Hydro One Networks, Inc.: Heat Pump Advantage – Water Heater Rebate Pilot Evaluation

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### Acronyms and Abbreviations

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<th>Definition</th>
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<td>ADC</td>
<td>Average daily consumption</td>
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<td>CDD</td>
<td>Cooling degree days</td>
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<tr>
<td>EM&amp;V Protocol</td>
<td><em>Evaluation, Measurement &amp; Verification Protocol</em></td>
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<tr>
<td>FSA</td>
<td>Forward sortation area</td>
</tr>
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<td>HDD</td>
<td>Heating degree days</td>
</tr>
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<td>HONI</td>
<td>Hydro One Networks, Inc.</td>
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<td>HPWH Pilot</td>
<td>Heat Pump Advantage – Water Heater Rebate Pilot</td>
</tr>
<tr>
<td>IESO</td>
<td>Independent Electricity System Operator</td>
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<td>LDC</td>
<td>Local distribution company</td>
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<td>LUEC</td>
<td>Levelized unit electricity costs</td>
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<td>NTGR</td>
<td>Net-to-gross ratio</td>
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<td>PAC</td>
<td>Program administrator cost test</td>
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<td>PY</td>
<td>Program year</td>
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<td>TRC</td>
<td>Total resource cost test</td>
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Executive Summary

Cadmus evaluated the Heat Pump Advantage – Water Heater Rebate Pilot (HPWH Pilot), which was offered by Hydro One Networks, Inc. (HONI). The team conducted a process evaluation in 2017 and impact evaluation in 2018, after sufficient post-installation advanced metering infrastructure data was available, to address several research objectives:

- Determine net and gross verified energy and summer peak demand savings
- Compare evaluated performance against reported participation and energy savings
- Assess delivery channel and marketing methods
- Assess stakeholder and participant experiences, including satisfaction and motivation
- Document areas of success, challenge and changes to the program
- Determine cost-effectiveness and greenhouse gas reductions

Pilot Description

HONI designed the pilot to target residential customers owning a home with a conventional electric water heater and residing in areas where natural gas is not available. HONI secured a delivery agent\(^1\) to provide additional outreach support, in-home energy advisors, help connect participants with an installation contractor and ultimately to install the heat pump water heaters and ensure consistent installation costs.

Through installation contractors, HONI offered customers a 30% discount (rebate) on the installed cost (up to $1,200) of ENERGY STAR\textsuperscript{®}-certified heat pump water heaters with an efficiency factor of 2.0 or higher. Contractors passed these savings along to the participant as a discount on their equipment purchase, and HONI reimbursed the contractor once it verified an installation was complete. HONI ensured that contractors discounted the equipment by requiring submitted invoices for approval before paying the discount.

In addition, HONI offered $100 to contractors for each participant they referred to the pilot. HONI expected contractors to drive as much as 50% of pilot participation; however, contractors ultimately referred less than 1% of participants. Roughly 700 customers initially applied for the discount, but most dropped out of the application process after receiving quotes from their contractor that were higher than expected. To further reduce the financial investment required by customers, HONI increased the maximum rebate level twice: first, from $570 to $800, and again from $800 to $1,200. Transitioning installation responsibilities from contractors to the implementer mid-pilot reduced costs for customers.

\(^1\) During the pilot, HONI transitioned implementation duties to a new delivery agent after the original delivery agent ceased doing business in Canada. The report refers to the delivery agents singularly, as either “the delivery agent” or “the implementer.”
further. Although the increased rebate levels and reduced installation costs positively affected participation rates, the pilot ultimately fell short of its final enrollment target of 250 customers.

Methodology

The Cadmus team conducted impact and process evaluations of the HPWH Pilot.

For the impact evaluation, the team determined net energy savings through a billing analysis of participant and matched nonparticipant consumption data using a post-pilot only regression model. Since the pilot could not be operated as a randomized control trial, the Cadmus team used propensity score matching to select a group of nonparticipants with similar characteristics to the participants to control for each customer’s pre-pilot consumption and for non-pilot consumption changes, such as naturally occurring efficiency. The team estimated the pilot’s overall first-year savings, as well as savings by season.

To estimate demand savings, the Cadmus team analyzed hourly data, applying the Evaluation, Measurement & Verification Protocol’s (EM&V Protocol) definition\(^2\) of peak demand periods for weather-sensitive measures. Using a similar approach for hourly data, the team compared changes in the average peak hour usage pre- and post-pilot between the participants and matched nonparticipants.

For the process evaluation, the Cadmus team gathered insights into the effectiveness of the pilot design and assessed the operation and performance of the pilot. The team conducted a comprehensive review of pilot documents, then interviewed HONI and implementation staff, as well as with the manufacturer and two participating contractors. In addition, the team completed 53 participant surveys to assess participant experience with the pilot.

Key Observations and Recommendations

As shown in Table ES-1, the HONI HPWH Pilot achieved net verified first year savings of 117 MWh and 0.018 MW and installed 69 heat pump water heaters. The Cadmus team estimated a gross realization rate of 87% for energy and 240% for demand.

The following summarizes the team’s key observations and recommendations:

**Key Observation 1. Due to the pilot’s limited participation and lack of a randomized control group, the estimated savings should be considered directional in nature as overall confidence and precision was 90% with precision of +/-47%.

- **Recommendation 1:** To achieve more robust savings estimates, future heat pump pilots should strive to achieve a larger participant sample size.

**Key Observation 2. High equipment costs, contractors’ limited experience with heat pump water heater technology and pilot rebate structure may have resulted in high installation quotes which may have inhibited participation levels.

- **Recommendation 2a:** Prior to launching a pilot promoting an emerging technology, investigate measure supply and pricing in the target pilot region. If installation contractors are inexperienced with the product or unsure how to price the technology and installation, consider working with a limited number of contractors who are believers in the technology and agree to a pricing schedule in exchange for referrals. This limited contractor model has worked well in other jurisdictions targeting either hard-to-reach markets or leading-edge technologies.

- **Recommendation 2b:** Deploy the pilot in a residential new construction application, which could rely on a limited number of contractors (as noted in recommendation 2a), provide training to the builder group, expect higher participation, and avoid the obstacles and additional costs associated with replacing old equipment in existing homes.

- **Recommendation 2c:** In addition to working with a limited number of dedicated contractors, determine if it is necessary to develop a training class for contractors provided by either HONI staff, manufacturers, or distributors to ensure best practices are followed during the installation process, and to help contractors understand the equipment specifications and costs so they can explain the benefits to customers. Develop marketing materials for contractors and customers highlighting energy savings and payback.
**Key Observation 3.** Although participating customers were mostly satisfied with the pilot, there is room to improve the contractor and manufacturer experience.

- **Recommendation 3:** See recommendation 2a and 2c.

