Big Data, Cloud Computing, and Real-Time Control: New Options for Integrated Demand Side Management and Customer Engagement

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ABSTRACT

Recently, the demand-side management (DSM) industry has been inundated with software products for a variety of commercial applications. These products streamline facility audits, provide enhanced transparency into facility operating patterns, dynamically optimize device operation, or provide real-time energy management. The development of data transparency and real-time analytics with optimization, along with the emergence of both ubiquitous connectivity and cloud computing, are creating promising new options for significant efficiency and demand management strategies leveraging software platforms. These platforms, including the emerging customer needs they address, are presenting new opportunities for utility incentive programs, with significant implications for regulators, utilities, program implementers and evaluators, financing agencies and facility managers alike. To that end, this paper examines how new revenue streams and granular device-level data transparency promise to improve demand-side project paybacks, provide added customer benefits, reduce project risks, boost confidence from the finance industry in project savings, and may beneficially change how DSM portfolio administrators implement and evaluate programs. While these solutions offer great promise, the lack of a standard impact evaluation framework for these platforms and the dearth of vetted evaluation studies beyond anecdotal information are limiting their more widespread deployment at utilities.

Background: A Traditional DSM Program

The typical DSM program objective is to deliver cost-effective energy and peak demand savings. The savings are evaluated ex-post after the end of a regulatory cycle, while Evaluation, Measurement, and Verification (EM&V) Reports are published one to several years later. Utility and regulatory concerns with cost-effectiveness and impact uncertainties surrounding net-to-gross (NTG) coefficients and other evaluation methodologies lead to changes to evaluated savings, which significantly diminish market confidence in the value of these preferred resources.

Most DSM programs offer two basic types of incentives: calculated or prescriptive. Once measures are installed and incentives are paid, there is little monitoring carried out to ensure savings persistence. Some utilities have begun offering incentives for monitoring-based commissioning (MBCx) which typically provide continuous measurement and verification (M&V) throughout the life of the project. However, a majority of incentive programs still rely on the standard calculated and prescriptive methodologies, and do not have a cost-effective technique to validate performance and persistence based on actual energy savings.

Customer engagement in a utility incentive program typically promotes specific technical measures without full consideration of the range of potential and ongoing engagement opportunities and technical solutions. Customers lack market knowledge and technical expertise whereas implementers lack critical facility information that can inform the presentation of opportunities to customers.

For calculated programs, retrospective baselines—which are valuable if building occupancy and use patterns have been constant for the past year and will remain constant going forward—can be inaccurate and/or lose relevance as conditions change. Since many significant energy optimization opportunities are implemented upon change of occupancy or ownership, the lack of prior metered baseline compromises accuracy and ultimately results in a lost opportunity for utilities to claim savings. For deemed programs, there is risk that measures will not be properly installed or maintained. This uncertainty surrounding project performance, whether technical or behavioral, increases investor uncertainty in energy efficiency projects and yields non-competitive discount rates for these projects.

Disruptive How?

Simply defined, a "disruptive technology" (or disruptive innovation) is a technology, strategy and/or application that significantly alters the status quo. Disruptive technologies have difficulty entering the market due to limited consumer awareness, underdeveloped supply chains and general paucity of data to substantiate impacts across markets. In 2013, Vladi Shunturov, CEO and co-founder of Lucid Design Group, made the point during a "TED Talk" that software applications in buildings would be the first disruptive building technology since the invention of the elevator (Shunturov, 2013). Shunturov's message was simple; for the last hundred years buildings have been about structure, shell and hardware, and while engineering has made great strides on each front, it is still business as usual.

To that point, a 2013 Groom Energy report on Enterprise Smart Grid (ESG) technologies found that in 2012 global investment in ESGs was $300 million, and expected to exceed $1 billion by 2020 (Baier 2013). Some estimate that United States (U.S.) organizations will create 290,000 to 340,000 new "big data" jobs by 2018, and that more than half of those jobs may go unfilled due to a shortage of skilled workers (Buday 2012). While the energy services industry is merely a small fraction of that study's scope, the larger implication is that workforce education and training (WET) in the energy industry needs to include basic network configuration, information technologies (IT) security and a more sophisticated and computer-literate workforce.

