PowerShift Atlantic

Final Report
For
Clean Energy Fund
(CEF)

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1.0 EXECUTIVE SUMMARY

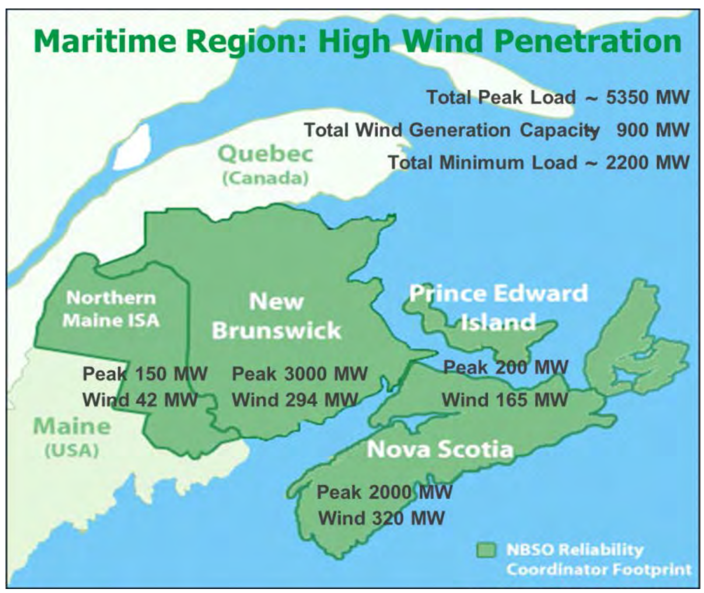
The international award winning and NRCan Clean Energy funded PowerShift Atlantic (PSA) demonstration project kicked off in October of 2010 in New Brunswick, Nova Scotia and Prince Edward Island. New Brunswick Power Corporation (NBPC) has led a collaborative consortium of other Maritime electrical utilities and an academic partner which include: Maritime Electric Company Limited (MECL), Saint John Energy (SJE), Nova Scotia Power Incorporated (NSPI) and the University of New Brunswick (UNB).

	NBPC	NSPI	MECL	SJE
Ownership	Government of NB	Emera	Fortis Inc.	Citizens of Saint John
Utility Configuration	Vertically Integrated	Vertically Integrated	Vertically Integrated	Local Distribution Company
Service Area	73,440 km^2	55,300 km^2	5,700 km^2	323 km^2
No. Employees	2,300	7,000	180	100
Residential Customers	328,000	450,000	58,000‡	32,200
Commercial Customers	33,000	35,000	1,700‡	4,200
Generation Capacity	3,511 MW	2,453 MW	149 MW	N/A – LDC
Peaking Period	Winter	Winter	Winter	Winter
System Load Min	900 MW	650 MW	90 MW	110 MW
System Load Max	3,300 MW	2,000 MW	227 MW	250 MW
	‡ - Does not include seasonal customers			

The objective of this demonstration project has been “to learn through doing” and determine if customer loads could be shifted (from a technical perspective) leveraging smart grid technologies to allow for more effective integration of renewable wind generation and to determine if this could be accomplished in a cost effective way. This objective was new and challenging since it has required a full time energy resource that could be continually shifted in both the upward and downward direction to correspond to the intermittency of the region’s wind generation at the system level. This set the PSA project apart from the more traditional but less challenging event driven demand response programs that are most often called upon intermittently for peak reduction events.

> **PSA is a customer project that leverages technology, not a technology project that leverages customers**

PSA continues to be of great interest to the industry and the PSA partners. Atlantic Canada has one of the best wind regimes in the world. This wind regime provides significant opportunities to provide ongoing and expanded renewable wind generation in the future. However there are additional challenges to effectively utilize this resource particularly as the portfolio of wind generation increases relative to flexible and controllable conventional generation assets. Total wind power between the three participating provinces (including Northern Maine, USA) is in the order of 900 MW. A collective minimum load is approximately 2200 MW with a winter peak in the order of 5500 MW. At times where the system is near minimum load, it can be a challenge to take maximum advantage of wind power due to the utility requirements to operate base load generation and to provide backup generation. In addition to this, low market price and limited hydro resources makes export of excess wind generation a challenge.

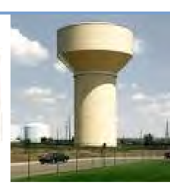


PSA was the first project in the world with the objective to partner with customers and build a relationship to allow utilities to intelligently shift customer loads to allow a more effective integration of renewable wind generation. PSA is a forerunner towards a paradigm shift of "load following generation" vs the traditional "generation following load". Traditionally, utilities have operated as monopolies and have done limited marketing and customer engagement. It was recognized very early that the PSA project was not a traditional utility project; it was a project that required customer participation. To be successful, utilities took the responsibility to establish a more trusted relationship with their customers. This mindset resulted in the adoption of our project mantra – "PSA is a customer project that leverages technology, not a technology project that leverages customers". This customer centric strategy has been the cornerstone for the approach in engaging and partnering with participating customers and we believe a fundamental key to our success. The team has learned that going from a monopoly to a sales and marketing organization and seeking to establish partnerships with customers, requires customer segmentation, new skills, sales and marketing efforts all while working with our customers to develop future solutions which add value to society.

The PSA project has included demonstrations with more than 1400 combined residential and commercial customers with approximately 17.3 MW of connected load within the four participating utilities' jurisdictions. These loads were shifted automatically as orchestrated by the project developed Virtual Power Plant (VPP). Over the course of the project the PSA solution became known as the Intelligent Load Management (ILM) system with the VPP as one of the core components. The name ILM was adopted since it reflected the objective and functionality of the solution.

Utility	Residential Customers	Commercial Customers	Total Customers
MECL	133	3	136
SJE	380	0	380
NSPI	600	17	617
NBPC	250	49	299
Total	1357	69	1426

The end-uses utilized within PSA all had to have the fundamental requirement of the ability to store energy to allow the usage patterns to be shifted. For the most part the selected end uses (see the following table) utilized thermal storage capability.

PSA End Uses					
Electrical Storage Heater (ETS)	Electrical Storage Furnace	Refrigeration	Water Storage	Domestic Electric Water Heater	Commercial HVAC
					

The PSA team established program guidelines during the discovery phase to maximize the programs opportunity for success. The guidelines included:

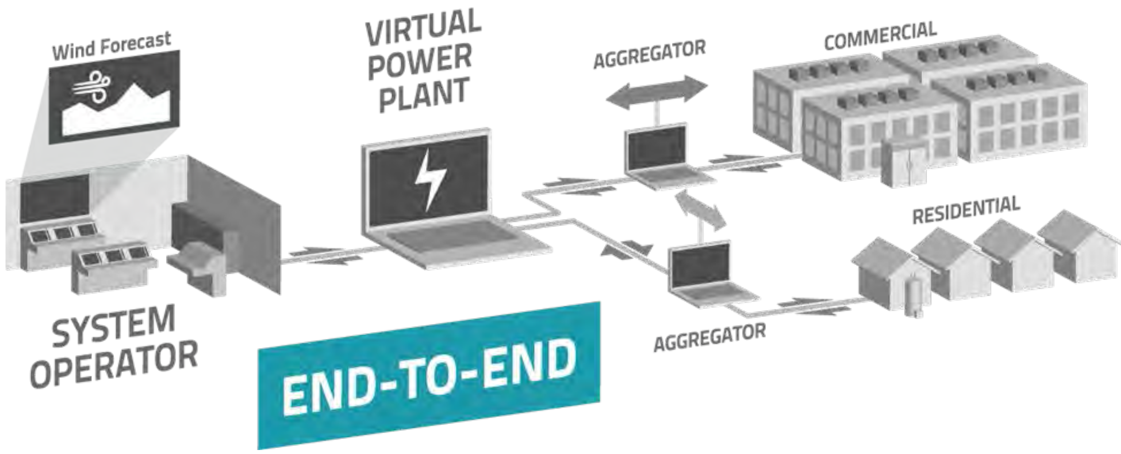
- Right sizing for a demonstration project. In the context of this project, right sizing refers to:

   - Sizing the project at the minimum scale to achieve meaningful results.
   - Developed to suit the demonstration project but not to a commercialized level.
   - Maximizing the use of existing infrastructure.
   - Maximizing the use of commercial off the shelf products and software.
   - Use of a hosted platform to house VPP.
- Putting the customer first - no negative impacts to the customer.
- Non-proprietary technologies with open interfaces to allow inclusion of all vendors and technologies.
- Consistent but scalable architecture.
- Targeting achievable objectives for the ILM that could be demonstrated.
- Providing a system level tool (ILM).
- Adherence to cyber security and customer privacy requirements.
- Connecting a meaningful amount of customer load – targeted 20 MW.
- Leveraging existing industry experience and capabilities related to load shifting.

...primary objective to provide load smoothing to cut peaks and fill valleys continuously and automatically which would allow more effective integration of wind generation by freeing up controllable conventional generation to balance the variability of wind..

With these primary guidelines established, it was determined that PSA would develop a system level tool with the primary objective to provide continuous and automatic load smoothing to reduce peaks and fill valleys. This would allow more effective integration of wind generation by freeing up controllable conventional generation to be used to balance against the variability of wind. The system was also designed to utilize and be dependent on forecasting from the system operator (load and wind forecasting) and from the aggregators (customer load inventory). It was decided that internet communications with appropriate security would be utilized to interface to an independent graphical user interface (GUI) at the system operator(s) and to system interfaces. It was also decided due to budget, schedule and logistics considerations that customer internet communications would be utilized to communicate with customer end-uses. These guidelines also drove the development of our “end to end” system architecture (see below) and our decision to utilize aggregators due to their:

- Existing knowledge and capabilities that could be leveraged to reduce connections to customers.
- Ability to interface to the ILM and to provide the “last mile” of integration.
- Knowledge of aggregation and ability to provide forecasting of the capability of inventory of end-devices.



In addition to continuous load smoothing, a complimentary second objective, *real time generation dispatch* or RTGD (comparable to10 minute bidirectional spinning reserve) was developed to provide added value to the ILM solution. The RTGD is an operator-invoked product (that has some of the characteristics of a fast start gas turbine) that shifts load up (generation down) or load down (generation up) within 10 minutes of being initiated and lasts for 60 minutes.

Customer engagement and retention have been critical components in PSA since customer participation was essential. Effort was required upfront starting in discovery phase and included:

- Best practices review.
- Surveys.
- Development of value proposition.
- Customer focus groups.
- One-on-one meetings with commercial customers.

As a result, PSA determined that residential customers were willing to participate without incentives but wanted to be kept informed along the way. The overall equipment cost and installation were covered by the project. Commercial customers were willing to participate but they were keen on potential cost reductions and new rate incentives in the future.

