CHANGING USES OF THE ELECTRIC GRID: RELIABILITY CHALLENGES AND CONCERNS

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Steve Mitnick of Build Energy America conducted this study for the Electric Markets Research Foundation (EMRF). EMRF was established in 2012 to conduct credible expert research on the experience in the United States with alternative electric utility market structures – those broadly characterized as the traditional regulated model where utilities have an obligation to serve all customers in a defined service area and in return receive the opportunity to earn a fair return on investments, and the centralized market model where generation is bid in to a central market to set prices and customers generally have a choice of electric supplier. During the first few years of restructured markets, numerous studies were done looking at how these two types of electric markets were operating and the results were mixed. But since those early studies, limited research has been done regarding how centralized markets and traditionally regulated utilities have fared. The Electric Markets Research Foundation has been formed to fund studies by academics and other experts on electric market issues of critical importance.

The Author

Steve Mitnick of Build Energy America has served in the leadership teams of energy consulting practices at McKinsey & Co., Marsh & McLennan, and PHB/Hagler Bailly. He has been president of transmission developer Conjunction LLC and chief energy advisor to the Governor of New York. Mr. Mitnick authored the book *Lines Down: How We Pay, Use, Value Grid Electricity Amid the Storm*, and nearly 25 articles in Public Utilities Fortnightly, The Electricity Journal, and Electric Perspectives. He has been quoted by The New York Times, Wall Street Journal and other media, and appeared as a guest on Dan Rather Reports and White House Chronicle. He has testified on electricity matters before the utility regulatory commissions of six states, the District of Columbia, the Federal Energy Regulatory Commission, and in Canada. Early in his career, he served on the faculty of Georgetown University where he taught microeconomics, macroeconomics and statistics.

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Foreword

There are many new demands being placed on the electric grid, the nation's network of power plants, long-distance high-voltage transmission lines, and local low-voltage distribution wires. The grid is increasingly being used differently than before. We now have distributed generation (numerous scattered small-scale producers of electricity); smart grids (digital monitoring of electrical flows); microgrids (small-scale electrical networks able to be isolated from the grid); demand response (payments or credits to customers who cut their electricity use at critical times); energy efficiency (using less electricity) and energy storage (holding electricity for release at later critical times). In addition, we have competition at the wholesale level for electricity sales to utilities and/or, in many areas of the country, at the retail level for electricity sales to end use customers.

But the grid was built with a different purpose in mind, to deliver electricity to end-use customers that is remotely generated at large-scale power plants. Through the years, utilities discovered that interconnecting these power plants could provide enhanced reliability at lower costs, and thus the nation's extraordinary, interconnected grid was developed.

The new technologies and business models being introduced to the grid today have the potential to offer significant benefits: even more diversity in how electricity is produced, even greater reliability of electric service, and an even smaller environmental footprint. Their success however depends on the robustness of the grid − the grid's ability to accommodate the new uses − while maintaining affordability and reliability. And all customers rely on the grid to meet their electricity needs. Even customers generating their own power supplies need the grid both to buy power when their own generation doesn't fully meet their needs or to sell power when they can generate more than what they need.

Some have suggested that customers may no longer need to be reliant on the grid for their future electricity needs – that they will be able to disconnect from the grid. Energy storage – particularly advanced batteries – has been in the news lately and has been touted in the press as a possible means for end-use customers to end reliance on the grid and their local utility. Most experts believe this is unlikely and uneconomic for the foreseeable future.

The peak need for electricity of an individual business or household would require an enormous uneconomic over-sizing of both on-premises distribution generation equipment (relative to the average need for electricity) and storage batteries. Most of the capability of this equipment would go unused most of the time. And disconnecting from the grid would deny the business or household the ability to sell any excess electricity it generates but doesn't need. Additionally, the isolated combination of on-premises generation and batteries is unlikely to approach the near 100% reliability of the grid with all its redundancy and backup capacity held in reserve. So even with increasing use and cost-effectiveness of battery (or other types of) storage, disconnection from the grid is unlikely.

Thus, electric customers will remain reliant on the grid at least for some, if not all of their electricity needs. But the changing use of the grid by customers has serious implications nonetheless. For example, solar panels placed on rooftops – a common form of distributed generation – causes power flows in two directions, not only from the grid to customers, but also from customers to the grid. This is very much a departure from the traditional mode of one-way power flows from the grid to customers. If not properly planned and implemented, power flows in two directions can risk the reliability and safety of the grid. And, for reasons to be described in this report, the changing use of the grid can risk the ability of utilities, under traditional utility regulation, to afford a prudent level of grid upkeep and expansion.

Concerned about the reliability, safety and economic consequences of such new technologies and business models and their integration into the nation's grid, the

Electricity Markets Research Foundation commissioned a study of the potential consequences and possible solutions for the electricity industry and public policy makers to consider. The Foundation retained Build Energy America to conduct this study and report on the findings.

The introduction and integration of new technologies and business models into the traditional model for the grid (referred to in this report as grid-based electric utility service) – both at the wholesale high-voltage (transmission) and retail low-voltage (distribution) ends of the grid – has been discussed and studied in many forums in recent years. Some of the most divisive issues have been vigorously debated, including the desirability of these changes, and the regulatory innovations that will be needed (for example, how solar or demand response should be valued).

This study does not attempt to address all of the controversies surrounding new uses of the grid. Rather, we aim to inform the reader on a single narrow issue among all the issues, albeit a vital one. The focus herein is on the potential implications for the reliability of electric service to end-use customers (America's businesses and households), and for the affordability of electricity for all.

In order to accommodate the changes being brought about by new technologies and business models and – at the same time – maintain the grid's reliability, more investment in the grid will be needed, not less. This reality further complicates the transformation of the electricity industry that is underway. Investment will be needed to upgrade the local low-voltage distribution end of the grid (to handle power flows in two directions), and for remote monitoring and control systems, power inverters, smart grid meters, sensors, and controls, and extremely quick-to-respond power plants to back up intermittent renewables like solar and wind instantaneously.

The report first explains the reasons for concern about grid reliability in particular (as well as the affordability of electricity for all). What makes the grid reliable? Why might reliability degrade? How do the changes in use of the grid that are underway impose such a risk? Who in society would be most vulnerable?

Then the report offers potential solutions. Their objective would be to preserve the national imperative of reliable electricity amid increasing challenges to the grid's owners and operators – utilities – and utility regulators.

Grid-Based Electric Utility Service, Defined

How businesses and households have received electricity ever since Thomas Edison's day – almost universally – is referred to in this report as ***grid-based electric utility service.*** We say almost universally because enormous changes are already underway. In the last twenty years, some states have moved to substitute a very different system for grid-based electric utility service. While in other states, changes are happening more incrementally as new technologies and business models are introduced. The traditional system through the early 1990's had brought electricity to everyone everywhere through a coordinated three-stage system: (1) generally large-scale power plants; (2) long-distance high-voltage transmission lines between power plants and cities, suburbs and towns; and (3) local low-voltage distribution wires to power individual businesses and households. Power flows were in one direction only, from power plants to end-use customers (businesses and homes). A utility had a legally-defined service territory of cities, suburbs and towns in which it was both the supplier and distributor of electricity.

Over the past two decades, this system (commonly referred to as vertically-integrated utilities) has changed in many states. In some, for instance, businesses and households may choose a supplier of electricity other than the local utility (while maintaining the utility as the distributor of electricity). What was vertically-integrated became vertically-disintegrated.

Power plant owners in these and nearby states – generally unregulated - sell the electricity they produce to both utilities and unregulated suppliers. These sales are mostly made via a central bid-based electronic marketplace.

An important point, however, is that in both these models, customers remain dependent on delivery of electricity through the grid. It is really only the nature of commercial relationships between customers and suppliers using the grid that has changed. In most ways, customers in the disintegrated, centralized markets receive electricity in the same way as customers of vertically-integrated utilities. And in both models, the operations and management of the grid is mostly the same. Both rely on economic dispatch of power plants within reliability constraints, and both models are required to operate within specified reliability standards. Again, it is the commercial and financial relationships that differ. Except for the opportunity to purchase power from alternative suppliers, how the grid works to provide reliable service in both models is opaque to customers. They flip a switch, and the light comes on.

We shall discuss in this report the changes underway and how they could upset our carefree reliance on electricity being available when and where we need it. But we'll first define how that reliability has been provided by grid-based electric utility service. This shall serve as a reference point for understanding the changes underway.

Businesses and households, customarily, have had their electricity delivered by a local utility. These days, there are some three thousand such public service organizations. Some are for-profit, with their profit strictly controlled by utility regulators. Some are not-for-profit electric cooperatives. And some are owned by federal, state, or local governments.

Regardless of how a customer's electricity is supplied (by the local utility or an unregulated supplier), the utility ensures reliable delivery. The system works so well that most of us rarely give a thought as to what happens behind the scenes. Flip the power switch and our machine, appliance or device instantly comes to life.

Just as we depend on the local utility, the local utility depends on the grid. Since the mid-20th century, the grid has grown into an incredibly potent, flexible and cost-efficient servant meeting all of our society's electricity needs and wants. Interruptions are few and far between, most often due to Mother Nature's extremes. The nation's grid has been called the single greatest engineering achievement of the 20th century.

The grid does its magic by networking and coordinating literally millions of mechanical, chemical, electrical and electronic components. From power plants to intra- and interstate transmission lines to regional transformers to neighborhood distribution wires, to pole-top transformers, and into the home. All monitored 24/7 by scores of utility control centers loaded with high-tech equipment sensing every hiccup.

If this is grid-based electric utility service, how else could businesses and households receive electricity? What might the alternative look like?

Today, there are a range of new technologies and business models shaping the alternative:

- A business or household installs the equipment to meet some of its electricity needs on its own premises with a natural gas-fueled generator or with rooftop solar panels (commonly referred to as distributed generation), replacing grid-based electric utility service in part. The customer still buys electricity from the grid as needed, and sells electricity back to the grid when there is an excess of that made on-premises. The business or household may own the distributed generation itself, or where allowed, lease it from a third party.

- A business or household installs the equipment to meet all of its electricity needs – 24/7 – with distributed generation (such as with a natural gas-fueled generator or with a combination of rooftop solar panels and batteries). The customer could disconnect from the grid though is unlikely to do so. The installed equipment can't approach the grids' near perfect reliability. So the grid is an invaluable backup, and necessary too for the sale of excess electricity back to the grid. Again, the business or household may own the distributed generation and batteries itself, or where allowed, lease it from a third party.

- A business or household buys all of its electricity from an unregulated supplier, rather than from the local utility, using the utility's transmission and distribution lines and wires for delivery of the electricity (commonly referred to as retail choice or retail competition). Individual states will determine whether customers can make such choices. The business or household might also buy demand management services from a third-party, whereby it agrees to reduce electricity use during certain high price peak periods in exchange for a payment of some kind.

- A third-party developer installs solar panels on a plot of land to serve nearby businesses and households (commonly referred to as a community solar garden), using the utility grid to distribute the garden's output.

- A group of businesses and households (such as a university or military base) builds a microgrid: distributed generation and a small-scale network of wires to connect the group. While a microgrid can operate independently from the grid as needed, the network (microgrid) will generally be connected to the utility grid as well (to buy electricity from the grid or sell electricity to it when economic).

- A business or household has a standby/backup generator that is run in emergency situations only (or potentially when the price of the grid's electricity spikes up and exceeds the costs of running the backup generator).

There are combinations and hybrids of these new technologies and business models that – like the above – are mostly partial alternatives to grid-based electric service. And there are of course other alternative business models emerging along with new technologies, and even the development and deployment of smart meters and smart grids are changing the way that the existing grid is used.

The pace and magnitude of market penetration by these technologies will vary by region and state. In California and the Desert Southwest, as well as in Hawaii, for example, rooftop solar panels have attained significant penetration already. Public policy-makers and regulators there are dealing with the ramifications. Elsewhere, the pace and magnitude of market penetration is slower to date. There is little doubt that the traditional grid and utility business model and its regulation will evolve over time across the country.

So we have a definition of grid-based electric utility service and a definition of developing technology and business model alternatives which will impact the grid. With these, we proceed to the report.

Executive Summary

Urgent question

This report aims to inform the layman and expert alike about a concern whose ultimate resolution will shape how and how well Americans receive electricity in the near future. How we receive electricity is rapidly changing in many areas of the country. How well we'll receive it is uncertain.

Encouraged by direct and indirect incentives and subsidies and other policies of the federal government and some states, there is increasing deployment of new technologies and business models. These are now essentially competing with for-profit regulated utilities, not-for-profit utilities, and unregulated power suppliers and taking over key roles from them.

Until recently, utilities had negligible competition, both in producing/supplying electricity and transmitting/distributing it to each business and household location. But with these new technologies and business models, competition is significant and growing, particularly with respect to the distribution of electricity over local wires to the end-use customer.

Competition between utilities and non-utility companies – one would think – shouldn't be a concern to electric consumers. However, it may be an important concern. How exactly this competition develops is critical to ensuring that electric service remains reliable and affordable for everyone. Electricity is different than other industries in this respect. In most industries, competition brings lower prices and better service. But because of the way the electric industry has developed and has been regulated, there can be unintended consequences of increased competition in this industry.

The urgent question, and the main focus of this report, is:

Will <u>all</u> Americans continue to enjoy uninterrupted unlimited electricity they can afford?

That the concern is important and urgent is indisputable. The constant supply and delivery of electricity to all of our 150 million or so residences and business structures is critical for our prosperity, culture, safety and health.

The public's dependence on uninterrupted unlimited electricity has become so extensive that the rare interruptions and limits that do take place from time to time put a virtual halt to modern life and commerce. Transportation, communications, banking, medical and emergency services, and food and water supply are increasingly crippled by blackouts, especially those outages that last for days.

In coming decades, our dependence on electricity will undoubtedly magnify as the economy continues to electrify. The number of machines, appliances and devices in the average home needing electricity is now around 60. And that excludes all of our lights. And as we electrify the transportation system, the consequences of outages will be even more magnified.

Electric service interruptions and limits will become more disruptive and more dangerous. What was an inconvenient prolonged blackout in the 1990's, with pre-Internet applications of electricity, was more disruptive to our way of life in the 2010's, in the early years of the Internet, will be catastrophic in the 2030's with pervasive hyper-dependence on electricity.

To all by all

In the late 19th century, Thomas Edison, Nikola Tesla and George Westinghouse – the industry pioneers – could have chosen an open distributed model for the supply and delivery of electricity. The very beginnings of the industry had distributed generation and networks without interconnections. But it became clear that a model of large-scale power plants, with long-distance high-voltage transmission lines serving local low-voltage distribution wires was more efficient and reliable for serving end-use customers. And then it became clear that by interconnecting distinct networks, greater efficiency and reliability could be achieved.

So industry leaders settled on a business model, with very extensive grids serving large parts of the country. Indeed, there are just three grids serving the entire continental United States and Canada: the Eastern Interconnection; the Western Interconnection; and the Texas grid operating only within that state. Each of the three operate as though it was one large electrical-mechanical-electronic machine, with regions within it coordinated for efficient reliable operation.

With its mesh of power plants, high-voltage interstate lines, high-to-low voltage transformers, and low-voltage neighborhood wires, a grid is finely tuned to provide electricity to businesses and households. A group of utilities in cooperation manages the entire operation end-to-end from power plants to neighborhoods.

It would not make economic sense to have competing grids in the same area. So for each area there's a single grid. This is why it's considered to be a natural monopoly (naturally a business in which competition is uneconomic).