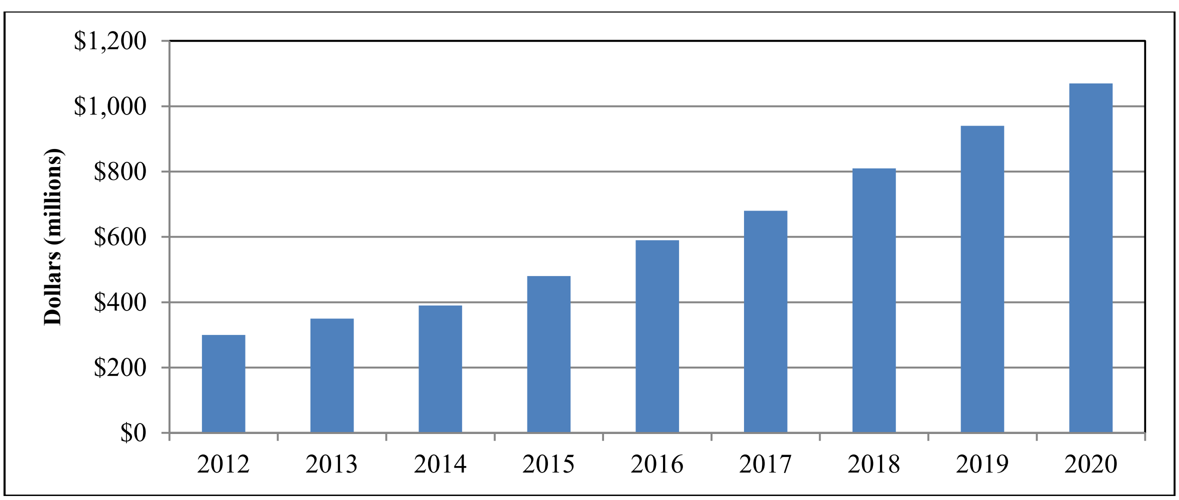

Figure 1. Smart Building Managed Services Spending, World Markets: 2012-2020. *Source*: Groom Energy, 2013.

The information technology investments made in the "dot.com" era of the 1990s has provided near ubiquitous network connectivity (at essentially zero marginal cost), cloud-based computational resources, and market acceptance of hosted software models pioneered by SalesForce, LinkedIn, WorkDay, and others. The technological innovations in the semiconductor industry and the proliferation of open-source software and networking technology, which provide exceptionally low-cost and highly accurate sensors and controls, have allowed nearly every power-consuming device the ability to communicate its status, as well as receive data and control instructions. These innovations have set the stage for the deployment of low-cost sensors and controls connected to cloud-based intelligence through this ubiquitous network. To the degree that sensors and controls communicate to the same "cloud", opportunities exist for highly disruptive innovations leveraging the intercommunication of services and information provided by these distributed devices—the so-called "internet of things". These devices provide a network with real-time control and reporting capabilities.

Real-time access and analysis of system performance can verify persistent savings to customers, financing agencies, program administrators, and evaluators. By contrast, neither deemed nor calculated incentive approaches can accurately value the unknown impacts from to-be-determined system efficiencies and non-energy benefits (NEB). This gap is ultimately resulting in program administrators not promoting market-ready technologies and leaving claimable savings on the table. The emergence of real-time telemetered devices and systems is an indication that the technical potential exists for such innovation however markets that recognize and monetize the innovative value streams do not yet exist.

The complexities of interactions specific to a particular facility are difficult to accurately quantify through calculated and prescriptive approaches. Whereas widgets reliably save measureable amounts of energy, a managed system of widgets leveraging operational, behavioral and environmental information to optimize the overall performance has unknown potential that is best measured directly from system performance data. The embedded ability of new devices and building systems to create heuristic or empirical models leveraging real-time performance data to measure and communicate their consumption allows for impact evaluation in real time by direct measurement—via the same methodology used by data logging approaches (Efficiency Valuation Organization, 2012). Software-enabled energy technologies with real-time performance capability allows for a transparency of impacts that concretely quantifies project performance and risk on a per project basis in real time.

