POWER.HOUSE Feasibility Study

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1. INTRODUCTION

In 2015, Alectra Utilities launched a residential solar storage pilot program, POWER.HOUSE[1], funded by the Independent Electricity System Operator (IESO) Conservation Fund[2]. The POWER.HOUSE pilot was designed to evaluate the economic and grid benefits that residential solar storage can contribute to electricity customers and the electricity system in Ontario.

Figure 1. POWER.HOUSE System Highlights

The pilot program enabled the deployment of 20 residential solar storage systems in homes within Alectra Utilities' service territory. The pilot enables participating customers to displace a significant portion of the electricity they source from the grid and better manage the electricity that they do use, resulting in reduced energy costs, lowered carbon footprint and improved efficiency. The system is also used by the utility to contribute to grid reliability and resiliency.

Figure 2. Customer Benefits of POWER.HOUSE System

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[1] POWER.HOUSE program website: https://www.powerstream.ca/innovation/power-house.html

[2] The IESO Conservation Fund supports new and innovative electricity conservation initiatives, to help Ontario's residents, businesses and institutions cost-effectively reduce their demand for electricity.

Alectra Utilities embarked on a feasibility study in partnership with the IESO in 2016 to investigate the benefits and challenges associated with widespread adoption of the POWER.HOUSE program in Ontario with a specific focus on York Region. The feasibility study was intended to primarily answer two questions:

1. Is it feasible to expand the program to a larger number of residential homes?
2. What are the costs and benefits of, and barriers to an expanded program?

The feasibility study conducted analyses to understand:

- » the potential adoption of the POWER.HOUSE technology within York Region from 2016 to 2031;
- » the potential value streams that could be realized through increased adoption of POWER.HOUSE;
- » the scalability and costs associated with increased adoption;
- » the technical capabilities of the technology;
- » the feasibility to defer or eliminate the need for transmission or distribution infrastructure upgrades to meet future demand growth;
- » the monetary value associated with the services the technology can provide; and
- » barriers and catalysts to widespread adoption.

The feasibility study did not examine adoption beyond York Region or specific funding requirements to accelerate technology adoption. In order to determine market potential and adoption rates, a baseline assumption of customer cost sharing and associated benefit was made (i.e. the proportion of total POWER.HOUSE system cost the participating customer would bear and the amount of value they would receive). Total costs were used in the overall cost/benefit analysis outlined in the report. The study identified and quantified these costs and benefits, but made no assumption on how they would be shared and distributed. More details can be found in section 6 of this report.

The results outlined below make a strong case for further study of the technical and commercial potential that residential solar storage can achieve when managed through a software control platform with advanced aggregation capabilities. Further study will also generate additional data for analysis and more opportunity to test against the assumptions contained in the report and to assess other Distributed Energy Resources (DER). The positive direction of these initial results will help inform future efforts that may see these technologies emerge as a sustainable option for thoughtful grid deployment over the course of time.

Virtual Power Plant

A Virtual Power Plant refers to a collection of Distributed Energy Resources controlled through an intelligent software platform to create the functional equivalent of a single, larger generation resource.

For simplicity, the study only examined the technical capabilities of both single POWER.HOUSE units and samples within the existing fleet of 20 units. A further examination of larger numbers of aggregated units within a Virtual Power Plant would be useful in identifying how the system operates under a variety of environmental and system conditions.

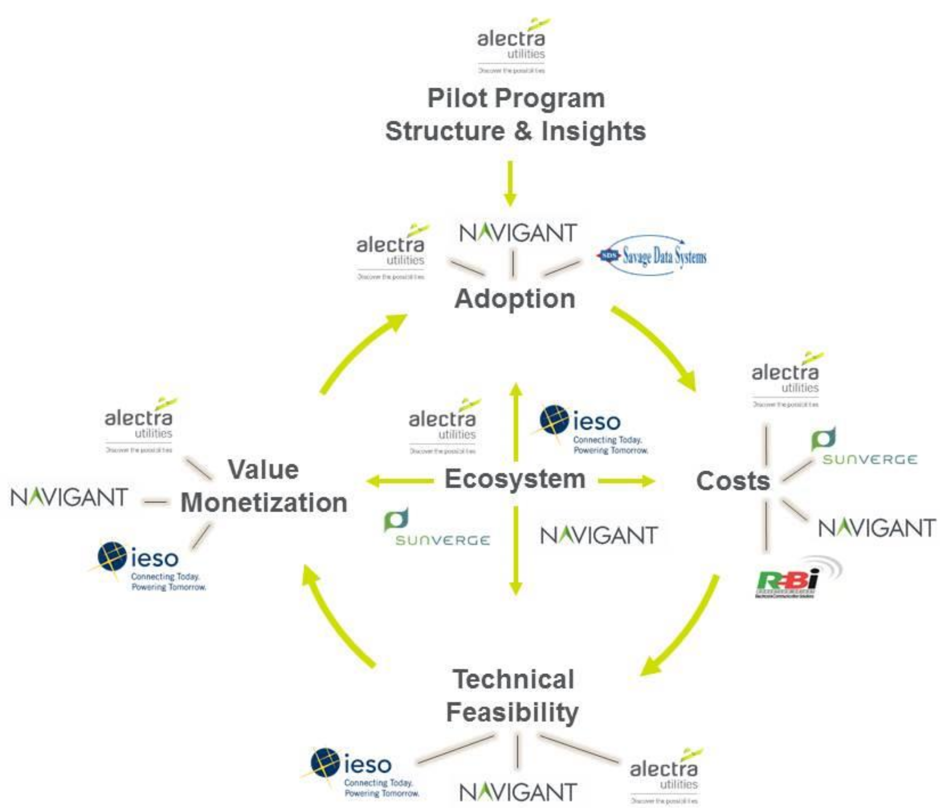
When examining the value streams, costs, and benefits, the study assessed the value of a large-scale POWER.HOUSE deployment on Ontario customers as a whole, independent of who pays or who benefits from the deployment. Two outlooks were established to represent a range of possible outcomes. The first, a base case, reflected existing trends in the electricity market and the cost of various system configurations were explicitly modeled. The second, a deep de-carbonization case, represented higher levels of electricity demand sparked by aggressive policy and market driven electrification. The second outlook contemplates several transformational market changes for both customers and the electricity system, and as such represents a more uncertain outlook compared to the baseline scenario. Actual outcomes will reflect the existence of different barriers and catalysts for adoption.

