Sustainable Zero Net Energy – Identifying the Essentials for Solutions

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ABSTRACT

The proliferation of advanced communications technologies, combined with rapid improvements in the cost competitiveness of energy efficiency technologies and distributed resources, especially solar PV, sets the stage for a profound transformation in today's electricity delivery. This transformation is granting customers unprecedented options in managing their energy consumption, generating and storing electricity, charging electric vehicles, and a host of other activities. The same trends enable zero net energy (ZNE) buildings, in which a customer "nets out" his or her energy demand over the course of a year using the renewable energy produced onsite. California stands at the forefront of these trends.

This evolution poses unique challenges to the traditional electricity system's infrastructure, operations and business models, which were originally designed under a vertically integrated model with centralized generation and one-way radial distribution. Without new approaches, the evolution of the electricity system will be neither fast nor smooth, resulting in economic inefficiencies, misaligned incentives and wasted energy.

This paper builds upon the work of an industry roundtable organized by the Rocky Mountain Institute (RMI) and PG&E, which explored the challenges and opportunities as the adoption of distributed generation, energy efficiency and ZNE designs grow.

- How will increased penetration of distributed resources and ZNE buildings affect cost and value for the grid, utilities and customers?
- How could rate structures be modified to enable sustainable, fair, and efficient development of these resources?
- How might utility business models change?

Introduction

> *"In five years, anyone would be crazy to design a building that isn't green. But I'll bet you that… in five years [it] won't just be about green buildings. It will be about zero net energy buildings, and about technologies to increase the amount of excess energy building owners can sell on the grid."*
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> *-Former President Bill Clinton, Greenbuild Keynote Address, November 2007*

Across the US, supportive policies combined with rapid technology cost declines and business model innovations (including third party financing and other financial innovations) have spurred distributed generation, particularly solar photovoltaics (PV), to grow rapidly in recent years. In parallel with these trends, growing numbers of buildings, campuses, and communities designed to be "zero net energy" (ZNE) will be exporting and importing electricity to and from the grid, bringing fundamental changes to the relationship between these customers and the utility. The electricity system of the future is likely to encompass an increasingly diverse and interconnected set of actors, with widely varying assets, behaviors, and motivations. These phenomena represent a fundamental shift in the formerly one-way power system from a technical, institutional and economic perspective.

Existing utility rate structures and business models, which have evolved over time to meet a complex set of policy and economic goals, are poorly adapted to this new environment. Already, there are signs of growing tensions and conflicts among stakeholders in the electricity system as distributed resources are more widely deployed. Rate structures and incentives designed to stimulate the early adoption and scale-up of rooftop solar systems, electric vehicles, and other new technologies and design approaches will need to be modified over time, as adoption rates increase. New technologies and design practices call for new approaches to managing utility operations and pricing electricity services to accurately reflect benefits and costs of distributed resources and provide a sustainable path for the increased deployment of these resources.

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Drivers of Change

Today, the net impact of technological innovation, cost reductions, and an encouraging policy environment is rapidly expanding the range of options for onsite generation and management of electricity. First, legislative and regulatory action to support renewable energy and efficiency is driving a significant shift in the demand for electricity and the generation mix to meet it. Policy-directed targets and mandates include efficiency goals that will reduce load growth, renewable portfolio standards (RPS) that mandate the adoption of clean energy technologies, and environmental regulations that limit the viability of heavily polluting power plants.

Second, a suite of financial mechanisms, such as tax incentives, encourages the continued growth of distributed and renewable generation technologies. Beyond ensuring that the development of distributed generation is economically viable for the adopter at the point of initial capital investment, additional policies and regulations within the electricity sector—such as net energy metering (NEM) policies, feed-in tariffs, and the relative cost of electricity itself—significantly affect the viability of distributed and/or renewable investments. Forty-three states and the District of Columbia have adopted NEM policies, which allow the customer to receive credit for the power they export to the grid (DSIRE, 2012).