The focus – in Edison's time and for over a hundred years since – was**: Consumer Convenience, Cost Efficiency and Reliability**. For over a hundred years since, this remains the industry's focus.

In the early 20th century, the natural monopoly model for electricity grew into a regulated public good. Eventually, businesses and households would share equitably in electricity's benefits provided **to all** and electricity's costs borne **by all**.

The regulated public good model was ushered in with the basic principle that costs would be allocated to customers who caused the costs to be incurred (commonly referred to as the cost causation principle). This fair sharing of costs was managed by utilities and enforced by utility regulators (first state regulators, later joined by federal regulators).

Utilities were assigned service territories. And they were granted the opportunity to earn a fair return on their investment, in return for satisfactorily serving all customers in their territories.

While the natural monopoly characteristics of some components of the grid have changed over time and particularly in the last several decades, some components of the system (for example, the costs of the transmission and distribution wires, and the administrative costs of operating and managing the grid) are still shared by all customers in all cases.

This report refers to this sharing system, which supplied and delivered electricity to all Americans until twenty years ago (and most Americans still today), by the term: Grid-Based Electric Utility Service. Here we define the terms' two parts.

Grid-Based because the continent's three mega-networks – collectively the grid – is the blood stream for our electricity, just as the Internet is the blood stream for our communications. It's an apt metaphor.

Blood circulates through large vessels and small capillaries nourishing every part of the body. Data circulates through server farms and cell towers connecting every digital device. Electricity circulates through the grid's interstate lines and neighborhood wires energizing every home and workplace.

Electric Utility Service because some three thousand for-profit and not-for-profit utilities work together to manage the grid. The actions of all these utilities are under constant scrutiny by regulators and – in the case of the not-for-profits – government or community appointed boards of directors.

There is no doubt that this shared system is under pressure in today's world. Pressures began after the oil embargo of the 1970's with passage of the Public Utility Regulatory Policies Act of 1978. Pressures increased with the decision by some states to allow end-use customers to choose their electricity suppliers in the early-1990's, and soon after with the establishment of independent operators of the grid in some regions. Pressures increased further with the emergence of centralized renewables (wind farms in particular) and distributed renewables (rooftop solar in particular).

These trends have been stimulated by government policy, particularly by providing direct and indirect subsidies and incentives (like the federal government's production tax credit and state governments' net metering incentive). They eased the way for new technologies and business models to compete with grid-based electric utility service.

States like New York are considering how to increase competition within the grid-based electric utility service model, making the local low-voltage distribution wires a platform for services offered by competing companies. Priorities in these states are to increase customers' choices, opening up their access to new and competing services, and stirring the development of environmentally benign sources of energy.

Other states have generally maintained the traditional system of shared, grid-based electric utility service. Notwithstanding the federal government's initiatives favoring new technologies and business models, these states have maintained a vertically-integrated utility sector with priorities remaining as they always have been: **Consumer Convenience, Cost Efficiency, and Reliability**.

Each on their own

The states moving away from the traditional vertically-integrated model of utilities managing all electricity generation, transmission and distribution have in so doing phased out – at least partially – the equitable non-discriminatory sharing of electricity's benefits and costs. The costs of electricity production/supply, for example, are generally no longer fairly shared by customers. Instead generation costs are spread among end-use customers based on how expertly they buy from a complicated competitive market.

The responsibility for managing long-distance high-voltage transmission lines (and their costs) has been turned over to third parties (commonly referred to as independent system operators) that are regulated by the Federal Energy Regulatory Commission rather than state regulators. All end-use customers within an independent system operator's area pay a share of the costs of managing a marketplace for electricity supply and for the transmission required to operate the market.

Phasing in is a new discriminatory system, an ***each on their own*** system, where self-interest predominates, in which individual households and businesses shop around for the best electricity deals. What of those consumers who don't or can't find an affordable deal to keep the lights on as they're accustomed to? What about customers that may be unprofitable to serve? Might they be left behind?

Might this lead to two societies? A privileged minority has the financial ability and inclination to work around grid-based electric service. They may choose a new supplier for their electricity needs, or they may lease a rooftop solar system from a third-party solar developer. Or if they have multiple office buildings, they may build a microgrid to serve their office park. As this minority opts out, the remaining majority may be left holding the bag, left dependent on the utility grid which now has less revenues to provide for its upkeep or expansion.

Consider that the one-quarter of households that take the most kilowatt-hours of electricity pay around one-half of utilities' residential electric bills in dollars.[1] What would be the implications if this minority of households – so vital to the funding of grid upkeep – largely abandons paying its fair share for the grid?

Could the remaining majority afford the added burden to make up the gap left by the minority? Even if the remaining majority could, would it be willing to pay the extra amounts needed to keep the grid in good working condition?

The privileged minority generally resides in large single-family detached suburban houses. They generally have higher income and better credit. With higher electric bills, they are naturally targeted by the new technology and business model companies, from the rooftop solar industry particularly.

The net metering incentive, common in many states, provides an example of what can happen when we transition from a system of shared costs by the many, to a system where individual consumers can find the best deal for themselves. Net metering generally enables customers who generate electricity on their premises to be paid the full retail rate charged by their utility for the electricity they generate in excess of their own needs.

But the utility saves only its variable costs when it takes this excess power from the customer. The difference between the utility's variable costs (which is what it actually avoids) and its full retail rate (which includes both fixed and variable costs) is lost in this net metering arrangement. Because utilities have the right to recover their prudently invested costs in electric rates and bills, the differences must be made up by other customers. Thus, net metering is a subsidy from customers not generating their own electricity to those customers with on-premises generation.

[1] Based on the author's research, as discussed in his 2013 book "Lines Down: How We Pay, Use, Value Grid Electricity Amid the Storm."

Proponents of the net metering incentive argue that the incentive is warranted because of the unique benefits or "value of solar" to consumers. As this report points out, consumers who generate on their premises should be properly compensated when they sell their excess electricity back to the grid. And that compensation should be based on the costs that the local utility avoids by not having to generate or buy the same amount of power itself. If, for example, the consumer with on-premises generation can help delay investments by the utility in grid generation, transmission or distribution facilities, that consumer should be compensated for a share of the savings that result.

But many who argue for compensation for the value of solar include avoided carbon dioxide emission effects and costs (or other environmental externalities) as a rationale for continuing a generous net metering incentive. Without taking a position as to what incentives or subsidies should be provided to rooftop solar, using utility ratemaking to provide an incentive, as is the case with net metering, is not the right approach and has unintended consequences.

First, the benefits of reducing environmental externalities accrues to all customers, but under net metering customers without on-premises generation mainly bear the costs. Second, it could provide a distorted economic price signal to consumers. Third, if environmental externalities are to be considered, generation sources that most effectively and efficiently reduce environmental externalities – such as the grid's zero-emission nuclear, hydro-electric, wind and utility-scale solar power facilities – may not receive an incentive while solar on the roof of large homeowners may. If subsidies or incentives are to be provided based on external benefits, they must be applied equally to all technologies based on their relative benefits.

The public may make the wrong decisions regarding their power supplies if based on distorted price signals. Any warranted subsidies should be even-handed – equally treating all environmentally-benign sources for example – and transparent to consumers.

Net metering is a double whammy to the utility. It is an incentive for customers to partially leave the grid, thereby reducing their contribution to the fixed costs of maintaining the grid. And it imposes additional costs on other customers, most notably the increased costs of integrating customer-owned generation into grid operations.

And more precisely, net metering is a double whammy to the large majority of the utility's customers who cannot or do not take advantage of the net metering incentive. The new costs are ultimately paid by them, including households and small businesses. And because low income and low usage customers may be the least likely to take advantage of the net metering subsidy, they may be disproportionately affected.

Efforts by utilities to phase out the net metering subsidy have been met with substantial resistance by companies that take advantage of it to finance or lease solar panels, or by others who believe such subsidies are warranted. But such subsidies from one group of customers to another is not sustainable. As the use of the incentive grows, either the funds for continued investment in the grid will be impacted resulting in concern over the degradation of the grid's reliability, or the costs of maintaining the grid to those still paying for it will become too great to withstand political scrutiny. New ways must be found to ensure that everyone continues to pay their fair share for what the grid does for them.

Erosion

The erosion of the grid's funding – from reduced payment for grid-based electric utility service by customers partially replacing grid-based electric service – could result in the erosion of utilities' ability to maintain, refurbish and replace aging plant and equipment. And, as previously mentioned, the new technologies and business models will actually require increased (not decreased) investment in the grid to ensure that reliability is maintained.

The corrosive effect would be felt by all businesses and households that continue to be dependent on the grid's upkeep and performance – which is most if not all customers. **Ironically, the large suburban house or business that installs rooftop solar depends on the grid even more than the average house or business.** But for the grid, a house or business with rooftop solar would have to waste much of the electricity that the panels produce. It simply couldn't sell any excess back to the utility. And any such excess power from generation on customer premises cause two-way power flows on the grid, and thus may require substantial utility investment in new equipment and systems. These investments increase the utility's costs. Yet, under net metering, the rooftop solar customers who create the need for these additional investments pay a lesser share of grid costs than do other customers without rooftop solar who do not need these investments to be made. And even without net metering, costs to other customers without rooftop solar may increase as a result of increased costs to the utility for which they bear no responsibility.

The net metering incentive is often what generally makes rooftop solar work financially which helps to explain why its phase out is so politically charged. Most of the companies competing with utilities have no intention to undermine the grid they and we all depend on. The concern, of course, is that if the net metering incentive continues to increase in use over time, the negative side effects might unintentionally bring down how the grid's upkeep is funded. If utilities are forced to cut back grid upkeep, for want of sufficient monies, there's no one standing behind utilities to step into the breach.

If – or when – the grid's performance is eroded, the negative effects will be most apparent to consumers in adverse and extreme scenarios. Consider how much more devastating the recent Polar Vortex and Superstorm Sandy would have been if the grid was weakened by years of under-funding, under-investment and neglect. Would utilities have had sufficient funds to harden their systems against the ravages of storm damage? A home may have lost power for as long as a week. That was bad enough. But suppose, because of grid under-funding and deterioration, a future weather event like Superstorm Sandy causes that home to be without power for as long as a month.

To make the giant leap from the sharing system to an ***each on their own*** system, without such harmful effects, the grid's traditional functionality must be kept in good working condition through the transformation <u>and</u> after the transformation. Plus, on top of this, new high-tech functionality must be integrated; a tall order.

As the Electric Power Research Institute and other experts have shown, to make this leap without harmful effects, new electrical and electronic functionality will be necessary to handle two-way electrical flow, intermittency, millions of micro-power suppliers, and distributed monitoring and control.

Even competition enthusiasts increasingly recognize that maintaining the grid's traditional functionality plus integrating this new functionality will require <u>greater</u> - <u>not lesser</u> - funding

Squeezed utilities

How can we mitigate the risk of negative side effects from the competition movement? There are four basic principles that are critical:

(1) The continuing transformation of the industry cannot harm the grid's reliability, requiring that utilities collect sufficient funds from customers to continue to invest in needed upkeep and expansion of the grid, including investments needed to accommodate new technologies and business models

(2) The returns earned by utilities on these necessary investments in the grid should be sufficient to maintain healthy credit ratings

(3) The transformation cannot conflict with traditional and fair regulatory principles which are based on allocating costs to those who cause the costs to be incurred, ensuring that customers make choices based on transparent economics (the actual costs) of their decisions, and

(4) The subsidies and incentives for new technologies and business models should not lead to unfair consequences, benefitting some customers at the expense of others.

Accomplishing this is easier said than done. The transformation to an ***each on their own*** system almost inevitably squeezes the monies that utilities can dedicate to grid upkeep:

↓ *Downward pressure* is put on the amounts that utilities collect from businesses and households by serving them because of traditional regulated rate structures

↑ *Upward pressure* is put on what utilities must pay out for investments in the equipment and technology needed to accommodate the transformation of the industry, as well as other government mandates, fees, subsidies and taxes (such as to subsidize energy efficiency, demand response, wind farms, rooftop solar, and energy research)

Rates should follow costs

There are practical options for preventing this funding squeeze. One way is to change the mix of variable and fixed charges in electric bills, appropriately reflecting that utilities' costs for grid upkeep are largely fixed (while electric bills are largely variable based on kilowatt-hour usage).

As shown in the final section of this report, the variable-fixed mix in electric bills can be changed to better reflect utilities' costs without significantly burdening low-income households or weakening the incentives for households' efficiency improvements. Having prices reflect the real costs to serve customers is one of the fundamental principles of good regulation – going back to the origins of regulation − and is the only pricing principle which ensures an economically efficient result.

Another way to better reflect true costs in prices is to have end-use customers pay for the electricity they take from the grid, based on the rate everyone pays, and for the grid to pay for the electricity it takes from those making electricity on-premises, based on the avoided costs to the grid of this distributed generation. Everyone paying the same rate for electricity, among a broad class of customers, is a longstanding and fair tradition. And ensuring that the grid pays for electricity made by third parties based on its value (the electricity's avoided cost) is the foundation for reimbursing small power projects under the Public Utility Regulatory Policies Act of 1978 – still Federal law – and is a longstanding and fair tradition as well.

The minority of customers with distributed generation would simply have two meters. One would be for measuring how much electricity they take from the grid. One would be for measuring how much they put back in.

Another way to better reflect true costs is to change the mix of long-term and short-term charges in electric bills, appropriately reflecting the fact that utilities' costs for grid upkeep are largely long-term (while electric bills are largely short-term).

The grid must have the capacity to handle – in stride – around-the-clock and peak demands on it, for decades into the future. Current market structures, however, tend to emphasize the short-term over the long-term.

These are but a few of the potential solutions to the problem. Any viable solution must ensure continued grid funding to maintain a reliable and affordable electric system. We cannot assume that all will be taken care of in due time; or that some benefits of distributed energy are so great that distortive subsidies – both direct and hidden – are warranted, no matter the side effects.

This report does not put forth a preferred solution. It rather describes the problem, why it needs to be solved with urgency, and outlines a number of potential solutions worthy of further consideration.

"And then one day the grid went down and never came back up."

Changing Uses of the Electric Grid:

Reliability Challenges and Concerns

I. Grid Essentials

A. <u>How Does the Grid Rely on Utility Funding?</u>

What is – after all – an electric utility? Some might say it's the company that sends them electric bills every month like clockwork. Some might say it's the company that demands state regulators approve an electric rate increase as soon as the last increase was allowed. Some might say it's the company that wants to build a power line through the neighborhood. And some might say it's the company that keeps the lights on, though exactly how it does that is a mystery.

While utilities bill monthly, propose rate increases (not being in a position to demand them), build power lines and other grid components, and keep the lights on, perhaps the most important function served by utilities is the raising of capital to invest in the assets and people necessary to maintain a reliable electric system so critical to our national economy, security and quality of life. Thus utilities are the grid's funders.

Grid funding works like this:

Since households and businesses can be counted upon to pay their electric bills

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And since state regulators can be counted upon to approve the recovery of (and a fair return on) the investments necessary keep up the grid and maintain reliable, affordable service

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And since, by allowing fair returns, state regulators allow utilities to keep up their financial standing in the eyes of the capital markets

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The capital markets remain willing to advance utilities the substantial funds that are required for grid upkeep

Circle of trust

The whole system relies on trust. A circle of trust linking a local utility's customers – businesses and households – with the utility's state regulators and them with the utility's capital investors, with the utility in the middle of it all.

