Evaluation of Verifying Cold Climate Air Source Head Pumps (CC ASHP), in Electrically Heated Residential Homes in Ontario, Canada

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Introduction

The Independent Electricity System Operator (IESO) contracted with the Cadmus team to evaluate the an air source heat pump pilot program. This poster describes the impact evaluation approach and preliminary results an Air Source Heat Pump pilot program in Ontario Canada. The Cadmus team conducted a billing analysis using customers' (participant and non-participants) consumption data to produce evaluated net energy and demand savings. In addition to consumption and tracking data for 112 pilot participants, we also reviewed records of 100,000 nonparticipants from the Utility's service territory – approximately 44,000 of whom were from the same postal codes as the participants – and for the same time period.

A matched comparison group was created using the nonparticipant data. The Evaluator used a Monte Carlo consumption-quartile matching technique to select a matched comparison group that was statistically equivalent to the pilot participants in terms of pre-participation consumption.

For both the participant and matched nonparticipant groups, the evaluator used the Princeton Scorekeeping Method (PRISM) and the pre/post conditional savings analysis (CSA) fixed-effects model to estimate average savings per customer.1 PRISM offers a savings value for each participant by calculating a weather-normalized pre- and post-period consumption value and subtracting the two (outside of a model) whereas the CSA model pools the participants into a single dataset and provides an average savings value across all participants. Therefore, although the two modeling approaches calculate savings differently, they both arrive at the same measurement per customer using the same information. Specifically, the PRISM and CSA models both controlled for weather and compared one year of a customer's consumption before participating in the pilot, up to one year after.

For both PRISM and CSA approaches, the evaluator first screened participants based on the completeness of their billing and tracking data fields and on various criteria of their pre- and post-period consumption monthly trend. These screening criteria included (among other such metrics): Insufficient billing days and months, usage below 1,200 kWh per month, usage change of more than 70% , added baseload or cooling or heating in the post-period and, Inconsistent or erroneous reads, or vacancies in the pre- or post-periods

In the PRISM model, the evaluator weather-normalized the pre- and post-installation period usage for each customer using a variable degree day PRISM modeling approach – allowing the heating and cooling reference temperatures (τ or tau) to change for each customer. In this approach, account-level models are estimated separately for the pre- and post-installation periods. The evaluator selected the model with the highest R-squared that best explained the relationship between usage and weather in the respective period for each customer. Finally, Cadmus weather normalized the PRISM model pre- and post-

[1] Both methods conform to the approach from: U.S. Department of Energy (DOE). *International Performance Measurement and Verification Protocol Whole Building, Option C*. Revised March 2002.

installation period usages to Canadian normal weather conditions, or the most applicable typical meteorological year available.

The CSA model used estimate savings parameters from a monthly panel dataset.[2] The fixed-effects estimator was obtained by ordinary least squares on the deviations from the means of each unit or time period. The evaluator used monthly pre- and post-installation data for each of the participants and the associated weather to estimate the monthly fixed-effects models.

The CSA model included a separate intercept for each customer and produces weather-normalized overall program savings and the additional pilot subgroup savings, similar to the PRISM models. The CSA model corrected for weather differences in the pre- and post-installation periods using interactions of heating and cooling degree days. The interactions between participation and the post-installation period indicator and heating and cooling degree days allowed for estimation of separate baseload, heating, and cooling components of savings. The Evaluator then used the average heating and cooling degree normals to obtain model-predicted weather-normalized savings estimates under normal weather conditions. This modeling approach provided an alternative weather-normalization methodology and savings estimation method to compare and triangulate with the PRISM-based savings estimates.

A total of 112 utility customers participated in the ASHP pilot as of July 2016. We used consumption data for these participants from January 2015 to February 2017. A full 12 months of pre- and post-participation consumption data for all participants was not available. This resulted in our excluding some participants on the grounds of insufficient data. Specifically, we excluded 11 participants from our sample who had less than 300 days of pre or post period data, resulting in a participant sample of 101 customers. Weather data from nearby stations was collected during this same period, reviewed tracking and consumption data fields, and screened for outliers. An additional 17 customers were removed from our sample due to unreliable data trends indicative of vacancies or occupancy changes, abnormal load changes, or insensitivity to weather, resulting in a final sample size of 84 participants. We used variable degree day PRISM to compute the optimal heating and cooling temperature bases for each customer. Finally, we excluded customers who participated in the Peak Savers pilot so as not to misattribute or confound ASHP pilot savings estimates. Only nonparticipants were dropped as a result of this final screen.

The evaluator used the D-in-D (PRISM and CSA) models to estimate *overall* first-year savings. In addition, we estimated demand reduction using the central and ductless heat pump load profiles developed through energy simulation modeling. The load profiles describe the typical annual electricity consumption of central heat pump and ductless heat pump systems in Ontario homes. Each load profile is a set of 8,760 hourly values that equal the fraction of the total annual electricity use consumed during that hour.

The pilot realized 203,083 kWh in total, or approximately 31% of the reported 660,450 kWh.
Out of 364 nonparticipants, the average pre/post savings was 2,192 kWh or 8.8%, which was much higher than expected,[3] and especially high compared to an average savings of 4,153 kWh for 84 participants. Cadmus had limited information on the nonparticipant's usage behaviors (we only had billing data). However, after discussions with the IESO, Cadmus believes the relatively high rate of nonparticipant savings may be due to other energy efficiency programs such as the Social Benchmarking Pilot, Coupons, HVAC, HAP, as well as other possible factors such as fuel switching or market forces that encourage energy savings.

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[2] Panel data were composed of monthly billing records for participating customers

[3] Cadmus typically finds nonparticipant changes in usage on the order of 0-2% for these types of analyses.