The sun shines on solar

Consciousness, efficiency and the surge in the solar economy

IBM Institute for Business Value

How IBM can help

New energy technologies and the changing economics of energy are altering the energy mix for utilities, increasing environmental and regulatory interventions, creating investment uncertainties and extending commercialization across the industry. IBM helps energy and utilities clients develop smarter energy capabilities to improve reliability, efficiency and return on assets, reduce costs, improve safety and transform operations for the 21st century. For more information about IBM energy and utilities offerings, visit **ibm.com**/industries/energy

Solar power gains traction

Decreasing energy production costs, increased public environmental responsibility and changing government policies are prompting more and more consumers to consider renewable energy sources. Solar energy, in particular, is gaining traction around the world. A new IBM Institute for Business value survey of more than 41,000 consumers reveals that, for energy and utility companies, increasing public affinity for solar power will potentially undermine established business models. How utilities respond to this changing environment will go a long way toward determining their future roles and extent of their success. Will they continue to focus mainly on power generation and delivery, or will they become orchestrators for a broader, richer, more highly coordinated power distribution ecosystem?

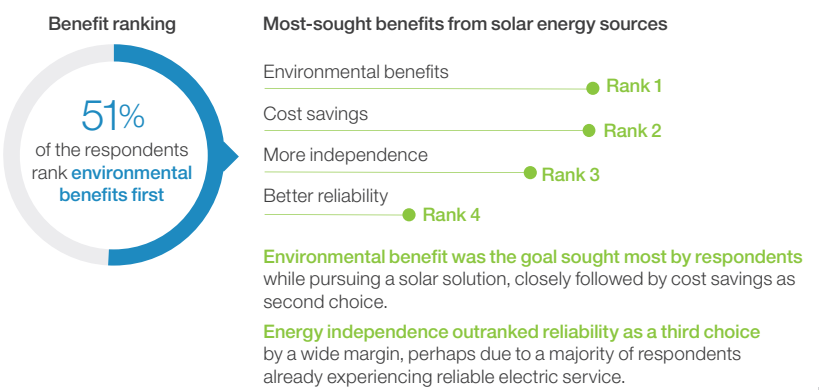
Executive summary

Renewable energy sources – particularly residential solar – are rapidly changing the energy marketplace. Numerous factors, led by environmental consciousness and reduced energy production costs, are contributing to the enthusiastic attention consumers are now placing on solar energy solutions (see Figure 1).

Populations around the globe understand the need to sustainably manage the planet's limited resources and fragile environment. In fact, protecting the environment tops public concerns in many nations.[1] In the United Kingdom, for example, 84 percent of the population supports the use of solar energy to improve the environment.[2] Research reveals, that an average solar power system can, over the course of years, save the amount of fossil fuel needed to drive around the world over 15 times.[3] To encourage solar power adoption and protect the environment, many governments have established incentives for consumers to install solar energy capabilities.

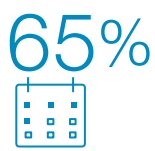
Figure 1

Respondents selected solar for the environmental benefits, followed closely by cost savings



Source: IBM Distributed Energy Survey 2016

The average price decrease of adding solar to a home or business since 2009.



The percentage of solar customers who expect payback in five years or less.

The average cost of one kilowatt-hour of solar electricity in the United States.

The benefits of solar energy are considerable. However, they come at a price for power companies – potentially a heavy one. As solar costs have rapidly declined, households are becoming not only consumers of power, but producers as well, making them "competitors" of a sort. These producer/consumers, or "prosumers" are becoming increasingly common and influential. How utilities interact with them – or, even, how they are allowed by regulators to interact with them – will be a significant factor in the roles utilities will play in the future. At the very least, a paradigm shift will be necessary as utilities must contemplate a role that focuses on more than just traditional power generation and delivery.

To get a view of how consumers view residential solar power, the IBM Institute for Business Value surveyed more than 41,000 people in six countries (the United States, United Kingdom, Germany, Italy, Spain and Japan) that have substantial solar markets. The purpose of this study is to understand consumer drivers and biases related to solar energy. Based on analysis of responses, we discuss the implications for energy and utility companies from the changing market dynamics and provide a set of recommendations and next steps.