Under the assumptions used in the study there may be an opportunity to defer the longer-term infrastructure needs in Vaughan for at least 2 years. The value of deferral depends on several uncertainties including the cost decline of technologies, provincial electricity supply outlook and rate of growth in York Region.

2. COLLABORATION

The feasibility study clearly demonstrated the collective benefit that can be achieved when LDCs, the system operator and private sector work in concert towards a common goal. The partners and supporting entities that took part in the study work streams are described in Figure 3, below. The outcomes and insights derived from the study were particularly relevant because they were based on assumptions that were vetted by industry experts. For example, in order to ensure that the technical tests performed as part of the feasibility study reflected realistic reliability services needed for system operations, IESO operations staff were involved in defining the test scenarios and their associated success criteria. IESO planning staff were also involved to help frame the mechanisms for assessing the value of the program to the electricity grid, as well as to validate assumptions, approaches, and results. IESO and Alectra Utilities planning staff also worked together to estimate the value of deferring transmission and distribution investments, as well as the technical requirements and operability the program would need in order to successfully defer upgrading the infrastructure. The feasibility study team's collaboration, organization and engagement enabled the study to be successfully completed by leveraging the expertise of all entities involved.

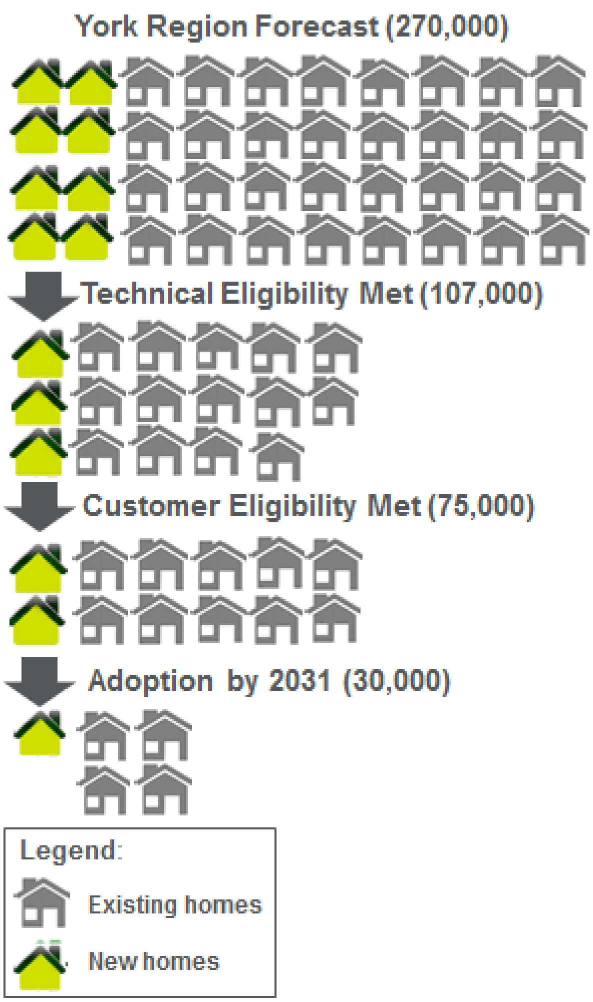
Figure 3. Feasibility Study Structure and Entities



3. POTENTIAL ADOPTION

An assessment was undertaken to understand the realistic adoption of POWER.HOUSE units within York Region, a geographic area in Southern Ontario representing more than one million customers and nine distinct municipalities. For simplicity, two representative configurations of POWER.HOUSE systems were developed: a system catered to larger homes with 5 kilowatt (kW) of solar and 11.6 kilowatt hours (kWh) of integrated storage (single family, detached home) and a smaller home configuration (semi-detached or row home with 3 kW of solar with 7.7 kWh of integrated storage). In order to assess the market adoption, a two stage analysis was performed to determine both the magnitude and pace of market adoption. The methodology is illustrated in Figure 4.

Figure 4. Adoption Methodology and Illustrative Results by 2031



Stage 1: Long Run Market Potential

The analysis began with York Region growth projections[3] expressed in terms of the number of existing and new homes within the 2016 to 2031 study period. To determine the number of homes that would ultimately adopt POWER.HOUSE by 2031, an analysis was conducted that factored both technical and customer eligibility, and was calibrated using a combination of public sources and Alectra Utilities' pilot experience.

Technical eligibility factors included, for example, roof orientation, shading, electrical load of the home, and physical space available for the system. This analysis leveraged both pilot program experience and a National Renewable Energy Laboratory (NREL) study[4].

Customer eligibility factors included, for example, whether a home is rented or owned, annual electricity consumption, and internet connectivity. This analysis leveraged Statistics Canada data and analysis of aggregate Alectra Utilities customer load data from Savage Data Systems.

