributors individually to establish and pitch value/business case for incentive program.	• Work with interested distributors to collaboratively establish i) technology requirements; ii) incentive amounts; iii) distributor administrative fees; iv) data collection requirements; and v) quality assurance and verification processes. • Details will likely be agreed upon via a memorandum of understanding (MOU) between the distributor and DCSEU.	• Create a shared online portal with the distributor (or other similar system) to track rebated systems and regularly reimburse distributors for rebates delivered.	• Develop mutually reinforcing strategy to support rebate program with marketing, contractor training, and other activities.

Sources: VEIC. *2017 Regional Cold Climate Air Source Heat Pump Market Transformation Workshop* (link); Interviews with DC-area distributors

Distributor Program | Practices and program features to avoid during implementation

Identify & Recruit Distributors	Establish Program Specifics	Develop Rebate Submission Channel	Collaborate on Program Support
• **Conflict with EmPOWER Maryland.** EmPOWER Maryland is piloting a distributor program for Minisplit ASHPs in Fall 2018. This may present opportunities to collaborate on aligned components of program design, but also may present challenges for distributors if they need to learn two different new programs concurrently.	• **No requirements for passing rebate downstream.** Expert interviews suggest that programs are easier to market and better-support customer heat pump adoption if they require a portion of the rebate to be passed to the contractor and end-customer.	• **Excessive data collection requirements.** Interviews indicate that distributors are only willing to collect limited installation information and may not offer rebates if excessive information requirements are imposed. Information that can be collected includes i) installation address; ii) installed technology	• **Lack of ongoing supply-chain engagement.** Examined programs emphasize the importance of ongoing engagement with distributors and contractors is essential for sustained program success. Some programs have assigned representatives for each distributor engaged in the program.

Sources: VEIC. *2017 Regional Cold Climate Air Source Heat Pump Market Transformation Workshop* (link); Interviews with DC-area distributors

Contractor Program | Case Study: NYSERDA's contractor rebate is designed to support contractor development and installation quality

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

In 2017, NYSERDA launched a rebate delivered directly to the contractor for residential heat pump installations

Program Design

- Contractors **not required to pass the incentive to the customer** (but may do so if they choose)
- Contractor **receives rebate within ten business days** of submission
- **Extensive contractor outreach** in partnership with manufacturers supported the program's launch
- The **first three installations for all program contractors are inspected,** with random inspections performed thereafter

Outcomes

- Contractor network has **grown to 200 participating contractors**, about 30% of which are the most frequent installers
- Program has **rebated about 5,000 installations** during first year
- NYSERDA has yet to complete its first full program evaluation (scheduled for 2018)

Sources: NYSERDA program website (link); Interview with NYSERDA program administrator

Contractor Program | Most effective for supporting installation quality, but may pose financial and administrative burden on capacity-limited contractors

Strengths	Challenges
• **Can leverage rebate to improve installation quality.** Contractor rebates are processed after the installation, meaning DCSEU can collect installation data and require submission of installation verification items (e.g. checklist, photos, customer signature). • **Contractor engagement and development.** During program outreach and awareness-building, DCSEU would establish direct relationships with contractors and increase contractor awareness of technology and the program, which would support market development. • **May motivate contractors to sell heat pumps to customers.** If contractors are convinced during outreach that the program can support their businesses, it may motivate them to more proactively sell heat pumps to customers.	• **Limited contractor financial capacity.** Compared to distributors, contractors have less working capital and thus more difficulty providing the rebate upfront to the customer and waiting for reimbursement. This limited capacity may decrease contractor participation in the program. During interviews, contractors expressed a preference not to wait for the rebate for longer than two weeks. • **Limited contractor administrative capacity.** Few smaller contractors have the administrative capacity (e.g. office manager) to be responsible for paperwork and rebate processing. • **Marketing program to customers.** Interviews with technology manufacturers suggest it is difficult to promote contractor rebates to the customer because customer does not receive the rebate directly.

Sources: Interviews with DC-area contractors; interviews with technology manufacturers

Contractor Program | Implementation steps and considerations

Conduct Contractor Outreach

- Engage existing and potential contractors to explain benefits of program, including the ability to either pass the rebate to the customer or keep rebate to increase profit margin on installation.
- See Contractor Education and Outreach section for engagement avenues and best practices.

Develop Online Rebate Submission Channel

- Improve setup of existing DCSEU portal to include a heat pump-specific option and make program requirements more clear.
- Alternatively, develop a new rebate submission portal available only to DCSEU contractors.

Develop Rebate Payment System

- A rapid verification and payment structure will be critical for program success to minimize time that the contractor waits for the rebate.
- For example, NYSERDA's program uses a SalesForce portal with direct deposit for participating contractors to streamline rebate processing. Contractors receive payment within 10 business days.

Contractor Program | Practices and program features to avoid during implementation

Conduct Contractor Outreach

- **Lack of program design information.** When NYSERDA launched their contractor rebate program, they hosted over ten webinars educating contractors on the rebate program and its benefits. While this number of webinars will not be necessary for DC's market (which is much smaller than New York's), thorough contractor engagement is critical for program success.

Develop Online Rebate Submission Channel

- **Excessive quality control requirements.** Although contractors can provide some installation information, they are unlikely to participate in programs that have excessive quality control requirements. For example, NYSERDA program's initial requirement for 15+ pictures of the heat pump installation was removed after contractor complaints.

Develop Rebate Payment System

- **Extended rebate processing and payment times.** Interviews with contractors suggest that rebates that take over two weeks to process will not be viable for business cashflow (timing is especially important for small businesses).

Contractor vs. Distributor Rebate Delivery | Key takeaways

- **Both distributor and contractor rebate models can successfully support market development.** Expert interviews and evaluated programs indicate that both program design options can effectively increase heat pump installations and support supply chain development.
- **Both program options require active management, administration, and supply chain engagement.** The rebate structure itself cannot dictate program success, but rather must be supported by additional program administration activities. Specifically, administrators of both program types emphasized that ongoing and active engagement with supply chain partners is critical to ensuring program success.
- **Contractor models offer greater contractor development and quality control opportunities than distributor models.** Program administrators pursuing improvements in installation quality implemented contractor rebates due to the direct oversight of contractor networks and the relative ease of implementing quality control activities enabled by this structure.

Program Design Components

- Contractor vs. Distributor Rebate Delivery
- Quality Assurance & Control
- Market Education & Outreach
- Technology Requirements
- Rebate Amount

Quality Assurance & Control | DCSEU's existing quality assurance and control activities

- District HVAC contactors are **required to submit certifications and licenses** to join DCSEU's contractor network (see summary of requirements in the box on the right)
- There are currently **no requirements for ASHP installation training**
- There are currently **no onsite inspections of heat pump installations** by DCSEU
  - For insurance reasons, DCSEU may not be able to conduct on-site inspections, but the Department of Consumer and Regulatory Affairs (DCRA) is allowed to inspect installations

DCSEU Contractor Requirements

Current requirements for the DCSEU's program include the following:

- Master Gas Fitting and Plumbing license
- Refrigeration/AC License
- Signed Contractor Participation Agreement and Confidentiality Guidelines Memo
- Certificate of Insurance
- Vendor Intake Form
- W-9 Form

Source: DCSEU "Contracting Opportunities" (link)

Quality Assurance & Control | Overview of program design options

Onsite inspections of heat pump installations

- Onsite inspection of percentage of rebated installations (generally 5-10%)by DCSEU staff or technical consultants with knowledge of heat pump installation best practices
- See Appendix C for NYSERDA case study and additional onsite inspection design and implementation considerations

Post-installation customer communications

- Heat pump operation and maintenance best practices sent to customer via mail following heat pump installation
- See Appendix C for additional customer communications design and implementation considerations

Contractor training requirement

- Require contractor to provide proof of manufacturer or distributor training for program participation (may be challenging for distributor rebate)
- See Appendix C for Massachusetts Clean Energy Center case study and additional contractor training design and implementation considerations

Installation checklist

- DC-specific installation checklist that must be submitted with rebate applications (not available for distributor rebate)
- See Appendix C for Efficiency Maine case study and additional installation checklist design and implementation considerations

Notes: Additional information for each program design option is available in Appendix C

Quality Assurance & Control | Key takeaways

» **All reviewed programs have implemented a quality assurance mechanism.** While investment in quality control varies between programs depending on market needs and program objectives, all reviewed programs include quality control in rebate design.

» **Contractor models offer more opportunities for quality assurance than distributor models.** Rebates delivered to the contractor enable the program administrator to directly oversee the contractor network and implement a variety of quality control activities.

» **Distributor models tend to primarily rely on onsite inspections for quality assurance.** Interviews indicate that some activities beyond onsite inspections are difficult to implement or enforce in distributor programs. For example, when Energize CT moved its ductless heat pump rebate from the customer to the distributor, it removed requirements for contractor training due to enforcement challenges.

Program Design Components

- Contractor vs. Distributor Rebate Delivery
- Quality Assurance & Control
- **Market Education & Outreach**
- Technology Requirements
- Rebate Amount

Market Education & Outreach | DCSEU's existing heat pump market education and outreach activities

- DCSEU's **current heat pump supply chain engagement is conducted by the organization's Trade Ally Manager**
  - Based on interviews with DCSEU staff, the Trade Ally Manager has been in contact with heat pump contractors, distributors, and manufacturers, but is not regularly in touch with these individuals/organizations
- **Existing program webpage has no educational information about heat pump technologies**
  - The existing webpage mentions heat pump technology requirements and rebate amount on its "Home Heating" page
  - Heat pumps are also not referenced in the "Home Cooling" page

Market Education & Outreach | Supply chain engagement avenues and best practices

Engage leading heat pump manufacturers

- Engage manufacturers to gain connections with their local distributors and contractors
- NYSERDA leveraged relationships with manufacturers to engage distributors and conduct 10+ contractor webinars during program launch
- Manufacturers interviewed for program design include Mitsubishi and Daikin, both of which expressed interest in supporting supply chain engagement

Engage DC-area distributors

- Engage distributors to educate them on the rebate program and to further engage their contractors
- Distributors interviewed for the program design include Ferguson and AireCo, both of which expressed interest in supporting program design and implementation as needed

Utilize online marketing platforms to engage contractors

- Utilize online marketing platforms to engage contractors servicing the DC area on the rebate program
- NYSERDA's targeted Facebook Ads and Google AdWords were considered highly effective for increasing contractor awareness of rebate program

Local contractor unions and trade groups

- Engage unions and trade groups to increase program awareness within local contractors
- Unions mentioned by contractors during interviews include: Local 602 Steamfitter Union, Local 100 Union, and Air Conditioning Contractors of America (ACCA)

Source: Interviews with local contractors, distributors and manufacturers; interviews with program administrators

» **All reviewed programs have dedicated heat pump web pages** where customers can learn more about heat pumps and the rebate program.

» **Heat pump educational information provided from a trusted resource** can be valuable for familiarizing customers with the technology and potentially helping contractors better engage with customers

» **See Appendix D** for example heat pump program webpages

Heat Pump Webpage Features

- **Heat pump FAQ** that cover the heat pump basics and common questions
- **Customer testimonials** from residents who have previously installed heat pumps
- **Representative case studies** that summarize potential project economics and applications
- **Information** on heat pump costs and available incentives

Source: Review of Northeast heat pump programs, including Efficiency Maine, Efficiency Vermont, Burlington Electric Department, NYSERDA, and Energize CT

Market Education & Outreach | Key takeaways

- **Direct supply chain engagement is critical for program success.** All interviewed program design experts emphasized that robust engagement throughout the supply chain is essential for driving participation in contractor and distributor rebate programs. Regardless of rebate delivery model, engagement should educate contractors and distributors extensively regarding rebate program design and how it will benefit their businesses.
- **Rebate recipient may require targeted engagement and program administration support.** Interviewees highlighted that because the rebate recipient will process program paperwork and provide the rebate upfront (i.e. wait to be reimbursed by DCSEU), they will need to be more thoroughly sold on the program benefits for their businesses. Additionally, they will require program administration support from DCSEU (e.g. in the form of efficient systems for tracking and monitoring rebates) to encourage program participation.
- **Online customer-facing educational materials can increase customer awareness of heat pumps and support contractor sales.** Interviews with contractors suggest that, given the limited awareness of heat pumps within the DC market, additional online DC-specific heat pump resources would be valuable to reference during customer conversations.

Program Design Components

- Contractor vs. Distributor Rebate Delivery
- Quality Assurance & Control
- Market Education & Outreach
- **Technology Requirements**
- Rebate Amount

Technology Requirements | DCSEU's existing technology requirements

» Technology requirements ensure that installed systems meet specified performance criteria, operate efficiently and achieve program energy saving objectives

» DCSEU current requirements are summarized in the table below[1]

› The current program **does not include a requirement for heat pumps to meet NEEP's Cold-Climate ASHP Specification**, which identifies technology that performs efficiently in the low temperatures experienced in the Northeast and Mid-Atlantic[2]

Program	Technology	HSPF	SEER	EER
DCSEU – Existing Requirements	Ductless ASHP Tier 1	≥8.5	≥18	≥12.5
	Ductless ASHP Tier 2	≥9.5	≥20	≥13
	Central ASHP Tier 1	≥9	≥16	≥13
	Central ASHP Tier 2	≥9.5	≥18	≥13

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Notes: 1. See Appendix E for summary of common efficiency performance ratings; 2. See Appendix E for a description of the NEEP Cold-Climate ASHP Specification

Technology Requirements | Existing requirements are well-aligned with regional benchmarks

- Existing **central heat pump requirements are well-aligned** with regional programs [1]
  - Current requirements are identical to EmPower Maryland and have slightly higher heating requirements than PPL Electric Utilities (located in Pennsylvania)
- Existing **ductless heat pump requirements have slightly higher cooling standards** than regional programs [1]
  - Current requirements have slightly higher cooling requirements than Empower Maryland and PPL Electric Utilities
  - EmPower Maryland has a multi-zone ductless rebate tier with lower heating and cooling requirements than its single-zone tier; the lower multi-zone requirement accounts for the necessary inefficiencies of installing multi-zone systems

Notes: [1] See Appendix E for comparison of DCSEU, EmPower Maryland, and PPL Electric Utilities requirements

Technology Requirements | Cold climate heat pump requirements are not essential for DC's winter climate

- NEEP's Cold Climate ASHP (ccASHP) Specification[1] identifies technology that performs efficiently in the low temperatures experienced in the Northeast and Mid-Atlantic
  - While HSPF tests are performed at a minimum of 17° F, NEEP ccASHP tests are performed at 5° F
- DC has **relatively mild winters compared to colder-climate US regions** that use the NEEP spec
  - In an average year, DC's dry bulb temperature is below 17.9° F for ~35 hours per year and below 21.6° F for ~88 hours per year
  - In 2017, DC's dry bulb temperature reached a minimum of 15° F for a total of eight hours [2]
- While ccASHPs perform more efficiently than traditional heat pumps in temperatures below 50° F[3], **cold-climate heat pumps are not essential for DC's climate** given the limited number of low-temperature hours
  - Additionally, Climate Ready DC projects that DC's climate will warm as the city moves toward its 2032 and 2050 targets, further reducing low-temperature hours

City	Heating Design Dry Bulb 99.6% (degrees)[4]
Washington DC	**17.9**
NYC	14.3
Boulder	-0.8
Burlington	-7.3

Notes and sources: [1]See Appendix E for additional information on ccASHP specification; [2]See Appendix E for chart of DC's design temperature by number of hours for 2017; [3]See Appendix E for analysis of heat pump performance relative to outdoor temperature; [4] Source: ASHRAE Fundamentals 2017 Chapter 14 Climatic Design Information. "Design Dry Bulb 99.6%"means that the temperature is above the specified level for 99.6% of hours in a year.

