2013

The eEnergy Vermont Collaborative: Bringing the Smart Grid to the State of Vermont

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A JOINT PUBLICATION OF THE UNIVERSITY OF VERMONT JAMES M. JEFFORDS CENTER AND SANDIA NATIONAL LABORATORIES

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February 15, 2013

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The evolution of the traditional analog power grid into a digital smart grid is slowly taking root within the United States and across the globe. Although the march toward a smart grid is not without its challenges, the opportunities promised by industry and policy leaders have been compelling enough for utility companies and their regulatory counterparts to begin a large scale strategic capital investment into the retooling of the nation's energy infrastructure. This article presents how one state is undertaking this effort.

The smart grid has the potential to transform the relationship between energy consumers, energy producers and energy distributors. Those who have followed the recent investments in smart grid technology have noted that substantial collaboration is required between utility companies, and between the utility industry and federal, state and local regulators in order to carry out this large-scale capital investment. The nature of this collaboration needs to be better understood, as new pricing schemes, the large scale collection of detailed forms of information regarding people's energy consumption patterns, and existing mixed patterns of regulatory and market mechanisms all add complexity to the evolving nature of smart grid governance and operations.

In the United States, it has been widely noted that the network of institutional actors and circumstances that drive energy distribution varies across different jurisdictions. The heterogeneity of energy distribution arrangement across different states (and nations) suggests that smart grid implementation will unfold within a diverse array of multi-institutional arrangements. The role that these arrangements play during the early scoping and implementation phases of smart grid investments will need to be understood.

As we will briefly explore in the next section, the generation and distribution of energy to a given region has been historically framed as the juxtaposition between regulatory and market forces. The introduction of smart grid infrastructure into any region raises new questions about the proper mix of these market and regulatory forces. Questions of pricing and consumer choice are amplified within the information-rich smart grid environment. Consumer incentive programs seeking to optimize and manage demand will seek to draw on consumer information to better anticipate and simulate anticipated behavior changes. With concerns over consumer privacy and health impacts of smart grid remaining, a proper balance between consumer and citizen rights, energy efficiencies and market-based incentives will be called for.

The decisions and multi-institutional arrangements set in place to implement the smart grid stand to shape and inform the new smart grid governance terrain. As we will demonstrate in this case, smart grid investments are path dependent, and largely shaped by decisions made early in the scoping and planning process. By undertaking a comprehensive case study of the Vermont case, we will explore how certain factors led to the state's investment in smart grid technologies. We highlight the evolving nature of the state's regulatory function and the willingness of the state's utilities to work together to achieve common goals. This case study focuses on the factors that contributed to the investment of capital to build a statewide smart grid infrastructure. This case does not focus on some of the current controversies surrounding the deployment of smart grid infrastructure, except when these concerns shaped investment and implementation decisions. We will note in the concluding section how some of these remaining concerns are being addressed, suggesting here that realizing the potential of the smart grid hinges on the protection of consumer privacy, the security of the energy grid, and the development of useful incentives to drive energy efficiency. As we will note, building a smart grid is just one phase in a process of evolving our energy distribution system.

Introduction

As one of the early leaders in the development of statewide smart meter infrastructure, Vermont serves as an important early example of investment in smart grid infrastructure. Vermont's

The smart grid is an intelligent, auto- balancing, self-monitoring power grid... It is a system that will allow society to optimize the use of renewable energy sources and minimize our collective environmental footprint. It is a grid that has the ability to sense when a part of its system is overloaded and reroute power to reduce that overload and prevent a potential outage situation; a grid that enables real-time communication between the consumer and utility allowing us to optimize a consumer's energy usage based on environmental and/or price preferences.[1]

story thus far has been noteworthy for the level of collaboration between the state's utility companies and cooperatives. A strong policy environment has led to the enactment of a series of energy conservation and renewable energy initiatives. The state's energy distribution and transmission organizations have maintained relatively stable and collaborative relations with state regulators. The creation of the eEnergy Vermont (eEVT) Collaborative has also been enabled by investments made in smart grid infrastructure by Congress and the US Department of Energy. This case demonstrates a clear and compelling example of "public-private partnership" in the area of large scale, public good capital improvements.

In this paper, the authors answer the following questions:

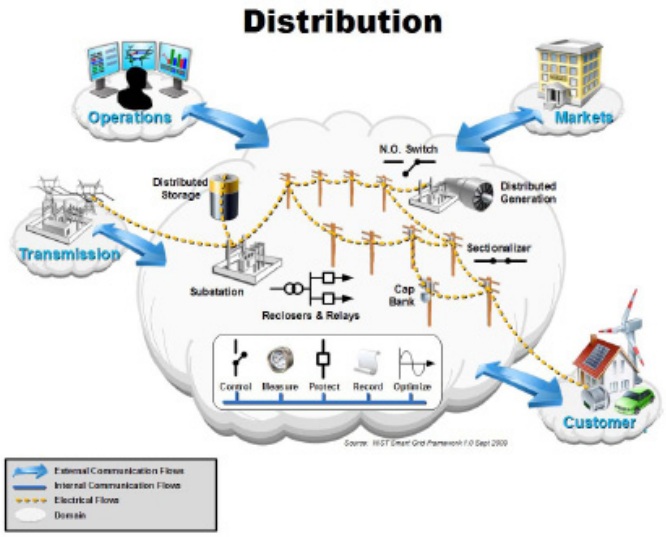
- How did Vermont, with its 22 different utilities and cooperatives, manage to pursue and successfully obtain the resources needed to implement a statewide smart grid infrastructure?
- What factors led up to the development of the eEnergy Vermont Collaborative (eEVT), the public-private partnership designed to implement smart grid infrastructure?

By asking these questions, lessons from Vermont's early adaptation of smart grid technologies will be identified. As a result, a foundation for an ongoing comparative analysis of other state-wide or regional development of smart grid infrastructures is established.

We begin with a review of the existing literature on energy transmission and distribution networks, defining these "networks" to mean the multi-institutional arrangements that have been created to provide energy to a region's households, institutions and businesses. After explaining our methodological approach, we lay out a description of notable events and activities that have marked Vermont's recent energy provision history. We then analyze this case for the key factors driving this initiative forward. We culminate the publication with a look forward, anticipating how the next phase of smart grid implementation (moving from infrastructure to pricing and applications) may be informed by the recent past. Implications for additional case studies are drawn.

Energy distribution networks in the United States

Since the very first laying of power lines in the United States in the late 1800s, the successful distribution of energy to a region has required the coordinated actions of utility distribution and transmission organizations operating within particular kinds of regulatory environments. Utility companies of diverse sizes and governance arrangements have collaborated with energy transmission institutions to provide the reliable flow of power to a designated region. Over the course of this history, energy distribution and energy transmission organizations have always had to work within certain regulatory subsystems. The composition of public, private and nonprofit organizations comprise the interorganizational, energy distribution networks responsible for the governance and distribution of power to the population of a region.



Source: NIST. (2010). NIST Smart Grid Interoperability Standards Program, Washington, D.C.

In the United States, the nature of these energy distribution networks remained largely consistent until the 1990s. Prior to the middle 1990s, the governance of these networks was tightly controlled by state-level utility regulators. As the deregulation movement began sweeping across many sectors, energy distribution networks experienced changes within those states that chose a reform agenda. Current regulatory environments range from those with very strong regulatory oversight to very weak regulatory oversight. The deregulation of the utility industry in some states has led to profound alterations in the balance of power between market forces and the public accountabilities carried out through regulatory oversight. In

those states that chose the path of deregulation, consumers are more likely free to choose their utility provider. Consumer voice is exercised most strongly through their choices of providers.

In those states that have retained a strong regulatory oversight or maintained successful municipal or cooperatively owned utilities, consumer voice and choice is exercised through the use of public hearings and democratically anchored regulatory bodies. The State of Vermont chose not to pursue deregulation and therefore falls into the latter category.

The core of any energy distribution network includes utility companies and cooperatives, state regulators and consumers of energy. These actors carry out basic functions: provision, management and use of energy. In the pre-smart grid era of energy distribution networks, consumers have a relatively passive role in the network. Utilities, regulatory agencies and other industry institutions are largely shaped by the nature of regulatory, cooperative and competitive ties that are permissible. These arrangements are likely to change as smart grid technologies allow for greater flow of information and decentralized control of energy generation. As more renewable energy sources are devised and a greater number of electric vehicles get into circulation, the nature of energy distribution networks will likely evolve with it. The eEVT case study explores how a coordinated smart meter project in one state is adopting to these realities.

To address these questions the authors conducted a series of interviews with representatives from utilities and cooperatives in the State of Vermont, VELCO, the Vermont Department of Public Service, the Vermont Public Service Board, and members of the Vermont Congressional staff. This interview data was triangulated with source documents found on websites and reports to the US DOE.

