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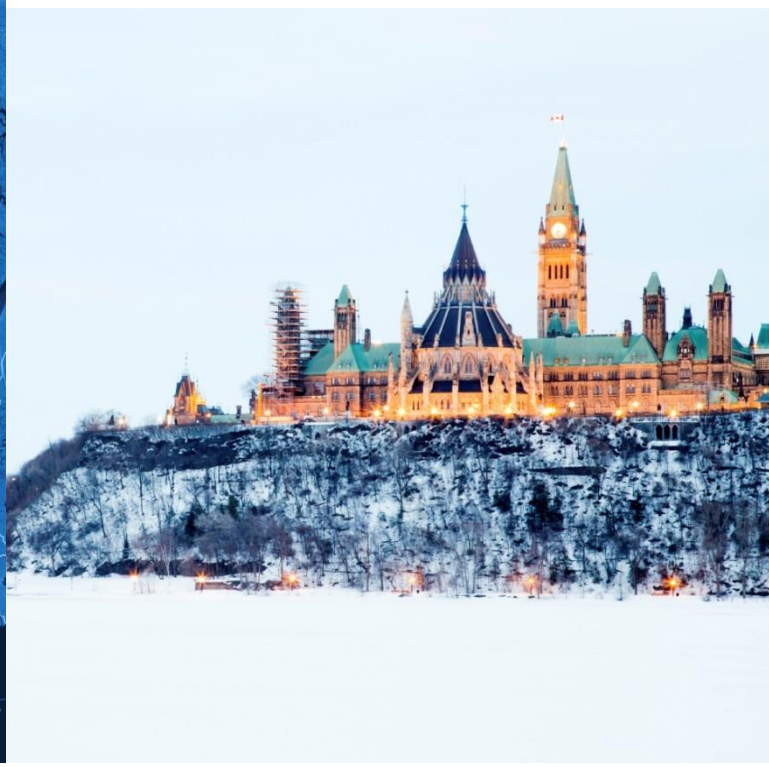


2016 Program Evaluation: Toronto Hydro PUMPsaver Pilot and Local Program

Submitted to Independent Electricity System Operator

October 2, 2017

Contents

1 Goals and Objectives

The goals and objectives of the 2016 evaluation of Toronto Hydro's PUMPsaver pilot and local program are to:

- Verify energy and demand savings with a high degree of confidence, taking into account;
  - Measure-specific characteristics and data
  - Spillover savings and pilot-enabled savings
- Review and evaluate key program elements;
- Conduct annual cost-effectiveness analyses;
- Report and attribute savings due to the pilot.

To estimate gross verified energy and peak-demand savings, the evaluation team conducted desk reviews of project documentation, followed by telephone and on-site surveys for a representative sample of projects. To estimate the direct influence of the pilot and local program in generating energy savings, the evaluation team conducted attribution surveys to calculate the rates of free ridership and spillover. This information was used to calculate a net-to-gross ratio, which was then applied to the gross verified savings to calculate the net savings. These scaling factors, along with the gross savings, were developed using random sampling methods to select and survey projects that were representative of the population at large.

2 Pilot and Local Program Description

The PUMPsaver pilot and corresponding local program were created to save electricity consumption through improving the efficiency of cooling and heating distribution systems. Specifically, the programs' objective is to re-engineer and re-balance inefficient closed loop heating and cooling distribution systems typically found in mid to high-rise buildings. The pilot and local program were identical in many key aspects, such as target market, measures offered, and delivery process, so both were combined and evaluated as a single program (referred to in this report simply as a single program).

The program provided participants a fully funded turn-key upgrade, which included an on-site assessment of existing conditions and measurement of associated electrical loads and consumption by qualified water auditing and balancing professionals. Retrofit of the hydronic distribution system was then implemented based upon recommendations from the assessment. Measurement of associated electrical loads and consumption were carried out again and compared to initial measurements to establish actual savings achieved from the system changes. The documentation provided by Toronto Hydro included the initial on-site assessment reports as well as post installation system performance reports.

The documentation provided by Toronto Hydro for each project in the program included: tracking database entries (e.g. site contact information, savings, costs), a preliminary investigation report (pilot projects only), and verification report.

3 Methodology

The sections below describe the methodologies used to complete the impact and process-related components of the evaluation.

3.1 Impact Evaluation Methodology

3.1.1 Sampling, Project Reviews and Evaluation

The Nexant team impact evaluation sample frame targeted 90% confidence level and 10% precision for the program and achieved 90/3 and 90/9 confidence and precision for energy and demand, respectively. The sample evaluated in this program, broken out by evaluation activity, and achieved precision is summarized in Table 3-1.

