TOWARD A 21ST CENTURY ELECTRICITY SYSTEM IN CALIFORNIA

A Joint Utility and Advanced Energy Industry Working Group Position Paper

August 11, 2015

ABOUT THIS DOCUMENT AND THE WORKING GROUP

This document summarizes the work, conducted over a four-month period, by an informal Working Group formed following an Advanced Energy Economy Institute (AEEI) led CEO Forum on the *21st Century Electricity System* in February 2015.[1] The purpose of this document is to aid in the development of a vision of the future electricity system in California. This document is not meant to be a substitute for, or preempt any aspects of, current regulatory proceedings in California, or represent the input that any stakeholders may provide in those proceedings, including from individual Working Group members. In developing this document, the Working Group did not review all aspects of the law as currently stated, nor did it conduct detailed analysis. Such analysis will need to be done to further evaluate the viability of the vision as well as the roles of the different stakeholders and potential future regulatory models. At that time, the Working Group members may develop their own recommendations and conclusions that differ from this exploratory work.

Representatives from the following companies and organizations participated in the Working Group:

Advanced Energy Economy Institute*
Bosch
BRIDGE Energy Group
California Independent System Operator
Chargepoint
EnergySavvy
EnerNOC
Enphase Energy
FirstFuel Software
General Electric
Gridco Systems
Itron
Navigant Consulting
Pacific Gas & Electric
Siemens
Simple Energy
SolarCity
Southern California Edison
Stem
SunEdison
SunPower Corporation

* AEEI served as the facilitator of the Working Group.

In addition, the following Advanced Energy Economy Business and Leadership Council member companies have endorsed the paper:

Ambri
Bergey Windpower Co
Brightergy
Clean Fuel Partners
Landis+Gyr
Next Step Living
Opower
Regatta Solutions
RES Americas
Smart Wires
Vestas

1. For more about the CEO Forums, go to https://www.aee.net/initiatives/21st-century-electricity-system.html.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

On February 25, 2015, Advanced Energy Economy Institute (AEEI) hosted a meeting of senior executives from advanced energy companies and California's investor-owned utilities (IOUs). This *California 21st Century Electricity System CEO Forum* was an opportunity for energy industry leaders to come together to develop a common inventory of the drivers of industry change and to start to examine utility business models and regulatory concepts that can adapt to and thrive in the emerging energy market environment.

Out of that meeting came a desire by the participants to advance the ideas and concepts discussed at the CEO Forum. This document summarizes that effort. It presents a broad vision of how stakeholders in California can move forward together in a more integrated fashion to achieve the state's ambitious and important energy and environmental policy objectives.

California's portfolio of policies, statutes and regulatory actions, whether existing or proposed, has set the state on a path to significant de-carbonization of its energy sector. When coupled with broader industry and societal trends, a transformation of the grid is underway at both the wholesale and retail levels.

A Vision of the Grid in 2030

The Working Group developed a collective vision for the grid in 2030 to guide its work. In this vision, California continues to be a world leader in the use of clean energy resources and the adoption of innovative technologies. The legislature, governor, principal regulatory agencies, utilities, generators, technology and service providers and other key stakeholders are aligned in working to meet the State's overarching policy objectives in a cost-effective and efficient way while maintaining core values of reliability, safety, affordability and universal access.

The roles and functions of the grid have changed, driven by changes in customer expectations, environmental and other policy objectives and the rapid advancement and deployment of enabling technologies. The utility business model has also evolved to accommodate these changes to enable a more integrated, "plug-and-play" electricity system.

Achieving the Vision

To achieve the vision, the Working Group identified three areas that must be pursued in parallel in order for an effective transition to occur:

1. Innovation in product and service delivery
2. System design and technology
3. Regulatory framework, incentives and revenue mechanisms

Innovation in Product and Service Delivery

While customers have historically had some tools to help them manage their electricity consumption, the options that have become available within the past several years have begun to change the role of customers from consumers to, in a growing number of cases, generators (including exporters of power at certain times). Customers now have more options to manage their energy costs and where their electricity comes from. These options include energy efficiency, demand response, distributed generation, electric vehicles, on-site batteries, control technology for air-conditioning or lighting, programmable controllable thermostats, and building energy management systems. In fact, many customers are employing multiple forms of these technologies. Enabled by these technologies, customers, on their own or working through their energy service provider(s), can also provide services to the grid in response to several types of grid conditions, so that supply and demand are more interactive than was previously possible and management of customer load becomes an asset for grid reliability and affordability.

In short, the information age has arrived in the energy sector and customers have an increasingly important role to play. With the expectation of policies for higher renewable energy and energy efficiency, and deeper greenhouse gas reductions, customer engagement will be critical for achieving these goals. Third-party companies, utilities and customers are expending significant capital to develop, provide and use products and services in this new age of energy information. Many third-party providers of various on-site generation and storage services have already been successful in developing novel ownership and financing models to expand their markets and are competing to offer innovative products and services both to utilities and their customers.

As a result of the changing role of the customer and the information that is now available, the relationship between central planning, utility planning and Distributed Energy Resources (DER)[2] deployment is an area of active investigation. As part of this effort, utilities will need analytical constructs to determine the locational value (benefit-cost) of DER and customers will need innovative products and services to realize their ability to provide grid services. In addition, data, data access, privacy and security are becoming increasingly important.

System Design and Technology

Meeting California's energy and environmental policy goals requires an evolution in electricity system design and operation using advanced technology and software analytics. The 21st century grid includes significant amounts of utility-scale renewables, more holistic integration of DER with the grid, and increasing third-party solutions that together help to maximize value to customers. The grid must be designed to accommodate rapid evolution in available technologies as well as emerging technologies. The grid architecture must consider the physical assets of the distribution grid including poles, wires, sensors, and customer devices as well as the communications, forecasting, control and other advanced algorithms that enable the collection of devices to work together. Utilities will need to increase investment in hardware and analytics, as well as to develop tools that optimize the contribution of customer-side resources.[3] Regulators will need to facilitate this change by designing policies that support the necessary infrastructure investments, allow experimentation, and require the development of standards and open protocols to ensure interoperability and integration, while addressing cyber security. In addition, utilities and regulators need to recognize that certain types of grid equipment and infrastructure can no longer be amortized over 20-30 years due to the shorter technology lifecycle.

2. DER is defined broadly to include distributed generation (CHP, PV, small wind, fuel cells, etc.), energy storage, electric vehicles, demand response, energy efficiency, and microgrids.
3. For example, see the work of the More Than Smart initiative: http://morethansmart.org/programs/more-than-smart/.

The growth of new DER interactions at the "grid edge" creates a much more complex operating environment for the distribution grid including two-way power flow, power production controlled by the customer, in addition to the utility, and unexpected variations in power quality. These conditions drive the need for greater visibility, digital intelligence (monitoring as well as predictive maintenance) and control as well as the ability to measure and manage power flow and power quality. Ideally, the very DER that is changing the grid environment can be utilized to optimize the grid. In essence, DER can serve the dual purpose of providing greater customer choice and control, and grid power quality and reliability benefiting both customers and utilities, provided that the necessary enabling technologies and adaptive regulatory frameworks are implemented. This environment is already being recognized on specific circuits and areas within California. Utilities and grid operators are in the process of adapting to it, with investments in grid modernization and modifications to traditional distribution planning processes.

A portfolio of enabling technologies will be necessary to support the envisioned products and services. The emerging capabilities of the 21st century electricity system include real-time granular system monitoring and visualization, failure prevention through predictive diagnostics, robust communications, advanced software applications such as outage management systems, advanced control systems such as advanced distribution management systems, advanced grid infrastructure such as distribution automation and advanced forecasting tools incorporating the capability of DER assets.

Regulatory Framework, Incentives, and Revenue Mechanisms

The current regulatory construct will be challenged to keep pace with changes that support the principles of universal service and how to equitably cover and share the costs of essential grid services, while also supporting individual customer-level options and the achievement of state policy objectives. There are several possible pathways, models and options that could be reviewed and evaluated for how they could be applied in California, covering utility organizational models, market operations/pricing models and potential future revenue models.

The California Public Utilities Commissions (CPUC) has already embarked on several parallel paths, via individual proceedings, to address a range of issues emerging from the changes taking place in the electricity sector. This has set the State of California on the path to achieving important state policy objectives and has also set the stage for the industry to evolve to a new structure. As the changes become more profound, it will become necessary to consider more fundamental changes, in particular on restructuring/aligning incentives to achieve the desired outcomes while maintaining the long-term viability of the utility. This should be done via an open and transparent process to consider all the options available. This would include:

- Identification of the regulatory issues that currently impede – or could enable – evolution from existing business models to new ones.
- An assessment of what is most appropriate for the regulated market versus the competitive market, and how the two would interact as the market evolves.
- A focus on regulatory process, in particular an assessment of how to best integrate/coordinate the various regulatory proceedings that are each addressing some aspects of the evolving industry structure into a comprehensive framework. This could help reduce the effort and time required to run all these proceedings and also lead to better results by considering issues more holistically.

The companies engaged in this effort encourage the CPUC as well as the California Energy Commission (CEC) to consider the above as they work to accelerate the transition to a high-performing electricity system in California for the 21st Century.

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LIST OF ACRONYMS

CAISO: California Independent System Operator

CPUC: California Public Utilities Commission

DER: Distributed Energy Resources, which is defined broadly to include energy efficiency, demand response, all forms of distributed generation, energy storage, electric vehicles and microgrids.

DR: Demand Response

DSM: Demand Side Management

EM&V: Evaluation, Measurement and Verification

EE: Energy Efficiency

RE: Renewable Energy

DRP: Distribution Resource Plan

DSO: Distribution System Operator

DSP: Distributed System Platform

IDSO: Independent Distribution System Operator

IOU: Investor-Owned Utility

PEV: Plug-in Electric Vehicle

SAIDI: System Average Interruption Duration Index, a common reliability indicator that measures the average outage duration for each customer served

SAIFI: System Average Interruption Frequency Index, a commonly reliability indicator that measures the average number of interruptions that a customer would experience

INTRODUCTION

Background and Objectives

Over the last century, the U.S. electric power sector has undergone significant changes in response to developments in technologies, markets, regulations and policies. The sector is once again entering a period of significant change, driven by new technology changes, evolving customer needs, environmental imperatives and an increased focus on grid resiliency. With these developments come challenges, but also new opportunities to create an electricity system that meets the changing requirements of consumers and society for the coming decades. California has often been a leader in energy and environmental policy and is once again leading the way on the creation of a *21st Century Electricity System*.

On February 25, 2015, Advanced Energy Economy Institute (AEEI) hosted a meeting of senior executives from advanced energy companies and California's investor-owned utilities (IOUs). This *California 21st Century Electricity System CEO Forum*[4] was an opportunity for energy industry leaders to come together to develop a common inventory of the drivers of industry change and to start to examine utility business models and regulatory concepts that can adapt to and thrive in the emerging environment.

Out of that meeting came a desire by the participants to advance the ideas and concepts discussed at the CEO Forum. This document, Towards a *21st Century Electricity System* in California, summarizes that follow-on effort. It represents the collective thinking of an informal Working Group composed of California IOUs and several national advanced energy companies. Despite the diversity of participating organizations and the range of perspectives within the Working Group, there was significant alignment across a number of issues.

The Working Group focused its efforts on describing potential changes to customer products and services, distribution network infrastructure, and California's regulatory framework. The Working Group did not conduct a full analysis of these potential changes to validate if they would promote the desired policy outcomes and facilitate the necessary investments, while ensuring a viable long-term utility business model that identifies and supports the roles of utilities and non-utility companies alike. Such analysis should be conducted before a potential change is determined to be a viable option. This paper is intended to be used by stakeholders to further inform their efforts to analyze and evolve policies that will result in a modernized regulatory framework that addresses the potential for new business models and spurs technological and market innovation to meet evolving customer needs and California's energy policy goals.

This paper is intended to be used by stakeholders to further inform their efforts to analyze and evolve policies that will result in a modernized regulatory framework.

4. This was the seventh such CEO Forum hosted by AEEI. For more information on this series, go to https://www.aee.net/initiatives/21st-century-electricity-system.html#21st-ces-ceo-forums.