- Customers trust a utility will use their bill payments well for keeping the lights on under the watchful eyes of regulators

- Regulators trust but verify that electric rates and bills are no more than is absolutely needed

- The utility trusts that customers will pay their bills. And that regulators will allow rates and bills to be enough to cover both what's required for grid upkeep and for keeping up the utility's financial standing (a fair return on investments)

- Finally, the capital markets – investors in the utility's stocks and bonds – trust that everyone else (customers, regulators and the utility) will play their part fairly. They trust but verify as well.

This brilliant system for grid upkeep can break down, from broken trust all around. Though it has rarely done so.

Results speak for themselves

The results are evident. The nation has a high-performance grid in place that cost nearly one and a half trillion dollars to erect and costs consumers nearly four hundred billion dollars annually (per the US Department of Energy, Energy Information Administration). Reliability is the envy of much of the world.

And despite the enormous total dollars involved, **the median American household pays only around $3.50 per day for all their electricity** (per the US Department of Labor, Bureau of Labor Statistics). Remarkably, that includes households in the south that intensively use air-conditioning almost year-round, when not using electric heating.

Blowback

No one likes to hear that their utility has proposed a rate increase. Media stories often amplify frustration with accounts of the hardship it would bring to low-income families, seniors and small businesses. Advocates for low-income families, seniors, and small (and all) businesses sometimes create an echo chamber of opposition that utility regulators hear loudly and clearly.

So when grid costs go up for any reason, necessitating a proposal to increase electric rates and bills, utilities understand the consternation and opposition it will create. This naturally makes them reticent to forward these proposals unless and until they are absolutely necessary to ensure that the lights stay on.

No-win

Utilities do not like to or want to be in conflict with their customers. It’s simply bad business, particularly now when customers have alternatives to grid-based electric utility service. But when government policy such as incentives and subsidies combine with some customers' desire to make some electricity themselves, there can be detrimental effects on a utility's ability to continue to provide reliable, affordable service.

It places the utility in a no-win situation. The utility knows grid costs will increase to accommodate some customers' desires to adopt new technologies. The utility also knows that, under existing utility regulation, the loss of grid sales will shift costs between these customers and the rest of us.

Trying to fix these problems, the utility will probably be castigated, for being anti-green, anti-solar, anti-competition, or worse. It's become a fact of life for utilities.

Costs shift into high gear

Why do costs go up? The grid we have today was designed for one-way flows of electricity, from large-scale power plants along long-distance high-voltage transmission lines and then along local low-voltage distribution wires to businesses and households. All these assets and equipment were traditionally owned and operated by a single utility.

When customers install rooftop solar, and sell their excess electricity back to the grid, the utility must make sure that the wires can handle this new use. It must deploy monitoring and controls on the lines to allow two-way flows. It must ensure that voltage levels and reactive power are sufficient so that equipment is not damaged. It must ensure safety for utility workers who are working on lines. It must ensure that the high-voltage end of the grid is not negatively affected by this new use of the low-voltage end of the grid.

Grid costs can also go up because many of the new technologies and business models rely on renewables, and the output of renewables is intermittent. Rooftop solar produces electricity only when the sun is out. When the sun goes behind a cloud, its operation shuts down quickly, often in an instant.

This requires the local utility to have backup sources of electricity that starts up just as quickly as rooftop solar shuts down.   This is especially true if there are many solar roofs within the same neighborhood. The need for quick-start backup is true for other intermittent technologies: microgrids, community solar gardens, wind farms.

Additional new costs to integrate these technologies and business models must be incurred to ensure the grid's voltage levels and system frequency remain within safe levels, and that circuits are not overloaded. All these new costs need to be paid for, but by whom? If those using the new technologies are paying less to their local utility for grid upkeep, the new costs must be paid by someone else.

Detour into utility regulation

Shouldn't those who utilize less of a utility's electric service – by putting solar panels on the roof for instance – pay the utility proportionately less? To answer the question, we take a little detour into the world of utility regulation, specifically how electric rates are set.

Suppose a utility requires an electric rate increase to cover increased costs or investment in the grid, like hardening substations and line equipment against the effects of storms. The utility has to first go before a state public service commission for permission. (Though sometimes, the commission calls upon the utility to come in and justify keeping rates at current levels.)

The utility opens its books to the commission and public "stakeholders," including advocates for business and household customers, who wish to take part in the regulatory proceeding. The burden of proof is on the utility. It must demonstrate what its costs really are, how much should be recoverable through customers' electric rates and bills, what return on investment should be allowed, and how its costs should be allocated to the different types of customers. The commission reviews all of this data, listens to the views of the advocates for customers and other participants, and renders a decision.

The primary driver in all of these cases is the regulatory compact. This "compact" is a principle that has developed as a result of case law and regulatory practice over many years, including landmark decisions of the US Supreme Court. The regulatory compact says utilities have an obligation to serve all customers without exception and without discrimination, within a specified service territory. In exchange, utilities are allowed (though importantly not guaranteed) to earn a reasonable financial return on the investments they make, to meet their obligation to serve.

Utility regulation is complicated by the fact that there are two kinds of electric power provided by the grid, two products in effect. They are commonly referred to as capacity and energy.

Capacity is the ability of the grid to meet the needs of all of its customers at the very instant when customers in aggregate take the most electricity. This is the grid's peak. The grid must maintain significantly more power plant, transmission and distribution capacity than what peak requires, to be very sure there will always be enough, even if some equipment temporarily fails to perform.

The other kind of electric power provided by the grid is energy. Energy is what end-use customers actually need and use on a moment to moment basis. Having sufficient capacity is essential to ensuring that customers have all the energy they need and want at all the times when they need or want it.

Crystal ball: how many lights will customers switch on?

The electricity industry is thus somewhat unique. The grid must maintain the capacity to produce more than what customers need on average, significantly more. And because electricity generally cannot be economically stored, the grid must continuously maintain all that capacity, including the surplus, even during most of the time when customers don't need all that the grid could produce.

But here's one of the problems that has arisen. When customers buy less grid electricity because they are making some of their own, on their own premises, it doesn't necessarily reduce the amount of capacity that the grid must continuously maintain.

This is because customers with their own on-premises generation may buy less grid electricity over the course of a month or year, but still buy some from time to time, including inopportunely when the grid strains to meet peak demand from all customers in aggregate. If the grid's utilities weren't maintaining sufficient capacity for all customers at peak – those with and without their own on-premises generation – then the grid could brown or black out inconveniencing all customers.

There wouldn't be a problem if a customer's on-premises output of electricity peaks at the same time as when the grid strains to meet peak demand. But this is hardly ever the case. For example, rooftop solar typically peaks in the mid- to late-afternoon. The grid's demand typically peaks in the early evening. Thus, there's usually a few hours between when solar output peaks and the grid's demand peaks. And wind energy typically peaks in night-time hours, when utility loads are low.

In addition, on the hottest day of the year, at the hottest busiest hour when the grid must keep everyone's air conditioners humming, there is no guarantee that the sun will shine on the solar panels on roofs or that the wind will blow. The grid's utilities can only assume they must meet peak demand under the worst of circumstances, such as without help (or with minimal help) from solar and wind.

Capacity so there's always enough energy

If regulators allowed utilities to bill customers for the costs of maintaining all this capacity regardless of how many kilowatt-hours of electricity customers take from the grid, then there wouldn't be a problem. Fixed costs of the grid would be proportionately paid by all end-use customers. Variable costs would be billed according to customers' energy (kilowatt-hours) use.

But that is not how utility regulators set electric rates. For several reasons, some or most of the fixed costs – to maintain the grid capacity that is needed – are instead generally included in the variable per-kilowatt-hour section of electric bills.

One reason for incorporating fixed costs into variable rates is that regulators have traditionally believed that heavy-usage customers should contribute more to a utility's fixed costs than light-usage customers. Thus, a 2,000 kilowatt-hour heavy-usage customer makes a contribution to fixed costs that is four times greater than a 500 kilowatt-hour light usage customer if all fixed costs are rolled into variable rates.

Regulators point to social-benefit reasons for including fixed costs in variable rates as well. They want to reduce the electric bills of light-usage customers who tend to have lower income than heavy-usage customers.

And including some or most fixed costs in the variable section of electric bills also, it is believed, helps to promote customers' energy efficiency. If instead electric bills were primarily based on fixed costs and less a function of how much electricity customers use, the concern is that customers would have less interest in making their homes more energy efficient, as the monthly savings to be achieved would be smaller.

So traditional utility regulation has built-in peculiarities with real implications as new technologies and business models lessen how much grid electricity customers use. But this also means that the financial viability of grid upkeep and expansion, under traditional regulation (if not modernized), can be undermined.

When customers lessen their grid electricity use – due to rooftop solar, microgrids, etc. – there are fewer kilowatt-hours billed by utilities responsible for grid upkeep. And because variable rates include a contribution to fixed costs, a smaller proportion of fixed costs can be paid for. Yet, utilities can't reduce these fixed costs, without either endangering the condition and performance of the grid or endangering their long-term financial viability.

Dear prudence

Under traditional regulation, if the minority of customers who can and do put solar panels on their roofs pay less because they take fewer kilowatt-hours from the grid, a utility's rates must adjust to compensate for the revenues that are lost. As a consequence, the majority of customers who cannot or do not put panels on their roof end up paying higher bills to make up for the lower bills paid by the minority of customers with solar rooftops.

In very many communities, a large majority of residential customers live in multi-family buildings or live in single-family houses unsuited for solar, or rent their homes, or don't have high enough credit scores to sign long-term solar leases, or don't want to put up solar panels for other reasons. The majority might be as large as three-quarters of households or more.

The minority of customers who do put solar panels on their roofs tend to have considerably higher income than the majority of customers. They typically live in large detached single-family houses, own their houses, and have high credit scores. The responsibility of paying for grid upkeep is thus shifted to those less able to afford higher electric bills.

If the rooftop solar minority no longer needed the grid, utilities could reduce investment and keep electric rates and bills fairly stable for the majority of customers (relative to general inflation). But the rooftop solar minority continues to need the grid even as they cut deeply into what they pay for it.

Utilities face an additional challenge due to the net metering incentive. The incentive enables customers with rooftop solar or other forms of distributed generation to run their electric meters backward in effect. These customers get out of paying the per-kilowatt-hour variable rates for the electricity they make for themselves on their own premises, plus they get a credit for excess electricity they send back to the grid.

In many states, the credit for the excess electricity they send back to the grid is, notably, at the utility's full retail rate. That full retail rate includes both fixed and variable costs of the utility. The credit reduces a customer's monthly electric bill. In some states if a customer's credit exceeds the size of its bill in one month, it can carry over that credit to the next month.

Thus the net metering customer is avoiding paying its share of grid costs in two ways. First, the customer doesn't pay any part of the fixed costs of the grid for the kilowatt-hours it generates for its own use. Second, when feeding excess power back to the grid, the net metering customer gets paid a credit that includes grid fixed costs. And since unused credits can often be carried over from month to month, with this generous incentive a customer could avoid paying anything for the grid for several months or longer. It is a peculiarity that allows many net metering customers to avoid paying their fair share.

1980's disco and net metering

The net metering incentive began in the 1980's to jump-start the early development of rooftop solar and other forms of distributed generation. These technologies were then new and unproven.

Thirty years later, there are now around 600,000 households nationally taking advantage of this incentive. While still a very small minority of all American households, about half of one percent, the number of net metering households is growing rapidly.[2]

Forty-three states and the District of Columbia have instituted this incentive. Fourteen of the states also have instituted some form of virtual net metering.[3] This broader incentive allows customers spread around a utility service territory participating in a distributed generation project – physically or just financially – to take net metering credits against their electric bills. Virtual net metering, which includes community solar gardens, raises additional concerns.

The avoidance of responsibility for grid upkeep arising from net metering goes further than just the sidestepping – by a minority of customers – of payment for the grid's fixed costs. Homeowners who can and do install distributed generation avoid contributing to other costs everyone else pays for, such as programs to improve customers' energy efficiency and to help low-income customers afford their electric bills. The rest of us without distributed generation and net metering are left to pick up the slack through higher electric rates and bills.

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[2] There were approximately 645 thousand residential solar installations through year-end 2014, according to the Solar Electric Power Association, and 126.4 million residences at mid-year 2014, according to the federal government's Consumer Expenditure Survey. Not all solar installations have the net metering incentive.

[3] According to the Database of State Incentives for Renewables & Efficiency, the federal government's National Renewable Energy Laboratory, and Intelligent Utility, although definitions of virtual net metering vary and thus the number of states allowing it.

Utility regulators have sometimes put into place rate designs enabling utilities to make up for stagnant or decreased sales of grid electricity – to continue to keep up the grid and programs like these – such as the decoupling of sales from revenues and lost revenue adjustments. But these regulatory innovations still end up raising electric rates for the majority of customers without distributed generation, to buffer the impact from the minority of customers with distributed generation.

An appendix to this report summarizes the fixed versus variable cost problem for utilities and the grid that the net metering incentive causes. Illustrative examples are provided there.

The net metering incentive violates the longstanding well-settled legal and regulatory principle of cost causation. Cost causation is so fundamental in utility regulation since it is both fair and is the only method of cost allocation that ensures economic efficiency.

In utility law and regulation, those types of customers who cause costs to be incurred by utilities – to maintain the grid – must pay for those costs. For example, utility investments in residential energy efficiency programs are charged only to the residential class of customers. Or costs to underground distribution lines in a sub-division are paid for by the developer and not by customers in other sub-divisions. That's fair.

Similarly, if large suburban homeowners put distributed generation in their backyards or on their roofs, but continue to use the grid extensively every day of the year anyway, then they must continue to help pay for the grid. That's the fairness of the cost causation principle at work again. The net metering incentive interferes with this basic fairness. A type of customer causes costs but doesn't pick up a fair share of the tab. As a result, the rest of us must pick up the check for them.

Valuing the good more than the not so good

The net metering incentive is also unfair and distortive by treating all installations of distributed generation as if they're equal in value. An installation in areas with constrained electrical capacity, such as in the center of a city, would likely save the utility and thus all of its customers much more than an installation in areas of abundant electrical capacity, such as in an outer suburban development of large single-family detached houses. Should the net metering incentive be as generous in such an area of abundant electrical capacity?

In the same manner, an installation that consistently reliably produces electricity during peak hours of the day – when a region's demands for electricity strain the grid – has more value than an installation that can't be counted on to produce much electricity during peak hours. Distributed generation installations situated in the areas of greatest need and those that consistently reliably produce electricity during peak hours are the most valuable to the grid, the local utility and thus all customers. It is these installations that should be compensated most generously. Other installations, situated in areas of lesser need and those that don't produce consistently and reliably at peak should be compensated less generously in accordance with their inferior value to all customers.

There are more equitable and cost-effective ways to spur and accelerate the development of solar and wind power and other renewables. This is clear when one sees that the greatest development of solar power in the US – by a wide margin – is taking place without the net metering incentive.

Nearly 62 percent of solar capacity and well over 62 percent of solar electricity output has been developed by utilities or for them by solar companies (commonly referred to as utility-scale solar).[4] None of these installations receive the net metering incentive. And their cost to customers – households and businesses – is generally a fraction of the cost of

[4] The 2014 capacity estimate according to the Solar Electric Power Association. The electricity output estimate because capacity utilization of utility solar significantly exceeds residential solar.

installations that receive the net metering incentive. Utility-scale solar is far less costly, far more efficient and far greater in aggregate scale. In contrast, residential rooftop solar accounts for only 18 percent of solar capacity and well less than 18 percent of solar electricity output.[5] Even with the built-in advantage of the net metering incentive.