Historical roots of Vermont's energy distribution network: A patchwork quilt

Vermont is the first state to scope and execute a statewide plan to install and utilize smart meters in 85% of all electricity consumers in the state. This document describes the factors that have contributed to the state's success thus far and provides some important insights for other states and government decision-makers.

In October 2009, a collaborative of twenty Vermont electric distribution utilities, an efficiency utility, and a transmission utility were awarded an American Recovery and Reinvestment Act (ARRA) Smart Grid Implementation Grant (SGIG) ("eEnergy Vermont") worth $69 million. The amount was matched with equal investments by local and regional utilities, providing $138 million to provide smart meters for 85% of all electricity consumers in Vermont by 2013.

Informed by stakeholder interviews and analysis of materials, this document summarizes the key drivers that have contributed to Vermont's success. These include: Vermont's ability to effectively leverage federal funding to implement smart grid technology, a forward looking policy environment within the state, collaboration between regulators and stakeholders, an innovative energy industry, and a strong legacy of integrated statewide strategic planning.

Vermont has a rich history of cross-sector collaboration within the energy utility industry, particularly as a means to achieve statewide energy efficiency goals. Throughout the last century, utilities have partnered with entities in the public and private sector, and the citizens of Vermont, to transform the state's electric enterprise through regulatory, technological and consumer behavior changes. The story of the development of Vermont's capacity to implement smart grid technology begins over a century ago, with the creation of the state's first utilities.

In 1893, Green Mountain Power (GMP) was founded in Colchester, VT. Today, GMP is Vermont's second largest investor-owned electric company and serves 90,000 customers in throughout the northeast.[2] Just over twenty years later, in 1905, the Burlington Electric Department (BED) was founded. City officials, led by Mayor James Burke, facilitated the formation of BED as a way to reduce consumer electricity costs. Today BED is the largest of Vermont's municipally owned utilities and serves over 19,600 customers in City of Burlington and the Burlington International Airport area.[3]

Large Actors in Vermont's Energy Distribution Network

On August 20, 1929, eight electric companies consolidated to form Central Vermont Public Service (CVPS). Today, CVPS is Vermont's largest electric company, serving 159,000 customers in 163 communities throughout the state. Nearly ten years later, in 1938, the Vermont Electric Cooperative, Inc. (VEC) was founded in Johnson, Vermont. VEC, a member-owned non-profit electric distribution cooperative, was established to serve residents in rural Lamoille County who were un-served by investor-owned utilities. VEC strategically grew its service territory (more than doubling its membership with the acquisition of Citizens Communications Company's Vermont Electric Division in 2004 and selling its Southern District, which served 2,770 members, to CVPS in 2006) and now serves approximately 34,000 members in 74 towns throughout northern Vermont.[4]

In 1956, Vermont utilities joined together to create thenation's first statewide "transmission only" company, the Vermont Electric Power Company (VELCO). The formation of VELCO is the first of many examples of unprecedented collaboration within the Vermont energy industry. The VELCO enterprise supported and encouraged utility collaboration because Vermont utilities shared ownership and were unified by a common goal – access to clean hydropower from the St. Lawrence River project.[5] Half a century later, VELCO is the country's fastest growing transmission company[6] and is still owned and controlled by Vermont utilities. The company plans, designs, constructs and operates Vermont's bulk power transmission system, which consists of: 660 miles of transmission lines, 12,000 acres of rights-

of-way, 44 substations, equipment that enables interconnected operations with Hydro-Quebec and fiber optic communication networks that monitor and control the electric system and provide the backbone for high-speed data internet access.[7]

VELCO also provides a strong unified voice on regional energy and climate issues by representing local utilities in power pool matters with the New England Independent System Operator (NE ISO).[8] In 2006, VELCO and local electric distribution companies collaborated and established Vermont Transco LLC. The new enterprise, which was tasked with managing Vermont's high-voltage electric transmission system (115 kV and above) and providing service under applicable Federal Energy Regulatory Commission (FERC) tariffs to Vermont's twenty electric distribution utilities, two small distribution utility loads in New Hampshire and loads throughout New England through the New England ISO, benefited from VELCO's fifty plus years of transmission system management.

Utility Name	Founded	Size	Governance
Green Mountain Power (GMP)	1893	90,000 customers throughout NE	Investor owned
Burlington Electric Department (BED)	1905	Over 19,600 customers in Burlington area	Municipally owned
Central Vermont Public Service (CVPS)- Merged with GMP in 2012	1929	159,000 customers in 163 VT communities – state's largest electric company	Made up of eight consolidated electric companies; Now merged with GMP
Vermont Electric Cooperative (VEC)	1938	34,000 members in 74 towns in Northern VT	Member owned non-profit electric distribution cooperative
Vermont Electric Power Company (VELCO)	1956	First statewide 'transmission only' company –encouraged utility collaboration	Owned and controlled by VT utilities
Vermont Transco LLC	2006	Manages VT's high voltage electric transmission system	Collaboration between VELCO and local electric distribution companies

A focus on energy efficiency takes root through regulatory action

While the utility industry in Vermont continued to grow through strategic collaboration, policy makers began to focus on promoting energy efficiency through the regulatory process. In 1970, Vermont enacted a land-use planning law (Act 250), which mandated that "energy efficiency" be one of the review criterion for major new construction project permits.[9] This effort was in many ways ahead of the national trend, having preceded the 1973 oil embargo, which peaked national interest in energy issues. As the rest of the country just began to be cognizant of energy issues, Vermont regulatory agencies were demonstrating their sustained commitments to energy efficiency, leading studies in "Demand Side Management" (DSM) and "Least Cost Planning" for utility companies throughout the 1980s. In response, several regulated electric utilities conducted pilot programs to further investigate energy efficiency. During this time (1978 – 1985), Vermont also conducted over 19,000 residential energy audits through "Energy Extension Agents."[10]

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In 1986, the Vermont Energy Investment Corporation (VEIC), a mission-driven non-profit organization focused on reducing the economic, social and environmental costs of energy consumption, was founded in Burlington, Vermont. With a current staff of 170 and annual budget of $40 million, VEIC now serves a wide variety of public and private sector clients in Vermont and across the world. VEIC consults nationally and internationally, and facilitates the development of policy at the local, regional, national and international levels. In addition to being recognized as a national leader of customer-sited renewable energy programs (e.g. the Northeast's first "Million Solar Roofs Partnership" with DOE in 1998), VEIC is acclaimed for the highly successful operation of Efficiency Vermont, the first "energy efficiency utility"[11] in the United States.

Vermont's utility industry has long been supported by statewide regulatory bodies who have attempted to work in a cooperative manner. This collaborative culture has been said to pave the way for innovation within the state's energy sector. The Vermont Public Service Board (PSB) is a quasi-judicial board that serves as the decision-making authority in Vermont utility regulatory cases and supervises the rates, quality of service and overall financial management of Vermont's public utilities. The PSB also organizes and facilitates working groups to address complex issues, like utility rates, consumer interface and communications, cybersecurity and interoperability.[12] Workshops can be requested by stakeholders (e.g. consumers, utilities, government officials) at any time, and serve as an informal opportunity to dialogue outside the official hearing process. There is a belief that the open communication between the PSB and its stakeholders