An effective transition requires a focus on innovation in product and service delivery, system design and technology, and the regulatory framework, incentives and revenue mechanisms. The Working Group recognizes that there has already been significant work done on this topic, including the work of the More than Smart initiative that has considered the requirements of the modern distribution grid and integrated distribution planning.[5] Rather than replicate this work, this paper seeks to build upon it by offering up a broad vision of how stakeholders in California can move forward together in a more integrated fashion to achieve the state's policy objectives.

The Current Situation in California

The Working Group took as its starting point the current efforts in California to modernize the grid and update utility practices that align with and support achieving state energy and environmental policy objectives. The Working Group applauds these efforts and believes that they provide a compelling justification for moving forward in a coordinated fashion to derive the greatest benefits possible from the changes taking place while avoiding potentially adverse outcomes. California has already demonstrated that economic growth and prosperity are fully compatible with environmental stewardship. The combination of California's abundant renewable energy resources and its culture of innovation provide the State with a unique opportunity to lead the transition to a low-carbon, prosperous economy.

The Drivers of Change

Several developments are converging to drive significant change in how electricity is produced, delivered and used. These include:

Technology developments, such as:

- Rising deployment and cost-effectiveness of distributed generation (DG)
- Increasing adoption of energy management technologies, including energy efficiency (EE) and demand response (DR)
- Deployment of smart grid technologies, products and services
- Growing adoption of plug-in electric vehicles (PEVs) and battery energy storage
- Deployment of microgrids, which combine some or all of the above technologies to meet customer and system needs
- The rise of big data and analytics enabled through low cost sensors and computing to drive high productivity within the utility system
- Expanded use of utility-scale renewables

Several developments are converging to drive significant change in how electricity is produced, delivered and used.

5. Greentechleadership.org/programs/smart-2014

Market and customer developments, including:

- Expectations for a more resilient system, including rapid outage restoration and better information and communication about outages, especially during severe weather events
- A desire from customers for more environmentally sustainable energy options
- Higher expectations for reliability and power quality based on the proliferation of electronic devices and the digital economy
- A desire for greater control of energy use and costs, including rising interest in customer-sited options, paving a way for the "empowered customer"
- Growth in energy products and services provided directly to customers by third parties, and the ability of customers and third parties to offer products and services to the utility as an alternative to traditional utility investments
- Heightened awareness of cyber security and threats on both the utility and customer side of the meter

Reinforcing these technology, market and customer developments are California's clean energy policies, which are, arguably, the most aggressive in the country, including greenhouse gas (GHG) reduction targets, the nation's most aggressive renewable portfolio standard, and an energy efficiency portfolio standard that sets energy and demand reduction targets through 2020.[6] In support of these goals, the state has implemented a number of programs and the California Public Utilities Commission (CPUC) has opened multiple proceedings and issued orders covering energy efficiency, solar power, energy storage, electrification of transport, smart inverter functionality, distributed energy resources (DER) communications, net metering, smart grid deployment, demand response, advanced metering infrastructure, residential rates and Distribution Resource Plans (DRPs) that are aimed at modernizing the electricity distribution system to accommodate two-way flows of energy and energy services. Even before these existing statutes and regulations are fully implemented, bolder action is already being contemplated.

Implications of Meeting California's Energy and Environmental Policy Goals

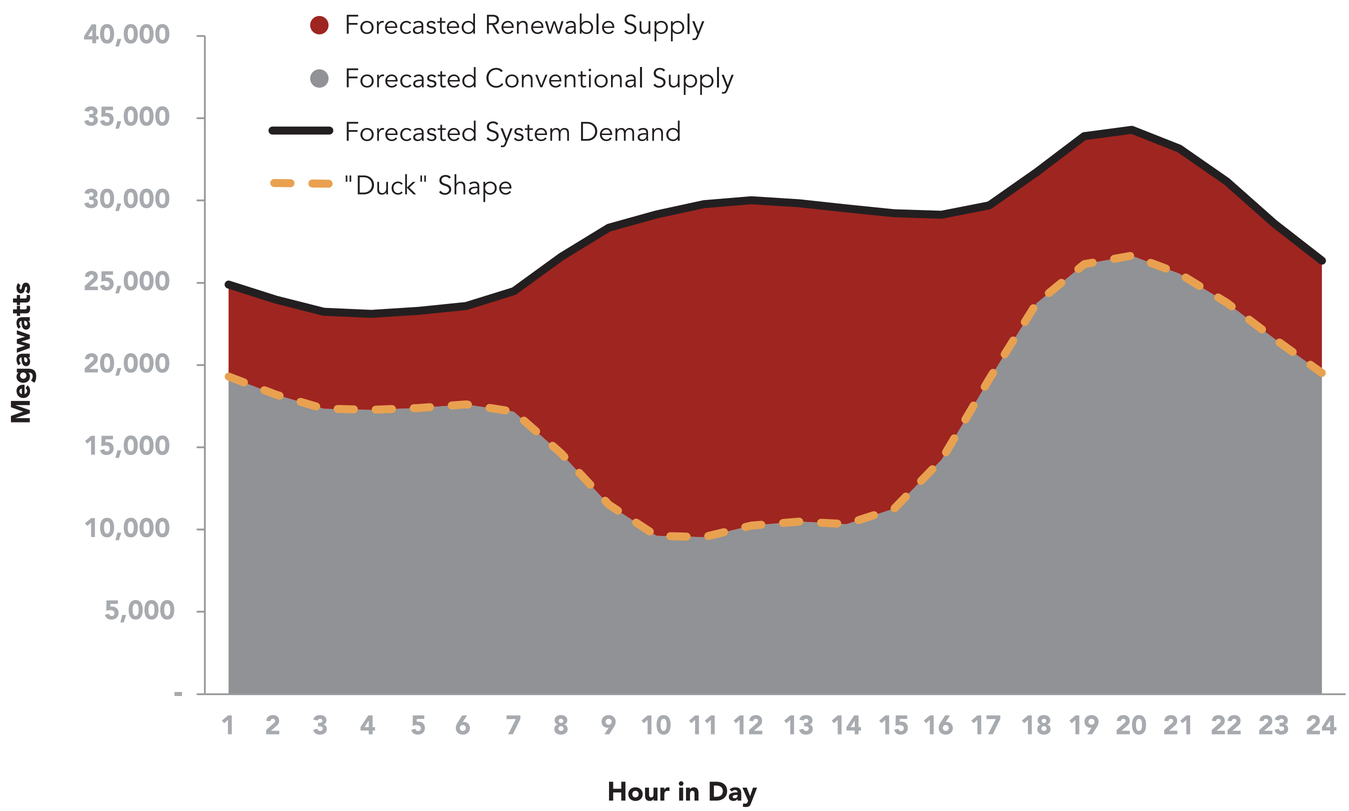
California's portfolio of policies, statutes and regulatory actions, whether existing or proposed, has set the state on a path to significant de-carbonization of its energy sector. When coupled with broader industry and societal trends, a transformation of the grid is underway at both the wholesale and retail levels. The Investor Owned Utilities (IOUs) are nearing the 33% RPS target with solar power now dominating RPS procurement in California. Energy storage procurements are also underway.

At the wholesale level, the addition of significant solar and wind resources requires changes in grid planning and operations. The so-called "duck chart"[7] (see Figure 1) has been used by the California Independent System Operator (CAISO) to illustrate future scenarios of net load curves and to highlight the need for more flexible resources to maintain system balance, accommodate faster ramp rates and avoid over-generation conditions, which could lead to uneconomic curtailment and dispatch. Potential solutions include combinations of retrofitting existing plants to enhance their operating flexibility, adding new flexible capacity or energy storage, ramping of aggregated DER resources, achieving customer behavior changes driven by sending time-of-use pricing signals aligned with grid conditions, promoting the use of more demand response through dynamic pricing, integrating smart electric vehicle charging, and sharing more resources across the Western United States. The Energy Imbalance Market is one option that is enabling such sharing.

6. See the Appendix for more details on California's clean energy policies and regulations.
7. https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.

Figure 1: California's Emerging Supply and Demand Profile

March 24, 2024



Source: Data taken from CAISO - LTPP 2014 Forecast

At the retail level, changes are equally profound, where the evolution is not limited to technical innovations, but extends to the fundamental role of the utility and third-party providers in meeting system and customer needs. The DRPs that California utilities filed in July 2015, will help address the need for the grid to develop new capabilities, as increasingly the utility is seen as a platform operator or key enabler that can integrate diverse resources to meet grid reliability needs and at the same time meet customer needs and achieve policy goals. The management and operations of this dynamic environment is reshaping distribution control room operations and is placing a high priority on increasing sensing capability to improve system visibility and control at the edge of the system to support reliability.

Document Contents and Organization

The main body of this paper has three sections. The first section, titled Guiding Principles, lays out a set of shared principles that informed the remainder of the work. This is followed by the End-State Vision, which provides a "snapshot" of where the electricity system is expected to be in 2030. The third section titled The Path Forward goes into greater detail on three areas that are critical for achieving the vision: (i) innovation in product and service delivery, (ii) system design and technology, and (iii) the regulatory framework, incentives and revenue mechanisms.

GUIDING PRINCIPLES

To guide the development of this paper, the Working Group agreed on the following five sets of principles during the *California 21st Century Electricity System CEO Forum* that was held by AEEI in San Francisco on February 25, 2015.

1. Approach the *21st Century Electricity System* holistically

The overarching goal should be to decarbonize the energy system in the 21st century, but this needs to be done in the most cost-effective[8] way possible. California can lead the world and create a model that can be replicated elsewhere.

Silos have given way to a more complex, interdependent ecosystem. Electricity, natural gas, transportation, water, and waste all need to be considered together to balance potentially competing interests and avoid unintended consequences.

This requires that we:

- **Focus on common interests**
- **Enable all stakeholders to optimize for common goals (such as GHG reduction)**
- **Be flexible, learn by doing and be willing to change course when a strategy or policy is not working.**

We need to understand the array of options and the time horizons associated with each. There is the need to move forward quickly, consistent with the goals. This involves picking "low hanging fruit" and taking intermediate steps while also addressing longer-term issues. It also involves pursuing parallel paths on a range of issues, such as regional coordination and customer-side opportunities.

It is necessary to "de-conflict" utility business models relative to broader goals. Utility business models are changing and should move in the direction of supporting broader goals. As just one example, load may grow due to electrification of transport, but this should not be in conflict with goals for reducing electricity consumption.

8. Throughout this paper we use the term "cost-effective" as it relates to meeting policy objectives, not in the "least cost" sense often used for planning. Cost effectiveness, if defined in an outdated way, can be a barrier to system innovation and transformation.

2. Core principles have not changed

Ensuring safety, reliability, affordability and equitable access/service remain core tenets of utility regulation. Achieving policy objectives must be done in the most cost-effective way possible, and we do not want to go backwards as we go forward.

We need to enhance cyber and physical security to ensure network and data security.

Markets should be used to the greatest extent possible.

3. Communication networks have a vital role to play

Utility networks, and increasingly, private networks, are essential for achieving common objectives. With the grid as an enabling platform, interoperability can ensure that different networks work well together. Information and communications technology is emerging as a vital "new power plant."

4. Stakeholder engagement is critical for success

Customers should be empowered with information, technology, tools, choices and pricing.

We need to provide appropriate price signals and rate structures, and be able to monetize value. The regulatory models and how utilities charge for services needs to change. We need to be able to monetize the value of grid investments and customer/third-party investments.

We want to encourage innovation and new entrants. Programs should be technology agnostic, as much as possible, to encourage innovative solutions. Utilities should also be incented to innovate. We need to identify and remove barriers to the adoption of new technologies and business models. In order to facilitate this innovation, utilities should provide transparency into grid capabilities.

California requires a properly trained workforce. The electricity system will be much more complex in the future. This requires stakeholders to work together and partner with the state, with particular attention to the community college system, to ensure appropriate training and curricula so that we have the right people with the right skills.

5. Regulatory and market certainty will accelerate progress

Clarifying stakeholder roles will create business certainty that can accelerate progress.

We need clear definitions of metrics about how parties will be evaluated.

Greater market certainty will be important to help attract needed financing and investment.

Regulations and approvals need to be simplified to the greatest extent possible. The regulatory complexity in California adds time and costs.

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END-STATE VISION: THE CALIFORNIA ELECTRICITY SYSTEM IN 2030

This section presents a snapshot of our collective vision for the grid in 2030. The "end state" was used to further guide development of the details that follow in the remainder of this report. Although we focused on some "days in the life of the grid" in 2030 as seen through the eyes of different stakeholders, it is important to note that this end state is really just another point along the path of the continued evolution of the grid.

