Ductless Heat Pumps for Residential Customers in Connecticut

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ABSTRACT

In the 1970s a new HVAC system was designed and developed in Japan—the inverter driven ductless heat pump (DHP)[1]. Today, almost all residential HVAC systems in Asia and the majority of systems in Europe are ductless. DHPs account for only one percent of the U.S. residential HVAC market and have primarily been installed in multi-family homes.

Approximately 100,000 residential customers in Connecticut heat with electric resistance heat. A disproportionate number of electric heat customers are limited-income and face extreme hardships, especially during the winter months as Connecticut's electricity rates are the highest in the continental United States. In 2007, a pilot was conducted in Connecticut and Massachusetts to test the feasibility of using DHPs in addition to electric resistance heat. DHPs were installed at 144 sites where electric heat was the primary heating source.

In 2009, a follow-up evaluation was completed that quantified the energy and demand savings impacts through on-site metering. The metering measured the electricity used by the entire home, DHP and baseline electric heaters. A concurrent qualitative evaluation captured participant and vendor perspectives on DHPs, including participant acceptance, comfort and reliability. The quantitative evaluation estimated the installed DHPs demonstrated savings of over 2,000 kilowatt-hours (kWh), or $400 annually per residence during the heating season and significantly reduced summer air conditioning electrical consumption. Additionally, over 85 percent of participants were satisfied with the quality of the heating and cooling.

Based on the results of the 2007 pilot, Connecticut Energy Efficiency Fund (CEEF) program administrators[2] have developed an aggressive DHP initiative to target electric resistance heat participants. The initiative includes increased participant incentives, contractor training, and upstream negotiated cooperative promotions with DHP manufacturers.

Introduction

This paper describes a pilot and subsequent evaluation undertaken in Connecticut and Massachusetts to assess the viability and energy savings of using DHPs as a retrofit measure for electric heat residential customers. The pilot involved the installation of 96 DHPs in Connecticut and 48 units in Massachusetts. Although the pilot was conducted in two states, this paper focuses on the Connecticut portion of the pilot and the state's bold efforts to move forward with a DHP initiative. It should be noted that the 2007 evaluation results were based on blended Connecticut and Massachusetts data points and are impossible to disaggregate without redoing the statistical analysis. The presentation of this paper with a Connecticut focus is not to suggest that DHPs are not a viable option in Massachusetts, or

[1] In Europe, these are often called air source heat pumps. In the United States, air source heat pumps refers primarily to conventional ducted system.
[2] The Connecticut Energy Efficiency Fund's programs were created in 1998 as part of Connecticut's electric restructuring legislation. The electric efficiency programs are administered by The Connecticut Light & Power Company (CL&P) and The United Illuminating Company (UI).

anywhere else, rather the authors are intimately familiar with Connecticut's portion of the pilot and efforts to move forward with a DHP initiative and have chosen to highlight Connecticut only for that reason.

Background

Approximately seven percent of Connecticut homes, or 100,000 households, use electric heat as their primary heat source.[3] This fact coupled with the highest electric rates in the continental United States results in many Connecticut families facing extreme hardship during the winter heating season. Approximately 40 percent of these electric heat homes are single-family units, with the remainder being condominiums, apartments and cottages.

The choice of electric heat in most Connecticut homes is based on three primary factors. First, many of the electric heat homes built in the late 1960s and early 1970s were built when electricity was "too cheap to meter." This subset of electrically-heated homes consists primarily of single-family homes. Ironically, in the 1960s and 1970s, many *Gold Medallion* homes (a term used to label efficient, all electric heated homes) were built. Secondly, a large percentage of electric heat homes were built during the 1980s housing boom where builders chose to install electric heating systems because of first cost economics (cheaper to install for the builder while more expensive to operate for the homeowner). A disproportionate percentage of these homes are condominiums and apartments versus single-family homes. Lastly, supply constraints in natural gas during the 1970s led some natural gas utilities to curtail signing up new customers.