**Key Observation 4.** The current program design is not cost-effective.

- **Recommendation 4:** Given that the measure level benefits ($1,120) are slightly below the costs ($1,153), a change in participation alone will not make the pilot cost-effective; a change in the combination of the following measure- and pilot-level attributes are needed to result in a positive benefit/cost ratio for the test(s) indicated in parentheses:
  - Increased net verified savings (TRC/PAC) which could be improved by targeting homes with larger electric water heating loads.
  - Decreased measure incremental costs (TRC); as the market for HPWHs matures in Ontario, the cost may also fall.

In addition, bundling the heat pump water heater measure with more cost-effective measures could help the pilot become cost-effective while still offering this cutting-edge technology.
Introduction

The Cadmus team evaluated the HPWH Pilot, which was offered by Hydro One Networks, Inc. (HONI). The team conducted a process evaluation in 2017, and once sufficient post-install consumption data was available, the team conducted the impact evaluation in 2018.

The Cadmus team conducted the impact and process evaluation to address several research objectives:

- Evaluate net and gross energy and summer peak demand savings
- Compare evaluated performance against reported participation and energy savings
- Assess delivery channel and marketing methods
- Assess stakeholder and participant experiences including satisfaction and motivation
- Document areas of success, challenge and changes to the program
- Determine cost-effectiveness and greenhouse gas (GHG) reductions using the Independent Electricity System Operator’s (IESO) CDM Cost Effectiveness Tool

The impact evaluation, process evaluation and cost-effectiveness methods and results are provided in separate chapters after this introduction. For the evaluation, the Cadmus team conducted several primary tasks:

- Document review
- Stakeholder interviews (LDC and implementation staff)
- Market actor interviews (contractors and manufacturer)
- Participant surveys
- Billing analysis

Pilot Description

HONI designed the HPWH Pilot to:

- Increase customer awareness and use of heat pump water heater technology
- Provide energy bill saving options for rural customers with electric water heating
- Encourage manufacturers to invest in heat pump water heater technology
- Investigate the possible inclusion of heat pump water heaters in existing province-wide programs

HONI designed the pilot to target residential customers in rate classes R1, R2 and UR owning a home with a conventional electric water heater and residing in areas where natural gas is not available. HONI secured a delivery agent to provide additional outreach support, in-home energy advisors, help connect participants with an installation contractor and ultimately to install the heat pump water heaters and ensure consistent installation costs.
Through installation contractors, HONI offered customers a 30% discount (rebate) on the installed cost (up to $1,200) of ENERGY STAR–certified heat pump water heaters with an efficiency factor of 2.0 or higher. Contractors passed these savings along to the participant as a discount on their equipment purchase, and HONI reimbursed the contractor once it had verified that an installation was complete. HONI ensured that contractors discounted the equipment by requiring submitted invoices for approval prior to paying the discount.

In addition, HONI offered $100 to contractors for each participant they referred to the pilot. HONI expected contractors to drive as much as 50% of pilot participation; however, contractors ultimately referred less than 1% of participants. Roughly 700 customers applied for the pilot, but the majority dropped out of the application process after receiving quotes from their contractor. To further reduce the initial financial investment required by customers, HONI increased the maximum rebate level—originally, from $570 to $800, and again from $800 to $1,200.

Although HONI planned to enroll roughly 650 pilot participants, 69 customers ultimately participated. Sixty-six of the 69 customers participated after the delivery agent replaced contractors and assumed the responsibility of completing all installations at fixed prices (rather than variable prices, as originally quoted by the contractors).
Impact Evaluation

The Cadmus team used billing analysis to develop net energy and demand saving for this pilot.

Methodology

As the pilot was not implemented with a randomized controlled trial design, the team constructed a matched group of nonparticipants to serve as a comparison group for the impact evaluation. The team analyzed the energy savings at the daily level and demand savings at the hourly level.

The following sections explain how the Cadmus team constructed the matched nonparticipant group and derived energy and demand savings.

Matched Nonparticipant Group

To identify nonparticipants with similar characteristics to pilot participants, and to control for naturally occurring changes in residential energy consumption among HONI customers during the analysis period, the Cadmus team used Imbens’ propensity score matching\(^3\) to construct a nonparticipant comparison group that closely resembled the load profile of the pilot participants. Propensity score matching creates a model for program participation using customer information and energy usage statistics and estimates a propensity score – an estimate of each customer’s likelihood of participating in the HPWH Pilot - for each participant and each nonparticipant. Each participant is then matched with the nonparticipant having the closest estimated propensity score.

The Cadmus team selected the nonparticipant group for the impact analysis using a sample of 100,000 nonparticipants provided by HONI. Before beginning the matching process, the team excluded customers with any of the following characteristics, applying the same filters to participants and nonparticipants:

1. Average daily consumption (ADC) in PY2015 that was outside the range observed in the participant group\(^4\)
2. Toronto metro area postcode\(^5\)


\(^4\) The lower bound of this range was 17 kWh per day and the upper bound was 122 kWh per day. The Cadmus team used data from PY2015 for this filter because the full year of data was available for most customers and it was before the first HPWH installation by the pilot in PY2016.

\(^5\) This filter removed two nonparticipants. There were no participants with Toronto metro area postal codes, as the pilot targeted rural customers without natural gas.
3. Nonparticipant and lacking AMI data through December 1, 2017\textsuperscript{6} or participant and lacking AMI data after participant date
4. Less than 271 days of AMI data in PY2015\textsuperscript{7}

These filters reduced the size of the nonparticipant group eligible for matching from 100,000 to 69,954 and reduced the size of the participant group from 69 to 66.

Next, the team created several variables to use as inputs to the propensity score model:

- An indicator for the rural forward sortation area (FSA)\textsuperscript{8}
- A matrix of indicators for the first letter of the customer’s FSA (K, L, N or P)\textsuperscript{9}
- An indicator for PeakSaver\textsuperscript{10} participation
- Age of account (number of years active)
- A matrix of variables for average hourly kilowatt-hours in PY2015, by season, by winter and summer peak periods and by morning, afternoon and evening for each season
- A matrix of variables for the PY2015 heating degree days (HDD) and cooling degree days (CDD), by season, at a range of different base temperatures

The Cadmus team then estimated each customer’s propensity to opt-in to the pilot using logistic regression models specified through forward stepwise model selection.\textsuperscript{11} Next, the team modelled the propensity to opt-in as a function of the selected variables using the scoring recommended in Imbens and Rubin (2015).

After selecting the final model, described in the \textit{Energy Savings} section below, the team calculated the predicted propensity score for each participant and nonparticipant account. Then the team created one-to-one matched pairs of participants and nonparticipants using the nearest-neighbor-matching-without-replacement method. That is, for each participant, the team selected a nonparticipant with the

\textsuperscript{6} This filter ensured that nonparticipants would have sufficient post-pilot period data for the impact analysis.
\textsuperscript{7} This filter ensured that nonparticipants would have a representative sample of pre-pilot period data from at least three seasons in PY2015. The Cadmus team did not require a full 365 days, which was not available for most participants, and 271 days was the most restrictive filter available without reducing the participant group size.
\textsuperscript{8} FSAs with zero as the middle character are classified as rural areas.
\textsuperscript{9} The first letter of the FSA identifies broad geographic regions within Ontario.
\textsuperscript{10} PeakSaver was a residential demand response program that was available in Ontario until 2017.
\textsuperscript{11} Stepwise selection is an automated model selection procedure that tests the statistical significance of each new variable added to the model and only selects variables for inclusion that improve the model to a statistically significant extent.
propensity score closest to that participant’s score. Without replacement means that only one nonparticipant account can be matched to one participant account.