Solar market breaks records

The U.S. solar industry expects to install 13.9 gigawatts of capacity by the end of 2016, which is nearly double the amount installed in a record-breaking 2015.[4] In 2015, the U.S. residential solar market saw substantial growth, with more than 320,000 new residential systems added, representing nearly 2,000 megawatts of new capacity.[5] Through the end of this decade, a robust growth is expected across all three market segments of solar power: residential, non-residential and utility. While the largest solar capacity growth segment will remain with utility-scale projects, residential consumers have pursued solar with considerable enthusiasm, despite the relatively high – but steadily decreasing – price tag. In a typical scenario, the estimated investment for a residential five-kilowatt solar roof-mounted system is $19,000 USD.[6]

In the United States, rapidly declining solar costs, and the potential expiration of an investment tax credit in 2016 accelerated installations over the past five years.[7] However, the extension of tax credits, combined with the continued decline in technology costs and the increasing prices of electricity, suggest that rooftop solar remains an increasingly attractive option for U.S. homeowners, businesses and, on a larger scale, even utilities. Further, environmental policies that penalize carbon emissions could lead to a further 20-30 percent rise in solar capacity by 2050.[8]

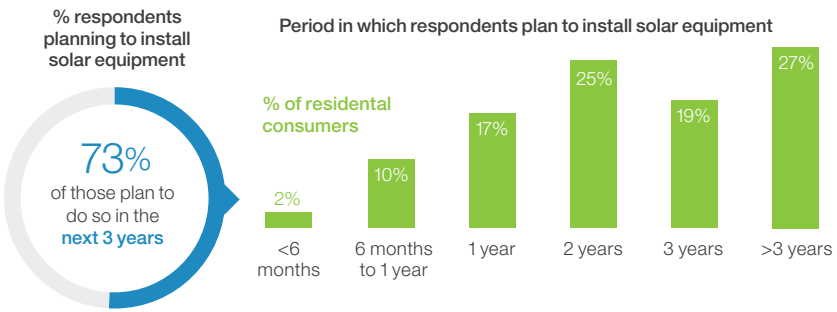
The average price of adding solar to a home or business has dropped by more than 70 percent since 2009. As installation and equipment costs continue to decrease, the estimated payback time in the United States is expected to decrease from over eight years to under five.[9] The energy payback time of solar systems is dependent on the geographical location. In Europe, for example, the payback for solar has historically been extremely attractive, often less than 1.5 years, driven by generous feed-in-tariffs and costly electricity.[10] In southern Italy, payback time can be as little as one year, depending on the deployed technologies.[11] But more recently, paybacks have been increasing due to reductions in rebates, incentives, and amounts paid through feed-in-tariffs.

Different customers, different expectations

Of the group of respondents in our survey who said they either had installed or intend to install solar equipment, 73 percent said they plan to do so within the next three years (see Figure 2). Businesses – with their larger power needs – are moving even faster, with 70 percent planning to move ahead in two years or less.[12] The major factors influencing these decisions, according to our survey, are environmental benefits, cost savings, energy independence and reliability.

Figure 2

Of those planning to install solar equipment – 73% plan to do so in the next 3 years



Businesses, with their corresponding larger solar systems, **are moving faster than residential, with 70% moving ahead in 2 years or less.**

With 5-year extension and phase-down of the federal investment tax credit in place, **the table is set for stable industry growth.**

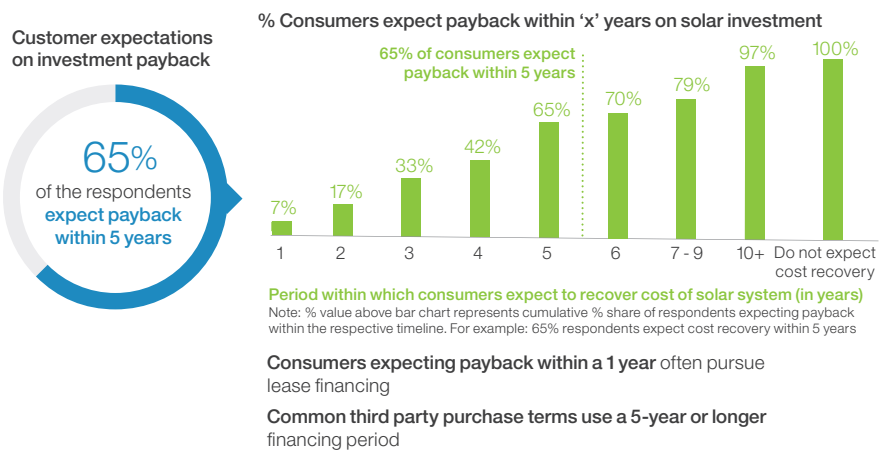
Source: IBM Distributed Energy Survey 2016