Approximately 15 percent[4] of Connecticut's residential electric heat customers utilize budget billing to avoid winter billing spikes. Because electric baseboard is typically controlled with individual room thermostats, some electric heat participants operate their electric heat "efficiently" by utilizing the thermostat like a light switch and turning on the heat as needed. Other homes supplement their electric heating system with wood stoves, pellet stoves, or kerosene heaters. While these strategies can help participants curtail and manage their electricity use, electric heat customers still use staggering amounts of electricity during the winter for heating purposes – in some cases over 30,000 kWh or more[5], or over $5,000 annually for heating based on current electric rates[6]. For many of these customers, this amount creates an extreme economic hardship. For a variety of reasons, electric heat customers historically have had limited options to help ease their energy burden. DHPs represent a viable, cost-effective solution for these customers.

Connecticut winters are notably cold. Temperature can dip below zero, and annual degree days range from approximately 5,500 along the shoreline to above 7,500 in the Northwest Hills area based on a 65 degree F base temperature. However, extremely cold temperatures are the exception. Connecticut has over 5,000 hours per year where the temperature is between 30 degrees F and 60 degrees F[7]. Thus there is significant potential to displace electric resistance heat with more efficient heat pump technologies. In addition, newer more advanced DHPs have superior cold weather ratings; thus the result of the pilot may be somewhat conservative when considering the newest generation of DHPs.[8]

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[3] Information from CL&P survey data and information provided from UI employees. Information regarding the percentage of these participants who utilize heat pumps is unknown.
[4] This is based on CL&P customer service data which covers approximately 75 percent of the state.
[5] Based on a review of the billing data of the CL&P pilot participants.
[6] Current Connecticut residential rates are approximately 18 cents per kWh for CL&P and 20 per kWh cents for UI.
[7] Based on a bin hour analysis using average Hartford, CT weather data.
[8] The vast majority of the DHPs installed in the pilot were Mitsubishi heat pumps which only maintained approximately 60 percent of their heating capacity at 17 degrees F. Newer units maintain 100 percent of their heating capacity at 5 degree F and 87 percent at (-4) degrees F according to Mitsubishi. See www.mevac.com.

Local DHP Market

In Europe and Asia, DHPs are used extensively as the primary residential space heating and air conditioning system. Almost all residential HVAC systems in Asia and the vast majority of systems in Europe are DHPs. Sales of DHPs in the United States are growing steadily, but estimated sales are only about one percent of the market, or approximately 300,000 units, but continue to increase.[9]

Sales figures for DHPs in Connecticut are unknown. In 2009, approximately 500 DHP rebates were processed by the CEEF. Since processed rebates reflect only units that meet high-efficiency standards, the actual number of DHP sales in Connecticut is most likely significantly higher. Assuming 50 percent of all DHP sales resulted in a CEEF incentive[10], Connecticut DHP annual sales are estimated at 1,000 units. Using the ratio of Connecticut households versus the ratio of U.S. households purchasing DHPs (approximately 1.2 percent), estimated DHP sales in Connecticut would be 3,600 annually. Therefore, it appears that Connecticut may be lagging well behind the rest of the United States in terms of residential DHP sales on a per household basis. This is logical given that Connecticut's climate is not conducive to heat pumps relative to many other areas of the United States.

Connecticut DHP Pilot

In 2007, CL&P and UI conducted a pilot to test the feasibility and participant acceptance of DHPs in electric heat homes. The pilot involved the installation of 96 DHPs in Connecticut homes that utilized electric baseboard or radiant panel heat. Units were installed between October and December of 2007. Of those units, 85 were installed in CL&P service territory and 11 units were installed in UI territory.[11] Thirty seven units were single zone systems with the remaining units being either multiple zone or multiple units[12]. In all instances, the existing electric heat system was not removed and left operable. Pilot participants were instructed by the installation contractor to set the electric baseboard at a lower temperature set point (or off) than the DHP temperature set point. This would allow the DHP to displace more load by having the electric resistance only operate when the DHP could not keep up. The quantitative pilot evaluation began in January 2008 and was completed in June 2009.

The pilot evaluation used three different methods to assess heating savings: (1) a Total Heat Regression which made use of data logging and used the existing electric heat system as the baseline; (2) a Whole Premise Regression which also involved data logging and used the total home energy consumption as the baseline; and (3) a Billing Analysis Regression. All the methods used a regression analysis to calculate the energy use of the baseline (pre-existing) electric resistance heat compared to the DHP's energy use as a function of outdoor temperature. Cooling savings was calculated using the DHP's interval data with adjustments made due to the fact that the DHP represented cooling that did not pre-exist or represented a larger cooling load. These results are presented below. For both heating and cooling, peak savings estimates were derived in addition to the energy savings estimates.