Software as a Service (SaaS) "intelligent" technologies that combine cloud-based software intelligence with local sensors and controls to actively optimize the operation of specific end-use devices yield multiple value streams in energy efficiency, demand response (DR), flexible capacity reserve, and customer satisfaction. This new class of energy technologies, often referred to as "intelligent efficiency", typically exhibit the following common set of characteristics:

- Specific customer segment (commercial building, industrial process, residential)
- Specific energy end use (HVAC, lighting, etc.)
- Specific operational control strategy (fan motor, compressor motor, lighting level, pump speed, etc.)
- Leverage existing telemetry infrastructure (wireless network, advanced metering infrastructure, energy management system, etc.)

- Combine local sensor or sensor network with data feed of external environmental conditions of interest (outdoor air temperature, wind speed, solar irradiation, humidity, etc.)
- Cloud-based learning algorithms or "artificial intelligence" (learn from customer exception overrides)
- Automatically establish per-customer heuristic empirical model for facility response
- Automatically establish per-customer "service" or "comfort" model of tolerance for service (acceptable temperature ranges, light levels, etc.)
- Periodically "test" assumptions by varying service levels above or below model ranges
- Ability to reestablish baselines periodically
- Typically claim 10 to 25% end-use efficiency savings

A few examples of these technologies for different customer segments and end use applications include:

- Residential Smart Thermostats (EcoFactor, Ecobee, Nest, etc.)
- Commercial [Roof Top] HVAC Optimization (Transformative Wave, REGEN, etc.)
- Commercial Package HVAC variable frequency drive (VFD) retrofit and controls kit
- Commercial [Central Plant] HVAC Optimization (BuildingIQ, Vigilent, etc.)
- Industrial Process Optimization (Enbala, EnerNOC, etc.)

Intelligent Value Streams

The traditional retail, advertising, marketing, and Internet industries have long understood the value of consumer behavior data. In an August 2013 Greenbiz article, Sudhi Sinha made the observation that *"in many other industries the data itself is a source of revenue and almost can be treated as a product. This phenomenon will permeate into the buildings industry too. The richness of data is very high and it can lead to multiple untapped revenue opportunities."* The value of detailed customer data is a claim often made by vendors of this new class of software-enabled energy technologies. These vendors are not typically bound by the same high level of restrictions that regulated utilities have on the use of customer data – bound instead only by data privacy and usage agreements made with each customer – so theoretically have greater latitude to leverage this data stream to provide valuable customer services. Google's recent $3.2 billion purchase of Nest was interpreted by many analysts as an interest in new rich streams of consumer data stemming from the growing field of home automation (see, for example, Johnston 2014).

Increasing retail power prices and the growing penetration of variable renewable generation combined with more complex tariff structures is increasing demand for demand management technologies that provide value to both the customer and the grid. These market trends are incubating innovation in the private sector. Technologies are emerging that intelligently manage consumption based on learned and observed—in real time—operations, environmental and behavioral trends. The value goes beyond widget-based energy conservation measures. These new software platforms enable intelligent and ongoing operational management based on learning algorithms that build heuristic or empirical models for both facility response and range of acceptable service or "comfort models". For example, products such as BuildingIQ are reducing consumption 10 to 20 percent simply by observing, learning, monitoring and proactively controlling commercial building HVAC systems. Such models allow for the reduction of energy consumption while maintaining service levels and increasing customer satisfaction—a significant value stream. In addition to enacting learned intelligent control strategies, customers can leverage these tools to shape their own loads to maximize productivity and minimize costs associated with demand charges, time-of-use (TOU) rates, and critical peak and real-time pricing, all while enabling participation in retail and wholesale capacity programs to capitalize on additional revenue streams.

A graphical example of how cooling capacity in a data center was changed to match heat load from hosted server systems is shown in Figure 2 below.