After conducting the matching, the team tested for differences in pre-pilot energy consumption between the participants and the matched nonparticipant group. The team compared total annual and average daily consumption between the two groups, as well as consumption in each season of 2015 (the pre-period). The team verified that there were no statistically significant differences between the participant and matched nonparticipant groups’ consumption before the start of the pilot, thereby verifying that the matched nonparticipant group could serve as a valid comparison group to estimate participant savings in the post-pilot installation period. Figure 1 shows that the distribution of pre-period average daily consumption across the two groups is similar. The team’s modelling approach controlled for any differences in pre-pilot consumption between customers by including this consumption as an explanatory variable in the energy and demand savings models, as described next.

![Figure 1. Comparison of Participant and Matched Nonparticipant Pre-Period Consumption](image)

**Energy Savings**

The Cadmus team developed statistical models using HONI customers’ consumption data to determine the net verified first-year pilot energy savings.

First, the team used customer-specific regressions with stepwise variable selection to select each customer’s individual best CDD and HDD base temperatures. This resulted in CDD and HDD variables

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12 For each customer, the team tested simple regression models using the customer’s pre-pilot data. The Cadmus team tested each combination of HDD and CDD base temperature between 7°C and 24°C in increments of approximately 3°C. If a customer exhibited negative estimated coefficients for CDD or HDD, the team set their individual CDD or HDD to zero, as the intent of these variables is to capture the impacts of heating and cooling on energy consumption.
that used base temperatures specific to each customer. This meant that each customer’s specific sensitivity to outdoor temperature, and the impact of that sensitivity on their usage of cooling and electric heating, were captured in the energy savings model described in this section.

To estimate the energy savings, the team used a post-pilot only regression model that only included daily kilowatt-hour observations from the first 12 months of each customer’s post-pilot installation period.\(^\text{13}\) To control for pre-pilot differences in energy consumption, each customer’s PY2015 ADC was entered into the regression model as a set of explanatory variables. The Cadmus team tested several different specifications of the savings model and found that changes to the model such as including or excluding variables did not significantly change the other model variable coefficients. The selected final model specification included the following explanatory variables:

- **An indicator variable for pilot participation.** The estimated coefficient of this variable was the average daily savings estimate.
- **An indicator variable for each day of the week, Monday through Sunday.** These captured energy patterns associated with days of the week.
- **An indicator variable for each month-year combination (for example, July 2016).** These captured energy consumption patterns associated with specific months not already captured by the weather variables below.
- **Weather variables:**
  - *In the summer model, CDD and CDD squared.* These captured the nonlinear effects of hot weather on energy consumption.
  - *In the winter model, HDD and HDD interacted with weekend days.* HDD captured the effects of cold weather on energy consumption. The interaction term captured customers’ additional sensitivity to cold weather on weekend days.\(^\text{14}\)
- **Each customer’s PY2015 ADC on each day of the week.** These seven variables controlled for differences in pre-pilot energy consumption across customers.

After estimating the final model, the Cadmus team calculated the annual first-year savings per customer by multiplying the coefficient on the participant variable—which estimated the average daily net savings across all participants—by 365.25 days, the average number of days in a year. These savings, as well as seasonal savings estimates, are reported in the *Impact Findings* section. Note that the team reported actual first year savings instead of weather-normalized savings for two reasons. First, the IESO cost effectiveness tool’s load profile for residential domestic hot water is not weather-sensitive. Second, the

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\(^\text{13}\) The team assigned each matched nonparticipant the same post-pilot installation date as their matched participant. The Cadmus team included only the first 12 months after each customer’s heat pump water heater installation so that our savings estimates reflect the first-year savings associated with the measure.

\(^\text{14}\) The Cadmus team tested the inclusion of an HDD squared term, but it was not significant and the team removed it from our final model specification. Likewise, CDD interacted with weekend days was not significant and the team did not include it in our final model.
team’s HPWH savings estimates did not show a clear correlation with outdoor temperatures, as described in the Impact Findings section.\textsuperscript{15}

Though savings estimates were not sensitive to changes in the model specification, the Cadmus team found that savings were highly sensitive to changes in the participant and matched nonparticipant groups. Including or excluding individual participants or rerunning the nonparticipant matching process with a different group of nonparticipants, led to large savings estimate differences. This is due to the small participant sample size (n=66 after the filters described previously) and the lack of a true, randomized control group of nonparticipants. **Though the team made every effort to select a matched nonparticipant group to approximate a control group, the challenges imposed by the small sample size, the self-selection inherent in the pilot’s opt-in design, and the lack of a randomly assigned control group could not be overcome given that data on customer characteristics such as home size, primary heating fuel, prior engagement with HONI programs, or number of occupants was also not available (Key Finding 1a).** For this reason, the savings estimates may be used to inform future program planning, however additional research with a larger sample size, and ideally a control group, is necessary to determine robust savings estimates.

**Demand Savings**

To estimate demand savings, the team used a similar approach as for estimating energy savings: post-pilot only regression models including hourly kilowatt-hour observations during each season’s peak hours\textsuperscript{16} from the first 12 months of each customer’s post-pilot installation period.\textsuperscript{17} To control for pre-pilot differences in energy consumption, each customer’s PY2015 peak-hour average demand was entered into the regression model as a set of explanatory variables (one variable for each hour).

To calculate summer peak demand savings separately from winter peak demand savings, the team estimated separate models for each season. The Cadmus team tested several different specifications of the savings model and found that the savings estimates were robust and variable coefficients stable

\textsuperscript{15} While HPWHs may exhibit more weather-sensitivity than conventional electric resistance water heaters due to their interactions with space heating and cooling, the results did not show a clear enough correlation with weather to lead the team to reclassify HPWHs as a weather-sensitive measure. Future HPWH pilot designs could address this issue by recording the location of the HPWHs within the home and each home’s primary heating fuel.

\textsuperscript{16} The Ontario Power Authority \textit{EM&amp;V Protocols} define the summer peak hours for non-weather-sensitive measures as weekdays from 1 p.m. to 7 p.m. in June, July and August and defines winter peak hours as weekdays from 6 p.m. to 8 p.m. in January, February and December. The protocol’s definition for non-weather-sensitive measures’ peak demand savings is the average savings during this period. The protocol is available at [http://www.ieso.ca/-/media/files/ieso/document-library/conservation/ldc-toolkit/emv-protocols-and-requirements-10312014.pdf?la=en](http://www.ieso.ca/-/media/files/ieso/document-library/conservation/ldc-toolkit/emv-protocols-and-requirements-10312014.pdf?la=en)

\textsuperscript{17} The team assigned each matched nonparticipant the same post-pilot installation date as their matched participant. The Cadmus team only included the first 12 months after each customer’s heat pump water heater installation so that our savings estimates reflect the first-year savings associated with the measure.
when individual variables were added or removed from the model specification. Our final model specification included the following explanatory variables:

- **An indicator variable for pilot participation.** The estimated coefficient of this variable was our average peak demand savings estimate.