Executing research and demonstration projects in a regulated environment is challenging due to the utility's operational business processes, limited research experience and risk averse nature. However there has been consensus between the PSA partners that they have benefited significantly from PSA. The project greatly enhanced each participant's knowledge, local smart grid, demand side expertise, and has developed an ongoing collaborative environment between consortium members. PSA has also influenced the industry to consider the development of new products or products with enhanced capabilities or functionality that may be able to participate in smart grid programs. Overall participation has assisted the participating utilities in charting their course in the path to the utility of the future and continued to bolster

POWERSHIFT ATLANTIC

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UNB's reputation as a subject matter expert in research involving wind power forecasting and load control.

The benefits of this project have been:

- Identifying the potential for ILM and the potential to scale up.
- Developing a better understanding of the end-use characteristics and capabilities.
- Developing a better understanding of the customer.
- Identifying the business process changes required to implement ILM.
- Development of local expertise related to ILM within utilities and various service providers.
- Shifting load with great value to the overall system and no impact to the customer (business as usual; i.e. hot water).

Many stakeholders in the electricity industry are beginning to explore and realize the real potential, flexibility and value an ILM of magnitude could provide. Available loads for shifting will vary from one jurisdiction to the next and some jurisdictions may have more potential than others but collectively, the total load with flexibility will be difficult to ignore as a real piece of the puzzle to sustainable electricity.
The four key messages from our work on PSA are as follows:

- Customers responded favorably to our project involving the effective integration of wind generated power and a positive impact to the environment.
- The ILM solution is technically feasible and is evolving.
- It is still "early days" in ILM. PSA is 4-5 years ahead of its time.
- PSA has revealed challenges in the business case, some of which were attributed to:
    - Lack of interoperability standards which adds cost to development and integration of solutions.
    - Architecture and the requirement for aggregation services which contribute to another layer of costs.
    - Availability of robust and secure communications infrastructure.
    - Availability of standardized products suitable for load shifting.

Three words that best describe the PSA Project: Collaboration, Innovation, and Transformation; Collaboration, that brought together utilities, academia, suppliers, technology providers, and most importantly customers; Innovation was at the core of the PSA Project by demonstrating the world's first fully grid-integrated virtual power plant designed to allow more effective integration of wind power; and Transformation, which will occur as utilities evolve from a commodity provider to a customer focused energy services provider.

In closing PSA would like to acknowledge the most important participant in our project, our customers. Every customer played a crucial role in helping us develop PSA and contributed to our learnings from various perspectives including customer engagement, recruitment, equipment installation and load shifting. We would like to recognize the patience our customers demonstrated in allowing us access into their businesses and homes to allow us to complete important research related to utilizing load shifting for the integration of renewable energy. We sincerely thank you for your participation in this important research and demonstration project.

This VPP is functional providing on-going load smoothing with minimal impact to the customer. Customers are in a "business as usual" state. This is the advantage of storage solutions which provide overall system flexibility to shave peaks, offset the need to build, and better integrate renewables. One can begin to imagine the potential of instrumented electric water heaters throughout all of North America and potential opportunities in the electric vehicle space.

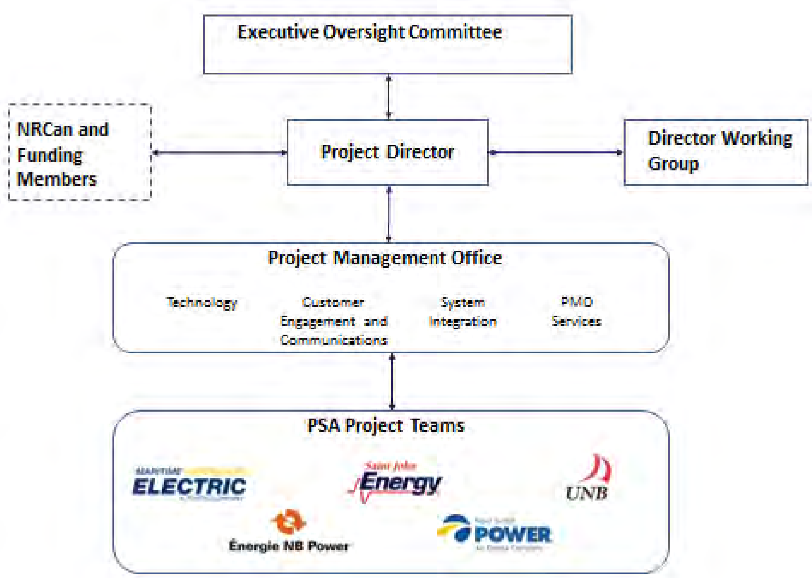
Interested parties are encouraged to contact the PowerShift Atlantic representatives identified in ***Appendix 1- PowerShift Atlantic Contact List*** for follow-up on any of the findings highlighted in this report.

2.0 INTRODUCTION

PSA is demonstrating one of the world's first fully grid-integrated VPPs designed to allow for more effective integration of wind power. The project is a collaborative demonstration led by New Brunswick Power Corporation (NBPC) in partnership with Maritime consortium members from academia, utilities and government. It is demonstrating the capability of VPPs to balance high penetrations of wind power on a cross-jurisdictional system. Unlike typical Demand Response services, the VPP uses load and wind forecasting and aggregation capabilities to perform near real-time continuous load shifting of commercial and residential loads and provide new ancillary services to the grid. This project was launched in 2010 and is scheduled for completion in the spring of 2015. It is jointly funded by Natural Resources Canada through the Clean Energy Fund and by members of the consortium.

One of the first tasks undertaken by the consortium was to establish a governance model displayed in Figure 1.0 below

Figure 1.0 PSA Governance Model



An *Executive Oversight Committee* was established to monitor project status, address escalated issues and ensure utility alignment was maintained with the PSA project.

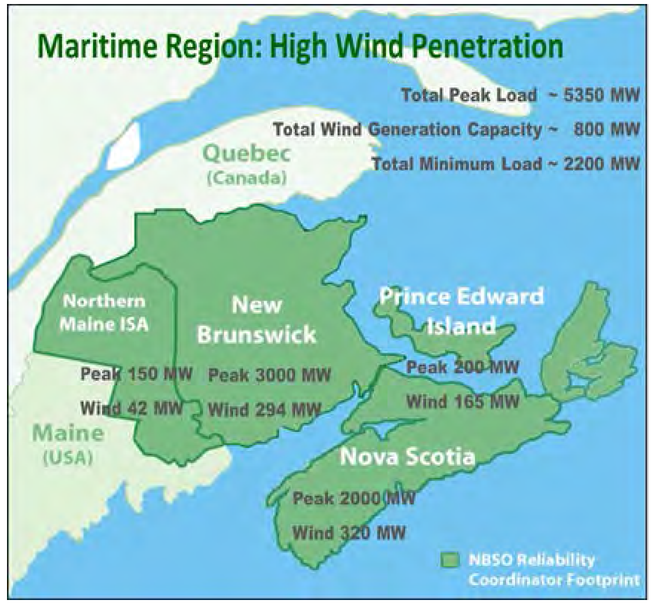
A *Director's Working Group,* consisting of senior level representatives from each consortium member, was established to provide strategic direction to the PSA Program Director in the overall project design and execution.

A *Project Management Office (PMO)* was established by engaging an external consultant to provide tactical direction and execute the project to meet the program objectives which also included managing the day to day activities and all aspects of project reporting.

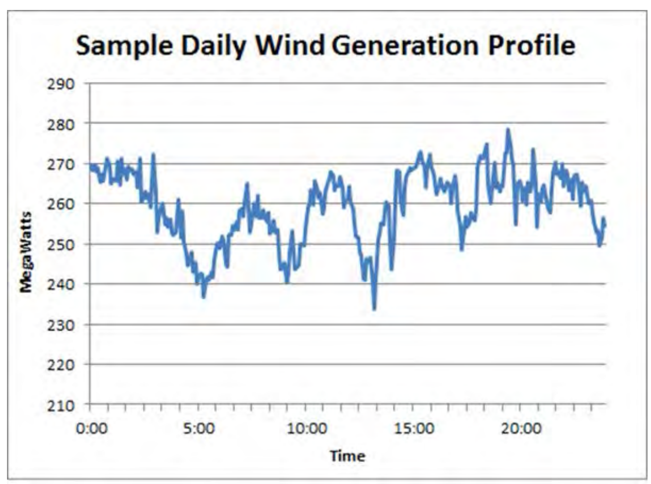
Each utility established their own *PSA Project teams* drawing on internal resources as required.

Having a robust and dedicated PMO office was recognized by PSA as a key differentiator for ensuring the program met objectives, maintained the appropriate level of profile within each organization, and effort was appropriate for research and demonstration.

3.0 BACKGROUND (PROGRAM BACKGROUND AND CONSORTIUM PARTICIPANT OVERVIEW



As of 2013, the Maritime region is host to one of the highest penetrations of wind energy in North America (9%). The variability of the wind generation profile coupled with the existing variable demand profiles are currently balanced with ancillary services which are provided by on-line generators (i.e. oil, gas, coal and hydro) and off-line generators which can be brought on-line as quickly as required. Load management via two VPPs in the PSA project could reduce the requirement for ancillary services from existing assets. In this way it has the potential to reduce the costs and emissions associated with the integration of current wind energy in the Maritimes, as well as to increase the potential for future renewable development.



The integration of wind generation into the supply mix does introduce challenges. Wind generation is variable, and is not controllable or dispatchable as conventional generation resources. The predictability of wind power generation is based on wind forecasting models. A sample daily wind generation profile demonstrating the variability of wind generation is shown to the right. This sample, taken across three wind farms in New Brunswick, consists of a total nameplate capacity of approximately 300 MW. The high degree of variability associated with wind generation generally makes it both challenging and expensive to balance.

The primary technical research conducted through the PSA project was to determine if shifting energy consumption patterns of energy storage devices at customers' premises was a viable solution to offset some of the variability of wind generation.

Table 1.0 provides a synopsis of the consortium members participating in PSA and characteristics of the Maritime utility market.

Table 1.0 PowerShift Atlantic Regional Characteristics

Project Ownership	PowerShift Atlantic is a collaboration between: • New Brunswick Power Corporation (NBPC). • Saint John Energy (SJE). • Maritime Electric Company Limited (MECL). • Nova Scotia Power Incorporated (NSPI). • New Brunswick Power System Operator (NBSO). • University of New Brunswick (UNB). • Government of New Brunswick. • Government of Prince Edward Island
Number of customers	Approximately 1 million, across the four (4) service areas. GWh mix: 40% residential, 26% commercial and 31% industrial loads (balance is street lighting and other non-metered loads).
Electricity delivered	26,055 GWh in 2011 across the 4 service areas.
Generation mix (based on energy generation)	Nuclear: NBP (35%) NSPI (0%). Fossil fuels: NBP (30%) NSPI (77%). Renewables: NBP (30%) NSPI (17%). Other (imports): NBP (5%) NSPI (6%).
Contact	Michel Losier, Program Director, PowerShift Atlantic, mlosier@nbpower.com

3.1 UTILITY OVERVIEW

This section provides an overview of each utility including a forecasted load growth and generation mix through to year 2020. This information provides some insight into the size of the utilities involved in the PSA project, their customer base, and organizational structure. Refer to Table 2.0 listed below.