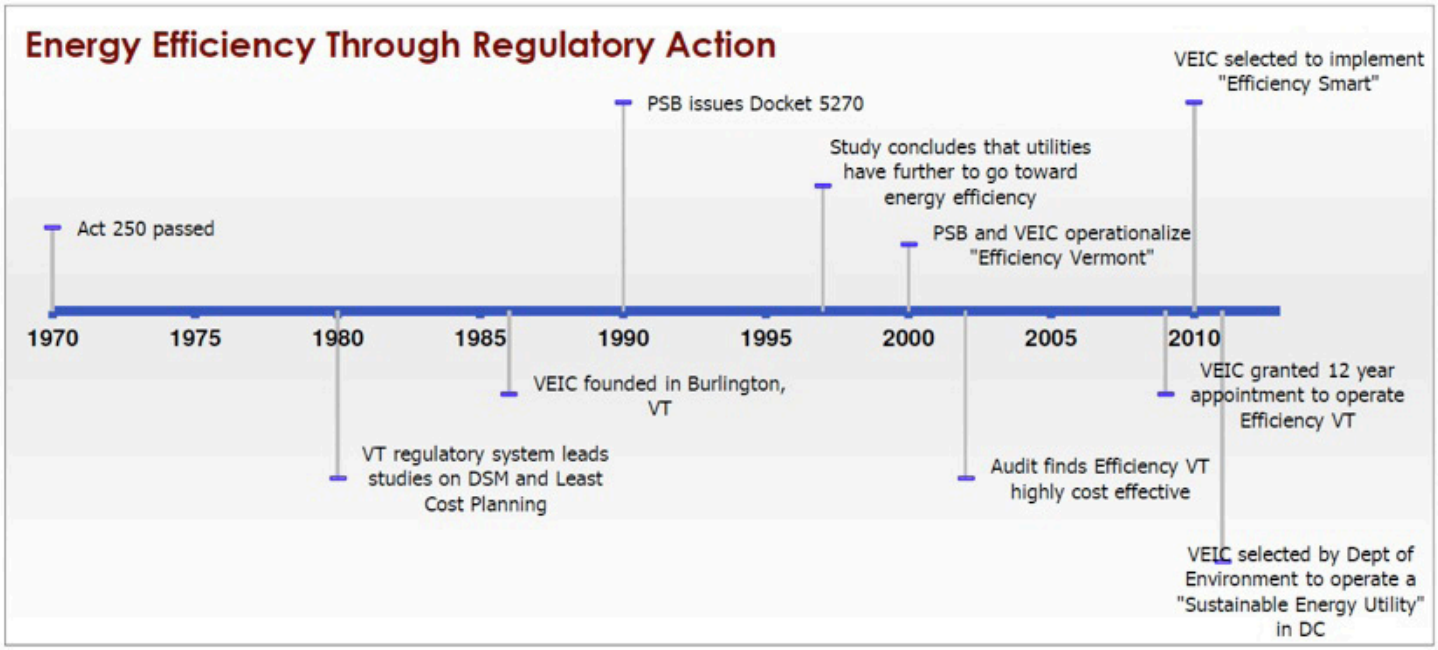
leads to a more collaborative and cordial relationship than exists in many other states. [13]

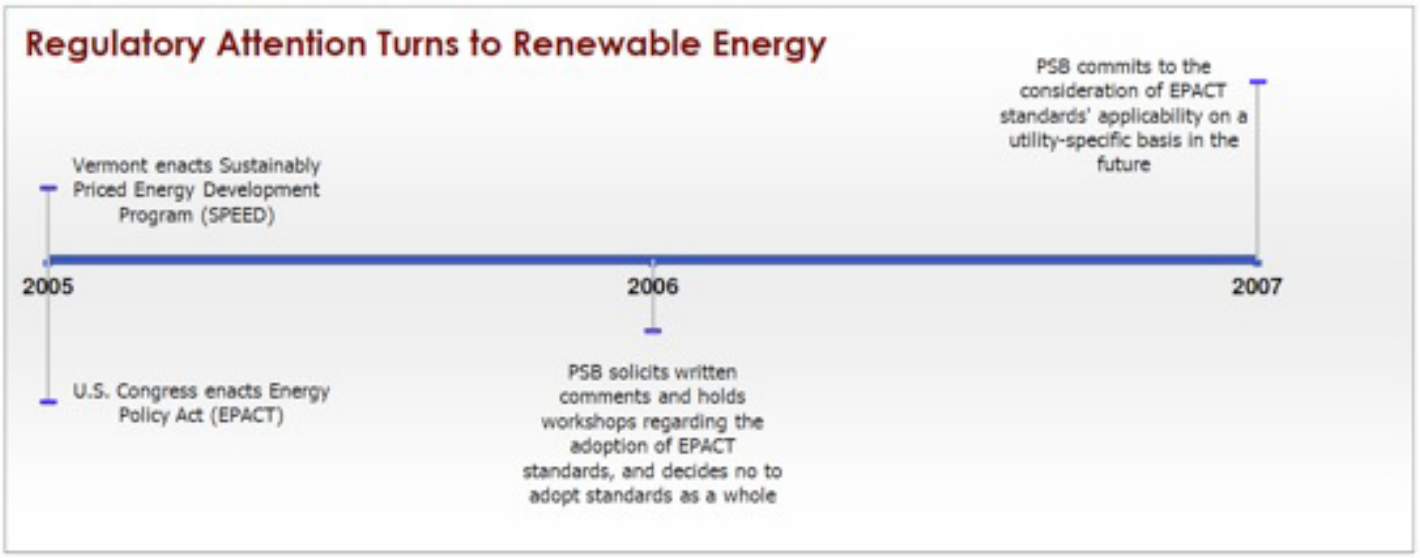
In 1990, the PSB issued a ruling (Docket 5270) based on the energy efficiency investigations and pilots conducted during the preceding two decades. The PSB found that implementing energy efficiency programs could save billions of dollars for Vermont consumers, while reducing environmental impacts. The ruling mandated that utilities develop and implement plans to pursue greater efficiency measures, effectively shifting the focus away from supply-side cost reduction measures to meet consumers' needs.[14] While this ruling laid the foundation for many of Vermont's most successful subsequent programs, and spurred considerable investment in energy efficiency, the "utility administration" model encountered many short-term problems. The core issue was lack of collaboration. With twenty-two different utilities focused on serving their customers while pursuing demand-side management, marginal cost pricing, least-cost planning and efficiency programs independently, the regulatory and administrative costs became burdensome. Additionally, there was an apparent misalignment between efficiency goals and utilities' profit structures, which were based on per unit sales rather than per capita reductions, creating a disincentive for utilities to invest in energy efficiency measures.[15]

Ongoing disputes between utilities and regulators culminated with a 1997 study, which concluded that while mandating energy efficiency spurred some short-term investments, most utilities could have achieved much greater savings through energy efficiency programs. Regulators were confronted with the challenge of encouraging a more collaborative approach to energy efficiency, while designing incentives to motivate utilities to more fully commit to it. A regulatory proceeding was opened to consider alternative models to promote efficiency, namely a single statewide entity. In 1999 the PSB reached a settlement with local utilities and received recommendations from the Vermont Department of Public Service (DPS) – an agency within the executive branch of Vermont state government charged with representing the public interest in matters regarding energy, telecommunications, water and wastewater. The PSB reacted to the newfound information about energy efficiency (S. 137) by creating the nation's first statewide "Energy Efficiency Utility" (EEU). The new utility was tasked with managing energy efficiency programs previously within the purview of individual utilities. It would operate under a performance-based contract with the PSB and be funded by a volumetric "Energy Efficiency Charge" added to the bills of all retail electric customers. VEIC won the contract to operate the EEU through a competitive bid process, and in 2000 VEIC and the PSB developed a brand identity and operationalized "Efficiency Vermont."[16]

Efficiency Vermont's fundamental role is to promote energy efficiency by influencing consumer decisions. It does so by offering technical assistance, financial incentives and public information. The organization provides technical assistance, particularly helping consumers with cost-effective upgrades for residences and offices, and working with product and service providers to develop, sell and operate energy efficient products. Another essential element of Efficiency Vermont's approach involves analyzing markets and barriers that affect consumer decisions about energy efficiency, particularly focusing on capturing savings from "lost opportunity markets." Efficiency Vermont's role is coupled with the roles of local utilities to deliver efficiency resources and energy generation, reinforcing a statewide focus on both collaboration and energy efficiency.[17]

An important component of the EEU contract through which Efficiency Vermont operates is the need for specific, measurable results, which should be consistently benchmarked through performance-based indicators. In 2002, an audit of Efficiency Vermont was conducted to verify the EEU annual energy and capacity savings estimates of the program. The audit found the program to be highly cost effective, as Efficiency Vermont had "met or exceeded nearly every goal set by regulators since its





inception in 2000."[18] In 2008 alone, Efficiency Vermont achieved annual savings equal to 2.5% of Vermont's sales (offering efficiency services at 2.9 c/kWhr, compared to 14 c/kWhr for new generation, and saved consumers $16M)[19], positioning Vermont as the first state in the country to achieve efficiency savings that more than offset growth in electric use. These savings enabled Vermont to maintain a negative electric load growth in both 2007 and 2008.[20]

In November 2009, the PSB reached a decision to adopt an "order of appointment" model to replace Efficiency Vermont's short-term competitive bid model. Subsequent studies showed that the incumbent contractor, VEIC, provided superior service to potential alternatives, and VEIC was granted a twelve-year appointment to operate Efficiency Vermont.