Cost competitiveness, driven by technology cost declines and innovative business models, is significantly accelerating adoption of customer generation. Experience, scale, and technological innovation continue to drive down the cost of emerging and rapidly maturing power generation technologies across global markets. For example, since the 1970s, the cost of solar module production has declined by 50% for every tenfold increase in production. Recently, the cost reduction trend has accelerated as global module prices fell by more than half from 2008 to 2011 (Barbose, G. et al., 2011).

Further, innovative ownership and financing arrangements are lowering the barrier to entry for hosts in the development of renewable distributed generation projects. Leveraging government tax incentives, many third party entities have proven particularly creative as they shift away from the customer-ownership model by building systems supported by customer lease or power purchase agreements (PPAs). Like a mortgage, lease agreements and PPAs allow system costs to be repaid over time, and require little or no money down. Customers can be cash flow positive immediately, dramatically reducing the investment hurdle to go solar. Third party owned projects now account for 57% of the market in California (Go Solar, 2012). Similarly, in Colorado, the market share of residential customers leasing systems has grown to 57% in the 18 months the state authorized leasing structures (Wesoff, 2011).

In California, these drivers have resulted in over 1 GW of installed solar PV capacity, representing 48% of the total U.S. solar capacity. Conservative forecasts by the California Energy Commission of statewide solar adoption project rooftop PV supplying 5% of total energy needs in 2022-assuming that all solar adoption would be behind or attached to the customer's meter (CEC, 2011). Combined with advances in IT and distribution technologies that enable bidirectional power flow, distributed intelligence and operational control, the interaction between buildings and the grid can potentially be "richer" in information and interaction. As a result, the role that customers and buildings play continues to expand, enabling the growth of zero net energy building design and communities.

Getting to Zero Net Energy: The Opportunity and the Challenge

In 2008, the California Public Utilities Commission established aggressive zero net energy (ZNE) goals: by 2020, all new residential construction in California will be ZNE. New commercial construction should reach the same goal by 2030 (CPUC, 2008). Although no consensus definition exists of ZNE, it is typically defined as achieving a net-zero energy balance annually through intensive energy efficiency and on-site renewable generation. In California, regulators defined zero net energy as a project that "employs a combination of energy efficiency design features, efficient appliances, clean distributed generation, and advanced energy management systems to result in no net purchases of energy from the grid."

California calls its ZNE goals Big Bold Energy Efficiency Strategies, or BBEES, "not only for their potential impact, but also for their easy comprehension and their ability to galvanize market players" (CPUC, 2008). Indeed, ZNE captures the imagination and inspires action. A goal to achieve zero net energy provides a tangible benchmark with an ostensibly clear finish line—at least on the building or community level. However, what about the system level? Does a world of zero net energy buildings make for a sustainable energy future?

Applying ZNE design principles has the potential to create superior environmentally sustainable buildings with multiple benefits. The design considerations that go into making a ZNE building dramatically more efficient can also simultaneously improve indoor environmental quality, comfort, and occupant satisfaction. For example, buildings that use daylight as a primary source of ambient lighting will generally have better indoor visibility. Attention to airflow in buildings results in better ventilation, and fresher interiors.

By design, most ZNE buildings will actively interact with the electricity grid, allowing the facility to draw on the grid for power when generation from onsite sources is insufficient to meet onsite load, or to export power when onsite generation exceeds onsite load. However, while the time scale of ZNE is annual, the electricity system operates on smaller time scales—

starting with milliseconds. Unlike other commodities, electricity cannot be stored cost effectively, which means supply and demand must be matched at all times. Although the total amount of electricity demanded from the grid in a ZNE building is smaller through efficiency and on-site renewable generation, the building's demand profile changes substantially. On smaller timescales, such as minutes, hours, days and weeks, the amount of grid power that must be imported or exported could fluctuate considerably. In fact, a ZNE building's peak use of the grid could be when it is *exporting* power.