Table 2.0 Utility Overview

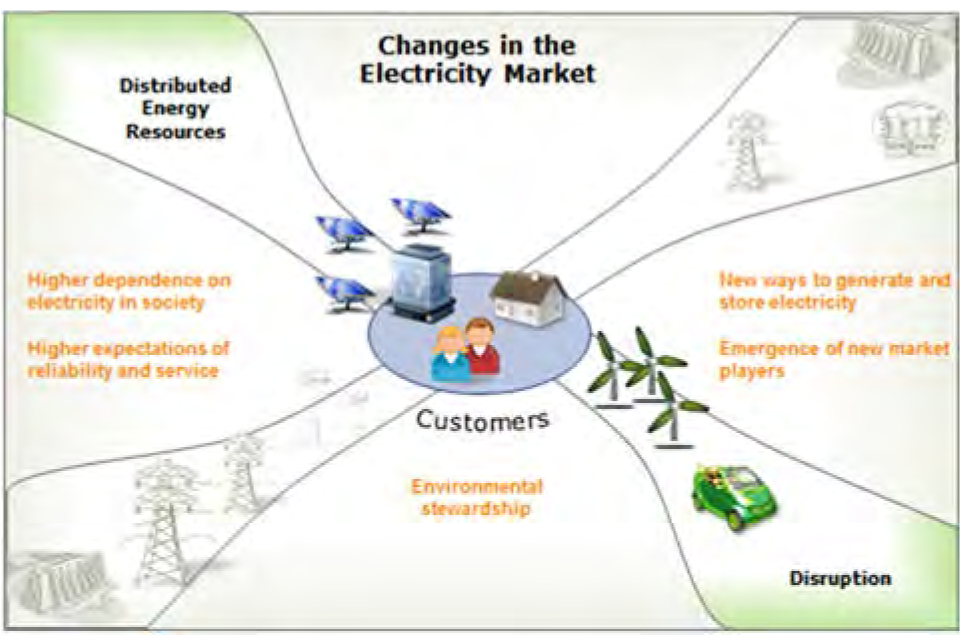
	NBPC	NSPI	MECL	SJE
Ownership	Government of NB	Emera	Fortis Inc.	Citizens of Saint John
Utility Configuration	Vertically Integrated	Vertically Integrated	Vertically Integrated	Local Distribution Company
Service Area	73,440 km^2	55,300 km^2	5,700 km^2	323 km^2
No. Employees	2,300	1,700	180	100
Residential Customers	328,000	450,000	58,000‡	32,200
Commercial Customers	33,000	35,000	7,000‡	4,200
Generation Capacity Generation Mix	3,511 MW Hydro, Wind	2,453 MW Hydro, Wind,	241 MW Wind, Oil	N/A – LDC N/A

	NBPC	NSPI	MECL	SJE
	Nuclear, NG, Oil, Coal	Tidal, BioMass, NG, Coal		
Peaking Period Projected Load Growth	Winter 0.5 - 1% per year until 2020	Winter -0.4% per year until 2020	Winter 3% per year until 2020	Winter 4 % annually on average
System Load Min	900 MW	650 MW	90 MW	110 MW
System Load Max	3,300 MW	2,000 MW	227 MW	250 MW
	ǂ - Does not include seasonal customers			

3.2 POWERSHIFT ATLANTIC – THE ROAD TO THE UTILITY OF FUTURE

For over a century, utilities have provided customers with affordable, reliable energy solutions. However, changes in the electricity marketplace (“disruptions”) such as solar photo voltaic (PV), referred to in Figure 2.0 are happening faster, are accelerating, and will be more disruptive to the utility than expected. All utilities are experiencing disruptive technologies to varying degrees and acknowledge these technologies may negatively impact their business unless managed. Utilities need to develop a strategy to address these challenges as they move forward. The future for utilities will be more complex and uncertain. The “final destination” is unknown and is very difficult to predict. Flexibility and adaptability are keys to future success.

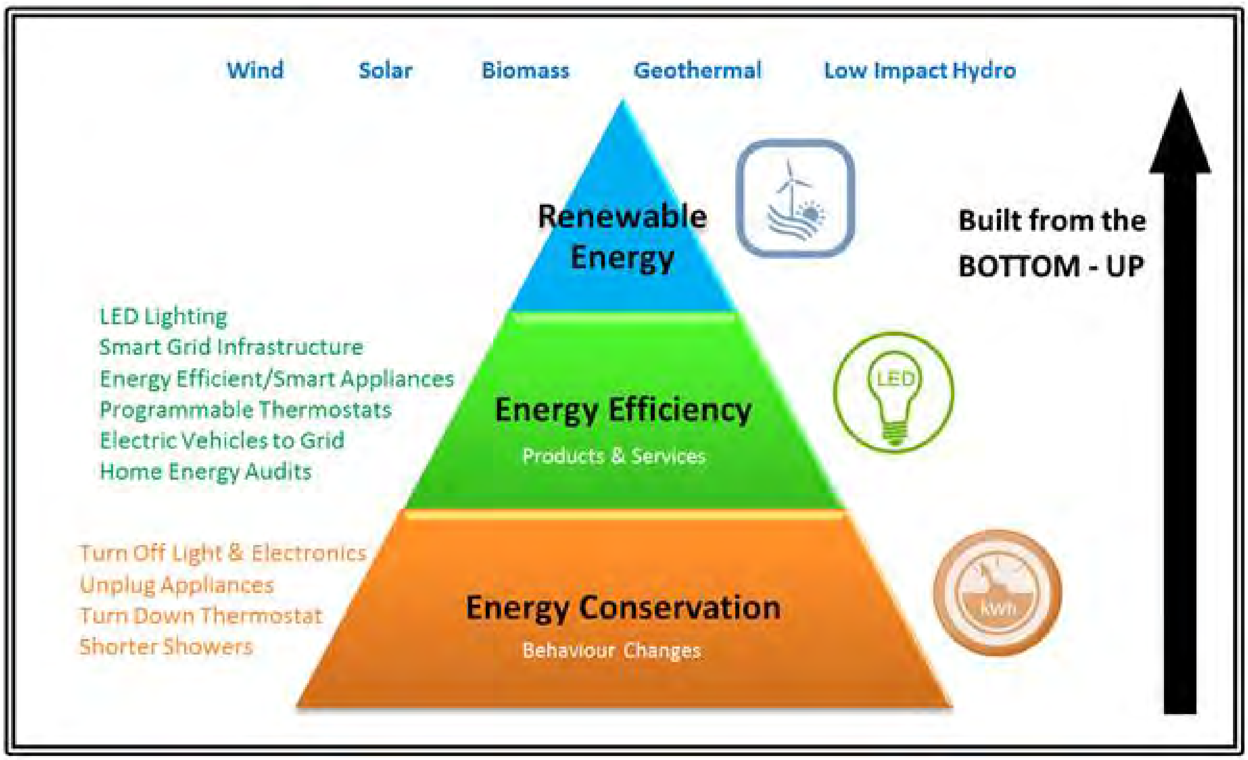
Figure 2.0 Changes in the Electricity Market



The utility of the future is looking for opportunities to optimize resources and move towards strategies like ILM that support the increased use of renewables. Technologies such as wind, solar PV, LED lights, electric vehicles, embedded generation, and battery storage are starting to reach the mainstream market and are poised for sustained growth. How does this impact the utility of the future?

The adoption and penetration of these energy technologies will have a direct impact on the traditional business model. At the same time, these technologies can affect the integrity and reliability of the electricity system. The intermittency of resources such as wind and the potential increase in peak demand by charging stations as a result of increasing electric vehicle penetration will require a change in infrastructure to balance these resources. The ultimate solution proposed by many in the industry is electricity storage through batteries and other technologies. However, many utilities already know that energy efficiency often is a lower cost alternative to building new resources. Before installing new electricity storage facilities, initial consideration should be made for energy efficiency. The typical energy pyramid shows this below in Figure 3.0

Figure 3.0 Typical Energy Pyramid



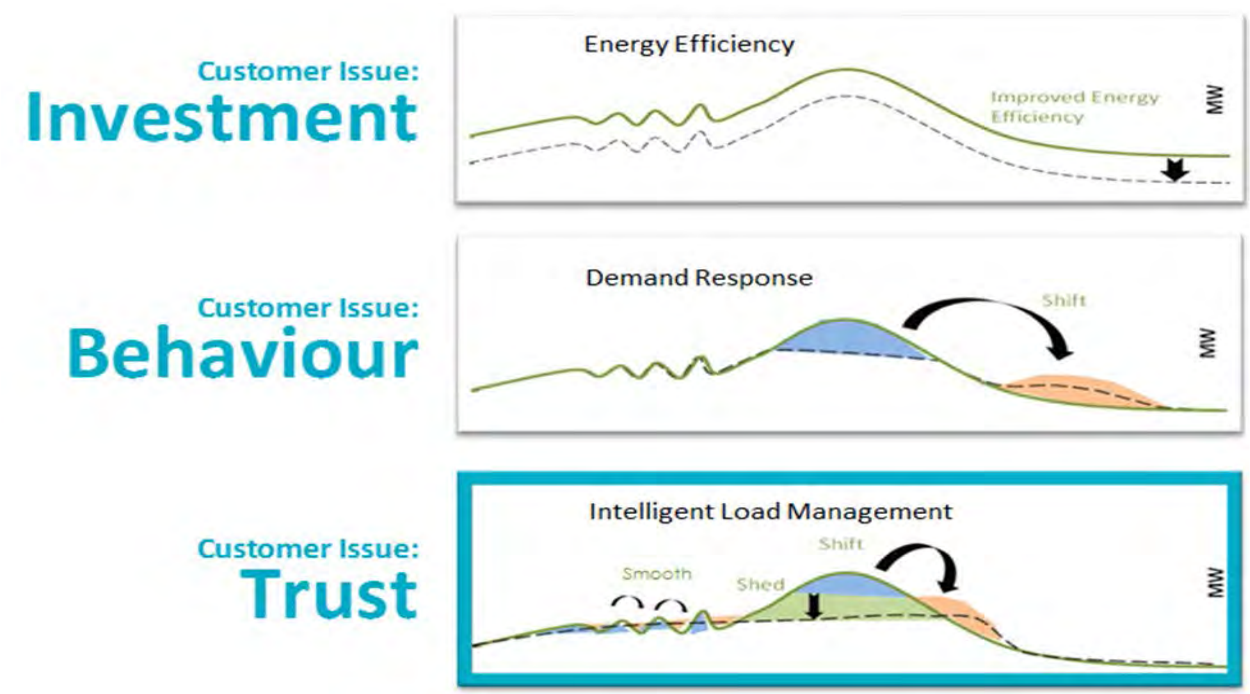
ILM, through the development of smart grid infrastructure, increases the efficiency of the electricity production and delivery system and becomes an enabler for increased intermittent resources such as wind and solar as well as electricity storage. The Energy Pyramid shows us that undertaking cost effective conservation and energy efficiency measures first will help determine the optimal system size before investing in new generation resources.