In 2010, VEIC was selected to implement "Efficiency Smart," an energy efficiency initiative serving 47+ communities in Ohio, Pennsylvania and Michigan, adding to the to 28 states, 7 Canadian Provinces and 7 countries outside North America that VEIC already worked with.[21] In April 2011, VEIC was selected by the Department of the Environment to create and operate a "Sustainable Energy Utility" in Washington, DC. [22]

Regulatory attention turns to renewable energy

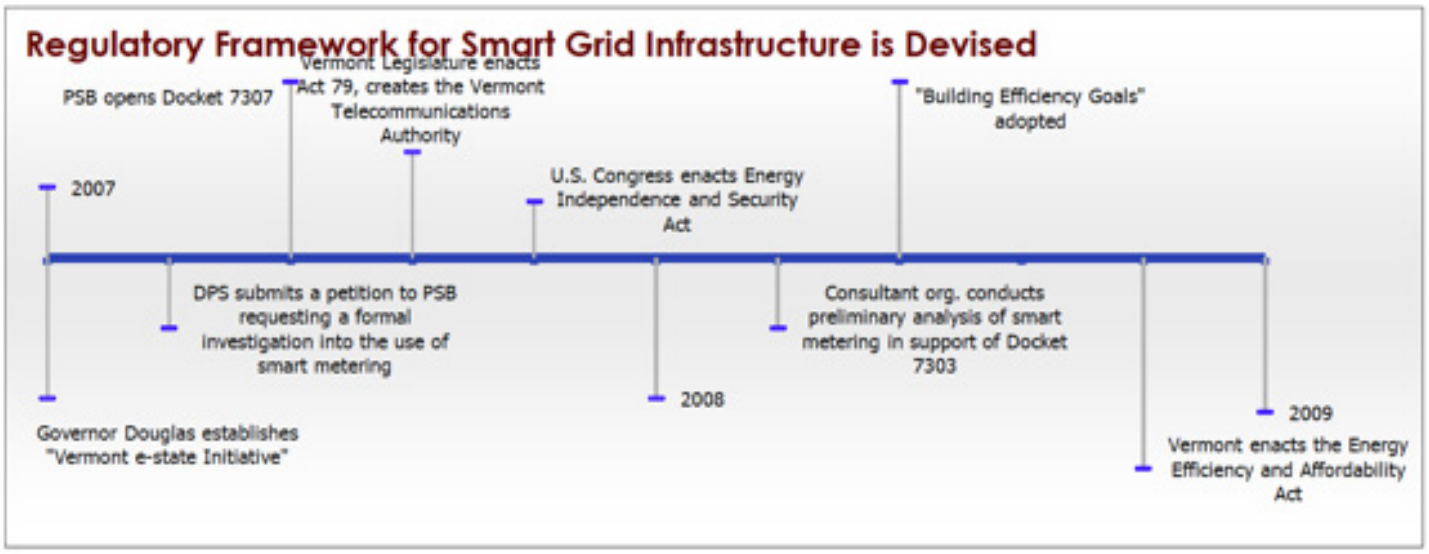
In June 2005, Vermont enacted the Sustainably Priced Energy Development (SPEED) Program (30 V.S.A. § 8005 and § 8001). The SPEED program, a State Renewable Portfolio Standards (RPS) mandate,[23] was designed to promote the development of in-state renewable energy sources and to ensure that the economic benefits of these new renewable energy sources flowed back into the Vermont economy, and specifically to rate-paying citizens.[24] In July 2005, the U.S. Congress enacted the Energy Policy Act (EPACT). EPACT called for state public utility commissions to consider the adoption of a set of five standards, "unless the state already has a comparable standard in effect, or the state commission has already conducted a proceeding considering implementation of a comparable standard, or the state legislature has already voted on the implementation of a comparable standard." [25]

Following the enactment of EPACT, the PSB solicited written comments and held workshops to collet input from utilities, state agencies and other interested parties regarding the adoption of EPACT standards. The PSB decided, based on the unique characteristics of Vermont's utilities, not to adopt the EPACT standards as a whole. In 2006 the PSB provided decisions about specific provisions, including the adoption of the "fuel diversity standard" and the "fossil fuel generation efficiency standard," but only so far as they were consistent with Vermont's Integrated Resource Plans (IRP). In 2007, the PSB committed to the consideration of the standard's applicability on a utility-specific basis in future rate-design cases, noting that because of the considerable differences among Vermont's distribution utilities (e.g. number and type of time-based rates they offered and implementation of smart-metering technologies), individual circumstances should be taken into account when determining whether to require a utility to change its rate design or its metering system. [26]

A regulatory framework for smart grid infrastructure is devised

In March 2007, then Governor James Douglas established the "Vermont e-state Initiative," which sought to provide broadband and wireless internet access to all Vermont residents by 2010. The e-state Initiative was the first of its kind, and promised benefits to both residents and the local software industry.[27] In April 2007, the DPS submitted a petition to the PSB requesting a formal investigation to evaluate the use of smart metering and time-based rates. In its petition before the PSB, the DPS stated:

- "The use of 'smart' metering equipment and the use of rates have the potential to provide numerous important benefits to Vermont electric consumers and utilities, including but not limited to sending more accurate price signals, load shifting, reduction in energy use, reduced meter reading costs, and improved customer service;



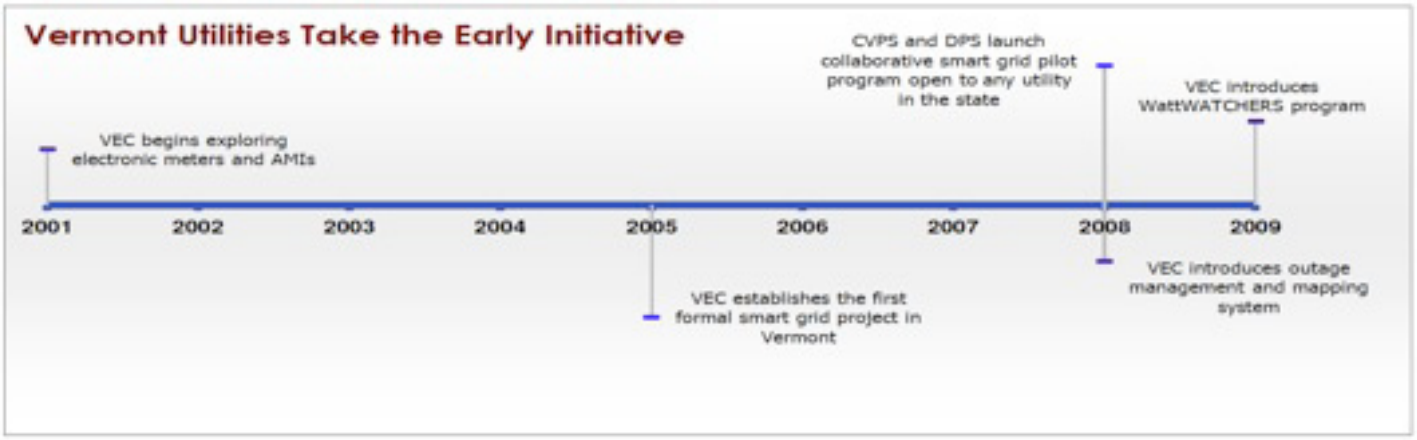
- Experience in other jurisdictions suggests that reductions in demand from pricing plans enabled through advanced meters generally correspond to peak periods when both utility costs and energy emissions are high;
- Potential benefits of "smart metering" also include more and better information about customer resource requirements for utility planners and the flow of that information to the final customer;
- Some Vermont utilities are deploying Automated Meter Reading (AMR) technologies. However, Advanced Meter Infrastructure holds more potential for overall value to ratepayers. Early deployment of AMR may undercut important ratepayer benefits from AMI technologies." [28]

The DPS' request for formal investigation of the costs and benefits of smart metering and time-based rates was granted on April 18, 2007 and the PSB opened Docket 7307, "Vermont Electric Utilities' Use of Smart Metering and Time-Based Rates." [29] The DPS stated that the investigation would, at a minimum, "evaluate the current status of Advanced Meter Reading and Advanced Meter Infrastructure technology deployment in Vermont and other jurisdictions, the costs and benefits of increased use of these technologies, analysis of barriers to implementation, the possible necessity of state-wide standards or other requirements, and the value (if any) to be gained by use of a pilot program." It would also "evaluate the use of time-based rates as they relate to smart metering, and may be expanded to include consideration of inclining block rates, should future legislation or a subsequent Board ruling require it."[30] Shortly thereafter, the Vermont General Assembly directed the PSB to investigate smart meters and to develop a report and implementation plan for AMI and alternative rate designs by December 31, 2008 (Act 92). Collectively, these measures created parallel investigations. [31]

On June 9, 2007, the Vermont Legislature enacted H.B. 248, Act 79, creating the Vermont Telecommunications Authority (VTA). The VTA was tasked with facilitating the establishment and delivery of mobile phone and internet access infrastructure and services. The initial focus of the telecommunications authority was specifically on un-served and under-served areas, with a long-term goal of broadband and mobile phone infrastructure throughout the state.[32]