Table 3-1: Impact Evaluation Sample

Participant Quantity*	90/10 Target Sample (Cv** = 0.5)	Achieved Evaluation Sample			Confidence/ Precision		
		Desk Review	On Site Verification	Total	Target	Achieved Energy	Achieved Demand
15	13	10	3	13	90 / 10	90 / 3	90 / 9

* Participant quantity includes PUMPsaver pilot and PUMPsaver local programs
** Cv: coefficient of variance

Data collection included both desk reviews and on-site verification. Desk reviews consisted of reviewing project documentation available in the program's database, such as program applications, verification reports, and any other documentation available to IESO. For each desk review, Nexant contacted the participant via phone to verify that the measure was installed and currently operating, as well as confirm measure characteristics such as equipment size, operating hours, and control strategies. The site visits expanded upon the work conducted from the desk reviews and also included an on-site review of the measures, which involved verifying pump nameplate information, verifying variable frequency drive (VFD) operating speed(s), and conducting an in-person interview with the site contacts.

Once the data had been collected, Nexant created hourly savings loadshapes based on observed measure parameters. These loadshapes where then used to derive verified annual energy savings and peak demand savings.

3.1.2 Net-to-Gross (NTG) Methodology

To calculate net savings, the portion of gross verified savings that were specifically attributable to each initiative were evaluated. Net savings were determined by multiplying the gross verified savings by the net-to-gross (NTG) ratio, as shown in Equation 3-1. This equation and general methodology are the same for estimating energy and demand savings.

Equation 3-1: Net Savings

$$Savings\ \text{net} = Savings\ verified \times NTG$$

Where:

Savings net = Net savings impact (kW or kWh)

Savings verified = Gross verified energy savings (kW or kWh)

NTG = Net-to-gross ratio

To estimate the direct influence of the pilot and local program in generating net energy savings, an attribution survey was implemented to calculate the free ridership (FR) and spillover (SO) rates, assessed as percentages of total reported savings. Free ridership represents program savings that would have occurred without program services or no-cost upgrades. Spillover refers to savings that occurred because of program influence but without program services or no-cost upgrades. For any group, the NTG ratio is defined by Equation 3-2, where FR is the free ridership percentage and SO is the spillover percentage:

Equation 3-2: Net-to-Gross Ratio

$$\text{NTG}=100\%-FR+SO$$

For the pilot and local program, spillover is calculated for a single project for each sampled participant.

3.2 Process Evaluation Methodology

3.2.1 Program Staff

The evaluation team completed one phone interview with Toronto Hydro program staff in May 2017. The purpose of the interview was to better understand how the program was administered in 2016, and to attain program staff perspectives regarding design and implementation. Topics covered include staff roles, any changes to the program, supply channel engagement, barriers

to implementation, and perspectives on the success of the program. The evaluation team identified the appropriate staff to be interviewed in consultation with the IESO evaluation staff. The Toronto Hydro program staff interviewed oversees the planning and implementation strategy. The interview took approximately an hour to complete.

3.2.2 Participants

The PUMPsaver survey asked a series of questions encompassing respondent characteristics, program outreach and marketing, participant motives and decision-making, participant satisfaction, free-ridership and spillover, and firm characteristics. Section 6.1 highlights the feedback received from the participant interviews.

Fifteen participants participated in the PUMPsaver pilot and local program in 2016. Ten participated in the pilot and five in the local program. Of the 10 pilot PUMPsaver projects, five completed surveys were conducted representing 7 projects. The remaining three surveys were not completed largely due to staff turnover resulting in no knowledgeable person available to complete the interview. Of the five local program projects, 4 phone surveys were completed (one contact was nonresponsive). Table 3-2 below summarizes the participant population disposition data.

Table 3-2 PUMPsaver Participant Population Disposition, 2016

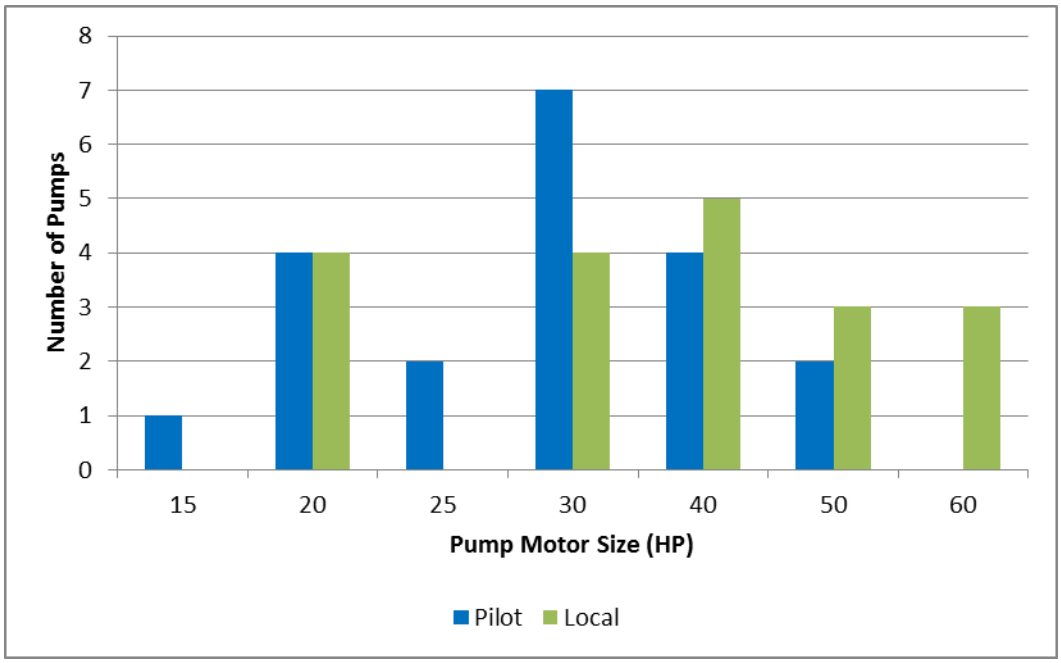
Item	Pilot	Local Program
Total Projects	10	5
Unique Participant Addresses	10	5
Unique Participant Contact Names	7	5
Phone surveys	5 contacts representing 7 projects	4 contacts representing 4 projects