Put another way, utility-scale solar is reducing the nation's carbon footprint more than three times as much as residential roof solar, without net metering and with far less cost to all of us. In part this is because utility solar is developed with economies of scale, with optimal placement relative to sunlight, with cutting edge technologies, with direct connection and coordination with the grid, and in the very most valuable locations for communities. And the costs and benefits of such solar installations accrue to all customers.

The net metering incentive may have made some sense in times past when the solar industry was just beginning to gain traction, to help the industry get over its first hurdles. Now that solar and other distributed generation has become cost-competitive for a range of applications, and sales have reached critical mass, the rationale for the incentive at this later stage has diminished.

The net metering incentive is a part of a broader spectrum of stimulus for new technologies and business models. Other incentives and subsidies include rebates, tax incentives, and low-cost financing.

None of this is to suggest that there are not benefits to the new technologies and business models. They clearly can have significant environmental benefits. And properly located, they can – in some cases – reduce or defer the need for new grid equipment.

Many studies attest to the benefits of distributed generation. The consistent reduction in their costs suggest these technologies and business models will continue to increase market penetration.

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[5] Ibid.

As we acknowledge the benefits, we must also recognize the additional costs of distributed generation to integrate into the grid and the other challenges it causes. Like any energy source or use, there are pluses and minuses to be weighed.

When government pushes for competition in the grid, we should also acknowledge that **the local utility faces a no-win dilemma**. The utility knows it has increasing investments to make – to accommodate the new technologies and business models as well as to comply with more stringent environmental regulation, to replace aging equipment, and to keep up with new business and household formation. The utility also knows that, under existing utility regulation, there may be shifts in costs and rates that might negatively impact a majority of customers, likely a large majority.

Do the right thing

In keeping with their public service role, utilities naturally support what customers' desire. And a utility's regulators and those who advocate for business and household customers would have it no other way.

And there's no reason why rooftop solar, microgrids, and other new technologies and business models should be incompatible with utilities' public service role and the needs of their investors and customers. But a solid dependable grid remains the backbone for our energy future. Utilities have an unshakable obligation to ensure the grid's reliability that cannot be taken lightly. And financial investors in utilities – holders of utility stocks and bonds like pension funds – must remain satisfied with what they receive back in return, or utilities will be unable to raise the investment funds needed to ensure upkeep of the grid.

Suppose a utility proposes to regulators to raise customers' rates to pay for new investments. Or to make up for its lost ability to pay for existing investments, as the penetration of new technologies and business models drain off some of the utility's funding.

Suppose instead a utility proposes to regulators changes to the way in which customers are billed for their grid connection and the electricity they take from the grid. To reduce cross-subsidies from some types of customers to others.

Typically, the response is unforgiving, or worse. Particularly by companies and interests leveraging those same cross-subsidies.

Even utilities that are global leaders in developing solar and wind power face stiff opposition and unkind rhetoric when proposing such changes. Recent experiences in states such as Arizona and California are case studies on fierce public and media blowback that can result.

The alternative is no better and likely much worse. What if a utility proposes to its regulators grid upkeep cuts in response to the revenue erosion from the cross-subsidies? In so doing, the utility throws the dice that the cuts won't so degrade the grid that blackouts will become more frequent and prolonged. That would spur even more public dissatisfaction.

Undistorted

There are practical solutions – discussed later in this report – that can be phased in to mitigate the unwanted side effects of the new technologies and business models. Customers who have installed rooftop solar can be grandfathered in as market-distorting incentives and subsidies are phased down. The development of larger-scale grid solar, which is considerably more economical and productive, and beneficial to all, can be accelerated.

Ultimately, everyone is best served if we all face the true undistorted costs of our energy choices. Then the most valuable of the new technologies and business models for customers will be the ones most likely to enjoy market success. And then customers continuing their traditional relationship with local utilities – the majority of customers – will not be unduly burdened with cross-subsidies. But if we are to continue to subsidize certain technologies, we should ensure that those subsidies are developed in a way that is fair and that minimizes both market distortions and cross subsidies among electric customers.

Death spiral

The incentives and subsidies for new technologies and business models have been largely ignored until recently. Their market penetration had been insignificant. As market penetration increases, however, the distortions of energy choices is becoming too consequential to be ignored.

For the utility, the situation can get worse, much worse. Suppose a generous net metering incentive stimulates a high rate of rooftop solar installations. In some states, ten percent of households might eventually install solar roofs, or twenty percent, or an even greater percentage. This is a real possibility particularly if the incentives and subsidies continue to be generous – relative to electric bills – as is being vigorously advocated by rooftop solar companies and supporters.

If this scenario unfolds, the grid can collapse financially into – what some industry pundits have called – a death spiral. As more and more customers cut their contributions to the grid, there are fewer and fewer customers to pay the lion's share of the costs of the grid and its upkeep.

The death spiral is a scary scenario. At some point, there would not be enough monies coming in to support the reliable electric system which we have come to rely on for modern life.

In particular, large homeowners with large roofs and many solar panels would severely cut their payments to utilities, tearing a hole in the fabric of a community sharing in the grid's costs. Such large homeowners, who naturally are the sales targets of the rooftop solar companies, are typically heavy-usage customers. So they have made larger payments to utilities than the average household up to now. If many of them slash their electric bills, utilities' revenues would fall substantially, and the amount of those revenues dedicated to paying the grid's fixed costs would fall substantially as well. This would leave other customers – such as small homeowners and renters – out in the cold, literally.

Example: Quality Power

The dilemma faced by utilities and their regulators can be illustrated with an example. Suppose Quality Power is a utility that serves one million households and two hundred thousand businesses.

Quality's household customers take one thousand kilowatt-hours per month on average, paying eleven cents for each. Doing the math, the average residential electric bill is $110. Per year that's $1,320 per household and $1.32 billion in total for all million households.

Quality's business customers – large and small – take ten thousand kilowatt-hours per month on average, paying eight cents for each. Businesses the world over pay less per kilowatt-hour than households due to their higher volume purchases and the economies of greater scale. Doing the math, the average industrial and commercial electric bill is $800. Per year that's $9,600 per business and $1.92 billion in total for all two hundred thousand businesses.

This means, over the course of a year, Quality collects $1.32 billion from residential customers and $1.92 billion from commercial and industrial customers. By adding the two amounts, we see that Quality has total revenues of $3.24 billion per annum. While $3.24 billion may seem like an immense sum, Quality has very many bills it must pay.

Quality's bills

Quality must pay fuel suppliers who send coal and natural gas to Quality's power plants, other power plant owners who send electricity to Quality's transmission lines, and regional transmission line owners and operators used in the process. These bills typically drain off half of Quality's revenues.

For everything else Quality must do, it has the remaining half of the revenues. For keeping Quality's power plants modern, efficient, safe and clean, for keeping its local network resilient, and for keeping residential, commercial and industrial customers satisfied with accurate bills and quick repairs, that remaining $1.62 billion might suffice. What makes Quality's job especially tough is that there are a lot more calls on those monies.

Quality must pay ever-increasing state, county and municipal government taxes, fees, subsidies and charges for a variety of public policy purposes. Some of the larger amounts are for the state's energy policies. Monies help support energy efficiency programs, provide help to low-income residential customers to pay electric bills, and provide rebates for customers installing solar on their roofs, for example.

Quality must also pay substantial amounts for the state's energy mandates. The state requires a certain percentage of all power used by Quality's customers be made by wind and solar farms. This is often expensive power compared to that produced by nuclear, hydro-electric, coal and natural gas plants, so the mandate siphons off more money from what Quality has left to spend on its core function: grid upkeep.

If state, county and municipal government taxes, fees, charges, subsidies and mandates cost Quality a quarter billion dollars annually, then the utility is left with $1.37 billion to spend on grid upkeep. Still seems like that might be just enough to keep the lights on for Quality's one million households and two hundred thousand businesses. After all, that's nearly a hundred dollars a month for each residential, commercial and industrial customer.

With $1.37 billion to spend, Quality does have enough to keep its power plants modern, efficient, safe and clean, its local power line network resilient, and its residential, commercial and industrial customers satisfied with accurate bills and quick repairs. Just enough, not any more, with Quality's regulators and ever-vigilant consumer advocates on the constant lookout for any place to cut utility expenditures and rates.

But what happens when Quality has less than this to spend? What happens when Quality doesn't have enough to keep its power plants modern, efficient, safe and clean, its local power line network resilient, and its residential, commercial and industrial customers satisfied with accurate bills and quick repairs?

Fatal or surface wound?

Suppose some number of Quality's heavy-usage customers start to make electricity on their own premises. In doing so, they replace grid electricity with their homebrew. Or suppose they continue to buy grid electricity, but switch who they buy it from, switching from the local utility to unregulated companies. Or suppose they discontinue buying grid electricity, buying electricity made by nearby microgrids instead.

Let's say that 20% of Quality's residential and large business customers install rooftop solar. And they reduce their usage of grid-based power by 80% (a conservative assumption since, with the net metering incentive, they might reduce their payment for it by 100%).

All this could cut Quality's customer revenues by about four percent, or $129 million per annum. For simplicity, let's set aside any increases and decreases in Quality's costs from these actions by the utility's heavy-usage customers. A $129 million per annum loss would slash the available funds for grid upkeep by almost ten percent. The available funds would fall from $1.37 billion down to $1.24 billion.

Would the ten percent shortfall be fatal to grid upkeep precipitating interruptions or limits in access to electricity? Or would it just be a surface wound that can mend over time?

Even expert electrical engineers can't precisely predict the consequences, though they are sure big risks with reliability would be taken

So a fairly modest market penetration of new technologies and business models can significantly reduce a utility's revenues, and can significantly erode the ability of a utility to maintain a reliable grid.

B. <u>What if the Grid's Upkeep is Under-funded?</u>

Less than two percent

At present, Americans' electric bills collectively contribute approximately three hundred billion dollars to the grid annually net of fuel expenses.[6] The money goes into the grid's

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[6] Americans paid $376.9 billion for electricity in 2013, of which $77.1 billion was paid to fuel suppliers, excluding nuclear fuel, according to the federal government's Energy Information Administration.

power plants, interstate lines, transformers, neighborhood wires, and related equipment. It's used to purchase and install new plants, lines, transformers, wires, etc., and to operate, maintain, repair and refurbish what's there now.

The money pays for, for example:

- ☑ The costs of capital investment for constructing new central-station power plants where needed
- ☑ building wind and solar power farms or purchasing their output
- ☑ putting up interstate transmission lines to transmit wind and solar power to our communities
- ☑ maintaining all of the grid infrastructure, including vegetation management around power lines
- ☑ adding environmental improvements ordered by the federal government
- ☑ making transformer substations and neighborhood wires storm-hardened
- ☑ protecting grid computer networks against malicious cyber-attacks and critical facilities from physical attacks
- ☑ extending the years existing equipment can operate economically and safely
- ☑ selectively upgrading equipment to provide greater efficiency
- ☑ installing technology to integrate distributed generation and intermittent renewables to work with the grid
- ☑ meeting mandatory reliability standards established by the North American Electric Reliability Corporation

All this so we can continue to rely on the grid. And so our electric bills remain affordable.

The investment needs for the grid seem enormous. But that's because our national economy is enormous. For some perspective, consider that the grid takes up only around two percent – less than one fiftieth – of the economy's total expenditures.

This amount has been around two percent of the economy for decades. Since the mid-20th century, the grid has consistently cost only this much for all the value it delivers.

Cuts to investment?

Funding for upkeep of the grid might need to be cut below this historic level in the near future. What would bring us to this dangerous point? Utilities may not be able to afford to do more. They may not be able to maintain grid upkeep at necessary levels.

They may be financially squeezed by new technologies and business models encouraged and subsidized by the federal government and some states. In these states, **competitors are simultaneously deflating utility revenues and inflating utility costs.** The squeeze is on when, for instance, government requires utilities to pay the generous net metering incentive to competing rooftop solar leasing companies.

Trouble brewing

One indication of the trouble that is brewing is the trend in electric utility bond ratings. The ratings have generally fallen since the year 2000. A large percentage of the ratings were around A. Now, utility bonds are commonly rated around BB. Many are rated lower.

What does it matter what a utility's bond rating is? It seems like a small concern. It seems like it shouldn't affect the public. But in a time when utilities are increasingly squeezed financially, the need to access the capital markets to afford grid upkeep becomes even more important.

When utility bond ratings fall, it's a signal from the capital markets. Or rather, an alarm. Investors are less willing to advance monies to utilities. And they expect utilities to pay a premium to get what monies are made available. The result, higher costs of debt and equity capital. This further squeezes utilities financially but more importantly, raises the costs of power to customers who ultimately pay, in their rates, the costs of utility capital for needed investments.

It's a continuing cycle with a feedback loop that keeps magnifying the problem. Utilities' finances become progressively worse and worse. As utilities are further squeezed, their need to access capital to afford grid upkeep becomes acute. And costs to customers increase.

Higher debt and equity costs exacerbate the problem. And that again increases utilities' need for capital. That is, if they maintain the historical level of grid upkeep.

If utilities don't maintain the historical level of grid upkeep, because they can't, the result is that local utilities will shrink in size and spend less on the grid. Utilities will survive. But the reliability and affordability of the grid will be imperiled, with unacceptable impacts to the national economy and security.

"I don't know what the big deal is. I've been having rolling blackouts for years."

II. Multiple Breaks in the Circuit

A. What Makes the Grid Reliable?

Three mega-networks

The Eastern Interconnection, the power grid for almost all of the US and Canada east of the Rockies, is the most complex and valuable machine ever made by mankind. The West and Texas have their own mega-networks. Even these two match up well – in complexity and value – with the largest power grids anywhere on earth, and with any other technology, the Internet included.

Each of North America's three mega-networks are made up of millions of mechanical, chemical, electrical and electronic components. In each of the three, all the components are linked together to work harmoniously as a single organism.

The Eastern Interconnection's components are spread from Quebec to Florida, from New York to Kansas. With over one hundred million taps into it, nearly a quarter of a billion people run their factories, warehouses, offices, server farms, stores, hospitals, schools and homes.

Although many of the grid's components are getting old – such as the West's Hoover Dam – high-tech equipment and devices are added every day. Some cut pollution. Some stand up better to fierce storms. Some reduce operating and maintenance costs.

The Eastern Interconnection alone will be adding five state-of-the-art nuclear power plants in the next few years, dozens of highly-sophisticated natural gas combined-cycle plants, and thousands of the most powerful wind turbines ever developed. The five new nuclear plants will – all by themselves – be enough to power half of New York City on a sweltering summer afternoon when air conditioners are run hardest.

If we cut corners

What if we – for some reason – didn't keep adding to our continent's three mega-networks at this pace? If we instead slowed the flow of high-tech components to replace and augment what's in place now? If we – more or less – stood pat?

Instead of adding over $100 billion in high-tech equipment and devices annually to keep up the Eastern Interconnection, for instance, if we tried to get by with $80 billion or $60 billion? What would be lost – if anything – if the US and Canada chose to do that?

The consequences might seem to be unknowable. Our countries have never cut corners on something as vital as society's life blood, electricity. So we can't know what would be the harm if we did cut corners now. Or can we?

Who's on the edge?

Societies much like ours – and within our own society in North America – have experimented with living on the edge when it comes to keeping up the grid. So we can look at what happened.

