

## MEMORANDUM

To: Massachusetts Program Administrators  
 From: COOL SMART Impact Evaluation Team  
 Subject: Ductless Mini-Split Heat Pump (DMSHP) Baseline Determination  
 Date: August 21, 2015

### ***Baseline Determination Overview***

This memorandum summarizes research regarding the determination of appropriate installed baselines for estimating gross energy impacts from ductless mini-split heat pumps (DMSHP) promoted through the electric PA's COOL SMART program. The challenge with establishing installed baselines for DMSHPs is that there is not a clear standard efficiency technology that is the lone alternative to a DMSHP. For instance, it does not make sense to use a DMSHP or ductless mini-split air conditioner (DMSAC) as an alternative to an inefficient central air-conditioner in the event that there are already ducts in the home. In addition, baseline use of the installed units needs to consider how the area affected by the new unit was previously conditioned, and how the installation has affected those use patterns. The DMSHP installation will either provide a new amenity in a new space or previously unconditioned space, or it will displace or replace existing heating and cooling equipment.

The determination of appropriate baselines is based on information gathered from program participants during on-site visits to install meters measuring the energy usage of the DMSHPs and other heating and cooling equipment found in each home. The determination is driven by:

- 1) The actual displaced equipment found in each home,
- 2) Customer intentions – whether the DMSHP<sup>1</sup> was purchased for its cooling capability, its heating capability, or both, and the
- 3) Stated alternative actions to purchasing the DMSHP, relative to the customer's purchase intentions.

These considerations help to identify the application of the installation – retrofit, replace upon failure, or new construction.<sup>2</sup> By identifying the application for each logic path, the following sections show how purchase intentions and the alternative actions of the participant inform the baseline.

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<sup>1</sup> DMSHP is referenced as singular – recognizing that in many homes these are systems that may have multiple condenser units and/or head units in a single home.

The evaluation team has defined the baseline for two distinct scenarios. In the first scenario, those participants who stated that they would have left their space unconditioned in the absence of purchasing their DMSHP are assumed to have a new construction application with a standard efficiency DMSHP or DMSAC as the baseline in these cases. In the second scenario, those participants who stated that they would have left their space unconditioned are considered to have a retrofit baseline with their unconditioned space as the baseline. These assumptions and their reasoning are discussed further in this memo.

Further, the evaluation team assumes that the costs and benefits for the DMSHP measure should correlate, and therefore, with savings against a fossil fuel heating baseline disallowed, costs against a fossil fuel heating baseline should also be disallowed, and therefore the fossil fuel heating baseline is disallowed in this case. The evaluation team has developed baselines for a case where fuel switching is allowed and one where it is not. The evaluation team proposes that, within both scenarios, any site for which a participant has a DMSHP baseline for either heating or cooling, a DMSHP is considered the baseline for both heating and cooling.

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<sup>2</sup> A **retrofit** application involves a replacement of existing equipment with a long remaining useful life. A **replace upon failure** application involves replacing a technology at the end of its useful life. A **new construction** application adds functionality to a space that was previously unused, unconditioned or under-conditioned.

## ***Proposed Baselines***

The evaluation team has developed results based on two different scenarios that reflect two ways of interpreting what the baseline should be for people who said they would have left the space unconditioned. There is likely some confusion on the part of respondents around what constitutes a conditioned or unconditioned space. Scenario 1 assumes that people who stated they would have left a space unheated if they said they bought the DMSHP for heating or left a space uncooled when they said they bought it for cooling were confused and that they really meant that they were only considering a DMSHP or DMSAC. Scenario 2 takes these same people at their word and allows an unconditioned baseline. The truth likely lies in between these two scenarios.

The evaluation team's proposed baselines for determining gross DMSHP impacts for each scenario are summarized in Table 1 and Table 2.

For Scenario 1, the blended baseline disallowing fuel switching consists of 94% standard efficiency DMSHP, and 6% existing and alternative electric systems for heating. The cooling blended baseline consists of 16% standard efficiency DMSHP, 31% DMSAC, 48% existing and alternative electric systems, and 5% where there was no existing cooling. In addition, the onsite metering study found that most sites with systems that participants claimed were purchased for cooling only are also being used for significant heating. Because the baseline for heating is 94% standard efficiency DMSHP in the fuel switching case, the baseline for cooling would also be up to 94% DMSHP or DMSAC.