[3] York Region 2041 Preferred Growth Scenario (https://www.york.ca/wps/wcm/connect/yorkpublic/77c5e970-8020-4b89-a3d0-ff62c60403f1/nov+5+preferred+att+2.pdf?MOD=AJPERES)

[4] Rooftop Photovoltaic Market Penetration Scenarios (http://www.nrel.gov/docs/fy08osti/42306.pdf)

Stage 2: Market Adoption

The pace and shape of adoption was driven primarily by program-specific variables. The adoption assessment considered the program structure; up-front and monthly costs incurred by the customer, anticipated bill savings, and assumed reliability benefits. The adoption presented in this section reflects the base case scenario. Higher anticipated bill savings and a more favourable payback arise when assessing the deep de-carbonization case resulting in higher participation. The pilot study provided market insight into customer payback tied to a specific program offering and provided the baseline economic analysis. The program offer was further refined to arrive at an archetype program offering to carry through the feasibility study. Payback analysis and pilot experience found this archetype offer to reflect a suitable example of a market offering that could support wide-spread deployment. The program offer is outlined in Table 1, below.

Local Dependable Capacity

The local dependable capacity value is a metric that was derived in order to represent the total effective capacity of the Virtual Power Plant while considering the intermittency of solar generation and capacity limitations of storage assets.

The maximum duration of the peak was determined to be three hours when deferring infrastructure capacity upgrades by up to two years, and is based on historical consumption patterns. The ability to meet this peak is based on performance of solar assets within the region and the energy capacity of the storage technology assumed for the feasibility study.

A 33% capacity factor was assumed for the solar assets, based on historical solar performance data in Ontario from the IESO[1]. Effective storage capacity took into account round trip efficiency losses, inverter limitations, and the 3 hour required duration in order to reliably reduce system peak.

Table 1. Feasibility Study Archetype Program Offer

Single family home:

- $4,500 per unit up-front
- $80/month for 10 years
- Payback between 4 and 5 years

Semi-detached/row home:

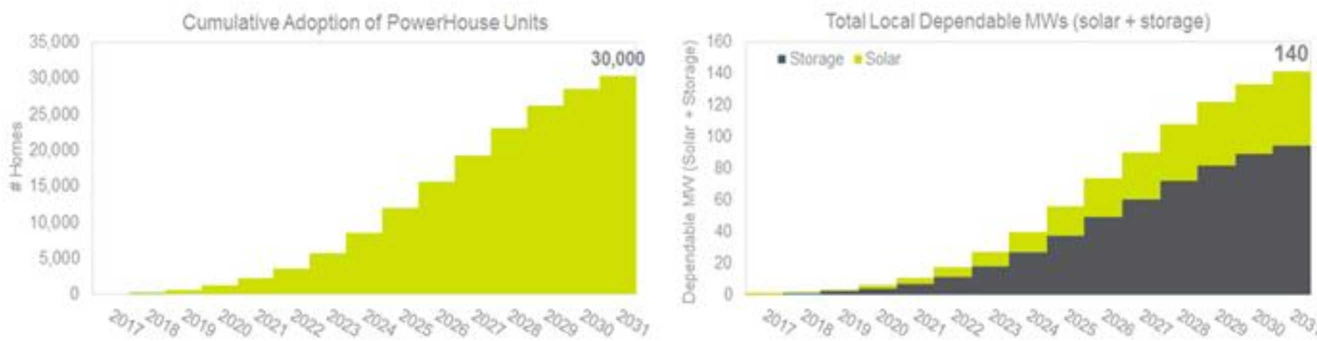
- $3,400 per unit up-front
- $55/month for 10 years
- Payback between 5 and 6 years

To ensure that the capacity identified could be safely and reliably integrated into the Alectra Utilities distribution system, Alectra' system planning staff completed a high-level assessment of the amount of distributed generation that could be connected to the distribution system. This assessment included CYME[5] simulations to ensure that thermal, short circuit, reverse power flow and voltage constraints were not violated on the feeders servicing the region under the proposed DER penetration levels. The assessment was completed for generic DER penetration levels rather than a specific assessment of solar-storage. The assessment found that the anticipated adoption would not result in any issues with the following caveats: the units must be reasonably distributed throughout the network and not all concentrated within a particular area and other DERs must not be growing by a significant amount. The final outcome of the market penetration analysis for the base case found that the adoption of the POWER.HOUSE program could feasibly reach approximately 30,000 residential homes

[5] CYME is a power engineering software package that primarily simulates load flows and distribution system dynamics to assist engineering analysis.

by 2031, which would represent 140 MW of local dependable capacity. The results over the life of the program are summarized in .

Figure 5. Feasibility Study Results: Adoption and Local Dependable MWs



4. SOLAR STORAGE AS A POTENTIAL NON-WIRES ALTERNATIVE

Even with the near-term actions and on-going conservation efforts identified in the 2015 York Region Integrated Regional Resources Plan, electricity demand growth is expected to exceed the system capability in York Region over the next 10 years. Infrastructure investments could be required in Markham-Richmond Hill in the early 2020s and in Vaughan-Northern York Region in the mid-2020s.

IESO and Alectra Utilities planning staff collaborated to determine whether the anticipated POWER.HOUSE adoption could defer the need for local transmission and/or distribution system investments within the 2016 to 2031 study period. The local dependable MW capacity results by year from 2016 to 2031 were assessed against the local needs for (1) Markham/Richmond Hill and (2) Vaughan based on electricity consumption growth projections for each area. The conclusions of the analysis are described below.