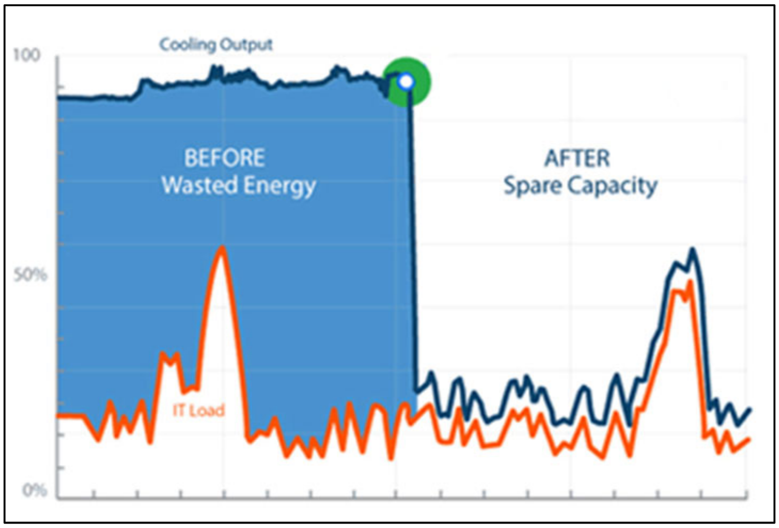

Figure 2. Energy savings via matching system operation to demand for system services. *Source:* Vigilent 2014**.**

The recent evolution of residential smart thermostats is an excellent example of how building intelligence can deliver significant energy efficiency savings, and more reliable performance of DR customers. For example, Nevada Energy's (NV Energy) residential DR program with EcoFactor has enrolled 14,000 customers (23,000 thermostats) representing about 47 megawatts (MW) of DR capacity. When a residential customer does not participate in a DR event, the curtailment service provider's (CSP) algorithm notes that pattern and during the next event will cycle equipment based on the learned behavior, resulting in unprecedented levels of participation—in terms of amount, participation rate and customer satisfaction. In 2013, NV Energy had 28 DR events in Southern Nevada, with one stretch of eight event days in a row. Few customers left the program after the eight-day stretch, and about 85 percent of enrolled NV Energy customers have positive attitudes towards the program (Howland 2014). Even with these successes, utilities often do not have enough confidence in performance claims across vendors to offer a vendor-neutral program design.

One example of a vendor-neutral pilot was Austin Energy's Bring Your Own Thermostat (BYOT) pilot with AutoGrid, EcoBee, Nest, EnergyHub, and ChargePoint (Wood 2013). A key element of this program was the integration, control, and transparency afforded by AutoGrid's Demand Response Optimization Management System (DROMS). This program design is innovative in that is one of the first examples of a scalable technology integration program design that creates an ecosystem of intercommunicating independent vendor clouds.

In addition to the direct energy and associated economic benefits, features such as fault detection and automatic diagnosis are helping to alert and inform maintenance activities;

occupancy sensors are being leveraged for asset management (room scheduling or parking space availability, for example); and temperature sensors are being integrated with fire sprinkler pumps to pre-pressurize sprinkler pumps when temperature suddenly spikes (indicating a potential fire). Thus, software and controls investments made for energy and demand purposes are yielding assets, productivity, and operational benefits that extend well-beyond energy and cost savings. These services are something businesses inherently value, and thus represent a non-energy benefit value stream the utility can offer its customers in exchange for the energy benefits useful to the utility but not of direct value to the customer, such as demand response.

As with the evolution and the adoption of the Internet, the true acceleration occurs when a utility objective (reliable telecommunications or demand capacity) becomes a customer enterprise value (the ability to increase sales productivity or reduce business operational risk) such that private entities independently make capital investments for non-energy benefits that impact their energy and demand profiles. It is clear that we are at such a juncture and are seeing an acceleration of private investments in software-managed operational infrastructure with energy impacts.

Utilities' value streams from software-enabled solutions include more accurate and timely M&V, new types of demand management resources, enhanced visibility into project and technology performance, enhanced information on customer use of the utility product, and new ways to continuously engage customers and bolster satisfaction. Utilities can implement software-based programs to mitigate impacts associated with codes and standards eroding baselines, droughts, difficulties with permitting carbon-emitting power plants, and expansion of intermittent renewables, plug-in electric vehicles (PEVs), and dynamic rate plans. Software enabled DSM programs can more accurately compensate customers for impacts, allocate risk across project stakeholders, and strengthen utility-customer relationships through continuous customer engagement. Such investments, to the extent that they in aggregate provide "generation-following" capability and thereby increase grid reliability and accommodate more renewables, are arguably capital investments in the distribution grid that can be capitalized as part of a rate case in a progressive utility business model.

Implications for Utility Demand Side Management Programs

The various applications of software enabled energy technologies for targeted end uses and customer types are a clear indication that customers have different needs and capabilities. Thus, utility programs need to be designed to dynamically capture what buildings have to offer. For example, one customer may not be able to curtail load for an entire four-hour DR event. However, a network of facilities communicating in real time may be able to provide the needed flexibility to the power system. A program offering that creates a network of loads communicating to provide grid flexibility opens the door for a wider range of customers to participate in grid balancing programs on terms that work for them.