4 Participation

The PUMPsaver pilot included 10 projects while the PUMPsaver local program included 5 projects. As mentioned previously, the pilot and local programs were identical in many key aspects so both were combined and evaluated as a single program that included 15 projects.

Most of the pumps had motor sizes in the range of 20 HP to 40 HP, as illustrated in Figure 4-1.

Figure 4-1: Profile of Pump Motor Sizes



5 Impact Evaluation Results

5.1 Energy and Peak Demand Savings

The program level savings are summarized in Table 5-1 below.

Table 5-1: Program Level Savings Results

Savings Type	Program	Gross Reported Savings	Realization Rate*	Gross Verified Savings	Net To Gross Ratio	Net Verified Savings
Energy (kWh)	Pilot	614,601	108.7%	667,979	1.00	667,979
	Local	767,376	108.7%	834,022	1.00	834,022
	Combined	1,381,977	108.7%	1,502,001	1.00	1,502,001
Peak Demand (kW)	Pilot	79.7	85.3%	68.0	1.00	68.0
	Local	87.6	85.3%	74.8	1.00	74.8
	Combined	167.3	85.3%	142.7	1.00	142.7

*Due to requirements to meet 90/10 sampling confidence and precision, energy and demand savings realization rates were calculated and applied across the combined set of pilot and local program participants only.

The reported savings calculations generally assumed year-round operation of the pumps on which the new VFDs were installed. While this was generally verified to be true, a few of the sampled projects deviated from this assumption for two reasons: the pumps served heating only systems and therefore did not operate in the summer, or the pump was used as the 'standby' (back up) pump and not the 'duty' (actively running) pump. These are the primary reasons the peak demand realization rate is below 100%.

Another operational parameter found to be different from the reported assumptions in a few projects was splitting pump load between multiple pumps. For example, two pumps of equal size may each run at 40% speed in lieu of a single pump running at 80% speed. The reported savings estimated savings, assuming one pump would run at 80% speed and the other would act as a standby. However, some sites operated both of their pumps at lower speeds, thereby increasing savings further at the expense of running both of their pumps more often. This additional savings helped boost the energy realization rate to 108.7%.

For more perspective, Figure 5-1 and Figure 5-2 display the reported and verified energy and peak demand savings by sampled projects. Generally verified savings mirrored reported savings, with all but two sampled projects having energy realization rates between 70% and 130%.

Figure 5-1: Energy Savings Comparison For Sampled Projects

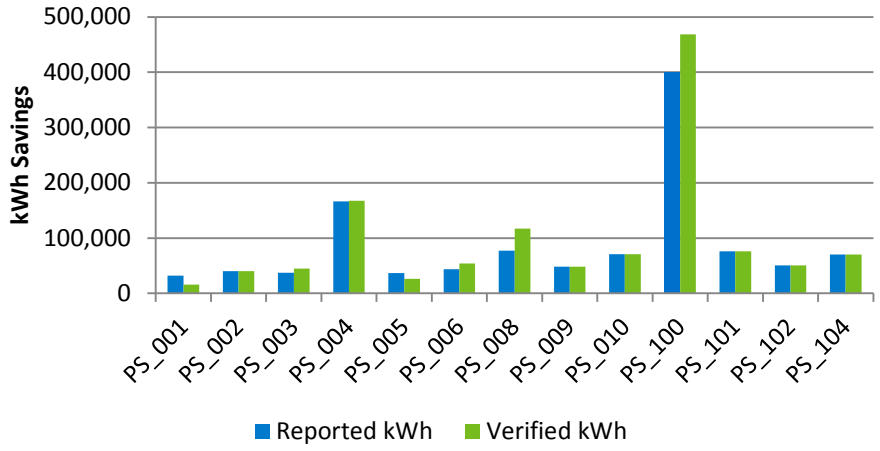
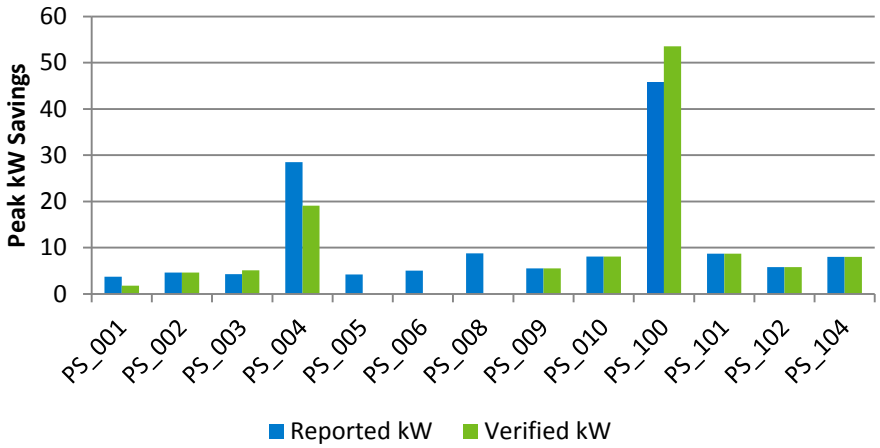


