Enabling new business models by utilizing flexibility in customer load - Addressing NB Power's winter peak demand challenge by using customer thermal storage flexibility

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Abstract

The energy sector is going through a major business transformation globally. While this sector has been dominated by natural monopolies in the past, new competitors are entering the marketplace (e.g. Telco, Retail, ICT) through the convergence of technologies and rapid innovation. There is also a trend to liberalize energy markets and increase customer adoption of renewable generation which creates new challenges for electric utilities. Economic market factors and the establishment of regulatory targets, such as emission reduction goals add further complexity. To enable increasing customer choice and competition, electric utilities are questioning their current ways of working, by breaking traditional functional boundaries of their organization, diffusing boundaries between operational and information technologies and finding a way to adapt their business models while understanding customer needs and behavior. This is accomplished by leveraging increasing availability of large amounts of data provided by advanced metering, field measurement and control devices - facilitated through complex and multifaceted business transformation.

In order to maintain low and stable rates, New Brunswick Power is building a portfolio of flexible demand side resources to enhance grid stability and optimize economic opportunities to benefit the grid. As NB Power develops its strategy for these new products and services, it will need new methodologies and tools to better understand its customer wants, needs, and how they perceive value in order to deliver the right products.

1 Flexibility in the Grid

The advent of new residential, commercial and industrial consumer devices connected to the distribution grid has been creating an increasing challenge to utility operations. Many of these devices allow increased control by the consumers which means they are increasingly hard to forecast, and these devices may even be mobile and therefore able to switch between different network segments, increasing the forecasting difficulty. These devices include various residential and commercial loads, such as eVehicles, distributed generation and storage options ofter referred to as Distributed Energy Resources.

This increase in the variability of the distributed loads results in increased forecasting errors which translates into increased operational costs, and inefficient usage of utility resources. This problem of increasing numbers of variable consumer devices will cause problems for old utility models but is also an opportunity for utilities willing to change.

Many of these devices could consume electricity at different times of the day without the consumer even being aware that the consumption pattern had changed. Furthermore, many of these new consumer devices are already control enabled via information and communication (ICT) technologies, and some also have energy storage capabilities. There are literally thousands to millions of these devices available on every power grid, and more are being purchased every day.

There is an opportunity for utilities to enable this flexibility by employing solutions that combine new business models, new business processes and ICT components. Once enabled, this flexibility can then be used to solve a multitude of business problems, and to realize new business opportunities.

1.1 Balancing in the Legacy Grid

Traditional day ahead grid balancing activities would involve producing a load forecast in the form of a shape file for the next day, then ensuring there is sufficient capacity to service these load requirements. Daily balancing activities would then dispatch generation resources to match the load requirements on an hourly and sub-hourly basis. Demand Side Management activities may employ some Demand Response techniques via behavioural programs, or perhaps using direct load control to respond to specific critical peaks. These DR programs are typically incentive type programs where the customer is paid to curtail energy, and as such the incentive would be considered an expense to the utility and the curtailment would additionally result in a loss in revenue.

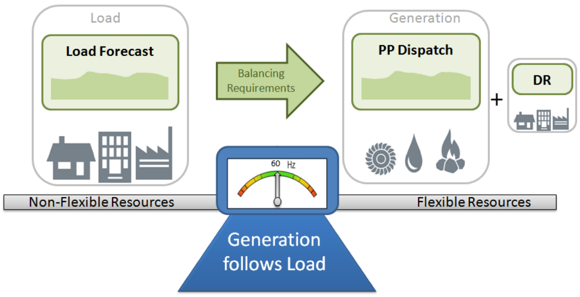

Fig. 1: Balancing in the traditional grid

1.2 Balancing in the Smart Grid

Balancing in the smart grid involves producing forecasts for the non-flexible resources. The non-flexible resources would include non-dispatchable generation (wind, photovoltaic) and combining it with the non-controllable load forecast. The resulting forecast indicates the shape that must be met to balance the grid. A variety of methods can be used to dispatch the flexible loads, but one approach would be to produce optimized dispatch schedules for the utility traditional power plants (coal or oil fired, hydro, etc.) and then dispatch the other flexible distributed energy resources to make up the difference. This technique a fundamental paradigm shift in the electricity sector is becoming known as "load follows generation". Its achievement is the breakthrough in NB Power's strategy of enabling new business models.