Technology Requirements | DCSEU's existing requirements do not require adjustments

- DC's current requirements are **well-aligned with DC's climate and regional benchmarks**, and do not require adjustments
- DCSEU can consider adding a ductless multi-zone standard with lower efficiency requirements to incentivize larger heat pump installations
  - This option would have to be explored further through an analysis of energy savings DCSEU could claim for lower-efficiency multi-zone systems

Program	Technology	HSPF	SEER	EER
DCSEU – Recommended Requirements	Ductless ASHP Tier 1	≥8.5	≥18	≥12.5
	Ductless ASHP Tier 2	≥9.5	≥20	≥13
	Central ASHP Tier 1	≥9	≥16	≥13
	Central ASHP Tier 2	≥9.5	≥18	≥13

Program Design Components

- Contractor vs. Distributor Rebate Delivery
- Quality Assurance & Control
- Market Education & Outreach
- Technology Requirements
- **Rebate Amount**

Rebate Amount | DCSEU's current rebate structure and limitations

- As summarized in the table below, **DCSEU currently offers two rebate levels**: $300 for Tier 1 ASHPs and $500 for Tier 2 ASHPs
- **The energy savings that DCSEU can claim for heat pump installations are limited by current regulations** that prevent DCSEU from tracking savings on fuel-switching installations (installations that switch the customer heating fuel type[1])
- Because DCSEU partially sets its rebates based on energy savings, the rebate amount that DCSEU is able to offer is also limited by fuel-switching regulations

Program	Technology	Amount
DCSEU – Existing Rebate Amounts	Ductless ASHP Tier 1	$300
	Ductless ASHP Tier 2	$500
	Central ASHP Tier 1	$300
	Central ASHP Tier 2	$500

Notes: [1] Based on interview with DCSEU

Model Methodology | Introduction to heat pump economics model

- To evaluate the impact of rebates on heat pump adoption, **Cadmus developed a model that estimates customer payback periods** for several different types of heat pump installations and baseline building conditions
- The economic evaluation enabled by the model is helpful for:
  i. Assessing current market economic conditions
  ii. Estimating the impact of rebates on heat pump economic viability
  iii. Estimating how shifts in fuel prices influence market dynamics
- The **payback period model is not intended to replace DCSEU's existing process for calculating its rebates** because DCSEU's analysis serves a different purpose and is related to the cost of the rebate compared to the allowed energy savings
- The model uses best available data for the District's HVAC market, but makes assumptions based on other markets where District-specific data is unavailable[1]
- **Payback periods presented in the results are simple paybacks,** and do not discount future savings

Notes: [1]See Appendix F for all model assumptions and sources

1. Baseline Building Conditions

Category	Options
Heating System	Electric Resistance
	Fuel Oil
	Natural Gas
	Propane
Air Conditioning	Central AC
	No AC
	Window AC

Baseline building conditions determine:

i) Existing heating and cooling operational costs

ii) Necessary installation costs to replace existing system

Assumptions for each baseline condition are provided on a following slide. All installations are assumed to be retrofits to existing buildings.

Model Methodology | Methodology for evaluating customer heat pump economics

1. Baseline Building Conditions

Category	Options
Heating System	Electric Resistance
	Fuel Oil
	Natural Gas
	Propane
Air Conditioning	Central AC
	No AC
	Window AC

2. Heat Pump Installation

Category	Options
Heat Pump Type Installed	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
Heat Pump Cost	High
	Low
Heat Pump Rebate	$0
	$300
	$500
	$700

- **Three different heat pump types** were modeled with different sizes. Depending on the size, the heat pump either partially or fully replaces the baseline heating and cooling systems (assumptions used for each heat pump type are available in a subsequent slide)
- **High and low estimates for heat pump installation costs** were assessed through interviews with DC-area contractors
- **Four different rebate amounts,** ranging from $0 to $700, were modeled for each of the heat pump installations to estimate the impact of rebates on customer payback periods

Model Methodology | Methodology for evaluating customer heat pump economics

1. Baseline Building Conditions → **2. Heat Pump Installation** → **3. Economic Impacts**

Category	Options
Heating System	Electric Resistance
	Fuel Oil
	Natural Gas
	Propane
Air Conditioning	Central AC
	No AC
	Window AC

Category	Options
Heat Pump Type Installed	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
Heat Pump Cost	High
	Low
Heat Pump Rebate	$0
	$300
	$500
	$700

Dimensions	Description
Net Upfront Cost	(heat pump installation cost) – (avoided installation cost)
Operational Cost Differential	(baseline heating and cooling costs) – (new heating and cooling costs)

Heat Pump Applications in the DC Market | Model assumptions and sources for heat pumps

	1.5-ton Minisplit	3-ton Minisplit	4-ton Central	Sources
Description	• One single-zone, ductless mini-split heat pump • Provides space heating & cooling to a single area	• Two single-zone, ductless mini-split heat pumps • Provides whole-home cooling and multi-zone heating	• Centrally-ducted ASHP • Serves as the primary heating and cooling source for the whole home	N/A
Estimated Installation Cost (for high-efficiency systems)	$4,500 - $5,500	$8,500 - $10,000	$11,000 - $13,000	Estimated from interviews with local contractors
Estimated Efficiency	HSPF: 9.5/SEER: 20 Duct Losses: 0%	HSPF: 9.5/SEER: 20 Duct Losses: 0%	HSPF: 9.5/SEER: 18 Duct Losses: 15%	DCSEU technology requirements; duct losses Mid-Atlantic TRM (link)
Fuel Cost	$0.13/kWh	$0.13/kWh	$0.13/kWh	BLS Data (link)
Estimated Heating Load Served	40%	80%	100%	Estimated based on heat pump size and DC full-load heating hours; varies by building insulation, size, etc.
Avoids Alt. Heating Costs	No	No	Yes	Based on heating load served
Estimated Cooling Load Served	50%	100%	100%	Estimated based on system capacity and DC full-load heating hours; varies by building insulation, size, etc.
Avoids Alt. Central AC Costs	No	Yes	Yes	Based on cooling load served
Avoids Alt. Window AC Costs	Yes – avoids 1 window AC unit	Yes – avoids 2 window AC units	Yes – avoids 3 window AC units	Estimated based on Window AC capacity vs. heat pump capacity
Equipment Lifetime	15 years	15 years	15 years	Standard assumption

Heat Pump Applications in the DC Market | Model assumptions and sources for alternative heating and cooling systems

Alternative Heating System Assumptions

	Natural Gas	Fuel Oil	Propane	Electricity (Electric Resistance)*	Sources
Description	Natural gas furnace or boiler to provide whole-home heating	Fuel oil furnace or boiler to provide whole-home heating	Propane furnace or boiler to provide whole-home heating	Electric resistance furnace or heater to provide whole-home heating	N/A
Estimated Installation Cost	$5,256	$8,223	$5,256	$800	Cadmus interviews with NY State contractors scaled to DC market by RS Means labor factors
Estimated Efficiency	Existing Unit AFUE: 85% New Unit AFUE: 95%	Existing Unit AFUE: 83% New Unit AFUE: 85%	Existing Unit AFUE: 85% New Unit AFUE: 95%	Existing Unit AFUE: 100% New Unit AFUE: 100%	Assumed from NYSERDA RH&C Framework (link)
Fuel Costs	$1.24/therm	$2.81/gallon	$3.09/gallon	$0.13/kWh	EIA (Fuel Oil – link; Propane – link) BLS (NG & Elec – (link)
Duct Losses	15%	15%	15%	0%	Mid-Atlantic TRM (link)

Alternative Cooling System Assumptions

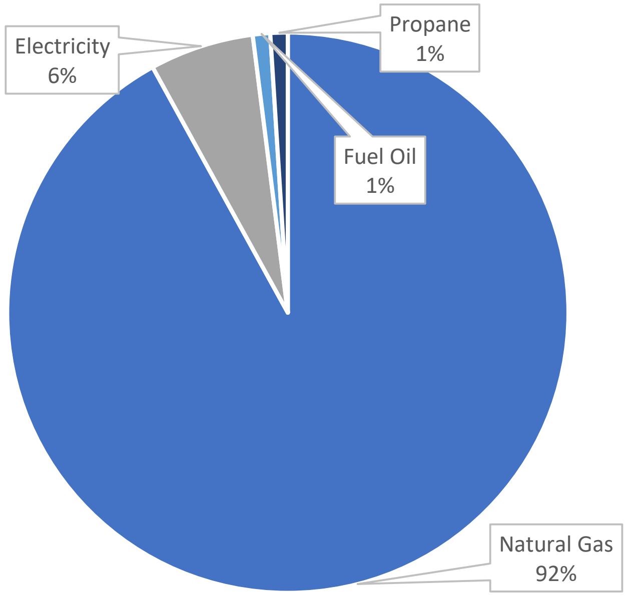
	Window AC	Central AC	Sources
Description	Window AC unit for single-zone cooling	Ducted AC system for whole-home cooling	N/A
Installation Cost	$500/unit	$2,890	Cadmus interviews with NY State contractors scaled to DC market by RS Means labor factors
Estimated Efficiency	SEER: 12	SEER: 16	Window AC – Energy Start Standards Central AC – DCSEU Technology Requirements
Duct Losses	0%	15%	Mid-Atlantic TRM (link)

Note: *Electric resistance systems are sometimes installed as backup systems for ASHP installations to provide heating in low temperatures when ASHPs are operating inefficiently and at low heating output. However, for the purposes of this model, electric resistance systems are considered alternative heating systems with an associated avoided installation cost.

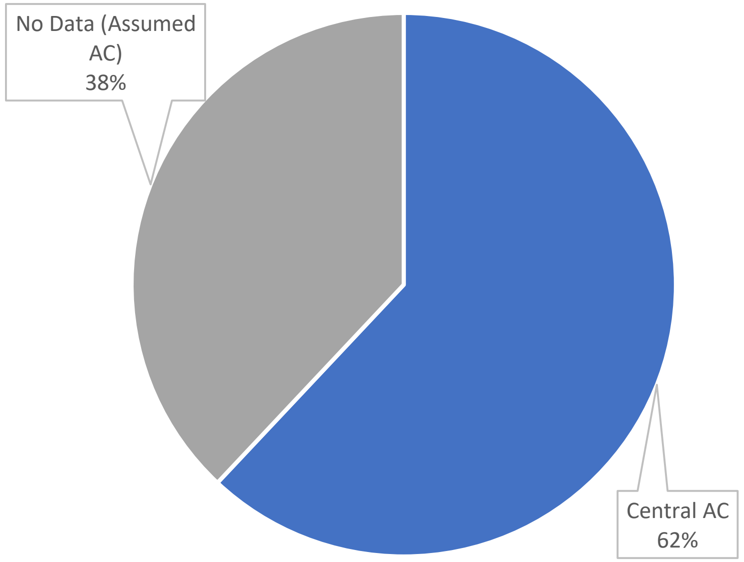
Market Conditions | Estimated market share of heating and cooling systems within the District

- DC's **heating market is dominated by natural gas,** which has an estimated 90+% of the market share
- Over **60% of District residents have Central AC**, while the remaining residents likely use Window AC units

Estimated Existing Residential Building Heating Systems



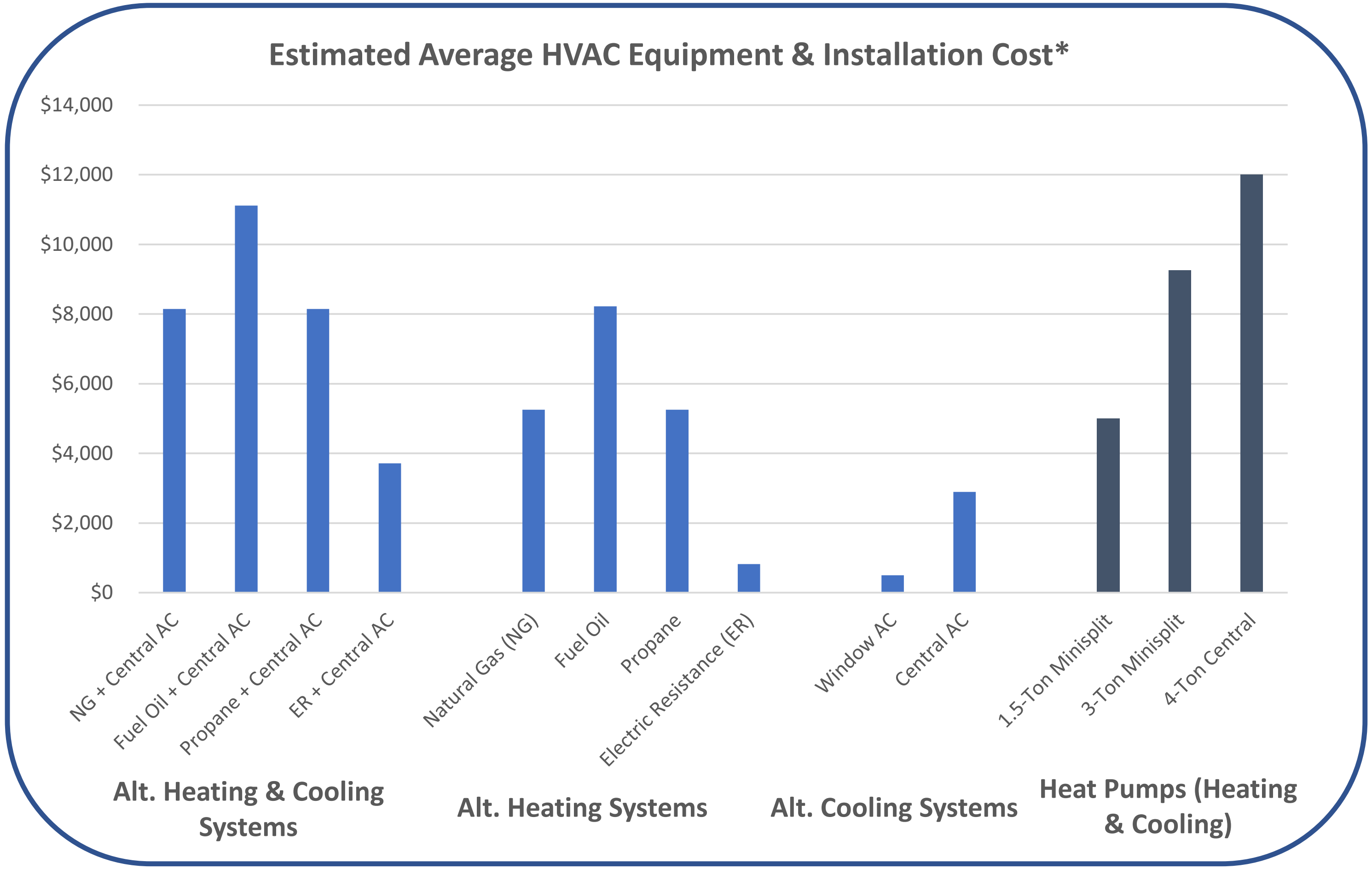
Estimated Existing Residential Building Cooling Systems



Source: American Community Survey estimates were adjusted based on interviews with DC-area contractors

Market Conditions | Heat pump upfront costs compared to alternative heating and cooling systems

- A **4-ton Central ASHP is the most expensive whole-home heating and cooling system** on the market
  - A 4-ton system is ~50% more expensive than a natural gas and central AC system
  - A fuel oil and central AC system has most comparable cost to the 4-ton ASHP
- A **1.5-ton Minisplit ASHP has a similar installation cost as a natural gas system**, but serves only ~40% of the heating load
  - The Minisplit system also serves ~50% of the cooling load
- All heat pump systems are more expensive than alternative cooling systems

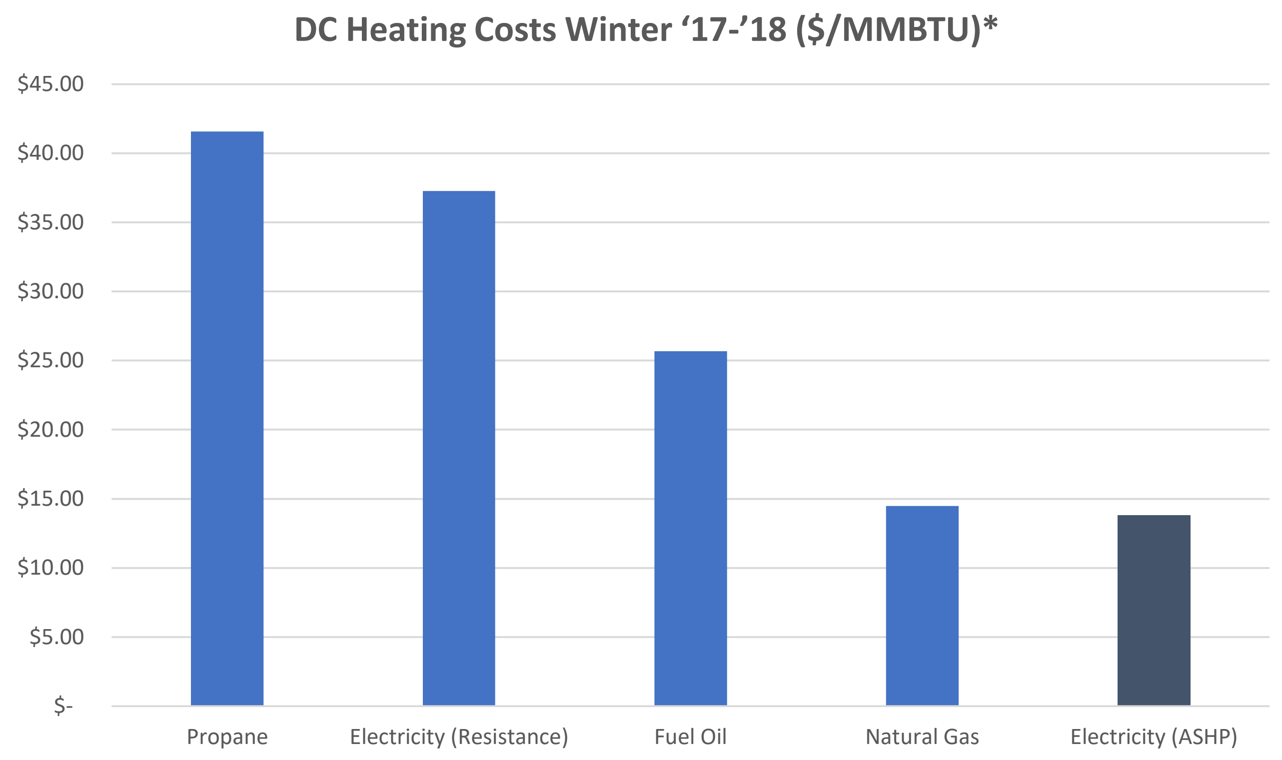


*Actual installation costs will vary considerably by contractor, building, and other factors

Sources & Assumptions: ***Heat pump installation costs:*** interviews with DC area contractors for high-efficiency system (presented as average of high and low estimates); ***Alternative heating system installation costs:*** Cadmus data compiled from New York State installation contractor interviews scaled through RS Means labor factors; ***Alternative cooling system installation costs:*** Window AC – average of units available on homedepot.com; Central AC RS Means data.