Figure 5-2: Peak Demand Savings Comparison For Sampled Projects



5.2 Lifetime Savings

The same measure (VFD on pump serving building HVAC system) was implemented in each project of the program. Therefore, the same effective useful life was used for all program

savings based on the Measures and Assumptions List value for VFDs - 15 years.[1] This means that the savings first observed in 2016 will be expected to last through 2030 on average Therefore, the net 2020 annual savings is expected to be identical to the net savings listed in Table 5-1.

5.3 Net-To-Gross

5.3.1 Free Ridership

The survey asked respondents when they had learned about the incentives offered by Toronto Hydro's PUMPsaver pilot or local program and what they would have done had they not learned about them. Eight respondents stated they learned about the program before they started planning their respective upgrades. One respondent said they learned about the program while they were planning their upgrade, but before implementing it

Respondents were also asked what they would have done had they not learned about the incentives. All nine respondents said the pilot or local program assisted with upgrades that they otherwise would not have been able to do, or would have had to delay. Six respondents said they would have cancelled the upgrade altogether and three respondents said they would have delayed the upgrade by at least one year (Table 5-2).

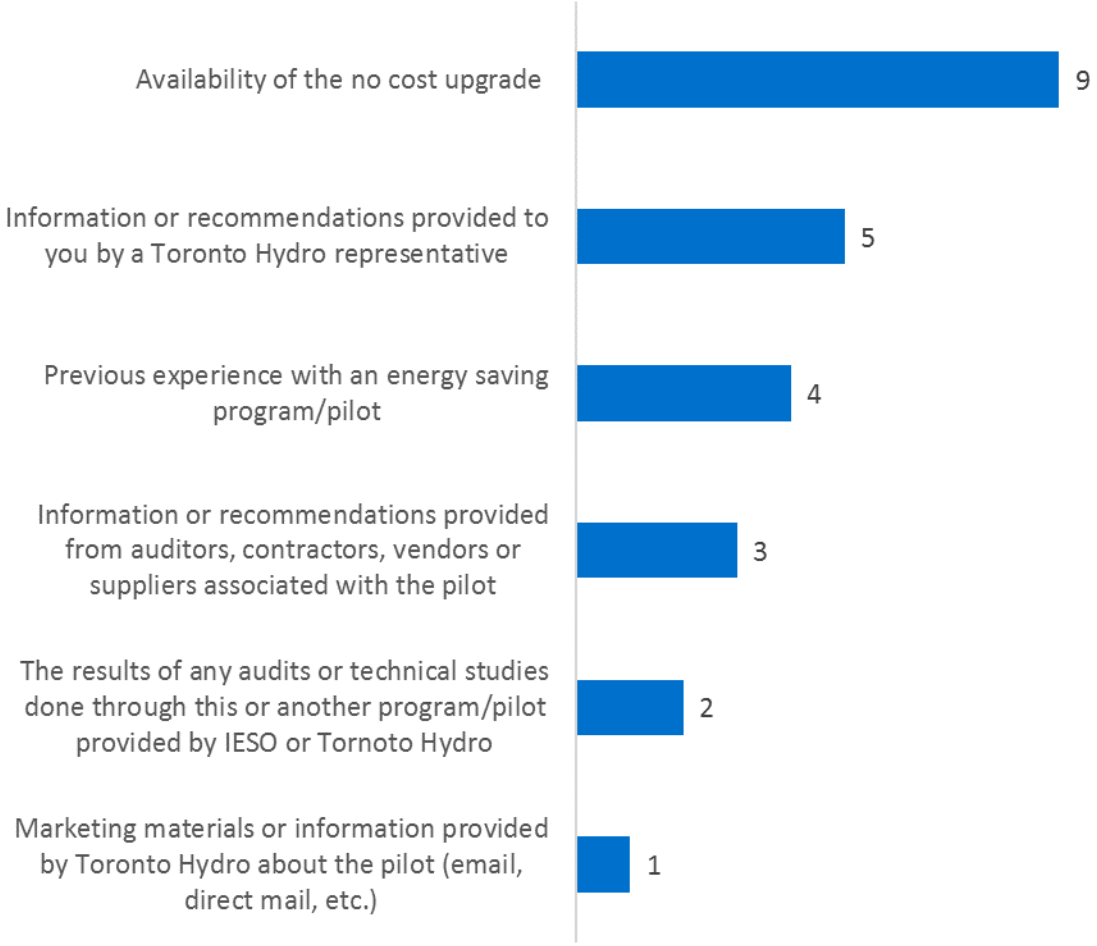
Table 5-2: Actions in Absence of Program/Pilot Incentives (n=9)