Markham-Richmond Hill Area: Given the timing and magnitude of electricity demand growth in Markham-Richmond Hill area, the study confirmed that it is not feasible to rely on residential solar-storage technology to defer the need in the Markham-Richmond Hill area. The amount of time it would take to procure and physically install the necessary assets, along with time needed for system integration into utility operations would exceed the deadline required to meet the area's capacity needs.

Vaughan: Based on the anticipated POWER.HOUSE adoption level, there may be an opportunity to defer the longer-term infrastructure needs in Vaughan for at least two years.

Using a base case scenario, in Vaughan the value of deferring upgrades for two years was estimated to be $12 million ($2016). There are several factors that influence the ability and value of deferring transmission and distribution investments. Some pertinent factors include whether lines are overhead or underground, growth scenarios (higher growth rates will lower the feasibility and value of deferral and lower growth rates will increase the feasibility and value of deferral), and evolution of climate policy in the province (intense electrification would increase electricity consumption and lower the feasibility and value of deferral). For clarity, it should be noted that the business case for deploying a Virtual Power Plant of distributed assets for the express purpose of infrastructure deferral was not considered in this study. Rather, the deferral benefit was seen as one of several benefit streams that contributed to the overall value proposition the technology may deliver under very specific future market conditions. Sensitivity modelling identified slower growth areas as the ideal candidates to deploy DERs if the system priority is to maximize deferral value. In high growth areas, such as York Region, the overall viability of the system is more closely tied to the evolution of market services, which rely on a variety of external conditions to materialize see section 7.

5. TECHNICAL FEASIBILITY

To determine the capabilities of the POWER.HOUSE technology in terms of providing reliability services to the electricity system, the feasibility study team worked with the IESO operations staff to test several scenarios. During this exercise, the team reviewed two key documents outlining use cases for storage assets: an EPRI abstract[6] and a Lawrence Berkeley National Lab report.[7] The team distilled potential functionality and reliability services/market products to four capabilities or use cases for testing. The team agreed that these four core capabilities were representative of the required functionality DERs would be required to demonstrate in order to participate in most grid support services. These capabilities are described in Table 2. To demonstrate a variety of operating scenarios, tests were conducted at the unit level across multiple units both as isolated, stand-alone capabilities, as well as interdependent or “stacked” capabilities.

Table 2. Technical Capabilities Tested

Capabilities	Potential Service/Market Product
Automatically follow a signal	• Regulation service or frequency regulation requires a unit to respond to a signal within seconds.
Respond to a trigger	• Operating reserve requires a unit to commit in advance to respond to an event when triggered within 10 minutes or 30 minutes.
Scheduled response	• Demand response requires a unit to commit in advance and respond to an event for a four-hour duration. • Potential future Flexibility Products such as responding to solar ramp out to offset the loss of solar generation output as the sun sets at the end of the day.
Sense and predict a home’s load + solar production and respond accordingly	• The control software leverages real-time analytics to optimize battery dispatch by considering customer load, time-of-use rates, solar insolation, and the battery’s state of charge. This intelligent control ensures that the battery charges when rates are lower and discharges to its maximum allowed capacity during higher priced hours.

[6] Common Functions for Smart Inverters, Version 3 (http://www.epri.com/abstracts/Pages/ProductAbstract. aspx?ProductId =000000003002002233).

[7] Distribution System Pricing with Distributed Energy Resources (https://emp.lbl.gov/publications/distribution-system-pricing).

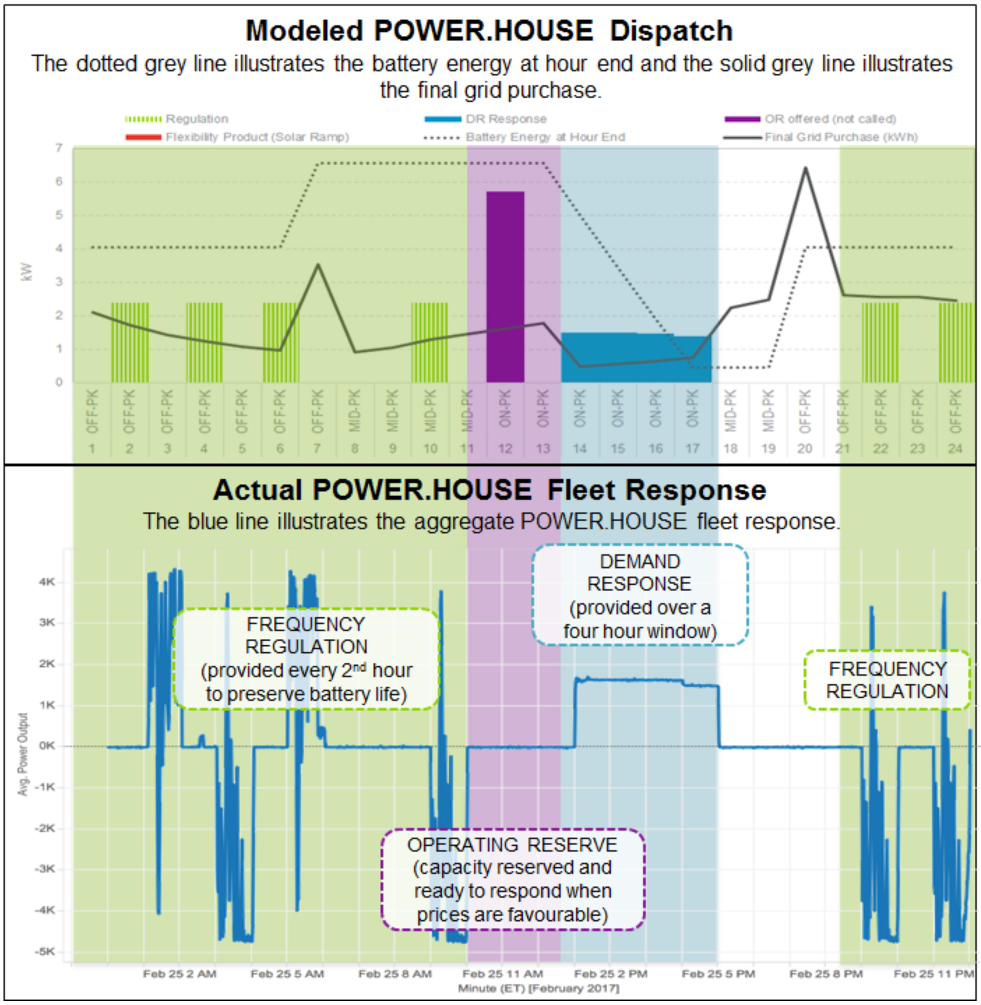
As the timeframe available for testing for this study was limited, the study team had to apply a number of constraints to ensure that the investigation would be completed within the desired timeframe. Table 3 describes the constraints of the testing phase.