In addition to quantifying energy savings, participant and contractor interviews were conducted with pilot participants and installation contractors. The purpose of the participant interviews was to

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[9] "Ductless Heat Pump Market Research and Analysis," NAHB Research Center for the Northwest Energy Efficiency Alliance, June 2008.

[10] The 2009 CEEF incentive for DHPs was $500 for units meeting Consortium for Energy Efficiency (CEE) Tier II requirements. It is assumed that this level of incentive would be high enough to drive at least of half of all participants to upgrade to the rebate criteria.

[11] As referenced earlier, 44 units were installed in Massachusetts.

[12] Many DHP models have the ability to serve multiple air handlers (up to four) for zoning. However, in some cases, installation contractors may decide to install separate systems rather than a multi-zone system due to the geometry or layout of the home.

assess participants' level of satisfaction with the DHP equipment, overall experience with the pilot, and willingness to pay for this technology. Contractors were interviewed to assess their perception of DHP unit installation in residential homes and their experience with the pilot.

Recruitment of Participants

Recruiting participants for the DHP pilot was not difficult since there was little risk involved for pilot participants. Units were provided for free, and existing heating systems were not removed. Of the 96 participants in Connecticut, 56 were CL&P participants recruited through a direct mail marketing piece distributed to approximately 800 single-family electric heat households. The marketing piece announced the pilot "to help customers with electric heat" and asked interested customers to return a short survey asking for information on the size of their home and existence and type of air conditioning system. The response rate on the letters was extremely high and exceeded 30 percent. From the respondent pool, pilot participants were selected based on several factors including: normalized annual electricity consumption, presence of window air conditioner(s), size of home, and willingness to have a contractor install a DHP unit in their home. Once selected, participants were asked to attend an informational meeting designed to educate participants about ductless heat pump performance and operation strategies, as well as to review the installation process with the participant.

In addition to these 56 homes, CL&P recruited 29 participants at a large senior condominium, all electric-heat complex in Southbury, Conn. Participants were recruited by the condominium complex's energy advisory committee. Since participant interest in the pilot exceeded the project's scope, these participants were selected via a lottery[13]. Once all participants were selected, the pilot participant's contact information was given to the single installation contractor selected by CL&P for the pilot. An informational meeting was held for the complex's participants prior to the installation of DHPs. Finally, the 11 participants selected in UI territory were electric heat participants that had recently participated in CEEF programs.

Energy Savings Results

Heating Savings Summary. The DHP pilot utilized three different methodologies to calculate heating savings. The Total Heat Regression methodology used interval metered power data on the pre-existing electric heat system and the DHP for 29 pilot participants. These participants were asked to turn off the DHP units for a period of two to four weeks and to operate their electric heat as they normally would have during that time period.

Whole Premise Regression methodology was conducted for 31 pilot participants (29 Total Heat Regression participants plus 2 additional participants who were not part of the Total Heat subset). Interval data was used to measure the household's total electric usage. Additionally, Billing Analysis methodology was conducted on all pilot participants with pre- and post monthly billing data. A total of 124 PRISM[14] regression models were created to estimate the normal heating savings for the pilot participants. Annual energy savings from the pilot are presented below for Hartford and Bridgeport as well as the load profile for a typical winter day.

While energy savings in all cases was significant, the results showed heating savings averaging 35 percent. This is lower than the expected savings based on the theoretical performance of DHPs.