Japan Following the tragic 2011 Tohuku earthquake and tsunami, Japan shut all of the nation's nuclear plants. They remain shut today. What resulted from Japan's abandonment – for at least a few years – of a core component of its two mega-networks? Already one of the world's most energy efficient of the developed countries, the government imposed electricity cutbacks on Japanese businesses and households. The government approved dramatic electric bill increases, to pay for expensive importations of coal, oil and natural gas. And it watched helplessly while Japan's climate change and local pollution emissions into the air shot upwards.

Germany Also following Japan's 2011 earthquake and tsunami, Germany will be shutting all of its nuclear plants, replacing them with wind farms primarily. What resulted from Germany's phased-in abandonment of its section of Europe's largest mega-network? As in Japan, the government imposed electricity cutbacks on businesses and households. The government approved dramatic electric bill increases to pay for expensive wind and solar power, to pay for coal and oil plants to keep the lights on when the wind stops blowing and sun stops shining, and to pay for power imports from neighboring countries. And it watched helplessly while Germany's climate change and local pollution emissions into the air shot upwards, as in Japan.

A Japanese family pays nearly three times what an American family pays for a kilowatt-hour. A German family pays over three times what an American family pays for a kilowatt-hour. German media are now reporting that many families there are struggling with energy poverty. Even after slashing their use of machines, appliances and devices, these families' electric bills are eating into the affordability of the other necessities of life.

Hawaii Hawaiian households have installed solar roofs at an unprecedented rate. But utility engineers and regulators became worried that the drastic zigs and zags of solar – from the sun shining and then not – would literally crash the network. The concern was so serious that a moratorium was placed on more installations. In a 2013 report, the North American Electric Reliability Corporation found that "[t]he Hawaiian Electric companies (Hawaiian Electric, Maui Electric, and Hawaii Electric Light) all have DER [*distributed energy resource*] penetration levels that already affect the local bulk power system reliability."[7]

Northeast New England is shutting its remaining coal and nuclear plants, making the region almost entirely dependent on its natural gas plants. New York appears to be

[7] North American Electric Reliability Corporation. "Performance of Distributed Energy Resources During and After System Disturbance: *Voltage and Frequency Ride-Through Requirements,"* A report by the Integration of Variable Generation Task Force (Task 1-7)," December 2013.

following this path. But New England and New York don't produce natural gas. Indeed, New York just banned gas production via fracking despite vast gas reserves upstate. Compounding the problem, it's extremely difficult to construct pipelines to import natural gas from elsewhere and power lines to import electricity from elsewhere (because of the inevitable political, legal and regulatory opposition). And the output from wind and solar remains insignificant relative to total electricity supplied and delivered.

By now, the region's utilities have generally been remade into "wires companies" with a narrow role.[8] Non-utilities have the broad role in the region's energy present and future. Nonetheless the Northeast has some of the nation's highest electricity prices (averaging around 50% higher than the nation overall) and continues to see real price increases. And the region has tightening margins of capacity for electricity production compared to the needs for electricity required to ensure 24/7 service for all.

Grid idea

The initial intellectual and technological innovations that form the basis for today's grid first took place way back in the 1880's – some 130 years ago – by Thomas Edison, Nikola Tesla and George Westinghouse. But the innovations are still unfolding, setting the stage for the next era of the age of electricity.

Edison decided that the best way to light the hundreds of homes of his first customers in lower Manhattan was to make electricity in a single power plant. Tesla and Westinghouse decided the best way to keep the lights on – and do so economically – was to make electricity in a diffuse redundant network of remotely-located plants. While Edison promoted direct current for electric service and Tesla and Westinghouse alternating current, both factions found:

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[8] See Mathew Morey et al, Christensen Associates Energy Consulting,. "Ensuring Adequate Power Supplies For Tomorrow's Electricity Needs," Prepared for the Electricity Markets Research Foundation, June 2014.

A centralized exclusive “grid” system for providing electric service is best for consumer convenience, cost efficiency and reliability

Like a defensive backfield

With the diffuse and redundant network that eventually grew from this breakthrough, if one piece of the grid’s equipment breaks down, the network can pick it up. Like when a football defensive backfield converges on a ball-carrying halfback after a missed tackle at the line; the linebackers and safeties cover the threat. As soon as grid equipment breaks, full-time specialists make the necessary repairs while the rest of the grid keeps operating. Electricity usually continues flowing into homes and workplaces without interruption or limit.

If an area’s customers spike up their electricity usage, the network can pick them up. Like when a defensive backfield adjusts to the offense lining up to flood a zone; the linebackers and safeties cover the threat. As soon as the area’s electricity usage spikes up, full-time specialists ramp up the most cost-efficient combination of power plants while the rest of the grid keeps operating.

The power grid can do all this because it has enormous capacity, flexibility and diversity. The Eastern Interconnection for instance is made up of millions of components distributed throughout North America east of the Rockies.

Major components like power plants and power lines
and minor components too
break down and require maintenance all the time

Nevertheless, the hundred million households and businesses
tapped into the Eastern Interconnection rarely notice

It takes two or three or more bad things to happen to the grid – all in the same region and all at once – to make customers' lights flicker. The mathematical probability of this is really low.

Redundancy makes it that low:

+ The more redundancy, the lower the likelihood peoples' lights will flicker or go out

– The less redundancy, the higher the likelihood

So the grid's redundancy is vital. As is the quality and working condition of the grid's myriad components. Utility regulators approved the current level of grid upkeep with the conviction no lesser level would maintain redundancy, quality and condition. And that a lesser level would degrade redundancy, quality and condition and so risk reliability that businesses and households need and want.

B. How Can the Grid's Reliability Erode?

Dune electricity

What would our society be like with an underfunded neglected grid? If the grid starts to have frequent blackouts and brownouts, what would that be like? If an increasing number of blackouts and brownouts last for days at a time, what would that be like? If storms easily swept away electricity for all but the fortunate – who've adequately provided for themselves – what would that be like?

This sounds like a bad dystopian novel. In this dark future, Americans could no longer take for granted uninterrupted unlimited use of machines, appliances and devices. Like in the Dune sci-fi trilogy, where water is so scarce that its availability and use is constantly on everyone's minds, **uncertain availability and rationed sporadic use of electricity would radically remake our society**.

Where today we're liberated by the certain availability of electricity and the freedom to use it as we see fit, uncertain availability and rationed sporadic use would render us less able to enjoy creative, productive, fulfilling and healthy lives. For example, further development of medical equipment that enriches and prolongs life would be stunted in this dark future as the equipment could not be depended upon to operate continuously.

Left behind

A hierarchy in electricity use could arise. The fortunate – with the ability to lessen their dependence on a finicky fickle grid – would insulate themselves from the uncertainties besetting their less fortunate neighbors. That already happens in countries with neglected grids.

The rest of us would be exposed to a coarser society we've never experienced. In telecom, after competition replaced regulation, only the aged and extreme poor were left behind with continued dependence on the legacy copper-wire landline network. The legacy network was cross-subsidized by highly profitable telecom utility affiliates.

In electricity, after competition replaces regulation, perhaps half or more of all businesses and households will be left behind with continued dependence on the legacy centralized power grid, if only because of the location, structure, density and ownership of our buildings. And the legacy grid would likely not be cross-subsidized by highly profitable electric utility affiliates.

Very few envision that half or more of all businesses and households would have their flow of electricity fully ensured by microgrids or solar roofs for the foreseeable future. Indeed, increasing dense urbanization and decreasing home ownership means well fewer than half of all of us will utilize this option.

These technologies competing with grid-based electric service are best-suited economically to large single-family suburban houses and housing developments. And to large suburban commercial real estate like big box stores and office parks. Far from all businesses and households in the US fall into these categories:

- What about urban poor living in multi-family apartment buildings in congested inner-cities?
- What about rural poor living a distance from any neighbor?
- What about the elderly who take little from the grid and so pay little in monthly bills?

Very few envision that a significant number of them will have microgrids and rooftop solar anytime soon. Especially in the many areas of the country without frequent sunshine.

Most of us are dependent on the grid

California's Governor recently set an ambitious and unprecedented goal for switching to renewable production of electricity, particularly wind and solar power. The goal is half of total production of electricity. So the other half would be non-renewable. The renewable half includes grid-based renewable production such as from wind and utility-scale solar farms. So much less than half would be from rooftop solar. The goal deadline is fifteen years into the future.

California might reach the goal in fifteen years or so. But one imagines the US overall wouldn't reach this goal until well past 2030. The US overall might not reach one-third market share for solar roofs until 2050 or well past that. But even with such an optimistic prediction for market penetration of residential solar, the grid will still be needed – even if battery storage becomes more economically viable. So most of us will continue to be dependent on our grid, at least in part, likely through 2050 and beyond, for most or all of our lives.

Consequences of a neglected grid

Clearly, Americans will continue to require a strong grid for their electricity needs and wants for decades to come. What would be the impact on our quality of life if the grid goes wanting for sufficient funding?

The extent of the nation's inequality problem – at present – can be debated. But imagine if our future has the fortunate paying for their own reliable microgrids in walled communities and rooftop solar, and the rest of us are stuck with an underfunded neglected grid. The have − have-not divide would significantly widen.

Those who seemingly opt out of our grid rarely understand they will continue to have a strong interest in its good working condition. Living through a three-week neighborhood blackout of the local utility, as one of the only houses around powering a few lights and a refrigerator, may not be all that satisfying.

Suppose the funding of grid upkeep by heretofore financially-strong utilities is weakened because our grid funding machines – utilities – weaken financially from this opting out. Less could and would be spent by utilities on new modern equipment, timely installation, and safe reliable operations.

What if grid upkeep receives ten percent less investment and maintenance from utilities? What if it receives twenty percent less or thirty percent less or even forty percent less?

Is there a breaking point?

What's the grid's breaking point? At what point does slashed funding for grid upkeep translate into a noticeable deterioration in the grid's vast machinery and how it performs for us?

Nobody knows for sure, even the greatest electrical engineers responsible for the grid's integrity and reliability. The grid is so expansive – and the threats to its continuous output for whatever Americans demand from it so varied – that even the top experts cannot know for sure. However, who would rationally want to take this risk?

An underfunded neglected grid isn't like an underfunded neglected bridge. As a bridge deteriorates, the poorer condition is quite apparent to expert inspection. Experts can show taxpayers and officials that a catastrophic failure is near – barring repair or replacement – that would have terrible consequences.

As the grid deteriorates, the poorer condition is not that apparent to even expert inspection. Complex mathematical modeling will suggest weaknesses. But the models are too complicated to convince taxpayers and public officials that the probability of various failures is heightened – barring repair or replacement – failures that would have terrible consequences.

If a particular ice storm blows in, the probability that a quarter million homes and workplaces would lose electricity for a week is increased if some substations and power lines are not periodically updated and kept resilient. But the experts can't say when that kind of ice storm will blow in. Or how often it will. They can't say so many homes and workplaces will be blacked out. Or how long this will last.

A half million might be blacked out, instead of a quarter million. They might be blacked out for two weeks rather than for one.

C. <u>What are the Potential Corrosive Side Effects?</u>

Picked off

The grid upkeep crisis – in which funding to keep the grid in good working condition is being squeezed – is exacerbated by well-meaning price plans for grid-based electric utility service in California and other states. The so-called inclining-block pricing in these plans intentionally decreases light-usage customers' bills to help predominantly low-income households, and increases heavy-usage customers' bills to spur them to curb their usage.

To say inclining-block pricing has serious side effects is an understatement. California's legislature recognized the problem, passing Assembly Bill 327 signed by the Governor in October 2013, and ordered the state's utility regulators to fix it.

Under California's inclining-block pricing, a heavy-usage customer that takes three times as much electricity from the grid than a light-usage customer pays ten times as much (per the utilities' 4-tier tariffs). As a result, the state's heavy-usage customers pay the highest residential electric bills in the continental US by far, at a tier 4 rate of around 35 cents per kilowatt-hour.

It sounds backwards from the quantity discounts that commercial and industrial customers receive for their grid-based electric utility service. Around the country, commercial and industrial customers pay a lower rate per kilowatt-hour than residential customers because there's economies of scale for heavier usage (the cost to serve these customers is significantly less on a per kilowatt-hour basis). California's inclining-block pricing treats heavy-usage residential customers in an opposite way, ignoring the economies of scale, making them pay a substantially higher rate per kilowatt-hour.

Other than inclining-block pricing being an oddity that defies the economics of electric service, what's the problem? As California has experienced, if heavy-usage customers are forced to pay monthly electric bills amounting to many hundreds of dollars, they will be tantalizing targets of the rooftop solar industry.

And since the financial viability of regulated utilities is so dependent on these same customers, when these customers are picked off by third-party rooftop solar companies, utilities' ability to adequately fund grid upkeep can be harmed. Particularly under the net metering incentive where those same large customers receive substantial electric bill credits from utilities (that is, other utility customers) and don't fully contribute to the grid upon which they continue to rely.

Utility revenues are flat in many cases

As a general rule, electric utility revenues are hardly growing. Utility revenues are actually decreasing in some areas when inflation is taken into account.

This isn't because businesses and households are using machines, appliances and devices any less. Anyone can see that we're using electrical things more and more, for our productivity, convenience, comfort, health, and entertainment.

Nonetheless, utility revenues are generally flat at best – inflation adjusted – due to four megatrends:

> ❶ Machines, appliances and devices are doing the same for us – or more – for fewer kilowatt-hours. Today's refrigerators for instance are both better in terms of consumer utility than older models and more energy-efficient.
>
> ❷ While households and most businesses aren't using machines, appliances and devices any less, industrial businesses are using them less, primarily because of the recession that began in 2008 and America's shrinking industrial base.
>
> ❸ Electric rates have generally not kept up with inflation. Many utilities have struggled to keep from raising electric rates during a time when some customers are having trouble paying their bills.
>
> ❹ In parts of the country, particularly California and the Desert Southwest, the availability of good sunshine, the net metering incentive and other subsidies, and an aggressive residential rooftop solar industry has led to a number of heavy-usage customers partially leaving the grid.

"Did management say you could go off the grid?"

III. Increasing Pressures on the Grid

A. Where's This Increasing Competition Coming From?

Competition at wholesale

Who are the for-profit unregulated companies taking market share – in many parts of the country – from grid-based electric utility service? And are potentially wearing down the mechanism that funds the grid we all use.

At the high-voltage wholesale end of the grid, the federal government introduced a first round of competition in 1978. Congressional passage that year of the Public Utility Regulatory Policies Act began the trend of unregulated power plant companies (commonly referred to as independent power producers). Until then, power plants were generally owned by utilities.

The law was intended to stimulate the development of cogeneration and small power plants, with the goal of improved power plant efficiency and increased renewable energy production. Eventually, independent power producers were allowed to develop any kind of power plant and sell the electricity they produced to utilities, for resale to end-use customers. In the 1990's, these independent producers expanded considerably by purchasing a great many power plants from utilities, a change required or encouraged by a number of state governments.

In the Northeast, Mid-Atlantic, some of the Great Lakes states, Texas, and California, the grid's power plant output is now primarily supplied by these independent producers. Utilities own only a very few of the power plants in these regions.

The independent producers sell virtually all of the grid's output in these regions – at the wholesale level – to regulated utilities and unregulated power retailers. In turn, regulated utilities and unregulated retailers sell the grid's output – at the retail level – to businesses and households.