If you had never learned you could get incentives from Toronto Hydro, which of the following best describes what your business would have done?	Respondents
Put off doing the upgrade for a least one year	3
Cancelled the upgrade altogether	6

The survey asked respondents how much of a role certain factors played in the decision to do the upgrades. They responded using a scale of 1 to 5, where 1=played no role and 5=played a great role. All nine respondents indicated that the availability of the program incentive played a role (4 or 5 rating) in their decision to do the energy efficient upgrades. In addition, five respondents indicated that information or recommendations from a Toronto Hydro representative played a role in their decision, and four respondents indicated previous program experience played a great role. Audits and technical studies, marketing materials, and information from vendors, contractors, and auditors played less of a role in decision-making (Figure 5-3).

[1] *Prescriptive Measures and Assumptions List*, Independent Electricity System Operator, version October 2015.

Figure 5-3: Influence on Upgrade Decision (n=9)
(Rating of 4 or 5 on a scale of 1 to 5)



5.3.2 Spillover

The participant survey did not find evidence of spillover. Respondents were asked whether they installed additional equipment for which they did not receive incentives, after participating in the program. One respondent made HVAC upgrades without pilot or local program assistance, and another installed lighting controls.

These two respondents were asked to rate how much of a role their participation in the PUMPsaver pilot or program had on their decision to make the additional upgrades. They responded using a scale of 1 to 5, where 1=played no role at all and 5=played a great role. One respondent indicated that their participation in the pilot/program played no role at all, and the other preferred not to answer the question.

5.3.3 Net-to-Gross Results

There were nine responses received for the net-to-gross (NTG) survey. The results from these surveys are presented in Table 5-3 below.

Table 5-3: Net-to-Gross Survey Results

Savings Type	NTG Ratio	Relative Precision at 90% Confidence Level
Energy	100.0%	0.0%
Demand	100.0%	0.0%

5.4 Cost Effectiveness

The evaluation team conducted a cost effectiveness analysis for both the pilot and the local program. This analysis was completed in accordance with the IESO requirements as set forth in the IESO *CDM Cost Effectiveness Test Guide* and using IESO's *CDM Energy Efficiency Cost Effectiveness Tool*. The energy and demand savings results from the impact evaluation were inputs into the IESO *Cost Effectiveness Tool* as well as budget information supplied from IESO.

Cost effectiveness results are presented in Table 5-4. The program passed the Total Resource Cost (TRC) and Program Administrator Cost test with both benefits exceeding their respective costs.

A key contributor to the high cost effectiveness ratios was the program's focus on only larger measures. With certain costs being fixed, regardless of project size, larger projects with expected year round savings (i.e. pumps that serve both heating and cooling systems) provide relatively more savings and thus improve cost effectiveness.

Table 5-4: Cost Effectiveness Results

Cost Effectiveness Test	Pilot Program Values	Local Program Values	Combined Values
Total Resource Cost (TRC)			
TRC Costs ($)	230,224	188,960	419,184
TRC Benefits ($)	582,513	570,973	1,153,486
TRC Net Benefits ($)	352,289	382,012	734,302
TRC Net Benefit (Ratio)	2.53	3.02	2.75
Program Administrator Cost (PAC)			
PAC Costs ($)	230,224	188,960	419,184
PAC Benefits ($)	506,533	496,498	1,003,031
PAC Net Benefits ($)	276,309	307,538	583,847
PAC Net Benefit (Ratio)	2.20	2.63	2.39
Levelized Delivery Cost			
$/kWh	0.03	0.02	0.03
$/kW	299.15	256.05	278.05

6 Process Evaluation Results

The sections below provide the process evaluation results.

6.1 Program Staff Perspective

The evaluation team interviewed the Toronto Hydro program staff to better understand how the program was administered in 2016 and to attain program staff perspectives regarding design and implementation. Feedback from the interview is summarized below.