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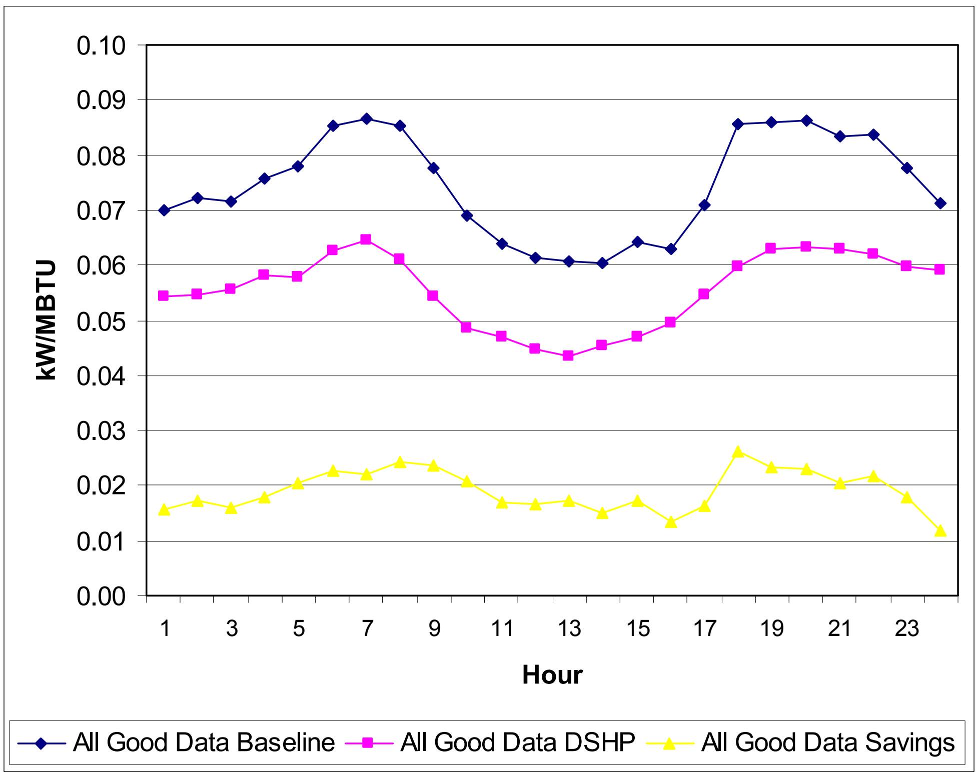
[13] Because the focus of the pilot was high use electric heat customers, participants in the lottery were required to be full-time winter residents. Other than that requirement, any interested resident could enter the lottery. There were approximately 100 full time residents who entered the lottery.

[14] Princeton Scorekeeping method (PRISM) is software tool which estimates savings based on billing data.

Table 1: Annual Heating Savings

Method	Sample Size	Average Annual kWh Savings	
		Hartford	Bridgeport
Total Heat	29	2,329	2,508
Whole Premise	31	2,431	2,610
Billing Analysis	124	2,764	2,636

Figure 1: Load Profile for Hartford on a Typical January Day



Cooling Savings Summary. The cooling savings calculation was more complex than the heating savings calculation since the baseline (pre-existing condition) varied among participants, and baseline cooling was measured directly. As was the case with heating, cooling hourly load models were developed based on data from 38 interval power loggers and manufacturers' performance data. These models were then compared to an expected baseline efficiency of 9.0 Energy Efficiency Ratio (EER). For some participants, the DHPs represented a new cooling system where none was previously present or an increase in the size of the cooling system. The cooling savings estimate included adjustment factors to account for both of these conditions.

Table 2: Annual Cooling Savings

Method	Sample Size	Annual kWh Cooling Savings	
		Hartford	Bridgeport
Adjusted Cooling Savings	38	79	82

Peak Savings. While the primary purpose of the pilot was to estimate customer energy savings, the evaluation estimated seasonal peak savings for heating and cooling. Residential customers in Connecticut do not pay a demand charge for electricity, and therefore peak savings does not provide a direct benefit to them. However, peak savings results are important from a system planning perspective. Connecticut reaches its electric peak in the summer. So while DHPs provide some peak heating savings, their impact on overall (summer) peak in Connecticut is negligible.

