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Linking Smart Grid Benefits to Solution Architecture

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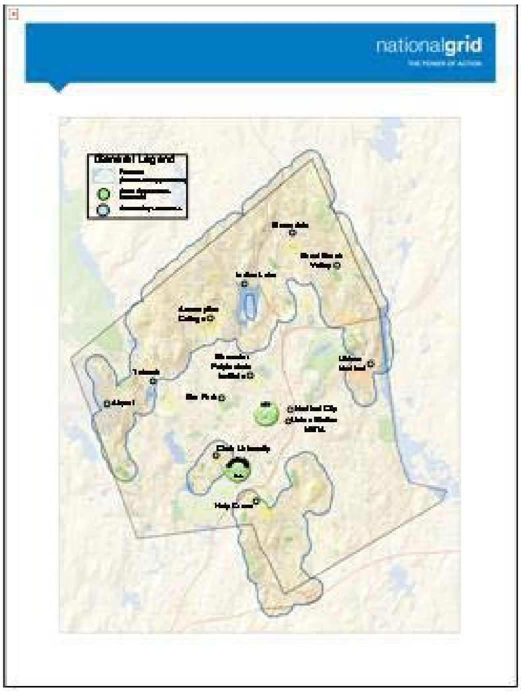
"Cloud" computing;



Northeast United States Smart Grid Pilot

National Grid is embarking on an exciting Smart Grid Pilot in the Northeast United States. The 2012 Pilot will be located in Worcester, MA, and will include approximately 15,000 customers, (2) Dynamic Pricing, provided through an "opt-out" tariff structure, (3) Energy Savings Goal seeking to achieve peak and average load reductions of a minimum of 5 percent from those customers who participate in the pilot, (4) Smart Technology to operate an integrated grid network communication system in the Worcester pilot area, which will include: (1) advanced meters that provide real-time measurement and communication of energy consumption; (2) automated, in-home load management systems; and (3) remote status detection and operation of distribution system equipment. This paper will provide insight into the drivers influencing National Grid's solution architect decision for their Smart Grid program.

SMART GRID DESIGN DRIVERS

While the United States, with its large land mass has a fairly homogenous national government from border-to-border, economies and energy policy making is much regionalized. Regional philosophies around green or smart grid initiatives have an impact on utility Smart Grid architecture decisions to meet energy efficiency objectives. For the Northeast United States and more specifically Massachusetts, there were basically four (4) key drivers that shaped National Grid's smart grid architecture decisions.

<u>Progressive Legislation</u>

The first and foremost is a progressive legislation, such as Section 85 of the Massachusetts Green Communities Act ("GCA"). The energy policy makers in the state of Massachusetts has required that each utility propose a smart grid pilot program that shall include, but not be limited to, advanced smart meters that provide real-time measurement and communication of energy consumption, automated load management systems embedded with current demand-side management programs and remote status detection and operation of distribution equipment.

Section 85 requires that any smart grid pilot program include time-of-use or hourly pricing for commodity service for a minimum of 0.25 percent of a company's customers. Further, Section 85 requires that a specific objective of any smart grid pilot program shall be to reduce by a minimum of five percent the peak and average loads of those customers who actively participate in the program. A company that designs a smart grid pilot program that includes a larger number of customers and demonstrates bill savings in excess of the minimum required is eligible to earn incentives.

Section 85 requires the Department to work with the electric distribution companies to identify specific areas of study, and the Department may incorporate and use information from D.P.U. 11-129 relevant past studies and pilot programs. Finally, Section 85 requires the electric distribution companies to include in their filings a proposed rate treatment for incremental smart grid pilot program costs for the Department's approval.

<u>Size and Location Matters</u>

While the Green Communities Act calls for only 0.25% of he customers, National Grid believes that more is needed to ensure that there would be significant event opportunities resulting in the necessary learnings to satisfy the objectives of the Green Communities Act. Therefore, 15,000 (1%) if a 1.1 million customer base in Massachusetts was chosen. Worcester is located at the geographic heart of the Commonwealth and its resident are representative of the rest of Massachusetts. Learnings from the locale was chosen due to the importance of enabling testing of smart technology over a variety of customer segments (urban, suburban, rural), customer types (single family, multi-family, small business), relevant and available third-party demographics (income, education, and technology adoptions), and load profiles (low to high, average, peak and seasonal). Furthermore, the Pilot size will allow for more represented answers during pre-pilot survey and messaging research on the following questions that interest both National Grid and the regulators: what do customers see as benefits; what is the participant's awareness of benefits? Worcester Massachusetts in its approximately 38 square miles contains all these customer attributes. In addition, the topology has suitable variation and considerable foliage, which will provide a good and challenging test bed for the communication systems being contemplated.