The impacts to regulated utilities, as control of power plants and their output transitioned from these regulated utilities to unregulated companies, were ameliorated. States allowed utilities to recover the costs of power plants they had built under regulation that were no longer worth as much under competition. Independent system operators came into being as not-for-profit neutral parties to operate the high-voltage end of the grid in real time. And to run it in much the same way as utilities had, dispatching power plants in order of least-cost to higher cost, subject to the imperative to maintain grid reliability.

So there were no significant impacts to operations in real time and everyday reliability. End-use customers pay utilities for grid upkeep who pay independent producers and operators to maintain power plant and transmission reliability.

But many states in the South, Midwest and Rocky Mountain regions retained the traditional vertically-integrated utility model. Utilities in these regions remain responsible for the grid from end-to-end, and state public service commissions remain responsible for comprehensive oversight.

Wholesale competition (as it is commonly referred to) has changed how electricity is generated and sold at the high-voltage end of the grid. But the impacts have been fairly well-managed. Utilities have made the necessary adjustments.

Retail competition (as it is commonly referred to) has changed how electricity is sold at the low-voltage end of the grid. End-use customers including households may choose a supplier of their electricity other than the local utility. These changes have also been fairly well-managed, and utilities again have made the necessary adjustments. Notwithstanding the changes from wholesale and retail competition, everyone still pays for the fixed costs of the transmission lines and distribution wires that were built for all.

The new competition that we are focusing on in this report, while primarily at the retail low-voltage level as well, is of a very different nature. Competition has now entered the realm of retail grid services, and the wires part of the utility business. There is no longer the assurance that utilities will recover the fixed costs of building and maintaining the grid. And the potential for serious and long-lasting impacts are far greater.

Competition at retail

At the low-voltage retail end of the grid (commonly referred to as the distribution system), we're now seeing multiple business models using different and emerging technologies to allow customers to partially leave the grid. Some of these business models were launched as early as the 1990's though they did not gain much momentum until the 2000's. They have garnered more attention now because of their greatly increased market penetration and impacts.

Some of these business models have developed because of changes in state regulatory policies or have been driven by state and federal subsidies. They have also been propelled, of course, by changing economics. For example, solar photovoltaic panels for rooftops have shown rapid and continual cost improvement. And retail choice in many states has allowed third parties to make arrangements to sell or lease solar panels directly to retail customers or to sell the output to them, taking advantage of changing economics and government policies. From these changes, whole new industries have emerged, including many unregulated solar and distributed generation companies, as well as a host of new power retailers. Just some examples:

Distributed Generation Installers

These companies sell, install and maintain solar panels, natural gas generators, diesel generators, or other forms of distributed generation for use by the homeowner or business on their own premises. Solar panels are usually installed on rooftops where they can receive maximum sun exposure. Customers pay for the equipment and its installation, and may have a maintenance agreement with the installer. Customers use the solar panels as their primary source of electricity when they are generating, but the grid is still used as a backup for the panels to send needed electricity to the premises when the customer's generation is insufficient to meet its needs, or during cloudy moments or at night. The grid is also used as the means by which the customer can sell any excess electricity back to the grid, where it can then be used or resold.

Customers may also install diesel or natural gas generators on their premises, which in many cases is primarily for use when grid service is out. Business customers (in particular) may use these generators to respond to real-time price signals, operating the generators when it is a cheaper option than buying from the grid and buying from the grid when that is a cheaper option.

Solar Leasing Companies

A fairly new kind of company, they may also sell and install solar panels, but their primary business is owning solar panels on the rooftops of utility customers and either leasing the panels to them or simply selling the output of the panels directly to them under a contractual agreement. Many of these businesses make claims of savings based on their projections of retail rate increases versus the costs of financing their own generation source. The key feature is that there is no up-front payment by the customer to install solar on its rooftop, but the contract often becomes part of the homeowner's mortgage obligation.

Competitive Power Retailers

These companies sell the grid's power plant output to households and businesses, which is then delivered to their premises over the local utility's wires. Competitive power retailers can buy power from the centralized markets of independent system operators, or they can sign bilateral contracts to buy the output of particular plants to serve their customers. A lot of these companies sign financial contracts to hedge their risk. While customers are still required to pay the utility for the delivery of power (over the transmission and distribution wires) there are other fixed costs of the grid that they may no longer contribute to. For instance, it's not always the case that power retailers or their customers have to contribute to the costs of reserves that are necessary to ensure reliability in the most challenging times.

Microgrid Developers

A microgrid developer typically finds a campus-like environment (e.g., a university, industrial park, neighborhood development, or a military base) with multiple buildings already linked by a local distribution system. It develops sources of generation to serve the defined campus and installs equipment allowing them to isolate the distribution network from the utility grid when the utility grid is experiencing problems. Some microgrids could separate from the grid entirely, but that is unlikely.

The type of generation installed doesn't matter, but is likely to be a mix of intermittent renewables and 24/7 gas capability. The primary reason for developing microgrids that is being espoused by its promoters is increased reliability (it can operate when the grid is down) and storm resiliency. For this reason, military bases seem to be the prime opportunity for microgrids, as reliability is critical to national defense at these locations.

The key feature of microgrids is that they have the capability to completely replace use of the utility grid, at least at times, but also remain connected to the grid during normal operations. Thus, there are also critical questions as to their responsibility for keeping the utility grid maintained.

Community Solar Gardens

A final example of the kind of new business model discussed in this report is the community solar garden. These "gardens" are developed in many cases by a non-profit organization, but could just as easily be developed by a for-profit entity.

> The developer finds a location, which could be rooftops of businesses and homes or could be an open field. The developer then finds a group or grouping of customers to buy the output. Unlike the solar developer model, here multiple homeowners or businesses buy solar output from a single developer. Such sales are generally allowed in retail choice states, but may be prohibited elsewhere as an illegal retail sale. There are also questions as to whether such "gardens" are eligible for net metering in states where that incentive is provided.

There are of course other business models or hybrids of the above. But what they all have in common is that they give the business or homeowner the ability to reduce reliance on the grid and reduce payments that would otherwise be collected for their use of grid services. These customers taking advantage of new business models are still relying on the grid in many ways but are no longer contributing a fair share of the costs of maintaining the grid.

Claims of benefits?

Only part of the solar industry targets solar rooftop installations for businesses and homeowners. Much of the solar industry is focused on major solar power facilities for utilities (or third parties that sell to utilities) who in turn supply all their customers with solar (whether a customer owns a large sunny roof or not).

The solar developers targeting homeowners have often claimed that substituting the grid's electricity with that from rooftop solar can cut a household's electric bills by thousands of dollars annually. Are these claims supportable?

- The typical American household only pays around thirteen hundred dollars per year for grid-based electric utility service, in total.[9] A heavy-usage

[9] American households paid an average of $1,470 for electricity in the four quarters through mid-year 2014, according to the federal government's Consumer Expenditure Survey. The median is

household only pays around two thousand dollars per year for grid-based service, again in total.

- It is noteworthy that these amounts are totals. They cover all the grid's needs including keeping the neighborhood's wires and related equipment in good working condition. That portion of the grid's needs that rooftop solar actually competes with – the grid's power output – is merely part of what a household's utility bills pay for (roughly half, differing somewhat from state to state).

- It's difficult to save thousands from a starting point of thirteen hundred or two thousand dollars. Especially when the savings are in just one section of utility bills, the power output section. Of that thirteen hundred dollars per year, probably only around half (six hundred and fifty dollars or so) is for power.[10] The other six hundred and fifty dollars is for other grid needs. **Thus, about half of a residential customer's total bill is for grid-related needs that are not avoided when a customer self-generates.** Rooftop solar doesn't save anything significantly in this second section of utility bills.

- It's particularly difficult to save thousands because rooftop solar, even with significantly reduced costs today, produces far more expensive power (when up-front capital costs are included) compared to the grid's power output. **This is due to the inherent advantages of the grid such as its enormous economies of scale and diverse deep mix of low-cost power plants.**

Considering the overall cost of solar panels shipped from China and their installation and maintenance atop a house, plus the grid's extra cost to handle the intermittent solar

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typically 80 to 90% of the average (therefore in the range of $1,200 to $1,300), and many heavy-usage households pay in the range of $2,000, according to the author's customer bill research discussed in *Lines Down: How We Pay, Use, Value Grid Electricity Amid the Storm*.

[10] The percentage of American households' electric bills that is for power output varies significantly from state to state. The percentage is typically in the broad range of 40 to 60%.

output, the panels can't possibly save thousands of dollars. Not when grid-based service costs about twelve cents per kilowatt-hour on average (according to the US Department of Energy, Energy Information Administration). And about six cents per kilowatt-hour for power output and six cents per kilowatt-hour for grid needs other than for power.

So, doing the arithmetic with year-round average household electricity use of 33 kilowatt-hours daily, all that solar panels save in the grid's power output – leaving aside the non-power supply section of a utility bill – is: (1) around thirty cents per hour for heavy-use mid-day hours when five kilowatt-hours are used, and (2) around fifteen cents per hour for other daylight hours when usage is half that. Per day, that's a little more than two dollars. It's too small to add up to the supposed thousands of dollars in annual savings.

Subsidies, good deal for some

That is, except if the federal government and states significantly subsidize rooftop solar, as they have done. From a society-wide view, rooftop solar cannot save money in comparison to grid-based service, without the subsidies. From the view of a homeowner of a large detached single-family suburban house, rooftop solar can look like a good deal, with the subsidies and incentives.

The subsidies that make rooftop solar look cost-competitive with grid-supplied electricity must come from somewhere. In part they come from sizable government tax credits, thus from taxpayers. In part they come from sizable electric bill credits as part of the net metering incentive, and thus are paid for through higher electric rates and bills to households and businesses without rooftop solar.

Of course, subsidies can be good or bad for our society. For instance, government can create subsidies to ease the way for promising infant industries; potentially a good use of taxpayer monies.

But there are always serious questions as to:

- How generous subsidies should be
- Who should pay for them (and how should they be structured)
- When are they no longer necessary and good for our society

These questions are at the heart of the debate about the generous subsidies (including the net metering incentive) that government has put in place to ease the way for solar installers to succeed and profit. **If the subsidies are too generous – and if they are kept in place too long (beyond when the solar industry needs them to emerge from infancy) – there can be damaging economic distortions.** To the solar industry itself, to impacted industries like utilities and their suppliers, and to the public generally.

B. <u>How Much Have Subsidies Affected Utilities?</u>

Subsidies are very generous

The technologies and business models that are concerning the utility industry have these common characteristics:

- They make use of the neighborhood utility wires to take the grid's output whenever, for example, their solar panels are under-producing or the sun is not out. In most cases the panels are not operating near their peak capacity when demands are greatest on the grid, the grid's peak – typically in the late afternoon or early evening – the key time of the day when grid equipment is most stressed.

- They make use of the neighborhood utility wires to spill their homemade excess whenever their solar panels are producing near or at their peak. This happens

> when the sun's rays are strong. Unfortunately, their mid-day peak is separated by hours from the grid's late afternoon to early evening peak when power production is most in need. Under federal law, utilities are required to buy the electricity output of anyone at the utility's "avoided cost" (how much it would cost from anyone else). But under state law, utilities are required to buy the excess electricity output of customers with the net metering incentive at the utility's full retail rate. This is a much higher amount (since the retail rate is designed to collect all of a utility's costs, not just the costs avoided by purchasing power from a third party).

In a few states, this spilling of their homemade excess can be quite lucrative. So much so that some who make electricity on-premises zero out their utility bills over the year even as they continue to rely on the grid. **These households and businesses skip out on paying anything for keeping the grid's neighborhood wires – as well as the grid's power plants and interstate transmission lines – in good working condition. Yet they continue to need those same assets to ensure a reliable supply of power at their home or business.**

Zeroing out utility bills – with the generous net metering incentive for homemade excess – can tilt the balance in favor of rooftop solar for large detached single-family suburban houses with large enough roof space to install thirty or more panels. That's how solar roof installations costing tens of thousands of dollars upfront can be packaged as a decent deal. The net metering and other subsidies and incentives – if generous enough – make all the difference.

It's no wonder that when a utility has suggested phasing down or eliminating the net metering incentive, that the part of the solar industry targeting those large suburban houses react strongly, arguing that the utility is trying to stop solar development or is simply trying to kill competition. Without this incentive, there would be far fewer instances where rooftop solar makes sense for the homeowner.

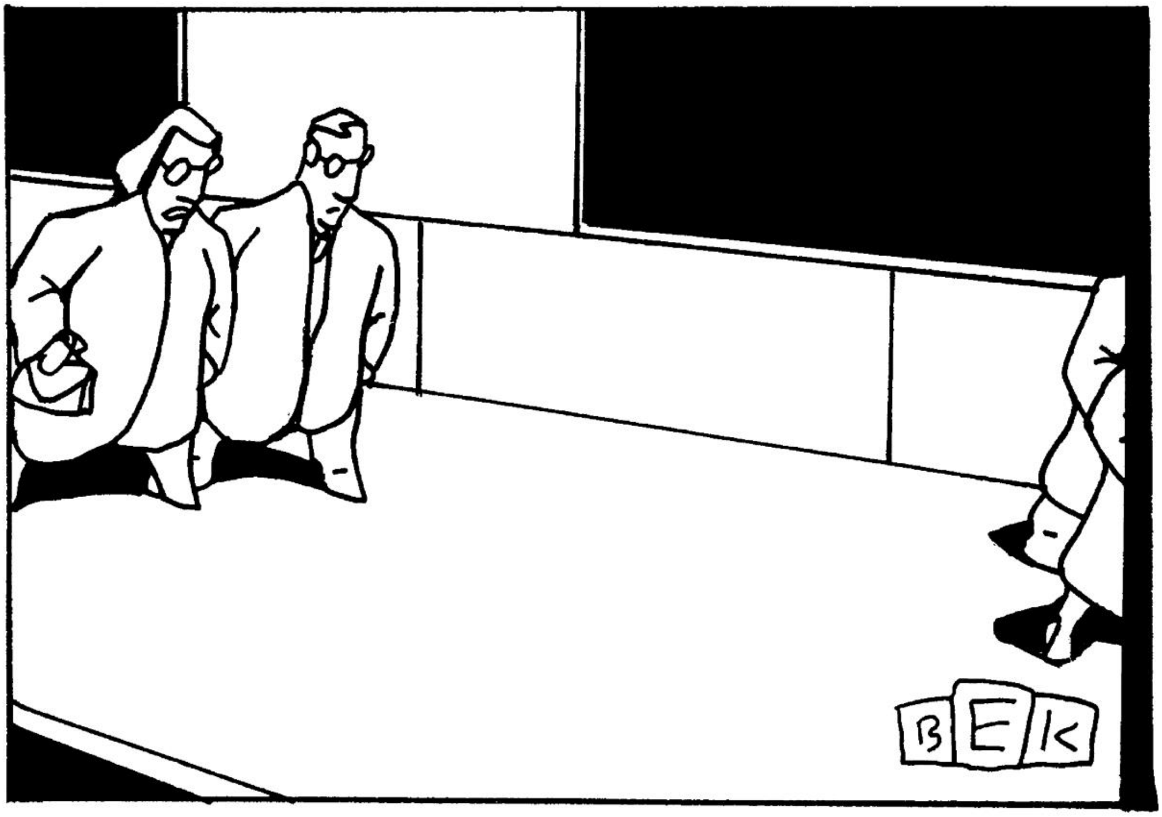
In the meantime, someone has to continue paying for grid upkeep. If homeowners with rooftop solar don't pay, other customers have to. There is no one else to foot the bill.