The California Electricity System in 2030

In 2030, California continues to be a world leader in the use of clean energy resources and the adoption of innovative technologies. The legislature, governor, principal regulatory agencies, utilities, generators, technology and service providers and other key stakeholders are aligned in working to meet the State's overarching policy objectives in a cost-effective and efficient way while maintaining the core values for a 21st century electricity system and enabling a growing, sustainable economy.

The roles and functions of the grid have changed over the last 15 years, driven by changes in customer expectations, environmental and other policy objectives and the rapid advancement and deployment of enabling technologies. The utility business model has also evolved to accommodate these changes to enable a more integrated, "plug-and-play" electricity system.

California's electricity system in 2030 is dynamic, meeting a diverse set of customer needs using a mix of basic services and new value-added services and transactions. The core attributes for this modern, integrated power system include:

- Outstanding reliability and power quality, particularly for this highly networked environment
- Affordability, so that no undue burden is placed on customers
- Environmental responsibility
- Resiliency
- Safety for customers, employees and the public
- Robust physical and cyber security, including assurance of data privacy
- Universal access
- Efficiency via system optimization utilizing the most cost-effective resources

California's electricity system in 2030 is dynamic, meeting a diverse set of customer needs using a mix of basic services and new value-added services and transactions.

A stable regulatory framework supports innovation, system-wide thinking, and new approaches, processes and business models to achieve balanced implementation of these core attributes.

Days in the Life of the Grid in 2030

In order to illustrate how the California electricity system looks in 2030, the following ten "vignettes" describe how different stakeholders interact with the electricity system.[9] These vignettes are not meant to fully describe the system in 2030, but rather to provide examples of new capabilities, as well as products and services that may be available from utilities and third parties alike.

Utility / Distribution System Operator

It is a stormy December day in 2030, with 65 mile per hour winds and driving rain in the Sierra Foothills and a chilly overcast of winter grey hanging across the state, limiting PV production. Holiday parties and festive lights fill both urban centers and small town hamlets, adding seasonal electricity demand. The utility is keeping essential electric service on for all customers with high power quality, regardless of location, diversity of energy program or load shape. The utility is providing basic service, power for self-generating customers connected to the utility grid whose systems are not generating enough to meet their needs, and premium service for highly sensitive commercial and government customers – everyone is safely receiving power despite the storm. The utility, in its role as the operator of the distribution system, is providing around the clock, vital, central systems integration and infrastructure-as-a-service. This keeps all nodes on the network in balance, consistently enabling all types of distributed energy transactions and ensuring that both grid and resource adequacy are achieved out to every edge of the grid. Customers never have to worry about energy or larger societal challenges like cyber security.

Tech Company / Aggregator / Third-party Provider

Harriet Belle, Senior Fleet Manager for All-Together Energy Solutions, an energy storage and demand response (DR) aggregator, starts her morning with a quick look at her "State of Charge" (SOC) dashboard, making sure the widespread DR assets under her control can fulfill the commitments she made the day before. All is green, but the Silicon Valley Distribution System Operator (DSO) has sent an alert to expect high pricing for "DR-up" service, absorbing abnormally high PV production expected in the area. Harriet checks the hourly prices in the CAISO wholesale market and tweaks the Silicon Valley Fleet algorithms for the day, but also calls a meeting with her regulatory analyst and channel sales manager. Because the "DR-up" alerts have been so frequent and some of the hourly prices so high, her team analyzes the potential for adjusting the market transaction regulations and upselling consumers additional technology for capturing that revenue. By the end of the day, they deliver a brief to their CEO recommending outreach to the CPUC and the DSO, and detailing the potential for added customer value, grid efficiency benefits and increased fleet profits.

Small Commercial Customer

George Polk, the facilities manager for Hotel California, receives an alert that his energy report is ready and brings up his building energy management system. The new smart refrigerators he installed for the pink champagne are already saving energy, as well as allowing the hotel to earn a bit more money in the local demand response market as well as the CAISO ancillary services market. But CAISO wholesale market hourly prices have dropped enough at certain times for the company that manages his on-site energy storage system to recommend changing how he uses the batteries. It takes George less than five minutes to adjust the settings to prioritize "Solar Shift" over "Grid Services" and he knows he can forget about energy for another week.

9. These ten vignettes are not meant to be taking place on the same day.

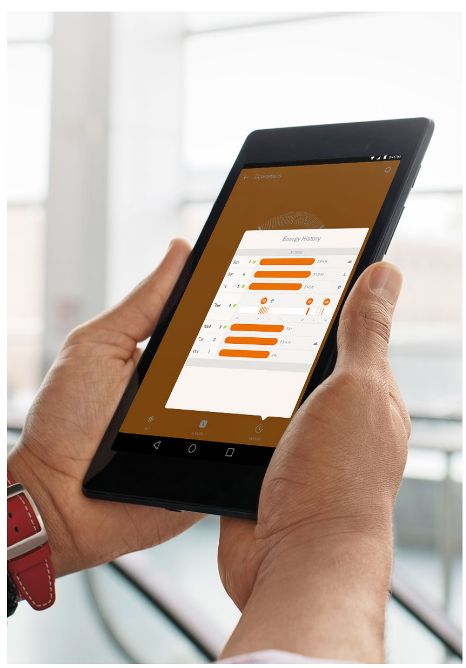
Commercial "Prosumer"

Green Earth Grocery Store Chain just completed their Whole Building Energy upgrade in partnership with their trusted utility partner. At today's celebration, Green Earth Grocery Store and their utility unveil the net zero commercial energy campus that they have achieved together through the application of innovations funded and supported by California policy through the utility market channel. Ten different technology companies participated in implementing the project. The project includes an integrated customer-side-of-the-meter microgrid operated by utility experts, but owned by the store. The microgrid utilizes a distributed generation system – PV integrated with an advanced anaerobic digester that takes food and kitchen waste and turns it into energy using a microturbine – with a distributed storage solution, advanced HVAC and chiller technology that reduces building water consumption by 70%, and a new bio-sensor food display system that dims LED lighting automatically in display cases when no shoppers are around, enhancing both food safety and energy efficiency. Their energy bill still includes payments for grid services and social program costs, but it is lower than it would have been absent their efforts to significantly reduce and manage their usage and to meet their remaining needs with on-site generation.

Average Residential Customer

Sandy and Glenn King are enjoying a well-earned retirement in San Francisco after rewarding careers as a teacher and ship repair foreman, respectively. They are fourth generation San Francisco natives and love their city, but they have to manage their budget to remain here. Frankly they do not want to have to think about energy – that feels like work. They want to enjoy their free time and spend it with their grandchildren. They signed up for a fixed bill plan that enables them to know exactly what their bill will be each month and plan accordingly. Because their simple, fixed bill is calculated with an advanced data model based on their actual usage from their home's own smart meter data, the utility is able to collect the revenue it needs while meeting the needs of Sandy and Glenn.

Residential "Prosumer"



Karen and Tom Smith love their smart home and their "ABC Energy App" provided by "CoolSolutions, Inc." that enables them to pre-cool and manage their desert California condo with a few taps on their smart watch. They also love their autonomous fully electric car that has an integrated smart-charging feature that communicates seamlessly with their Energy app and enables them to coordinate timing of their car charging with the best grid electricity pricing. That way, their total energy bill for both home and car never exceeds their desired monthly bill. Because they live in a condo, they actually do not own a roof for PV, but they can participate in their utility's voluntary 100% carbon-free energy program and feel great about it. When they do not need to use their autonomous EV, they can switch it into V2G (vehicle-to-grid) battery mode and participate in a dispatchable utility DR program. This adds credits to their utility bill based on hourly CAISO wholesale prices and other factors and is also integrated into their Energy app, while the actual electrons are seamlessly aggregated and dispatched to the utility through "Make it Happen Energy Services Co."

Low-income Residential

PV4All a non-profit solar installer, partnered with Burbank Housing to lower the electricity bills for its low income residential properties in Sonoma County. PV4All configured each property with an intelligent energy management system (iEMS) including rooftop solar, smart inverters, energy storage and sensors/controls on HVAC and water heaters. Together, these technologies are networked and work collectively to optimize each homeowner's load to ensure maximum energy savings. In addition, PV4All, as the owner/aggregator, uses the iEMS to provide grid support services to the distribution operator and the CAISO such as load curtailment and ramping as well as power quality management (i.e., voltage control) that Burbank Housing is able to monetize and use to lower the energy bills of its tenants.

Local Community

Jennifer, the City of Berkeley's Sustainability Manager, is responsible for tracking the City's progress towards achieving the 80% GHG reduction by 2050 target outlined in the City's Climate Action Plan. Jennifer coordinates a number of programs and services to reduce GHG emissions, including energy efficiency, renewables, green buildings, water, solid waste recycling, sustainable transportation, and local supply chain initiatives. Jennifer also coordinates the property-assessed clean energy (PACE) financing program for clean energy projects and works with a DR aggregator to manage the City's DR assets via a real-time dashboard. She's worked diligently over the years to deploy EV charging infrastructure throughout the city, develop community solar and energy storage and make use of smart grid technologies to ensure that critical city infrastructure (police, fire, hospitals, etc.) are supported by microgrids. Transportation and traffic systems are also closely coordinated with the energy systems to support critical transportation arteries and modes and to reduce traffic congestion.

CPUC Policymaker

CPUC President Henley reviews the draft 2030 "21st Century Electricity System Goals" report with considerable satisfaction, knowing that the flexible regulatory structures that were enacted in collaboration with utilities and market participants were instrumental in achieving these goals, reaffirming California's policy and market leadership for decades to come. A new regulatory equilibrium was established with the reforms enacted in 2020 that fostered the innovation and enabling investments by utilities and other market participants. By setting targets for grid optimization, GHG emissions, renewables and efficiency with metrics that reward risk-taking and a portfolio approach, the Commission motivates both utilities and third-party companies to innovate towards common goals. Henley then turns to the latest recommendations from the Distributed Market Design Working Group, published just yesterday, on the joint agencies' public California Energy Planning website. It took only two months for the SoCal West DSO to craft a new transaction type between DER aggregators and the ISO wholesale market, providing 10-year forward pricing for capacity deferral and GHG reduction for the 2040 targets. As the assigned Commissioner, he fast tracks the idea to be available in local markets statewide next month.

California Independent System Operator

At an AEEI conference on August 1, 2030, attendees marvel at a presentation by Haley Potter, an executive from the regional grid operator. Haley highlights a grid that has long since evolved from a unidirectional set of transmission and distribution lines into a two-way network, in which energy and communications flow bi-directionally, between utilities and consumers. She reminds conference guests of a time when utility-scale resources and customer-owned power systems were not integrated, telling stories of ramping challenges and over-generation, which affected the region before we unlocked the power of consumer participation. She grins when an audience member asks if it was true that the grid was not always integrated between the western states. With a smile and a nod of the head, she says, "Yes, but thank goodness those times are behind us. We're all better off now, with plentiful, affordable and reliable clean energy."

THE PATH FORWARD

Having set the vision for what the California grid will look like in 2030, the question becomes, "How do we get from here to there?" To achieve the end-state vision, the Working Group identified three parallel paths upon which to move forward. These are:

- Innovation in product and service delivery
- System design and technology
- Regulatory framework, incentives and revenue mechanisms

Each is discussed in more detail below.

Innovation in Product and Service Delivery

Introduction

While customers have historically had some tools to help them manage their electricity consumption, the options that have become available within the past several years have begun to change the role of customers from consumers to, in a growing number of cases, generators (including exporters of power at certain times). Customers now have more options to help them manage their costs and source of electricity to meet their needs. These options include energy efficiency, demand response or other energy management technologies, on-site solar, wind, fuel cells or other forms of distributed generation, electric vehicles, on-site batteries or other forms of energy storage, control technology for air-conditioning or lighting, programmable controllable thermostats, and building energy management systems. In fact, many customers are employing multiple forms of these technologies.