Market Conditions | Heat pump operational costs compared to alternative heating systems

- Heat pumps **reduce heating operational costs compared to non-gas heating** systems
  - Lower operational costs support customer paybacks over time
- Heat pumps have **slightly lower operational costs than natural gas heating** systems
  - Slightly lower costs support paybacks over a long time period
- Fuel prices vary year-to-year, influencing market dynamics

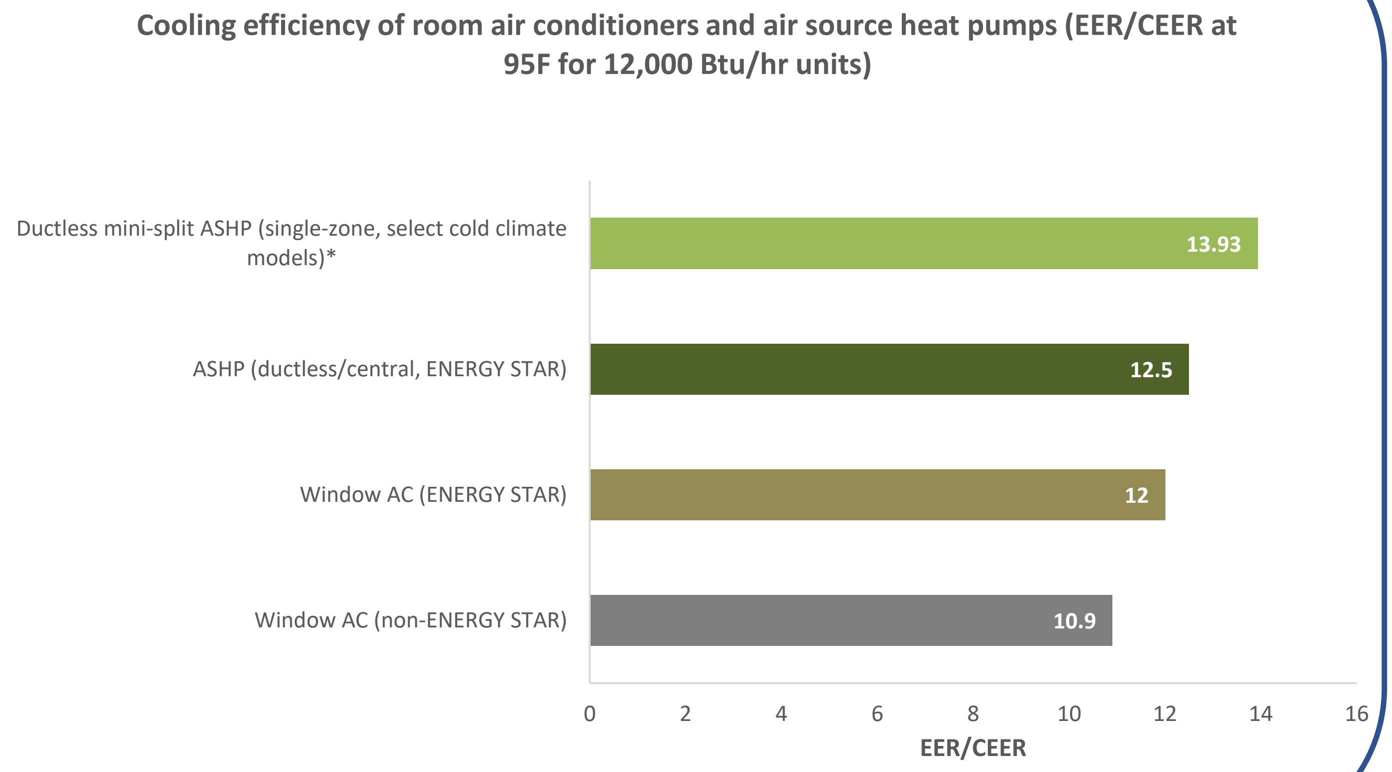


*Costs vary year-by-year

Sources & Assumptions: BLS and EIA average prices for DC/Mid-Atlantic; DOE assumptions for heating content per unit of fuel; efficiency assumptions of 85% for oil, 85% for propane and gas, and seasonal COP of 2.7 for ASHP; 2016 average fuel prices: electricity ($0.13/kWh), oil ($3.02/gal), propane ($3.22/gal), and gas ($1.19/therm)

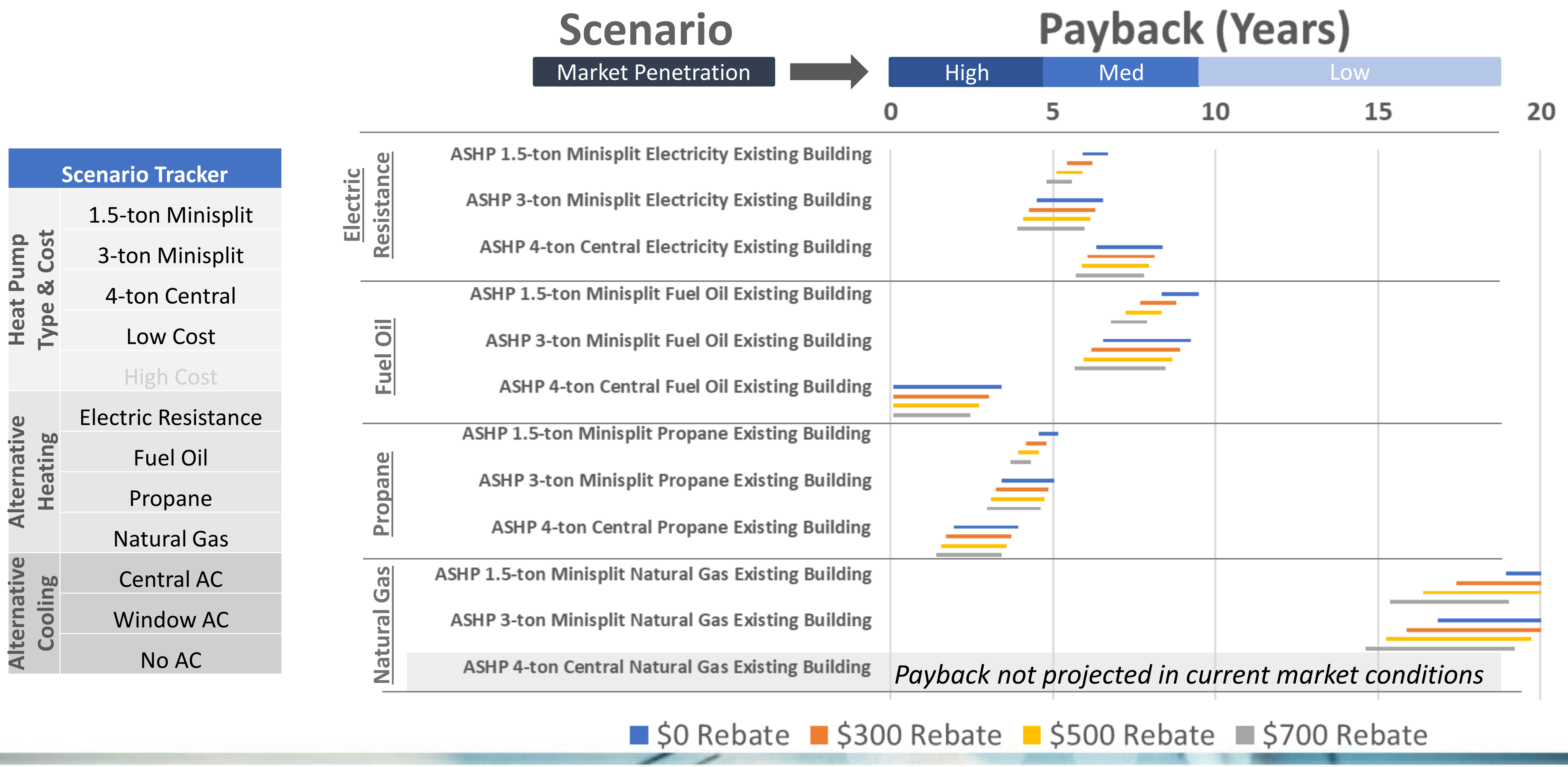
Market Conditions | Heat pump operational costs compared to alternative cooling systems

- Heat pumps **reduce cooling operational costs compared to window AC** systems[1]
  - Lower operational costs support customer paybacks over time
- Heat pumps have **similar or slightly lower operational costs than centrally ducted AC** systems
  - Ductless heat pumps operate slightly more efficiently than typical central AC systems, reducing home cooling costs and supporting paybacks over time



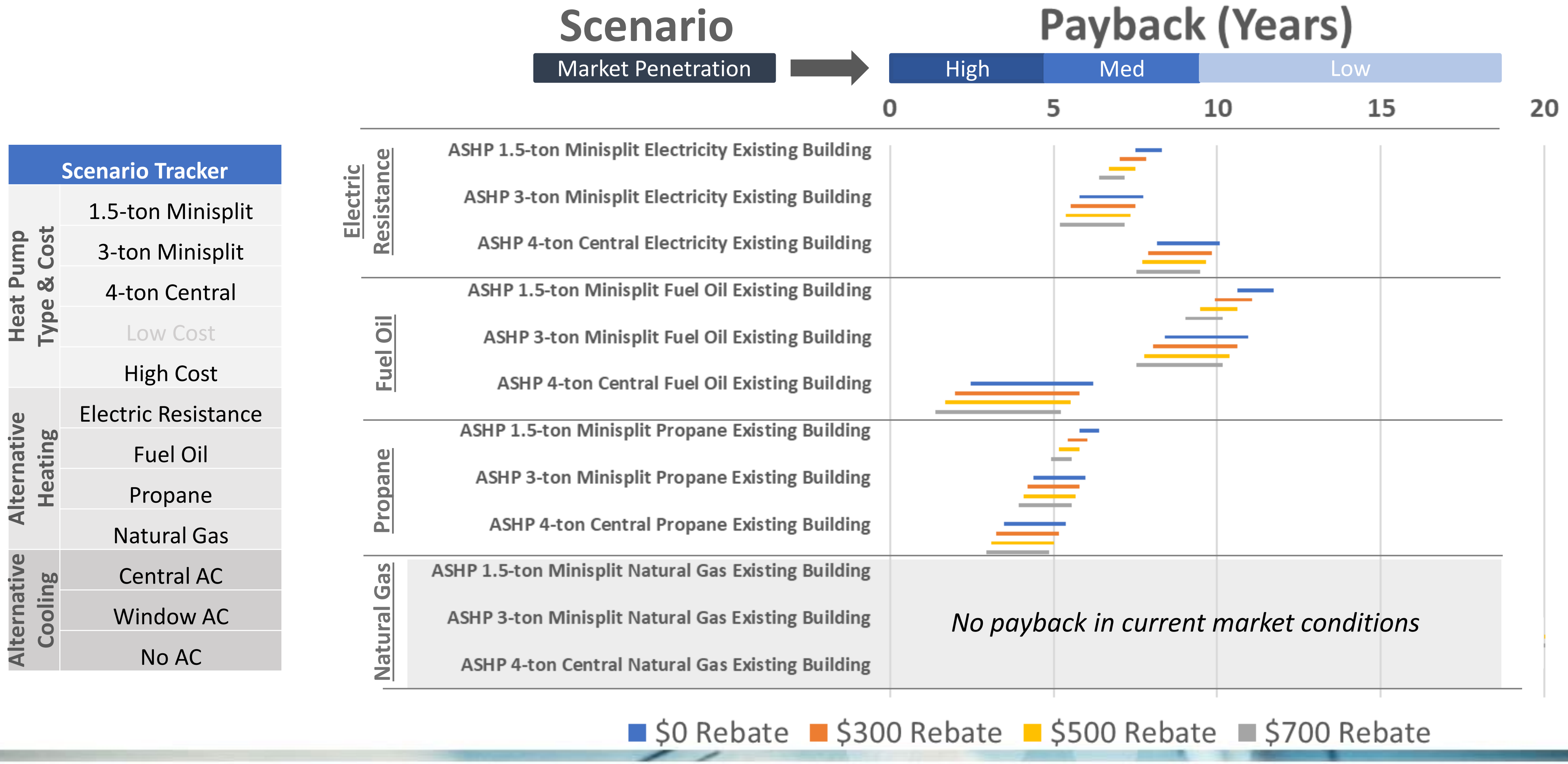
Sources & Assumptions: [1]Assuming total cooling demand is held constant. Sources: ENERGY STAR Product Specification for Room Air Conditioners (version 4.0, eff. Oct. 2015); Minimum federal standards for room AC/split ASHP in 10 CFR 430.32(b); Window AC uses CEER while ASHP uses EER; for cold climate ASHP, avg. ratings of 3 frequently installed, 1-ton, single-zone ductless ASHP selected from NEEP Cold Climate Specification (Mitsubishi MUZ-FH12NA, Daikin RX12LVJU, and Fujitsu AOU12RLS3H)

Modeling Results | Summary of estimated heat pump payback periods for low heat pump cost (presents range of avoided cooling installation scenarios)



Notes: Payback range presents impact of different avoided cooling installation costs (e.g. avoiding central AC installation vs. no avoided AC installation)

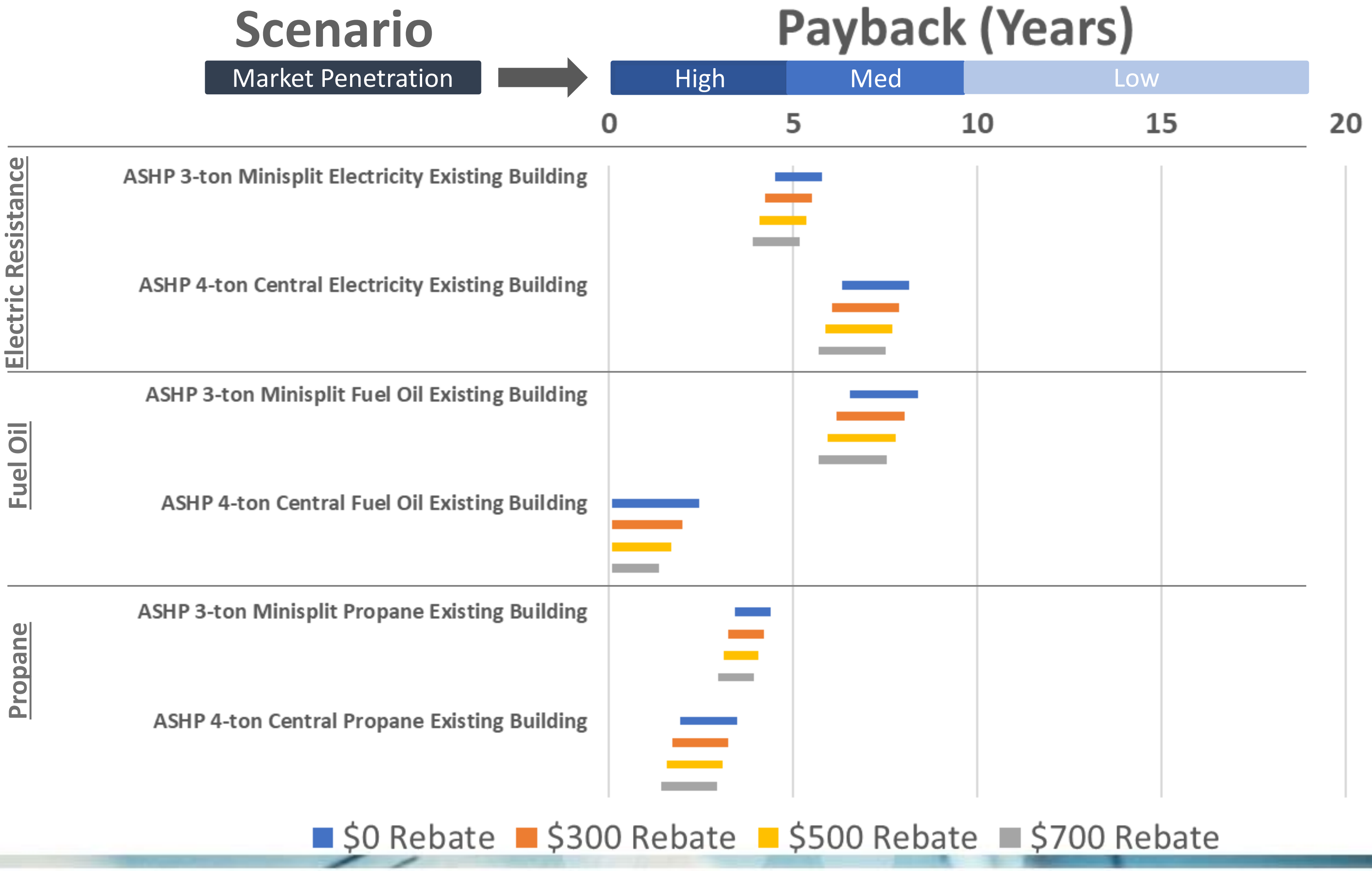
Modeling Results | Summary of estimated heat pump payback periods for high heat pump cost (presents range of avoided cooling installation scenarios)