In December 2007, the U.S. Congress enacted the Energy Independence and Security Act. It provided federal grants for up to 20% of the cost of smart grid technologies and directed states to consider authorizing utilities to recover costs of AMI deployment through the rate base.[33] Under the Energy Independence and Security Act, the Federal Energy Regulatory Commission (FERC), the independent agency that regulates the interstate transmission of electricity, natural gas and oil,[34] required that utilities pursue optimal functionality and interoperability. Docket 7307 built on the federal expectations at the state level, while integrating the views of a diverse set of stakeholders.[35] In March 2008, in support of Docket 7307, consultant organization Freeman, Sullivan & Co. produced a preliminary analysis of the benefits and costs associated with the implementation of smart metering and time-based rates in Vermont.[36] The DPS commissioned the report, but the cost was, per statute, billed back to all the Vermont electric utilities, with contribution based on load share.[37] The Freeman, Sullivan & Co. analysis suggested that implementation of AMI and time-based pricing would likely reduce the cost of electricity supply and delivery in Vermont, when compared to a "business as usual" future scenario. Although the findings of the report indicated negative net benefits for nine of the ten utilities examined, the authors suggested that the benefit streams used in the analysis were quite modest. They also noted that the aggregate negative net benefit was largely driven by a single utility, Green Mountain Power (GMP) whose practices at the time of investigation

In November 2008, all Vermont distribution and transmission utilities, the DPS and the Conservation Law Foundation filed a Memorandum of Understanding (MOU 7307) with the PSB to establish a framework for the regulatory treatment of smart metering.



resulted in extremely low meter reading costs and therefore GMP stood to gain little from implementation of AMI.

Following the release of Freeman, Sullivan & Co.'s initial findings about smart metering and time-based rates (2008), the Vermont General Assembly directed the PSB to investigate the benefits and costs of constructing a fiber-optic or other telecommunications facility network to link electric company substations, and to submit a report to the Legislature by January 15, 2009.[38] While the PSB pursued an investigation of telecommunications access, the Vermont Legislature moved towards the realization of statewide energy efficiency through a series of goals. The "Building Efficiency Goals," (10 V.S.A. § 581)[39], adopted in 2008, sought to substantially improve the "energy fitness" of at least 20% of the state's housing stock by 2017 and 25% by 2020. To reduce annual fuel needs and fuel bills by an average of 25% in the housing units served. The goals also included a commitment to reduce total fossil fuel consumption across all buildings by an additional .5% per year, save Vermont families and businesses a total of $1.5 billion on their fuel bills and increase weatherization services to low income Vermont residents.[40]

Later in 2008, a second set of goals, "Greenhouse Gas Reduction Goals" (10 V.S.A. § 578)[41], were adopted. The specific include reduction of emissions of greenhouse gases from the 1990 baseline by 25% by January 1, 2012, 50% by January 1, 2028 and 75% by January 1, 2050. Additionally, the goals outlined the establishment of the Vermont Climate Collaborative, which would: (1) unite higher education, business, agricultural, labor and environmental communities; (2) lead to the creation and implementation of a state-wide programs to reduce greenhouse gas emissions; and (3) promote and coordinate advocacy for cap and trade program for greenhouse gases.[42]

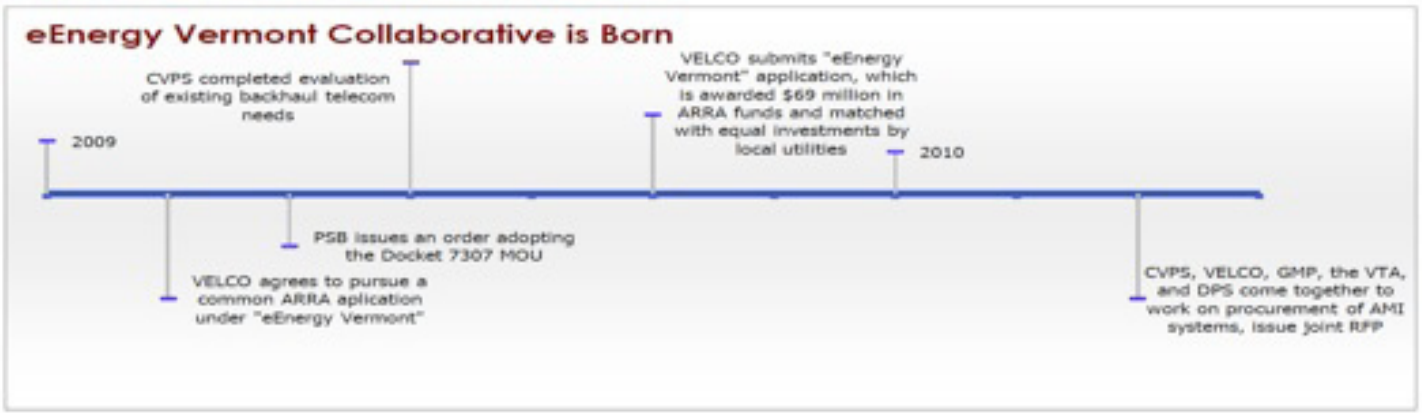
In March 2008, after establishing goals to address energy efficiency and greenhouse gas reduction, Vermont enacted the Energy Efficiency and Affordability Act (H.B. 520). Similar to EPACT 2005, it directs Vermont's PSB to "investigate opportunities for Vermont electric utilities cost effectively to install advanced 'smart' metering equipment capable of sending two way signals and sufficient to support advanced time of use pricing during periods of critical peaks or hourly differentiated time of use pricing." Additionally, it directs the PSB to require each utility to develop plans for "deploying smart meters and TOU pricing, provided that the utility serves a territory where such a deployment is appropriate and cost-effective." [43]

Throughout the fall of 2008, utilities communicated with the PSB regarding rate recovery assurance as it related to the implementation of smart metering. Utility companies sought some assurance through the DPS to mitigate the risks associated with the installation and implementation of smart meter technology. The PSB viewed the issue as a matter of cost effectiveness, and approved a measure to provide cost recovery assurance for utilities whose plans were approved by the PSB.[44] The decision both benefited utilities, by ensuring that they weren't moving forward on smart grid alone, and the PSB, by ensuring that utilities would pursue smart metering and maintain open communication with the PSB about their plans,[45] which will be essential in ensuring "interoperability of the system."[46] There was a belief within the DPS that funds needed to be leveraged for the benefit of the state.[47] However, because of its organizational mission, DPS had to be cautious about partnering with the utility industry while maintaining the public interest. Open communication between utilities and consumers was an essential component of this balance. [48]

Vermont utilities take the early initiative

In early 2001, VEC began exploring electronic meters and AMIs, along with a GPS-enabled outage management and mapping system (OMS), web-based access to consumer energy usage information and a SCADA system for substation automation and connection to a control center with fiber backhaul.[49] VEC recognized the significant potential benefits to consumers (e.g. prompter responses to power outages, lower rates as a result of greater operating efficiencies, ability to analyze consumption patterns electronically, ability to utilize smart appliances, etc.), as well as those afforded to the organization by virtue of being an early adopter of smart grid technology. VEC's motivations were somewhat different than those of other energy organizations, like Efficiency Vermont, in that its primary objective initially was to improve service, rather than change end user behavior.

In 2005, VEC began implementing a smart metering system and advanced metering infrastructure (AMI) technology, effectively establishing the first formal smart grid project in Vermont.



In February 2008, VEC introduced an outage management and mapping system (OMS) system, which enabled it to communicate and manage outages more efficiently than before. Shortly thereafter, VEC undertook substation upgrades, which incorporated a local fiber loop that connected automated reclosers, smart regulators, intelligent breakers, substation transformers and a SCADA system that provided substation information to the operations control center. In May 2009, at its annual member meeting, VEC introduced the "WattWATCHERS" program, which enabled customers to view usage details electronically.[50] VEC continued to develop smart grid projects and presently serves more than 80% of its clients through AMI technology.[51]

In response to the board decision to provide cost recovery for approved plans, CVPS created a strategic roadmap for transitioning its business operations to AMI, in addition to a strategy for the acquisition, deployment and integration of AMI into its operations in 2008. CVPS also undertook a "Strategic Telecommunications Study" to examine its communications network and identify short- and long-term potential solution for upgrades to support the requirements of an AMI system. Simultaneously, CVPS began collaborating with the VTA via a Working Group in the development and conduct of "Vermont AMI/DII/E-State Joint Backbone Network Feasibility Study."[52]

In August 2008, CVPS and the DPS launched a collaborative Smart Grid pilot program, which was open to participation by any utility in the state to establish "templates and standards for new meter and communications technology."[53] CVPS also developed "SmartPower," a program to analyze and install the latest metering technology through 2013. [54]

The alignment of interests and available resources opens a window

In November 2008, all Vermont utilities, the DPS, the Conservation Law Foundation (CLF), VELCO, and Vermont Transco LLC filed a Memorandum of Understanding (MOU 7307) with the PSB. MOU 7307 established a framework for the regulatory treatment of smart metering, which enabled utilities to move forward individually with smart metering. Individual utilities' progress as of November 2008 was as follows:

- "VEC is in the process of implementing advanced metering throughout its system.
- CVPS is planning for system-wide implementation of advanced metering.
- Burlington Electric Department has engaged a third-party vendor that uses AMI capability to implement demand response.
- Green Mountain Power has conducted a 300-customer smart meter pilot project in the City of Winooski
- VELCO is implementing a statewide radio project that will greatly upgrade capability for wireless communication across the elements of the electric system."[55]

In December 2008, an earmark supporting smart grid implementation was on the floor of the Vermont State Legislature for 45 minutes before being rejected. [56] In February 2009, the U.S. Congress enacted the American Recovery and Reinvestment Act (ARRA). ARRA provided $11 billion for grid modernization, $3.4 billion of which was designated for Smart Grid Investment Grants (SGIG). It also increased general matched funds for smart grid investments from 20% – 50%. [57]

eEnergy Vermont Collaborative is born

In March 2009, after much groundwork was laid by VELCO Vice President, Kerrick Johnson, the VELCO Board of Directors agreed to pursue a common ARRA SGIG application under the name of "eEnergy Vermont." Soon thereafter, a collaboration of 20 distribution utilities (investor-owned, municipal and rural cooperatives), VELCO, Efficiency Vermont, University of Vermont, Norwich University, Vermont Office of Economic Stimulus and Recovery, Vermont DPS, Vermont VTA, Vermont Chief Technology Officer (Tom Evslin), Vermont Congressional Delegation and other state officials, began developing an ARRA SGIG application. There was recognition early in the process that Vermont would need to differentiate itself from other applicants, and to do so, the effort would need to be truly statewide. There was also recognition of the potential challenges associated with multi-stakeholder collaboration. Accordingly, the ARRA working group drafted an MOU to document the scope of the project, schedule and budget early in the process.[58] The six page document, which was drafted by the executive director of the Vermont Public Power Supply Authority, David Mullet provided a governance framework for the working group and helped it to

work as a unified entity. In addition to the structure provided by the MOU, many see Allen Stamp's leadership as a key source of the working group's success. Mr. Stamp has a background in project management and was valued for his skill at soliciting and integrating input from a wide variety of stakeholders. He encouraged the working group to be deliberate and thoughtful by asking members to allow for "soak time" before making a decision about any given issue, which allowed the group to make the majority of decisions by consensus.

The ARRA working group, coordinated by VELCO, has inspired the creation of additional working groups focused on related smart grid infrastructure and deployment issues, such as a coordinated communications plan. With the ARRA working group as the hub of this implementation network, industry representatives and government officials meet regularly to identify problems, derive solutions, and make strategic decisions regarding the implementation of smart meter infrastructure. The willingness of these stakeholders to share information, discuss differences, and work together to find solutions has been a critical feature of the eEnergy Vermont collaborative's success to date.

In addition to the ARRA working group meetings, the DPS hosted three meetings (2008 – 2009) with local and regional CEOs of the state's utilities to clarify the private industry's position(s) on topics related to smart grid, like dynamic pricing and use of potential ARRA SGIG funds. [59]

"In 2010, the 'eEnergy Vermont' collaborative was awarded $69 million from ARRA SGIG funds. The amount was matched with equal investments by local utilities, providing $138 million to provide smart meters for 85% of all electricity consumers in Vermont by 2013."

In August of 2009 the PSB issued an order adopting that MOU. The Docket 7307 MOU, which was adopted by the Board in an order, contains many of the tenets, requirements and processes for utilities that plan to seek board approval for AMI.[60] In 2009, CVPS completed an evaluation of existing backhaul technology and identified options for supporting SmartPower's backhaul telecommunications needs. Anticipating the amount of meter interval data that would be produced by AMI Smart-Meters, CVPS entered into a conditional agreement to purchase a commercial Meter Data Management System (MDMS). [61]

On August 6, 2009, after six months of meetings, Allen Stamp as SGIG Program Manager and VELCO as lead applicant, submitted "eEnergy Vermont," a collaborative SGIG application for ARRA funds, on behalf of all Vermont electric distribution utilities, Efficiency Vermont and VELCO. Later that year, the "eEnergy Vermont" collaborative was awarded $69 million ($68,928,650) from ARRA SGIG funds. The amount was matched with equal investments by local utilities, providing $138 million to provide smart meters for 85% of all electricity consumers in Vermont by 2013.[62]

In the summer of 2010, CVPS, VELCO, GMP, the VTA and the DPS came together to work on the procurement of AMI systems. Together, they issued a joint RFP soliciting proposals from commercial communications carriers for supporting utility smart grid communicators and state broadband communication goals.[63]

Communications and transmission infrastructure investments meet smart grid needs

During the summer of 2010,Vermont Telephone Company (VTel), a telecommunication company based in Springfield, Vermont, began to pursue solutions for backhaul from meters to substations. There was a push to develop and utilize new broadband capacity to meet utilities' backhaul infrastructure needs. However, some utilities were concerned about the reliability of a system that would be externally owned and managed.[64]

June 2010, ISO New England (ISO-NE) received a $7.9 million ARRA GIG grant for a "Synchrophasor Infrastructure and Data Utilization in the ISO New England Transmission Region" project, a three-year project to deploy synchrophasor technology. Among other things, the project provided funding to install PMU-based disturbance detection and monitoring system to support advanced Smart Grid applications in six New England region states, including Vermont.[65] This project both helped develop infrastructure to support smart grid and further strengthen the relationship between Vermont and ISO-NE (e.g., VELCO receiving 80% of funding to pursue backhaul solutions from ISO-NE). [66]

In August 2010, the U.S. Department of Agriculture (USDA) awarded VTel an $81 million broadband stimulus grant and a $35 million government backed loan.[67] The federal funds enabled the company to build a "Wireless Open World" (WOW), a 4G wireless system designed to provide internet access to Vermont residents and businesses, particularly those who were un-served by existing networks. It also funded a one-gigabit fiber network for VTel's existing customers and supported the development and deployment of a community visit program to educate residents about social and economic opportunities afforded by broadband access.[68] After VTel received the ARRA grant, utilities' concerns shifted away from reliability and toward compatibility and capacity of new systems.[69]

Voters and shareholders weigh in on smart grid investments

In June 2011, voters in Burlington, Vermont approved a $7.5 million Burlington Electric Department (BED) bond to fund the implementation of smart grid technology. The bond allowed BED to raise the necessary capital to match federal funding for the project.[70]

Merger, TelCom, and Awards

Just a few weeks later (July 2011), the leaders of CVPS and Gaz

Métro Limited announced the merger of CVPS and GMP, a subsidiary of Gaz Métro, into one utility. [71] The merger promised significant benefits for customers, community, employees and shareholders, namely $144 million in customer savings over 10 years, a Vermont ownership interest in VELCO and the establishment of the Headquarters for Operations and Energy Innovation in Colchester, Vermont.[72]

One week after the proposed merger of CVPS and GMP was announced (July 2011), the two utilities and VTel finalized a

"Vermont is the first state to utilize a 'wireless canopy' to implement a smart grid system."

smart grid broadband agreement that would allow electric utilities to use the newly expanded broadband system to transmit smart meter data. Because utilities would share costs with their telecommunications counterpart, VTel would be able to expand broadband internet service territory by as much as 25%.[73] Other utilities reportedly would have a chance to join the agreement later. According to Governor Peter Shumlin, anticipated benefits included increased electric reliability, improved broadband access, more accurate information about demand and renewable capacity and greater accommodation of electric vehicles. As a result of the agreement, Vermont is the first state to utilize a "wireless canopy" to implement a smart grid system. [74]

In August 2011, VEC won Power Magazine's first ever "Power Smart Grid Award" for its early deployment of smart grid technology. In addition to being at least a decade ahead of the market, VEC was recognized for deploying innovative technologies, including, electronic meters, AMIs, GPS-enabled OMS, web-based access to consumer energy usage information and a SCADA system. Power magazine praised VEC for cutting outages in half, reducing outage time and improving consumers' understanding of their monthly bills.[75]

Vermont Department of Health Issues Report on Smart Meter Health Impacts

In February of 2012, the Vermont Department of Health issues a report titled, "Radio Frequency Radiation and Health: Smart Meters."[76] The Department of Health surveyed the existing scientific literature on the impacts of radio frequency radiation (RFR) and conducted their own measurements of RFR from the type of smart meters being installed in Vermont. To quote the report: "Smart meters, according to both mathematical modeling and field tests, emit RFR at very low levels, lower than mobile telephones. The current health protection standards established for mobile telephones in the U.S. and in most other countries around the world are generally accepted as sufficient to prevent health effects from smart meters.