The current utility business model is being challenged from intermediation that often is outside of utility control. This means that the cost of doing nothing is not zero to the utility. The risk also extends to the electricity system because that same intermediation has potential to adversely affect the reliability of the system. One solution to help mitigate these challenges is through the development of ILM.

The utility of the future needs to consider the following shifts in their landscape:

- Two-way customer relationship. Today's customer wants to have more insight into their individual energy consumption through self-serve portals, smart tools etc. and influence how they can reduce their usage and costs. The utility of the future should now be moving beyond the meter with the introduction of smart grid tools and concepts such as ILM. This requires a new level of trust between the utility and the customer, and provides the utility with much more information on customer behavior. Figure 4.0 below represents the change in the customer relationship as a utility moves from more traditional Demand Side Management and Demand Response to the continuous load shifting introduced through ILM.

Figure 4.0 Customer Relationship



Energy Efficiency and Conservation Programs implement policies and measures which serve to control, influence, and generally reduce electricity demand on the consumption side. Energy Efficiency aims to improve final electricity-using systems and reduce consumption, while preserving the same level of service and comfort. An example would be by replacing an old refrigerator with a new energy efficient refrigerator. Energy Efficiency requires customer investment in a product or service, while conservation focuses on behavioral changes.

Demand Response (DR) programs are event driven and are designed to enable customers to participate through incentives and contribute to energy load reduction during times of peak demand. DR requires customer choice and changes in behavior, which means the utility, cannot necessarily depend on the peak demand reduction to occur.

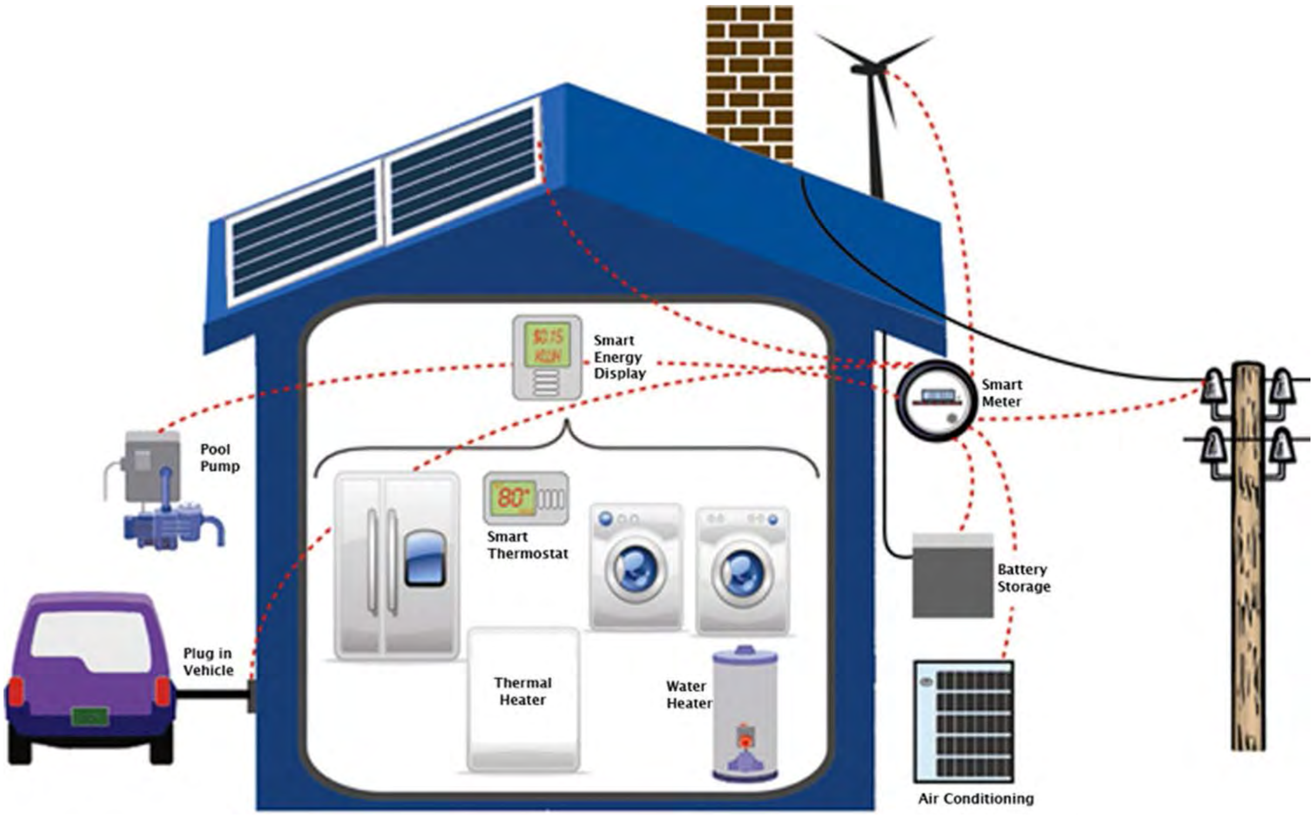
Intelligent Load Management is utility driven and has the direct ability to control the load at the customer site without inconveniencing the customer. Intelligent Load Management is a more advanced DR product and can perform DR, but most importantly is a dynamic tool that can assist in maintaining a balance between generation and load. It requires little change in customer behavior, but instead requires a higher level of trust between customers and their utility since the utility will have the ability to directly shift energy usage patterns. It uses an "intelligent" system, such as a Virtual Power Plant, that has the capability to manage and optimize the usage patterns of multiple loads. The PSA ILM Solution uses existing thermal energy storage capacity of certain customer loads without the use of batteries or conventional energy storage facilities.

- Potential for new revenue streams through new energy services, strategic bundling of customer products and services including turnkey financing options, customer self-serve portals, and ability to integrate distributed generation from customers.

- Develop strategic partnerships with 3rd party providers for non-core utility services such as the supply, sales, leasing or rental of heat pumps, domestic electric water heaters, smart thermostats, solar panels, electric vehicle charging stations, etc.

- The continued need to push industry to incorporate intelligence, functionality, and develop standards at the end-device level. Research projects such as PSA continue to promote change in industry which is ultimately required to provide cost effective scalable products and services that allow the utility and the customer to prosper and incorporate more renewable energy sources. Doing so will reduce the utility's need to build generation units to meet future capacity requirements. Today's customer (refer to Figure 5.0) is demanding smart products and this demand will drive change in the industry.

Figure 5.0 Today's Customer



The customer of the future will continue to take advantage of various energy efficiency products and programs whether or not they are offered through their utility. Customers want more control over, and information on, their energy usage and will continue to adopt new opportunities for self-serve generated distribution as these technologies become more cost effective. This can be a win-win for the utility and the customer if the utility takes steps today to ensure they continue to provide energy options that are cost effective, reliable, safe and flexible to meet the changing needs of the customer.

4.0 OBJECTIVES

Table 2.0 lists the primary and secondary objectives as originally stated at the start of PSA Project. Early into the project, the decision was made to move beyond the concept of "Demand Response" to Intelligent Load Management (ILM). ILM is more dynamic than traditional demand response, involving continuous load shifting to help smooth out the energy demand curve. The main objective of the ILM is to manage end-devices such that system level peaks are reduced and valleys are filled. As the project progressed the primary objective also evolved and can be re-stated to be that of determining if load shifting can provide an economic and effective alternative to building new supply side ancillary services for the integration of wind with minimal or no disruption to participating utility customers.

As such there is technical, business, environmental, and customer benefit research objectives that this project seeks to achieve:

Table 2.0 PSA Objectives

The primary objectives of PSA are:

1. Evaluate if load control is a cost effective and reliable ancillary service to dispatch net requirements.
2. Evaluate load control performance in response to measured and forecasted wind power.
3. Evaluate the customers' role and their acceptance of utility control for the purposes of renewable energy integration.

The projects secondary Objectives are:

1. Develop Smart Grid technologies that include demand response concepts and wind energy forecasting tools that will result in cost savings and operational efficiencies for Maritime power utilities.
2. Articulate the costs to install the new technologies and refine the business case and technological capability for scalability and a broader application of load control.
3. Determine customer load potential and best load characteristic for Demand Response.
4. Evaluate the role and acceptance of customers utility load control.
5. Determine additional benefits from 2-way communications such as innovative rate design.
6. Determine additional benefits/applications of smart grid configuration for Maritime utilities.

Technical benefit: Test the ability of VPPs managing customer loads to perform in sync with system balancing and forecasted wind profiles, and to offer a reliable alternative for balancing renewable generation.

Business benefit: Test the cost effectiveness of operating VPPs as ancillary service providers (10 minute bidirectional spinning reserve as "Real Time Generation Dispatch (RTGD)") and determine appropriate business models for integrating the components of a VPP within a vertically-integrated utility.

Customer benefit: Explore new customer roles and customer relationships that support customer participation in load management, and capture value for the customer. Determine best practices for establishing relationships of trust for direct load shifting.

Environmental benefit: Determine the GHG reduction potential by operating a VPP as opposed to operating flexible fossil fuel generation (such as a peaking gas turbine) to balance variable supply and load profiles.

5.0 PROJECT EVOLUTION

PSA is a research and demonstration project and the challenge with any R&D project is you "don't know what you don't know". As the project progressed and we learned, the direction taken to meet the overall goals and objectives had to be able to change quickly. It was important to have the project model in place to allow the flexibility to change tactics to take advantage of successes and failures early in the technical arena. For PSA we established a number of guidelines at project inception which were used to guide the project. These included:

- ***Be customer focused:*** PSA could not meet its research objectives without significant customer involvement. With minimal incentives and no mandate to save the customer money, it had to be "easier than doing nothing" for the customer to participate. Involvement in PSA should not negatively impact the customer (i.e. increased cost or customer discomfort).