With the proliferation of more ZNE buildings, there could be more and steeper peaks and valleys that grid operators will have to meet. If the building-grid interaction at smaller time-scales is not considered, as might be the case for some ZNE buildings, these buildings could have unintended and unanticipated impacts for the electrical grid and/or miss opportunities for additional value creation.

Figure 1. A grid-connected customer with distributed energy resources demands less total electricity from the grid, but uses grid services to export and import electricity while the demand profile (timing and magnitude) could change dramatically.

Further, under typical residential rate structures, most or all fixed costs of utility service are collected as a function of usage, i.e. volumetric rates. Electricity rate structures that bundle the utility's many disparate costs into a single volumetric rate provide customers with simple electricity bills together with strong incentives for energy efficiency and distributed generation. With significant penetration of customer-level generation, ZNE and net metering, however, this pricing model begins to break down.

To explore this break down, we consider customer-generation that is taking advantage of a net metering tariff. Although policies vary, most net metering (NEM) policies credit exports at the retail rate (DSIRE, 2012). As customer-generators offset their energy use, they are reimbursed at their retail volumetric rate, which includes the fixed costs that the utility incurs on their behalf. If these costs are not outweighed or offset by the benefits to the system from the customer generator, the result is revenue from these customers that declines to a greater degree than the cost to serve them. Essentially, current volumetric rates do not appropriately charge these customers for the service that they receive from the utility, nor are they appropriately crediting customers for the services that they provide to the utility. Further, a misallocation of who is paying and who is benefiting could create significant equity issues between NEM customers and non-NEM customers.[1]

Although analysts disagree about the level of "cost shift" that results from retail net energy metering policies, there is broad agreement that the results are heavily influenced by rate design. The generation of onsite power is not in itself flawed; rather, the problem is deeply rooted in the underlying rate structure. Existing rates and policies obscure the costs and benefits of distributed resources to the grid and limit the ability to add smarter integration technologies, which could add value.

Approach to Solutions

What steps can be taken to appropriately align the interests of DG customers, ZNE building owners, building designers, other electricity customers, utilities, and other stakeholders, such as legislators, regulators, environmental proponents? The following discussion builds upon a framework for solutions created as part of a collaboration between the Rocky Mountain Institute (RMI) and PG&E and presented in the report, *Net Energy Metering, Zero Net Energy and the Distributed Energy Resource Future: Adapting Electric Utility Business Models for the 21st Century.* The objective of the effort was to build a shared understanding of the problems and challenges facing stakeholders in the electric system and to identify the essential characteristics of workable long-term solutions. Toward this end, the framework for solutions must include:

1. Identify and measure impacts, costs and values of distributed energy resources;
2. Remedy misalignments between economic incentives to customers and the cost and value to the system provided by distributed resources; and
3. Adapt utility business models to create and sustain value in a future characterized by higher levels of efficiency and increased deployment of distributed resources.

Identify and Measure Impacts

More rigorous analysis is needed to fully assess the costs and benefits of distributed energy resources. Such analysis will require evaluation of impacts of distribution system capital and operating costs, equipment lifetimes, balancing costs, generation capacity costs, fuel price risks, implications for the reliability and resilience of the electricity grid, and a wide range of other considerations. New data collection and analysis methods will be necessary to develop estimates of these costs and benefits while ensuring accountability, transparency, and verifiability of cost and benefit estimates that will provide the foundation for policymaking.

A key challenge is the degree of impact and value of distributed resources to the grid depends on the relationship among timing, magnitude and location of distributed supplies and to the needs of the electricity system. Put another way, DG that is at the "right place at the right

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[1] For example, many investor-owned utilities operate under a "decoupled" business structure, where revenues are decoupled from sales. This means that the shareholders are indifferent when sales decrease, for whatever reason (weather, energy efficiency, or customer generation). In other words, costs not recovered from the customer who installs the generation are paid by other customers, creating a cost-shift.

time" will create the greatest value. Additionally, the value of distributed resources is affected not only by timing and location, but also by the flexibility, predictability and controllability of the resource.