- **An indicator variable for each hour of the peak period.** The summer model included indicators for 1 p.m., 6 p.m. and each hour in between. These captured energy patterns associated with each hour of the peak period.

- **An indicator variable for each month-year combination (for example, July 2016).** These captured any energy consumption patterns associated with specific months that were not captured by the weather variables below.

- **Weather variables:**
  - *In the summer model, CDD and CDD squared.* These captured the nonlinear effects of hot weather on customer demand.
  - *In the winter model, HDD.* This captured the effects of cold weather on energy consumption.\(^{18}\)

- **Customer-specific average demand, by hour.** These variables controlled for differences in pre-pilot demand across customers, allowing their pre-pilot data to have a different effect in each hour of the peak period.

The participation variable estimated coefficient yielded the estimated peak demand savings for the winter and summer seasons. By using a regression analysis method with hourly AMI data from peak periods, the Cadmus team directly estimated net demand savings resulting from pilot participation.

However, demand savings analysis was also limited by the pilot design and sample size as described in the energy savings section, above. For this reason, the demand savings estimates may be used to inform future program planning, however additional research with a larger sample size is necessary to determine robust savings estimates.

**Impact Findings**

This section describes the verified net pilot impacts for annual and seasonal energy savings as well as summer and winter demand savings. Note, the billing analysis reflects all energy efficient actions taken. To control for exogenous factors, we use a comparison group so that the net difference is attributable to the pilot. Therefore, a net-to-gross ratio is not calculated via survey for this pilot.

\(^{18}\) The Cadmus team tested the inclusion of HDD squared and HDD interacted with weekend days interaction terms, but neither was significant and they were removed from the final model specification. Likewise, CDD interacted with weekend days was not significant in the summer model and the team did not include it in our final model.
Net Verified Unit Energy Savings

Table 1 presents the net verified first-year energy savings. The pilot realized 117 MWh in total, or approximately 87% of the reported 135 MWh.

Table 1. Annual Energy Savings

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Energy Savings (kWh)</th>
<th>Number Installed</th>
<th>Total Energy Savings (MWh)</th>
<th>Realization Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>4.6</td>
<td>1,698</td>
<td>69</td>
<td>117</td>
</tr>
<tr>
<td>Annual</td>
<td>1,088</td>
<td>69</td>
<td>117</td>
<td>135</td>
</tr>
<tr>
<td>Verified Net First Year</td>
<td>117</td>
<td></td>
<td></td>
<td>87%</td>
</tr>
<tr>
<td>Verified Net 2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reported</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Values are rounded.

The daily savings estimate is statistically significant with 90% confidence\(^{19}\), absolute precision of 2.1790 kWh, and relative precision of 47%. However, as discussed in the Energy Savings portion of the Methodology section above, the Cadmus team found that these savings estimates were highly sensitive to changes in the participant and matched nonparticipant groups. Including or excluding specific customers resulted in annual savings estimates that sometimes fell as low as 900 kWh. This issue is inherent to the small sample size and the non-experimental pilot design.

Table 2 presents the daily savings estimates by season.

Table 2. Daily Savings Estimates by Season

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Daily Energy Savings (kWh/day) *</th>
<th>Statistically Significant at 90% Confidence?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>3.6</td>
<td>No</td>
</tr>
<tr>
<td>Spring</td>
<td>4.9</td>
<td>Yes</td>
</tr>
<tr>
<td>Summer</td>
<td>4.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Fall</td>
<td>5.6</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Values are rounded.

As shown in Table 2, savings were highest during the fall, followed by spring. Fall may achieve the highest savings due to the combination of mild outdoor temperatures and typical daily hot water consumption patterns during this season. Similar patterns may explain the high savings in spring, though cold water supply temperatures remain low during this season.

The savings estimate for winter was lower than for the other seasons and was not statistically significant. The lower winter savings estimates may be due to poor low-temperature heat pump performance (when the heat pump water heater is in an unconditioned basement or garage), as the unit’s coefficient of performance falls as air temperatures decrease and it is more likely to rely on its conventional, electric resistance heating element to meet hot water demand. When the heat pump water heater is in a conditioned space, it absorbs heat from the surrounding conditioned air, which improves its coefficient of performance and reduces its energy consumption. However, in electrically heated homes this will increase electric energy consumption from heating. The winter savings estimate

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\(^{19}\) The standard error of the daily savings estimate of 4.6486 kWh is 1.3246.
was not statistically significant due to both the lower magnitude of winter savings relative to other seasons and also to higher variance of savings across participants in this season\textsuperscript{20}.

The savings for summer were lower than for fall or spring. Absent behavioral differences, the team would expect highest savings in summer, when the heat pump water heater does not contribute to electric heating load and reduces air conditioning load in air-conditioned homes. Further, the team expected heat pump water heaters in unconditioned spaces to perform best in the summer, when the higher outdoor temperatures correspond with higher heat pump performance. However, these factors may have been counteracted by lower domestic hot water consumption during the summer, and minimal air conditioning loads which reduced achievable summer savings.

Though the magnitude of these savings varied substantially among individual homes, these seasonal savings patterns held constant, with spring and fall consistently showing the highest savings and winter showing the lowest savings.

**Net Verified Unit Demand Savings**

Table 3 presents the demand savings by season. The Cadmus team calculated the net verified first year demand savings using IESO’s seasonal peak definitions.\textsuperscript{21}

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Demand Savings (kW)\textsuperscript{a}</th>
<th>Number Installed</th>
<th>Total Demand Savings (MW)</th>
<th>Realization Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Verified Net First Year</td>
<td>Verified Net 2020</td>
</tr>
<tr>
<td>Summer</td>
<td>0.264</td>
<td>69</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>Winter</td>
<td>0.253</td>
<td>69</td>
<td>0.018</td>
<td>0.018</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Values are rounded.

Both seasons’ peak demand savings estimates were statistically significant with 90% confidence. The magnitude of the estimated savings was approximately the same in summer as in winter. The demand savings are relatively modest in comparison to the energy savings, possibly reflecting a wide variety of individual hot water demand load curves across a geographically diverse participant population. However, unlike the energy savings realization rate (87%), the team’s net verified savings estimates were larger than the reported demand savings (0.11 kW per unit), leading to a summer demand realization rate of 240%.

\textsuperscript{20} The standard error of the winter daily savings estimate was 3.5979, while the standard errors of the other seasons’ estimates were between 1.4587 and 2.4466.