- ***Start small and scale up:*** Initial recruitment for both commercial and residential customers targeted employees, internal branch offices, or existing customers with whom a strong relationship and history of working together previously existed. Learnings on installation processes, customer messaging, liability expectations, and equipment operation were incorporated when scaling up to the larger demonstration targets.

- ***Maximize existing utility infrastructure and processes:*** This includes "right sizing" the processes and the amount of integration to utility back office systems. For example, in general, the program was not integrated into utility enterprise systems such as financial and customer support systems. Also, for communications the customer's existing internet was utilized. This is a challenge given the risk averse nature of both utilities and service providers when the impact to the customer is unknown.

- ***Build an open technical architecture:*** At the onset of this project there was limited industry experience with the concept of ILM. Allowing the project team to steer the research required full control of the technical architecture defining the VPP. The PSA architecture uses standard web service interfaces to allow multiple service providers to connect to the VPP. This approach allowed the team to dictate the technical design of the VPP rather than making concessions on the design and making a significant capital investment to an unproven product. As well, multiple aggregators were able to participate, enabling PSA to engage a wider cross section of energy management service providers from across industry.

- ***Develop products of value to the System Operator (SO):*** Ultimately, the SO is responsible for providing a reliable and balanced electrical transmission system so the ILM was developed as a system level tool to assist in system balancing.

5.1 MAJOR DEVIATIONS FROM ORIGINAL PROJECT CONCEPT

Table 3.0 provides an overview of the major deviations from the original project concept over the project lifecycle from various perspectives:

Table 3.0 – Overview of the Major Deviations

Original Project Submission	***Implemented through PSA***
Schedule	
Discovery Phase to start April 1, 2010 – project end date March 31, 2014 including one (1) year of demonstration.	Discovery Phase started September 22, 2010. Request to extend project end date to March 31, 2015 to complete customer installations and conduct one full year of demonstration approved November 30, 2012.
Pilot Size	
1 pilot with 750 Customers, combined commercial industrial and residential in New Brunswick, Nova Scotia and Prince Edward Island.	Four pilots with various customer types – each participating utility: • SJE –Residential. • MECL-Residential, Commercial. • NSP –Residential, Commercial. • NBP –Residential, Commercial. Approximately 1440 customers participating across the Maritimes as of October 1, 2014.
One balancing authority.	Two Balancing Authorities • Nova Scotia Power System Operator • New Brunswick Power balancing authority for NB, PEI and Northern Maine.
Technology	
Single technology partner for controllers and communication backhaul. Single technology partner to develop commercial algorithm and incorporate UNB residential algorithm into "load control system" to interface with single system operator. Wind following.	Multiple technology partners. Maximizing use of commercial off the shelf products. • Use existing customer energy management systems where possible. • Use multiple technologies and products. • Adopted a virtual power plant solution. • PowerShift team developed the ILM optimization strategy and algorithm. • Virtual power plant incorporated UNB's un-instrumented domestic electric water heater control algorithm. • Right sized amount of integration into utility back office systems (customer support, billing etc.). • Continuous load smoothing of forecasted

Table 3.0 – Overview of the Major Deviations	
Original Project Submission	***Implemented through PSA***
	load minus wind.
Advanced Metering Infrastructure (AMI) – The original solution envisioned a significant investment in AMI infrastructure with smart meters on all participating customers residential and commercial for all utilities.	Solution includes virtual power plants interfacing with the NBSO/NSSO and using existing customer infrastructure or new as required. • Smart meters not required to support the solution to the extent initially envisioned.
Purchase and installation of a Meter Data Management and Repository (MDMR) with interfaces to the system operator and customer Information system DMR at NB Power and NS Power. • Data from smart meters and GE Solution would interface with the MDMR.	Solution includes virtual power plants interfacing with the NBSO/NSSO and using existing customer infrastructure or new as required. • Smart meters not required to support the solution to the extent initially envisioned. • MDMR not required to support the solution. • Required significant end-use hardware installed at customer site.
Customer	
Single Pilot with up to 750 Customers, combined commercial industrial and residential in New Brunswick, Nova Scotia and Prince Edward Island.	More than 1400 customers across Maritime Provinces. Multiple end-use technologies involved: • Targeted commercial customers with greatest potential (low risk, large load). • Targeted customers where no competitive advantage gained through participation. • Four pilot types required increased effort and coordination with parallel activities in multiple jurisdictions.
Single geographic area.	No geographical constraints.
Area – Budget	
Original budget submission over four (4) year period was 32.05M with spending projection by budget areas as follows: A Project Management and Business Case Development **12.7%** B Customer Engagement and Customer Program Design **14.4%** C Communications Backhaul and AMI **16.1%** D Software Development and System	Resulting budget distribution as of October 31, 2014 on a projected budget of $33.45M A Project Management and Business Case Development **24.5%** B Customer Engagement and Customer Program Design **12.4%** C Communications Backhaul and AMI **1.4%** D Software Development and System

Table 3.0 – Overview of the Major Deviations					
Original Project Submission			***Implemented through PSA***		
	Integration	**22.7%**		Integration	**20.5%**
E	Load Control Equipment and Installation Process	**29.8%**	E	Load Control Equipment and Installation Process	**37.8%**
F	Testing Production and Reporting	**4.4%**	F	Testing Production and Reporting	**3.4%**

5.2 PSA PROJECT TIMELINE

Given the number of pilots, variety of technologies involved, number of customers targeted, and the associated challenges with customer recruitment especially in the commercial sector, it is challenging to provide a summary of the major milestones and achievements for the project. Each pilot project reached common goals such as selecting target end devices, selecting their technology partners, establishing connectivity to the VPP, achieving end-to-end connectivity, meeting their customer targets, overcoming technical obstacles, etc.

The following diagram depicts the high level project timeline and description of the key focus for each fiscal year. The one year demonstration period ended October 1, 2014 with project completion scheduled for March 31, 2015. The key program milestones achieved over the project lifecycle are listed from three perspectives: Customer, Technology and Business Case. The intent is to provide an overview of when and where energies were focused over the five year timeline.

PSA PROGRAM TIMELINE

	2010/11	2011/12	2012/13	2013/14	2014/15
Overall	**Discovery & Initial Design**	**Design, Pilot Planning, Recruiting, and Launch**	**Recruiting, Growing Customers, & Operating**	**Full Demonstration, Monitoring & Capturing Learnings**	**Extension to Complete Installations & One Year Demonstration**
Customer	• Best Practice Research	• Focus Groups & 1-on-1 meetings • Engagement Plan • Launched PSA website • 1st Customer Survey • Develop Recruitment Pgm (Residential & Commercial)	• Focus on recruitment and installations • 800 residential cust. • 51 commercial cust. • 4.74 MW connected load	• 1 year demonstration started Oct 1, 2013 • 1,100 residential cust. • 65 commercial cust. • 12 MW connected load	• Project completion & customer transition strategy • Exit Survey • 1439 customers • 17.3MW connected load
Technical	• Best Practice Research on Direct Load Control for Wind Integration • System Architecture for VPP concept	• Est. Demonstration Roadmap • 4 Pilots underway • VPP hosted platform selected • Aggregators selected • VPP & Interface architecture completed	• 2 VPPs implemented • System Operator interface implemented • All Aggregators connected to VPP • Wind Power Forecast tool developed	• Resolve technical challenges for end-to-end load control • Interface communications • Aggregator forecasting • Equipment installations	• VPP & Aggregator monitoring and evaluation • Customized test targeting VPP objectives, specific load classes, and aggregator capabilities
Business Case	• Develop common approach to program roll-out	• Develop Cust. Satisfaction Pgm • Develop Pgm performance measurement/ evaluation • PLEXOS simulation tool selected to model Atlantic region's energy system	• PSA granted 1 year extension to complete demonstration • Defined Key Performance Indicators for program measurement	• 1st PLEXOS simulations completed for 750 MW un-instrumented water heaters • Est. central data repository for consolidated technical, customer, and cost KPI data	• Complete PLEXOS simulations for variety of sizes and load mixes • Complete business case using technical, customer, and cost KPI data

6.0 PSA CUSTOMERS

There were 1,400 plus residential and commercial customers across the Maritimes participating in the PSA project as of September 2014. If you explore the breakdown of customers across all pilots you will see that 67% of the 17.3MW total connected load was provided by 4% of the participating customers classified as commercial customers. (More information on the customer segmentation is provided in section **7.0 Description of System and Its Application**)

So how did PSA develop the customer mix in place through the pilot projects?

It is important to recognize that target markets were identified as part of Participation Agreement between the consortium members and NRCan. Only NSPI and NBPC pilots formally incorporated recruitment of commercial customer into their pilot scope.

A significant learning from our PSA experience is the effort to attain commercial customer approval to participate is considerably longer than residential customers and the elapsed time between initial contact and completing installation of equipment can be months. As well, the risk of a negative customer experience is much higher in the commercial space. Having school closure or business shut down due to heating issues has a much larger footprint and could negatively impact the utility's ability to recruit other like customers in PSA or future programs.

The customer recruitment process described below reflects an organized cautious approach to customer recruitment for PSA. Although the industry research conducted to develop the PSA program confirms customers philosophically embrace the concept of using more renewable energy like wind, it should be noted that customer recruitment would be challenging without a clear value proposition for the customer.

6.1 CUSTOMER RECRUITMENT GUIDING PRINCIPLES

For all recruitment (residential and commercial) the following guiding principles were followed and communicated to the customer as part of the recruitment process:

- Other than the provision of new products to be piloted, installation of these products (and in some cases installation allowance to address minor cosmetic issues resulting from installation), no financial incentives were provided.
- There was no cost to the customer to participate.

- Cost savings to the customer was not an objective of this project. PSA was a research and demonstration project and customer participation was helping the utility to develop future programs for more efficient integration of renewable energy like wind.
- No negative customer experience and no change in user behavior. Participation in PSA should be "easier than doing nothing".
- No competitive advantage created as a result of participating in PSA (specific to commercial customers).

6.2 CUSTOMER RECRUITMENT CHALLENGES

Answering the following questions helps to shed more light on the customer mix and some of the challenges with customer recruitment:

- **Why didn't the utilities try to recruit more commercial customers?**

  Both NSPI and NBP put significant emphasis and effort into recruiting commercial customers with varying degrees of success. Both shared some common experiences:

  The larger the company the harder to obtain approval to participate.

  Companies with several levels of management or companies that cross several provincial jurisdictions required multiple information and education sessions. With no cost savings objective, no long term commitment, and no incentive other than "no cost to participate", competing business priorities take precedence over research and demonstration projects of this nature. The utilities had more success recruiting commercial customers that had the following attributes:

  - Were locally owned and operated.
  - Had a flat organization structure.
  - Where participation resonated well with the customer's client base and their employees.