Household electricity costs are expected to decline with solar implementation (see Figure 3). Forty-five percent of consumers in our survey indicated they expected solar installation to save them a minimum of 10 percent on electricity cost.[13]

When consumers choose to install solar power, their providers of choice have generally been specialty suppliers and HVAC contractors. Surprisingly, despite a relatively limited presence in the field, utilities ranked high as well, outpacing both residential/commercial contractors and several others (see Figure 4).[14] Interestingly, consumers in our study said solar installation was much less complex than they thought. Fifty-nine percent expected a very complex operation, but only 38 percent found it complex. Thirty percent said they actually found the process to be easy.[15]

Figure 3

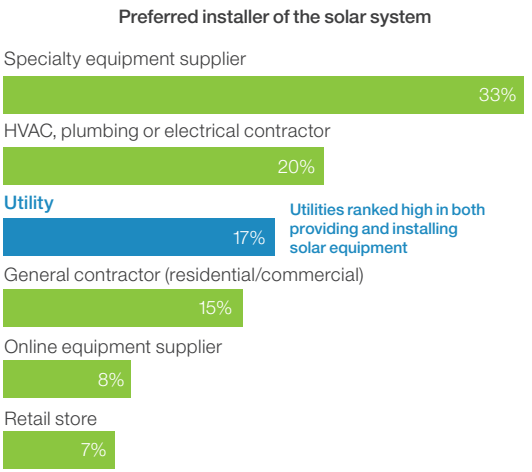
Most consumers expect payback within 5 years



Source: IBM Distributed Energy Survey 2016

Figure 4

Utilities were ranked high as both preferred provider & installer of solar systems despite limited presence

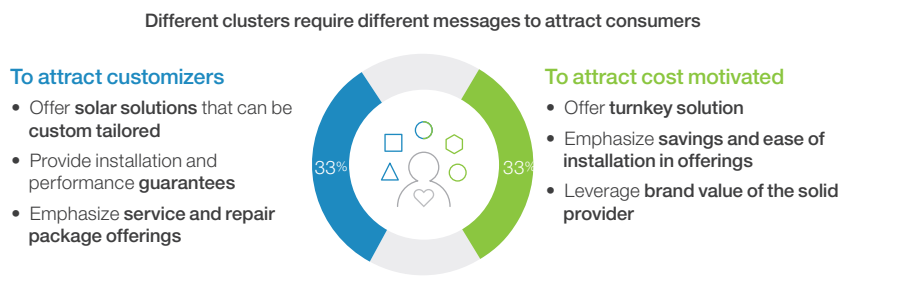


Source: IBM Distributed Energy Survey 2016

Market opportunities exist for utility companies in solar, and they are already providing measurable support. Of respondents who installed solar systems, 57 percent were satisfied by the support offered by the local utility.[16]

However, as solar demand grows, consumer requirements will both increase and diverge. To illustrate this, as part of our study, IBM conducted a cluster analysis to identify distinct behavioral characteristics of those respondents who had either installed a solar system or were planning to do so. The analysis separated consumers into two distinct groups: Cost conscious and customizers (see Figure 5). It also revealed study respondents shared some common traits, such as environmental consciousness and their concern about initial cost and financing. But there were also some key differences.

Figure 5
What do the clusters mean for utilities?



Source: IBM Distributed Energy Survey 2016

Cost-conscious consumers were focused much more on anticipated cost savings and were far more probable to accept a simple turnkey solution. They wanted to focus on cost reduction and use a supplier with strong market reputation. They placed a greater emphasis on insulation and energy audits and were more likely to have a smart thermostat. They had a greater knowledge of possible solar incentives. And of the possible installers, they tended to prefer utilities or general contractors.