"In January 2012, the Vermont Department of Health made actual measurements at active smart meters installed by Green Mountain Power in Colchester. The readings from these devices verify that they emit no more than a small fraction of the RFR emitted from a wireless phone, even at very close proximity to the meter, and are well below regulatory limits set by the Federal Communications Commission (FCC)."

Measures put in place to protect consumer privacy and allow for AIM opt-out

In September 2011, at the urging of the Vermont Public Service Department, the Vermont Public Service Board held public hearings regarding the privacy and health concerns arising from smart meter installation.

In May of 2012, the Vermont State Legislature passed Act 0170 that allowed for utility customers to opt-out of having AIMs placed within their homes without being charged a fee, making the State of Vermont the first state in the country to allow for an opt-out option that does not mean increased fees to the customer. It remains to be seen how widely the opt-out option will

According to the World Economic Forum, "The execution phase [of smart grid implementation] is a dynamic environment, with various elements of the technology and business processes being challenged and revised on a regular basis. Such complexity requires a clear governance structure from the scoping stage onwards, with a commitment throughout the delivery phase and strong project managemetn capable of ensuring alignment and communication between all consortium partners and workstreams."

be exercised, how the costs of allowing customers to opt-out will be absorbed, or the challenges associated with maintaining the communications infrastructure given the holes in the network that arise when some units are off line.

To ensure the protection of consumer privacy, the main utility companies involved in the implementation have written privacy policies. It remains to be seen how third parties will be able to gain access to consumer data as new applications for using finer grain smart data become available. The Vermont Public Service Board remains committed to monitoring this issue and has of-

fered a set of principles of practice to guide policy development in this area.

Analysis of Critical Factors Leading to Smart Grid Deployment

A variety of factors led to the development of the eEVT Collaborative and the statewide effort to install smart meters to 85% of the state's households and businesses. In this section we highlight five major features of the Vermont case that appear to have driven innovation in this sector in this state.

1) Building on Federal Priorities

Recent federal legislation and grant programs have been one of the key drivers in advancing Vermont's capacity to implement smart meters. The federal government has adopted policies that address our national priorities of strengthening energy independence and reducing carbon emissions. There is growing recognition that adoption and deployment of "smart grid" technology could provide a pathway forward in addressing our key national priorities. Three pieces of recent legislation highlight the federal government's regulatory commitment to the development and implementation of smart grid technology: The Federal Energy Policy Act (EPACT) of 2005; The Federal Energy Independence and Security Act of 2007; and The American Recovery and Reinvestment Action (ARRA) of 2009.

The Federal Energy Policy Acts of 2005 and 2007 helped to focus the attention of state regulators and utility industry leaders on smart grid technologies. These acts stimulated a series of efforts, beginning with the development of policies relating to net metering and eventually smart metering, which created the foundation for the industry-regulator partnership to follow. The availability of the ARRA funding made it possible for Vermont to pursue a statewide strategy. It is clearly evident that without the legislative initiative of the federal government and the availability of federal funding to leverage private and non-federal public resources, the Vermont smart metering initiative would not have been possible.

2) Proactive State Policy

Although policies surrounding smart grid technology were not formally addressed by the Vermont Assembly Legislature and Executive branch until the late 2000s, Vermont has a long legacy of forward looking energy policy, particularly in regards to energy efficiency. Some of the more significant policies and initiatives set forth by the Vermont General Assembly include:

- Legislation (S. 137), approved in 1999, granted the Public Service Board authority to create an independent statewide energy efficiency entity ("Energy Efficiency Utility").
- Sustainably Priced Energy Development (SPEED) Program of 2005 – a State Renewable Portfolio Standards (RPS) mandate designed to promote the development of in-state renewable energy sources.
- Building Efficiency Goals of 2008 – sought to substantially improve the "energy fitness" of at least 20 percent of the state's housing stock by 2017, and 25 percent by 2020.
- Greenhouse Gas Reduction Goals of 2008 – outlined the establishment of the Vermont Climate Collaborative.
- Energy Efficiency and Affordability Act 2008 – directed Vermont's Public Service Board (PSB) to "investigate opportunities for Vermont electric utilities […] to install advanced 'smart' metering equipment."

While these are only a sample of the most salient policies that have contributed to the expansion of smart grid technology and energy efficiency in Vermont, they are representative of a broader commitment of state level policy-makers to the strategic evolution of the state's energy policy. Vermont's history of progressive energy efficiency initiatives created a pool of political and social capital that was drawn on in recent years to develop the smart grid scoping, planning and implementation effort.

3) An Innovative and Responsive Regulatory Environment

Vermont's legislative commitment to energy efficiency and implementation of smart grid technology has been supported by statewide regulatory bodies who have attempted to work with stakeholders in a cooperative manner and pave the way for innovation within the state's energy sector.

The Vermont Public Service Board (PSB), a quasi-judicial board that serves as the decision-making authority in Vermont utility regulatory cases and supervises the rates, quality of service and financial management of Vermont's public utilities, encourages collaboration by organizing working groups to address issues, like rates, consumer interface and communications, cybersecurity, and interoperability. These working groups, which can be requested by stakeholders (consumers, utilities, public officials) at any time, provide an informal opportunity to dialogue outside the official hearing process.

The PSB works closely with the Vermont Department of Public Service (DPS), the executive branch agency charged with representing the public interest in matters regarding energy, telecommunications, water, and wastewater. The DPS represents the public interest in utility cases before the PSB, along with federal regulatory agencies and state and federal courts. It also develops and supports statewide strategic planning related to energy efficiency (e.g., the Vermont Electric Plan) and telecom-

munications.

The PSB and DPS have a long history of supporting and driving Vermont's energy efficiency, and later smart grid, agendas. As early as the 1980s, the PSB began leading studies in "Demand Side Management" and "Least Cost Planning" for utility companies, which led to several regulated electric utilities conducting pilot programs to further investigate energy efficiency.

In 1990, the PSB issued a ruling (Docket 5270) based on the energy efficiency investigations and pilots conducted during the preceding two decades. The PSB found that implementing energy efficiency programs could save billions of dollars for Vermont consumers, while reducing environmental impacts. The ruling mandated that utilities develop and implement plans to pursue greater efficiency measures, effectively shifting the focus away from supply-side cost reduction measures to meet consumers' needs.

In the years following the ruling, regulators faced the challenge of encouraging a more collaborative approach to energy efficiency, while designing incentives to motivate utilities to more fully commit to it.

Spurred by federal regulation, and in parallel with the state's legislative agenda, Vermont's regulators began to address smart grid technology as a means to achieve greater energy efficiency in the late 2000s. In April 2007, the PSB responded to DPS' request to launch an investigation to evaluate the use of smart metering and time-based rates. The investigation (Docket 7307) evaluated the current status of Advanced Meter Reading and AMI technology deployment in Vermont, the costs and benefits of increased use of these technologies, an analysis of barriers to implementation, and the use of time-based rates. Throughout the process, PSB worked to integrate the views of a diverse set of stakeholders.

During the fall of 2008, local utilities communicated with the PSB regarding rate recovery assurance as it related to the implementation of smart metering. Utility companies looked to the DPS to mitigate some of the financial risks associated with the installation and implementation of smart meters. The PSB viewed the issue as a matter of cost effectiveness, and approved a measure to provide cost recovery assurance for utilities whose plans were approved by the PSB. The decision benefited both utilities, by ensuring that they were bearing the smart grid investment burden alone, and the PSB, by ensuring that utilities would pursue smart metering and maintain open communication with the PSB about their plans, allowing the PSB to ensure the "interoperability of the system." In November 2008, all Vermont distribution and transmission utilities, the DPS and the Conservation Law Foundation filed a Memorandum of Understanding (MOU 7307) with the PSB to establish a framework for the regulatory treatment of smart metering. Vermont's case follows the recommendations stemming from studies of other states, which suggest that, "without prior guidance from regulators, utilities will not necessarily anticipate all the attributes necessary to meeting public-interest requirements." [77]

Maturity Model developed by Carnegie Mellon University. One of the critical features of successful implementation is the building of a multidsicplinary team with clear roles and design authority. "The scoping phase is an important window to establish the capabilities and governance for implementation. Pilots should ensure that they gain early alignment on the goals and objectives across the consortium members and senior management commitment."[78]

4) Collaborative Utility Industry, Strong Leadership and Project Management Framework

Another key component of Vermont's successful implementation of smart grid technology thus far has been its innovative utility industry. Although Vermont's retail electricity market is comparatively small, it hosts a diversity of utility companies, which vary in size (from 400 to 180,000 customers) and structure (investor owned utilities, municipal electric departments, cooperatives, and utilities dedicated to specific functions, like transmission and efficiency).