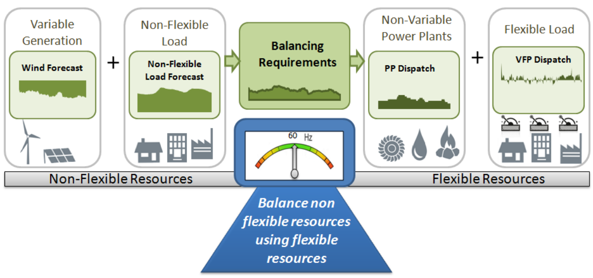

Fig. 2: Balancing in the smart grid

2 Defining, Managing and Using Flexibility

The solution described in Figure 2, includes processes and tools to allow the definition of flexibility programs, to allow customer service to support the programs, and to allow the System Operators to dispatch and use this flexibility to help them manage the grid.

2.1 Technical Solution to Enable Flexibility in the Grid

The technical solution involves connecting and orchestrating control signals sent to different ICT components that reside at the customers premise. The components at the customers premise include ICT controllers which are connected to a variety of loads. The ICT controllers were connected via ICT connections to the Siemens Integrated Load Management System (ILM). The Roadmap to plan this technical capability was designed with the Siemens Smart Grid Compass^{TM} .

The loads enabled this winter included: Residential electric baseboard heaters, Residential electric water heaters, Commercial building HVAC loads.The ILM was responsible for optimizing, scheduling and dispatching the various loads within the constraints defined by the NB Power Demand Side Management (DSM) program, and according to the dispatch instructions recieved from Grid Operations. Additionally the ILM provided interfaces to: i) allow DSM Program Management to define and configure DSM flexibility programs in the system, ii) allow Installers to install and commission the ICT components at the customers premise, iii) allow Customer Service to handle any customer issues related to the ICT components, iv) allow Grid Operations to dispatch the loads.

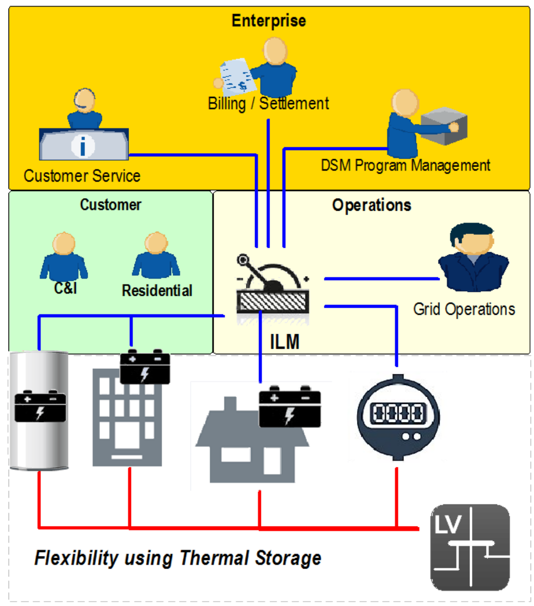

Fig. 3: Enabling Thermal Storage Flexibility - Conceptual Architecture

2.2 Defining and Creating Flexibility Programs

The first step in process focused on allowing the business to define energy problems and opportunities. The winter peak problem was selected as the first problem to address using flexibility. The energy problems / opportunities are then described as an energy profile shape. Potential distributed energy resources and services, either already available on the system, or new on the market can be identified as potential solution elements.

Business cases and flexibility programs can then be formulated around these possible solution elements. When designing the business cases , NB Power looks at each of the solutions as potential revenue opportunities, and examines new business models to support the programs. The ILM provides graphical user interfaces that allow DSM program and flexibility contracts to be defined in the system. These program and contract parameters constrain the shape of the flexibility of the resources participating in the program. The ILM is responsible for enforcing the various program and contract constraints.

2.3 Supporting Flexibility Programs

The flexibility programs include service requirements which must be fulfilled by the NB Power Customer Service department. Processes have been employed to ensure these service requirements filter down to the customer support department to be realized for the customers. The ILM provides graphical user interfaces to allow customer service to view the status of the ICT components and to support the programs.

2.4 Using Flexibility to Manage the Grid

To allow the usage of the flexibility in normal grid operations, the following process has been employed. The ILM provides a 'load corridor' file to the system operator. This file includes the forecast of the controllable portion of the load if they do not dispatch, an upper flexibility shape and a lower flexibility shape. The system operator can then send a dispatch shape file to the ILM within the bounds of the upper and lower corridor shapes.