Process Evaluation

This section outlines results from the Cadmus team’s process tasks, conducted to address the research objectives (listed in the Introduction).

Methodology

The Cadmus team began with a review of pilot documentation that included the business case and inspection form. Then the team conducted phone interviews with one HONI and one implementation staff member, one manufacturer and two contractors and surveyed 53 participants. These data collection activities offered insights into pilot operations and helped the team understand stakeholder, market actor and participant experiences, including pilot successes and challenges and motivations to participate, participation barriers and overall satisfaction.

Stakeholder In-Depth Interviews

The team conducted one telephone interview each with HONI and delivery agent staff to gather information on the pilot’s design, delivery, successes and challenges, as well as the future plans of administrative and implementation staff.

Market Actor In-Depth Interviews

The team conducted one phone interview with a heat pump water heater manufacturer and two interviews with contractors to assess the market actors’ understanding of and motivation to participate in the pilot, their perception of customer awareness of and demand for heat pump water heater technology and the successes and challenges the market actors experienced.

Participant Surveys

The team contacted all 69 participants multiple times, including leaving message to increase the number of completes. Ultimately, the Cadmus team completed 53 surveys, seeking to assess customers’ awareness of and demand for heat pump water heater technology, as well as their decision making, satisfaction, home characteristics and demographics.

Findings

This section provides findings from the stakeholder and market actor interviews, along with results from participant surveys that address the following:

- Pilot design and delivery
- Awareness and motivation
- Market actor and participant experiences
- Pilot successes, challenges and future plans

The home characteristic and demographic details are included as Appendix A.
Pilot Design and Delivery
This section describes the pilot’s intended and actual design and delivery including eligibility and rebate, recruitment and participation, application process, contractor vetting and change of implementation vendor.

Eligibility
HONI staff said the pilot targeted residential customers owning a home with a conventional electric water heater and residing in a rural area where natural gas is not available.

Changes to Pilot Design
Quoted prices from contractors (roughly $1,700 to $2,200 for a 50-gallon water heater) frequently exceeded the price HONI used for its payback analysis by $1,000 or more. Program staff made three critical changes to the pilot design:

- **The delivery agent took over installation duties from contractors.** Using the delivery agent’s in-house technicians simplified pilot implementation. The delivery agent ultimately completed 66 of the 69 pilot projects.
- **HONI switched to a fixed-price model for equipment installations.** Using a fixed-price model prevented contractors from marking up installation quotes and made the pilot offer more affordable for customers interested in participating.
- **HONI staff increased the maximum rebate level,** first to $800, and later to $1,200. HONI staff considered one more increase (up to $1,600) but decided against it, as the pilot would not have been cost-effective.

Rebate Structure
HONI originally offered customers a 30% rebate on the installed cost of ENERGY STAR-certified heat pump water heaters with an efficiency factor of 2.0 or higher. HONI initially limited the maximum rebate to $570 based on payback analysis, although it later increased the maximum to $1,200, as discussed in Changes to Pilot Design. To alleviate the initial financial burden for customers, participating contractors (and, later, the delivery agent’s in-house technicians) were expected to apply the rebate to the customer’s installation cost, with HONI reimbursing contractors after verifying each installation.

Recruitment and Participation
HONI planned to enroll approximately 650 participants, from which it expected to achieve 1,267,949 kWh of energy savings and 73 kW of peak demand savings. Ultimately, the pilot recruited only 69 participants (Key Finding 2a). HONI staff reportedly set the participation and savings goals based on research of its service territory’s largest household end uses (HVAC and water heating). Staff said they anticipated market potential for heat pump water heaters due to of the number of households with electric water heaters in its service territory and the lack of effective energy-saving upgrades for water heaters. HONI staff later reduced the participation target from 650 to 400 customers.

HONI staff targeted customers not already enrolled in other HONI pilots to prevent overlaps in billing and consumption data that would complicate each pilot’s savings analyses. Customers who qualified for
and applied to both the HPWH and Air-Source Heat Pump Advantage pilots were given the choice to participate in one or the other.

HONI staff offered $100 to contractors for each participant they referred to the pilot and expected contractors to drive as much as 50% of the pilot participation. Because of pilot budget limitations preventing additional advertising, HONI initially targeted 10,000 to 15,000 customers via email and hoped the referral incentive would encourage contractors to market the program. HONI staff later targeted approximately 5,000 more customers and the implementer followed up on the initial email invitations with phone calls. These follow-up efforts produced few additional applicants.

One contractor interviewed by Cadmus promoted the pilot on his website and distributed fliers independently of HONI and was able to recruit customers. Less than 1% of survey respondents reportedly learned about the pilot from their contractors. The manufacturer interviewed by Cadmus did not conduct any marketing (with the understanding that HONI would handle all pilot marketing).

**Application Process**

Of roughly 700 customers applying for the discount, 69 participated. HONI staff outlined the following application process:

- **Initial interest and pre-pilot inspection:** Customers applied to receive the discount through the pilot. HONI approved applications and provided the applicant list to the implementer to schedule pre-pilot inspections. Then an energy adviser, part of the implementation team, either visited in person or called the applicant to collect data such as home size, home type and existing equipment specifications using a pre-pilot installation paper form and photos that would be later scanned and converted into digital.

- **Eligibility and quote:** During the pre-pilot inspection, energy advisors confirmed if applicants had electric water heating and disqualified those who did not. Eligible applicants then received quotes for equipment, installation and eligible rebate from a contractor.

- **Decision to participate:** After receiving an installation quote from the implementer, eligible applicants could accept or decline to participate. Implementers asked applicants choosing to participate to specify their preferred installation contractor or assigning a contractor if there was no customer preference.

- **Verification of quote:** Participants received official cost quotes from the contractor, which HONI reviewed to verify that the unit and rebate amount were correct. Once the delivery agent assumed installation duties, HONI charged fixed prices for installations based on water heater size and therefore discontinued quote verification.

**Contractor Vetting**

The implementer recruited contractors mainly through publicizing the pilot at trade shows. HONI staff provided the Cadmus team with a roster of 33 contractors that signed up for the HPWH Pilot, of whom only three completed an installation before the implementer took over installation duties (Key Finding 3b). The implementer vetted contractors by requiring documentation of insurance coverage,
workers’ compensation, licensing and Electrical Safety Authority permits. The implementer also said it required contractors to be properly qualified to install the equipment. This meant that contractors obtained training from select manufacturers who require training to sell their equipment but training itself was not mandated for contractors to participate in the pilot. Ultimately, the delivery agent took over installation duties from contractors and completed all but three of the pilot projects, as discussed in *Changes to Pilot Design*.

**Implementation Vendor Change**

HONI staff said implementation duties transitioned from one delivery agent to another in January 2017 after the original delivery agent stopped conducting business in Canada in November 2016. Several members of the original delivery agent team, including the implementation lead, continued employment with the new delivery agent, making the transition relatively smooth.