Many of these utilities have been leaders in technology innovations. In 2008, VEC introduced an outage management and mapping system (OMS), which enabled it to communicate and manage outages more efficiently. VEC also undertook substation upgrades, which incorporated a local fiber loop that connected automated reclosers, smart regulators, intelligent breakers, substation transformers, and a SCADA system that provided substation data to the operations control center. Later that year, CVPS created a strategic roadmap for transitioning its business operations to AMI, in addition to a strategy for the acquisition, deployment and integration of AMI into its operations. CVPS also developed a "SmartPower," program to analyze and install the latest metering technology. In May 2009, VEC introduced the "WattWATCHERS" program, which enabled customers to view hourly usage details electronically.

Vermont's utilities have also been drivers of cross-sector collaboration. In August 2008, CVPS and DPS launched a collaborative Smart Grid pilot program to establish "templates and standards for new meter and communications technology." In November 2008, all Vermont utilities, the DPS, the Conservation Law Foundation, VELCO, and Vermont Transco LLC filed a Memorandum of Understanding (MOU 7307) with the PSB to establish a framework for the regulatory treatment of smart metering.

Individual vision and leadership also played a critical role in brining out these early successes. The eEnergy Vermont Col-

laborative needed an early champion. That champion was Kerrick Johnson, VP at VELCO, who successfully lobbied state level elected officials and members of the VELCO board of directors to agree to move forward on the project. It was widely noted that without Johnson's stewardship, the eEnergy Vermont Collaborative would not have been born.

Vermont's executive branch has also been supportive of energy efficiency policies, and has coupled complimentary statewide goals, like broader access to telecommunications and implementation of smart grid. Former Governor James Douglas and Governor Peter Schumlin have worked with the state's legislature, regulators, and Congressional delegation to pursue integrated statewide strategic planning.

Finally, the working group that is coordinated by VELCO has inspired the creation of additional working groups focused on related smart grid infrastructure and deployment issues, such as a coordinated communications plan. With the ARRA working group as the hub of this implementation network, industry representatives and government officials meet regularly to identify problems, derive solutions, and make strategic decisions regarding the implementation of smart meter infrastructure. The willingness of these stakeholders to share information, discuss differences, and work together to find solutions has been a critical feature of the eEnergy Vermont collaborative's success to date.

Smart Grid Governance: Considering the future

In the opening section of this publication we noted how the governance of a region's energy distribution network will likely vary across different jurisdiction. Vermont is a state that selected not to pursue a reform of deregulation during the 1990s. It chose instead to pursue a path marked by a durable relationship between the state's utilities and regulators. With a patchwork quilt of twenty-one cooperatives, municipally owned, and stockholder driven utility companies providing services across the state, it might stand to reason that the kind of collaborations outlined here would be difficult to materialize. This might be case had it not been for the collective ownership of VELCO, the state's transmission company, by the state's utilities, historically strong leadership from the state's political leadership, and a commitment of the state's utilities to find common solutions to distributed problems. The combination of shared ownership, strong leadership, and collaborative cultures provided a strong foundation for the kind of energy distribution network found in Vermont. These factors contribute to a clear and apparently effective governance model that is in place here.

The World Economic Forum (2010), as well as industry leaders in utility infrastructure and operation (Smart Grid Maturity Model), agree on the importance of clear governance structure in regions undertaking smart grid implementation projects. According to the WEF, "The execution phase [of smart grid implementation] is a dynamic environment, with various elements of the technology and business processes being challenged and revised on a regular basis. Such complexity requires a clear governance structure from the scoping stage onwards, with a commitment throughout the delivery phase and strong project management capable of ensuring alignment and communication between all consortium partners and workstreams" (2010, P.35).

In the case of the eEVT Collaborative, consortium partners have created an effective project management framework to coordinate the implementation phases of smart meter and backhaul installation. Our interviews with stakeholders operating across all segments of the network suggests that this project management framework has worked effectively, in part, because of its capacity to adapt to the common challenges. Again according to the WEF, utilities, "will realize the full benefit of smart grid pilots if they ensure that a strong and adaptable governance process, with clear roles and responsibilities, is agreed across all consortium members early in the planning stage…" (2012, P.38). This appears to be the case here.

All indications suggest that Vermont is on target to meet its 2013 goals of having 85 percent of the state furnished with smart meters. Several deployment challenges remain, including refining privacy, opt-out, and cybersecurity policies. In addition, plans are needed to utilize smart grid technologies in the areas of improving efficiencies through interoperability systems and demand management strategies. The foundations that Vermont has established to garner the resources and tap into the collaborative capacity of stakeholders should serve the state well as it enters the next phase of smart grid implementation: the utilization of these technologies to improve efficiencies, expand the use of renewable energy, and provide customers with increased access to smart grid applications.

The addition of smart grid technology broadens the scope of this network and changes the relationship between consumers and their utility companies. As a result, new information and knowledge management systems will need to be developed.

In Vermont's case, it remains to be seen what the role that the state's efficiency utility, VEIC, will take on, particularly as the market expands for the differentiation of consumption pricing and demand management applications. Policies related to use of consumer energy data by utility companies, and the sharing of such data to third parties, are still under development. To realize the potential that has been promised with the deployment of smart grid technology a balance must be struck between consumer privacy, cyber security, and the effective application of information and incentives to reduce energy consumption.

When asked about the major ongoing challenges facing the next stage of smart grid development, the following four issues consistently emerged:

1. Ensuring consumer privacy
2. Ensuring that the energy gird is secure from cyber threats
3. Devising ways for consumers to use the information about their energy consumption patterns to reduce their energy footprints
4. Creating effective pricing schemes that are both palatable to consumers and the utility companies.

It was also widely recognized that concerns persist relative to the perceived health risks associated with the smart grid. The PSB consulted with health experts and concluded that the evidence for adverse health effects from AIM is negligible. That said, a democratically responsive regulatory system will continue to need to keep public health considerations and concerns in mind.

In a fully realized smart grid, new actors will need to be integrated into a smart grid energy distribution network, including the suppliers of smaller scale renewable energy -- small to mid size businesses as well as private land and home owners -- who will need to be brought into an overarching governance framework that allows for the integration of many more decentralized power generation units. In order to provide some pricing stability to the state energy market, state and federal laws and regulations will need to be clarified. State wide incentive structures and pilot programs will need some coordination. As the transportation sector expands its use of electric batteries, the traditional infrastructure of energy delivery to the transportation sector (eg. gas stations) will need to evolve. It is likely that it will take initial public-private partnerships to experiment with the most efficient and effective means for ushering in an era of electric vehicles. Some measure of coordination will need to take place with the manufacturers of smart gird appliances, renewable energy manufacturers, etc. Lastly, public information tools and educational outreach activities will need to be undertaken to inform consumers of the changes to their energy production and consumption patterns, to influence consumer decision making by using smart-grid technology to manage energy supply and demand, and to interact with citizens about the policy issues that will likely arise in the future.

Of these policy concerns, privacy and security measures remain at the forefront. In addition to allowing for consumers to opt-out of their smart meters, safeguards against violations of consumer privacy have been set in place. National cybersecurity standards have been devised and are expected to be a central feature of all smart grid security plans.

Conclusion

Considering the heterogeneity of energy distribution networks in other states, drawing more generalizable conclusions from the Vermont experience with the smart grid is difficult. We recommend that in depth case studies of other smart grid implementation projects be undertaken. Factors such as the region's regulatory environment, its history of innovative public policy, the roles of its elected officials, and the leveraging of federal funding should be considered.

The successful development of a smart grid infrastructure for Vermont and beyond will likely be predicated on the capacity of existing social, behavioral and policy systems to adapt to a new way of making, valuing and regulating energy decisions and use. Smart grid development allows for smarter use of energy in appliances, plug-in hybrid and electric automobiles, small scale renewable energy set -ups, and decentralized micro-grid networks. Smart grid technology will allow for the flow of energy production and consumption informatics relating to the real time management of the grid itself. An expanded capacity to collect and use an entirely new set of informatics leads to a range of questions concerning the coordination, governance and regulation of the smart grid infrastructure. Cooperative agreements, public-private partnerships, pilot incentive programs, and conflict mediation needs are likely to surface in response to the new opportunities and challenges that face smart grid managers and users. The challenges and opportunities that a smart grid infrastructure deployment brings to existing governance arrangements and policy and behavioral systems is a topic in need of attention.

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ACKNOWLEDGEMENTS

The authors would like to thank representatives from the following organizations for their support for this project: Central Vermont Public Service (CVPS), Green Mountain Power (GMP), Vermont Electric Power Company (VELCO), Vermont Electric Cooperative (VEC), The Vermont Public Service Board, the Vermont Department of Public Service, Sandia National Laboratories, and the University of Vermont.

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