Enabled by these technologies, customers, on their own or working through their energy service provider(s), can now provide services to the grid in response to several types of grid conditions, so that supply and demand are more interactive than was previously possible. Customized alerts through pricing or other forms of automated signaling can provide information when the electricity system is experiencing supply shortages and when there is surplus supply available, especially from renewable generation. These signals can also be tailored to specific areas experiencing congested pathways, or air pollution alert days through energy meter data and advanced analytics. Customers also have tools to better understand their own consumption behavior and how they compare to others. Armed with this information customers can determine adjustments they can make to lower their own costs and to provide broader system benefits, possibly earning additional revenue by providing grid services.

Customized alerts through pricing or other forms of automated signaling can provide information when the electricity system is experiencing supply shortages and when there is surplus supply available, especially from renewable generation.

In short, the information age has arrived in the energy sector and customers have an increasingly important role to play. As with any advancement of this type, some customers see value in greater engagement while others do not. Some customers choose to respond to certain information, while others do not. There is a real opportunity to understand what is important to customers and to provide them with increased value and control over their bill and thus drive increased satisfaction.

Increased customer engagement can also result in benefits to the system by managing peak demands, shifting load from periods of high use to low use or to periods of high renewable generation, and providing voltage or frequency support or other valuable grid services. This does not mean that it is necessary to connect residential customers to the real-time wholesale market; however, more real-time information can enable engaged customers to adjust their behavior in a manner that will support broader grid objectives. This will become increasingly important for managing quick ramping needs (increasing and decreasing energy consumption) associated with the availability, or lack thereof, of renewable resources throughout the day. Addressing the late afternoon ramping requirements highlighted by the "duck curve" does not need to rely solely on new resource additions if instead demand on the system can be "reshaped," with hourly prices providing one of the financial incentives. With the growing capability of customers to respond to conditions and the dynamic resources that can be accessed, the response to over-generation can be multi-faceted. With the expectation of policies for higher renewable energy, energy efficiency and greenhouse gas reduction, customer engagement will be critical for achieving these goals. Third-party companies, utilities and customers are expending significant capital to develop, provide and use products and services in this new age of energy information.

More real-time information can enable engaged customers to adjust their behavior in a manner that will support broader grid objectives.

As a result of the changing role of the customer and the information that is now available, the relationship between central planning, IOU planning and DER deployment is an area of active investigation. Currently, the growth in on-site energy management and generation has created some difficulties in grid planning and operation, because behind-the-meter applications are not visible to the grid operators and create difficulties with forecasting their use. Utility operations will become increasingly more sophisticated to enhance visibility to DER and to manage a dynamic grid edge environment as outlined in the System Design and Technology section of this paper. An opportunity for innovation lies in the use of DER data for grid planning and operations and regulatory policies that enable the use of this data.

The Current Paradigm for Providing Products and Services

The current set of product and services available to customers is due in large measure to decades of public policy intended to leverage utilities – natural monopolies within their service territories – as vehicles to provide societal benefits in addition to their core mission of safe, reliable, affordable, and non-discriminatory universal access to essential service. The core ratemaking construct was built upon a presumption that monopoly utilities would provide all electricity services within their territory where they could rely on recovery of their investment plus an opportunity to earn a reasonable return on that investment, at a time when such investments and customer demand were often growing. In this environment, the emphasis was on stable retail rates and limited, uniform service options. In a broad sense, there is a legacy of regulatory policies through utility rate design based upon cost causation and allocation, with the fundamental intent of providing reliable service at just and reasonable rates and ensuring appropriate public and stakeholder involvement.

Some of these policies include:

- The decoupling of utility earnings from sales, which removes the disincentive for utilities to pursue energy efficiency, and generally aligns economic and resource stewardship interests of the broader society with those of utility shareholders.
- The inclusion in utility rates of the costs associated with various state policy initiatives (e.g., renewable portfolio standards) and financial incentive and pricing programs designed to enable customers to use energy more efficiently and to change the timing of consumption to better align with supply characteristics.
- The recovery of utility costs through rate schedules that cover large populations of customers based on average customer characteristics over a broad geographic area.
- Rate designs that are generally comprised of a relatively limited number of charge types, where much of the system costs are recovered through non-time-differentiated volumetric rates.
- Rate discounts for low-income customers.

The net result of this system is one where state environmental and social objectives are supported through a complex and heavily regulated structure. Customers have long been accustomed to the stable rate plans and have not been expected to be engaged consumers. This has negatively impacted the development and use of actionable, time-varying price signals sent to customers to automate or encourage behavior that might align with system objectives to optimize demand, compensate DER customers for services that they might provide to the grid or charge DER customers for services they might receive from the grid.

Current customer-grid interactions are also limited and quite often do not reflect customer preference, resource availability, and acceptance of resource participation for grid needs. However, a convergence of technological advancements (e.g., advanced metering, smart thermostats, rooftop solar cost declines, home area networking) and general consumer expectations for greater control and convenience are beginning to push against the current structure in a manner that is highlighting – and challenging – the sustainability of the embedded costs and cross subsidies that are mandated through state policies.

A New Paradigm for Providing New Products and Services

Customer preferences are becoming more diverse with a "one size fits all" regulatory construct no longer meeting expectations. Customers wish to prioritize different objectives. Environmental consciousness drives some customers' decisions while others focus on cost-effectiveness or the convenience of using web-based and mobile applications to conduct business. Still others are early adopters of new technologies and services. Utilities and third parties are expected to develop new products and services to meet the various objectives of their customers, and the challenges inherent with the existing regulatory framework offer significant opportunities for innovation.

Customer preferences are becoming more diverse with a "one size fits all" regulatory construct no longer meeting expectations.

As outlined in the Guiding Principles, the desire is to retain many of the foundational benefits of the current system while at the same time improving it to provide a platform for innovation around products and services that offer greater customer convenience, control and participation. This includes a market structure that uses accurate two-way price or control signals for the subset of utility customers who are increasing their level of "energy engagement" by way of supplying their own energy or providing significant grid services through storage or other customer DER technologies. This structure should also enable appropriate compensation for services provided through rates, utility tariffs or other market mechanisms. As straightforward as this may sound, it will likely require an extensive examination of both current and future services to adequately define value for these services. This examination should be used to determine compensation for when customers provide grid services and charges for grid services customers may receive. Table 1 provides an initial list of these current and potential grid services, recognizing that not all of these services are currently provided or available at the distribution level.

Table 1: List of Potential Grid Services

Service Category	Potential Grid Services
Fundamental Services	• 24/7 electrical energy • Reliability services (outage scheduling, system redundancy) • Managing for circuit load growth • Accommodating a diversity of customer load needs (e.g. motor start-ups with high inrush currents) • Accommodating a diversity of customer choices for energy management including installation of on-site generation, energy storage and other demand-side measures
Maintenance	• Proactive and responsive replacement of system equipment
Protection	• Fault detection and isolation
Power Quality	• Flicker & harmonics
Balancing Services	• Balancing circuit load and generation, and distribution phases • Voltage/VAR support • Frequency regulation
Additional Services	• Broader grid acts as a "battery" for current DG customers

Any changes in the retail market structure need to take into account the fact that not all customers will be equally engaged and must ensure that customers are fairly treated (e.g., those who participate are rewarded for their contribution or charged for their additional needs, but those who choose not to participate are not adversely impacted). Future retail market structures must also take into account the spatial diversity of the distribution system, allowing the utility to more granularly and effectively manage capacity, power quality and reliability at the level of individual distribution circuits.

As part of this effort, utilities will need analytical constructs to determine the locational value (benefit-cost) of DER. Once the locational value of DER is well understood, utilities can provide appropriate price or control signals to customer DER to provide and be compensated for grid services. Additionally, charges to compensate for the impact DER might have on the grid could be assessed. To develop market and control signals, utilities will need to:

- Accurately model distribution circuits including interconnected DER
- Incorporate the impact of DER

- Account for ISO wholesale market prices and at the same time reflect the current state and needs of the specific distribution circuit[10]
- Actively monitor grid and customer assets to measure response
- Actively manage grid assets to coordinate grid resources for reliability and scalability

With the pace of technology change as rapid as it is, the pace of regulatory review can be an obstacle to the deployment of new products and services. Not only does the pace of regulatory review need to accelerate, but the standard by which such services are evaluated also needs to change. Regulators need to adopt an "incubator" mentality. Not all products and services that go into the incubator are going to be successful. There will be failures and there will be successes; but there has to be a willingness to allow utilities to take some reasonable risks and encourage innovation and entrepreneurship, and a willingness to pass at least some costs of failed enterprises on to end-use customers.

Not only does the pace of regulatory review need to accelerate, but the standard by which such services are evaluated also needs to change.

The Increasing Importance of Data

In addition to providing customers with two-way signals to modify and reward behavior, there are other means by which products and services can be enabled. For example, customers can authorize greater availability of customer-specific energy use information and more sophisticated analysis of that data on their own behalf. This data could be used to more effectively design, implement and target energy savings and demand management strategies as well as to quantify program effectiveness. In addition, through data mining and advanced analytics of anonymous and aggregated data, utilities and third parties are able to gain insights from large volumes of data to identify and pursue new business opportunities by segmenting the customer population to understand and isolate specific unmet needs and subpar customer experiences.

There has to be a willingness to allow utilities to take some reasonable risks and encourage innovation and entrepreneurship.

Many third-party providers of various on-site generation and storage services have been successful in developing novel ownership and financing models to expand their markets and are competing to offer innovative products and services both to utilities and their customers. The innovation of these products and services is based on the application of new technologies, data, and data-driven services that address existing and emerging customer needs. These third parties are beginning to collect their own customer data using sensor technologies such as web-connected smart thermostats and building energy management systems, all of which can be shared with utilities with the permission of the customer.

In addition, large investments in systems to collect valuable grid and customer interval meter data have been made. These investments allow the utility to collect important grid-side data using sensors and instrumentation assets and supporting software analytics. This enables "big data" outcomes, such as failure prediction, and it results in cost efficiencies that can be passed down to the end customer in the form of greater reliability and more affordable energy prices.

10. For example, utilities may add a distribution component to the wholesale market price (e.g., a locational marginal price, or LMP) to provide a locational value of energy delivered to or generated in a specific location.

Over time, increased access to customer intelligence tools will help to efficiently target customers, drive engagement and lower acquisition costs for demand side management (DSM) programs. Customer data enables products and services providers to proactively identify customer needs, personalize customer-facing programs and service offerings, as well as accurately measure and monitor energy savings over time. At the same time, customer data and other confidential data must be protected under privacy laws in order to protect the intellectual property and physical and cyber-security of utilities and third parties who own or access the data.

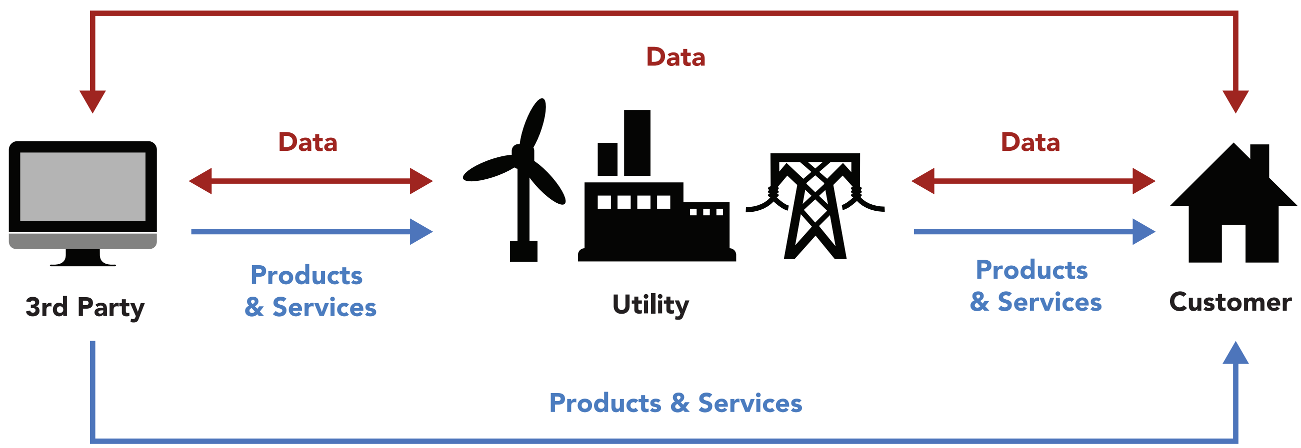
Customer data enables products and services providers to proactively identify customer needs, personalize customer-facing programs and service offerings, as well as accurately measure and monitor energy savings over time.