Plums, cherries

Under the regulated system for electricity that was the norm nationally into the 1990's, all households and businesses in similar circumstances were treated equally. All similarly situated households served by Big City Electric, for example, received equal service and paid equal rates. Unequal treatment – known as undue discrimination in state law – was expressly prohibited and is so today.

This is not the case under the industry transformation that has replaced the traditional vertically-integrated, franchised service area model in some states. With unregulated companies free to target their sales pitches to the choicest customers (for example, large detached single-family suburban houses), households in Big City will not receive equal service and will not pay equal rates.

The choicest customers were the plums of grid-based electric utility service. They contributed disproportionately to grid upkeep in accordance with their heavy-usage of electricity. **When unregulated companies cherry-pick heavy-usage, less-costly to serve customers, these companies assume the preferred slice of market share. It is their gain and the grid's loss.**



"She went off the grid to write a book about being off the grid so she could come back to a better place on the grid."

IV. Accommodating Competition and Preserving Reliability

Search for solutions

Over the past twenty years, the federal government and some states have embraced a policy – as a priority – to make the supply of electricity determined by a competitive marketplace rather than considered as a regulated public good. These governmental actions have several goals. There is the expectation or hope that unregulated for-profit companies – once unleashed – will make electricity more economical, lessen its environmental impacts, increase the electric industry's innovation, and better satisfy households and businesses with the right to shop around for the best value propositions.

Many states however have not signed on to this competition movement. Grid-based electric utility service in these states is seen as reasonably economical and with acceptable environmental characteristics, and that the industry's innovation and value proposition are satisfactory.

Nonetheless, a new group of unregulated companies – and their advocates and financial backers – are urging all states to remake not only the supply but also the delivery of electricity. This puts them on a collision course with utilities, heretofore the suppliers of electricity for much of the country and the deliverers of electricity for all.

As has been discussed in this report, a collision – a transformation not carefully managed – could risk the reliability of electric service that Americans have enjoyed and taken for granted. Reliability could significantly degrade for some of us if not for all.

The economic and social costs – if some or all Americans could no longer count on uninterrupted unlimited electricity – would be devastating. So there is a search for solutions that would both accommodate the competition movement and – at the same time – preserve the bedrock of reliability for all Americans. A promising set of solutions involves reforming the electric bill.

Reform: shift bills' variable-fixed mix in amount

A possible reform would provide for the entry of the new technologies and business models discussed in this report but still preserve utilities' ability to maintain the grid. Utility regulators would shift the mix of variable and fixed charges in electric bills so that rates more accurately reflect the costs of serving different types of business or residential customers. That is, rates would reflect "cost causation," as a large slice of the utilities' costs (in the range of 50 percent) are fixed costs related to serving customers and preserving and maintaining the grid.

To offset an increase in fixed charges, everyone's variable charges would fall a little. The average bill would not go up or down. But customers would be affected differently.

Light-usage customers (that take less than the average amount of kilowatt-hours from the grid) would be negatively affected. They would pay a higher fixed cost, but per-kilowatt-hour savings wouldn't be enough to make up for this. The reform would increase the light-usage customer's bill.

Heavy-usage customers (that take more than the average amount of kilowatt-hours from the grid) would be positively affected. Their bills are far more weighted to the variable charges side than all customers generally. For them, a major increase in fixed charges would be more than offset by a decrease in variable charges. So the reform would decrease the heavy-usage customer's bill.

While there would be some economic disruption to customers, in the long run having customers pay for their use of the grid in proportion to the costs they impose would lead to greater economic efficiency and be fairer to all customers. It would also preclude costs being left for other customers to pick up when some customers partially leave the grid.

Reform: shift bills' variable-fixed mix in percentage

An alternative reform would shift electric bills' variable-fixed mix in percentage, instead of in amount. For example, it could set everyone's fixed charges to what it is presently for light-usage households. For example, to 15%.

To offset this, medium-usage and heavy-usage households' variable charges would fall a little. Again, the average bill would not go up or down.

There would be no change for light-usage households, many of whom have low incomes. They would not be negatively impacted.

There would be a small decrease in the monetary incentive for energy efficiency for medium-usage and heavy-usage households. But the incentive would become more understandable, since the savings from efficiency improvements for all customers would become uniform.

Reform: shift long-term-short-term mix

Another reform could shift the long-term-short-term mix in utilities' costs. Consistent with the cost causation principle of utility regulation – that links utilities' costs to electric bills – this would mean a one-for-one shift in bills as well.

This would appropriately reflect that utilities' costs for grid upkeep are (or should be) largely long-term, such as keeping needed power plants in operation and to bringing on needed new power plants and interstate lines. As well as bringing on needed new natural gas pipelines and storage facilities, on which the grid's power plants are increasingly dependent.

Our grid must have the capacity to handle in stride both around-the-clock demands on it and peak demands on it. And our grid must have this capacity for decades out into the future.

Reform: making the net metering incentive fair for all customers

The net metering incentive for rooftop solar, to be sustainable, should and can be reconstructed. If policymakers believe incentives continue to be necessary and beneficial, there are other, practical ways to structure incentives without adding costs to customers without residential rooftop solar.

Customers who purchase or lease rooftop solar should pay their fair share of the costs for electricity they take from the grid. And they should pay their fair share of the costs for the 24/7 capacity the grid must always have ready when the rooftop solar customer needs it (perhaps through backup and standby rates). Any other path requires subsidies from customers without rooftop solar to those with such installations.

And when customers with rooftop solar feed their excess electricity to the grid, they should be paid at a fair rate. Fairness means this sell-back rate is equivalent to what the grid saves by receiving this excess electricity and thereby not having to generate the electricity on its own.

If there are capacity savings to the grid, the sell-back should include a capacity adder. But real-world grid operations and real cost savings should dictate the fair capacity adder.

Conclusion

These are not the only potential solutions. Nor does this report recommend a single particular fix. We do believe, however, that the current regulatory framework must be re-evaluated in light of the changes taking place in the supply and delivery of electricity and new competitive realities. We're encouraged that a broad range of stakeholders agree.

Cost causation is the fundamental regulatory principle that has allowed the electric industry and the nation to develop a grid that has served us well. Customers who cause costs for the grid should, under this key principle, not be able to avoid those costs.

Solving the regulatory problems discussed in this report would place utilities in a much better position to satisfy the desires of all their customers. There would be less concern that a distorted variable-fixed mix and a distorted long-term-short-term mix in electric bills – unrepresentative of actual grid costs – will lead to a death spiral crippling utilities' ability to fund grid upkeep. In those states that want to foster the development of new business models, substantial change could be accommodated while preserving reliability. But utility regulation must be modernized.

The bottom line is that all the new technologies and business models discussed here are an addition or augmentation to the grid, and none replace grid-based electric service, at least for the foreseeable future. None of these technologies and models would be viable without a robust grid. It was crucial to all of us before this new industry transformation, and it shall continue to be crucial to all of us with the transformation underway.

APPENDIX: The Regulatory Problem of Variable versus Fixed Costs

Variable versus fixed

A residential electric bill, even though it lists a number of itemized amounts, has two kinds of charges:

- The first kind are variable charges. These vary with a customer's kilowatt-hour usage. If a customer takes and uses more kilowatt-hours in a month (compared to the prior month), the variable charges in that month's bill will go up. If the customer takes and uses less kilowatt-hours the next month, the variable charges will go back down. Variable charges go up and down in complete lockstep with usage.

- The second kind are fixed charges. These don't vary with a customer's kilowatt-hour usage. If a customer takes and uses more kilowatt-hours in a month (again compared to the prior month), the fixed charges in that month's bill will not go up or down, but will remain exactly the same. Fixed charges typically vary only by class of customer, which is usually related to their size. For example, for many utilities every residential customer pays the same fixed charge every month, every small business customer pays the same fixed charge every month, every medium-sized business pays the same fixed charges every month, etc. – regardless of their monthly kilowatt-hour usage.

A customer could shut the electricity off to the house for a month to travel overseas. This would zero out kilowatt-hour usage, but it wouldn't have an effect on fixed charges in the bill. A bill with one month's fixed charges would await in the customer's mailbox.

Why is part of a residential electric bill variable and the other part fixed? Shouldn't the cost of any good or service – grid-based electric utility service included – be one or the other?

The cost of some goods and services is exclusively variable. Consider a consumer buying milk at the supermarket. The consumer's expenditure in a month is entirely based on how many quarts he or she buys that month. The expenditure is equal to the multiplication of the per unit price and the volume taken. Billing is therefore volumetric.

On the other hand, the cost of some goods and services is exclusively fixed. Consider a consumer renting an apartment. The consumer's expenditure in a month is entirely based on whether or not he or she is renting that month. The expenditure is equal to the per month price when the consumer is renting. The per month price is the same no matter how much the apartment is used (for example, all the time versus only occasionally). The bill drops to zero only when the consumer stops renting.

Variable-fixed mix

Yet, there are some goods and services – including grid-based electric service – whose cost isn't exclusively variable or exclusively fixed. The cost to the consumer is a variable-fixed mix.

Consider the cost to the consumer of mobile phone service. While phone plans do vary, they generally have both per megabyte variable charges – volumetric billing – and per month fixed charges.

Individual phone companies know that their share of the costs to maintain, modernize and manage the nation's telecom grid – to the high standard of capability and reliability that the public demands – is a variable-fixed mix. Customers' calls, texts, apps and surfing must be instantly and always available, even during peak usage times, even when walking in dense or remote areas.

Just like individual electric utilities know that their share of the costs to maintain, modernize and manage the nation's power grid – to the high standard of capability and reliability that the public demands – is a variable-fixed mix. Customers' lighting, heating, cooling, electronics, etc. must be instantly and always available, even during peak usage times, even for homes in dense or remote areas.

Mixes not in sync

It wouldn't be fair if a local utility – or any company with a variable-fixed cost mix – exclusively priced (or billed) volumetrically. Just as it wouldn't be fair if a utility or any company exclusively priced at a set amount, without regard to the volume taken by customers.

Either way some customers would be disadvantaged and justifiably outraged. And the skewed pricing would be economically inefficient as well.

For example, if a company with a variable-fixed cost mix of half and half exclusively priced its goods or services strictly volumetrically (variably) – per unit taken by a customer – customers who take a large volume would pay more than they should. Customers who take a small volume would pay less than they should.

Inevitably, disadvantaged large volume customers would find ways around the inequity and inefficiency. They would seek and buy substitute goods and services.

It also wouldn't be fair or efficient if a utility (or any company) priced their product with a variable-fixed mix that doesn't even closely resemble the utility's (or company's) actual mix of variable and fixed costs. Again, some customers would be disadvantaged and justifiably outraged.

Yet, this is what we find in residential electric bills:

- Grid costs are a variable-fixed mix
- Electric bills are a variable-fixed mix

But in the effort by regulators to balance often competing public policy goals, , the two – grid costs and electric bills − have dramatically different proportions of variable and fixed parts.

It is unsurprising that disadvantaged large volume customers have found ways around the inequity and inefficiency. They have sought and bought substitute goods and services, including rooftop solar to substitute for grid-based electric service.

Example: Good P&L

Suppose the Smith family lives in a large suburban home and the Johnson family lives in a small city apartment. Both households receive their electricity from the same utility, Good Power & Light. If the Smiths take ten times as much electricity from Good P&L as the Johnsons, then the Smith electric bill will be nearly ten times as much.

That the fixed charges in the Smith and Johnson electric bills are identical matters little. The Smith bill for the electricity they took and used in June might be $446. The Johnson bill for June might be $50.

The Smiths pay 8.9 times more. Not quite ten times more, but nearly so.

Both bills had $6 in fixed charges. This is typical of electric bills across the country. The amount is the same regardless of a customer's home (large suburban house versus small city apartment), and of kilowatt-hour usage (profligate use versus penny-pinching use).

On the other hand, the two bills had starkly different variable charges. The Smith bill had variable charges amounting to $440. They took and used four thousand kilowatt-hours in June. In contrast, the Johnson bill had variable charges amounting to $44. The Johnsons took and used four hundred kilowatt-hours. Since the Smiths kilowatt-hour take was ten times as much as the Johnsons, their variable charges were ten times as much.

Good P&L's variable-fixed mix

There are other key differences:

• The Smith bill is 99% variable and 1% fixed. For the Smith family, the $6 per month fixed charge is virtually an afterthought. Their bill is all about per kilowatt-hour variable charges.

• The Johnson bill is 88% variable and 12% fixed. For the Johnson family, the $6 per month fixed charge is more than an afterthought. Still, how much their bill is, is largely dictated by their per kilowatt-hour variable charges; as for the Smiths.

Notably, the variable-fixed mix for both families is 88% or more variable. But both families' electric bills are supposed to reflect the variable-fixed mix of Good P&L, according to the cost causation principle, a foundation of utility law and regulation from time immemorial.

Good P&L's variable-fixed cost mix however is likely in the range of <u>50% variable and 50% fixed</u>

The disparity – relative to the variable-fixed mix in the Smith and Johnson electric bills – is extraordinary

If the Smith bill reflected the Good P&L variable - fixed cost mix, appropriately, the $446 bill would be made up of: $223 in variable charges, and $223 in fixed charges. Rather than $440 in variable charges and $6 in fixed charges.

The $50 Johnson bill would be made up of: $25 in variable charges, and $25 in fixed charges. Rather than $44 in variable charges and $6 in fixed charges.

The implications would be enormous. In particular, the Smith bill's variable cost would be 5.6 cents per kilowatt-hour instead of 11 cents.

Solar For You

Suppose "Solar For You" offers to install rooftop solar panels for the Smiths. But now, every kilowatt-hour that the Smiths would buy from Solar For You – rather than from Good P&L – would save them 5.6 cents rather than 11 cents. The Solar For You deal doesn't look quite as enticing.

One can imagine what Solar For You thinks about utilities and regulators making electric bills – the variable-fixed mix in them – more consistent with the cost causation principle of utility law and regulation. Bills more reflective of the costs of grid-based service would make solar roof savings more reflective of actual savings.

Making electric bills more reflective of the costs of grid-based service has been portrayed as ideologically anti-solar by roof installers like Solar For You. Of course such companies prefer their competition – regulated utilities – to stick with skewed pricing. It drives utility customers to them, the installers.

Utilities are clearly not ideologically anti-solar. Their grid-based solar farms have far outpaced solar roofs in power produced and efficiency. Indeed, grid-based farms produce around three times as much solar power per dollar as does rooftop solar installations.

Endnotes

I. Grid Essentials

A. How Does the Grid Rely on Utility Funding?

Page 3. Investor-owned utilities' property, plant & equipment, in-service, gross of depreciation, as of year-end 2014 = $1,212.1 billion. When that of public power and co-op utilities and that of non-utility power plant owners is added, this amount should be in the range of $1,500 billion.

Edison Electric Institute, "2014 Financial Review: Annual Report of the U.S. Investor-Owned Electric Utility Industry," page 15.

Page 3. Utility revenues, 2014 = $389.1 billion. This amount equals all expenditures for the power grid including costs of capital.

U.S. Energy Information Administration, Electric Power Monthly, "Table 5.2, Revenue for Retail Sales of Electricity to Ultimate Customers."

Page 3. Average consumer expenditures on electricity, 3rd quarter 2013 through 2nd quarter 2014 = $1,470 US total, $1,396 Northeast, $1,284 Midwest, $1,792 South, $1,179 West. Or $4.03, $3.82, $3.52, $4.91, $3.23 per household daily, respectively. Medians tend to be below averages.

U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, "Table 1800. Region of residence: Annual Expenditure Means, Shares, Standard Errors, and Coefficient of Variation," 3rd quarter 2013 through 2nd quarter 2014.