Notes: Payback range presents impact of different avoided cooling installation costs (e.g. avoiding central AC installation vs. no avoided AC installation)

Modeling Results | Estimated heat pump payback periods for assuming avoided central AC installation (presents range of high and low heat pump cost scenarios)

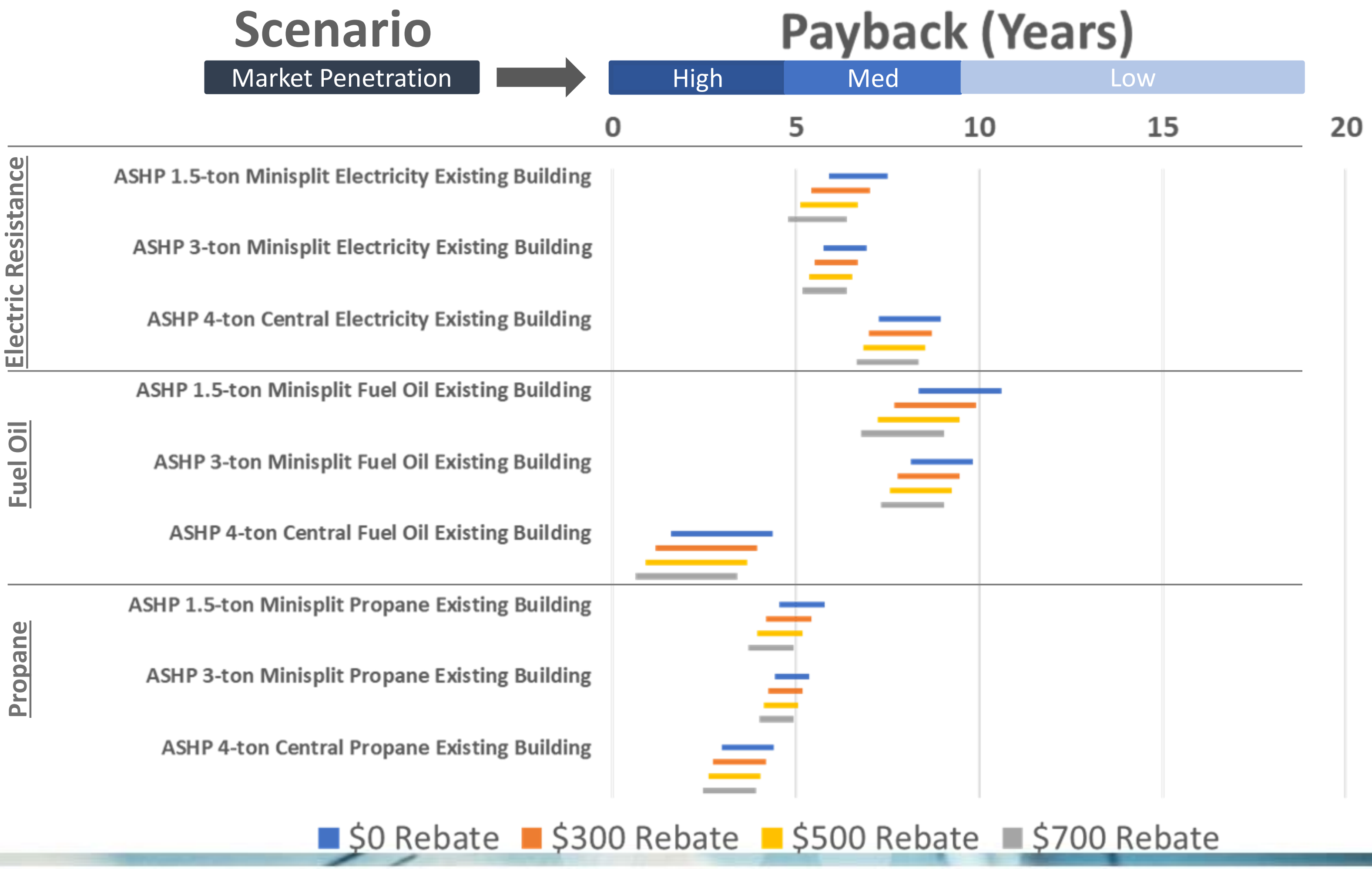
Scenario Tracker	
Heat Pump Type & Cost	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
	Low Cost
	High Cost
Alternative Heating	Electric Resistance
	Fuel Oil
	Propane
	Natural Gas
Alternative Cooling	Central AC
	Window AC
	No AC



Notes: Payback bars present range of high and low ASHP installation cost assumptions; 1.5-ton Minisplit scenario not presented because the system cannot replace a central AC system

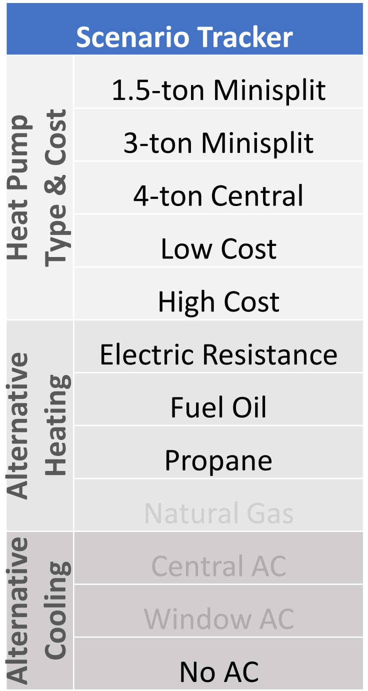
Modeling Results | Estimated heat pump payback periods for assuming avoided window AC installation (presents range of high and low heat pump cost scenarios)

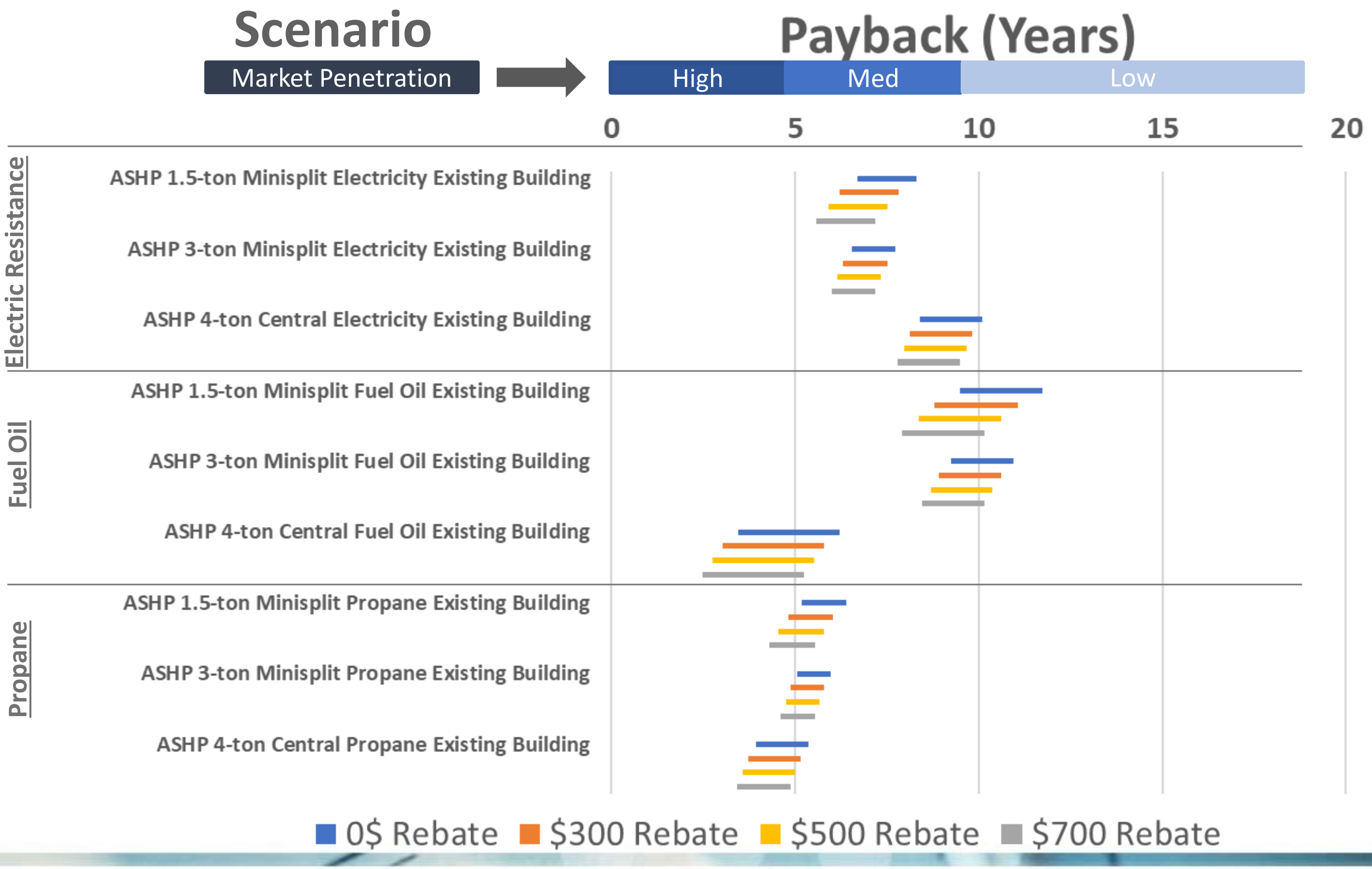
Scenario Tracker	
Heat Pump Type & Cost	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
	Low Cost
	High Cost
Alternative Heating	Electric Resistance
	Fuel Oil
	Propane
	Natural Gas
Alternative Cooling	Central AC
	Window AC
	No AC



Notes: Payback bars present range of high and low ASHP installation cost assumptions

Modeling Results | Estimated heat pump payback periods for assuming no avoided AC installation (presents range of high and low heat pump cost scenarios)





Notes: Payback bars present range of high and low ASHP installation cost assumptions

Modeling Results | Key market takeaways from payback period analysis

- **Market conditions support heat pump adoption for District customers that heat with non-gas fuels and would otherwise install/replace a cooling system.** For 3- or 4-ton heat pump installations that enable a non-gas customer to avoid a central AC system installation, paybacks are under 7-8 years in nearly all cases (even when assuming high heat pump cost). Additionally, 1.5-ton heat pump installation paybacks range from 3-10 years assuming an avoided cooling system installation. Paybacks are shortest for 4-ton heat pumps that replace a fuel oil heating and central AC system.
- **Natural gas customers do not receive viable heat pump paybacks in current market conditions.** Due to higher upfront costs and similar operational costs, heat pumps are not economically cost competitive with natural gas systems (even when avoided central AC costs are included in the analysis). Natural gas is estimated to provide heating for over 90% of DC's market, limiting potential for widespread heat pump adoption.
- **Heat pump's cooling application is essential for supporting paybacks for large systems.** Heat pump system paybacks for 3-ton and 4-ton systems are up to five years shorter if they enable a homeowner to avoid installing/upgrading a central AC system, indicating that the cooling application of heat pumps is essential for economic viability in the DC market.
- **Heat pump installation cost assumptions significantly impact market dynamics.** Assuming a low ASHP installation cost can reduce upfront costs by up to $2,000 and shorten paybacks by 3-4 years, supporting higher adoption by non-gas customers.

Rebate Amount | Implications and considerations for DCSEU rebate amount

- **Moderate increases in existing rebates will not significantly alter the market context.** Increasing DCSEU's existing rebates of $300/$500 to $500/$700 will not significantly shift the market context because higher rebates are insufficient to support paybacks for natural gas systems, which dominate DC's market. The higher rebates do shorten payback periods for existing electric resistance, fuel oil, and propane customers, which can support increased adoption within these market segments.
- **Reductions in rebate amount may reduce program participant interest.** Based on interviews with DC-area supply chain representatives, reducing the rebate substantially below existing levels may suppress contractor's interest in joining the program or processing the rebates. If DCSEU is considering lowering rebates, they should ensure that the program accessibility is increased to keep a balance between rebate amount and administrative burden for program participants.
- **Low-interest financing programs can also support increased market adoption.** Although not included in this payback analysis or program design, several reviewed heat pump programs utilize attractive financing to improve customer economics. For example, Massachusetts has the MassSave HEAT Loan with 0% interest for up to 7 years for qualified homeowners, which improves economic evaluations for heat pump installations. [1]
- **Non-economic factors often drive heat pump installations.** Based on data from heat pump campaigns throughout the Northeast, up to 33% of installations are for homes currently using natural gas for heating.[2] These installations are motivated by non-economic factors such as zone control, cooling, home comfort, or environmental considerations. This trend is supported by interviews with District contractors, who suggest that most customers install heat pumps primarily for cooling benefits.

Sources: [1] Mass Save HEAT Loan (link); [2]Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities (link)

- In current market conditions, **heat pumps are economically viable for a limited portion of DC customers** that i) heat with non-gas fuels; and ii) would otherwise install central AC system (or window AC system for 1.5-ton heat pumps)
- To drive widespread adoption within the District, heat pump paybacks need to improve for both non-gas and gas heating customers and installing heat pumps to avoid cooling system installations will remain critical for heat pump economic viability
- The following section **examines possibilities for driving market growth by improving economics for two different customer types**:
  - i. Improving economics for **electric resistance, propane, and fuel oil heating customers** by increasing heat pump rebate amount
  - ii. Improving economics for **gas heating customers** by increasing natural gas prices

Improving Customer Economics | Improving heat pump economics for electric resistance, fuel oil, and propane heating customers

- Although electricity, fuel oil, and propane customers are a small portion of the market (estimated <10%), they have **the most viable existing payback periods that could be shortened through higher rebates**
- The table to the right summarizes the **potential customer heat pump adoption supported by certain payback periods**
  - Note that actual market adoption may vary considerably based on market factors outside of payback period (e.g. market awareness, consumer priorities, etc.)
- This section **evaluates the rebates required to achieve 3, 5, and 7 year paybacks** for heat pump installations
- Key assumptions include:
  - 3-ton and 4-ton ASHP installations assume avoided central AC installation to present best possible case
  - 1.5-ton ASHP installations assume avoided window AC installation to present best possible case

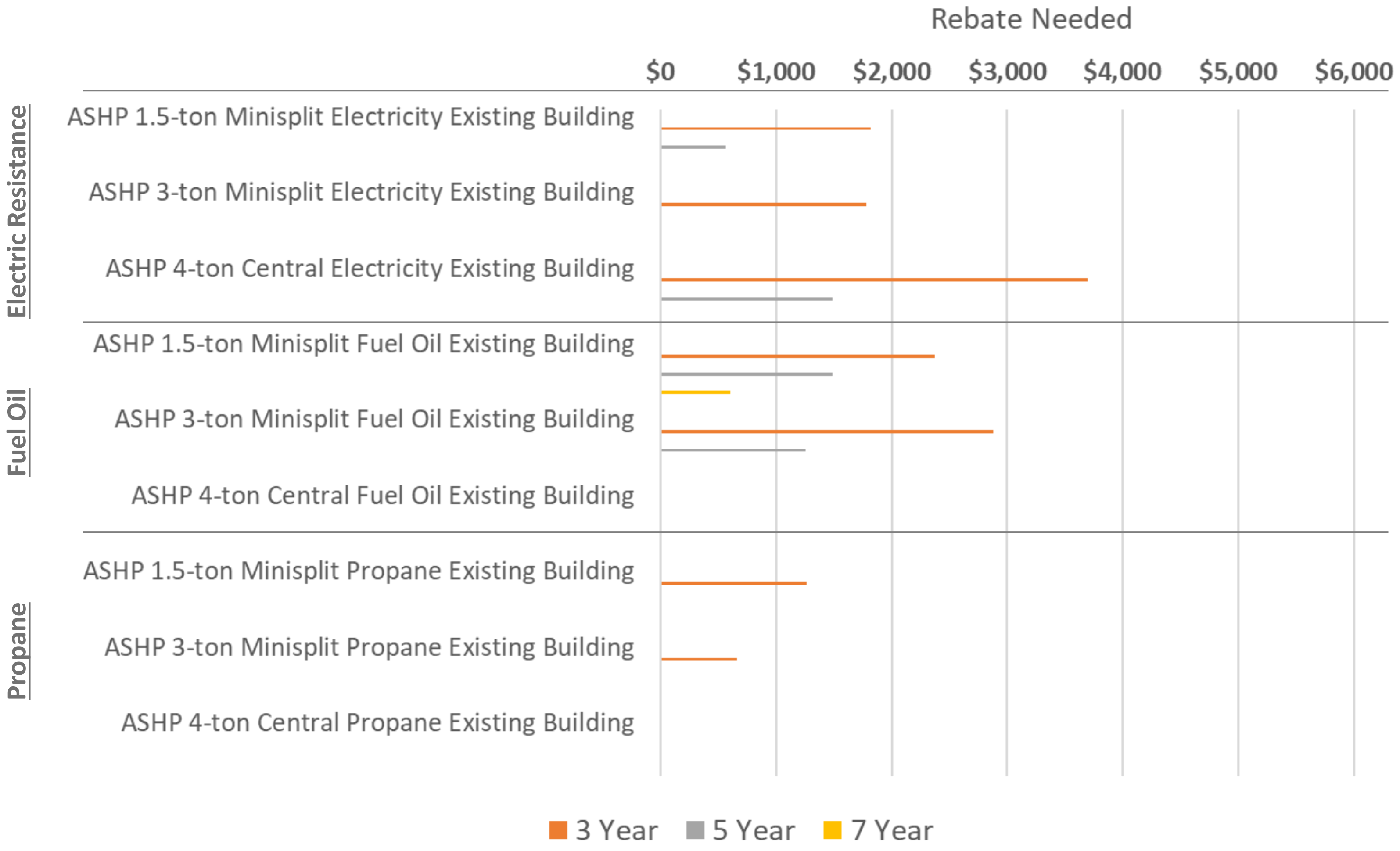
Potential Market Adoption Supported by Payback Periods[1]

Payback	Adoption
3 years	High
5 years	Medium
7 years	Medium – Low

Sources: [1] These high-level estimates are based on technology adoption curves created from customer interviews about their likeliness of adopting . These curves are evaluated for energy efficiency technologies generally, but are not specific to heat pumps.