<u>Listen, Test and Learn</u>

It was clear from the beginning that no one in the industry had truly cracked the code on customer engagement. National Grid was determined to try. Starting early in 2011, the Company focused its efforts on improving customer engagement around smart grid benefits. The Company began a program to engage customer stakeholder groups in Worcester to both discuss the potential benefits of smart grid technology and to understand which of those benefits, or other potential benefits, they would prefer from the Company's smart grid efforts. In reviewing the experiences of other smart grid projects around the country it was recognized how vital early and positive engagement with customers and the community is to the success of a smart grid project.

National Grid wanted to make sure that the Pilot was a collaborative effort that met the community's and consumers' goals both today and tomorrow. To that end, the Company partnered with the City of Worcester to host the Green2Growth Summit (the "Summit" – green2growth.com) which was held in Worcester in September 2011. The Summit provided the Company with invaluable insight into the vision of our customers regarding the future of energy delivery in their city. In particular, the Company learned that its customers are increasingly aware of new opportunities to manage their energy consumption and are open to learning more about the potential uses and benefits of smart technology. In the end, National Grid believes a core theme that needs to be embedded in the architecture is providing customers with choice on rates that fit their lifestyle, a choice on the technologies that will help them achieve savings, and the ability the provide these choices to a very diverse population.

www.Green2Growth.com

<u>Cost and Scalability</u>

While the Green Communities Act promotes far reaching objectives and the use of a wide range of technologies, a utility is faced with a critical deployment decision. Should the architecture selected be step 1 in a full-scale roll-out or be sized to that of an experiment scale. The full-scale approach touches many legacy systems, a long list of system integrations, and many business processes. This approach can be costly and forces a utility to contemplate long-term decisions on legacy systems such as meter data management systems on systems performing billing for approximately 3.4 million customers in the US. Considering a 15,000 customer pilot driving those long-term system decisions, along with business process impacts drove National Grid to approach this pilot with an experiment scale. Couple that with the current downfall in the economy, made the decision that much more palatable. With this approach National Grid was determined to avoid giving up on the necessary customer features to achieve the Green Community Act objectives. With the advances and acceptance of *Cloud* computing, National Grid was able to achieve the necessary balance.

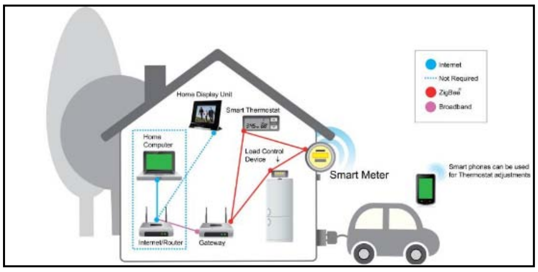
ARCHITECTURE DECISIONS

The focus of National Grid's 2012 Pilot is to provide more efficient and timely communication of energy usage information between the customer and the Company through advanced in home energy management technology, meters, and internet-based communications and storage systems. The core components of National Grid's smart grid technology end-to-end solution are (1) Advanced Metering Infrastructure ("AMI"); (2) in-home energy management devices; (3) two way communications systems; and (4) "Cloud" computing. In contrast to the current system whereby customers receive their consumption use information days or weeks after they use electricity, the 2012 Pilot's proposed Smart Grid solution will provide customers with near real-time access to more detailed energy consumption, cost/pricing information, and greater choice in controlling their energy use, with a goal of reducing energy costs.

Advanced Metering Infrastructure ("AMI") Technology

While many people think that AMI only includes a smart meter, it is actually an integrated system to collect and analyze energy usage, either on request or on a schedule. AMI extends current AMR technology by providing two-way meter communications, allowing commands to be sent toward the home for multiple purposes, including "time-of-use" pricing information, and demand-response actions. In addition to meters, AMI systems include what is known as a Meter Head End System.

The Head End System ("HES") manages two-way communication, using hardware and software, between National Grid's back office and the "smart" devices installed at customer's premises. The AMI systems also include the software and hardware to process, store and view meter data (the "Meter Data Management System" or "MDMS"), and communications systems between the meters and the Company. A key component of the meter communication system is the router (also referred to as a "Connected Grid Router"). These routers will be explained in more detail in the communications section below.