For example, the capacity value of distributed energy resources, especially DG, is temporally, operationally and geographically specific and varies by distribution feeder, transmission line configuration, and composition of the generation fleet. Further, capacity investments, such as transmission upgrades or centralized generation plants, are "lumpy" in nature; therefore, it is necessary to determine the sufficient capacity demand reduction to avoid or defer distribution or transmission system investments. Distribution feeders with large amounts of DG capacity downstream may require upgrades to maintain power quality, or, conversely, if implemented thoughtfully, may alleviate congestion and potentially defer the need for upgrades. The ability of distributed energy resources to defer centralized generation investments will likewise depend on need for and timing of investment decisions. Thus, the capacity costs and benefits are highly variable and non-linear in nature, with the greatest value accruing in places of high system congestion and at times of peak demand.

At present, although the lack of tools and analysis to fully address these questions remains a stumbling block, a growing number of studies are beginning to fill this void. Recently, four utilities have published analyses on the impacts of high penetrations of distributed PV systems within their service territories.[2] The studies range in scope from impacts on the distribution system to regional balancing operations. The range of results is indicative of the case-specific nature of determining the impacts of distributed energy resources on utility operations and planning. Several ongoing utility studies on the impact of high penetrations of distributed energy resources on their networks will add to the body of knowledge over the next several years.

Building Metrics

In a closely related corollary, more accurate metrics and data are needed at the building level, especially in zero net energy design, to better reflect their energy performance and interaction with the overall electricity system. As noted, there is no standard definition of the ZNE concept, although it most typically defines the energy balance on an annual basis. In a recent review of ZNE definitions and calculation methodologies, 11 of the 12 methodologies profiled were based on an annual balance and do not address smaller time scales or grid interaction. However, "this approach is currently changing and more research focused on investigating the interaction that would be a benefit for the building as well as for the energy infrastructure" (I. Sartori, et al., 2012).

At the international level, the International Energy Agency (IEA) is leading work to harmonize ZNE definitions and standards through a partnership of two IEA research programs, the Solar Heating and Cooling Program (SHCP) and the Energy Conservation in Buildings and Community Systems Program. The project, "Towards Net Zero Energy Solar Buildings," aims to develop a common and unambiguous definition of ZNE and a robust and communicable calculation methodology for energy balance, both of which could serve to inform national building codes or international standards.

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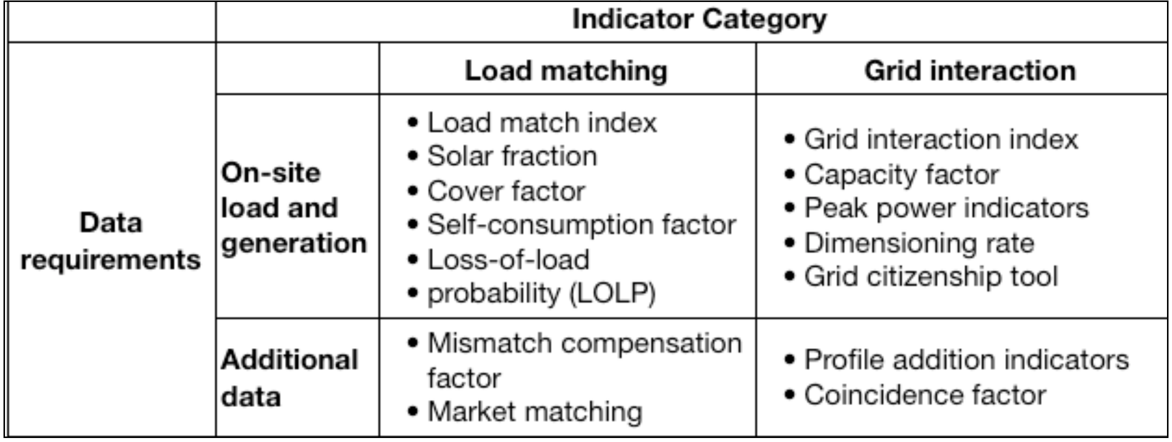
[2] Studies conducted by Sacramento Municipal Utility District, Arizona Public Service, Southern California Edison and Nevada Energy are included in references.