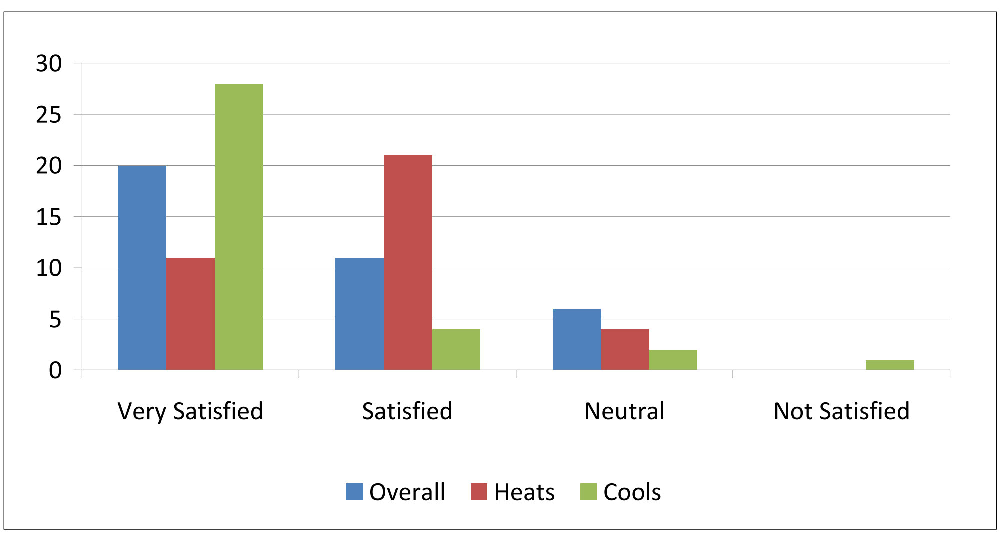
Table 3: Peak Savings

Seasonal Peak kW Savings	Hartford	Bridgeport
Heating	0.307	0.512
Cooling	0.044	0.036

Participant Feedback. Pilot participants and contractors were interviewed to assess overall satisfaction of the ductless mini-split heat pump system. This qualitative data includes participant satisfaction with the pilot over the course of a calendar year and includes feedback from Connecticut and Massachusetts participants. Overall, satisfaction was very high, with 38 of the 40 participants surveyed rating their satisfaction with a four or five on a one-to-five scale, where one is “not at all satisfied” and five is “very satisfied.” In addition to overall satisfaction, participants were also satisfied with how well the system works in heating and cooling performance, but were more strongly satisfied with the cooling performance. Twenty-eight of 35 respondents rated the system as a 5 for cooling; while 11 out of 36 respondents rated the system a 5 for heating, where one is “not at all satisfied” and five is “very satisfied.”

Participants also compared the heat pump to their previous heating/cooling system. Thirty-one participants indicated that their new system worked better than their old system (based on ratings of seven or higher on a zero-to-ten scale, where zero indicates that the original system worked better and ten that the new system works better). In fact, 19 of these 31 participants gave their new system a rating of nine or ten in comparison to the old system.

Chart 2: DHP Participant Satisfaction



Participants were asked to rate the likelihood of them installing a DHP if they had to incur the full installation cost. Ten of the 40 respondents stated that they would keep their pre-existing system over the DHP. Four of the 22 respondents in Connecticut said that they would likely install a ductless system. However, 11 of the 40 respondents (Connecticut and Massachusetts combined) said that they would likely install a DHP system. These results are not entirely consistent with the overall satisfaction results. Based on this, it seems likely that the installed cost is a potential barrier.

Table 4: Participant Willingness to Install a DHP

Level of Certainty	Number of Respondents		
	CT	MA	Total
Would Likely keep existing system (0 - 3)	6	4	10
Not Sure Which System Would Choose (4 - 6)	4	2	6
Would Likely Install Ductless System (7 - 10)	4	7	11
Don't Know/Missing	8	5	13
Total	22	18	40