For example, Hawaii Energy Company (HECO) is implementing a Fast DR pilot leveraging AutoGrid demand response software platform that allows customers to participate in 80 short-notice, short-duration DR events annually. Whereas in Hawaii intermittent power and abnormal peaks are catalyzing innovative program designs, wholesale power markets such as PJM Regional Transmission Organizations and emerging wholesale markets like the Electric Reliability Council of Texas (ERCOT) and the New York Independent Electricity System Operator are driving demand for new demand management resources (Texas capacity prices are scheduled to increase from $5,000/MW to $9,000/MW in June 2015).

The remainder of this section examines differing aspects of some of the program implications associated with integrating real-time device-level data, cloud computing and real-time control into utility demand side management programs.

Administration

Administration includes meetings, application processing and approval, contracting, incentive fulfillment, and reporting. Administrative software system functionality is already proven in the marketplace and present in utility and third-party product information systems, including customer relationship management (CRM) system, billing systems, etc.). Utilities use these tools to pay and manage contractors and customers, execute customer engagement and marketing campaigns, and a breadth of other valuable functions. In mass-market prescriptive incentive programs these types of software platforms are engaged in common practice, while in niche programs they are less frequent. In a program where a software platform is coordinating and automating the engagement, utilities can integrate with their customer billing systems, streamline customer engagement, track project workflows, and automate a variety of administrative functions that may result from a "real-time program". Energy management software solutions can integrate with utility customer relationship management (CRM) systems to create streamlined energy information systems driven by customer-specific considerations. Real-time reporting, as discussed below, of program impacts provide complete transparency on the progress of the program towards goals and allow administrators more notice to make program adjustments to meet goal. This transparency also provides the opportunity to ensure that the program is delivering on impacts promised to customers—both in terms of benefits and project schedules—to ensure customer satisfaction. Incentive payments can also be more directly tied to the realization of program impacts creating a greater incentive for customers to meet projected performance.

Marketing and Enrollment

Marketing and Enrollment includes segmentation, prospecting, mixed media campaigns, education, sales, and many other activities. It is widely known that marketing is one of the largest program costs associated with customer acquisition. As a result, utilities are encouraging implementers and contractors to facilitate cross-program participation. While initial software platform deployments could focus on reengaging past program participants who installed enabling equipment (as the majority of these technologies are complimentary to hardware solutions), once projects are proving savings, the real-time performance can be displayed in an interactive manner to engage other customers and influence them to participate in the program and in follow-on programs. The ability to show prospective customers how other projects are performing in real-time increases customer confidence that they will also achieve these forecasted benefits. With real-time reporting and detailed analytics provided by software-enabled energy technologies, every single project has the potential to be a data-driven "case study" which can be leveraged to recruit new customers and substantiate programs benefits.

Another challenge in enrolling customers is getting them to commit to a service agreement. Whereas customers have traditionally had to make capital investments in order to participate in a utility incentive program, in a program with continuously reported impacts, customers can execute service agreements—Energy Efficiency as a Service—to leverage these benefits in an off-balance sheet manner without capital investments. Such new service models are closer to service agreements for telecommunications services than they are to traditional capital purchases and offer much of the same flexibility and benefits to businesses.

Project Incentives and Financing

Project Incentives and Financing include the monetary value utilities and third parties provide to help customers implement projects. Pervasive real-time data can provide utilities and financing agents visibility into how these investments are performing and offer the promise of allowing for the securitization of energy efficiency investments. If parties seek more rigorous savings validation, these intelligent platforms can periodically reestablish and measure baseline conditions simply by deactivating the analytics and control features.

It is conceivable that utilities could provide a real-time incentive that is similar to MBCx but made much more rigorous by these technologies. This sort of real-time incentive could be accounted for on the customer's energy bill as a "true up" at the end of the month. It could also be a private financing company that will finance an entire project and collect from the utility and/or customer.