Project contributors have highlighted the development of indicators that more accurately describe the energy performance of a building or community on smaller time scales that include the integration and interaction between onsite generation, load and the grid. Load Matching and Grid Interaction Indicators (LMGI) are quantifiable indices that illuminate the interaction between a building and grid and vary in their complexity, time resolution and data requirements. Table 1 provides categorizes indicator types (Salom J. et al., 2011). Whereas load-matching indicators measure the match between demand profile and onsite generation, grid interaction indicators measure the variability of energy interchange between the building and the grid. Different audiences, including building designers, owners, community planners, and grid operators, could use appropriate indices to guide planning, design and investment decisions.

Table 1. Load Matching Grid Interaction Indicators



		Indicator Category	
		Load matching	**Grid interaction**
Data requirements	**On-site load and generation**	• Load match index • Solar fraction • Cover factor • Self-consumption factor • Loss-of-load • probability (LOLP)	• Grid interaction index • Capacity factor • Peak power indicators • Dimensioning rate • Grid citizenship tool
	Additional data	• Mismatch compensation factor • Market matching	• Profile addition indicators • Coincidence factor

Source: Salom, J. et al., 2011

Remedy Misalignments Through Price Signals

Rate design is a critically important tool that, if properly executed, can serve several objectives: 1) ensure utilities charge and receive fair, adequate compensation to cover their prudent costs, 2) distribute those costs among customers equitably, so a customer's electricity bill is appropriately representative of the value of the services provided to, and by, that customer, 3) communicate the needs of the grid system through price signals, 4) align price signals with policy and social objectives. At present, most rates and incentives fail to provide accurate economic signals to align distributed energy resource investment with system costs and benefits over the long term (planning) and in the short term (operations). The issue will become increasingly important as more investment is made outside of the utility's control.

Price signals could direct that investment for greatest system benefit and uncover new sources of value to the electricity system. For example, new price signals might provide incentives for the customer to provide distributed generation in locations and under circumstances that could support the grid, or provide voltage support or other ancillary services that reduce overall system costs.

In developing new rate structures, utilities and regulators will need to ask: can the pricing model pay for operational services, properly capture and promote value to the system, and be implemented effectively with the flexibility to accommodate further market changes? To start, utilities will be forced to reexamine the fundamental elements of the “cost to serve”—capacity related fixed costs, non-capacity-related fixed costs and variable costs—and the allocation of these costs as they pertain to customer-generators. Needless to say, the costs and benefits of distributed generation will be a critical input into the appropriate cost allocation moving forward.

Getting the “price right” is not the only consideration. Technological constraints may limit the level of specificity that rates may have and determine the degree to which time and location may be valued. Further, the rate design must strike a balance between the interests of traditional customers and customer-generators, while remaining simple enough to be understood by customers. The potential consequences in terms of load shifting and load growth (or reduction) must also be considered. Optimally, significant rate restructuring would be done over time, avoiding “rate shock” and allowing customers an opportunity to appropriately modify their energy use choices.

Further, significant tension must be recognized between rate simplicity, the need to support energy efficiency and customer generation, and the need for accurately allocating benefits and costs. For example, California has a tiered volumetric rate structure for residential customers with a primary goal of encouraging energy efficiency. That is, the price for electricity (cost per kWh) increases as the amount of electricity a customer uses increases over a billing period. Thus, reductions in electricity consumption will be valued at the marginal tiered rate, and higher electricity consumers will have a larger incentive to invest in distributed energy resources. California’s volumetric tiered rate structure and decoupling of rates and sales has helped keep per-capita electricity use flat for the last 30 years and made California the largest energy efficiency market in the country. However, this rate structure could also contribute to shifting costs to non-participating customers as distributed energy resources and ZNE become more prevalent. Yet, wholesale replacement could have the unintended consequence that energy efficiency becomes less attractive for customers. An appropriate balance must be reached between strict cost of service rates and socialization of the “cost shift”.