Table 1. Proposed Baselines for Determining Gross DMSHP Impacts – Scenario 1 (All Participants, n=116)

Cooling Baseline Scenario Breakdown			Heating Baseline Scenario Breakdown		
	Fuel Switching Allowed	No Fuel Switching Allowed		Fuel Switching Allowed	No Fuel Switching
<b>Standard Efficiency DMSHP</b>	<b>16%</b>	<b>94%</b>	<b>Standard Efficiency DMSHP</b>	<b>16%</b>	<b>94%</b>
<b>Standard Efficiency DMSAC</b>	<b>31%</b>				
<b>Not a DMSHP or DMSAC Existing or Stated Alternative Technology</b>	<b>48%</b>	<b>1%</b>	<b>Existing or Stated Alternative Technology</b>	<b>84%</b>	<b>6%</b>
New Room AC	9%	1%	New Gas	2%	0%
New Central AC	3%		New Electric Resistance	3%	3%
Existing Room AC	28%		Extend Existing System (unstated)	3%	0%
Existing Central AC	8%		Existing Gas	24%	0%
Extend Existing System (unstated)	1%		Existing Oil	47%	0%
			Existing Electric Resistance	3%	3%
			Existing Wood, Pellet, or Fireplace	3%	0%
<b>Unconditioned</b>	<b>5%</b>	<b>5%</b>	<b>Unconditioned</b>	<b>0%</b>	<b>0%</b>
<b>Total</b>	<b>100%</b>			<b>100%</b>	<b>100%</b>

For Scenario 2, the blended baseline disallowing fuel switching consists of 90% standard efficiency DMSHP, and 6% existing and alternative electric systems for heating. The cooling blended baseline consists of up to 6% standard efficiency DMSHP, 25% DMSAC, 48% existing and alternative electric systems, and 21% where there was no existing cooling. Because the baseline for heating is 90% standard efficiency DMSHP, the baseline for cooling would also be up to 90% DMSHP or DMSAC.

**Table 2. Proposed Baselines for Determining Gross DMSHP Impacts – Scenario 2 (All participants, n=116)**

Cooling Baseline Scenario Breakdown			Heating Baseline Scenario Breakdown		
	Fuel Switching Allowed	No Fuel Switching		Fuel Switching Allowed	No Fuel Switching
<b>Standard Efficiency DMSHP</b>	<b>6%</b>	<b>90%</b>	<b>Standard Efficiency DMSHP</b>	<b>4%</b>	<b>90%</b>
<b>Standard Efficiency DMSAC</b>	<b>25%</b>				
<b>Existing or Stated Alternative Technology</b>	<b>48%</b>		<b>Existing or Stated Alternative Technology</b>	<b>92%</b>	<b>6%</b>
New Room AC	9%		New Gas	2%	0%
New Central AC	3%		New Electric Resistance	3%	3%
Existing Room AC	28%		Extend Existing System (unstated)	3%	0%
Existing Central AC	8%		Existing Gas	24%	0%
Extend Existing System (unstated)	1%		Existing Oil	39%	0%
			Existing Electric Resistance	4%	4%
			Existing Wood, Pellet, or Fireplace	3%	0%
<b>Existing (no previous cooling)</b>	<b>21%</b>	<b>10%</b>	<b>Existing (no previous heating)</b>	<b>4%</b>	<b>4%</b>
<b>Total</b>	<b>100%</b>			<b>100%</b>	<b>100%</b>

The remainder of this memorandum contains the supporting documentation for these recommendations.

### **Discerning Customer Purchase Intentions**

During on-site visits, the evaluation team asked metering study participants whether they purchased the DMSHP for its cooling capability and/or whether they purchased the DMSHP for its heating capability. The responses indicate what amenities the participant was looking for when he or she sought out the DMSHP. For example, if a participant states that he or she bought the unit for cooling, one can narrow the baseline options to something that provides a similar cooling amenity to the DMSHP. Conversely, if a participant states that he or she bought the unit for heating, the baseline options must provide a similar heating amenity to the DMSHP.

The data the evaluation team collected on site yielded quality responses for 116 participants. Of these participants, 35 stated that they had bought the DMSHP only for cooling; four stated that they had

bought the DMSHP only for heating; and 77 stated that they had bought the DMSHP for both heating and cooling.<sup>3</sup> For all participants, and especially those who stated that they had bought the DMSHP for both heating and cooling, the evaluation team conducted further analysis of alternative actions to identify what kind of amenity the participant was seeking, as described below.

### **Alternative Actions**

The evaluation team collected additional data during the on-site visits by asking metering study participants which options they had considered for both heating and cooling, had they not purchased the high-efficiency DMSHP. The team used this data to further understand the participants' motives as well as to identify baseline technologies.