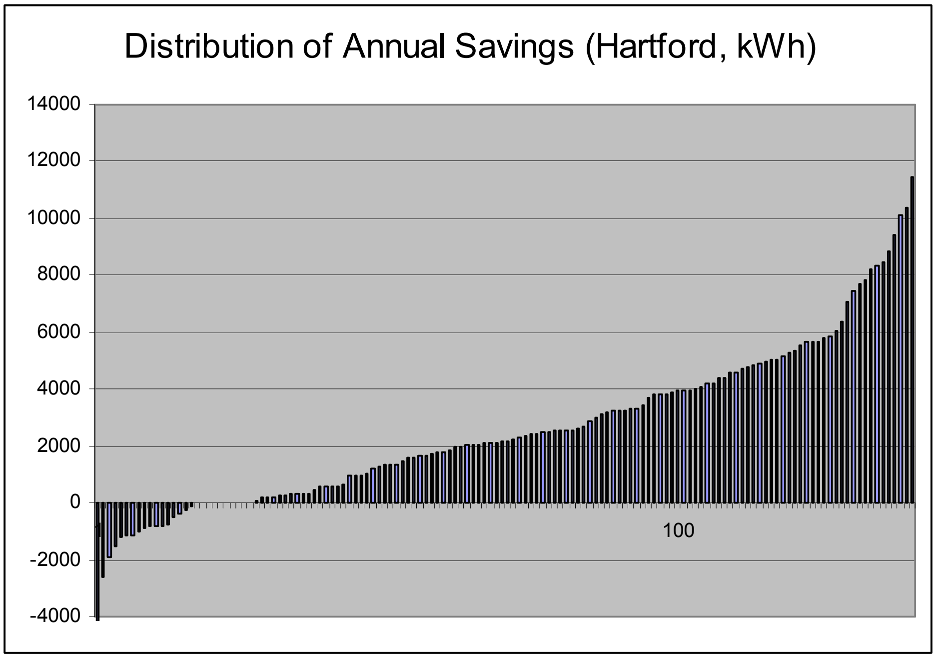
A Closer Look at the Results

The DHP pilot's average heating savings was approximately 2,500 kWh, representing approximately a 30 percent heating savings. While this level of savings is significant, it is lower than the theoretical savings that the DHP should produce, even when considering Connecticut's cold climate. CL&P predicted savings from the pilot would reach or exceed 50 percent. There is a limited amount of research directed towards DHPs. One noteworthy study that is available is taking place in the Northwest United States[15] that estimates energy savings at over 40 percent. However, it is not clear whether those results would be transferable to Connecticut because of weather differences.

A review of CL&P participant bills from the pilot showed that while some participants appeared to save a significant amount of energy after the installation of the DHP, some did not appear to save anything. This is consistent with the participant interviews where some participants mentioned that they believed the DHP provided neutral or negative savings.

[15] Ecotope, Inc. June 2009, Inc. "Residential Ductless Mini-Split Heat Pump Retrofit Monitoring". Prepared for Bonneville Power Administration, June 2009. Average weather adjusted heating savings for 13 sites that were monitored in this study was 4,442 kWh.

Chart 3: Distribution of Heating Savings



Source: Based on participant billing information provided by KEMA.

To better understand the results, the lead author contacted KEMA in order to look closer at participant data to see if the information provided insight into the pilot's results. Upon close inspection of the data (in particular, the billing analysis), KEMA determined that some participants did indeed realize 50 percent heating savings, while a small percentage of participants appeared to realize very little, if any, heating savings. The following are possible reasons why this may have occurred.

Sizing and Zone Control. Electric heat is typically controlled via individual thermostats to control relatively small zones or areas. In contrast, DHPs are typically designed to only directly condition main living space(s). In fact, almost half (70/144) of the pilot participants had single zone DHPs. While these single heat pumps may have been effective within their installed zone, other areas of the home likely continued to use electric resistance heat. In a worst case scenario, the heat produced in the outer zones could have back spilled into the DHP thereby causing it to operate less. For the participant, this scenario would have been easy to miss because DHPs continue to operate (on a lower speed) unless they are manually turned off completely.

Most participants commented that the DHP provided superior comfort and even temperature. This would suggest that perhaps the DHPs are doing a superior job at providing even temperature throughout the zone they are conditioning. The fact that DHPs provide even temperatures by constantly circulating air could effectively increase heat loss and could increase the amount of energy a DHP is using versus baseboard systems. There are countless reports about baseboard systems (and thermostats) contributing to cold spots within rooms. This condition may have been exacerbated by the fact many of the DHPs were two ton, single zone systems capable of adequately providing even temperatures throughout the installed zones.

Some participants, in particular the participants who installed multiple zone systems, may have effectively increased the size of the zone(s) that they were heating. We know anecdotally that oftentimes, electric heat participants will only heat primary living spaces and will turn off heat (or use on a limited basis) heat in non-primary spaces. In some cases, the DHP may have been producing more heat than the pre-existing electric baseboard because it was heating (either directly or indirectly) more space. This may or may not have been the intention of the participant!

Unfortunately, the evaluation did not provide information on how much electric heat was actually being displaced. In hindsight, this critical piece of information would have been helpful in terms of understanding the savings, specifically how much of the savings was attributed to the heat pump efficiency, and how much of the savings was attributed to either the sizing of the heat pump and how well it matched the load it was intended to displaced. It's likely that the DHP was not a perfect one-for-one substitute in terms of the amount of heat it produced and the zones it served. A follow up evaluation should take a closer look at the findings to determine which attributes of the DHP contributed to the savings.