By sharing electricity system[11] and DER market and operational data under appropriate privacy and information security protections, utilities and third parties can collectively provide the new products and services desired by various customer segments. One service might be community renewable programs, where customers are able to support the development of new renewable resources that might be located at a distance from their homes or businesses. Another example is microgrids, where either individuals or groups of customers connected to the grid can support, and benefit from, a combination of generation, storage, controls and other on-grid devices that can provide higher reliability and allow disconnection from the grid during broader outages. A third example is to leverage installed residential customer devices to participate in demand response programs. For example, the replacement and installation of new Internet-enabled devices such as smart thermostats could be used to respond to rates tailored to specific customers based on their characteristics and energy consumption patterns.

To further facilitate the development of new products and services, utilities and third parties may need to use customer, grid and market information and share this information with each other. Data privacy and security concerns about sharing information with third parties may be addressed in a number of ways, such as by requiring that data be anonymous or via data aggregation. Regulators will also need to ensure that utilities are fairly compensated for the investments they make in the necessary infrastructure. Figure 2 below provides a simplified representation of the flow of data, products and services between utilities, customers, and third parties.

11. This could include wholesale market data and information about the distribution system.

Figure 2:



Flow of Data, Products and Services between Utilities, Customers, and Third Parties

Source: Navigant Consulting

Utilities could use data analytics to generate additional revenue to reduce the overall revenue requirement, and thereby rates, for all customers. For example, utilities and third parties could analyze behavioral and operational information about customers to recommend additional energy efficient products and provide the direct ability to purchase, receive incentives and finance such products. Well-designed research and development programs that allow for thoughtful design, evaluation, measurement and verification (EM&V) of these new models are an important part of the product development process. Likewise, as energy efficiency programs expand, new analytics enabled by EM&V approaches will be critical to help close the evaluation feedback loop and provide comprehensive measurement at increased speeds and reduced costs. "EM&V 2.0" approaches, such as savings measurement software, can empower utilities to conduct comprehensive automated EM&V for energy efficiency programs.

Utilities could use data analytics to generate additional revenue to reduce the overall revenue requirement, and thereby rates, for all customers.

Summary

While it is difficult to predict what innovations will be brought to market in the coming years, one can imagine that many of them will address the evolving customer needs related to managing energy costs, comfort and convenience. Others will address the utilities' need to integrate large amount of DER in a safe and reliable manner, reduce costs, and meet customer expectations. In addition new products and services will bring greater diversity to the electricity system and be vital to the advancement of broader policy goals. Regardless of what new innovations may occur, it is clear that the following three things are needed to accommodate the innovation:

1. Changes to the existing regulatory framework that enable the development of these new products and services and clearly define the roles of utilities and third-party providers.
2. A new market structure that provides two-way market signals to modify and reward behavior.
3. Data exchange and circuit-level coordination of available grid and customer resources.

System Design and Technology

A New Paradigm and Operating Environment

Meeting California's energy and environmental policy goals requires an evolution in electricity system design incorporating advanced technology and analytics. The 21st century grid includes more holistic integration of DER with the grid and increasing third-party solutions that together help to maximize value to customers. The grid must be designed to accommodate rapid evolution in available technologies as well as emerging technologies. The grid architecture must consider the physical assets of the distribution grid including poles, wires, sensors, and customer devices as well as the communications, forecasting, control and other advanced algorithms that enable the collection of devices to work together. Utilities will need to increase investment in hardware and analytics as well as to develop tools that maximize the contribution of customer-side resources.[12] Regulators will need to facilitate this change by designing policies that support the necessary infrastructure investments, allow experimentation, and require the development of standards and open protocols to ensure interoperability and integration. In addition, utilities and regulators need to recognize that certain types of grid equipment and infrastructure can no longer be expected to be amortized over 20-30 years due to the shorter technology lifecycle.

Customer actions have fueled a large part of DER growth. Driven by utility programs, state incentives, and third-party providers, customers are increasingly becoming electricity producers through the adoption of rooftop solar, small-scale wind power, fuel cells and other forms of distributed generation. Customers are installing devices to improve energy efficiency and provide demand management capabilities to reduce their electric bill. Purchases of electric vehicles are increasing demand for electricity while reducing consumer transportation fuel costs and contributing to a cleaner environment.

Together this suite of new DER interactions at the "grid edge" creates a much more complex operating environment for the distribution grid including two-way power flow, power production controlled by the customer in addition to the utility, and unexpected variations in power quality. These conditions drive the need for greater visibility, digital intelligence and control as well as the ability to measure and manage power flow and power quality. Ideally, the very DER that is changing the grid environment can be utilized to optimize the grid. In essence, DER resources can serve the dual purpose of providing greater customer choices and control, and grid power quality and reliability benefiting both customers and utilities, provided that the necessary enabling technologies and adaptive regulatory frameworks are implemented. This environment is already being recognized on specific circuits and areas within California. Utilities and grid operators are in the process of adapting to it, with investments in grid modernization and modifications to traditional distribution planning processes.

Evolution of Distribution Planning and Operations

Given these trends occurring at the grid edge, the distribution system and its supporting planning and operations processes must accommodate the needs of a changing operational paradigm. Distribution system planners and operators will need new tools and capabilities to meet their changing responsibilities that will become the "new normal" of what the regulated utility will need to provide.

System planners are responsible for evaluating the future needs of the grid to meet reliability requirements, customer needs, and state energy and environmental objectives. System planners must be able to improve their tools, data, and methodologies to improve the accuracy of future system demand forecasts and proactively

12. For example, see the work of the More Than Smart initiative: http://morethansmart.org/programs/more-than-smart/.

recommend and initiate actions to meet projected needs. As customer-sited DER penetration levels increase, the complexity of grid planning also increases. Planners must have a comprehensive understanding of grid asset capabilities as well as those of interconnected DER resources, and the extent to which those DER resources can reliably meet system needs, in order to predict system performance.

The fundamental responsibility of distribution grid operations is to ensure that system parameters, such as voltage and equipment limitations, are maintained under all conditions to ensure safety and reliability and to quickly recognize outages and dispatch crews to restore service when needed. Operators utilize grid management systems to continuously monitor and control essential grid functions under both normal and emergency conditions. In real time, operators must understand the state of the grid and actively respond to changing conditions by making changes to system devices or system configurations to ensure continued system operation. As customer-sited DER penetration levels increase, the complexity of system operation also increases. Grid operators must take into account their impact on grid voltage, protection and other coordination schemes and the impact of DER assets on one another.

Enabling Technologies and Capabilities

In the future, infrastructure investments will have to balance maintaining traditional infrastructure components like poles and wires with expanded investments in new technologies like intelligent devices and IT platforms. The following describes key enabling technologies and capabilities for planning and operating the 21st century electric grid.

Real-Time Granular System Monitoring and Visualization

Increased situational awareness of system performance is imperative to enable effective planning and operation of the grid, in order to maintain situational awareness, as well as the safety and reliability of the grid. The data is required both from grid assets as well as from the customer side of the meter. Data latency requirements change depending on whether the data will be used for planning or operational purposes. Regardless, the sources of data available today are insufficient to meet the needs of the 21st Century grid. More monitoring points along utility circuits are needed to collect more real- and near-real-time operational data to understand the state of the grid. For example, grid operators will need to understand among other things, the voltage along the length of a circuit, the direction of the power flow, customer loads, power quality, and the location of faults. Advanced feeder telemetry will need to be available from networked utility equipment such as switches, capacitor banks, fault detectors, and line and transformer sensors. Grid operators will also need more data from the customer side of the meter in order to understand the loads and operational state of DER assets. Smart inverters will need to monitor in near real-time the generation and power quality of DER and report it to grid operators. Data from other customer-side sensors such as digital energy management systems and devices will be required to populate planning and operational models.

More monitoring points along utility circuits are needed to collect more real- and near-real-time operational data to understand the state of the grid.

Robust Communications

Increased amounts of system-level data from utility distribution feeders and customers require the development of a robust communications network that meets bandwidth, latency, and availability requirements. Various technologies such as fiber optics, microwave, cellular and other wireless radio frequency communication systems can be combined to meet the need depending on the distance and quantity of data being transmitted. Utility communication networks will have to be expanded to reach more grid assets closer to the grid edge, customer smart inverters, and third party/ technology providers' data. This communications network will need to be resilient, secure, and standards-based. The electric grid will require a communications topology that will be used to monitor and control DER. Bi-directional communications will allow DER to provide grid support autonomously or under the control of a distribution operator depending on the specific requirements necessary to maintain system equilibrium. Examples of communications technologies include wireless mesh networks, point-to-point cellular systems, high-density Wi-Fi networks and fiber backbone.

Advanced Software Applications

Once the data is collected and transmitted, it must be processed and analyzed to draw insights in order to translate the data into useful information and drive action. Grid management systems will need to be developed and deployed that can process large amounts of data and present it to operators in an easily consumable format. Operators must be able to utilize the information to make real-time decisions in response to system conditions. In order to do this effectively, operators must be able to quickly access and interpret system data as well as predict the results of potential actions.

Today's distribution management systems provide a means of control over distribution system devices, but they are limited in their ability to comprehensively understand DER system conditions. 21st century grid operators will require management systems that incorporate information on DER operational status and are able to perform state and load estimation and load flow analysis of the integrated grid, as well as to predict the behavior of the grid and DER under normal and abnormal operating conditions.

Similarly, system planners need software tools that can enhance forecasting capabilities and failure avoidance through data analytics. These tools also need to provide system planners with the ability to model changing system conditions and a variety of potential projects to achieve an optimal solution. In addition, system planning tools need to evaluate load profiles over the entire year on an hour-by-hour (and potentially a sub-hourly) basis to effectively evaluate the impacts and capabilities of distributed resources. This will ensure that reliability can be maintained during peak and off-peak conditions. Examples of advanced software applications include Outage Management Systems (OMS) and Geographic Information Systems (GIS).

Advanced Control Systems

In order to take advantage of improved grid monitoring and predictive capabilities and to increase the operational flexibility of the distribution grid to support a more dynamic demand/supply and services-oriented environment, advanced control capabilities are needed for grid assets and interconnected DER. With advanced power flow control, the distribution grid can more effectively manage and coordinate grid-side and customer-side resources on an increasingly granular time-scale and locational basis to continue delivering safe, reliable, and affordable electric service while enabling new value-added bi-directional services. In addition to enhanced protection and system automation, new methods of control and interaction with DER, for generation and advanced functionality management, and new methods of dynamic power flow and power quality control on the grid, for voltage and capacity management, are critically needed by the future distribution grid. These advanced controls will result in improved system reliability, optimized use of DER, including electric vehicles, microgrid enablement, and, ultimately, a more agile and market-oriented distribution system. For example, demand response and energy storage can be dispatched during peak load conditions in order to alleviate loading concerns. In addition, inverter-based DER can change power factor at the point of delivery to mitigate voltage issues.

Control schemes must allow for distributed devices to respond to local signals in order to achieve desired outputs under normal conditions. Under abnormal conditions, it will also be necessary for a centralized control scheme, through advanced modeling and data analytics, to adapt to these changing conditions accordingly by working in concert with distributed control systems to effectively maintain system reliability and performance. Examples of advanced control systems include Advanced Distribution Management Systems (ADMS) and Distributed Energy Resource Management Systems (DERMS).

Advanced Grid Infrastructure

In addition to greater situational awareness and more advanced control systems, advanced power electronics based grid-side devices that can dynamically control power quality and power flow will likely be needed. These utility-owned and operated devices can quickly and continuously respond to voltage and frequency fluctuations, load variations, bi-directional power flows, phase imbalances and other challenging system conditions. Using power electronics alone or in combination with energy storage, these devices have the opportunity to be more cost effective than conventional grid reinforcement techniques, enabling T&D deferral, and can increase the flexibility and capability of the utility distribution grid. These devices will ultimately help the grid continue to increase DER hosting capacity, and maintain or increase system capacity, efficiency and reliability.[13] Examples of advanced grid infrastructure include solutions categorized as "distribution automation" such as remote fault identification and isolation.

Advanced power electronics based grid-side devices that can dynamically control power quality and power flow will likely be needed.

Advanced Forecasting Tools

Today wholesale market operation requires economic analysis to be done based on supply and demand on the electricity system. Market operators forecast short-term and long-term demand requirements and schedule central generation resources to meet forecasted needs. This activity requires an understanding of the capabilities of various resources as well as the underlying economics. However, today's wholesale market operators do not have DER information.