### **Participant Characterization**

The evaluation team used the stated alternative actions coupled with participants' purchase intentions to determine the proposed cooling and heating baselines for each potential path.

### **Participants Who Had Purchased the DMSHP for the Cooling Amenity Only**

Participants who had bought the DMSHP primarily for the cooling amenity were motivated by the added benefit of central cooling in their house and the additional amenities associated with a ductless system (quiet central cooling without expensive duct retrofits).<sup>4</sup> Participants who had bought the DMSHP for the cooling amenity had no other comparable options to achieve the same goal other than a ductless system. Their purchase of a DMSHP was substantially more expensive than purchasing individual room air conditioners, and installing ducts where none exist for a traditional central air conditioner would have been substantially more invasive, leaving no other options but to install a DMSHP or DMSAC.

For this group, all participants have the same baseline regardless of their alternative actions because the DMSAC is the only equipment on the market with the added functionality that participants desire (such as a quiet system that can be retrofitted into a house without ducts). The consumer experience of owning a DMSAC is much different than that of owning room air conditioners and so the two cannot be properly compared.<sup>5</sup> Of the 32% of the participants who previously had cooling in the space that is now served by the DMSHP, 89% stated that the previous equipment had been removed from the space.

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<sup>3</sup> In the future, the evaluation team may adjust the participants' stated purchase intent using the actual logged data from the participant sites to understand how participants are actually using their systems. The evaluation team completed a billing data disaggregation using one year of post-installation electric billing data to confirm the participant's true purchase intent and usage. However, this analysis resulted in inconclusive findings due to missing data and data integrity issues.

<sup>4</sup> While DMSHPs do not provide true central heating and cooling, the effect of a DMSHP is similar to a central system in that it provides the conditioning amenity without having to remove it seasonally, the heating and cooling is more evenly distributed throughout a room, and a zonal effect is easily achievable with multi-head systems.

<sup>5</sup> Room air conditioners are not a sufficient baseline for central air conditioners because of the difference in amenities offered and the difference in consumer experience. In the same way, room air conditioners are not a reasonable baseline for DMSHPs.

Therefore, the most reasonable baseline for all participants in this group is a **standard efficiency DMSAC for cooling and the existing heating equipment for heating**.<sup>6</sup>

### Participants Who Had Purchased the DMSHP for the Heating Amenity Only

Participants who had bought the DMSHP primarily for the heating amenity were motivated by a desire to either save money on heating fuel with a more efficient system, or to add heating to a previously unheated or under-heated space. In order to determine a baseline for these participants, the evaluation team considered the participants' stated alternative action to achieve the same heating amenity. None of the participants with this characterization stated an alternative action for the cooling amenity because they confirmed that they had not bought the unit for cooling. This participant characterization is divided among the following subgroups:

- Participants who stated that they would have “left the space unconditioned” fit into a new construction application. They are adding heat to a previously unheated or under-heated space, and they would have still installed a heating system without the rebate. The program incented them to install a more efficient unit in this case. The most reasonable baseline for participants in this group is a **standard efficiency DMSHP for both heating and cooling**.
- Participants who stated that they would have “left their other heating system installed” fit into a retrofit application. Of the participants who had previous heating in the space served by their DMSHP, 95% stated that their previous heating system is still installed in the space. The most reasonable baseline for participants in this group is the **existing equipment that previously served the space (which is currently served by the DMSHP for both heating and cooling)**.
- Participants who stated that they “would have installed an alternative heating technology” fit into a replace-upon-failure application, with the nuance that they stated an alternative measure that they would have implemented. Because these participants offered that they had bought the unit for heating and stated an alternative technology that they would have adopted in the absence of the program, **the heating baseline is the stated alternative heating technology. The cooling baseline is the existing equipment (if any existed). If no cooling equipment previously existed, this is reflected in the proposed baseline**, and results in increased energy consumption during the cooling season with the increase equal to the measured DMSHP consumption for these participants.<sup>7</sup>

### Participants Who Had Purchased the DMSHP for Both Heating and Cooling Amenities

Participants who had bought the DMSHP for both heating and cooling amenities had mixed motivations. These participants were more nuanced in their purchase decisions, and, therefore, require a more detailed look at their stated alternative actions.

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<sup>6</sup> This study did not investigate alternate efficiency levels or collect market data to identify the current DMSHP market. Therefore, the evaluation team recommends using a standard efficiency DMSHP (rather than a higher efficiency, but still non-qualifying DMSHP) for cases in which the DMSHP is the most reasonable baseline).