6.1.1 Changes from Pilot to Local Program

The most significant changes made to the pilot when designing the local program include:

- Expanding the range of the motor rating at both the lower and higher end of the pilot's horsepower maximum and minimum limits.
- Revising the program management software platform.
- Obtaining more competitive pricing from service providers; and
- Including a preferred contractor list to enable more service providers to participate in the program. Pilot included only one service provider.

6.1.2 Barriers to Implementation

The program discussed some of the barriers to implementation of the pilot and local program. In general, program staff felt the program has been very successful in terms of saving energy and participation. The main challenges and barrier were identified to include:

- Service providers not included in the pilot felt left out and worried customers about the variable frequency drive (VFD) technology. This created misinformation and misunderstanding about the technology and the program.
- Interest from participants exceeded expectation and created a challenge to respond within a reasonable time frame. This challenge was addressed by the service provider, who added more resources

6.1.3 Success of the Program to Date and Improvements

Program staff was asked for their perspectives on the success of the program to date. They viewed it as very successful in attaining energy savings and participation. Improvements to the pilot that were included in the local program are the same as the changes that were made, which are discussed above in Section 6.1.1.

6.2 Participant Perspectives

The evaluation completed nine telephone interviews, covering eleven projects, with PUMPsaver participants to better understand participant perspectives related to program delivery. Feedback from these interviews is summarized below.

6.2.1 Firmographics

Respondents were asked about their position in the company. Given titles are summarized below in Table 6-1.

Table 6-1: Title of Respondent

Pilot / Local Program	Given Titles
Pilot	Director of Environmental Compliance Plant Operations Manager Condominium Manager Property Manager District Manager
Local Program	Superintendent Condominium Manager Project Engineering Manager Energy and Sustainability Manager

6.2.2 Program Outreach and Marketing

To assess how participants are hearing about the PUMPsaver pilot program, respondents were asked how they first heard about the program. All of the participants initially heard about the program via a representative from their utility. Of the five surveyed pilot participants, two heard about the program via a representative from their utility, 2 via a colleague or competitor, and 1 via a contractor or equipment vendor (as shown in Table 6-2 below).

Table 6-2 Sources of PUMPsaver pilot awareness

Item	Pilot	Local Program	Total
A representative from your utility	2	4	**6**
A contractor or equipment vendor	1	0	**1**
A colleague or competitor	2	0	**2**

When becoming aware of the program via a utility representative, contact was initiated both by the utility and by the participant. The six respondents that had heard of the program from a

representative from their utility were asked if the utility initiated the conversation or if the participant did. Two comments indicate strong back-and-forth communication between the participant and the utility to the extent that it is difficult to assess who initiated the conversation about this specific project:

- "We're in constant communication"
- "We're tight. My position is also a program through Toronto Hydro"

Specific answers are summarized in Table 6-3 below, indicating the majority of PUMPsaver pilot participants either contacted the utility directly or were in direct communication, so it is difficult to respond as to who initiated the conversations.

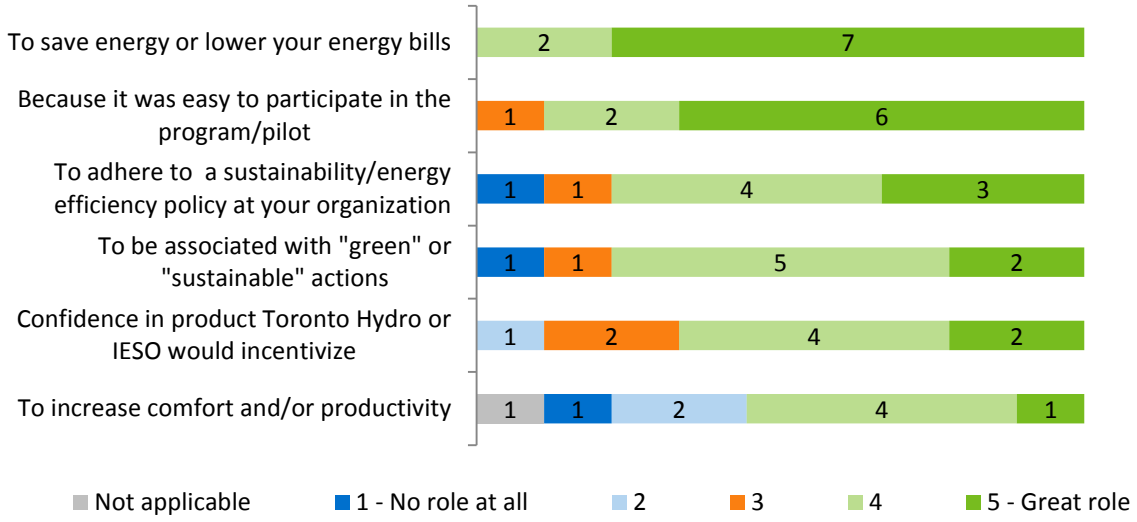
Table 6-3 Source of utility contact about PUMPsaver pilot

Item	Pilot	Local Program	Total
I contacted the utility directly	1	2	**3**
The utility contacted me to inform me of the pilot offering		1	**1**
Both	1	1	**2**

6.2.3 Participant Motives and Decision Making

The survey asked participants to rate their agreement with listed motivational factors to participate in the program. For each factor participants indicate how much of a role it played in their decision to implement the upgrade on a five-point scale where 1 indicates "no role at all" and 5 indicates a "great role". The main two factors participants indicate are, to save energy or lower energy bills, and the ease of participation. All rankings are summarized in Figure 6-1 below.