Improving Customer Economics | Rebates needed to achieve targeted heat pump paybacks for electric resistance, fuel oil, and propane customers (assuming low heat pump cost)

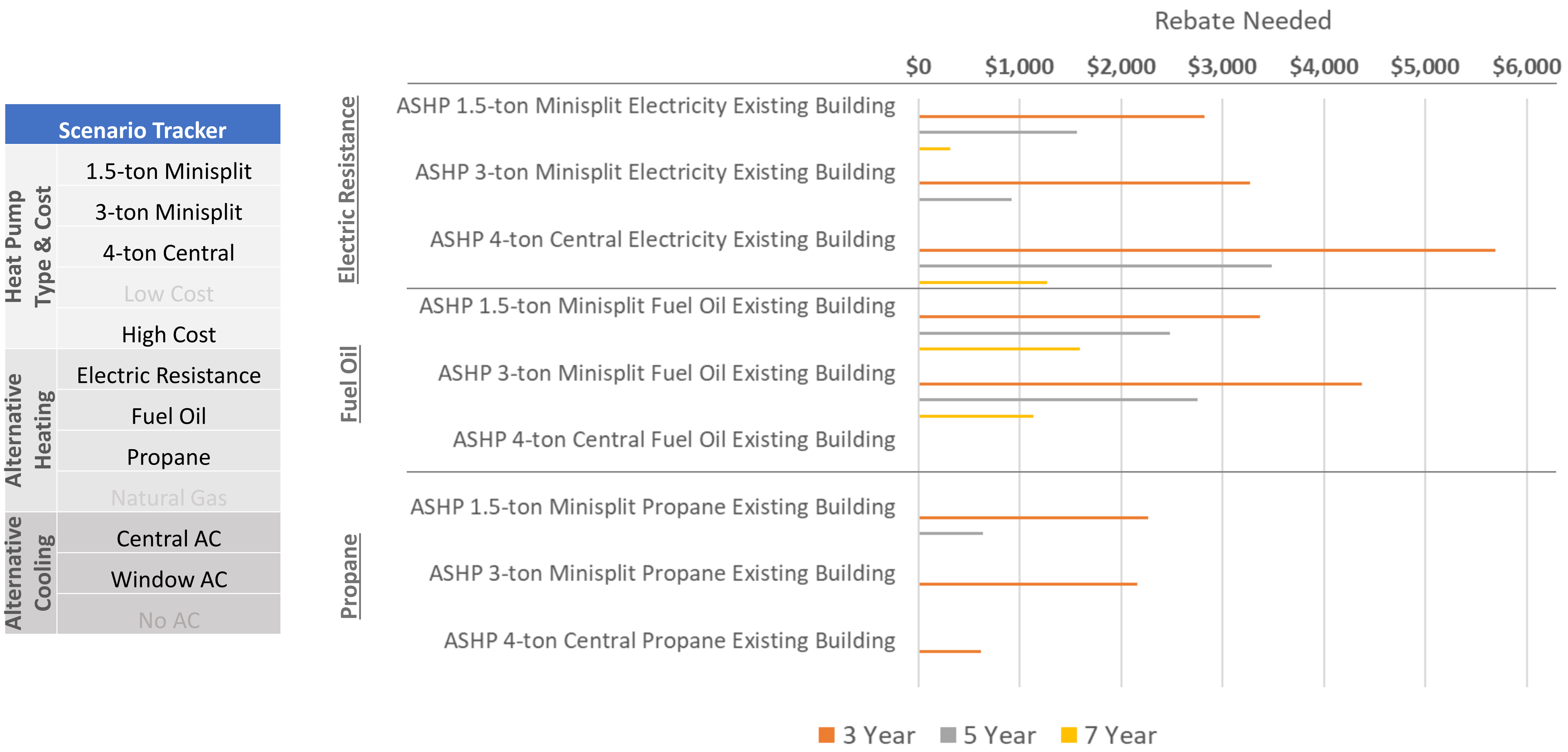
Scenario Tracker	
Heat Pump Type & Cost	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
	Low Cost
	High Cost
Alternative Heating	Electric Resistance
	Fuel Oil
	Propane
	Natural Gas
Alternative Cooling	Central AC
	Window AC
	No AC



(blanks indicate that payback level already achieved; no rebate needed)

Notes: 3-and 4-ton ASHP scenarios assume avoided central AC installation; 1.5-ton scenario assumes avoided window AC installation

Improving Customer Economics | Rebates needed to achieve targeted heat pump paybacks for electric resistance, fuel oil, and propane customers (assuming high heat pump cost)



(blanks indicate that payback level already achieved; no rebate needed)

Notes: 3-and 4-ton ASHP scenarios assume avoided central AC installation; 1.5-ton scenario assumes avoided window AC installation

Improving Customer Economics | Key takeaways for improving electric resistance, fuel oil, and propane customer heat pump economics

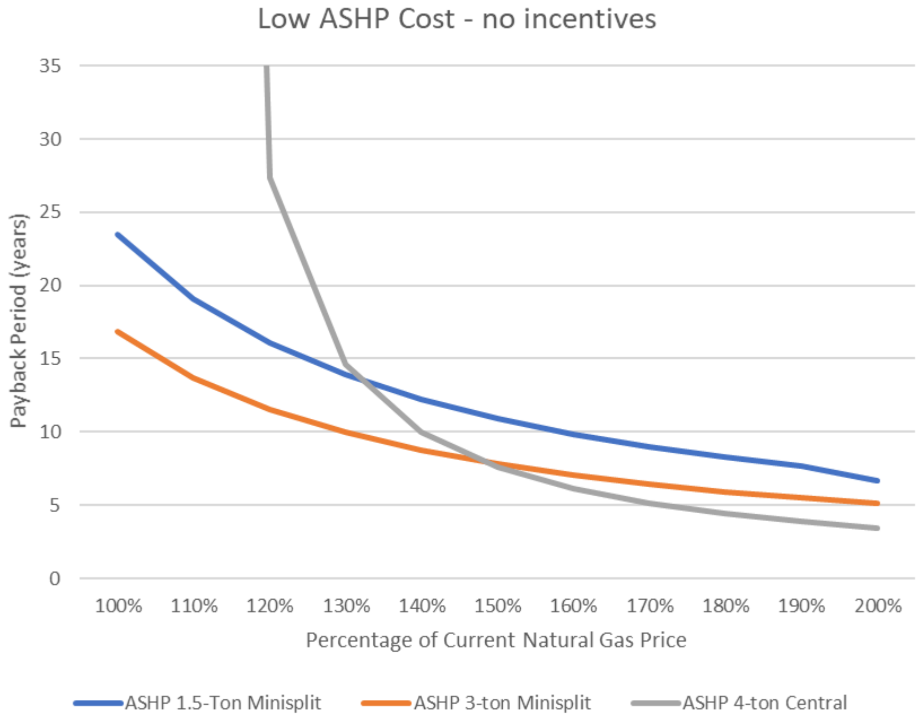
- **Whole-home heating and cooling replacements are well-supported by the existing rebate program.** Even in high heat pump cost scenarios, existing rebates are sufficient to support 3-year paybacks for existing fuel oil and propane customers conducting a whole-home heating and cooling replacement. This indicates that these applications already receive sufficient economic support through DCSEU's existing program.
- **Although electric resistance customers have favorable long-term economics for heat pump adoption, supporting 3-year paybacks requires rebates of at least $1,800.** Operational costs for electric resistance systems are around three times higher than for heat pumps, but electric resistance systems also have the lowest installation cost of any heating system, making it difficult to achieve paybacks in the 3-year window. However, the outlook for electric resistance customers improves over time: 5-year packs are already supported by current rebates in a low cost scenario, and 7-year paybacks are supported by current rebates in the high cost scenario.
- **Single-zone installations require over $1,000 in rebates to achieve 3-year paybacks.** Even in low heat pump cost scenarios, 1.5-ton Minisplit heat pumps require over $1,000 rebates to support 3-year paybacks against any of the alternative fuel-types. However, these systems are often installed to provide heating and cooling for specific zones of a home, so adoption is frequently driven by non-economic considerations.
- **Required rebate amount to achieve targeted payback varies considerably by assumed heat pump type and assumed installation cost.** Because estimates for heat pump cost vary by up to $2,000 and heat pump type influences avoided alternative heating and cooling costs, the required rebate to support targeted payback period has a wide range, even within the same fuel-type. This highlights that actual paybacks will vary considerably based on the specific home or situation being evaluated.

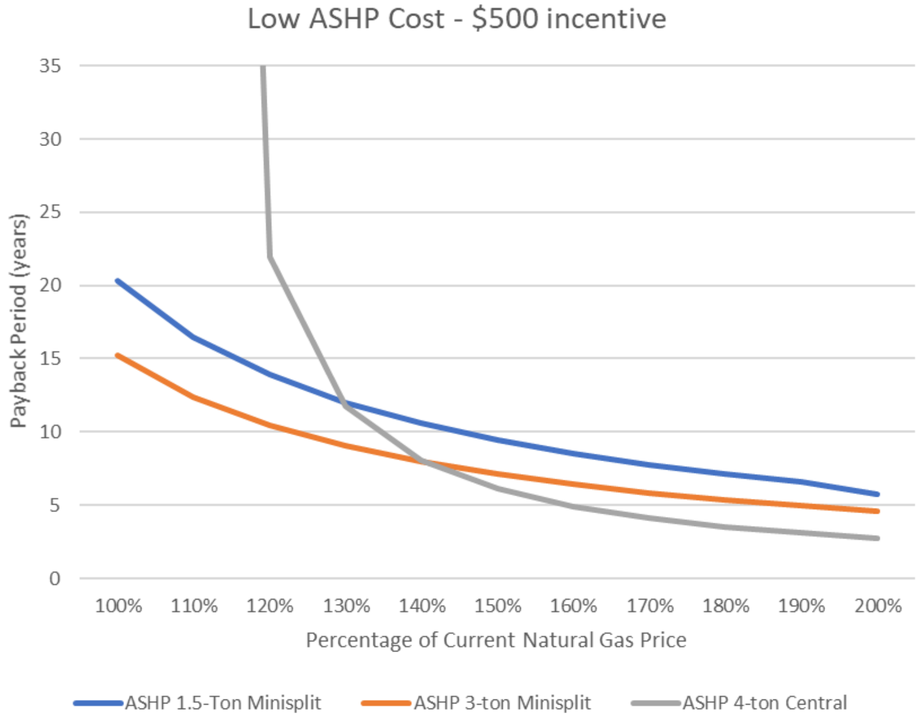
Improving Customer Economics | Improving payback periods for natural gas heating customers

- Heat pumps are not economically viable against natural gas systems in current market conditions because the similar operational costs between the two systems do not support customer paybacks over time
  - While high heat pump installation costs are also a economic challenge, propane systems have similar installation costs as natural gas systems but provide paybacks for heat pump customers because they are expensive to operate (see operational heating cost chart above)
- The following section **evaluates the potential for higher natural gas prices to reduce customer payback periods** and support higher levels of market adoption
- Key assumptions include:
  - Electricity prices are held constant at current prices
  - All installation costs are held constant at current estimates
  - 3-ton and 4-ton ASHP installations assume avoided central AC installation to present best possible case
  - 1.5-ton ASHP installations assume avoided window AC installation to present best possible case

Improving Customer Economics | Relationship between natural gas price and heat pump paybacks

Scenario Tracker	
Heat Pump Type & Cost	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
	Low Cost
	High Cost
Alternative Heating	Electric Resistance
	Fuel Oil
	Propane
	Natural Gas
Alternative Cooling	Central AC
	Window AC
	No AC

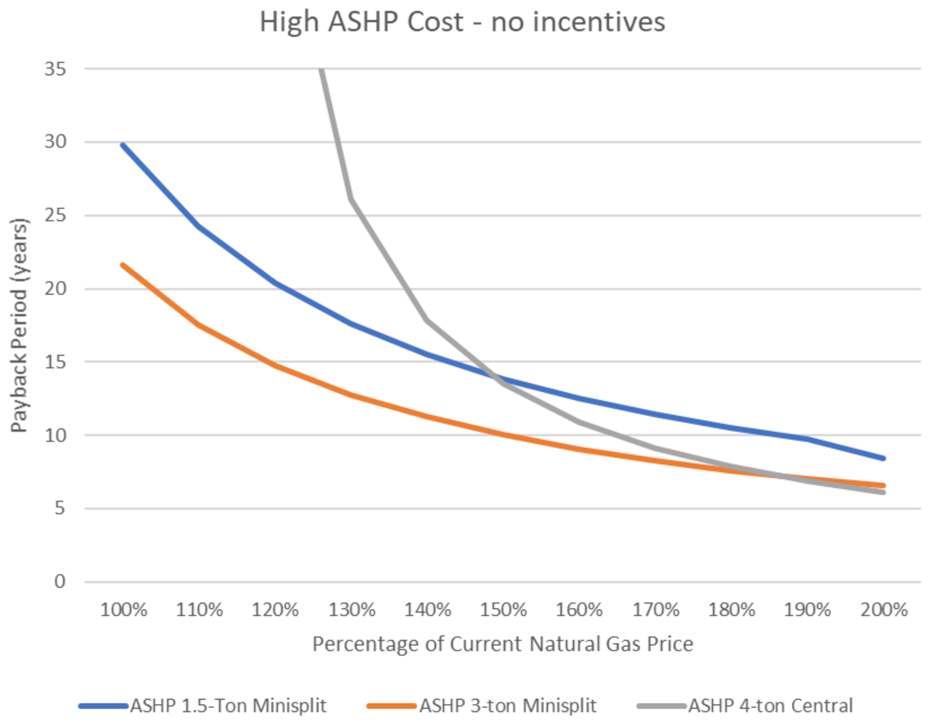


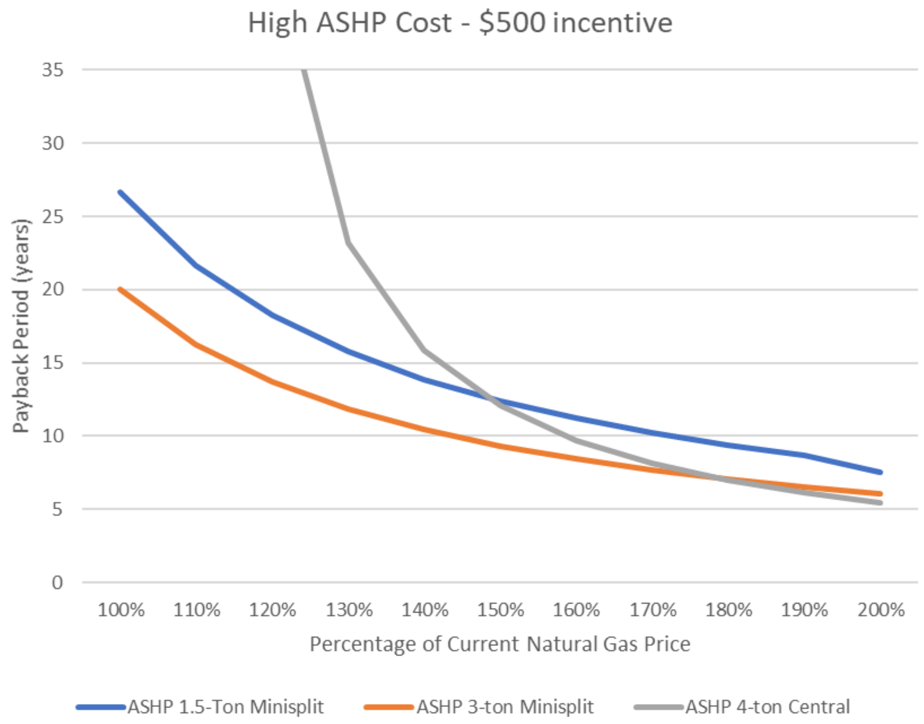


Notes: 3-and 4-ton ASHP scenarios assume avoided central AC installation; 1.5-ton scenario assumes avoided window AC installation