Customizers were much more inclined to desire tailored solutions and seek guarantees that their selected energy sources will operate correctly, be installed properly and offer a service and repair package. They tend to prefer legacy electric providers when choosing from among competitive suppliers, have longer planning horizons, expect longer payback periods and are less likely to inform their utilities of their plans. They also indicated they felt their utilities did not adequately support their solar installations.

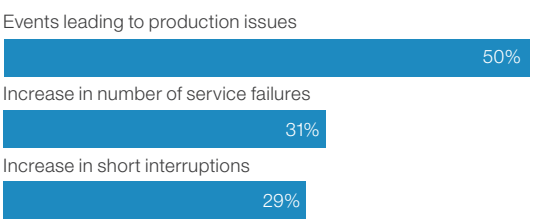
For utilities, the analysis indicates that if utilities pursue the residential solar market, each segment demands a different approach to gain its business. For customizers, utilities need to offer solar solutions that can be custom-tailored, provide installation and performance guarantees and emphasize service-and-repair package offerings. For the cost conscious, utilities should offer turnkey solutions, emphasize savings, ease of installation and leverage the brand value of a solid provider.

Figure 6

German industrial facilities are experiencing increased interruptions from renewable energy

Sudden fluctuations in Germany's power grid are causing **major damage** to a number of industrial companies. Their responses have varied from acquiring their own power generators to installing voltage regulators to help minimize the risks. The risks need quick resolution to avoid an industry exodus.

Power quality has periodically suffered



A survey of members of the Association of German Industrial Energy Companies (VIK) revealed that the number of short interruptions to the German electricity grid has increased.

Source: "Grid Instability Has Industry Scrambling for Solutions", Der Speigel, August 16, 2012, http://www.spiegel.de/international/germany/instability-in-power-grid-comes-at-high-cost-for-german-industry-a-850419.html

Changing business models for changing times

The advent of increased solar and other renewable energy sources creates a profoundly different business environment for utility operations. Although not every utility or market will change in the same way or magnitude, developing a planned path forward will help each utility to reach its "optimal" strategy. Complicating this process is a series of emerging solar-related disruptions, decisions or events that could cause and accelerate electric sector change. Utilities should consider the technical challenges along with changes needed in comprehensive system planning. The advent of the energy-producing consumer (prosumer) will create new communication requirements. And, as the energy market changes, there will be a need for traditional generation suppliers to becoming energy orchestrators.

Technical challenges

As residential solar becomes even more cost effective, utility transmission and distribution networks may see significant technical challenges. Uncontrolled widespread rooftop solar rollout (without adequate coordination and technical checks) runs the risk of voltage and power quality problems. The likelihood and severity of problems will be dependent on historical network design practices and the extent to which network operations are optimized.

Maintaining voltage levels may require more expensive dynamically controlled connection technology, or require the utility to invest in larger wires and transformers. High levels of rooftop solar penetration (as in Germany) necessitated new and innovative approaches to managing power quality, which, in turn, resulted in new power delivery standards (see Figure 6).[17]

When solar generation exceeds the local load, reverse power flow in the distribution network can be problematic due to the resulting voltage rise. The distribution network has been designed and operated to curb the impact of voltage drops, not voltage increases. The voltage control philosophy is such that during periods of low-loading the maximum voltages may

already be close to the allowable limits. Local generation (causing a voltage rise) may then result in the maximum voltage limits being violated, leading to the failure or reduced efficiency of customer appliances.

In the normal three-phase distribution network, phase connections that are not well managed could inadvertently become attached to the same phase. The resulting voltage increase could be substantial and could limit the loading capability of distribution transformers.

As solar matures, the associated infrastructure and related technologies must also become more robust to maintain utility network performance. The commercial deployment of such technologies can fundamentally change the nature of the distribution business and will need to be supported by new business models and processes.