Table 3. Testing Constraints

Constraint	Description
Test Sample Size	Tests were conducted on the fleet of existing POWER.HOUSE systems currently installed in Alectra Utilities' territory. To minimize the impact on customers while still providing consistency for analysis, a subset of POWER.HOUSE systems were used for the majority of tests.
Test Capacity Limitations	To maintain existing contractual customer commitments, only a portion of the battery was available for testing. POWER.HOUSE customers are currently entitled to retain 50 per cent of the battery's rated capacity at all times to protect against unplanned outages.
Quantity of Tests	The scope was constrained to demonstrating functionality and technical capability. However, testing to verify repeatability or consistent performance in a variety of changing conditions was not conducted, such conditions include time of day, time of year, weather, communications type, customer type, and location.
Fleet diversity	One of the major advantages of having a large diverse fleet of distributed assets is the flexibility that it provides. Testing was performed on a subset of the fleet, imposing individual constraints on each unit. In practice, the entire aggregate fleet would be seen as a uniform resource and a variety of dynamic dispatch strategies could be used to overcome the limitations of any one (or set of) units. The fleet could, for example, be segmented, and dispatch could be staggered to increase the capacity that could bid into various ancillary services markets. Testing to capture and value such diversity was not within scope of the functional testing.

In order to determine how to stack the proposed value streams, a baseline dispatch model was constructed. The team used a combination of historical and simulated market data to develop an optimized hourly system dispatch profile for a given reference year. This dispatch profile was seen as the reference profile to maximize the value generated by the system both from a customer and market revenue perspective (please refer to the figure in the following section for more detail on system modeling). Figure 5, illustrates both a modeled operating profile extracted directly from the dispatch model and the real time implementation of this operating profile on the fleet of POWER.HOUSE pilot units during the technical testing phase of the study. The figure illustrates a day in which the units provide regulation service every second hour of the day for the full hour, operating reserve during one hour of the day, and demand response over a four hour window in the afternoon. Flexibility product is not provided on this day. Solar generation was minimal and thus provided little opportunity to charge the battery during on-peak hours. The modeled dispatch is presented alongside tests conducted on the fleet of POWER.HOUSE pilot units to implement the optimized profile under actual field conditions.

Figure 5. Modeled and Actual Hourly Dispatch Profile



Additional technical tests were conducted on an opportunistic basis, for example, response of the POWER.HOUSE units during a power outage.

These promising results, although only demonstrated over a short period of time, would suggest that, when aggregated, these systems have the potential to provide these types of reliability services. The technical testing provided the basis for the modeling and analysis described in the following section.

6. VALUE STREAMS AND COST-BENEFIT

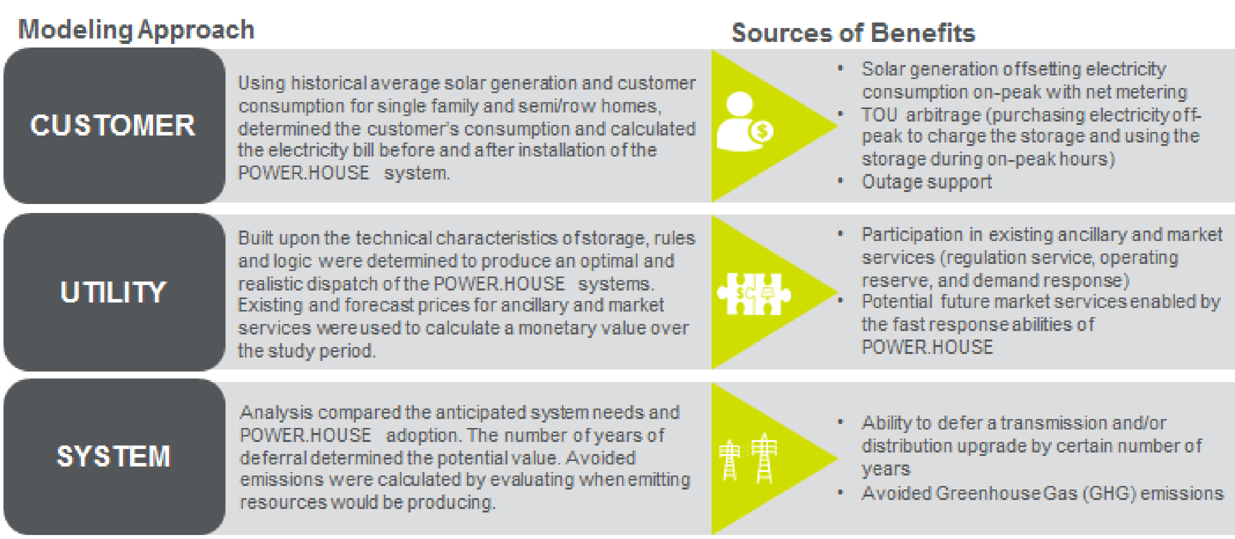
The feasibility study team worked with IESO planning staff to assess the various value streams and the cost-benefits of a large scale POWER.HOUSE deployment in York Region. The focus of the analysis was to assess the economic impact of a large-scale POWER.HOUSE deployment on Ontario electricity customers as a whole, independent of who pays or who benefits from the deployment. This approach is consistent with the perspective used in supporting Long-Term Energy Plan (LTEP) analyses and is expressed in terms of cumulative net benefit reflecting both the total costs and total benefits. Although assumptions about customer's cost contribution to the program were made to estimate the adoption rate and market potential of the POWER.HOUSE technology, the allocation of costs and benefits (e.g., who pays or who benefits) or cost-benefit analysis for each of stakeholder (e.g., the participating customer, other customers, the utility etc.) were beyond the scope of this study.