Figure 6-1 Participant ranking of motivational factors to participate



Adherence to a corporate sustainability policy had the third highest count of 4's and 5's indicating it plays a large role in the decision-making process to participate in the program. Respondents that indicated the presence of a corporate sustainability or energy efficiency policy were asked to describe what the policy requires. The following comments were received (by program type):

Pilot Responses:

- "We have an energy management program and an energy policy. The public sector is required to develop and publish external goals, and we also set internal goals."
- "There is no real policy in place and there are no specific requirements, though we follow recommendations through audits to increase energy efficiency"
- "No specific requirements, our corporation does want to be green and save energy"
- "No requirements, we just save money when we can. Utilities are a large part of our budget"
- "We have nothing written, but we do have a management mandate to save money where you can, and implement energy savings if possible."

Local Program Responses:

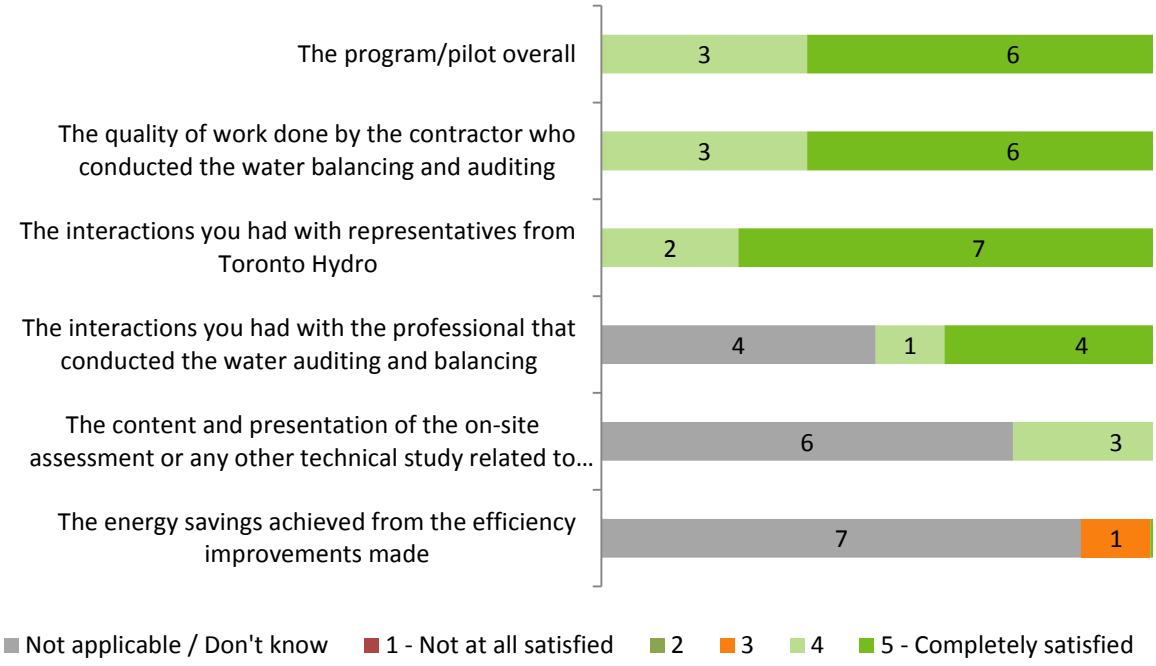
- "We have a long, complicated policy. We try to manage what we can and there are steps and protocols"
- "We are preparing a mission statement for the board right now. We do what we can to be more energy efficient. Energy costs are going up and we want to keep our fees low. (Energy is 40% of our budget).
- "No requirements"

Based on these responses and the rated importance of sustainability policies on decision making, even without a formal written policy in place survey responses indicate participating organizations have a strong sense that their corporate culture supports decisions that support energy saving or sustainability–related activities.

6.2.4 Participant Satisfaction

Satisfaction with program related factors is assessed by asking participants to rank given factors on a 5-point scale, where 1 indicates “not at all satisfied” and 5 indicates “completely satisfied”. Responses indicate high satisfaction (4 or 5 rating) with the majority of aspects of this program. Only one respondent gave a neutral (3) satisfaction rating, and this was related to the specific version of the equipment installed. The participant was not clear that a model without a bypass was being installed to replace the original, and noted that they would have preferred that a model with the bypass be installed to allow for needed system redundancy. .