As the amount of variable renewable resources increases, market and grid operators must be able to forecast changing weather patterns in much more granular level to fully understand resource capabilities on the distribution grid. In addition, operators must be able to adequately forecast changing customer demand to ensure that available resources are able to sufficiently meet the need. To accomplish this, advanced forecasting tools need to be developed. These tools and the underlying information about the capability of DER assets will be orders of magnitude more complex than those used today for the wholesale market.

Creating a Secure System

Adequate cyber security and interoperability must also be implemented against a backdrop of rapidly changing technology, both in terms of DER and the intelligent systems deployed on the grid. None of the changes envisioned, and indeed required, to enable a 21st century electricity system, will be possible without adequate cyber security. This is required for reliable and safe operation, but also to provide consumers with the confidence they need to become more active participants in the system, as more of their energy use data

13. "The Integration of Distribution Level Generation & Storage into the Grid – Problems and Solutions" Policy Paper. R. Elliott, Energy Division, CPUC. August 2014.

is made available to the utility and third parties. As the number of interconnections increases, so does the complexity of providing this cyber security.

People & Processes

The implementation of new technologies within the electric utility and across the broader system is a complex undertaking that is ultimately reliant upon the skills and approach of individuals. The visibility and enhanced grid management capabilities we outline in this section represent a whole new set of business processes and operational approaches for the electric utilities, the CAISO and market participants. As data availability and the need to share data across utility operations and with participants continue to grow, the work environment will shift from a siloed structure to an interdependent one.

The people and process aspect of the evolution to a modern electricity system is often overlooked as the focus is placed upon the capital-intensive infrastructure investments that modernize the grid. However many industry practitioners have long identified business process and cultural change within organizations as the vital element of grid transformation. Well-developed change management plans and a skilled and engaged workforce not only can implement new technology but also optimize it to achieve the policy objectives and organizational goals.

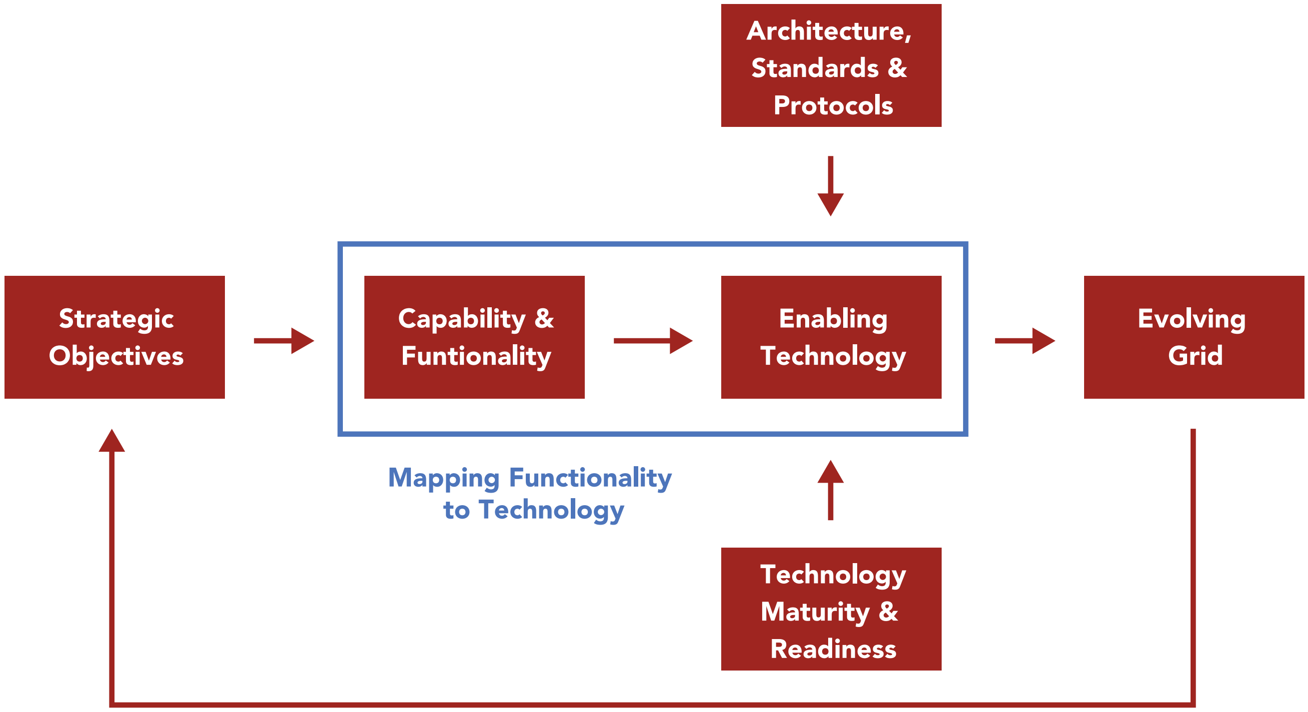
With the transformation of the electricity system and the underlying business models of utilities, there will be dramatic shifts in the day-to-day functions within organizations, and skill requirements will evolve accordingly. It will be critically important for policymakers and regulators to become familiar with these issues and begin to examine the role they can play to create the environment that fosters workforce development and cultural change. The vision for the California electricity system is one that will be dynamic and innovative, much like the heritage of Silicon Valley, and to achieve that vision a whole new skill set and approach will be paramount. As we discuss below in the Regulatory section of this paper, new approaches that foster innovation by providing flexibility and incentives based on outcomes can help create the kind of environment that will attract the 21st century utility workforce.

The vision for the California electricity system is one that will be dynamic and innovative, much like the heritage of Silicon Valley, and to achieve that vision a whole new skill set and approach will be paramount.

Summary – Creating a Flexible System

It is difficult to envision all the future technologies, products and services that will be developed or how policy will continue to evolve. The objective is to remain flexible while adapting to an evolving future state. Figure below provides a framework of how policy, grid functionality, technology, and the evolving grid platform interact over time. The technology that is deployed must support the desired capabilities and functionalities needed to achieve policy objectives.

Figure 3: Mapping Functionality to Technology to Create a Flexible Electricity System



Source: BRIDGE Energy Group

To create a flexible and scalable distributed grid, interoperability of devices is a prerequisite, including for those devices located on the utility side of the meter and on customer premises. Standards and protocols must be developed, and to the greatest extent possible national standards should be used, as this will help drive efficiency across the country as technology providers develop solutions for different markets.

To create a flexible and scalable distributed grid, interoperability of devices is a prerequisite, including for those devices located on the utility side of the meter and on customer premises.

Regulatory Framework, Incentives, and Revenue Mechanisms

Introduction

For more than a century, California's retail electric utilities have operated under the regulatory direction of either their local governing body (for publicly-owned utilities) or the CPUC (for investor-owned utilities) to provide power to all of the state's residents and businesses. Under the current traditional utility business model and "regulatory compact" with government regulators, electric utilities are legally obligated to provide safe, reliable and universal electric service to customers at affordable rates on a non-discriminatory basis. In return, regulators approve a revenue requirement for each utility that provides a reasonable rate of return based on the utility's capital investment in the system that benefits all users regardless of type. The compact was historically based upon a presumption that utilities would be assured of demand from within their designated territory and in return utilities, with an obligation to serve, would attract the private capital needed to underwrite the infrastructure investment required. As this paper outlines throughout, this historical business environment has begun to shift, with changing consumption profiles of customers and third-party solutions that are structurally altering the revenue profile of incumbent utilities.

California is already a leader in the development and deployment of technologies that enable individual consumers to adopt DER including photovoltaics (PV), energy storage, EE and DR for both economic and non-economic reasons. Climate change provides an added imperative to accelerate the deployment of these options in order to dramatically reduce greenhouse gas emissions. Governor Jerry Brown's recent Executive Order to reduce emissions in California by 40% below 1990 levels by 2030 signals the need for additional de-carbonization of California's power sector.[14] In keeping with this Executive Order, California's electricity system is already on a path to achieving these climate and decarbonization objectives. The challenge in California is how to transition to this lower carbon future in a manner that balances the other vital societal objectives of providing reliable, safe and affordable electricity to customers.

As detailed in the System Design and Technology section of this paper, a shift in investments in grid infrastructure will likely be needed to accommodate greater deployment of DER and the resulting two-way electricity flows, and ultimately to establish the grid as a "plug-and-play" technology- and innovation-enabling platform. Operation of the grid will need to become more dynamic through greater control of interconnected devices and/or greater use of market price signals. Even as these changes occur, the underlying costs to maintain the grid will remain.

The current regulatory construct will be challenged to keep pace with changes that support the principles of universal service and how to equitably cover and share the costs of essential grid services, while also supporting individual customer-level options and the achievement of state policy objectives. Regulators will need to address important questions, including:

- Will allowing a rate of return based solely on utility investment (rate base) provide adequate compensation to utilities for the services they provide?
    - If volumetric energy sales are declining due to energy efficiency and distributed generation, how do utilities continue to recover their revenue requirements?
    - How can utilities be incented to support and facilitate a more consumer-focused, distributed generation and low-carbon electricity future, including the deployment of new technologies and services that do not add to their rate base?
- What approach should be taken for utility legacy investments that may become stranded or underutilized?
- How can the regulatory framework be reformed to more clearly specify the boundaries between regulated and competitive services?
    - What are the appropriate future roles for regulated utilities and third-party providers?
- How can utilities be incented to invest in cost-effective technology options that could be provided by third parties, such as demand response, rather than traditional distribution system solutions?
- How can pricing signals be used to appropriately encourage and value third-party technology and service investments and incent desired customer responses?
- What steps can regulators take to help reduce barriers to innovation that utilities face, particularly related to innovative customer solutions, third-party strategic partnerships, and financing initiatives?

Fundamental to answering these questions is whether we need a comprehensive regulatory shift or more incremental reform of the traditional utility business model to realize the desired end state for the electric grid of the future and the roles of the utility and third-party providers. To support this kind of a conversation, we

14. http://gov.ca.gov/news.php?id=18938

present here a wide range of considerations regarding the regulatory framework, utility business models, rates, services, and system planning and operations. That some of this has been and is currently being considered in statute, regulations, or within ongoing CPUC proceedings is a testament to the degree to which California has already begun to address the underlying drivers of change. This includes the successor tariffs to net energy metering, reform of residential retail rates and the DRPs.[15] Despite these ongoing activities, it is worthwhile to step back and examine how all the pieces fit together and to consider if additional changes may be warranted, without being constrained by existing statutes or regulations.

Adjusting the Regulatory Framework

California policymakers have often established goals that are addressed in long regulatory proceedings. However, technology is changing rapidly, costs are falling, customers are seeking more choices and control, and utilities and third-party providers need to be able to address changing customer expectations quickly. Clearly, regulatory processes will need to keep up with the accelerating pace of technological innovation and with changing customer requirements. The regulatory process needs to be improved to become more nimble so that both customers and utilities can benefit from technological advancements sooner and differentiated programs and services can be offered and altered to meet changing needs and expectations.

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Addressing the timing for reviewing and approving new services to market is a specific example of how the regulatory framework can be improved. The speed of change of customer services is likely to outstrip the pace that the Commission would normally take to review, approve and deploy new services. Without abandoning the Commission's core responsibilities and mandate, there needs to be recognition that some of the rigor currently applied may be counter-productive to the deployment of new services. In fact, some of the services may be out of date within the timeframe that the CPUC reviews and approves the application. The CPUC could adopt more of an "incubator" mentality with someone within the CPUC that is tasked with advising on these projects and the development of a more streamlined process.[16]

Not every new idea is going to be a good one, but there has to be a willingness to try and to accept a certain amount of failure or less-than-stellar results. There should be a willingness to allow a certain margin of error for new and experimental methods in comparison with tried-and-true methods. Otherwise, approving new services may become a bottleneck. California is home to Silicon Valley, the global leader in technology and business model innovation – some of what has been developed there could be applied to electricity system regulation.

In addition to new technologies and services, it is critical that utilities have an opportunity to test tariffs in simplified proceedings. There should be the opportunity for rapid innovation and quick successes or failures – involving small numbers of customers, just like any pilot – after which the CPUC can consider larger-scale expansion. The tariff pilot process in California is currently too cumbersome such that the results are often out of date by the time the reports are published. Utilities should also be encouraged to engage in new, innovative and experimental services that are designed to meet a system or local need with third-party providers as well.