**Awareness and Motivation**

This section outlines how manufacturers, contractors and participants became aware of the pilot and why they chose to participate.

**Awareness**

Seventy-two percent of participant respondents (36 of 50) learned about the pilot via a HONI email, while 12% (six of 50) learned about it via the Hydro One website and 10% (five of 50) though their bill (Figure 2). "Other" responses (three of 50) included learning about the pilot either from their contractor (one), via word of mouth (one) and from the newspaper. Note: HONI did not use bill inserts or newspaper advertisements to promote the program.

![Figure 2. How Respondents First Learned about the Pilot](image_url)

Source: Participant Survey Question B1. “How did you first learn that Hydro One Networks was offering rebates on new heat pump water heaters?” (n=50; multiple response)
The interviewed manufacturer representative reportedly learned about the pilot directly from a HONI representative, and said the implementer provided a list of potential installation contractors. Both the interviewed contractors said they learned about the pilot from the implementer.

The manufacturer representative said there is some awareness of and demand for heat pump water heater technology in HONI’s service territory, but not as much as it expected. Accordingly, 21% of respondents (11 of 53) knew about heat pump water heater technology prior to participating in the pilot.

The manufacturer representative and one of two contractors concluded that the pilot had very little impact on demand for heat pump water heater technology. The manufacturer representative acknowledged that most people do not think about replacing their existing water heater until it breaks. When it does break, the manufacturer said, “that’s not the time you’re thinking about going to a heat pump water heater,” noting instead that customers typically want to replace a broken unit with a new, but exactly the same, unit. The manufacturer representative hoped the pilot would encourage “proactive replacement” of water heater units—upgrading existing, functioning units to save money.

The manufacturer representative noted that lack of awareness is a twofold issue: (1) it’s difficult to encourage customers to consider proactive replacement and encourage contractors to sell the units when there is limited customer awareness, and (2) there is a lack of contractor knowledge, namely about the product’s energy and bill savings.

**Motivation**

The manufacturer representative reportedly agreed to participate in the pilot to increase equipment sales. Both contractors said they hoped the pilot would help them become more familiar with energy-efficient equipment.

Survey respondents reported being motivated to purchase a new heat pump water heater primarily to save money (64%, 34 of 53) and just under half wanted to save energy (43%, 23 of 53) or to upgrade existing but working equipment (40%, 21 of 53). Another 13% (seven of 53) wanted the pilot rebate (Figure 3).

---

22 The second interviewed contractor did not end up installing any heat pump water heaters through the pilot.
Figure 3. Respondent Motivations for Pilot Participation

Source: Participant Survey Question B3. “Overall, what motivated you to purchase your new heat pump water heater?” (n=53; multiple response)

The manufacturer representative said he thought that 80% of participants were motivated by the rebate and the remaining 20% are “green folks” and early adopters. As shown in Figure 3, participant survey data suggest that the percentage of early adopters (represented by those upgrading existing and working equipment) might be twice the manufacturer’s estimate (at 40%).

Participant and Market Actor Experiences
This section discusses participants’ experiences, including overall satisfaction and pilot impacts, followed by manufacturer and contractor experiences.

Participant Experience
The Cadmus team administered a post-pilot installation survey to measure participant satisfaction, the importance of specific pilot components and pilot impacts on energy usage and energy saving actions and to gather suggestions for improvement and collect demographic information (described in Appendix A). Fifty-three participants responded to the survey.

Satisfaction
All respondents were very satisfied or somewhat satisfied with their new equipment and most were satisfied with their installation contractor (96%), the rebate (94%) and the pilot overall (96%) (Key finding 3a), as shown in Figure 4. The six respondents who said they were a little satisfied or not at all satisfied with any of these pilot elements reported being dissatisfied with their contractor (n=3) or the equipment or energy costs (n=3).
Figure 4. Respondent Satisfaction with Pilot Components

Source: Participant Survey Questions D1, D3, D5 and D9. “How satisfied are you with the . . . ?”

**Importance of Pilot Components**

Eleven of 53 respondents (21%) said they had previously heard of heat pump water heater technology. Among those 11, eight rated the pilot rebate as very important to their decision to participate in the pilot (Figure 5). Respondents reported an average rebate of $1,037.59.

Figure 5. Importance of Pilot Components to Respondents

Source: Participant Survey Questions E4–E7. “How important was the . . . ?”
As shown in Figure 5, about half of respondents (45%, five of 11) rated the educational materials as very important, but only a few rated the marketing/advertising (27%, three of 11) or contractor recommendation (20%, two of 10) as very important.

**Pilot Impact**

**Equipment Usage**
All 53 survey respondents replaced an electric conventional tank water heater. Fifty-eight percent (31 of 53) reported adjusting the operational controls on their new water heater, as shown in Figure 6, most frequently turning it to:

- **Hybrid Mode** (55%, 17 of 31), which extracts warmth from the surrounding air, concentrating the heat and transferring it to the water.
- **Efficiency Mode** (39%, 12 of 31), which uses the heat pump for efficiency but will use the element for quick recovery following increased hot water usage.
- **Vacation Mode** (6%, two of 31), which maintains tank temperature at 15.6°C (60°F) during vacation or extended absences to reduce operating costs and provide freeze protection.

![Figure 6. Heat Pump Water Heater Operational Mode Used](source)

Source: Participant Survey Question C5. “What operating setting did you set your heat pump water heater to?” (n=31)

---

When asked how often their new water heaters were operating, 18 of 25 respondents who adjusted their heat pump’s controls were evenly divided in their responses between all the time (36%, nine of 25) and somewhat often (36%, nine of 25). The remaining six respondents (28%) adjusted their heat pump’s controls not too often.

**Energy-Efficient Actions**
Twenty-three of 53 respondents (43%) reported making one or more additional energy-efficient upgrades to their home after participating in the pilot. These upgrades are outlined in Figure 7.

![Figure 7. Respondents’ Additional Energy-Efficient Upgrades](image)

Among the 23 respondents who made energy-efficient upgrades, nine rated the pilot as either very important (n=5) or somewhat important (n=4) in their decisions to make additional upgrades, while 10 said it was not at all important.

**Potential Improvements**
Survey respondents most frequently cited better educational materials (16%, six of 38) followed by better contractors (13%, five of 38) as recommendations to improve the pilot. They also recommended better communication, more accurate payback estimates and more promotion/marketing (11%, four each). “Other” responses (16%, six of 38) included simplifying the participation process and expanding the contractor network.

**Manufacturer Experience**
The interviewed manufacturer representative said he was generally satisfied with the pilot despite minor communication issues with the implementer (Key Findings 3d). The representative communicated with HONI occasionally by phone or email to provide updates on its progress and that he
met with the implementer face-to-face to ensure staffs’ understanding of the requirements for each installation.

The manufacturer representative lamented that some contractors developed unrealistic installation cost quotes and said, “if we had the opportunity to sit down and train these guys, they wouldn’t have had to price their installations at the high end of a learning curve.” In addition, the manufacturer representative noted two barriers to customer participation: initial cost and sizing (that the equipment may not fit all homes). Furthermore, the manufacturer representative noted that almost all its market traction is in new construction rather than existing homes, reflecting that new construction might be a better market.