In one approach to the issue, several utilities have instituted or increased fixed charges for their residential and small commercial customers. San Diego Gas and Electric Company (SDG&E) provides an example of a utility attempting to modify its rates as it prepares for higher penetrations of DG. As part of its General Rate Case in October 2011, SDG&E proposed modifying its residential electric rates to include a “Network Use Charge,” which would bill customers for the costs associated with all network use, including electricity exports. Proponents of the Network Use Charge note that it would allow SDG&E to ensure that NEM customers contribute to their fair share of distribution system costs when exporting power, while reducing the inequitable cost shifts that result from retail NEM. However, the measure met with fierce opposition from the solar industry, consumer advocates, environmentalists, and NEM customers. These groups argue that the Network Use Charge does not account for the benefits that DG systems provide to the network, that it runs contrary to California's renewable energy goals by discouraging solar, and that it does not send price signals that encourage reduction in coincident peak demand-rather, it pushes PV owners to shift their demand to times when their system is producing, i.e. midday. At present, SDG&E is conducting a stakeholder process as part of its General Rate Case, which has resulted in a commitment to re-examine the costs and value of distributed solar installations.[3] SDG&E's Network Use Charge illustrates the difficulty of the

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[3] SDG&E also proposed a network use charge that would have charged customers who export power under net metering arrangement to pay for the use of the grid. The CPUC found that such a change would require legislative action and ruled it beyond the scope of the instant rate case.

challenge, and the sensitivity of many stakeholders to the implications of any proposed change to existing rates.

In another approach, Austin Energy recently proposed a new residential solar rate to replace conventional net energy metering in their territory (Rábago, K. R. et al. 2012). The rate calculation is based on the distributed costs and benefits study completed in 2006, which was referenced earlier. The rate is designed to include an annually adjusted value for distributed solar energy to the grid, which includes calculations that estimate savings from avoided losses, energy, generation capacity, transmission and distribution capacity and environmental benefits. The rate also attempts to address unintended consequences of net energy metering, such as reduced incentives for energy efficiency, by decoupling the customer's charge for electricity service fron the value of solar energy produced. According to the author's, "The new value of solar rate provides a more fair and accurate credit to the customer for solar generation than the traditionally calculated marginal avoided cost approach, and is more accurate than the traditional net metering approach of crediting the customer at the retail rate for solar generation offsetting consumption and a marginal avoided cost for excess generation" (Rábago, K. R. et al. 2012).

Regardless of the approach, acceptable rate structure solutions will need to balance the needs of the network with the concerns of its stakeholders, which will likely require compromise from both sides. This process will ultimately create new profit opportunities that, given the right price signals, will allow distributed generators to adapt and provide new sources of value to the utility system.

Utility Business Model

California has already pioneered the alignment of the utility profit motive with social and policy objectives. Both decoupling of rates (which separated profits from sales) and the energy efficiency incentive structure (where utilities actually capture shareholder earnings by meeting pre-set goals for energy efficiency implementation) have led to a utility-customer-policy alignment in California that has fostered a healthy energy efficiency market for over 30 years. Is there a similar alignment available for distributed generation and ZNE?

Utility business models are largely shaped by the regulatory environment, including legislative and regulatory policies. Within that regulatory structure, customers have more choice today about how to meet their energy requirements: energy efficiency, on-site generation, demand response, direct access, community choice aggregation, and municipalization. Two broad approaches to utility regulation that could begin the alignment that was so successful for energy efficiency:

- New forms of incentive regulation to support a more expansive role for utilities in managing distributed resources, and
- A more limited network utility model that relies on highly differentiated price signals to direct investment in distributed resources (including ZNE) by customers or other intermediaries for greatest system benefit.