Planning

Since utilities have planning horizons that range from annual to 20 years or more, depending on the topic, high solar penetration levels impact utility long-term plans across many business functions. The ability to forecast solar generation as part of a utility's Integrated Resource Plan (IRP) is a relatively new skill and, as penetration rises, distribution plans may have to be adjusted to account for feeder-specific impacts and distribution technology deployment. Both of these factors may cause long-term transmission addition plans to change. Many utilities file IRPs with their state commissions, which, in turn, will necessitate a consistent approach to treatment of solar resources, as well as communication of resource planning decisions to regulators. A key component of determining the impact on long-term plans as solar penetration increases will be obtaining and analyzing the significant amount of granular data on system loads and asset health.

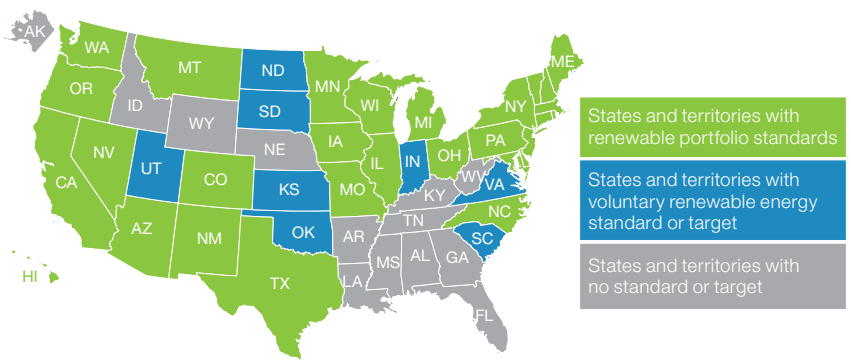
Renewable portfolio standards[19]

The United States has been active in adopting or increasing renewable portfolio standards, and 29 states now have them (see Figure 7). These standards require utilities to sell a specified percentage or amount of renewable electricity. The requirement can apply only to investor-owned utilities, but many states also include municipalities and electric cooperatives (municipalities and co-ops), though their requirements are usually lower.

The development cycle for solar resources can be substantially faster than traditional fossil fueled resources. Since access to high-voltage transmission lines is key for the development of utility-scale solar power projects, transmission planning, right of way acquisition and construction must meet the aggressive timelines often pursued by solar developers – while achieving the development goals set forth in state renewable portfolio standards (RPS). Renewable energy and the required transmission infrastructure will need to be vigorously pursued to achieve the RPS objectives, often requiring 10-20 percent or more renewable energy in each utilities' capacity portfolio.[18]

Figure 7

Renewable portfolio standards will help drive solar adoption



Source: State Renewable Portfolio Standards and Goals. NCSL. http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

Customer interaction

Solar and other self-generation consumers will become electricity prosumers. Interdependency is the key distinction between a consumer and a prosumer and will be a significant factor in assessing the total value of the prosumer relationship to utilities. Prosumer value will be different for each utility. It will also become dynamic, with variable rates of change for key factors in valuations. Utilities, for example, must consider geographic, weather and solar irradiance data. They must correlate this data with information about the performance of the power grid and anticipate the timing of any excess energy deliveries. While some network attributes are relatively fixed on the grid, like transformers, prosumer demands are likely to change along with their load patterns. The challenge for utilities is that the numbers of assets and variables that impact grid operations will vastly increase. The net result: a profoundly different business environment for energy suppliers.

An entirely new method of customer interaction will be needed for the prosumer (see Figure 8). Electricity delivery will eventually need to be a personalized, highly automated process that will include different service options based on customer needs. These will be driven by such factors as the need for more timely focused communications and the potential need for network controls, device monitoring and energy sales forecasts. Moreover, considering the significant changes triggered by the rapid decrease in the cost of solar, current, and future prosumers will need to consider that regulatory frameworks might change over the course of the life of their solar systems, resulting in different payment frameworks for the energy provided.

Prosumers may have to adapt to technological changes (for example, installing new inverters, as required for some systems in Germany), the introduction of new means of communication between solar PV systems and local (or onsite) loads, as well as the real-time behavior of the distribution grid. If future regulatory changes occur in an erratic manner, or are too onerous or restrictive, this could impact the financial attractiveness and acceptance rates of distributed solar and increase regulatory and political risks for prosumers. Collectively or individually, these disruptive technologies will continue to impact the industry, and another wave of transformation, such as a further decline in solar costs or improved battery technology, can radically impact utilities.