Operations. Several participants mentioned that they were confused and did not understand how to operate the heat pump. This is understandable given that the remote control operation of the heat pump is certainly more complicated than the typical electric heat thermostat. One participant reported that he had inadvertently run the air conditioning during the winter because he did not understand the symbols on the control unit. All of the CL&P pilot participants were required to attend an informational session prior to the installation of the heat pump. In addition, the installation contractor provided instructions to participants on proper operation, so most participants presumably had some training, yet there were some participants who reportedly had difficulty understanding how to operate the DHP using the remote control. Since many of the pilot participants were senior citizens, it's possible that they did not understand the "gadget" nature of the remote control. Regardless, the pilot provided strong evidence that DHP training could influence savings.

Snapback. Snapback, or direct rebound effect, is a term used to describe an increase in energy consumption after the installation of an energy-efficient measure because the new more efficient equipment is operated more or at a different set point. Pilot participants were told that these heat pumps would provide some savings. While the pilot evaluation did not estimate snapback, some participants may have made the conscious or unconscious decision to trade energy savings for a higher level of comfort.[16]

Benefit-Cost and Payback

One obvious question is how DHPs (and the results of the pilot) will translate to cost-effective savings for energy-efficiency programs both within and outside of Connecticut, as well as how DHPs can provide relief for electric heat residential participants. It is expected that savings for electric heat participants will trend roughly with heating consumption. For example, annual energy consumption to heat a small electric heat apartment could be as low as 1,000 kWh while some electric heat single-family homes have heating consumption exceeding 30,000 kWh. Heating consumption for the Connecticut homes in the pilot was approximately 10,000 kWh (pre-installation of DHP). Based on the results of the pilot, CL&P believes that realistic savings estimates for electric heat homes retrofitted with a DHP is 40 percent.

[16] There have been various studies that have quantified the impact of snapback including. See Frank Gottron, CRS Report for Congress: "RS20981: Energy Efficiency and the Rebound Effect: Does Increasing Efficiency Decrease Demand?" July 30, 2001.

Table 5 provides savings and benefits for three scenarios: a low, average, and high savings. Table 5 is not intended to cover all scenarios and all permutations of heat pumps, zones, existence of cooling, etc. Rather, it is intended to show the approximate savings and benefits of a cross range of scenarios for the purpose of informing participants and efficiency program administrators.

Table 5: Savings and Benefit-Cost Ratios

		Low	**Average**	**High**
Pre DHP Heating Consumption	A	3,000	10,000	20,000
DHP Annual Heating Savings (kWh)	B	1,200	4,000	8,000
Pre DHP Cooling Consumption	C	60	120	300
DHP Cooling Savings (kWh)	D	40	80	200
Total Dollar Annual Savings *(note 1)*	E = 0.18 x (B + D)	$223	$734	$1,476
Heat Pump Size (Btu/hr) *(note 2)*		12,000	24,000	36,000
Gross Installed Cost *(note 3)*	F	$3,000	$4,500	$6,000
CEEF Incentive	G	$1,000	$1,000	$1,000
Federal Tax Credit (30% capped at $1,500)	H = 0.30 x (F-G)	$600	$1,050	$1,500
Final Customer Cost *(note 4)*	I = F-G-H	$1,400	$2,450	$3,500
Simple Payback (Years)		6.3	3.3	2.4
Electric Benefit *(note 5)*	J	$1,848	$6,040	$12,170
Utility Benefit-Cost Ratio	J ÷ G	1.85	6.04	12.17
Total Resource Benefit-Cost Ratio	J ÷ F	0.62	1.34	2.03
Customer Benefit-Cost Ratio *(note 6)*	18 x E / I	2.9	5.4	7.6

Notes:
1) Based on assumed average Connecticut rate of 18 cents per kWh.
2) Estimated heat pump based on size of heating load.
3) Costs based on review of CL&P rebate data. Assumes single zone system for Low and Average case, and a two system for the high case.
4) Final cost reflects 30% U.S. federal tax credit and current CEEF incentive of $1,000.
5) Calculated using current CL&P avoided costs as filed in the CL&P and UI 2010 Conservation & Load Management Plan.
6) Calculated based on an 18 year estimated measure life. This number represents total lifetime savings divided by customer cost. Savings is not discounted.