The multiple value streams created by this new class of technology—efficiency, demand control, customer comfort, productivity, etc.—provide the opportunity for utilities to divvy up the value streams as incentives to different program participants. In one larger scale example of this, NV Energy routinely offers its customers the efficiency and comfort "value streams" in exchange for agreements to participate in scheduled demand response events. Residential customers receive the free installation of EcoFactor's smart thermostats which provide increased comfort and satisfaction while reducing energy costs via operational efficiency in exchange for letting NV Energy call demand response events on their HVAC unit. Commercial building customers receive a similar offer leveraging BuildingIQ's technology to intelligently manage HVAC air handlers. As the efficiency savings associated with optimization is challenging for current EM&V methodologies to assess, offering this value stream to the customer—who realizes it immediately on their bill each month—while claiming the DR impacts are an innovative program implementation afforded by these new technologies.

Regardless the incentive structure, program designs should keep objectives aligned and reward customers and implementers with additional payments for achieving additional energy savings beyond the scope of the initial deployment. For example, a persistence-based incentive structure would allow implementers and customers to increase performance-based revenues if they unlock additional savings opportunities. Customers recognize economic benefits and utilities benefit from improved customer satisfaction. This is fundamentally different than the current model that pays customers and implementers in full at project completion without any controls in place to ensure persistent savings. An additional benefit of the persistence-based real-time incentive for utilities is that both the customer and the implementer are accountable to their utility's investment in their facility. With less capital provided upfront from the utility incentive, integrated demand side management (IDSM) financing could accelerate.

System Operation and Maintenance

System Operation and Maintenance in a software-enabled energy technology includes enacting real-time intelligence-based control strategies to manage energy consumption, and informing and targeting maintenance. Investments in building automation and control technologies have never been higher, so the versatility and scalability of cloud-based software platforms are complementary to the vast building systems available in the market. Pacific Northwest National Lab, in coordination with other U.S. Department of Energy (DOE) labs, is already testing a flexible integration platform (VOLTTRON Lite) for the Transactional Network project.

> *"The purpose of the Transactional Network project is to demonstrate and propagate an open-source, open architecture platform that enables a variety of site/equipment specific applications to be applied in a cost-effective and scalable way. Such an open-source platform will lower the cost of entry for both existing and new service providers because the data transport or information exchange typically required for operational and energy related products and services will be ubiquitous and interoperable." (Haack 2013)*

"The [VOLTTRON] platform is intended to support energy, operational and financial transactions between networks entities" (Haack 2013). This type of open-source platform that allows for agent-based optimization is a foundational element of a smart grid. It can create new value streams for customers, challenging grid operators and regulators to enable new transactional markets, and the private sector to develop technical solutions that capitalize on transactional opportunities while ensuring reliable supply-demand optimization.

Aside from innovative pre-commercial projects such as the VOLTTRON and Transactional Network projects, many commercially available and cost-effective technologies are already using data analytics to inform maintenance activities. For example, Transformative Wave's CATALYST and eIQ technologies leverage data from 4 to 6 new sensors and in one-minute intervals to optimize roof top HVAC units (RTU) and identify when equipment is operating abnormally. Moreover, the censor data and data granularity can often inform technicians what the malfunction is so that they can arrive to service the equipment with the necessary parts and tools. This package is yielding 50 percent energy savings and unprecedented visibility into entire portfolios of RTU assets.

Measurement and Verification

Measurement and verification includes the aggregation and reporting of data from vendor clouds. Some program administrators such as New York State Energy Research and Development Authority (NYSERDA) provide an additional incentive on a project for MBCx because this more rigorous M&V practice reduces uncertainty and labor associated with traditional ex-post evaluations. It is conceivable that EM&V budgets could be reduced as much as 80 percent in a real-time program. M&V will become more about setting up information systems and data flow processes. When this becomes the norm, EM&V consultants will be more deeply involved in program design and implementation and will require expertise in IT.

A similar approach to real-time impacts reporting was applied to California's solar industry via the California Solar Statistics public reporting website. The near-real-time data on contractor pricing, system location, characteristics, sizing and performance, along with the solar lease model, were a catalyst for transforming California's solar market. Perhaps a less publicized benefit of the California Solar Statistics public reporting website was that the significantly reduced program M&V costs resulting in the opportunity to reallocate unspent M&V budget to enhanced program activities. Emerging software-enabled energy technologies include key disruptive elements observed in the California Solar market: real-time reporting and a new delivery model.