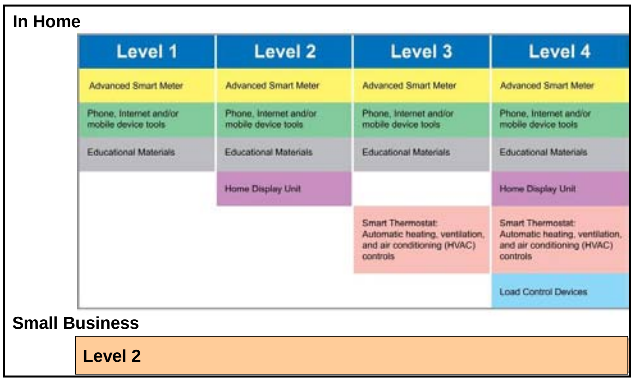


The meters selected and proposed for the Pilot will both measure the customer's energy consumption and report the consumption data in 15 minute increments to the Company. The meter will measure and report total consumption, interval consumption, demand, and energy supplied by the grid. The meters will be deployed to customers located within the Pilot area acting as a portal between in-home customer information and energy management technologies and outside the home to a neighborhood communications collector. While the meter decision appears innocuous on the surface, it is the heart of much of the information used to communicate with customers. Yes it houses newly created time-of-use programs. However, great care must be taken in the decision and the partnership required to be formed with the selected vendor, as it is the first step in creating your communication system over various topologies, your interface with the tools National Grid is providing inside customer's homes, the interface to a newly formed customer energy bills and the origination and access point for more timely online usage presentment.

In Home Energy Management Technology

The in-home energy management technologies proposed for the Pilot will enable customers to monitor their energy consumption in real time. Such technologies include picture frame displays, switches, and thermostats inside customer's homes. This system will allow customers to access detailed information on their energy consumption behavior and the system will help customers find ways of optimizing their energy use in a manner that fits their lifestyle preferences. In-home solutions are also linked to incentives to be achieved through TOU rates and demand response programs that reward customers for altering their energy consumption patterns. National Grid's in-home offerings will include a variety of ways to engage customers via two way communications.

The in-home energy management technology offerings are designed to allow customers to participate at multiple levels, have choice on tools, and not have to rely on broad-band internet connectivity to play. Customers will be provided with energy consumption information to provide them choice about their energy usage at the time of use. If customers elect to become more engaged, the information and tools available to them to actively manage their energy consumption and usage become increasingly detailed, timely and interactive, with more options and greater flexibility for the customer. Four different levels of in-home energy management technologies will be provided to customers. The levels and offerings are noted below.



Level 1 will include a smart meter which will provide customers with 15-minute interval information about their energy use. All participating Pilot customers will be given Level 1 equipment and services. The offering also includes ways for customers to manage their energy usage through their phone, the internet and/or mobile devices. For those customers who use the internet, these tools allow them secure access to a website hosted by National Grid where they can view their own energy usage information. Lastly, the consumer will be able to receive targeted educational content from National Grid through written, audio or video media (via phone, web, text and/or email) to provide information to them about techniques that they can employ to reduce their energy consumption.

Level 2 will include everything in Level 1. Also, Level 2 offering will include a home display unit ("HDU"). The HDU opens a two-way education and communication tool with our customers allowing them to learn more about their own energy use. Along with assisting the customers in participating in demand response events, the HDU will also provide customers with near real-time consumption information directly from the meter and informational alert messages from National Grid. Additionally, Small Commercial & Industrial (or Small C&I) customers will receive the ability to select this option.

Level 3 will include a smart meter, phone, internet and mobile access to energy consumption as well as targeted educational material. Also, Level 3 will include automatic heating, ventilation, and air conditioning ("HVAC") controls. With the addition of the automatic HVAC controls to the platform offerings, National Grid will be able to use this technology segment to better understand the impact of a programmable communicating thermostat ("PCT") on customer usage patterns. This group will also provide insight into the potential for behavioral changes in use by these customers, since roughly 50 percent of residential customer load can be attributed to HVAC. Two versions of a PCT will be used. One that does rely on broad-band connectivity and another that has slightly less features that do not require broadband.

Technology in this level will give customers choice to enroll in a direct load control program that allows National Grid to control the thermostat in a customer's home or business during system critical peak events.

Level 4 will consist of everything from Level 1 thru Level 3 including a HDU, automatic HVAC controls and the addition of load control devices. The use of a load control devices will provide customers choice about how they manage usage and other information for their appliances (e.g., pool pumps, lights, air conditioners, game systems, PCs,) in order to estimate the load reduction value that would occur during a demand response event.

This final technology segment will not be used to illustrate any one device as a controlled variable, but will attempt to show how all of the offerings interoperating together can maximize customer participation in the Pilot and ultimately lower and/or modify consumer load and demand patterns.

Communications Technology

The proposed Pilot communications network will consist of multiple layers with differing communications technologies at each layer. The goal is to have each "smart" system utilize a common communications network infrastructure. Communications will occur starting with the customer's home area network ("HAN"), which will communicate data within 50-100 feet of a customer's home, and then proceeding to the Company through a local area network ("LAN") that communicates data within 500-1500 feet of the customer's home, a wide area network ("WAN") that communicates data within one to five miles of the customer's home, and then to the Company through either dedicated communications lines or wirelessly.