Figure 8

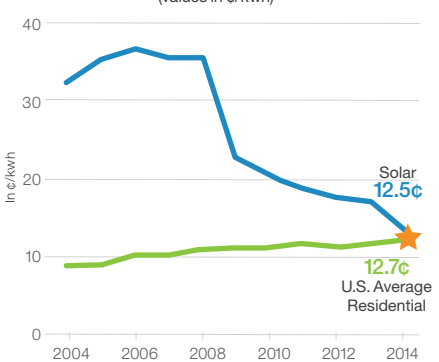
Reaching parity with traditional grid prices increases the potential for prosumer growth

Prosumer growth is inevitable but challenging

- **Solar will be more cost effective**. Compelling economics will undoubtedly create a surge in adoption, but other factors play an equally important role.
- **Price alone** does not create conditions for prosumer scale-up. State net metering laws, along with confusion over enabling policies that allow solar and batteries to connect with the grid, have a role.
- **Plans from regulators** for dealing with a growth in prosumers are lacking.

Average retail price of electricity – U.S. Residential[1]

(values in ¢/kwh)



Sources: "Electricity statistics on electric power plants, capacity, generation, fuel consumption, sales, prices and customers." U.S. Energy Information Administration (EIA), http://www.eia.gov/electricity/data.cfm#sales – historical rates; "Solar electricity costs (Avg. prices in U.S.) – Levelized cost data." Solar cell central, 2015, http://solarcellcentral.com/cost_page.html

The energy integrator

The new energy marketplace will be driven by competition, disruptive forces and environmental consciousness. Some of the traditional "core" utility processes will no longer be sustainable. Energy supply and demand forecasting, distribution planning, network connectivity and communications, along with consumer interaction, are all expected to need significant changes. As a result, new business models will be necessary. To combat these rapid, complex and disruptive market changes, energy and utility companies should rethink some of the ways they do business. They need to transition from being solely legacy generation suppliers and managers to becoming energy orchestrators that manage potentially thousands of suppliers. However, in many areas, regulatory environments may impede the ability of utilities to change. It will be essential for utilities to collaborate with regulators to attempt to address these issues.

Already, some fundamental restructuring of the industry is underway as companies begin to embrace becoming energy integrators. For example, New York's Reforming Energy Vision program is implementing regulatory changes to promote renewable energy. The program introduces the new role of distributed service platform provider (DSPP), which provides for transforming distribution utilities from the role they play today into distributed service platform providers for a decentralized energy system.[19] European Distribution System Operators (DSOs) are facing new challenges. Besides their traditional mission to operate, maintain and develop an efficient electricity distribution system, European DSOs are asked to fulfill a new role: facilitate effective and well-functioning retail markets. In the United Kingdom, Flexitricity offers such integrator services, with a focus on demand response and using renewables to mitigate frequency issues and balance reserves.[20]

Case study: Renewables require business model change[21]

Utilities will experience fundamental changes as traditional generation roles combine with renewables. For example, a German utility is revising its business model to make grid services its core business after renewable energy growth decimated its legacy power generation earnings. The transition was brought about by the massive erosion of wholesale prices caused by the growth of German photovoltaics.

The new direction will leverage skillsets by taking a "capital-light" approach, positioning the company as a project enabler, operator and system integrator of renewables.

Where to go from here?

Solar energy will impact the future growth of utilities and the regulations that govern their deployment. Business models, customer impacts, business processes, rates and technology are all key components that utilities must address. Five critical success factors emerge for solar energy pioneers:

Incorporate new, complex technologies – Renewable technologies will place new burdens on utilities. With the potential increase in controlling two-way power flows and leveraging IOT for renewables, new requirements for grid monitoring, communications and controls are likely. These requirements will place new demands on network operating centers and create a need for greater communication of generation impacts on distribution level infrastructure. Larger, utility-scale solar farms may require new employee skills to operate and produce the greatest economic value from solar technologies. Solar farm project development is complicated, as there are particularities to each utility company, each regional transmission operator (RTO) and/or each state and county. For that reason, increased risk is associated with early stage development, which often encourages utilities to partner with solar developers or consider project acquisitions after the project is deemed commercially viable. The ability of utilities to properly evaluate these new solar technologies is a skill that will need to be acquired.