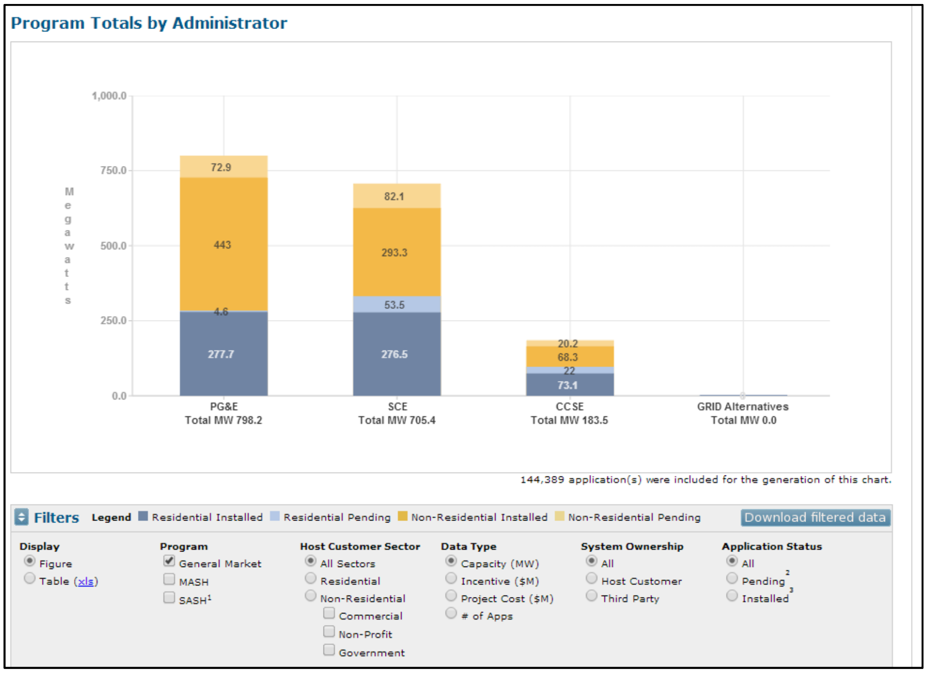

Figure 3. California Solar Initiative capacity (MW) by program administrator. *Source*: California solar statistics public reporting website, (http://www.californiasolarstatistics.ca.gov/)

A real-time approach to M&V makes it easy to calculate both from code and at-the-meter impacts, in addition to providing more timely, relevant and routine program evaluations. These advanced reporting capabilities become the backbone innovative performance contracts and program delivery models. While the transparency associated with more granular data reporting clearly enables evaluation, traditional M&V approaches do not lend themselves easily to impacts associated with running a system at reduced levels optimized by local conditions as many of these new technologies facilitate. These technologies are new enough that the first widespread ex-post evaluation studies are just now being completed. Until more widespread evaluation data is available and evaluation frameworks and standard workpapers developed, it will limit the application of these technologies in utility programs. The development of standard evaluation frameworks for this new class of technology is will be necessary to enable more widespread adoption.

Risk Management and Security

Risk management and security includes all the evaluations, policies and program structure surrounding the deluge of information potentially arriving from near real-time data capture. The introduction of smart-devices implies new levels support and security implications not present in today's widget-centric environment. Any smart metering/measurement device runs a software stack that will have software flaws (and thus require period firmware updates). As essentially "always connected" devices, external exploitation of these devices must be expected and management plans must be put in place beforehand to mitigate potential risks. These risks have been highlighted recently from devices as simple as internet-connected power switches. This was recently highlighted with exploitable vulnerabilities on devices ranging from simple internet-connected power switches (Belkin's WeMo) all the way to full-scale building management systems (Google Australia).

The capture and storage of device data streams must also be carefully evaluated. The value of this data from a program design and implementation perspective brings with it coincident value for external parties for nefarious purposes (for example, capturing the stream of energy usage of a building can indicate the building's occupancy and thus potential for theft). Risk management and due diligence surrounding vendor selection, data encryption and public disclosure of associated analyses will be a critical component in both utility commission approval and consumer comfort with the increased granularity of data held on their behalf.