15. See the Appendix for additional information on these existing statutes, regulations and ongoing proceedings.
16. As an example of how this may work, the CPUC could direct utilities to either run RFPs or develop a market to procure/trade services that can meet anticipated system needs. These approaches would be technology-neutral, would not presuppose the solution(s), and therefore would be much less likely to become "out of date," since ongoing innovations could be incorporated as they are developed.

Modernizing Rates and Services

Customers are not homogenous. They have different electricity needs, different levels of interest in managing their electricity needs, and different willingness to pay for reliability and various electricity services. Utilities should have the opportunity to offer differentiated customer rates and services. In addition, regulators must continue to address equity and cross-subsidy concerns that come with establishing simplified rate structures for a large population of heterogeneous customers. Regulators and customers should be comfortable with and understand the underlying value and cost relationship that is reflected in electricity rates.[17] Regulators must also grapple with redesigning rates to achieve a more complex set of objectives than is currently the case. Many of these issues are already being addressed in whole or in part within various proceedings at the CPUC. This list, while not exhaustive, is designed to put in one place the range of issues that may be currently addressed in a more piecemeal fashion:

- Assess and understand customer preference on available rates, i.e., the preferred option by customer and customer class
- To the greatest extent possible, align customer revenues with the underlying cost of service, while maintaining equitable, universal service that is consistent with environmental policy goals
- Address drivers of cost of service, such as time- and location-based differences
- Incent innovation of demand-side management technologies and environmentally beneficial behavior
- Encourage value-added services, which could require different rate structures or could allow unregulated parties to provide services in a market that aligns with locational needs and benefits
- Allow for hourly pricing and variable pricing pilots without initiating new proceedings, for example via advice letters within a pre-approved budget
- Accommodate new and differentiated revenue opportunities for utilities due to the effects of flat to negative load growth
- Build a knowledgeable customer base that has the capability to make informed choices on available options
- Enable technologies and a framework to support the introduction of an hourly pricing option (i.e., real-time pricing)
- Provide access by third parties to real-time customer data to enable market innovation and encourage competition (while ensuring privacy and data security)

Distribution System Planning and Operations

Today's existing distribution grid planning and operations structure is based on what is largely a radial, unidirectional flow of power from the transmission grid to end-use customers. Planning and operating criteria are designed to reliably serve forecasted customer needs under peak conditions and to restore service quickly in the event that individual components of the distribution grid fail or are damaged. In the future, a significant quantity of power generation is expected to take place within the distribution grid, either "behind the meter" at customer locations, or locally "in front of the meter" with developers installing facilities to provide services to the grid operator, to customers or to wholesale markets. In addition, the development of energy storage and other technologies that "dispatch" individual appliances in a coordinated manner creates opportunities to improve the efficiency of the grid. These are profound changes that redefine the very nature of a customer into someone who could be both an end user and producer of electricity (and related services). As noted above, this

17. Customers should at least have a qualitative understanding of the value of the service they receive and how that relates to costs and rates.

is being addressed to a degree within existing CPUC proceedings, such as with the DRPs. Nevertheless, these changes may necessitate an ongoing evolution of the existing regulatory framework, distribution planning and operational models, beyond what is currently being considered.

Potential Future Models

There are several possible pathways, models and options that could be reviewed and evaluated for how they align with the Guiding Principles and End-State Vision outlined in this paper. We recognize that there is not a single "silver bullet," but rather the best outcome for California will be a solution that optimally balances the multiple priorities, principles and values articulated here. While we have not fully analyzed all the options and concluded that the existing regulatory framework and utility business model must be changed, the following presents and describes several possible regulatory models and revenue mechanisms that could be considered going forward, in addition to the current framework and mechanism. These models and revenue mechanisms are neither exhaustive nor mutually exclusive. We have separated them into three areas that would need to be combined in some way so as to fully describe the future regulatory framework and utility business model. These are:

1. Organizational models
2. Market operations/pricing models
3. Potential future revenue models

As noted above, the Working Group has put forward these options with the understanding that some have been or are being addressed, either in whole or in part, within existing statute and CPUC regulations and proceedings.

Organizational Models

Determining an appropriate organizational structure and the utility functions to support the new operational model is very important. This paper has examined the vital role California's utilities continue to play in distribution grid operations and how a more dynamic business environment is emerging that includes new roles for customers and third-party product and service providers. This new environment necessitates a transformation to a grid as an integrating platform. There are a number of possible structures to achieve transformation, two of which are described below. Both fall under the broad category of distribution system operator (DSO) models, which are meant to represent the evolving role of the grid and the utility as an integrating platform.

Distributed System Platform (DSP) Model

The "Distributed System Platform" (DSP) organizational model would retain all distribution grid operations within a single integrated distribution utility, with the DSP responsible for grid operations, animating a market environment, establishing the platform for DER integration, and performing an integrated planning process. In order for this model to work effectively, the regulatory framework and the utility incentives would need to be structured in such a way as to make the DSP indifferent to whether it pursued a traditional "wires" solution versus a distributed resources solution for meeting distribution grid reliability needs. The DSP, as the distribution grid asset owner, would need to invest in a sufficiently robust grid so as to accommodate the reasonable requirements of customers with behind-the-meter generation and developers seeking to interconnect within the distribution grid. Establishing organizational "firewalls," i.e., functional separation of the planning and the asset owner roles within the distribution utility, would be a necessary condition for the DSP model.

In its Reforming the Energy Vision (REV) proceeding,[18] the New York Public Service Commission (NY PSC) adopted a framework in which utilities will function as DSPs and are charged with developing and supporting DER as part of their traditional utility role. The NY PSC anticipates a significant change in the utilities' methods of grid operations to dynamically support a rapidly changing distribution system "topology."

Independent Distribution System Operator (IDSO) Model

A second potential model, the "Independent Distribution System Operator (IDSO)," would separate the distribution utility around two distinct functions:

- An asset owner for the distribution grid infrastructure
- The planner/operator of the distribution grid (the IDSO)[19]

This structure would be similar to how the California Independent System Operator is structured to plan and operate portions of the transmission grid. In this model, the IDSO would be responsible for performing an integrated planning process, animating a market environment, and establishing the platform for DER integration. Based on objective criteria, the IDSO would then choose between a "wires" solution and a distributed resources solution for meeting distribution grid reliability needs, and would then either direct the distribution grid asset owner to pursue a grid upgrade or would undertake some form of procurement or purchase of distributed resources. The IDSO would also direct the distribution grid asset owner to invest in a sufficiently robust grid so as to accommodate the reasonable requirements of customers with behind the meter generation and developers seeking to interconnect within the distribution grid.

To better understand how the IDSO and DSP models would differ, Table 2 provides a summary of the key functions and who would carry them out.

18. State of New York, Public Service Commission, Order Adopting Regulatory Policy Framework and Implementation Plan, Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision., February 26, 2015.
19. Perhaps the best-known proponent of the ISDO model is ex-FERC Chair Jon Wellinghoff. See: http://www.fortnightly.com/fortnightly/2014/08/rooftop-parity (subscription required)

Table 2: DSP vs. IDSO

Grid Functions			
Grid Function Categories	**Summary of Grid Function**	**Distributed System Platform Provider (DSP)**	**Independent Distribution System Operator (IDSO)**
Distribution Planning	**Planning:** Plan and design a safe and reliable distribution system in a manner that integrates DER as primary means of meeting system needs.	Distribution Utility	Independent Entity/ Distribution Utility (asset owner)[20]
Distribution Market Facilitation	**Products/Services:** Identify and define products/ services to be exchanged between participants (e.g., via locational benefits of DER).	Distribution Utility	Independent Entity
	Pricing: Develop pricing structures for products/ services (market-based, tariff-based, contractual).		
	Scheduling and Settlement: Integrate resources plans, coordinate energy schedules, and administer and verify settlements.		
Distribution System Management	**Power Systems Operations:** Direct the operation and coordination of power flows to satisfy system needs and imbalance variations, including supply and demand; operate system to ensure economical, reliable and stable delivery of electric power.	Distribution Utility	Independent Entity
	Physical Operation: Coordination and operation of equipment in the field, including unplanned outage response, emergency response, circuit reconfiguration, equipment setting adjustments, routine clearances, etc.	Distribution Utility	Distribution Utility (asset owner)
	Distribution Grid Asset Management: Managing asset life cycle of the distribution grid to meet the desired level of reliability at the lowest total cost of ownership possible, where the distribution grid provides an integrating platform for competitive market participants selling products and services to end customers.	Distribution Utility	Distribution Utility (asset owner)

20. It is likely that the distribution asset owner will need to play some role in planning, even if the effort is led by the IDSO.

Market Operations/Pricing Models

As the State of California focuses on achieving its long-term GHG reduction goals, the metrics used to assess performance could be adjusted to reflect the state's aims. For example, the performance of utility energy efficiency offerings today are measured on the incremental energy savings each measure achieves; in the future, regulators could consider assessing performance on the effect energy efficiency and other energy savings and management measures have on grid reliability, cost savings, changes in energy use per customer, and the greenhouse gas emissions avoided by their implementation, including as is envisioned in the U.S. Environmental Protection Agency's Clean Power Plan.[21] More broadly, the Commission could consider setting performance targets for utilities and then establishing a regulatory framework that incents utilities and third parties to achieve the goals through a portfolio of measures.

Within the basic business structure, the following models describe ways in which distribution utilities could organize the dynamic operation of the grid.

Regional Grid Optimization (RGO) Model

In the "Regional Grid Optimization" (RGO) model, the distribution utility would optimize the flow of power within the distribution system to enhance the value of DER for customers and developers and to lessen the cost of maintaining the system. The distribution utility would explicitly encourage the siting of DER as part of its planning process, and it would procure grid services from customers and developers to "operate" the distribution system efficiently. An important element of this model would be to explicitly allow hourly wholesale market prices to be conveyed to customers via regulated utility tariffs, so that customers and third-party developers are able to fully monetize the cost and value of their electricity consumption and production without intruding on the CAISO's price setting authority.

Distribution Marginal Pricing (DMP) Model

Another potential operational model would have the distribution utility develop and make available prices at numerous points (nodes) within the distribution grid, such as at segments within a distribution circuit (also called a distribution feeder). In this "Distribution Marginal Pricing" (DMP) model, these distribution prices would capture both the wholesale market price at the distribution node and any price variations within the distribution grid due to congestion and losses. The resulting price signals would provide incentives to customers and developers for where it is financially attractive to locate generation (or storage or other DER) and for how to operate dispatchable resources. Wires investments would still be undertaken by the distribution utility, but only when distribution prices are not sufficient to attract DER or when it would be necessary to expand service into new areas. Compared to the RGO model, the DMP model would rely more on pricing, as opposed to utility planning and procurement of services, to meet system needs.[22]

Potential Future Revenue Models

To address the revenue challenge, utility incentives should be adjusted to provide financial compensation to utilities for managing both utility-owned investments and third-party contracts for services that contribute towards delivery of safe, reliable, affordable and clean electricity to ratepayers. At the same time, as new market entrants are able to provide energy services directly to utility customers and the grid, utilities will need to adjust their cost structures to account for services they may no longer provide.

21. See http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

22. . The DMP model was identified for the "jog" phase by the More than Smart Working Group http://morethansmart.org/programs/more-than-smart/

Under the current regulatory model, utility shareholders are generally compensated for owning infrastructure, but not for buying third-party solutions that deliver infrastructure as a service. This restricts the ability of DER resources to provide grid services and to be adequately compensated and thus severely limits the market for third-party grid services at the distribution level, leading to less than the full potential of DER being realized by the grid. This problem will persist as long as utility shareholder returns are based exclusively on utility-owned capital investments, which creates a structural barrier to utilities embracing competitive distribution marketplaces where they are not the sole provider of grid infrastructure. While the cost-of-service regulatory model envisions that utilities will act in the best interest of their customers since their assets are dedicated to public service, the seeming misalignment of incentives raises concerns about utility willingness to pursue cost-effective third-party solutions.

Utility shareholders are generally compensated for owning infrastructure, but not for buying third-party solutions that deliver infrastructure as a service. This restricts the ability of DER resources to provide grid services and to be adequately compensated.