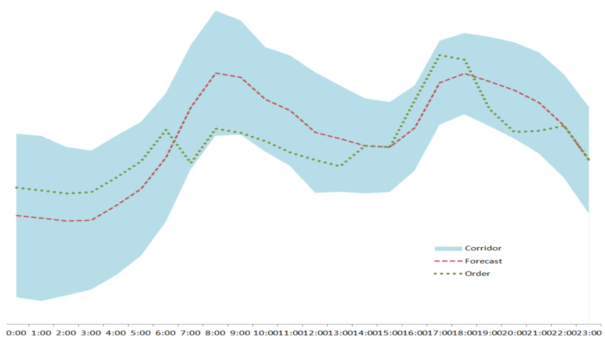

Fig. 4: The flexibility corridor - ILM Load Corridor

3 The Winter Peaking Problem

3.1 The challenge

The problem identified to be solved initially is what is described as the winter peak demand challenge. New Brunswick experiences high seasonal load conditions due to extreme cold conditions and due to a high proliferation of residential and commercial electric heating in the province. This results in the need for expensive 'peaking power plants' which are often required for only 12 days out of the year. It should be noted that although the typical annual peak would be expected to occur between 7am - 10am, changing weather patterns and other variability is increasingly changing the period in which these peaks will occur. Due to a fairly high penetration of wind generation, wind fluctuations can dramatically change the energy requirements from one day to the next for this same period of the day. This variablility further supports the business case for enabling flexibility that can be changed on a daily basis rather than solutions that would simple shift energy out of a set period every day (timer based solutions, for example).

3.2 Describing the problem 'shape'

The energy problem was described as follows: Winter Peaking Season: December 15 - March 31 Event Frequency and Duration: 1 - 2 events can be scheduled each day, with a maximum duration of 3 hours per event, and a minimum of 5 hours between events.

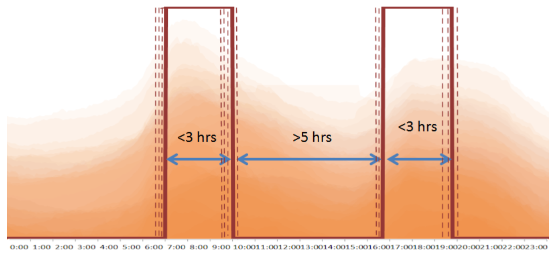

Fig. 5: Winter Peak Problem Shape

4 Potential Resources and Services to solve the challenge

Based on the energy problem profile described above, several possible solutions were identified that may be used to fit this energy profile. NB Power decided to perform winter pilots in the 2015-2016 Winter Peaking Season to validate that these are viable solutions. The possible solutions show the following preliminary results:

Type	*KW*	*KWH*
Res. Building Envelope Thermal Storage	1.7	3.5
Res. Water Heater Thermal Storage	0.9	6
Com. ETS (Electric Thermal Storage) Unit	80	360
Commercial Thermal Storage	203	13.4

Table 1: Thermal Storage Solutions - Preliminary results

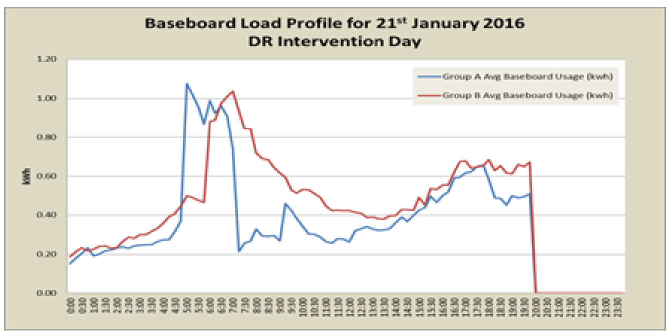

Fig. 6: Res. Building Envelope Thermal Storage Profile - Preheating (blue) vs. Baseline (red)