Cumulative Net Benefit

The economic impact and resulting value to Ontario electricity customers as a whole reflecting both total costs and benefits, independent of who pays or who benefits from the deployment. This approach is consistent with the perspective used in supporting Long-Term Energy Plan (LTEP) analyses.

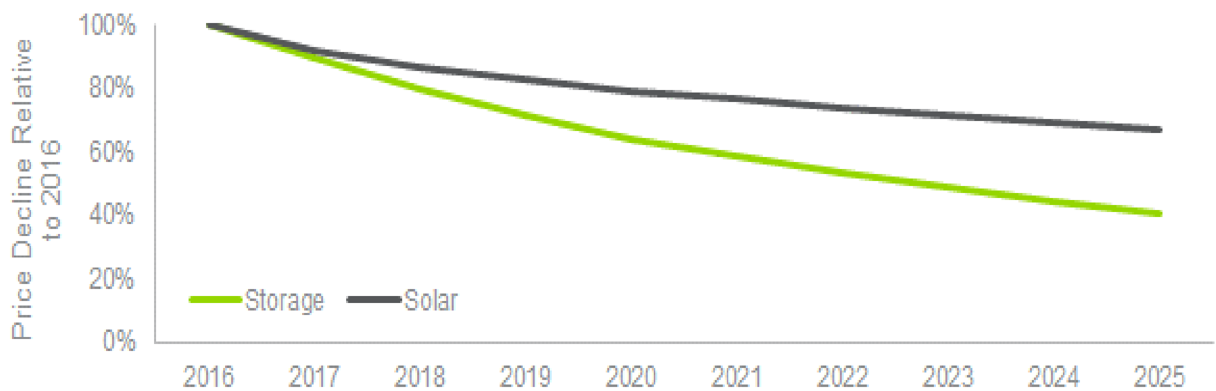
To determine the extent to which large scale POWER.HOUSE deployment would provide a net benefit to all Ontario electricity customers, the study team compared the total cost of deployment, including equipment, installation, and enabling software over the life of the program against the total monetary benefits to all Ontario electricity customers. To assess the total monetary benefits, the study team quantified and summed the various values streams, including the value of deferring transmission and distribution infrastructure in York Region, providing additional energy, capacity, and ancillary services to the electricity system. Increased customer reliability/outage protection and avoided GHG emission were identified as potential value streams, but were considered in a qualitative manner. The modeling approach used to quantify the specific benefits is outlined in Figure 7.

Figure 6. Modeling Approach



The costs associated with POWER.HOUSE technology includes solar PV panels, lithium-ion battery storage, a hybrid inverter, an Energy Management System (EMS), and installation. Costs for storage technologies, solar panels and “balance of system” equipment have declined in the recent past and are anticipated to continue to decline as adoption increases across North America, as illustrated in Figure 7.

Figure 7. Estimated Price Decline of Distributed Solar and Storage Relative to 2016[8,9]



The analysis underpinning this report leverages information from both the 2013 Long Term Energy Plan[10] and Ontario Planning Outlook (OPO)[11] to project prices into the future. Within the Ontario Planning Outlook (OPO), the IESO stated the following.

> *“The demand for electricity is the starting point used in assessing the outlook for the electricity system. There is uncertainty in any demand outlook, as future demand will depend on the economy, demographic, policy, and other considerations. Electricity planning explicitly recognizes the uncertainties in any of these drivers by addressing a range of potential futures.”*

As such, the uncertainty highlighted in the statement above should be considered when reviewing this assessment. The monetary value of the benefits and costs assessed for the POWER.HOUSE feasibility study depend on projections of electricity prices, forecast consumption patterns and the supply mix in Ontario over the next 15 years.

The feasibility study leveraged historical data available from the IESO website for operating reserve prices, demand response auction clearing prices, and leveraged Alectra Utilities’ website to obtain time-of-use rates and distribution charges. Estimates were developed for regulation service payments using historical IESO data for regulation services in aggregate and information from other jurisdictions. The relative proportion of each value stream to the entire stack varied over the years to reflect the fact that certain market products are not currently available and therefore could only be captured in later years.

[8] Residential Energy Storage Systems. Utility Technology Disruption Report. Navigant Research. 3Q 2016.