Contractor Experience

The two interviewed contractors were divided in their satisfaction with the pilot (Key Findings 3c). The one interviewed contractor who sold equipment through the pilot said he was “not a big believer” in heat pump water heater technology and acknowledged that he does not know if the payback will be substantial enough to encourage participation. He also disliked the lack of product options for customers. Despite these critiques, he said “everything else is good,” having encountered no obstacles or challenges with the pilot. He said all his communications were “good and smooth” with HONI, the implementer and the manufacturers with whom he regularly interacted, and he would “definitely” participate again in the future.

The inactive contractor (who did not sell any equipment through the pilot) said the lack of reliable savings data discouraged applicants from participating noting that the initial price point did not appeal to applicants. He also admitted that he did not have any experience with heat pump water heaters. He suggested that it might be advantageous to market the technology to new construction rather than existing homes as customers who did not participate were reluctant to replace existing, working equipment. He said he was not very satisfied with the pilot.

Successes, Challenges and Future Planning

This section outlines areas of pilot success (such as high participant satisfaction), challenges (such as equipment costs) and future planning considerations.

Successes

Despite the numerous pilot challenges, the clear area of success was customer participant satisfaction. As noted above, most respondents were very satisfied or somewhat satisfied with their new equipment (100%), their installation contractor (96%), the rebate (94%) and the pilot overall (96%).

Challenges

The HONI and implementation staff, as well as the manufacturer and both contractors, noted several challenges: high equipment costs, limited equipment information and experience, and a rebate structure that may have encouraged higher cost quotes (Key Finding 2b).
• **Equipment costs and limited information.** HONI reported that the rebate simply was not large enough to encourage more participation; however, staff indicated that if the rebate were any larger, the pilot would not have been financially feasible. In addition, HONI and the implementer started conducting installations in-house after observing exorbitant contractor quotes that deterred applicants from participating. Meanwhile, HONI, the manufacturer and the two contractors said the pilot did not have reliable payback information to deliver to applicants. HONI and the manufacturer thought contractors’ lack of knowledge about the technology contributed to their higher quoted costs.

• **Rebate structure.** HONI staff speculated that the rebate may have incented contractors to inflate their quoted costs to turn a higher per-unit profit.

**Future Planning**
HONI has no plans to extend or expand the pilot into a full program offering unless the pilot savings analysis exceeds HONI’s expectations. HONI staff reported that they considered the idea of incorporating heat pump water heaters into another program but ultimately decided against it due to the lack of interest from customers. To effectively market heat pump water heaters, HONI would have to set the rebate at too high of a level to make the equipment cost-effective. Despite all the challenges, the manufacturer and one of the two interviewed contractors thought the pilot could succeed if it specifically targeted new construction projects rather than existing households that would need to replace failed units or be early adopters.
Cost-Effectiveness and Greenhouse Gas Impacts

This section provides the cost-effectiveness methodology and findings for the HONI HPWH Pilot.

Methodology

The Cadmus team reviewed the initial pilot planning cost-effectiveness inputs prepared by local distribution companies, then used the IESO’s CDM Cost Effectiveness Tool to perform the TRC, PAC and LUEC cost-effectiveness tests and obtain greenhouse gas (GHG) reductions. The cost-effectiveness tests assess several critical performance metrics: benefits, costs, net benefits and benefit/cost ratios. Programs are cost-effective when the benefits exceed the costs, meaning the program must have a benefit/cost ratio greater than 1.0.

Table 4 shows the various components included in each test and whether they are treated as a benefit or cost.

<table>
<thead>
<tr>
<th>Component</th>
<th>TRC</th>
<th>PAC</th>
<th>LUEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Energy Costs</td>
<td>Benefit</td>
<td>Benefit</td>
<td>-</td>
</tr>
<tr>
<td>Non-Energy Benefits</td>
<td>Benefit</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Secondary Fuel Savings (Natural Gas)</td>
<td>Benefit</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Incremental Participant Costs</td>
<td>Cost</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Administration Costs</td>
<td>Cost</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>Incentive Payments</td>
<td>-</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>Participant Bill Savings</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Discounted Lifetime Energy Savings</td>
<td>-</td>
<td>-</td>
<td>Benefit</td>
</tr>
</tbody>
</table>

The remainder of this section presents the three cost-effectiveness tests in detail, as well as CDM Cost Effectiveness Tool inputs.

Total Resource Cost Test

The TRC measures the overall impacts of program benefits and costs. The test compares the total resource benefits to total resource costs to society to determine if the benefits received by the populace outweigh the total costs incurred by the customers, the LDC and the IESO. In addition, the TRC includes a non-energy benefit adder of 15%. The TRC uses the following benefit/cost ratio equation:

\[
\text{Equation 1. Total Resource Cost Test} \\
TRC \frac{B}{C} = \frac{PV [(Value\ of\ Gross\ Saved\ Energy + Value\ of\ Gross\ Non\ Energy\ Benefits) * NTGR]}{PV [Program\ Administrative\ Costs + (Incremental\ Participant\ Cost * NTGR)]}
\]

Where:

\[
B = \text{Benefits} \\
C = \text{Costs}
\]
PV = Present value (discount rate (real) + societal discount rate (real) = 4.00%)

Value of Gross Saved Energy = Gross savings multiplied by utility avoided energy and capacity costs

Incremental Participant Cost = Additional costs incurred by participants to install the energy-efficient technology over baseline or standard equipment typically installed in the absence of efficient technology

NTGR = Net-to-gross ratio

Program Administrator Cost Test

The PAC examines program benefits and costs solely from the administrators’ perspective using the following benefit/cost ratio equation:

\[
PAC = \frac{PV \cdot [Value \ of \ Gross \ Saved \ Energy \times NTGR]}{PV \cdot [Administrative \ Costs \ + \ Incentive \ Payments]}
\]

Levelized Unit Electricity Costs

The LUEC measures the overall competitiveness of different electricity sources, which allows for comparing demand-side management programs, programs over different timeframes or supply-side options. The LUEC represents the annualized costs (discounted costs and lifetime savings) per lifetime kilowatt-hours from the PAC test perspective (administrative, delivery and incentive costs) using the following equation (costs divided by kilowatt-hours):

\[
LUEC = \frac{PV \cdot [Administrative \ Costs \ + \ Incentive \ Payments]}{PV \cdot [Gross \ Lifetime \ kWh \times NTGR]}
\]

Inputs and Assumptions

For the cost-effectiveness analysis, the Cadmus team relied on these evaluation impact results:

- Gross per-unit savings
- Measure installation quantity
- Measure effective useful life and NTGR

The team combined the evaluation data with the following program financial data provided in the CDM Cost Effectiveness Tool:

- Administrative costs (LDC)
- Incentive payments
- IESO and LDC variable program costs

The team used the “PSP-Consumer-Residential-Domestic_Hot_Water” load profile in the LDC provided CDM Cost Effectiveness Tool from the IESO’s library of load shapes.
**Findings**

Pilot programs typically have benefit/cost ratios less than 1.0 as overhead costs frequently outweigh the benefits from a limited number of participants. As shown in Table 5, the HONI HPWH Pilot is not cost-effective from a TRC perspective, with a test result of 0.17, or from a PAC perspective, with a test result of 0.15 (Key Finding 4a). Based on the CE tool, at the measure level TRC benefits are $1,120 while costs are $1,153, which means the pilot will never be cost-effective based on a stand-alone HPWH measure unless more savings per measure can be attained and sufficient volume achieved to offset administrative costs.