Build new capacity planning capabilities – Generation and network capacity planning will become more complex as more renewables are added and, especially, as more and more generation is provided through third parties. Organizations must realistically assess their capabilities. For example, creating generation forecasts to account for solar, weather impacts and the associated customer adoption rates are expected to be a series of new skills. Performing dynamic distribution system modeling and quantifying the financial impact of renewables will be difficult. These new capabilities are likely to be needed – regardless of the position taken on solar generation.

Case study: Solar forecasting[22]

While utilities have extensive experience with load forecasting, solar adds a new element of variability and uncertainty to system load not captured by existing load forecasting methods. Operational strategies and market structure changes are required to address new levels of uncertainty that high penetration of solar presents to utility companies and grid operators due to their intermittent nature. The use of advanced forecasting of variable generation is one of these essential strategies.

A western U.S. utility has been conducting research on solar forecasting with researchers at a state university to develop a solar forecasting system that will eventually be integrated into the company's energy management system. The forecasting approach uses inputs from residential rooftop solar systems as a proxy for the measurement of irradiance. A clear-sky expectation for the output of each system is obtained and deviations from the clear-sky expected output are used to infer cloud impacts on system performance. The output from the sample is scaled-up to represent the output of all utility-scale and distributed solar within the service territory. Better forecasting enables coupling of deferrable loads to renewables and, for example, could link solar energy production with scheduled electric vehicle charging.

Adjust pricing models – Pricing will become more complex as more renewables are added to the network. The historical use of net metering to compensate customers is under review in many states. In most instances, the evaluation of net metering has resulted in a decrease in customer payments and an associated reduction in solar interest. Feed-in-tariffs are often used to stimulate growth, but effective utilization requires providing proper market signals, as solar investment recoveries are forecasted for five-to ten years or more. Residential electricity rates have increased 47 percent in Germany since 2006, while feed-in tariffs paid for residential solar have fallen.[23] As an example, homeowners are incented to use storage to be able to accumulate and consume more of the renewable energy they produce. Utilities must evaluate pricing to fairly compensate energy sales through net metering and feed-in tariffs and avoid setting a false initial customer expectation – or face the backlash from consumers.

Reassess customer engagement practices – Utilities, like it or not, exist in a new world of personalization. In the past, it was all about class averages and rate groups, but now organizations must be able to think about how they evolve in a world where differentiated services allow customers to make, at their option, simple choices that might allow them to see tangible differences in services or cost effectiveness. To successfully engage the new solar customer, utilities must determine the new differentiated services to be offered. Our survey depicted two distinct customer groups, each with varying levels of interest in topics, such as installation services, warranties, financing and brand awareness. Utilities will need to understand and effectively utilize customer segmentation and the knowledge derived from solar technologies to become trusted solar energy advisors. Customers are clearly looking to utilities for greater solar understanding. This is the perfect opportunity to leverage new meter data to provide greater customer understanding and recommend options for savings. But, it will be necessary to have the internal knowledge and training to clearly articulate the alternatives or provide energy efficiency options that support solar power.

Evaluate your core business model – The impact of solar is ongoing and will continue to evolve over the next several years and the impact on utility business models will vary by country, region and regulatory influences. Utilities can't invest in every dimension of the future electric system, so they must selectively partner with others. As an example, our customer survey clearly indicated that customers prefer third-party providers for solar installation services, but utility preference was also strong. Utilities need to evaluate the degree to which they want to participate in the renewable market and find the right opportunities and potential partners for renewables.

Restructuring will be heavily dependent on business model choices. Will utilities elect a hands-off approach and let third parties pursue a perceived niche market, or will utilities actively pursue their own solar generation capabilities in alignment with customers? Will renewables impact at such a level as to consider exiting the supply of generation as experienced in Europe? What new business processes and skills may be needed to pursue solar? A realistic assessment of solar business value, coordinated with regulatory expectations, will drive utilities to their ultimate structure. As a result, define your organization's value proposition for renewables and chart a course of action.

Key questions

- How are you thinking through the potential impacts to your organization from the growth in solar generation?
- What is your solar business strategy?
- How will you forecast the impact of the growth in new solar generation?
- How are you considering external customer expectations related to solar?
- What new data must be leveraged to meet these key objectives and business requirements?

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