  Risk averse nature

  Any industry dependent on maintaining a strong relationship with their customer has a low risk tolerance for introducing technology that could negatively impact this relationship. Both the utility and the customer are risk averse by nature. Tri-party agreements between the utility, customer and aggregator were perceived to be overly complex and did not adequately address the liability concerns expressed by the customer. In hindsight, to get commercial customer participation in a research and demonstration project, utilities (and technical partner like the aggregators) need to assume the bulk of the liability, assure the customer they will be taken care of if problems arise and take the appropriate steps to mitigate risks that could jeopardize the customer relationship or drive up cost. Mitigation steps include:

  - Early site assessment with established selection criteria to quickly identify ineligible candidates, and avoid complex and expensive installations.

- Target low risk/ high return end-uses and avoid customers with high risk end-uses or significant risk to process and operations.

- Allow the customer to have influence on their level of participation and how they participate. In PSA, commercial customers are able to set min and max load consumption parameters, dictate hours of operation, and time of day restrictions.

No competitive advantage as a result of participating in PSA.

This PSA recruitment guideline is specific to commercial customers. A customer could not be perceived to be gaining a competitive advantage as a result of participating in PSA. For this reason commercial recruitment targeted primarily customers such as government, municipalities, schools etc. with the following attributes:

- Local to the province, flat organization structure, and no competitive advantage as a result of participating in PSA.

- Target low risk - high return end-uses and avoid customers with high risk end-uses or significant risk to process and operations.

- Customer owned building location versus renting.

- Customers where PSA involvement resonated well with the customer's client base and their employees.

- **What about large industrial customers?**

Early on in the project NB Power targeted some of the larger commercial customers believed to have more sophisticated Energy Management Information Systems (EMIS) with the technical infrastructure in place to control multiple sites from a centralized location. After further analysis, and in some cases site visits with their energy management providers, it was determined that:

- In some cases, the EMIS systems in place were not as sophisticated as implied and required significant investment in order to modify the EMIS to allow participation in PSA through our open architecture.

- In some cases, the EMIS service providers already had optimized energy saving mechanisms in place which limited the amount of load that could be made available for load control.

- There are very few commercial customers in the Maritime Provinces with an integrated EMIS that was technically capable to participate even if it was cost effective to include in the research.

- Often involved a manufacturing process, i.e. saw mill, paper plant, therefore decision was determined not to proceed as the risk with loss of products, materials, etc. was too great.

- Large customers with nation-wide operations were not interested in participating in R&D projects with no incentives, no cost saving objective and no guarantee of cash savings down the road. These customers felt participation would be a distraction. At a minimum these customers would require involvement to be transparent, zero cost and zero risk.

- **What were the main challenges in recruiting commercial customers to participate?**

    - Risk averse nature of utility and customer with regards to liability.

    - Customers with multi-level management structure requiring approval at each level.

    - Customer acceptance of complex customer participation agreements.

    - Customer ineligibility due to technical restrictions or complications encountered through the eligibility evaluation process.

- **What approach was used to recruit customers and what were the main challenges to overcome?**

    Every pilot customer had the potential to become a key supporter or opponent of the project, so it is crucial that communications/engagement efforts are focused on building and maintaining positive relationships with participants. Effective identification and engagement of pilot participants in a sustainable way throughout the project were key components to recruitment and continued participation. Both qualitative (focus groups and one-on-one interviews) and quantitative (1100 customers across the Maritimes surveyed to determine level of awareness with smart grid, wind integration, and level of interest to participate in research project) analysis was conducted to develop the messaging and value proposition that would resonate with customer.

    One challenge with customer recruitment was managing public awareness and expectations especially since participation had to be limited for a research and demonstration project. As a result the level of public awareness was closely linked to the target number of participants. For both commercial and residential customers the strategy for initial recruitment was the same:

    - Recruitment started with friendlies/early adopters and employees prior to going out to wider audience. This approach allowed a safe environment to test messaging, confirm the value proposition, refine the installation process, train installers and reduce risk of a negative customer experience.

    - For further expansion a variety of methods were used to recruit customers. For residential this included:

- Attendance at home shows, targeted customer emails (i.e. customers in a specific regional area) and customer call campaigns by phone complete with call scripts and narrative training. Care was taken not to over recruit and also not to build too large a backlog to minimize the time between recruitment and installation.
- Utilities established selection criteria to quickly identify eligible customers meeting mandatory requirements. Selection criteria was determined based on the target end-use (i.e. pre-qualifications for those participating in NBPC Water Heater Rental program required internet access, 60 gallon tank, tank age qualified for replacement, easy accessibility to avoid complex retrofit installs. Pre-qualifications for residential Electric Thermal Storage (ETS) space heaters included 200 amp entrance, internet access, not replacing primary heat source, and easy accessibility for retrofit.
- A combination of utility staff and third party contractors were used to perform site assessments to confirm ability to participate. For example, NSPI has a well-established ETS space heater program and local installer network already trained on the product whereas ETS is a new product in the New Brunswick marketplace. Installers and customers had to be trained on the product and the program.
- Provided flexible after hours scheduling to better accommodate residential customer's schedule.

In all cases it was critical to ensure the installer was knowledgeable of the PSA program and how it worked or was accompanied by a PSA subject matter expert from the utility.

Commercial recruitment was conducted one-on-one using a combination of utility customer representatives, PSA subject matter experts and end-use installation experts. Utilities established selection criteria to quickly screen for eligible customers. Pre-qualification site assessments were conducted and recruitment material was established based on consistent and repetitive messaging to inform and build awareness and interest.

Although PSA has successfully managed the number of customers participating in PSA, it became increasingly challenging as:

- Word of mouth spread and customers took advantage of co-branding available.
- Social media is unpredictable and outside our ability to control what a customer might say regarding their PSA experience.
- Third party service providers promoted their involvement in PSA on their own websites and are designing and developing new products based on their involvement with PSA.

7.0 RESULTS

This section highlights the project results from various perspectives (customer, technology, VPP performance etc.) coming out from the research and data analysis conducted over the PSA project lifecycle. Data analysis has taken many forms throughout this project including:

- Industry best practice research.
- Customer surveys.
- Qualitative and quantitative baseline research on commercial and residential customers.
- Key performance indicators to track customer recruitment and retention, cost, and technical performance.

It is not the intent of this report to restate all of the findings from the various forms of research conducted in the course of the definition and execution of this project. Readers are encouraged to contact the appropriate PSA representative indicated in ***Appendix 1 – PSA Project Contact List*** if you have specific questions on research conducted to support the design, development, and implementation of the PSA program.

This section provides an overview on the key outcomes related to the following areas:

- Customer - identifying the primary drivers for participation, overall customer experience, types of customers, and recruitment/retention challenges.
- Technical - key performance indicators on end-use/load class, VPP primary and secondary functions, and aggregation challenges.
- Business Case and the role of Plexos modelling tool in extrapolating to larger scale VPP.

7.1 CUSTOMER SURVEY RESULTS

One of the challenges with measuring customer satisfaction through participation in PSA is the fact that the customer is typically not aware that load shifting is occurring. Once the installation process is complete the goal is business as usual for the customer. Load shifting on water heaters, space heaters, HVAC etc. is conducted continuously throughout the day. This re-enforced the need for on-going customer communications to keep the customer engaged and a mechanism to collect feedback on their experiences.

ILM is practically invisible to the customer – we can do things smarter and not impact the customer… M. Losier, PSA Program Director

RESULTS
June 22, 2015

The first customer survey was conducted in April 2012. In total seven (7) customer surveys were conducted. The method of delivery involved a combination of email with a link to an on-line survey. Surveys were conducted for both commercial and residential customers. The research objectives for conducting these surveys included:

- Monitor customer satisfaction and engagement in the program over time.
- Provide a means for customers to provide feedback directly.

From the outset of this program respondents have used these customer engagement surveys as a means of communicating with program representatives for everything from advising of upcoming moves to requesting follow-up on previously disclosed equipment issues.

Ultimately, we are trying to determine if the customer is going to accept ILM for the purposes of renewable energy integration. What conclusions can we draw from the survey results specifically looking at customer acceptance?

Before moving on to these conclusions please note the following limitations to be considered when interpreting the results captured through the survey:

- Some customers may not have participated in all surveys. Utility participation in the survey was optional. Some utilities may have opted out depending on what stage they were at with regards to customer recruitment, installations and connectivity to the VPP.
- Each utility determined which customers would receive a specific survey. In some cases only customers who had equipment installed within the last four (4) months would receive a survey. This also applies to utilities who had met their customer recruitment targets earlier in the project. They may have opted out based on feedback from their customer base on the preferred frequency of communication with the customer. They may have opted out for a group of customers due to the seasonal nature of specific load classes involved such as space heating or HVAC.
- The uptake on the commercial survey was much lower (23%) than with residential customers (64%) and in some cases some of the conclusions drawn for commercial customers are more of a “gut feel” given the existing customer relationship rather than based on the statistics derived from the survey results.

Even with the stated limitations, there are a number of conclusions that can be made based on the survey results. For this report these conclusions are organized under the following categories: customer recruitment, participation in the survey, customer satisfaction, and motivation for participating. Detailed information on all customer survey results is available upon request. Refer to ***Appendix 2 Project Artifacts*** for a complete list of supporting documentation available.

7.1.1 Customer Recruitment

Residential

From the beginning of the program through to demonstration, all aspects of recruitment and installation improved. Survey respondents are generally satisfied with their recruitment, installation and overall program experience which is what would be expected as recruiters become familiar with the process and with the questions and concerns of potential participants.

Commercial

Recruitment for customers is much more involved in the commercial arena. The turnaround time from initial engagement to customer approval to proceed was much longer than anticipated. The primary challenges for commercial recruitment included:

- Risk averse nature of utility and customer with regards to liability.
- Customers with multi-level management structure requiring approval at each level.
- Customer acceptance of complex customer participation agreements.
- Customer ineligibility due to technical restrictions or complications encountered through the eligibility evaluation process.

Refer to Section ***6.0 PSA Customers*** for more insight on challenges with commercial customer recruitment.

The survey results on customer recruitment for residential and commercial support the following conclusions:

- There is a segment of residential customers that would be early adopters. Customers were recruited through a variety of methods (mass email, regular mail, home shows, telephone) with varying degrees of success.
- Have eligibility criteria clearly defined to quickly rule out ineligible customers.
- Include a site assessment as customers don't really know what they have (60 gallon tank, internet access, 100 amp breaker etc.).