1. Home Area Network ("HAN")

The HAN consists of the communications between both the in-home devices and from the in-home devices to the meter. Each meter deployed as part of the 2012 Pilot will have Zigbee communications enabled. This technology will provide a communications path from the meter into the home. Real time consumption information, simple messaging, and demand response communications will be able to be transmitted through the Zigbee communications module. All hardware will support Smart Energy Profile ("SEP") 1.0 with the ability to migrate to 2.0 when that standard is ratified. Utilizing Zigbee SEP 1.0 ensures compatibility with a wide range of vendor hardware for use in the home. By following this standard, National Grid will be able to test multiple hardware configurations as part of the 2012 Pilot. Zigbee will provide a base communications capability into all customer homes. For a subset of customers in the Pilot, advanced in-home energy management devices will be provided, as described previously, including a web portal, home energy management tools and remote control of appliances and lighting.

2. Local Area Network ("LAN")

The primary layer is considered the LAN. This layer of the overall network architecture communicates data approximately 500-1500 feet from a customer's location and will use a new and improved Internet based communications system which expands the number of devices that now can be connected to the Internet. Internet Protocol version 6 ("IPv6") technology will provide the most up-to date security and interoperability capabilities.

The LAN utilizes wireless "mesh" network architecture to increase the efficiency of the communications of data from the meters to National Grid. The main components of the mesh network include the connection of the new advanced customer meters and routers. The meters connect to each other in the mesh. When one meter in the mesh is unable to communicate to the router, the rest of the meters in the mesh can still communicate and will pass the encrypted data through to its final destination. The mesh sustains signal strength by breaking long distances into a series of shorter jumps.

3. Wide Area Network ("WAN")

The WAN layer will consist of approximately nine base stations. Base stations will be located at existing third party cellular towers and on National Grid structures, as necessary. The WAN layer will be based on private wireless network using Worldwide Interoperability for Microwave Access ("WiMAX") technology. WiMAX is an international standard for wireless high bandwidth communications. Data collected by WiMAX base stations will be connected to the Company applications through various means.

The WAN base stations will be co-located with the routers as well and will transmit data to and from the routers where applicable. They will also communicate directly to all grid devices. The WAN will support communications for technologies like automated switching and reconfiguration of feeders along with other grid systems. From the WiMAX base stations, data will be communicated to the Company utilizing existing fiber optic networks, microwave radio or public carrier technology. Detailed design will determine the actual technology at each location.

Cloud Computing

The Company believes that the emergence of "cloud computing" will enable the Company to take advantage of services leased from third-parties to gather and manage customers' energy consumption data, rather than require the Company to incur the costs of purchasing, building and operating these systems in house, as would be required in a step 1, full-scale rollout approach. Using leased data services for meter data management and in-home technologies is a key cost saving opportunity since no long-term investment is required in computer systems or software to collect, analyze and store data for the Pilot program. It will also allow the Company to evaluate the potential long-term value for customers through the use of this model.

Cloud computing will be used by the Company for the Pilot in order to store, view and process data communicated to the Company through the HAN, LAN, and WAN. Cloud computing encompasses many elements of computing beyond software, including the buildings that house the cloud services (including access security and space conditioning) underlying hardware (infrastructure), the operating systems (platforms), and software. With cloud computing, all three elements are "leased" over the Internet, rather than being managed locally. Simply stated a user can store, view and process their data on the Internet rather than on a computer or a network of computers.

The strategy and inherent design of a functioning "cloud" draws its parallel from the concept of an electrical grid. The utility provides the customer with energy, the delivery of which is coupled with maintenance and other services all at reasonable rate. With cloud computing, a vendor will provide technology that delivers data and information processing capacity and capability at a nominal rate. Centralized data processing, hardware, software, applications, and telecommunications facilities at the vendor's location connect the user community such that the system can flex on-demand to accommodate increased needs. It does this by enabling the many different secondary clusters of cloud computing resources to become available when the demand is high. The Company only leases these additional resources as required thereby reducing the cost.

CONCLUSION

There are four (4) key drivers influencing National Grid's technology architecture decisions: *Progressive Legislation* calling for energy savings on the power system and providing tools for customers to achieve those goals; *Size and Location* big enough to ensure believable results across a diverse population in terrain that is representative of the utility service territory; *Listen, Test and Learn* outlook to ensure open engagement with the community; and *Cost and Scalability* to ensure minimum burden to customers, while being able to test scalable technology that claims to be future-proof. National Grid believes that the proposal for their 2012 smart grid pilot has addressed all of these drivers with fitting technology decisions to achieve the Massachusetts Green Communities Act objectives, that will have results that will be statistically significant in a representative area, that will provide customers from diverse backgrounds with choice that fit their lifestyle, and decisions that demonstrated cost prudency. These conclusions were most recently buoyed by a positive approval decision by the Massachusetts State Regulators. At the writing of this article, National Grid is ramping up and entering the design and deployment phases.