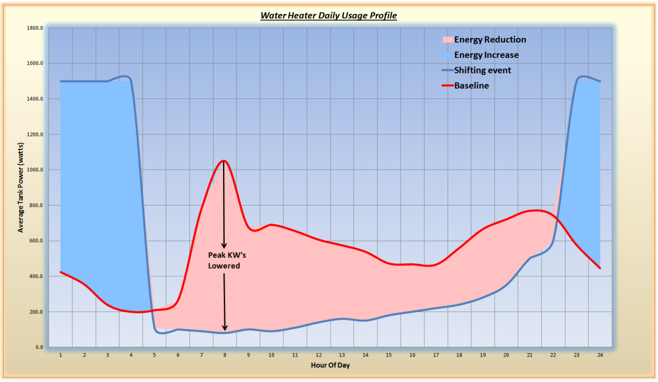

Fig. 7: Res. Water Heater Thermal Storage Profile

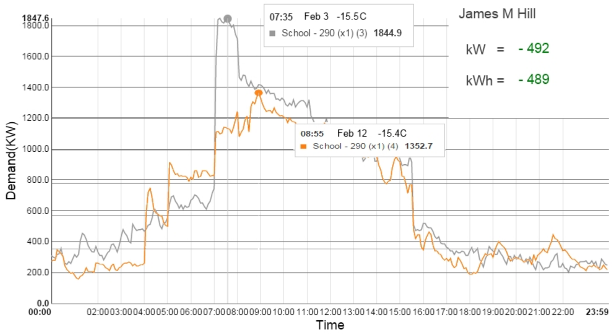

Fig. 8: Commercial Thermal Storage Profile - Ramp up strategy (orange) vs. Baseline (grey)

5 New business model possibilities

As NB power defines new flexibility characteristics in each of its market sectors, it must also reevaluate its relationship with customers to unlock its potential. Currently, on the demand side, customers interact with NB Power through energy efficiency and demand response programs that target specific products and behaviors to help customers save energy and reduce demand. Although NB Power could achieve its energy and peak reduction goals through traditional DSM, these programs focus on critical peaks and tend to put upward pressure on rates until they reach full maturity.

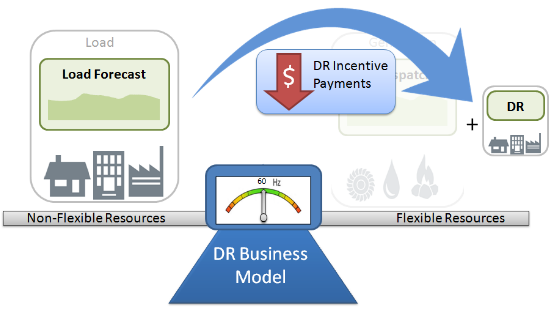

Fig. 9: The cost of Demand Response

To ensure low cost, sustainable savings are realized, NB power must move beyond simply incentivizing energy efficient products and curtailing load through demand response programs. It must position itself as a trusted partner with the expertise to help its customers build, design, and implement energy and demand management plans that leverage process improvements and technologies that benefit both the customer and the utility. Unlike traditional DSM programs, which promote participation through incentive schemes, utilities may realize new revenue by offering energy management consulting services mainly to commercial and industrial customers (but also on a smaller scale to residential customers). Utilities are also uniquely positioned to help customers derive a new revenue source by selling their flexible loads back to the grid using static or dynamic feed-in tariffs. NB Power must develop new business models to lower operational cost yet still deliver reliable, low-cost power to its customers. The main driver of these new models must be to transition a customers load from non-flexible to flexible and do so at a lower cost than developing new supply side capacity and if possible, be self-sustaining by generating new sources of revenue for the utility.

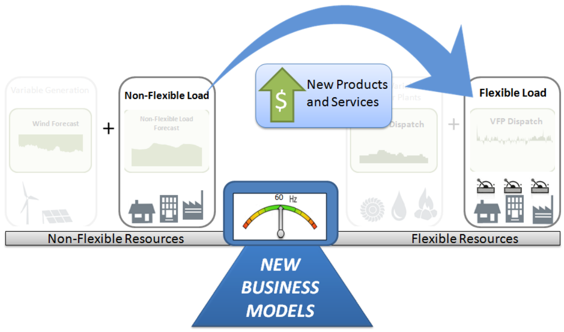

Fig. 10: Generate revenue through new offerings

6 Conclusion

As NB Power develops its strategy in order to establish a portfolio of new products & services to address its challenges through thermal energy storage flexibility, it is crucial to implement new methodologies, processes and tools and ensure corporate readiness. This transformation can only be successful if the utility moves beyond incentivizing traditional energy efficient products and load curtailing through demand response. Utilities have to leverage their unique position and expertise to become their customers' trusted partner in designing and implementing energy and demand management plans that leverage both customers and utilities.

A partnership between NB Power & Siemens

NB Power in cooperation with Siemens developed a ten year business transformation strategy to introduce new capabilities to the business and better leverage technology implementations to maximize value generation and ensure achievement of corporate objectives. These new capabilities will enable NB Power to evolve its business model beyond solely generating and delivering electricity to becoming a company that can deliver multiple energy products and services to its customers. Within this journey NB Power follows a structured approach outlined by the Siemens Smart Grid Compass^{TM} methodology.