These approaches suggest different emphasis in how to overcome the limitations inherent in existing policies, but they are not mutually exclusive and solutions could be constructed with elements from each.

New approaches to incentive regulation could provide utilities with stronger motivation to direct and manage investments in distributed energy resources. Performance incentives include performance based earnings, shared savings, and incentive rates-of-return. These mechanisms could be used to reward utilities for performance in achieving distributed resource deployment targets, and in doing so in a way that minimizes costs for the system as a whole. In the same way that revenue decoupling and shared savings policies together can provide strong incentives for utilities to invest in energy efficiency, a similar approach could strengthen incentives for utilities to invest in distributed generation, storage, microgrids, smart electric vehicle charging, smart inverters, or other distributed technologies to reduce operating costs and/or defer or avoid the need for investments to expand capacity of distribution feeders or invest in other electricity supply, transmission, or distribution assets. Under some scenarios, the utility might be allowed to invest in and earn a return on assets on the customer side of the meter that offer the least-cost means of delivering service.

Proponents of this approach argue that utilities are in the best position to understand how and where to deploy distributed resources for greatest system benefits and should be allowed greater freedom to direct these investments to the areas on their system where they provide the greatest value. Moreover, performance incentives should ensure that utilities earn profits by finding the least-cost ways to address system needs. If it costs less to deploy distributed resources in a targeted fashion than it would to make rate- based investments to reinforce or upgrade the grid, then utilities should be made better off by implementing the solutions that costs customers the least.

Under this model, the utility would fill the role of both network orchestrator and service provider. The utility would continue to perform many of the key functions of a historically vertically integrated utility, such as ensuring reliable power delivery, as well as owning and operating some generation resources. It could offer a variety of emerging new services that are enabled with the technological advances in distributed generation, grid intelligence and communications. This approach would require significant changes in the current regulatory paradigm to ensure a level playing field for service providers, including energy service companies and other onsite generation providers. New opportunities for distributed generation providers include a stable, steady long-term customer in the utility that could open an expanded market for distributed generation. A key challenge is that alternatives to the conventional return-on-rate base, such as performance-based regulation, have proven complex and difficult to execute.

Incentive regulation can take relatively simple forms. For example, legislation introduced in the U.S. Senate by Senators Amy Klobuchar (D-MN) and Tim Johnson (D-SD) in the summer of 2011 proposed a “Renewable Integration” tax credit to offset the costs of integrating wind and solar resources to the grid. The tax credit would provide an incentive for utilities to adopt more renewable power by offering a tax credit of up to 0.6 cents per kWh for power supplied from variable renewable sources such as wind and solar. If utilities can integrate supplies from these sources at a cost less than the level of the tax credit, they can profit accordingly.

Under a network utility approach, the utility would provide highly differentiated price signals to direct investments by other service providers. In this case, the utility’s role would increasingly be focused on maintaining and operating the grid and on creating markets, managing transactions, replacing aging distribution equipment, and/or making smart grid investments and interconnecting buyers and sellers with the network. This network utility would shepherd and coordinate the network of increasingly complex transactions among growing number of actors. The utility in this scenario would evolve toward a role more like that of grid owner/operators at the wholesale level, enabling markets for energy, capacity, reserves, and ancillary services that differentiate value for these services according to time and location.

New product revenue streams to achieve profitability would include investments that improve network operations and facilitate markets. Distributed generation providers could benefit from the creation of new value streams for products such as capacity, voltage support, or regulation or from price premiums for congested locations on the distribution grid. Key challenges in this paradigm are determining how a network utility should be compensated as the enabler of the network and in setting benchmarks for performance.