Moreover, as third-party assets supplant utility investment, opportunities for new traditional utility income is eroded just as the need grows for strong performance in facilitating the overall management of an increasingly complex system, which requires a strong, performance-oriented organization.

To address these challenges, utility incentives should be adjusted to equally incent utility-owned investments and third-party contracts for services that contribute towards delivery of safe, reliable, affordable and clean electricity to ratepayers. Below are some options for new utility incentive approaches.

Utility Income Based on Total Expenditure (TOTEX) Accounting Mechanism

One potential approach is to expand the scope of current accounting methodologies to calculate the utility's regulated asset value (RAV), upon which shareholders earn regulated returns. This general framework has been called total expenditure accounting (TOTEX) in the United Kingdom, where it is currently applied to the country's 14 electric and gas distribution companies to steer £30 billion in forecasted investment over the next decade.[23] Under the TOTEX approach, utilities would be eligible to earn shareholder income on both the traditional invested capital as well as operational expenditures (OpEx) that are categorized as "slow," which would include long-term contracts with third-parties for grid services. Many traditional operating expenses, such as employee salaries, would continue to be passed through to ratepayers as "fast" recovery of operating expenses.

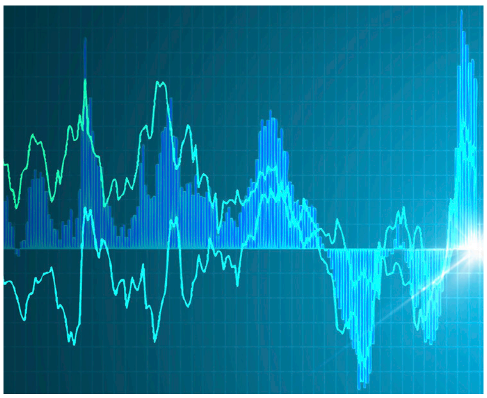
Under a TOTEX approach, the incentive to invest in infrastructure would be the same as the incentive to contract for services, since regulated returns would be determined based on a combination of capital expenditures (including utility-owned assets) and some operational expenditures (including third-party contracts), rather than only capital expenditures under the current model. Although on its own TOTEX may not fully equalize the "build vs. buy" decision, it could help set the foundation for grid-interactive DER and enable competitive markets for grid services.

23. For example, see Strategy decision for the RIIO-ED1 electricity distribution price control; financial issues, March 4, 2013. Available at https://www.ofgem.gov.uk/ofgem-publications/47071/riioed1decfinancialissues.pdf

Utility Income for Assets Under Management Mechanism

An approach somewhat related to the TOTEX approach would be to determine the long-term cost commitment associated with contracts that the utilities enter into with third parties for grid services and make such costs eligible for a rate of return. Under this approach, utilities would be compensated based on the assets that are controlled by the utility as a result of establishing long-term contracts with third parties. Similar to a TOTEX approach, the incentive to invest in infrastructure would be the same as the incentive to contract for services. In addition, this approach would explicitly address an ongoing financial problem faced by utilities due to the imputed "debt equivalence" of these long-term contractual obligations by rating agencies.

Performance Incentives for Capital Utilization



A very different approach would be to retain existing revenue requirement ratemaking, perhaps modified as described above, and apply performance-based compensation tied to the effectiveness with which utilities manage the capital investments they own or that they control through third-party service agreements. This approach would develop an index of capital utilization that measures the utility's overall performance at delivering distribution services relative to the capital investments and expenditures made to provide those services. In addition to traditional reliability metrics (e.g., SAIDI and SAIFI)[24], the capital utilization index would incorporate both financial and service-based components.

Summary

The CPUC has already embarked on several parallel paths, via individual proceedings, to address a range of issues emerging from the changes taking place in the electricity sector. For example, in August 2014, the CPUC instituted a rulemaking that requires the utilities to file Distribution Resources Plans (DRPs).[25] Related efforts are already underway. For example, Southern California Edison (SCE) has initiated a "Preferred Resources Pilot" to measure the impact on the grid of "preferred resources" as alternatives to building new gas-fired plants.[26]

This has set the State of California on the path to achieving important state policy objectives and has also set the stage for the industry to evolve to a new structure. As the changes become more profound, it will become necessary to consider more fundamental changes along the lines of what has been discussed here, in particular on restructuring/aligning incentives to achieve the desired outcomes while maintaining the long-term viability of the utility. This should be done via an open and transparent process to consider all the options available, including:

- Identification of the regulatory issues that currently impede – or could enable – evolution from existing business models to new ones.

- An assessment of what is most appropriate for the regulated market versus the competitive market, and how the two would interact as the market evolves.

24. SAIDI and SAIFI are common measures of reliability. See the List of Acronyms for more details.
25. Order Instituting Rulemaking Regarding Policies, Procedures and Rules for Development of Distribution Resources Plans Pursuant to Public Utilities Code Section 769, Rulemaking 14-08-013, February 6, 2015.
26. https://www.sce.com/wps/portal/home/about-us/reliability/meeting-demand/our-preferred-resources-pilot

- A focus on regulatory process, in particular an assessment of how to best integrate/coordinate the various regulatory proceedings that are each addressing some aspects of the evolving industry structure into a comprehensive framework. This could help reduce the effort and time required to run all these proceedings and also lead to better results by considering issues more holistically.

Lastly, although not discussed at length here, any consideration of new regulatory frameworks and business models will need to examine the role of rate design. A transition to a grid that serves more as a platform may shift the emphasis towards interconnection and integration instead of sales or delivery of electrons, which suggests that the long-run financial integrity of the grid as a platform will be dependent upon rate design that reflects this changing role.[27]

27. For example, In July 2014, the CPUC adopted Rulemaking (R.) 14-07-002 to develop a successor to existing net metering tariffs, pursuant to Public Utilities Code Section 2827.1.

CONCLUSIONS

California has been, and continues to be, a national and global leader in advancing energy efficiency, renewable resource development, greenhouse gas reduction, grid modernization, and new technology adoption. The continued deployment of low-carbon distributed energy resources, technological and financing innovation and rapidly changing customer needs and expectations support the need for a 21st century electricity system, and by starting with these ten recommendations, the State can continue to blaze a trail forward. Even as the state is set to achieve its 2020 goals, even more aggressive policy goals are being set for 2030 and beyond. These policies are changing not only the way that energy is delivered to customers, but also the way customers make decisions to consume or generate electricity with the attendant impacts on the grid. Electrification of transport using electric vehicles extends the implications of the changes taking place on the grid into the transportation sector that has traditionally been dominated by petroleum-based fuels.

A key enabler to achieving 21st century electricity system goals for the State of California is a set of policies that spur technological and market innovation along with a modern regulatory framework that recognizes the potential for new business models (at a company and industry level) to better align the incentives and opportunities for all actors to more effectively contribute to the achievement of these goals. At the same time, utilities will need to maintain safety, reliability, universal access and reasonable cost of service.

The transition to a more agile and flexible platform that supports high levels of DER, bi-directional services and differentiated customer options will impact all areas of the electricity system. Such a 21st century electricity system must accommodate a higher rate of technological change and incorporate that technology into existing, legacy systems. New market entrants have the potential to address new customer needs and develop products and services that also support the role of the utility. Utilities should be encouraged to participate in research and innovation and to partner with new market entrants.

Underlying the technical capabilities of the 21st Century electricity system are business process and workforce changes needed to ensure integrated planning and operations across generation, transmission and distribution. This will require a well-defined process and workforce strategy that accommodates shifts in resource availability/planning, transformation of existing roles and creation of new system planning and operational roles, as well as field workforce transformation.

To summarize, the Working Group offers these 10 key recommendations to help the State of California achieve a 21st Century Electricity System:

1. Develop a comprehensive framework that integrates/coordinates the existing regulatory proceedings
2. Restructure/align/create new incentives to achieve the desired outcomes while maintaining the long-term viability of the utility and recognizing the value of the grid
3. Develop new market structures that enable two-way market signals to allow customer participation
4. Encourage data exchange and circuit-level coordination of available grid and customer resources
5. Utilize standards and protocols, ideally drawing from National standards, to ensure interoperability of devices located on the utility side of the meter and on customer premises

6. Assess what is appropriate for the regulated vs. competitive market and how the two would interact as the market evolves
7. Encourage training of the workforce that will develop the skills needed for the *21st Century Electricity System*
8. Accelerate the pace of regulatory review and allow utilities to take reasonable risks to encourage innovation and entrepreneurship and accelerate commercialization of new products and services
9. Examine the role of rate design in helping to achieve the long-run financial integrity of the grid as a platform
10. Examine the functionality and enabling technologies that will be integral to the distribution grid of the 21st century

APPENDIX: SUMMARY OF KEY CALIFORNIA CLEAN ENERGY POLICIES AND REGULATIONS

The State of California has been pursuing clean energy development and deployment along multiple parallel paths, with the key elements listed below. This section is not meant to provide a complete accounting of all of California's energy and environmental policies, regulations, either existing or proposed.

Existing Clean Energy Policies

- Greenhouse gas (GHG) reduction targets (AB 32) requiring emissions in 2020 to be reduced to 1990 levels. Covered industries include energy producers, large industrial facilities, transportation fuels, and entities operating in California that emit GHG emissions over a specified level.
- A Renewable Portfolio Standard (RPS), requiring IOUs, municipal utilities, direct access providers and community choice aggregators to procure 33% of electricity from renewable sources by 2020, with interim targets. The majority of renewable energy will come from inside California or sources that are directly connected to a California Independent System Operator (CAISO) controlled transmission line.
- Originally established by AB 2012, and finalized in CPUC Decision 08-07-047 (July 31, 2008), California has an energy efficiency portfolio standard that sets energy and demand reduction targets through 2020.

Regulations and Regulatory Proceedings

- Energy efficiency rules at the California Energy Commission (CEC), with a continued focus on improving the efficiency of appliances and new and existing housing stock through new standards and grants/loans.
- The California Solar Initiative, a 10-year program of declining incentives with the goal of transforming the market for customer-sited solar power systems.
- The Loading Order that establishes a preference for procuring energy efficiency, demand response and renewable resources before conventional resources are considered.[28]
- The Demand Response Rulemaking (R.13-09-011) that bifurcates DR resources into load modifying (retail) and supply-side (wholesale) resources, and seeks to identify and remove barriers to wholesale market participation, identify future potential of DR and identify proper valuation of the resources.
- The Energy Storage Target – per the CPUC implementation of AB 2514, 1,325 MW of storage will be required to be in operation by 2024. CPUC Decision 13-10-040, issued in October 2013, set a timeline and standards for procurement for both large-scale and distributed energy storage.
- Transportation Electrification – As a result of Governor Brown's executive order to have 1.5 million zero-emission vehicles on the road by 2025 and in response to CPUC Decision 14-12-07, which permits IOUs to own electric vehicle charging infrastructure, the three major IOUs have submitted their initial proposals for that build-out.

28. The "loading order" is identified in The Energy Action Plan and codified in PU Code Section 454.5 (b)(9)(C).

- Other CPUC proceedings on net metering (14-07-002), smart grid deployment (08-12-009), demand response and advanced metering infrastructure (11-09-011) and residential rates (12-06-013), cover many other aspects of implementation to achieve state policy objectives.
- The Integrated Demand-Side Management Program
- More recently, CPUC proceeding 14-08-013 (enabled by AB 327) requires the state's IOUs to develop "Distribution Resource Plans" (DRPs) to be filed by July 2015, which are designed to:
    - Modernize the electricity distribution system to accommodate two-way flows of energy and energy services throughout the IOUs' networks;
    - Enable customer choice of new technologies and services that reduce emissions and improve reliability in a cost-efficient manner; and
    - Animate opportunities for DER to realize benefits through the provision of grid services.

Emerging Policies and Proposed Legislation

- Executive Order B-30-15, setting a target to reduce GHG emissions to 40% below 1990 levels by 2030.
- SB 32 (Pavley) to extend the current AB 32 requirements to 2030, with increased GHG-reduction targets and set the goal of 80% reduction below 1990 levels by 2050
- SB 350 (De León) – the so-called 50/50/50 legislation – that would create a 50% RPS, mandate a 50% increase in already scheduled improvements in building efficiency by the CEC and reduce petroleum use in transportation by 50%, all by 2030.
- AB 793 (Quirk) - incentives to encourage customer adoption of energy management technologies.
- AB 1330 (Bloom) - adopt an EE and DR procurement standard.

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