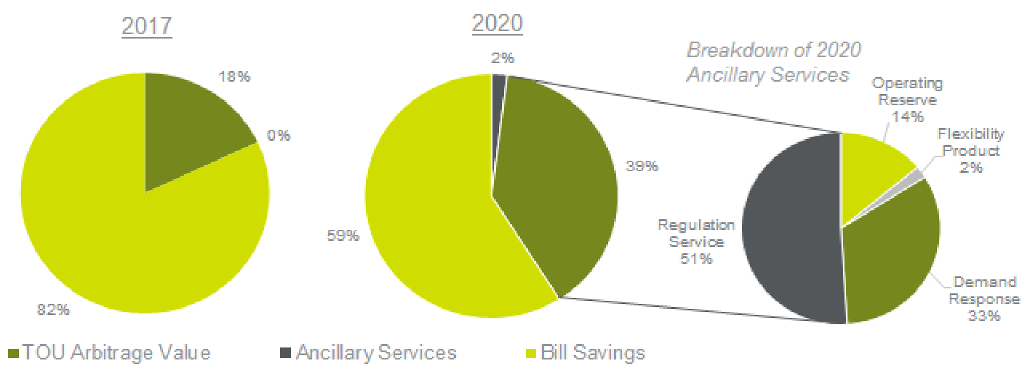
[9] Distributed Solar PV. Navigant Research. Q3 2015.

[10] Long Term Energy Plan (http://www.ieso.ca/Pages/Ontario%27s-Power-System/LTEP/Actual-vs-Forecast-Data.aspx)

[11] Ontario Planning Outlook (http://www.ieso.ca/Pages/Ontario's-Power-System/Ontario-Planning-Outlook/default.aspx)

Figure 9 outlines the proportionate value of each stream in two years of the feasibility study under the base case outlook.

Figure 8. Proportionate Value



As stated earlier, there is considerable uncertainty surrounding these projections. To understand the range and sensitivity of the cumulative net benefit, the feasibility study assessed POWER.HOUSE using two outlooks:

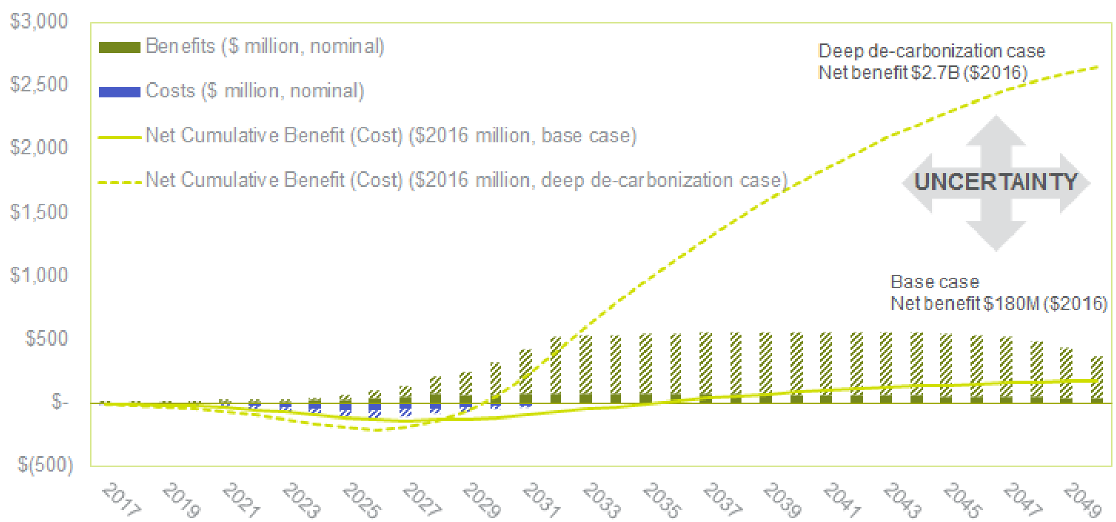
1. **Base case:** derived using publicly available market data, where available, estimates from Navigant, and projections from the 2013 Long Term Energy Plan (e.g., total cost for electricity service, wholesale market services costs, residential bill forecast).
2. **Deep de-carbonization case:** derived using publicly available market data, where available, estimates from Navigant, and electricity system cost outlook projections adapted from the OPO outlook D released in September 2016[12]. OPO outlook D reflects higher levels of demand driven by a high level of electrification associated with potential policy decisions on climate change. This outlook contemplates a transformational change to both customers and the electricity system by considering more aggressive growth in areas such as EV adoption and customer conversions to electric heating. The outcomes associated to this case carry more uncertainty than those outlined in the base case.

Figure 10, illustrates the results for both scenarios. The costs associated with the base case are shown with solid blue bars and the deep de-carbonization case is shown with diagonal blue bars. The benefits associated with the base case are shown with solid green bars and the deep de-carbonization case is shown with diagonal green bars. The cumulative net benefit for the base case is represented by a solid yellow line and the deep de-carbonization case is represented by a dotted yellow line. As illustrated in the figure below, the base case and the deep de-carbonization scenario represent a wide band of uncertainty.

[12] Ontario Planning Outlook (OPO) projections were not available at the same level of detail as LTEP 2013. As such, Navigant developed an escalator which was applied to projections used in the base case. The escalator was calculated by comparing the Total Cost of Electricity Service in OPO, Outlook D and LTEP 2013.