7.1.2 Participation in Survey

Residential

Overall survey response rate has been consistent with average response rate of 65%

- The overall response rate for residential customers in these surveys have been consistent hovering in the mid-sixties throughout the program with an average response rate of is 65% across the seven surveys. Industry standards for on-line survey response rates indicates a typical response rate for a customer satisfaction or customer engagement survey is between 10 and 30%, depending on whether or not participants had an incentive to complete the survey.

Commercial

- Commercial response rates for the individual utilities were erratic throughout the program. Overall response rates hovered between 10% and 40% throughout. Given the small pool of participants available to be surveyed, there were not enough respondents to yield statistically significant results.

Commercial survey response were erratic through-out the program

Through consultation with commercial customers we have concluded a lower response rate due to the following reasons:

  - Other more pressing priorities with day to day business operations.
  - Unlike residential, there are multiple people within the organization involved with various stages such as customer approval and sign off, recruitment, installation, operations etc., such that no one person can answer questions targeting a specific stage. Counting on the person receiving the initial survey request to facilitate getting questions answered by the appropriate person within their organization does not work.
  - The turnaround time between customer approval and having equipment installed, connected and available for load shifting was longer than anticipated which resulted in lost momentum and interest.

The survey results on customer participation in surveys support the following conclusions:

  - Participants were engaged and interested in the program and how they individually were contributing to the research.
  - Effective communication is required to let the customer know how they are participating and contributing to the research – even more so when the solution is transparent to the customer. The PSA customer does not know when load shifting is being performed.
  - There is some expectation of savings down the road. Utilities need to manage customer expectations on what follows the end of the research and demonstration phase.

7.1.3 Customer Satisfaction

Residential

Survey respondents are generally satisfied with their recruitment, installation and overall program experience. The average satisfaction rate for the seven surveys is 80%. The overall satisfaction indicator is calculated by combining the respondents who are "very satisfied" and "somewhat satisfied".

The overall dissatisfaction rate for the seven surveys is less than 2% and is calculated by combining the percentage of respondents who are "very dissatisfied" and "somewhat dissatisfied"

Commercial

The number of participants who have considered themselves satisfied has jockeyed for position with those who are neutral throughout the program. The number of "somewhat dissatisfied" participants has remained steady; however survey results towards the end of the project indicated a slight increase in the level of dissatisfaction.

The survey results on customer satisfaction support the following conclusions:

- The customer's experience with the installation process is very important. Installers need to be knowledgeable of the equipment, the research goals/objectives and work around customer's schedule.
- The utility will inherit any perceived problems once past the installation phase. Complicated installations should be avoided through prequalification assessment.
- The utility needs the ability to clearly show the customer how and when they were actively participating in the program.

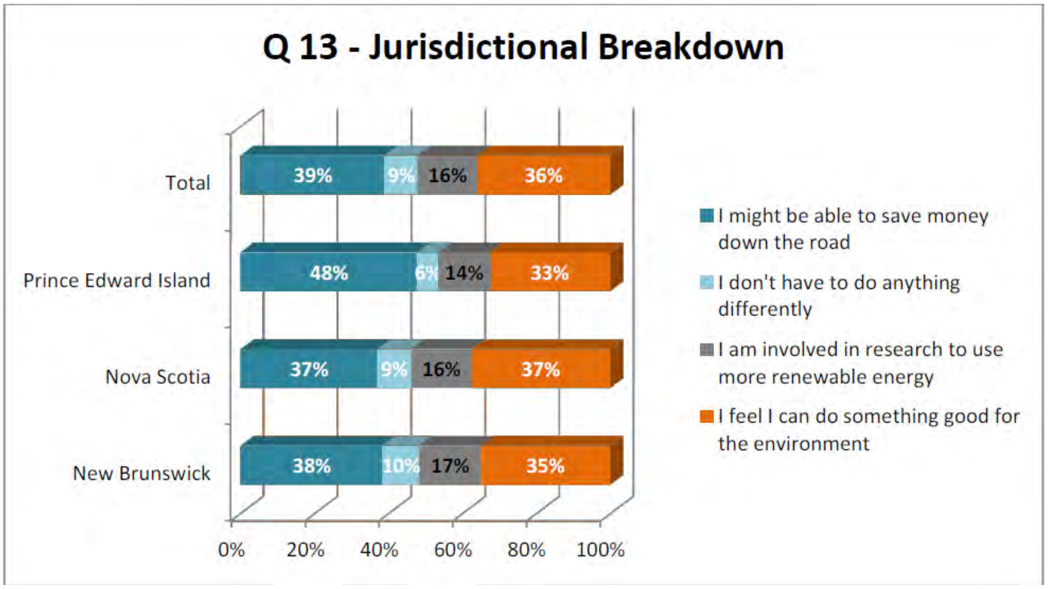
Despite best efforts to communicate otherwise, some survey respondents held on to the expectation that the program would save them money

7.1.4 Motivation for Participating

Cost savings to the customer is not a PSA objective and was re-enforced in customer communications, and during the customer recruitment process. The objective was to find out if ILM technology works and gauge if customers would be receptive to this type of relationship with their utility and understand the cost involved to scale up from demonstration to a full blown program.

Residential

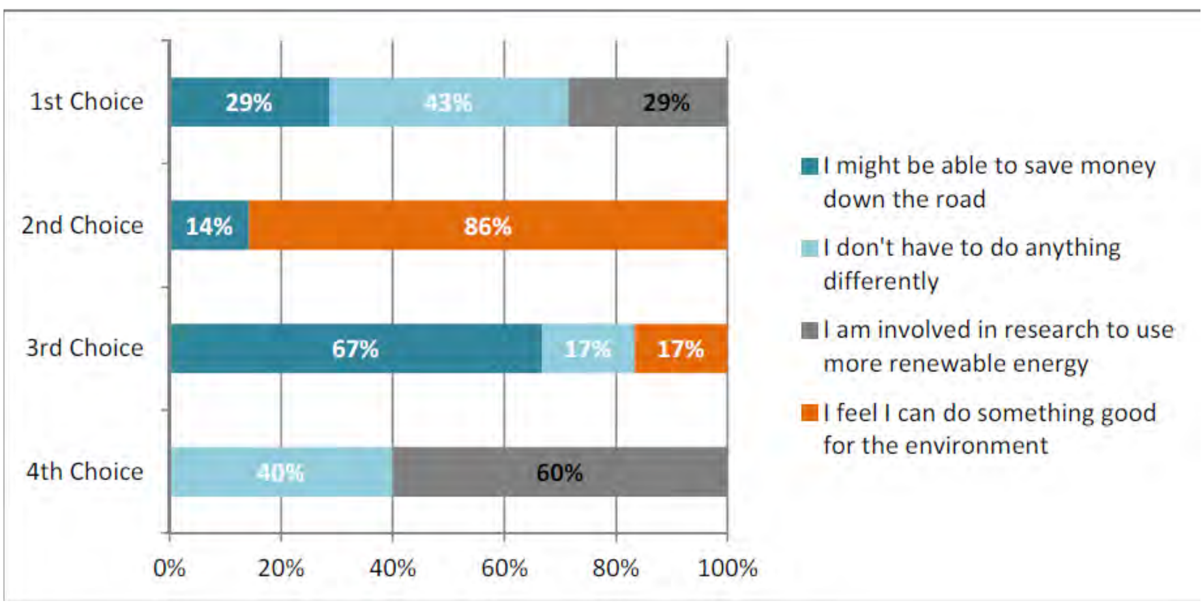
Program participants continued to be motivated to take part in the program by the potential to save money down the road and their desire to do something good for the environment. These primary drivers remained consistent throughout the program.



Commercial

Program-long trends related to motivation to participate were more difficult to pinpoint due to the relatively low number of commercial customers and the low survey response rate.

The top choice among reasons to participate was 'I don't have to do anything differently', whereas the overwhelming second choice is the desire to do something good for the environment. The potential to save money down the road or a new rate structure was the leader for third choice.



The survey results on motivation for participating support the following conclusions:

- Customers are interested to participate in programs targeted at improved use of renewable energy and doing something good for the environment that will benefit future generations. These goals resonate well with both commercial and residential customers however it must be easy for the customer to participate and not require a change to customer behavior.
- Customers' participation was achieved with no incentives beyond having no increased costs incurred by the customer to participate.
- There will be an expectation by the customer to experience savings over the long term.

Note that the majority of commercial customers involved in the PSA project are in the non-retail sector by design. Early exploration with customers in the retail sector and larger industrial customers indicated a clear expectation of demonstrable cost savings through their involvement in PSA. Cost savings to the customer is not an objective of the PSA project.

Retail sector and larger industrial customers indicated a clear expectation of demonstrable cost savings...

7.2 TECHNICAL RESULTS

The technical results review the performance of the VPP and its component load classes that group similar end devices. This includes performance at the VPP level, as well a lower level review of individual load classes that the VPP is controlling.

At the VPP level, the performance is examined in terms of its ability to execute its two objectives; continuous smoothing operation of the input load curve, and ability to execute real-time generation dispatch commands (10 minute bidirectional spinning reserve requests).

At the load class level, similar load classes of end devices are grouped into streams (e.g. instrumented water heaters, commercial electric thermal storage units, etc.) and these are examined in terms of their ability to execute their forecasting and dispatching requirements.

Generally, all results are taken from analysis of data gathered over the course of system operations during the one-year demonstration period. Since all data is coming from the VPP system, the most granular level of data available is at the load class level (and not at the individual end device level). Individual aggregators were responsible for directly controlling the end devices and their systems contain data at that level, but only consolidated results were reported back to the VPP.

Data from the VPPs was transferred and transformed into a centralized reporting database configured for data analysis purposes. A number of standard reports were built and used to analyze the results for both the VPPs and load classes. A summary of these reports and their intended purposes is shown in Table 6.0.