Figure 6-2 PUMPsaver Participant Satisfaction



6.2.5 Suggestions for Program Improvement

When asked if pilot participants had any suggestions for how to improve the PUMPsaver pilot and local program, seven of the nine surveyed participants responded:

Pilot Responses:

- "We're very happy with [the program], it went smoothly. Some things not included that would add value are a tie-in to BAS. This wasn't part of the scope and it would be great if it was incorporated."
- "We had an issue where the electrical safety authority inspected and either the installer didn't take out a permit, or at least the permit wasn't logged in. Authorization was presented later, but it would have been best to have all related permits onsite." (This respondent gave the 3 satisfaction rating above).
- "More communication and awareness among property managers. Toronto Hydro is doing a great job of getting the word out, but managers have so many balls in the air, putting out fires, no time for these important initiatives. Can't have too much communication."

Local Program Responses:

- "Would love in-person onsite follow-up to look at equipment and how it is operating, verify results."
- "All the opportunities seem haphazard. Is there a global overview? We'd like an energy audit and identification of opportunities. We know we need VFDs and AHU's, and are interested in a Building Automation System."
- "Good to get a better technical understanding of equipment. No bypass was put in. If VFD fails we have no way to get electricity to the pump, and as a hospital we need redundancy. We didn't realize a base model was being installed. We would have opted for a model with a bypass."
- "Specific issue was the way they advertised. They advertised to everyone as a no-cost program and everyone jumped on it, causing backlog and delays. Some buildings have been waiting 5 months. They could have better managed these timing expectations."

Participants were also asked how likely they would be to recommend the program to others. On a 5-point scale where 1 indicates "not at all likely" and 5 indicates "extremely likely", all respondents rated their likelihood as a 5, except for one local program participant that rated likelihood of recommendation neutral at a 3. The participant that rated a three is the facility which commented that they did not realize the new install would not have a bypass.

7 Key Findings

7.1 Impact Key Findings and Recommendations

7.1.1 Impact Evaluation

Listed below are the key findings and recommendations from the pilot and local program's impact evaluation:

- The program's project qualification criteria and market targeting are key contributors to the program's savings and cost effectiveness.
  - Motor size minimum: requiring motors of at least 15 horsepower ensures higher levels of savings per motor; and when looking at fixed costs associated with implementing the program, the larger motor measures may contribute more savings per motor for the same fixed cost.

    Recommendation: *If there is a sufficiently large enough market to continue focusing on larger motor upgrades while still meeting other program goals (e.g. kW or kWh savings), then it is recommended to stay focused on larger motors to help maintain a strong cost effectiveness.*

  - Targeted applications: the program specifically targeted pumps that were believed to be operating year-round serving HVAC systems, which typically run much or all of the year and will therefore produce higher levels of savings.

    Recommendation: *It is recommended that the program continue to pursue pumps with high run hours but also consider pumps in non-HVAC applications such as those used in service of industrial processes.*

- One project that was not a multi-family residential building (a hospital) contributed ~29% of the program's total reported energy savings.

  Recommendation: *Perhaps it is worth placing a greater effort on performing more projects in the healthcare segment.*

- The program's current savings approach relies on using a VFD to reduce a pump's run speed to another new, but still fixed, run speed.

  Recommendation: *VFDs have the ability to vary in response to changes in their system conditions and setpoints so it is recommended the program includes applications where*

the VFD run speed varies over time. Including these pump applications in the program would greatly broaden the potential participant pool.

7.1.2 Net-to-Gross Key Findings

The key findings from the 2016 pilot impact evaluation pertaining to net-to-gross include:

- Participant feedback is indicative of low free ridership. All nine respondents reported that they would have had to cancel or delay upgrades without the pilot or local program. All respondents rated many program-related factors, such as the incentive, previous experience with efficiency programs, and recommendations from Toronto Hydro, as influential in their decision to have the upgrades performed.
- The participant survey did not find evidence of spillover.

7.2 Process Key Findings and Recommendations

The key findings and recommendation from the 2016 local program process evaluation include:

- In general, program staff felt the program has been very successful in terms of saving energy and participation, and the main barrier was identified as misinformation communicated by service providers who were not included in the program.

  Recommendation: *Create standard topics energy managers should cover prior to participating in the program, and ensure the energy manager informs the participant upfront about expected outcomes.*

- Representative and marketing outreach from Toronto Hydro were participants' primary source of information.

  Recommendation: *A tandem of strategies where the LDC continues to conduct outreach via marketing materials and direct contact via informed representatives.*

- Respondents were satisfied overall with the pilot, and rated most satisfaction elements as high.
- The desire to save or reduce energy bills and the ease of participation were the major influences in the participation of the program

  Recommendation: *Continue to promote information about energy savings and program benefits in marketing materials and talking points.*

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