<sup>7</sup> This scenario is not expected to significantly affect the impacts for DMSHPs, unless the households purchasing the equipment for heating decide to ultimately make use of cooling.

The evaluation team decided that participants who had bought the unit for both heating and cooling amenities and otherwise would have left the space unconditioned for either heating or cooling, effectively represent a new construction-type application. This group of participants was assigned a **standard efficiency DMSHP as the baseline for both heating and cooling** because the sheer cost of a baseline unit – at least \$3,000 – dwarfs the incremental costs of a high-efficiency unit of approximately \$600. In the opinion of the evaluation team, the Cool Smart DMSHP incentive of \$150-\$500 did not motivate customers to install a DMSHP as opposed to leaving the space unconditioned in the alternative. In these instances, the team believes that the customer did not understand or appreciate the distinction of DMSHPs by efficiency level, thus responding that they otherwise would have done nothing despite saying they had been motivated to condition the space. It is possible that these customers are freeriders, but such a determination is not within the scope of the current research into baselines and gross energy savings.

Alternatively, the team considered whether to characterize these baselines separately as a partial-new construction, partial-retrofit scenario. However, this option complicates the characterization, and it does not adequately indicate that the participant was able to add new functionality for both heating and cooling with the purchase of a DMSHP -- functionality that they had been looking to attain with or without the program's influence.

### ***Detailed Cross-Tabulated Results***

The evaluation team developed additional results tables for each scenario and fuel-switching case for each purchase decision group. These results are presented in the attached PowerPoint appendix.



MA - Cool Smart  
Baseline Scenarios 2

### ***Verbatim Responses to On-site Survey Question***

During the on-site survey, the field technicians probed to determine what each participant had asked their contractor for when he or she asked for a DMSHP. This question was intended to make the participants' underlying intentions clearer in cases when the participant seemed hesitant about their purchase intent.

Some of the responses that were collected on site for the various permutations of answers for participants who stated that they bought the DMSHP for both cooling and heating amenities are shown in Table 3. These verbatim responses show that even the participants who would ordinarily fit into a clear logic path to determine the baseline may actually have mixed intentions. Nevertheless, on balance these verbatim responses support the baseline assignments and recommendations.

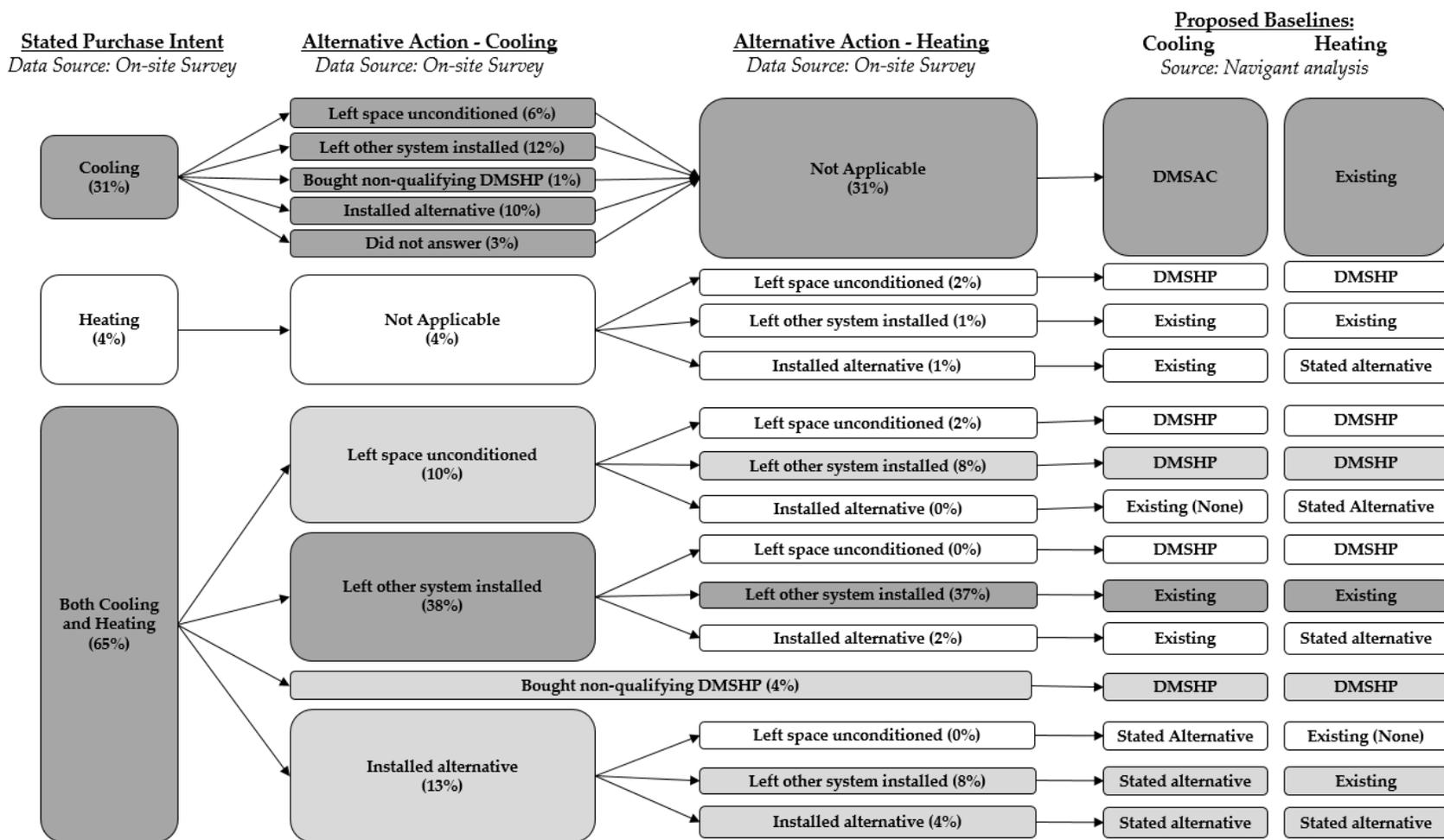
**Table 3. Selected Verbatim Responses for Participants Who Bought DMSHP for Both Cooling and Heating**