Improving Customer Economics | Relationship between natural gas price and heat pump paybacks

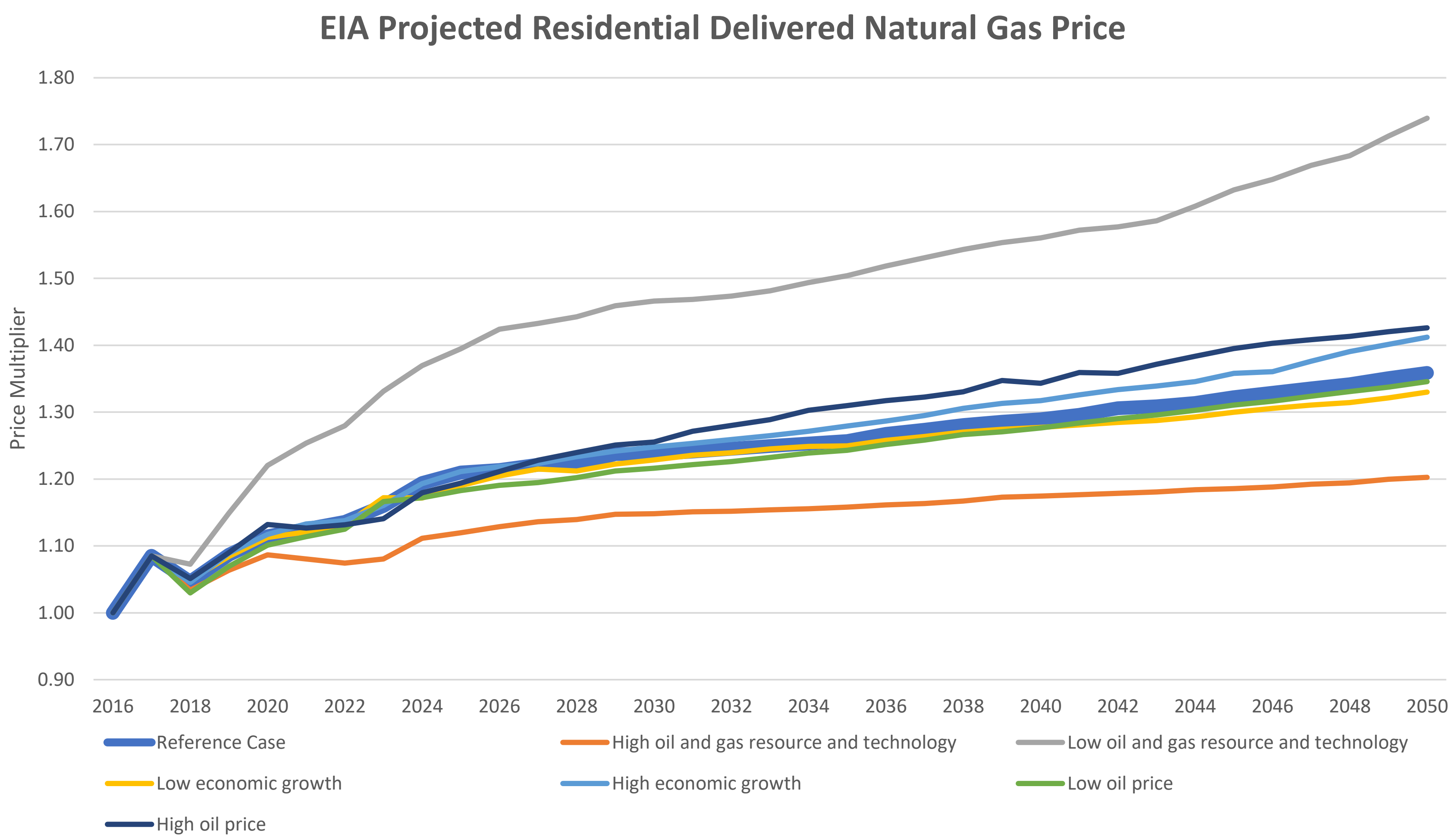
Scenario Tracker	
Heat Pump Type & Cost	1.5-ton Minisplit
	3-ton Minisplit
	4-ton Central
	Low Cost
	High Cost
Alternative Heating	Electric Resistance
	Fuel Oil
	Propane
	Natural Gas
Alternative Cooling	Central AC
	Window AC
	No AC





Notes: 3-and 4-ton ASHP scenarios assume avoided central AC installation; 1.5-ton scenario assumes avoided window AC installation

Improving Customer Economics | EIA projected natural gas prices for residential customers



Source: EIA Annual Energy Outlook (link)

Improving Customer Economics | Key takeaways for supporting natural gas customer adoption

- **Business-as-usual projected natural gas price increases are insufficient to shift market economics.** EIA Reference Case projections indicate that gas prices will increase about 20% over the next ten years, which is insufficient to support a significant shift in current market economics. This finding indicates that some other shift (e.g. policy or regulatory shift, decrease in heat pump installation prices) may be needed to support competition between gas and efficient electric systems.
- **The natural gas price must increase 50%-90% to achieve ~7 year paybacks for large heat pump installations.** Assuming no rebates are provided, both 3-ton and 4-ton installations achieve ~7 years paybacks if natural gas prices increase 50% (low cost scenario) to 90% (high cost scenario). This range decreases to ~40-80% if existing $500 rebates are provided. Even in the EIA scenario with the fastest price increase, a 50% increase in natural gas price is not expected until the mid 2030s.
- **Doubling the natural gas price would generate a significant shift in market context.** A 100% increase in natural gas price and maintaining existing rebates would lead to payback periods between 3-7 years for all heat pump types in high and low heat pump cost scenarios. These payback periods could support high levels of market adoption among existing gas customers, driving market transformation.
- **1.5-ton heat pump installations require greater increases in natural gas prices to achieve paybacks that enable adoption.** Because 1.5-ton Minisplit heat pumps do not fully replace an alternative heating system or central AC installation, they require higher natural gas prices to support short payback periods. Assuming existing $500 rebates, the natural gas price must increase 50-80% to drop 1.5-ton paybacks below 10-years.

Contents

Appendix Contents

Customer Benefits of ASHPs | Heat pumps can provide year-round home comfort in DC's climate and improved zoning control

» **Improved heating.** New cold climate air source heat pumps (ccASHPs) are optimized for year-round performance in cold weather. These heat pumps produce useful heat down to -10°F and below and do not include built-in electric resistance.

- › The District rarely faces such temperature extremes, though field performance studies in MA and RI indicate that cold climate ductless ASHPs outperform non-cold climate systems (by nearly 15% in average seasonal efficiency) while maintaining above-ENERGY STAR cooling performance (as indicated by testing).

» **Improved cooling.** Ductless ASHPs provide quieter, higher-efficiency cooling and dehumidification than window/built-in AC units and can be installed in rooms that might not be suitable for window/built-in units.

- › Roughly 62% (or more) of homes in the District have central AC, with the remainder mostly using window units. Homes with window or built-in AC units (or no AC) can be ideal candidates for ductless ASHPs.
- › Recent in-field evaluation studies of cold climate ductless ASHPs in Massachusetts, Rhode Island, and Vermont found that cooling electricity usage was decreased by replacing a window/portable AC unit with a single-zone ductless ASHP.

» **Zoning control.** With individual indoor units in different zones, homeowners have greater control over heating and cooling zones of their homes. This can allow homeowners to turn down their indoor units in rooms they are not using, reducing energy usage—or allow for different temperatures in different rooms to meet occupant comfort requirements.

Sources: Analysis of DC Tax Assessor Data; Walczyk, J. (2017). Evaluation of Cold Climate Heat Pumps in Vermont. Prepared by the Cadmus Group for Vermont Public Service Department; Korn, D. et al. (2016). Ductless Mini-Split Heat Pump Impact Evaluation. Prepared by the Cadmus Group for the Electric and Gas Program Administrators of Massachusetts and Rhode Island

Customer Challenges of ASHPs | Technical challenges may prevent heat pumps from being an ideal solution for some households

- **May not provide 100% of household needs.** ASHPs are often used in parallel with alternative heating systems. Cold-climate ASHPs have mitigated this challenge, but many homeowners still prefer having a backup heating system.
- **System controls.** ASHPs can require control systems to maximize efficiency and home comfort. These systems (e.g. Nest, ecobee) are available, but far more expensive than standard programmable thermostats and may not always work optimally with advanced variable-speed heat pumps.
- **System sizing.** Sizing is an important component of ASHP performance. ASHPs that are oversized will run less efficiently and provide less comfortable space conditioning. ASHPs that are undersized will rely more on backup power systems, reducing overall efficiency gains. Appropriate sizing is influenced by insulation, which varies within District homes and may be challenging for contractors to accurately estimate.
- **Refrigerants.** Potential for high-emitting refrigerant leakage may reduce the emission reductions for ASHPs.

Customer Segmentation Methodology | Good Candidates for ASHP installations in DC

Opportunities for ASHP installation depend on the following building attributes:

» **Building size:** 1-4 family homes are currently the best candidates. Installations are more challenging in rental or multifamily units and in taller buildings. This analysis was restricted to 1-4 family buildings and condominiums.

» **Fuel Type:** There is greater operational cost parity between electric ccASHPs and HVAC systems using heating oil vs. HVAC systems using natural gas

» **HVAC Equipment Age:** Customers that need to replace their central AC or heating system and are planning to make a purchase

» **Envelope Performance:** Better building envelope performance will increase the capacity of ASHPs to meet heating load

» **Availability of Central AC:** Homeowners without central AC (or lacking ductwork for central AC) may find ductless ASHP appealing

» **Other Building Characteristics:** Buildings may have physical characteristics that would affect installation costs, such the number of rooms or existing ductwork

Customer Segmentation Methodology | What do we know about DC buildings?

A variety of indicators were selected to represent the technical, economic, and market suitability of installing ductless and central cold climate air source heat pumps (ASHP).

Category	Indicators	
	Ductless ASHP	**Central ASHP**
Technical	• Building type	
	• Number of floors	• Presence of ducted heating system
Economic	• Heating Fuel (gas, electricity, or fuel oil) • Median Income • Heating System replacement year	
Market	• Renter- or owner-occupied • Presence of solar PV • Presence of central AC • Presence of existing heat pump • Located in historic district	

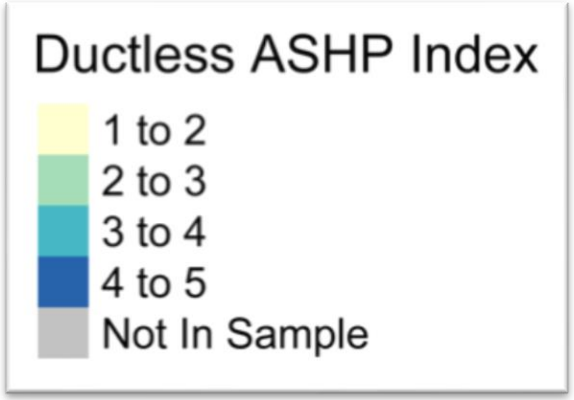
Customer Segmentation Methodology | Developing a Suitability Index

- To create a Suitability Index, each indicator has:
  - A ranking scheme to give it a suitability score. For example, the suitability score for gas-heated homes is low, for oil-heated homes is moderate, and for electrically-heated homes is high.
  - A weighting to create a prioritization of the indicators based on their importance to the technology (central or ductless ASHP). For example, whether a building is owner-occupied is more important to a building's market suitability than the homeowner's income level. The owner/renter-occupied indicator was assigned a higher weighting than income level indicator.
- The ranking values for each indicator were multiplied by the weighting, and each parcel's index value was normalized on a scale of 1-5.

Raw Data → Ranking within each Indicator → Weighting across each Indicator → Index Results

Customer Segmentation Methodology | Interpreting Results

- Index is on a scale from 1 to 5
  - 5 = High potential candidate (dark blue)
  - 1 = Low potential candidate (cream/yellow)
  - Buildings “not in sample” were not analyzed (grey)
- Results
  - Ductless and Central ASHP have a separate index
  - Maps are useful for identifying parts of cities with clusters of high potential candidates
  - Histograms are useful for capturing how many homes are in each index category (e.g. 4 to 5)



Appendix Contents

Distributor Rebate Program

- **Instant rebate** from distributor to contractor at point of purchase for all qualified products
- After submitting sale information collected at the point of purchase, **distributor receives payment from DCSEU** as reimbursement for instant rebate
- Distributor also receives **administrative fee** for processing the rebate; based on research, this fee should be between $15-$75
- **Contractor may or may not be expected to pass all of the rebate to the end-customer** via a line-item on the bill depending on program objectives and design
- Following installation, the **customer receives a postcard from DCSEU** informing them that they have received a rebated system–the postcard could also include information on best practices for heat pump operations and maintenance best practices (see Quality Control section)

Contractor Rebate Program

- Depending on program objectives, **contractor may or may not be expected to pass rebate to customer**
- Following installation, **contractor submits required installation information online** via DCSEU's existing platform (or new platform/variation on the existing platform)
- **DCSEU processes rebate and pays contractor** via direct deposit, check, or other form of payment
- Following installation, the **customer receives a postcard from DCSEU** informing them that they have received a rebated system–the postcard could also include information on best practices for heat pump operations and maintenance best practices (see Quality Control section)

Rebate Recipient & Delivery | Additional resources

- VEIC. *2017 Regional Cold Climate Air Source Heat Pump Market Transformation Workshop* (link). Presentation from VEIC describing the organization's methodology for implementing midstream (distributor) rebate program.
- ENERGY STAR. "Best Practices: Learn the Right Way to Run a Distributor-Focused Midstream Program" (link). Online resource with best practices and example distributor-based programs.
- ACEEE. *Swimming to Midstream: New Residential HVAC Program Models and Tools* (link). 2016 white paper summarizing programs that have implemented midstream incentives.
- VEIC. *Driving the Market for Heat Pumps in the Northeast* (link). Review of efficiency programs of all types (distributor, contractor, and customer) throughout the Northeast.

Appendix Contents

Onsite Inspections | Overview and case study

» Onsite inspections of a percentage of rebated systems help to **promote high-quality installations and identify key installation challenges** to address with training

» Inspections should be **conducted by DCSEU staff or technical consultants** with knowledge of heat pump installation best practices

» Onsite visits can also be **useful for engaging customers on heat pump operations and maintenance** best practices

Case Study: NYSERDA Inspections

NYSERDA's program includes has two types of onsite inspections:

- **New Contractors.** Contractors that are new to the program have their first three installations inspected and graded from 1-5. Score averages must exceed a minimum threshold for contractor to be admitted to program
- **Approved Contractors.** Once approved, contractor's installations are randomly inspected. Contractors with low initial scores are inspected more frequently

Source: Interviews with program administrators; review of heat pump programs

Onsite Inspections | Implementation considerations

Determine appropriate percentage of installations to inspect

- Interviews with program administrators suggest that 5-10% of installations should be inspected
- Inspections should be more frequent for contractors that are new to the program or have recent low-quality installations, and less frequent for experienced and high-quality contractors

Determine appropriate timeframe for inspection

- Interviews with local contractors suggest that inspections should occur 3-6 months after installation–this timeframe is long enough for installation defects to surface, but short enough to ensure that issues can be corrected by the contractor

Delineate inspection guidelines and system

- Inspections should have standard guidelines to ensure that installations are evaluated thoroughly and consistently
- Installation defects should be noted to identify challenges experienced across installations that can be targeted with contractor training

Identify resources for contractors with poor installations

- Work with manufacturers and distributors to identify appropriate training program(s) for contractors with consistently poor installations
- Determine criteria for program removal if installation problems persist

Source: Interview with NYSERDA Program Administrator, Kerry Hogan

Customer Communications | Overview

- Communicating with heat pump customers after their installation is an effective way to **establish a direct relationship with the customer** and provide information relevant to their heat pump installation
- Several programs reviewed for this study **send postcards to customers** informing them that they have received a rebated system, which helps to ensure that contractors are informing customers that the system has been price-reduced
- Mailings are also used to **inform customers of best practices for operating and maintaining a heat pump** for long-term efficiency

Source: Interviews with program administrators; review of heat pump programs

Develop summary of heat pump operations and maintenance best practices

- Work with supply chain partners and leverage available content to develop a one-page summary of best practices for heat pump operations and maintenance that ensures maximum energy, cost savings, and long-term heat pump performance
- Based on research, these items include: filter cleaning and changing, outdoor unit airflow cleaning, thermostat settings.

Implement process for post-installation customer mailing

- Use rebated system data to mail heat pump customers the one-page summary of best practices (along with a notification that their heat pump has been rebated/price-reduced by DCSEU)

Distribute best practices summary to DCSEU contractors

- Supplying a operations and maintenance best practices summary to program contractors will enable customers to receive the a summary of best practices at the time of installation in addition to when they receive the follow-up postcard

Contractor Training | Overview

- Requiring contractors to receive technology installation training will **likely increase the quality of installations** rebated through the program
- **Manufacturers and distributors provide regular trainings** in the DC area that can be required for program participation
- Contractors must be required to **submit verification of training** via a contractor or distributor letter

Source: DCSEU "Contracting Opportunities" (link)

Contractor Training | Case Study: Massachusetts Clean Energy Center contractor training requirements

MASSACHUSETTS CLEAN ENERGY CENTER

Massachusetts Clean Energy Center supports installations of high-efficiency ductless and ducted ASHPs and requires contractors participating in the program to undergo heat pump training.