New Program Opportunities

A New York University (NYU) student team recently was recognized for their vision of utilities in 2020. The students coined the term "energy concierge" to define a utility that proactively assists customers with making the right energy decisions—from rooftop solar, to storage, to DR (Berst 2014). In a utility program environment, real-time telemetry, analytics and control can advance the utility role in helping customers manage energy. So long as utilities have confidence in the metering devices, M&V algorithms and reporting systems, program design, implementation, evaluation and innovation can essentially happen in parallel.

This does not need to happen all at once. Technologies such as Enlighted, Daintree Networks (Wireless Lighting Solutions), Transformative Wave (Package HVAC Optimization), BuildingIQ (Variable Air Volume HVAC Optimization) and others are already metering performance data; however, that data is not universally accepted to validate savings. As an incremental step, utilities can integrate program design elements that aggregate savings from vendor clouds. Overtime, programs can infuse elements such as real-time incentives and performance contracts, co-branding user interfaces and innovative project financing models. As new program elements are implemented it is crucial that each hypothesis and result is carefully documented so that lessons can be shared across utility territories and departments. During the program design stage utilities need to work closely with product vendors, implementers and evaluators to establish adequate data management and reporting protocols, incentive mechanisms and messaging.

As software-enabled systems provide increasing resolution on how customers are using energy, this affords the utility the opportunity to offer highly differentiated product offerings to support their customers' businesses. Such differentiated offerings allow for increased customer satisfaction and new revenue streams for the utility by way of monetizing NEBs and acting as a business consultant as well as a power provider. Other industries have long understood this value proposition and leverage data mining techniques to characterize how their customers procure and use their products and help their customers make the best use of energy services to support their businesses. For utilities this new software-enabled paradigm is enabling their two primary objectives: 1) reliable and cost-effective delivery of energy and support of demand for customers, and 2) improved customer satisfaction. In a utility future that sees more and more third-party-owned intermittent renewable generation, reliability will remain the responsibility of the utility and an increasingly valid concern. Maintaining customers (and load) will become an equally important and equally challenging goal. Utilities must find ways to maintain their customer base amidst increasing energy prices, deferred transmission and distribution maintenance costs, and reductions in the price of distributed generation. Intelligent software platforms that customer-specific models for service needs with the optimization energy delivery afford utilities the opportunity to learn more about their customers to manage demand while increasing customer satisfaction.

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References and Notes

Baier, Paul. 2013. “The 2013 Enterprise Smart Grid with a Corporate Buyers’ Guide for Energy Management Software.”

Berst, Jesse. 2014. “The utility of 2020 will be an energy concierge, NYU students predict.”

Buday, Bob, and Leo Hermacinski. 2012. *Big Data and Analytics: A Major Market Opportunity for Massachusetts.*

Efficiency Valuation Organization. 2012. *International Performance and Verification Protocol*.

Haack, JN, BA Akyol, S Katipamula, and RG Lutes. 2013. *Volttron Lite: Integration Platform for the Transactional Network.* Richland.

Howland, Ethan. 2014. *How NV Energy integrated demand response and energy efficiency at scale.* Utility Dive. February 14. Web. Accessed March 6, 2014.

Johnston, Casey. 2014. *What Google can really do with Nest, or really, Nest’s data.* Ars technica. http://arstechnica.com/business/2014/01/what-google-can-really-do-with-nest-or-really-nests-data/

Kind, Peter. 2013. *Disruptive Challenges: Financial Implications and Strategic Responses to a Challenging Retail Electric Business.* Washington, D.C.

Shunturov, Vladi. 2013. *The Next Disruptive Innovation in Buildings*. TEDx, 2013. Film. February 1. http://www.youtube.com/watch?v=wbpgWkS8U30.

Thompson, David. 2014. *Flipping the Grid.* Honolulu. 36-43.

Utility Business Models. 2014. *Reforming the Energy Vision.* NYS Department of Public Service Staff Report and Proposal, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, CASE 14-M-0101, 24 April 2014; Hawaii PUC Proceeding Reference; California PUC En Banc Reference to Utility Business Model of the Future.

Vigilent Corporate. 2014. http://www.vigilent.com/products-and-services/vigilent-dynamic-cooling-management-system/.

Wood, Elisa. 2013. "You Are Cordially Invited to a Texas Demand Response Party. BYOT.", Energy Efficiency Markets. August 8. http://www.energyefficiencymarkets.com/you-are-cordially-invited-to-an-electric-demand-response-party-in-texas-byot/.