Table 6.0 Standard Technical Results Analysis Reports		
Purpose	**Report Name**	**Level**
Examine the amount of forecasted controllable load available for shifting purposes: • Normal mode (continuous smoothing). • RTGD mode (real-time generation dispatch for bidirectional spinning reserves).	Normal mode Capacity Report	VPP
	Normal mode Capacity Report	Load Class
	RTGD mode Capacity Report	VPP
Examine how well the load classes can forecast their unmanaged load values.	Forecast Accuracy Test Report	Load Class
Examine the reasonableness of the forecasted upper and lower bounds.	Forecasted Upper Bound / Lower Bound Validation Test Report	Load Class
Examine how well load classes can meet the target load levels sent from the VPP.	Dispatch Performance Accuracy Report	Load Class
Examine the requested and actual amount of load shifted over a reporting period.	Work Done Estimation Report	VPP & Load Class
Example and compare forecasts, dispatch power levels, and actual power levels.	Forecast, Dispatch, Actual Comparison Report	Load Class
Examine relationship between the input load curve from the System Operator to the overall VPP dispatch and actual power levels.	Continuous Smoothing Operation Report	VPP

7.3 AGGREGATOR FEEDBACK

The PSA project technical architecture was designed from inception requiring aggregation services. It was noted early on in PSA that the success of the project was dependent on aggregation services provided by several aggregators. As a result the conscious decision was made to engage the aggregators not just as service providers but as partners. We believe that the project achieved greater success due to these efforts to learn from each other and to look at the project and the challenges we faced through each other's perspectives. During the course of the project PSA hosted a two day aggregator workshop which was attended by all aggregators. During this workshop the PSA team and aggregators discussed and explored the project related to aggregation based on the experiences gained by all parties. To continue the team culture established with the aggregators a series of questions were developed and sent to Steffes, Integral Analytics and Enbala at the conclusion of the PSA project to capture any additional information and insights. These can be found in **Appendix 5 - Aggregator's Responses to Project Close-Out Questions**

8.0 LESSONS LEARNED

The major lessons learned, or "what we would do differently if we were to do this again" based on the PSA experience and associated research and demonstration will be explored in this section. The following areas will be considered:

- *Customer Recruitment, Customer Retention, Customer Support, Deployment of Equipment, Technical Solution, Project Governance, Aggregator Capabilities etc.*
- *Major technical challenges with regards to the Architecture and Aggregator Functional Requirements (Load Forecasting, establishing Min/Max Boundaries, Communications, Dispatching, 15 minute interval, multiple load classes).*
- *Gaps/opportunities that may add value to the VPP.*

There are many sources feeding the overall project learnings including Customer Surveys, Industry Best Practice Research , Customer Motivation Program definition, equipment purchase and installation cost tracking etc. that were conducted over the PSA Program lifecycle. These are well documented and are available as a project artifact (Refer to ***Appendix 2 List of Project Artifacts***).

Another source of learnings is those lessons "learned through doing". Throughout the PSA project, lessons learned from various pilot team experiences were captured and logged into a lessons learned registry. As you would expect, each pilot project varies significantly in the technical solution implemented, the end-use devices targeted, the approach to customer recruitment, the type and number of customers involved, the size of the geographical area involved etc. As a result, their customer recruitment experiences and technical installation challenges can be very specific to their pilot project and load class. The following table provides a summarized list of the key lessons learned by the consortium members that were "learned through doing". These learnings resulted in continued process improvement across all aspects of the project lifecycle including recruitment, installations, customer support, and refining technical requirements of the technical solution and various integration points. Some effort has been made to role these up into a more general form as these are believed to be applicable to most customer focused R& D projects involving technology.

Technical Architecture	Providing an open standard interface allowed multiple vendors to participate using various technologies and equipment versus locking into an existing vendor solution which would limit the R&D opportunities: • Best approach for research and demonstration but introduces some challenges in developing cost effective business case. Refer to section 7.4 VPP Core Subsystems and Modules
	Industry has not reached a maturity level for widespread intelligent load management deployments: • Development of industry standards and products needs to continue to evolve with decreasing costs and increased capabilities.
Technology (Includes - hardware, software, communications systems)	Ability for remote deployment of firmware and network communication upgrades to end devices is mandatory otherwise is not scalable or sustainable.
	Number of commercial customers with a fully integrated Energy Management Information System is small in Maritime Provinces.
	Short of a power outage, in the event of a breakdown in network communication between the head end and end device, the end device must be able to automatically revert to normal operational behavior until communication can be re-established: • Failsafe design in products required to protect the customer.
	Encountered challenges with technical aspect of network communications i.e. using customer internet for both res/commercial (firewall restrictions, various types of routers, different internet provider firmware, and protocol for lost communications, not tamper proof, limitations with wireless etc.).
Customer	The effort to manage the customer relationship (recruit, retain, educate etc.) was significantly underestimated: • PSA is a "customer focused project using technology" versus a "technology project involving customers".
	Utility should own the customer relationship: • Leverage existing programs/processes for customer recruitment/support.
	Public's overall lack of understanding of energy and electric utility • Don't underestimate the requirement to educate the customer.

	Once you go beyond the meter the customer relationship is much more complex. Site assessment criteria is important to quickly eliminate ineligible customers and is key to mitigate dealing with high-risk or challenging installations: • Customers don't know what equipment they have. • Avoid overly complex installs. • Utility will inherit any pre-existing problems once into the installation stage.
	Residential customers are more open to participating in R&D projects with minimal or no incentives.
	Commercial - larger rate of participation with small/ midsize local companies versus larger multi-site, multi-jurisdictional companies.
	A relevant value proposition is required for customers to participate in the long term and would be different for a commercial program.
	When piloting new equipment, prototypes or technologies, keep the customer sample size small.
Customer Retention	Customers are willing to participate in R&D projects of this nature: • Very few requests to withdraw from project. • Still anticipate to eventually receive some type of savings/incentives as a result of their involvement in the program.
Technical Solution	The technical solution implemented works! There are over 1400 customers with 17.6 MW of connected load. Various end devices are being controlled up, down, on, off through a 3rd party aggregator with minimal impact to customer behavior and comfort.
	Aggregators are erring on the side of caution with regards to the percentage of connected load actually made available for load shifting rather than risk negative impact to customers.
Installations	Positive initial installation experience important for customer: • Installer must be knowledgeable on the product, the research objectives, and potential impacts to customer. • Leverage existing contractor networks/relationships. • Work with contractors that customers (in particular commercial) know and trust • Service contractors very territorial (geographic/customer).
	Limit customers to a small geographic area for serviceability. This guideline was harder to adhere to for commercial customers as the focus was on maximizing the most load in a cost effective manner.

	More opportunity to have a one size fits all solution for residential customers compared to commercial customers as the installation is a more consistent and repeatable solution
Project Execution	Alignment on the definition of success is challenging. R&D projects tend to be benchmarked and evaluated against typical utility capital or O&M projects. With R&D there is no guarantee of a successful business case or a commercialized product. Focus should be on the learnings around customer, technology, industry capabilities.
	Challenging to execute an R&D project within a utility environment due to the risk averse nature of utility, expectation to adhere to formal business processes, and other competing utility priorities.

9.0 PATH FORWARD

From the very start of PSA participating customers have been made aware that PSA is a research and demonstration project with a defined start and end date. Participating customers are anticipating the project is coming to a close at the end of March 2015. The formal demonstration period ended September 30, 2014 and the utilities are using the collective learnings and experiences from the PSA project to move forward. The majority of equipment installed through PSA will remain at the customer site.

The four pilot projects are in various stages of transitioning their customers back to "normal" operation while they finalize their path forward. All participants agree that the PSA project has been very beneficial in growing the utility's knowledge base with ILM, their customer, and the need to be a "smart utility".

Each utility has unique problems to address which will dictate how ILM plays into their future programs:

- MECL is seeing changing market circumstances (oil heat converting to electricity, steady increase of mini-split heat pump installations) which are introducing load growth and new peaks into their electric system. They will look to leverage the PSA experience to find cost effective solutions to help address these new peaks, load growth and to integrate more wind generation.

- SJE will target intelligent peak reduction and continue to find ways to utilize and expand their existing AMI infrastructure. As a distribution company, SJE has no mandate or incentive to perform system balancing or provision of ancillary services and hence there is no business case for a VPP implementation under the current industry structure and prices.

- NSPI recognizes that PSA has helped shape their path forward. They are looking closely at a DEWH program as PSA has shown this can be done. Some investment in AMI is also likely and they will continue to explore future demand response opportunities.

- NB Power experience with PSA has directly influenced and confirmed their decision to take on larger initiatives including:

    - New marketing and customer service strategy and campaign to move their relationship and brand with the customer to beyond the meter. This is a new territory for utilities.
    - Reduce and Shift Demand strategy (RASD) where PSA customers will have the opportunity to participate in RASD programs as they become available.

UNB has emerged as a leader in the academic research community and through PSA has taken a leadership role in the areas of wind power forecasting and the development of control algorithms for various end-devices such as domestic electric water heaters. They will continue to look for opportunities to partner with private enterprise to further these initiatives.

10.0 CONCLUSIONS

Increased use of renewable energy sources in a cost effective, safe, and reliable manner is a global issue. The electricity industry in North America is witnessing unprecedented focus on renewable energy and distributed energy resource options (i.e. solar PV, battery storage) for customers from intermediaries. The transformation of the industry will force utilities to make significant changes to their existing systems. This will require new business models, new technology, a new way of thinking for all industry stakeholders and most importantly, engaged customers with a new "partnership" with their utilities.

The PSA project has successfully demonstrated that while customer load shifting through an automated ILM system is possible, it still needs to overcome challenges to become viable and cost effective. Many of these challenges are due to the fact that although the concept is not new, it is immature. The PSA project did not show a compelling business case for utilities based on the scaled-up demonstration actuals, but the results are encouraging. The costs of controllable and ‘smart’ technologies have already begun to decrease. As their market penetration grows, costs will continue to decrease. It is also anticipated that improved controllability of connected load, load forecasting capabilities, interoperability standards, and a broader deployment of controls/smart technology will positively influence the business case.

Industry research indicates that thermal (hot/cold) storage has the highest energy efficiency and among the highest discharge duration capabilities of energy storage options in the market today. A high level comparison showed the ILM Solution can be a cost effective alternative to other energy storage technologies, such as batteries, as well as conventional combustion turbines. Although the demonstration costs of the PSA ILM Solution are higher than most energy storage costs, it is expected that over time costs will be driven down.

The PSA Project also identified the importance of developing a new “partnership” with customers and that customer acceptance and participation is central to the success of any intelligent load management system. Future projects should be seen by utilities as a “customer project with technology”, as opposed to “a technology project with customers”. PSA has led the participating utilities to the realization that intelligent load management is one enabler for utilities to offer new products and services on the customer side of the meter. This will be a significant paradigm shift for utilities; moving from the “production and delivery” of electricity monopoly to a “sales and marketing” of products and services organization. This will require an appetite to transition, increased marketing focus, regulatory involvement, possible rate design changes, incentives, and most importantly, time to build the relationship and trust with customers. Most importantly, utilities will need to demonstrate a compelling value proposition to customers to ensure participation.

PSA was the first project of its kind and initiated the discussion and actions to address the changing face of utilities. The results have shown there is potential to take this beyond research and demonstration, to drive down costs, and find ways to improve and increase load control capability. PSA has helped push forward the industry by demonstrating that non-disruptive control of demand-side resources can have a direct influence on the integration of greater amounts of variable, renewable generation. The commercial aggregators that participated in the project, Enbala, Steffes, and Integral Analytics, agree that PSA demonstrations have proven the ILM Solution to be technically possible with existing technology; a milestone for the smart grid industry.