- MassCEC's incentive program **requires participating contractors to provide a letter of certificate from the manufacturer** verifying training
  - Minimum of **four hours of training within the last five years** for products they are installing through the program
  - If multiple installers work for the same company, **each primary installer must provide evidence of training**
  - Program also includes onsite inspections of a portion of completed projects to ensure high-quality installations
- MassCEC provides rebates of up to $2000 for installations, which enables them to enforce more stringent quality control requirements

Source: Mass CEC program manual (link)

Work with supply chain partners to communicate requirements

- Manufacturers and distributors interviewed for this program design were interested in working with contractors to improve installation quality within DC. They will be supportive partners in communicating contractor training requirements and directing contractors to the relevant resources and trainings

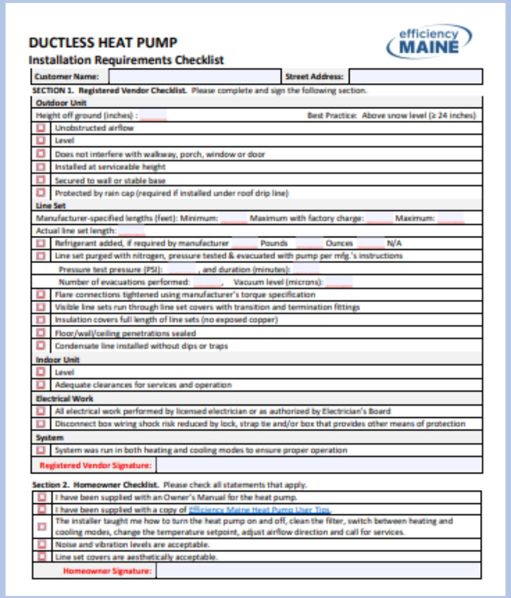
Balance training requirements with barriers to participation

- Excessive training requirements may dissuade contractors from participating in the program, so DCSEU should communicate with trusted contractors to ensure requirements are reasonable
- Contractors interviewed for this program design were open to DCSEU adding training requirements to the program if they were not overly onerous (note that contractor reactions will vary depending on the type of contractor engaged)

Installation Checklist | Overview and case study

- » Installation checklists **summarize requirements** for a high-quality heat pump installation and are a simple method for certifying that installations meet certain criteria
- » DCSEU can **require that rebate applications include a completed checklist** with contractor and customer signatures
- » Checklists are **only an option for rebates delivered to the contractor or the homeowner**, because they must be completed after the installation

Case Study: Efficiency Maine



DUCTLESS HEAT PUMP
Installation Requirements Checklist

efficiency MAINE

Customer Name:		**Street Address:**	

SECTION 1. Registered Vendor Checklist. Please complete and sign the following section.

Outdoor Unit	
Height off ground (inches) : ____	Best Practice: Above snow level (≥ 24 inches)
☐	Unobstructed airflow
☐	Level
☐	Does not interfere with walkway, porch, window or door
☐	Installed at serviceable height
☐	Secured to wall or stable base
☐	Protected by rain cap (required if installed under roof drip line)
Line Set	
Manufacturer-specified lengths (feet): Minimum: ____ Maximum with factory charge: ____ Maximum: ____	
Actual line set length: ____	
☐	Refrigerant added, if required by manufacturer ____ Pounds ____ Ounces ____ N/A
☐	Line set purged with nitrogen, pressure tested & evacuated with pump per mfg.'s instructions
	Pressure test pressure (PSI): ____, and duration (minutes): ____
	Number of evacuations performed: ____, Vacuum level (microns): ____
☐	Flare connections tightened using manufacturer's torque specification
☐	Visible line sets run through line set covers with transition and termination fittings
☐	Insulation covers full length of line sets (no exposed copper)
☐	Floor/wall/ceiling penetrations sealed
☐	Condensate line installed without dips or traps
Indoor Unit	
☐	Level
☐	Adequate clearances for services and operation
Electrical Work	
☐	All electrical work performed by licensed electrician or as authorized by Electrician's Board
☐	Disconnect box wiring shock risk reduced by lock, strap tie and/or box that provides other means of protection
System	
☐	System was run in both heating and cooling modes to ensure proper operation
Registered Vendor Signature:	

Section 2. Homeowner Checklist. Please check all statements that apply.

☐	I have been supplied with an Owner's Manual for the heat pump.
☐	I have been supplied with a copy of Efficiency Maine Heat Pump User Tips.
☐	The installer taught me how to turn the heat pump on and off, clean the filter, switch between heating and cooling modes, change the temperature setpoint, adjust airflow direction and call for services.
☐	Noise and vibration levels are acceptable.
☐	Line set covers are aesthetically acceptable.
Homeowner Signature:	

Checklist includes guidance for outdoor unit, line set, indoor unit, electrical work, and homeowner education

Source: Interviews with program administrators; review of heat pump programs

Design DC-specific checklist

- Work with contractors and distributors to design a checklist that addresses DC-specific installation considerations and challenges
- Based on interviews, this checklist should address considerations related to outdoor unit placement, line placement and protection, unit sizing, and duct expansion (for centrally ducted systems)

Ensure contractor usability

- Design the checklist such that it can be easily completed online and submitted with the rebate application
- Efficiency Maine's program provides a good example of how the rebate application and checklist can be integrated into one document

Source: Efficiency Maine "Ductless Heat Pump Rebate Claim"

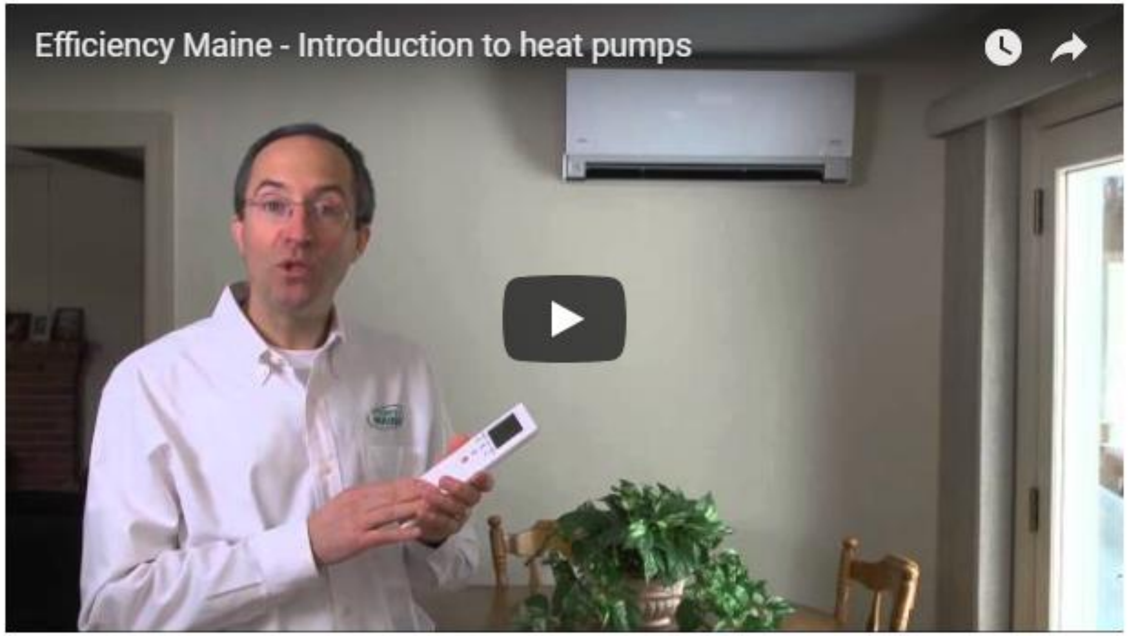
Appendix Contents

Market Education and Outreach | Case Study: Efficiency Maine heat pump website

Efficiency Maine's heat pump website summarizes heat pump operations and benefits through text, images, and videos. The website also has links to case studies, installation considerations, and user best practices.

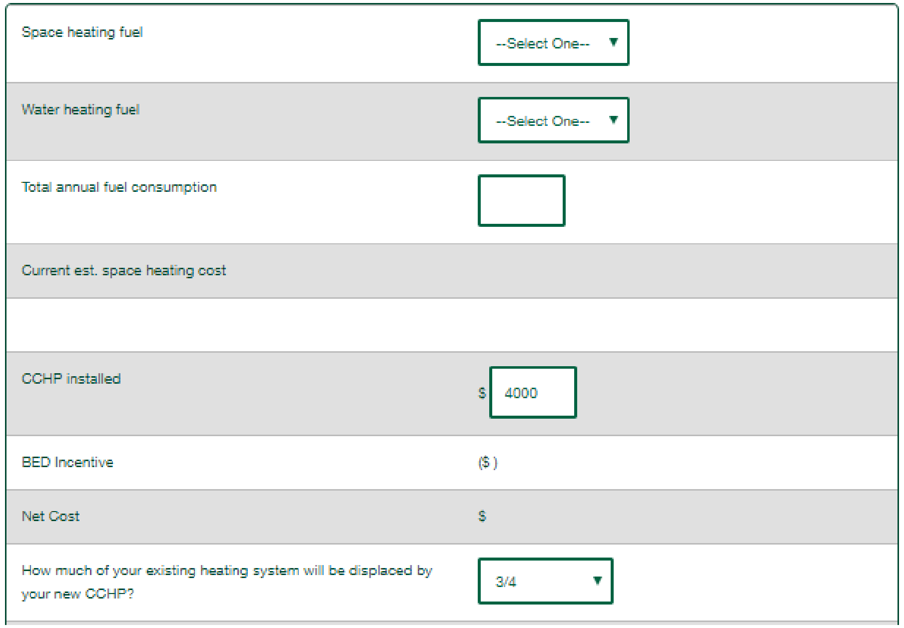
How do they work?

Ductless heat pumps provide heat by extracting heat from outside air and delivering it indoors as needed. Because they are moving heat, rather than generating it through combustion or resistance, heat pumps can achieve efficiencies well above 100%. Long used for cooling in warm climates, heat pumps are now able to provide efficient heating in cold climates even at outdoor temperatures as low as -15 °F.



Burlington Electric Department developed an online tool to help customers calculate their cost-savings and payback for a heat pump installation in addition to text and video introducing heat pumps.

CCHP Energy Savings Calculator



COLD CLIMATE HEAT PUMPS

Source: Burlington Electric Department. "Cold Climate Heat Pumps." (link)

Appendix Contents

Technology Requirements | Definition of common efficiency performance ratings

Performance Rating	Applications	Technologies	Definition
Heating Seasonal Performance Factor (HSPF)	Space heating	ASHP	The ratio of **heating energy output** (Btu) over the course of the **heating season** to the net **electricity input** (Wh)
Coefficient of Performance (COP)	Space heating	ASHP, GSHP	The ratio of energy output (Wh) to net energy input (Wh) (*dimensionless)*
Annual Fuel Utilization Efficiency (AFUE)	Space heating	Conventional furnaces	The percentage of **fuel consumed** converted into **usable heat**
Energy Factor (EF)	Water heating	HPWH and other water heaters (not solar)	The ratio of **heating energy** output (Wh or Btu) to net energy input (Wh or Btu) over a **24-hour standard test period**
Seasonal Energy Efficiency Rating (SEER)	Space cooling	ASHP	The ratio of **cooling energy output** (Btu) over the course of the **cooling season** to the net electricity input (Wh)
Energy Efficiency Ratio (EER)	Space cooling	ASHP, GSHP	The ratio of cooling energy output (Btu) to the net electricity input (Wh) (*dimensionless)*

Challenges with HSPF as a metric for heating performance in cold climates

- HSPF assumes Climate Zone IV test conditions (mid-Atlantic)
- HSPF only tests down to 17°F, assumes use of backup electric resistance, and tests in steady state (no modulation/variable speed)
- Researchers from FSEC in 2004 created an estimate conversion factor for colder climates for traditional unitary ASHPs

Technology Requirements | NEEP Cold Climate ASHP Specification

Context

» Standard performance rating for measuring heating performance (HSPF) is inadequate for cold-climate regions

» Northeast Energy Efficiency Partnerships (NEEP) developed and manages a specification certifying over 800 models of ductless and central ASHPs as "cold climate"

» Does not emphasize cooling output, though does require ENERGY STAR certification

Requirements:

» Variable-speed compressor, ENERGY STAR-certified, indoor/outdoor units part of AHRI-matched system

» HSPF ≥ 10

» Must achieve COP ≥ 1.75 at 5°F (at max capacity), provide lab testing/engineering data demonstrating performance at 5°F

Technology Requirements | DCSEU requirements compared to regional programs

- For central systems, DCSEU's existing **cooling and heating requirements are well-aligned** with regional benchmarks
- For ductless systems, DCSEU's existing **cooling requirements are slightly higher** than regional benchmarks

Program/Standard	Technology Type	HSPF	SEER	EER	Amount	Notes
EmPOWER Maryland[1]	*Ductless Single-Zone*	*≥9*	*≥18*	*≥12.5*	*$250*	
	Ductless Multi-Zone	*≥8.6*	*≥15.5*	*≥12.5*	*$400*	Multi-zone has lower requirements
	Central Tier 1	*≥9*	*≥16*	*≥13*	*$400*	
	Central Tier 2	*≥9.5*	*≥18*	*≥13*	*$650*	
DCSEU Existing Program[2]	*Ductless Tier 1*	*≥8.5*	*≥18*	*≥12.5*	*$300*	Minimum HSPF across programs
	Ductless Tier 2	*≥9.5*	*≥20*	*≥13*	*$500*	Maximum SEER across programs
	Central Tier 1	*≥9*	*≥16*	*≥13*	*$300*	Aligned with EmPower program
	Central Tier 2	*≥9.5*	*≥18*	*≥13*	*$500*	Aligned with EmPower program
Pennsylvania (PP&L)[3]	*Ductless Tier 1*	*≥8.6*	*≥16*	*≥12.5*	*$100/ton*	
	Ductless Tier 2	*≥9.5*	*≥17*	*≥12.5*	*$150/ton*	
	Ductless Tier 3	*≥10.5*	*≥19*	*≥12.5*	*$200/ton*	
	Central Tier 1	*≥8.5*	*≥16*	*≥12.5*	*$100*	
	Central Tier 2	*≥8.5*	*≥17*	*≥12.5*	*$300*	

Sources: [1] https://bgesmartenergy.com/residential/heating-cooling [2] https://www.dcseu.com/homes/home-heating [3] https://neep.org/sites/default/files/resources/2017ASHPSnapshot.pdf

Technology Requirements | Other ASHP incentive requirements in the Northeast/mid-Atlantic

(Updated October 2017)