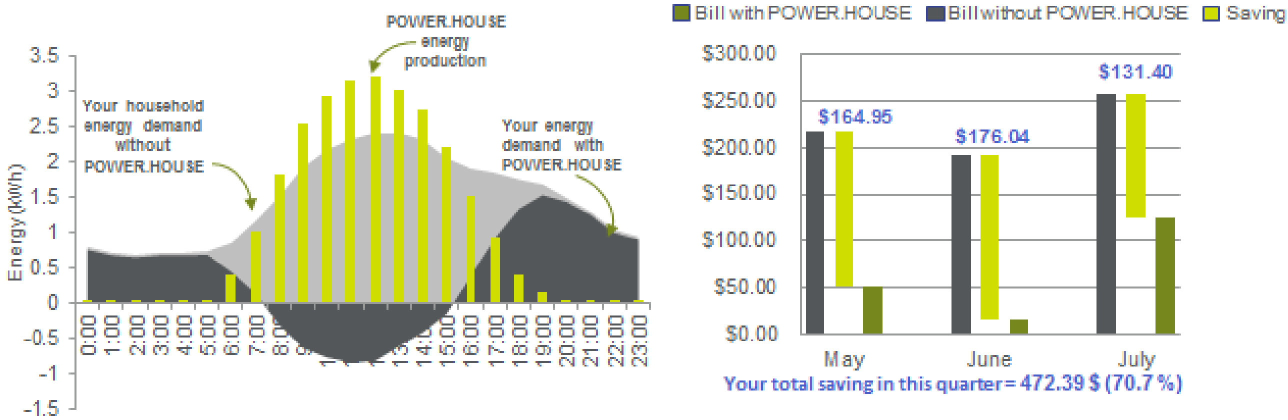
However, positive cumulative net benefit is expected over the longer-term, with the deep carbonization scenario achieving positive values by late 2020's and the base case by the mid 2030's. As with most large infrastructure development, initial investments need to be made several years prior to when their maximum benefit will be realized. In the case of the POWER.HOUSE program, the timing at which benefits can be realized will be greatly impacted by the availability and timing of certain market mechanisms, policy decisions, and other factors. Some key factors affecting the ability of POWER.HOUSE to realize the benefits contemplated in the analysis are described in section 7. These systems however are very flexible and have the ability to adapt to changing market conditions that will help mitigate some of these risks. Avoided GHG emissions provide additional benefits estimated at over $16 million ($2016).

Figure 9. Cumulative Net Benefit of POWER.HOUSE



As part of the analysis, an effort was undertaken to quantify the actual customer benefits that the existing fleet of POWER.HOUSE units has delivered since pilot launch. While the initial data is preliminary and represents a small data set, the early indications are strong that the pilot units are demonstrating significant savings to customers through the solar production and a reduction in electricity consumption from the grid during on-peak time-of-use periods. From May to July 2016, average customer savings were $142/month, for an approximately 77 per cent reduction in total energy costs. Results from a typical customer are illustrated in Figure 11. This data was adjusted for seasonality and used to validate the assumptions made in the report regarding customer benefits and long term savings.

Figure 10. Customer Value



7. KEY ENABLERS

Throughout the feasibility study, a number of key enablers were identified. Capturing these helps build an understanding of the factors that would be required to support or alternately, if not in place, impair the widespread adoption of the POWER.HOUSE system. There are many details that still need to be determined through further study in order to support wide-spread adoption, including building understanding and the infrastructure required to support Virtual Power Plants in Ontario. Though a number of key enablers have been identified throughout the report, four were identified as critical to support the adoption rates identified within the study.

1. **Ancillary Services Market**
   - Utility value is highly dependent on access to demand response and ancillary service markets over the life of the program, beginning in year two.
   - Products, procurement mechanisms and participation requirements would have to be defined while considering cost impacts.
2. **Regulatory**
   - Key regulation changes, including permissions for third party ownership of DERs and recognition of storage as a renewable asset would have to be incorporated into the net metering regulation.
   - Establishment of regulatory structures surrounding DER's in Ontario – particularly if net metering growth becomes extensive.
   - Changes to Ontario's smart metering data management systems would be required to accommodate time-of-use pricing for net metered customers.
3. **Interconnection**
   - Locational incentives for DERs are still lacking.
   - LDCs will have to develop rules on how they manage the allocation of feeder capacity between their own programs such as POWER.HOUSE, other forms of DERs, and electric vehicles that may begin to grow over the next decade

4. Utility and Regional Planning

- Need to formalize processes to incorporate DER integration into traditional utility and regional planning to mitigate local capacity issues.
- No clear regulations on cost responsibility for DER options to meet regional needs (i.e., who pays for DER solutions to address local needs).

8. CONCLUSION

This feasibility study is an important starting point to better understand the capabilities, value streams, costs, and benefits of POWER.HOUSE and the potential for significant large scale adoption of the technology. The study also demonstrates the collective benefit that can be achieved when LDCs, the system operator, and the private sector work in concert towards a common goal. Through collaboration, the team was able to quantify the value of an innovative program that can provide benefits to customers, the electricity system, and the utility. The key achievements of the study are summarized in Figure 12.

Figure 11. Study Highlights

STUDY HIGHLIGHTS

COLLABORATION	High degree of involvement and collaboration between Alectra Utilities, IESO and the private sector.
POTENTIAL ADOPTION	POWER.HOUSE can feasibly reach meaningful uptake in York Region within the study period (2016-2031) - 30,000 units and 140 megawatts (MW) of capacity.
POTENTIAL NON-WIRES ALTERNATIVE	POWER.HOUSE could defer at least 2 years of local transmission/distribution investment in late 2020 timeframe.
TECHNICAL FEASIBILITY	The team worked to understand potential market and reliability services and customer value that the technology could provide.
VALUE STREAMS AND COST-BENEFIT	The team quantified the costs and benefits across two outlooks which saw a positive net benefit by the mid-2030's under the base case scenario or by the late 2020's under a deep de-carbonisation scenario.
KEY ENABLERS	The team identified the factors that would support or alternatively impair the widespread adoption of the POWER.HOUSE system.