Page 13. … it would take about 5,500 residential rooftop installations to equal the output of a relatively modest 17-megawatt facility ... Not surprisingly, the cost and rate impact to [utility] customers of solar facilities varies depending on scale, configuration and many other factors. Studies show that the cost per installed watt of utility-scale systems is as little as one third that of rooftop systems.

James A. Hughes, CEO, First Solar, "Utilities Right to Seek Most Bang for Their Solar Buck," Arizona Republic, June 3, 2013.

Page 13. Solar PV – Rooftop Residential: $180 – 265 $/MWh levelized cost (unsubsidized).

Solar PV – Crystalline Utility Scale and Thin Film Utility Scale: $60 – 86 $/MWh levelized cost (unsubsidized).

Lazard, "Levelized Cost of Energy Analysis – Version 8.0," September 2014.

Page 13. There is no doubt that utility-scale solar is less expensive than rooftop systems, as a result of economies of scale. In addition, central station solar plants can be sited in locations where the solar resource is most favorable, can be designed to minimize shading, are more likely to use tracking, and may benefit from scale economies in maintenance. The result is that utility-scale plants achieve higher capacity factors and lower levelized costs of energy than rooftop systems.

Crossborder Energy, "Relative Benefits and Costs of Rooftop and Utility-scale Solar," R. Thomas Beach and Patrick G. McGuire, page 2, July 28, 2014.

Page 17. Utilities seem indispensable. Yet suddenly there is talk on Wall Street of a looming "death spiral" for the business, with solar power being the culprit… The result: Utilities must spread their high fixed costs for things like repairing the grid over fewer kilowatt-hours, making solar power even more competitive and pushing more people to adopt it in a vicious circle.

Wall Street Journal, "Lights Flicker for Utilities," Liam Denning, December 22, 2013.

Page 17. … the whole aura of the utility as a safe widows-and-orphans investment could lose its allure. Stagnant or falling demand, upward price pressures, and nonproductive investment burdens to modernize or clean up old assets are all shrinking utilities' domain of financial stability. Building big, slow, lumpy, costly plants could shrink them further – perhaps triggering a repeat of the "death spiral" of rising prices and falling demand that many utilities suffered in the 1980's.

Amory B. Lovins, "Reinventing Fire: Bold Energy Solutions for the New Energy Era," Chelsea Green Publishing, page 186, 2011.

B. What if the Grid's Upkeep is Under-funded?

Page 22. Gross Domestic Product, 2014 = $17,418.9 billion (and Personal Expenditures = $11,930.3 billion). As previously noted, per U.S. Energy Information Administration, utility revenues, 2014 = $389.1 billion. Utility revenues divided by Gross Domestic Product yields 2.2%. This same calculation yields this same percentage for 2004, 10 years earlier.

U.S. Department of Commerce, Bureau of Economic Analysis, "Table 1.1.5, Gross Domestic Product," 2014.

Page 23. Maintaining reliability under competition also poses uncertainty. Most of us take the reliability of electric power for granted, but it doesn't happen by accident. It has required investments in equipment and manpower and emergency assistance to other utilities that at times have gone beyond legal requirements.

Office of Technology Assessment, Congress of the United States, "Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition," page 8, 1989.

Page 23. Investor-owned utilities' bond ratings, as rated by Standard & Poor's, as of year-end 2014 = 4% A, 23% A-, 32% BBB+, 30% BBB, 8% BBB-, 4% below BBB-. Bond ratings, as of year-end 2001 = 25% A, 17% A-, 26% BBB+, 14% BBB, 10% BBB-, 8% below BBB-.

Ibid (Edison Electric Institute), page 73.

II. Multiple Breaks In the Circuit

A. What Makes the Grid Reliable?

Page 25. The factors requiring unified planning, construction, and operation of generating and transmission networks have been present from the very beginning of the industry, but the size of the area most efficiently covered by a single network has grown as advances in electric technology have increased the economic transmission distance and enlarged the savings from using larger scale equipment.

Federal Power Commission, National Power Survey, 1964, quoted by Charles F. Phillips, Jr., "The Regulation of Public Utilities," page 523, Public Utilities Reports, 1984.

Page 26. Investor-owned utilities' capital expenditures, 2014 = $98.1 billion. When that of public power and co-op American utilities, all Canadian utilities, and non-utility power plant owners is added, and that of all American and Canadian utilities in the west and Texas super-networks is subtracted, this amount should be in the range of $100 billion.

Ibid (Edison Electric Institute), page 17.

Page 27. If the [proposed high-voltage transmission] lines are not built, supporters said, the stress on the existing power grid will be enormous. Already it is strained by the swings in power between sunny, windy days when renewable energy surges, and dark, still winter days when it is all but absent. The country could be pushed back towards more coal or nuclear power.

New York Times, "Germans Balk at Plan for Wind Power Lines," Melissa Eddy, December 24, 2014.

Page 27. The high use of renewable energy in eastern Germany driven by government green energy policies is causing instability to its own electric grid as well as to neighboring countries, resulting in industrial companies having to purchase generators and emergency back-up systems rather than face replacing equipment damaged during disruptions of service. Electricity bills are also expected to go up by 10 percent this year. With residential electricity prices in Germany already about 3 times higher than prices in the United States and increasing further, it is no wonder that 800,000 German households can't afford their electricity bills.

Institute for Energy Research, "Germany's Green Energy Destabilizing Electric Grids," January 23, 2013.

Page 27. See, for example, regarding the solar roof moratorium in Hawaii: *Bloomberg*, "Utilities Feeling Rooftop Solar Heat Start Fighting Back," Mark Chediak, Christopher Martin and Ken Wells, December 26, 2013.

Page 27. Utilities typically have no way to measure the amount of electricity being put on power lines by solar panels, in real time. Nor can they control it. That didn't matter when there wasn't solar production. But some Honolulu neighborhoods have so many solar-equipped homes cranking out electricity in the middle of the day, when people are at work, that the power can swamp electrical lines and back up into power substations, where it could harm equipment there and in other parts of the grid.

Wall Street Journal, "Hawaii Wrestles with Vagaries of Solar Power," Rebecca Smith and Lynn Cook, June 28, 2015.

Page 28. Although shale gas from the Marcellus formation is plentiful and inexpensive, getting it to New England from Pennsylvania is a huge challenge. The six New England states are supplied by only two major pipelines and both are at full capacity. Energy experts have warned New England that it would pay a price for using more natural gas for heating and electric power generation without making investments in expanding natural gas pipelines … The situation will only get worse as New England is in the process of shuttering more coal-fired units and the Vermont Yankee nuclear plant. The lack of a diversified fuel mix for electricity generation along with insufficient pipeline capacity to move natural gas to markets has caused electric rate increases ...

Institute for Energy Research, "Electricity Rate Increases Begin in New England," November 25, 2014.

Page 28. New England generator retirements and additions (2014), nameplate summer capacity: -604.3 MW nuclear, -451.1 MW coal, -437.9 MW petroleum liquids, -12.6 MW natural gas, +3.4 MW wind, +89.6 MW solar.

Capacity mix, end of 2014, percent of total (33,247 MW): 41% natural gas, 21% petroleum liquids, 12% nuclear, 11% hydroelectric, 6% coal, 5% biomass, 2% wind, <1% solar.

U.S. Energy Information Administration, "NERC Assessment Examines Winter Power System Reliability, Fuel Diversity," January 20, 2015.

Page 28. Change in average residential electricity prices by Census division (first half 2014 versus first half 2013): 11.8% New England, 6.7% Mid-Atlantic, 4.5% Mountain, 4.0% South Atlantic, 3.7% East North Central, 3.1% East South Central, 2.4% West South Central, 1.8% West North Central, -2.5% Pacific contiguous.

U.S. Energy Information Administration, "Residential Electricity Prices are Rising," September 2, 2014.

Page 28. See, for example, regarding the concern of New England's Governors: New England States Committee on Electricity, Letter to the CEO of the Independent System Operator New England, January 21, 2014.

B. How Can the Grid's Reliability Erode?

Page 31. Especially in a large city, even a temporary stoppage (a "brownout") of electric power service is serious, and a prolonged cessation (a "blackout") would be disastrous. This recognized public importance of adequate utility service, available without delay at reasonable rates and without unjust discrimination, certainly helped to account for the public demand for regulation even in a period of American history which was notably unfriendly towards government interference with business.

James C. Bonbright, Albert L. Danielsen and David R. Kamerschen, “Principles of Public Utility Rates,” page 15, Public Utilities Reports, 1988.

Page 32. One professed benefit of a transformed electric industry is that it would empower utility customers to become more active participants in the marketplace. Do customers, especially residential customers, desire to be more engaged, or do they just want reliable service at reasonable rates? We know that transaction costs would have to be minimal for small customers to switch electricity supplies, including to [distributed generation]. States can draw upon the experiences of both electric and natural gas retail competition where the vast majority of eligible residential customers have decided to continue receiving their total service from the local utility.

Ken Costello, National Regulatory Research Institute, “Recent Developments in the U.S. Electric Industry: Options for State Utility Regulators,” page 47, November 2014.

Page 32. For regulated utilities, the idea that solar panels will enable everyone to leave the grid, making such networks redundant, is overstated. Solar power is intermittent. Batteries can help, but ISI Group estimates their price needs to drop by a factor of 10 to be competitive with grid power. Moreover, distributed energy’s small penetration means the existing grid is needed for a while to come. So regulators have to balance encouraging renewable power with the continuing need to prevent blackouts.

Ibid (*Wall Street Journal*).

Page 32. California all net generation, April 2015 year-to-date = 54,846 thousand megawatt-hours. California net generation from grid-connected solar, April 2015 year-to-date = 4,280 thousand megawatt-hours. Grid-connected solar was therefore 7.8% of all net generation. However, California retail sales of electricity, April 2015 year-to-date = 77,612 thousand megawatt-hours, meaning imports from other states was 22,766 thousand megawatt-hours and grid-connected solar was likely significantly less than 7.8% of retail sales; it was 5.5%. Generation from residential solar roofs has been around 25% of grid-connected solar generation, so it was in the range of 1 – 2% of retail sales.

U.S. Energy Information Administration, Electric Power Monthly, “Table 1.6.B., Net Generation,” “Table 1.20.B. Net Generation from Solar,” and “Table 5.4.B., Retail Sales of Electricity to Ultimate Customers.

C. What Are the Potential Corrosive Side Effects?

Page 35. California’s Governor signed Assembly Bill 327 on October 7, 2013. The legislation requires the California Public Utilities Commission to review and potentially change the steeply inclining block rate structure for residential utility customers that charges approximately 35 cents per kilowatt-hour for heavy-usage households, nearly three times the average for all American households.

Page 37. This leads to the question of whether society requires too much from electric utilities. We expect utilities to maintain financial viability, make electricity affordable to all customers, adopt and accommodate new technologies that compete with their core business, decarbonize their generation portfolio, promote less usage of electricity by their customers, and increase consumer empowerment.

Ibid (Costello), page 49.

Page 37. Utility revenues = $363,583 million in 2008, $353,289 million in 2009, $368,918 million in 2010, $371,049 million in 2011, $363,687 million in 2012, $376,884 million in 2013, $389,111 million in 2014. 6-year increase 2008 – 2014 = 7.0%, or 1.13% annualized.

U.S. Energy Information Administration, Electric Power Monthly, "Table 5.2, Revenue from Retail Sales of Electricity to Ultimate Customers."

III. Increasing Pressure on the Grid

A. Where's This Increasing Competition Coming From?

Page 40. "If the cost of solar panels keeps coming down, installation costs come down and if they combine solar with battery technology and a power management system, then we have someone just using [the power grid] for backup," [Rogers] said.

Bloomberg, "NRG Skirts Utilities Taking Solar Panels to U.S. Rooftop," Christopher Martin and Naureen S. Malik, quoting Jim Rogers, CEO, Duke Energy, Mar 25, 2013.

Page 40. "The individual homeowner should be able to tie a machine to their natural gas line and tie that with solar on the roof and suddenly they can say to the [utility], 'Disconnect that line.' " Crane said.

Ibid, quoting David Crane, CEO, NRG Energy.

Page 41. See, for example, regarding the representations of some solar roof installers, www.directenergysolar.com: "you can go solar for $0 down and start making money on

Day 1," and "going solar also reduces our reliance on overseas oil and gas, and it increases our energy independence as a country." (The company markets in continental US where overseas oil and gas is extremely rarely used by grid power plants to produce electricity.)

Page 43. As noted above, average consumer expenditures on electricity, West, 3rd quarter 2013 through 2nd quarter 2014 = $1,179, or $3.23 per household daily. This is the region where the overwhelmingly majority of residential solar roof installations have taken place to date.

Ibid (Bureau of Labor Statistics).

Page 43. Average retail price, residential customers, 2014 = 12.5 cents per kilowatt-hour.

U.S. Energy Information Administration, Electric Power Monthly, "Table 5.3, Average Retail Price of Electricity to Ultimate Customers."

Page 43. Despite recent increases, retail electricity prices have historically risen at a lower rate than the general rate of inflation, and the real price of electricity is lower than it was prior to 1995. Measured in constant 2014 dollars, the U.S. residential electricity price averaged 12.5 cents per kilowatt-hour in 2014, up slightly from its lowest point (in real terms) of 11.1 cents per kilowatt-hour in 2002.

U.S. Energy Information Administration, "Growth in Residential Electricity Prices Highest in 6 Years, But Expected to Slow in 2015," March 16, 2015.

Page 46. This paper ends by observing that policymakers might be slighting the capability of the free market to direct the future path of the electric industry. In an ideal market, for example, clean energy technologies would compete with one another and with the technologies they seek to replace, not for government handouts or regulatory or legislative favors that effectively function as inefficient, rent-seeking actions. In addition to minimal subsidies, essential conditions for well-functioning markets include consumer empowerment, robust incentives for innovation and economically rational pricing.

Ibid (Costello), page vii.

B. How Much Have Subsidies Affected Utilities?

Page 47. Regulators should ask whether the current vision is less of a prediction than a scenario that represents special-interest desires or their perception of an ideal utility future … Special interest groups are currently dominating the dialogue over the future of the electric industry. These groups stand to gain financially or otherwise from a high [distributed generation]/high tech/clean energy industry future.

Ibid (Costello), page 46.

Page 48. [Distributed generation] advocates seem to want their cake and eat it too: They adamantly oppose what they consider any "unfair" action that would suppress the prospects for [distributed generation] growth, including their unwillingness to surrender any subsidies or favoritism that they presently enjoy.

Ibid (Costello), page 50.

IV. Accommodating Competition and Preserving Reliability

Page 50. Unavoidable charges also reduce everyone's incentive to reduce energy use by reducing the savings from conservation and measures like rooftop solar. For example, in its analysis of the utilities' proposed rates, the Sierra Club determined that the $10 fixed charge would increase the average payback period for a rooftop solar investment for [utility] customers by an average of 1.4 years, making the decision to go solar significantly less economic.

Sierra Club, "Poisoned Chalice: California Rate Design Reform and Its Consequences for Rooftop Solar, Efficiency, and Conservation," October 15, 2014.

Page 51. … energy hogs should pay more because they impose greater costs by driving the need for new gas plants and more expensive peak power. In addition, rates should reinforce state energy and climate policies, not undermine them. Rates with meaningful differences between tiers are not only fair, but also critical to encouraging clean energy solutions like energy efficiency and rooftop solar.

Ibid.