Incentive and Requirement Summary for **Ductless Heat Pumps**

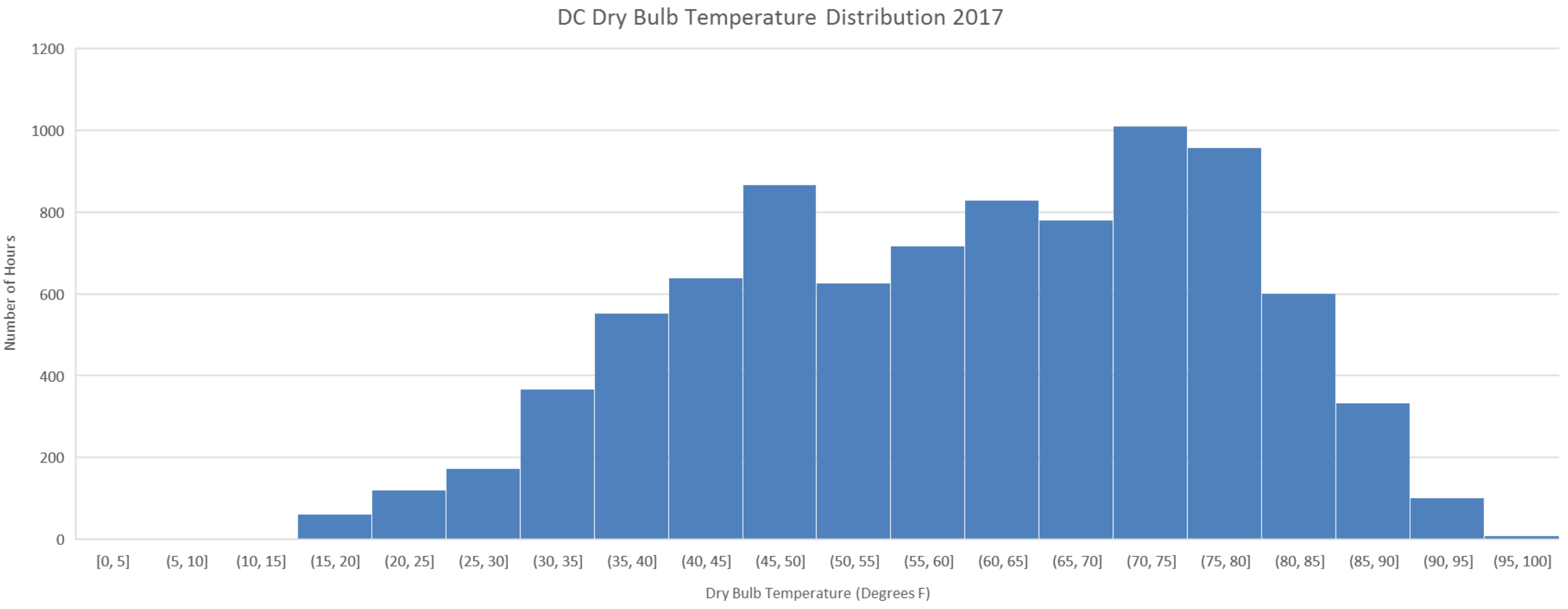
State	Rebate Incentive	ENERGY STAR certification	HSPF	SEER	EER	Other Requirements
Connecticut[1]	$300/Home (Single-Zone)	X	10	20	12.5	Midstream Program.
	$500/home (Multi-Zone)	X	9	18	12.5	
Massachusetts	$100/indoor unit	X	≥ 10	≥ 18		
	$300/indoor unit	X	≥ 12	≥ 20		
Massachusetts Clean Energy Center[2]	$625 (Single- Zone)	X	≥ 10	≥ 20	≥ 12.5	NEEP ccASHP Spec, 100% of rated heating capacity delivered at 5°F
	$625/ton (Multi-Zone)	X	≥ 10	≥ 17	≥ 12.5	
Rhode Island	$100/indoor unit	X	≥ 10	≥ 18		
	$300/indoor unit	X	≥ 12	≥ 20		
Vermont	$600 (Single-Zone)		≥ 10.0	≥ 20	≥ 12.0	COP @5°F ≥ 1.75; operation at -5° Midstream Program. Updated list here.
	$800 (Multi-Zone)		≥ 10.0	≥ 17	≥ 12.0	
New Hampshire[3]	$250/ton of cooling	X	≥ 8.5	≥ 15	≥ 12.5	
	$500/ton of cooling	X	≥ 10	≥ 18	≥ 12.5	
Maine	$500 (Single-Zone)		≥12			
	$750 (Multi-Zone)		≥10			
New Jersey	$500 ($200/Indoor Unit Bonus)[4]	X	≥10	≥ 15	≥12.5	Must be listed on NEEP ASHP Spec
	$500		≥10	≥ 20	≥12.5	
New York (NYSERDA)			≥10	≥ 15	≥12.5	Must be listed on NEEP ccASHP Spec, Mid-stream Program
Pennsylvania (PP&L)	$100/ton	X	≥ 8.6	≥ 16	12.5	
	$150/ton		≥ 9.5	≥ 17	12.5	
	$200/ton		10.5	19	12.5	
Energy Save PA	$100		≥ 8.5	≥ 15		
Washington D.C.[5]	$300		≥ 9	≥ 18	≥ 12.5	
	$500		≥ 10	≥ 20	≥ 13	

Incentive and Requirement Summary for **Ducted Heat Pumps**

State	Rebate Incentive	ENERGY STAR certification[3]	HSPF	SEER	EER	Other Requirements
Connecticut	$500	X	≥ 10	≥ 16	≥ 12.5	
Massachusetts	$250	X	≥ 8.5	≥ 16		
	$500	X	≥ 9.6	≥ 18		
Massachusetts Clean Energy Center[6]	$625/ton	X	≥ 10	≥ 17	≥ 12.5	NEEP ccASHP Spec, 100% of rated heating Capacity Delivered at 5°F
Rhode Island	$250	X	≥ 8.5	≥ 16		
	$500	X	≥ 9.6	≥ 18		
New Hampshire	$70/ton	X		≥ 15	≥12.5	
Maine	$500	X	≥10			
New Jersey	$300		≥10	≥ 16	≥13	For units purchased through June 30, 2017.
	$500		≥10	≥ 18	≥13	
New York (NYSERDA)		X	≥10	≥ 15	≥12.5	NEEP ccASHP Spec Mid-stream Program
PSEG- Long Island	$350		≥8.5	≥15		
	$450		≥8.5	≥16		
Pennsylvania (PP&L)	$200		≥8.5	≥ 16	≥12.5	
Energy Save PA	$250		≥8.5	≥ 14.5		
	$325		≥8.5	≥ 15		
	$400		≥8.5	≥ 16		
Washington D.C.[7]	$350		≥ 9	≥ 16	≥ 13	
	$750		≥ 9.5	≥ 18	≥ 13	

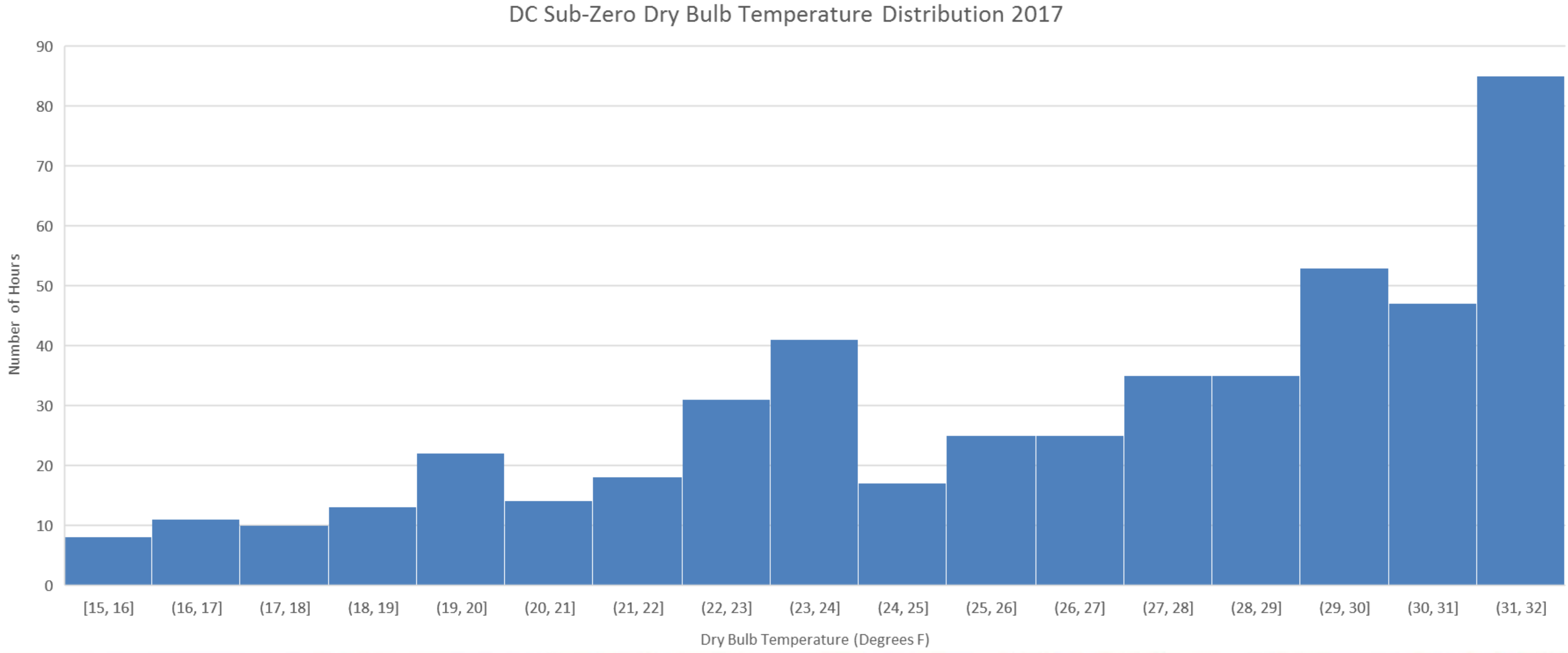
Source: http://www.neep.org/sites/default/files/resources/2017ASHPSnapshot.pdf

Technology Requirements | DC's Dry Bulb Temperature 2017



Source: NOAA National Center for Environmental Information – 2017 Data for Ronald Reagan International Airport

Technology Requirements | DC's Heating Design Temperature 2017



Source: NOAA National Center for Environmental Information – 2017 Data for Ronald Reagan International Airport

Figure ES-4. Average Heating COP vs. Outdoor Air Temperature for Cold-Climate and Non-Cold-Climate Systems—Winter 2015

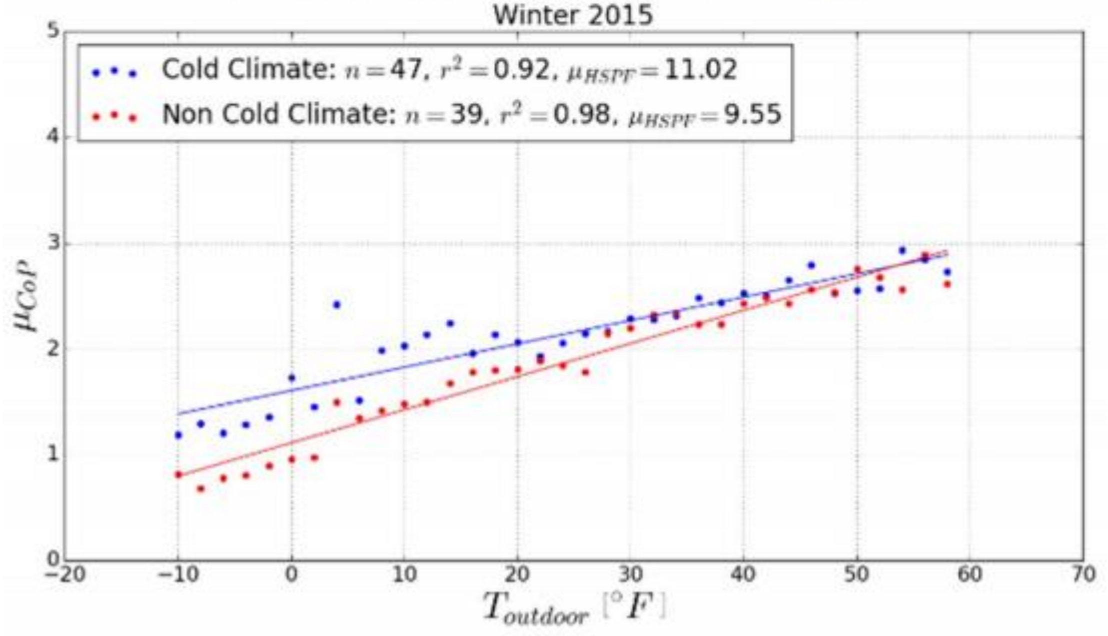
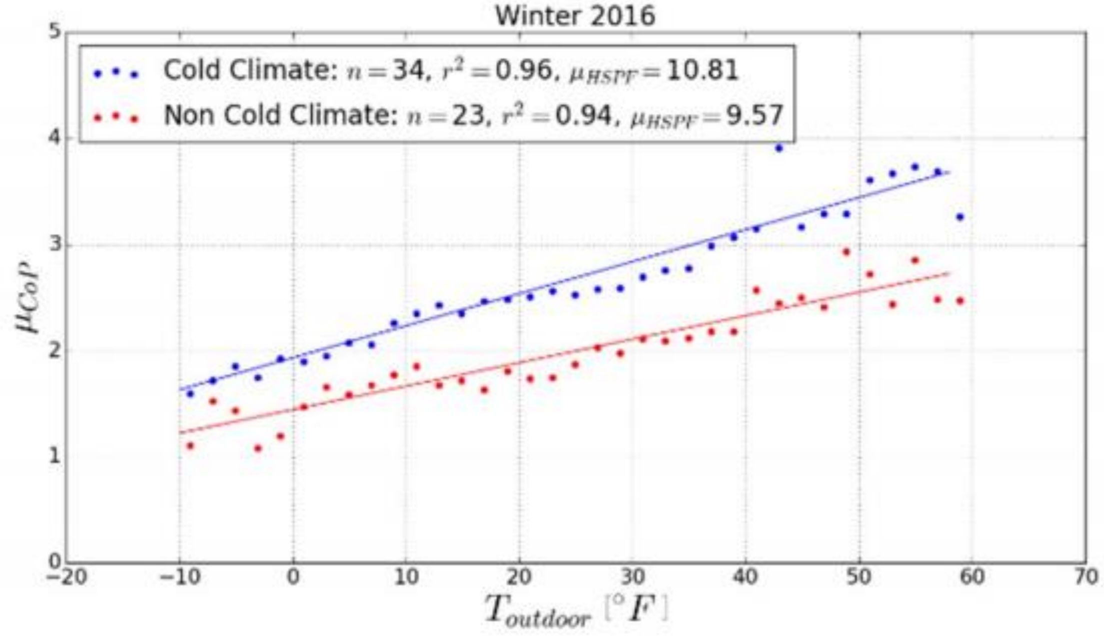


Figure ES-5. Average Heating COP vs. Outdoor Air Temperature for Cold-Climate and Non-Cold-Climate Systems—Winter 2016



Source: Cadmus, Ductless Mini-Split Heat Pump Evaluation, http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf

- Northeast Energy Efficiency Partnerships (NEEP). *2017 Air Source Heat Pump Incentive Summary.* (link). Summary of incentive technology requirements and amounts for over ten programs in the Northeast.
- VEIC. *Driving the Market for Heat Pumps in the Northeast* (link)**.** Review of efficiency programs of all types (distributor, contractor, and customer) throughout the Northeast.
- Northeast Energy Efficiency Partnerships (NEEP). "Cold Climate Air Source Heat Pump." Summarizes NEEP's ccASHP standards and provides regularly updated list of qualifying technology.

Appendix Contents

Heat Pump Applications in the DC Market | Model assumptions and sources for heat pumps

	1.5-ton Minisplit	3-ton Minisplit	4-ton Central	Sources
Description	• One single-zone, ductless mini-split heat pump • Provides space heating & cooling to a single area	• Two single-zone, ductless mini-split heat pumps • Provides whole-home cooling and multi-zone heating	• Centrally-ducted ASHP • Serves as the primary heating and cooling source for the whole home	N/A
Estimated Installation Cost (for high-efficiency systems)	$4,500 - $5,500	$8,500 - $10,000	$11,000 - $13,000	Estimated from interviews with local contractors
Estimated Efficiency	HSPF: 9.5/SEER: 20 Duct Losses: 0%	HSPF: 9.5/SEER: 20 Duct Losses: 0%	HSPF: 9.5/SEER: 18 Duct Losses: 15%	DCSEU technology requirements; duct losses Mid-Atlantic TRM (link)
Fuel Cost	$0.13/kWh	$0.13/kWh	$0.13/kWh	BLS Data (link)
Estimated Heating Load Served	40%	80%	100%	Estimated based on heat pump size and DC full-load heating hours; varies by building insulation, size, etc.
Avoids Alt. Heating Costs	No	No	Yes	Based on heating load served
Estimated Cooling Load Served	50%	100%	100%	Estimated based on system capacity and DC full-load heating hours; varies by building insulation, size, etc.
Avoids Alt. Central AC Costs	No	Yes	Yes	Based on cooling load served
Avoids Alt. Window AC Costs	Yes – avoids 1 window AC unit	Yes – avoids 2 window AC units	Yes – avoids 3 window AC units	Estimated based on Window AC capacity vs. heat pump capacity
Equipment Lifetime	15 years	15 years	15 years	Standard assumption

Heat Pump Applications in the DC Market | Model assumptions and sources for alternative heating and cooling systems

Alternative Heating System Assumptions

	Natural Gas	Fuel Oil	Propane	Electricity (Electric Resistance)	Sources
Description	Natural gas furnace or boiler to provide whole-home heating	Fuel oil furnace or boiler to provide whole-home heating	Propane furnace or boiler to provide whole-home heating	Electric resistance furnace or heater to provide whole-home heating	N/A
Estimated Installation Cost	$5,256	$8,223	$5,256	$800	Cadmus interviews with NY State contractors scaled to DC market by RS Means labor factors
Estimated Efficiency	Existing Unit AFUE: 85% New Unit AFUE: 95%	Existing Unit AFUE: 83% New Unit AFUE: 85%	Existing Unit AFUE: 85% New Unit AFUE: 95%	Existing Unit AFUE: 100% New Unit AFUE: 100%	Assumed
Fuel Costs	$1.24/therm	$2.81/gallon	$3.09/gallon	$0.13/kWh	EIA (Fuel Oil – link; Propane – link) BLS (NG & Elec – (link)
Duct Losses	15%	15%	15%	0%	Mid-Atlantic TRM (link)

Alternative Cooling System Assumptions

	Window AC	Central AC	Sources
Description	Window AC unit for single-zone cooling	Ducted AC system for whole-home cooling	N/A
Installation Cost	$500/unit	$2,890	Cadmus interviews with NY State contractors scaled to DC market by RS Means labor factors
Estimated Efficiency	SEER: 12	SEER: 16	Window AC – Energy Start Standards Central AC – DCSEU Technology Requirements
Duct Losses	0%	15%	Mid-Atlantic TRM (link)