<table>
<thead>
<tr>
<th>Table 5. TRC and PAC Ratios and Net Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>TRC</td>
</tr>
<tr>
<td>PAC</td>
</tr>
</tbody>
</table>

Table 6 shows the pilot has a LEUC of $0.50 per kilowatt-hour overall.

<table>
<thead>
<tr>
<th>Table 6. LUEC Ratio Results for Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ratio ($/kWh)</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>$0.50</td>
</tr>
</tbody>
</table>

Table 7 shows the pilot level first year and lifetime GHG reduction in tonnes from the CE calculator.

<table>
<thead>
<tr>
<th>Table 7. GHG Reduction</th>
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</thead>
<tbody>
<tr>
<td><strong>Tonnes CO₂ equivalent</strong></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>24</td>
</tr>
</tbody>
</table>
Key Observations and Recommendations

The following statements present an overview of the team’s key observations and recommendations, based on the research and analysis conducted for the HONI HPWH pilot:

Key Observation 1. Due to the pilot’s limited participation and lack of a randomized control group, the estimated savings should be considered directional in nature. Though the Cadmus team’s savings models were robust in that including or excluding different variables did not significantly change the other model coefficient variables, and the team made every effort to select a matched nonparticipant group that would approximate a true control group, the challenges imposed by the small sample size and the pilot design could not be overcome given the limited amount of customer characteristics data available for the evaluation. Therefore, although the energy and demand savings estimates may be used to inform future program planning, additional research with a larger sample size is necessary to determine robust savings estimates. (Finding 1a).

- Recommendation 1: To achieve more robust savings estimates, future heat pump pilots should strive to achieve a larger participant sample size.

Key Observation 2. High equipment costs, contractors’ limited experience with heat pump water heater technology and pilot rebate structure may have resulted in high installation quotes which may have inhibited participation levels. Although HONI planned to enroll roughly 650 customers and 700 applied for the pilot, after receiving installation quotes, only 69 ultimately chose to participate (Finding 2a). HONI and implementation staff, as well as the manufacturer and contractors, noted several challenges which may have contributed to lower participation: high equipment costs, limited equipment information and experience and a rebate structure that may have encouraged higher cost quotes (Finding 2b).

- Recommendation 2a: Prior to launching a pilot promoting an emerging technology, investigate measure supply and pricing in the target pilot region. If installation contractors are inexperienced with the product or unsure how to price the technology and installation, consider working with a limited number of contractors who are believers in the technology and agree to a pricing schedule in exchange for referrals. This limited contractor model has worked well in other jurisdictions targeting either hard to reach markets or leading-edge technologies.

- Recommendation 2b: In addition to working with a limited number of dedicated contractors, determine if it is necessary to develop a training class for contractors provided by either HONI staff or manufacturers to ensure best practices are followed during the installation process, and to help contractors understand the equipment specifications and costs so they can explain the benefits to customers. Develop marketing materials for contractors and customers highlighting energy savings and payback.

Key Observation 3. Although participating customers were mostly satisfied with the pilot, there is room to improve the contractor and manufacturer experience. The vast majority of respondents were very satisfied or somewhat satisfied with their new equipment (100%), their installation contractor
(96%), the rebate (94%) and the pilot overall (96%) (Finding 3a). Despite clear satisfaction from participating customers, only three of the 33 enrolled contractors completed an installation before the implementer took over equipment installation duties (Finding 3b). In addition, the two interviewed contractors were divided in their satisfaction with the pilot: one was satisfied with his experience while the other, who sold no pilot-incented equipment, was dissatisfied (Finding 3c).

- **Recommendation 3**: See recommendation 2a and 2b.

**Key Observation 4. The current pilot design is not cost-effective.** The HONI HPWH Pilot is not cost-effective, with a TRC of 0.17, a PAC of 0.15 and a LUEC of $0.50; however, typically pilots are not cost-effective (with benefit/cost ratios of less than 1.0) (Finding 4a).

- **Recommendation 4**: Given that the measure level benefits ($1,120) are slightly below the costs ($1,153), a change in participation alone will not make the pilot cost-effective; a change in the combination of the following measure- and pilot-level attributes are needed to result in a positive benefit/cost ratio for the test(s) indicated in parentheses:
  - Increased net verified savings (TRC/PAC) which could be improved by targeting homes with larger electric water heating loads.
  - Decreased measure incremental costs (TRC); as the market for HPWHs matures in Ontario, the cost may also fall.

In addition, bundling the heat pump water heater measure with more cost-effective measures could help the program become cost-effective while still offering this leading-edge technology.
Appendix A. HPWH Pilot Participant Demographics

This appendix presents the number of household occupants, primary languages, education levels, household incomes and ownership status of survey respondents, as well as home characteristics.

Thirty-nine percent of survey respondents reported living in home with two people, 26% reported living with four people, 21% reported living with three people and 7% reported being the only person in the home.

![Figure 8. Number of Household Occupants](image)

Ninety-two percent of survey respondent households (n=49) speak English as their first language compared to 79% of Ontario residents. All survey respondents (n=53) graduated from high school compared to 78% of Ontario residents, as shown in Figure 9. Just over half of survey respondents (57%, 30 of 53) graduated from university (or more) compared to 20% of Ontario residents.
Most survey respondent households (86%, n=38) earned at least $60,000 compared to roughly 26% of Ontario residents, as shown in Figure 10. The median survey respondent household earned $100,000 to less than $120,000 and the largest percentage of households fell in the bracket of earning $120,000 or more.
All the survey respondents’ homes were single-family detached houses. Ninety-two percent of respondent homes (49 of 53) have at least three bedrooms and 81% have at least two bathrooms (43 of 53), compared to 66% and 52% of Ontario residents’ homes, respectively. Ninety-eight percent of survey respondent homes are less than three stories tall. Forty-two of 53 respondent homes are smaller than 3,000 square feet. Fifty of 53 survey respondent homes have wireless internet (94%). Finally, as shown in Figure 11, 43 of 53 respondent homes are 42 years or newer (81%), with 14 built in 1995 or later (26%).

**Figure 11. Age Ranges of Households, in Years**

Source: Participant Survey Question G9. “How old is your home? An estimate is fine.” (n=53)