Cooling Alternative Action	Heating Alternative Action	Sample Represented	Originally Approached Contractor About...
Left space unconditioned	Left space unconditioned	2%	<ul style="list-style-type: none"> <li>- Interested in making whole house more efficient; there's a chance we would have installed less efficient DMSHP but it's hard to say.</li> <li>- Wanted to get away from oil. For AC, there was no space for ductwork.</li> </ul>
Left space unconditioned	Left other system installed	8%	<ul style="list-style-type: none"> <li>- Wanted dehumidification</li> <li>- Motivated by saving energy and good green will</li> <li>- Wanted central heat pump but contractor said to try DMSHP before installing ducts</li> <li>- Wanted a DMSHP</li> <li>- Wanted air conditioning</li> </ul>
Left other system installed	Left other system installed	37%	<ul style="list-style-type: none"> <li>- Wanted the most efficient unit I could get</li> <li>- Wanted a ductless system for heating and cooling because the room was particularly cold</li> <li>- Looking to save money on HVAC system</li> <li>- Looking for alternative to window units</li> <li>- Looking to supplement existing systems in end of house</li> </ul>
Left other system installed	Installed alternative	2%	<ul style="list-style-type: none"> <li>- Wanted cooling originally and contractor suggested DMSHP since it would also provide heat.</li> <li>- Wanted a DMSHP</li> </ul>
Installed alternative	Left other system installed	8%	<ul style="list-style-type: none"> <li>- Wanted non-window AC; didn't have ductwork and wanted an efficient system.</li> <li>- We did our homework and knew we wanted a DMSHP.</li> <li>- Wanted to save money on heating and cooling</li> <li>- Originally looking for AC</li> <li>- Wanted mini splits for the whole house</li> </ul>
Installed alternative	Installed alternative	4%	<ul style="list-style-type: none"> <li>- Wanted to get the best bang for the buck</li> <li>- Wanted a DMSHP</li> <li>- Wanted to tap into existing ductwork but contractor said it wouldn't perform well, so he suggested DMSHP</li> <li>- Wanted something cost effective. Also looked into propane and geothermal.</li> </ul>

### **Baseline Logic Details**

Figure 1 and Figure 2 illustrate a detailed view of the logic flow chart for Scenario 1 and Scenario 2, respectively. Specific percentages within each box indicate how the metered population fits into this schema. The boxes in the figure with darker shading represent responses that were given most frequently.

Figure 1. Logic Flow Chart to Determine Baseline, with Response Percentages – Scenario 1 (n = 116)



\*Note: In cases for which a DMSHP is proposed as a baseline, the evaluation team will use a standard efficiency, non-qualifying DMSHP for an energy consumption comparison.

Figure 2. Logic Flow Chart to Determine Baseline, with Response Percentages – Scenario 1 (n = 116)