Future Challenges and Opportunities

An increasingly distributed energy future is fast approaching with manifold implications. Important questions are arising about how best to design the rules in the electricity sector to ensure distributed resources are developed in a way that provides greatest benefits to electricity customers and to society as a whole. If this emerging system is to sustainably achieve societal goals for the electricity system— providing reliable and resilient energy services at reasonable cost while meeting standards for fairness and environmental stewardship—then the decisions and behaviors of utilities and their customers must be harmonized to an unprecedented degree. The behaviors of many actors must be aligned to match fluctuations of supply and demand in real time. Investments in distributed resources must be made with a view to the temporal and geographic variations in the value and cost of electricity supply. Overall, the effectiveness of a utility's role in conducting the orchestra of distributed energy resources that interact with its system will be a critical factor in achieving favorable outcomes for all stakeholders. And the long-term health and stability of the electricity grid will be essential to making such a system work.

References

[CPUC] California Public Utilities Commission, “Strategic Plan” adopted in Decision 08-09-040, September 18, 2008. http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/91068.htm

[CEC] California Energy Commission. 2011. *Preliminary California Energy Demand Forecast 2012-22.* August.

Barbose G., N. Dargouth, R. Wiser. 2011. *Tracking the Sun IV: An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2010.* Lawrence Berkeley National Laboratory, September. eetd.lbl.gov/ea/ems/reports/lbnl-5047e.pdf

Drury, E, et al. “The Transformation of Southern California's Residential Photovoltaics Market through Third-Party Ownership”, submitted to Energy Policy.

DSIRE database: http://www.dsireusa.org/

Go Solar California: http://www.californiasolarstatistics.ca.gov/

Keesee, Mike. 2010. "Impact of Distributed Solar on SMUD's Peak Load and Local Distribution

System." Presentation to 4th International Conference on Integration of Renewable and Distributed Energy Resources, Dec 6. http:// www.4thintegrationconference.com/downloads/Session%20 3-6_Keesee-New.pdf

Mather, Barry and Benjamin Kropowski. 2011. *Southern California Edison High-Penetration Photovoltaic Project – Year 1.* National Renewable Energy Laboratory, June. www.nrel.gov/docs/ fy11osti/50875.pdf

Marzal, A. J., et al. 2011. "Zero Energy Buildings - A Review of Definitions and Calculation Methodologies." *Energy Buildings* (2011), doi:101.1016/j.enbuild.2010.12.022

Navigant Consulting, Inc. 2011. *Large Scale PV Integration Study*. NV Energy, June. http://www.navigant.com/insights/library/ energy/large-scale_pv_integration_study/

Rábago, K. R. et al. 2012. "Designing Austin Energy's Solar Tariff Using a Distributed PV Value Calculator." In *Proceedings of World Renewable Energy Forum 2012.*

Rocky Mountain Institute. 2012. *Net Energy Metering, Zero Net Energy, and the Distributed Resource Future: Aligning Electric Utility Business Models for the 21st Century.* http://www.rmi.org/rmi_pge_adapting_utility_business_models.

R.W. Beck. 2009. *Distributed Renewable Energy Operating Impacts and Valuation Study.* Arizona Public Service, January. www.aps.com/files/solarRenewable/DistRenEnOpImpactsStudy.pdf

Salom, J. et al. 2011. "Understanding Net Zero Energy Buildings: Evaluation of Load Matching and Grid Interaction Indicators." In *Proceedings of Building Simulation,* Sydney, AU, 14-16 November, 2011.

Sartori, I. et al., "Net Zero Energy Buildings: A Consistent Definition Framework." *Energy Buildings* (2012), doi:10.1016/j.enbuild.2012.01.032

Sherwood, Larry. *US Solar Market Trends 2010.* IREC, June 2011.

Voss, K. et al. 2010. "Load Matching and Grid Interaction of Net Zero Energy Buildings," in *Proceedings of EuroSun 2010*, Graz, AT.

Wesoff, Eric. 2011. "Third-Party-Owned Solar Dominates the California Market." Greentech Media, September 30. www.greentechmedia.com/articles/read/Third-Party-Owned-Solar-Drives-California-Market/