There are several important facts that fall out of this analysis. From a homeowner's perspective, DHPs can provide quick paybacks – two to three years for many participants. The presence of incentive programs and tax credits significantly reduce the initial cost of DHPs and are significant drivers in making them attractive options. The participant benefit-cost ratio ranges from 2.9 to 7.6. This number represents the simple return on investment from a participant's perspective.

From an efficiency program perspective, DHPs can be a cost-effective measure and yield Total Resource Benefit Cost ratios of above 1.0 for the Average and High scenarios (DHPs are not cost effective for a the Low scenario using the Total Resource Cost Test), and utility benefit-cost ratios above 9.0 for the High scenario. Obviously, any DHP program should target high users to maximize savings and cost-effectiveness.

Next Steps

Prior to the pilot, the CEEF offered a $500 rebate for residential participants who installed ENERGY STAR central air conditioners or heat pumps (including DHPs). Both CL&P and UI agreed that a higher incentive would help jump start Connecticut's residential DHP market. Therefore, in August 2009, a request was filed with the Connecticut Department of Utility Control (DPUC) to increase the incentive available to participants through the CEEF programs to $1,000 for participants with electric resistance heat and for DHPs that have a Heating Season Performance Factor (HSPF) of 10 or greater.

The request generated a series of data requests from the DPUC regarding DHPs[17] requesting clarification on the DHP pilot's evaluation results, potential for DHP savings in Connecticut, and information surrounding the proposed $1,000 incentive for high-efficiency DHPs. On October 27, 2009, the DPUC held an official meeting at the pilot's condominium complex site to formally announce their approval of the $1,000 DHP incentive. However, recognizing the importance of educating participants on proper operation, the DPUC requires that participating contractors receive training to address participant education.

At the end of 2009, this program was rolled out to contractors and is beginning to generate interest in the HVAC contractor community. As of May 1, 2010, there are 219 participating companies that have met the program requirements and 353 DHP units have been installed. For marketing and promotional purposes, a website has been developed around the DHP rebate program (www.GoingDuctless.com/ct) which provides useful information to participants regarding DHPs, the DHP rebate program, as well as information to participating contractors.

In 2010, based on the result of the pilot, a new DHP program has been created in Connecticut and has received regulatory approval from the DPUC. The following strategies will be used by the CEEF in this program to increase penetration of DHPs in Connecticut residential buildings:

1) Direct marketing to electric heat participants. These will primarily be letters mailed to electric heat participants inviting them to informational sessions on DHPs and providing information on the program and its benefits.

2) Increased contractor training and certification. Training and certification of DHP installers was a requirement established by the DPUC as part of the approval of this program. Much of the training is offered in conjunction with existing dealer and distributor training.

3) Newer generation of DHPs with higher efficiency ratings and better cold weather performance. The Connecticut DHP program requires a HSPF of 10 or greater. This requirement encourages the use of models which have superior cold weather performance compared to the pilot DHPs. The majority of the pilot DHPs installed had an HSPF of 8.2 and substandard cold weather performance relative to units available today.

4) Possibility of utilizing DHPs in new construction. The CEEF's Residential New Construction Program offers a Zero Energy Option. The extraordinary low heating needs for these energy-efficient homes makes DHPs a viable option as a whole house heating and cooling system.

5) Positioning DHPs and geothermal heat pumps as "options for electric heat participants." Currently, a marketing campaign is being developed which will target electric heat participants in Connecticut to raise awareness about available DHP and geothermal options.

6) The CEEF will be conducting an on-the-bill financing pilot in 2010 for residential customers. It is hoped that financing will be an important tool to help increase the installation of DHPs especially in limited-income settings where the up front cost is likely to be a significant barrier.

[17] Connecticut Department of Public Utility Control, Docket No. 08-10-03 RE01.

This pilot study provided estimates of savings and cost-effectiveness for DHPs and demonstrated that DHPs can be a cost-effective solution for customers. However the study estimated energy savings at a high level. Additional follow up work should be performed to provide more information on how DHP design and operation can influence savings. This would include studying the interaction of DHPs with the existing baseboard heating system as well as the impact that sizing, operation and the number of zones may have on savings. Finally, follow up work should be considered for other similar technologies that can be used to help displace electric heat including ducted heat pumps and ground source heat pumps.

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