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Energy Policy Case Study – California: Renewables and Distributed Energy Resources

September 2016

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Prepared for
the U.S. Department of Energy
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Executive Summary

The purpose of this document is to present a case study of energy policies in California related to power system transformation and renewable and distributed energy resources (DERs). Distributed energy resources represent a broad range of technologies that can significantly impact how much, and when, electricity is demanded from the grid. In this report, DERs include distributed generation and storage technologies that are more modular than traditional power plants and that reside on a utility's primary distribution system or on the premises of an end-use consumer. DERs also include demand response and other enabling technologies that allow grid operators and consumers to better manage individual and system demand.

California has more installed DER capacity than any other state. High levels of DERs are supported by policies that promote their deployment and integration. The main drivers behind the DER-led power system transformation are environmental and climate goals, as reflected in key legislative actions discussed in this paper. Many of the policies that have resulted in changes to the electricity resource mix and utility operations in California originated at the legislative and executive levels of state government and then implemented in regulatory spheres. Relatively high electricity rates in California compared to other states are also contributing to high levels of DERs in the state, as are climate concerns stemming from drought and heat waves and reverberations of the California energy crisis of 2000–2001. This paper outlines a number of initiatives that are the driving force behind grid transformation in California. Distribution Resource Planning requirements are critical in supporting grid integration of increasing levels of distributed resources.

Key policies and proceedings related to power system transformation and DERs are grouped into the following categories:

1. Policies that support **achieving environmental and climate goals**
2. Policies that **promote deployment of DERs**
3. Policies that support **reliability and integration of DERs**
4. Policies that promote **market animation** and support **customer choice**.

Major challenges going forward are forecasting and modeling DERs, regulatory and utility business model issues, reliability, valuation and pricing, and data management and sharing.

Acronyms and Abbreviations

| | |
|-----------------|--|
| AB | Assembly Bill |
| AMI | Advanced Metering Infrastructure |
| CAISO | California Independent System Operator |
| CCA | community choice aggregation |
| CEC | California Energy Commission |
| CO ₂ | carbon dioxide |
| CPUC | California Public Utilities Commission |
| DER | distributed energy resource |
| DERP | distributed energy resource provider |
| DR | demand response |
| DRAM | Demand Response Auction Mechanism |
| DRP | distribution resource plan |
| EIA | U.S. Energy Information Administration |
| EIM | energy imbalance market |
| GHG | greenhouse gas |
| GWh | gigawatt hour(s) |
| IDSR | Integrated Demand-Side Resources |
| IOU | investor-owned utility |
| ISO | independent system operator |
| kW | kilowatt(s) |
| kWh | kilowatt-hour(s) |
| MW | megawatt(s) |
| MWh | megawatt-hour(s) |
| NEM | net energy metering |
| PG&E | Pacific Gas & Electric |
| PUC | Public Utilities Commission |
| R. | Rulemaking |
| ReMAT | Renewable Market Adjusting Tariff |
| RPS | Renewable Portfolio Standard |
| SB | Senate Bill |
| SCE | Southern California Edison |
| SDG&E | San Diego Gas & Electric |
| SGIP | Self-Generation Incentive Program |
| TOU | time of use |
| ZEV | zero-emission vehicle |

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1.0 California Energy Context

California is the third-largest state in the United States in area, behind Alaska and Texas, and is the most populated state in the United States with over 39 million people.¹ California is the world's eighth largest economy (CEC 2016a).

California is served by six investor-owned utilities (IOUs), 22 electric service providers, 46 publicly owned utilities, four rural electric cooperatives, and three community choice aggregators (CEC 2016a). California utilities produce 68% of the electricity used in the state, with the other 32% coming from outside the state.

In 2015, California's power mix included 44% natural gas, 21.9% renewables, 13.5% unspecified sources of power, 9.2% nuclear, 6% coal, and 5.4% large hydro (CEC 2016b). Of the total renewables, 37% is wind, 20% is geothermal, 27% is solar, 12% is biomass, and 4% is small hydro (CEC 2016b).

California's electricity use per capita is well below the national average, with California households using 31% less energy than the U.S. average (EIA 2009). In 2013, California's per capita energy consumption ranked 48th in the nation.

According to the U.S. Energy Information Administration (EIA), the average retail residential electric rate in California as of April 2016 was 12.4¢/kWh with 12.67¢/kWh being the overall rate for all sectors (residential, commercial, industrial, and transportation) (EIA 2016b). The national average retail residential price of electricity was 12.4¢/kWh and 9.81¢/kWh for all sectors as of April 2016.

1.1 Penetration of Distributed Energy Resources

California has the highest installed capacity of distributed energy resources (DERs) of any state in the United States. As of December 2014, California had 3154 MW of DERs installed.³ In terms of installed DER capacity per capita, California has the 11th highest DER penetration per capita in the United States, with 8 kW per 100 persons. Maine and Hawaii have the highest per capita installed DER capacity, with 38 and 37 kW per 100 persons, respectively (EIA 2014). This high level of DER penetration in California both results from state policies that support distributed energy resources and drives new policies that address results of high levels of DER penetration.

1.2 Penetration of Advanced Metering Infrastructure

Advanced metering infrastructure (AMI) supports enhanced outage detection, remote electric meter reading, time of use rates and a more detailed understanding of customer usage patterns which allows for targeted energy efficiency and demand response programs (Wood 2006; EPRI 2007). AMI is a key part of an intelligent and responsive power system.

¹ Estimates are based on the 2010 Census and reflect changes to the April 1, 2010, population due to the Count Question Resolution program and geographic program revisions. All geographic boundaries for the 2015 population estimates series except statistical area delineations are as of Jan. 1, 2015. For population estimates methodology statements, see <http://www.census.gov/popest/methodology/index.html>.

³ In this calculation, DERs are defined as solar, wind, geothermal, hydro, biomass, and energy storage systems less than 1 MW in size. No demand response is included in this calculation. Data are from the EIA 2014 Form 860 database, EIA Form 861, and EIA Form 826.

Table 1 shows the number of AMI meters installed in 2014 compared to the total meters installed (EIA 2014a, 2014b, 2014c). In California, 82% of all residential meters are AMI meters, whereas only 64% of transportation meters use AMI technology. TOU, CPP, and RTP programs enabled by AMI can help manage peak demand on the distribution and transmission system.

Table 1. Penetration of AMI Meters in California in 2014 (EIA 2014a)

| | Residential | Commercial | Industrial | Total |
|--------------|--------------------|-------------------|-------------------|--------------|
| AMI Meters | 10,948,200 | 1,395,892 | 50,496 | 12,394,671 |
| Total Meters | 13,282,816 | 1,748,695 | 78,573 | 15,110,302 |
| % AMI Meters | 82% | 80% | 64% | 82% |

1.3 Regulatory Oversight

California’s three large IOUs—Pacific Gas & Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE)—are regulated by the California Public Utilities Commission (CPUC). The CPUC sets electricity and natural gas retail rates, ensures IOUs meet the state’s renewable energy goals, approves long-term contracts with independent generators, promotes energy efficiency and DR through the IOU energy efficiency portfolio, ensures electric, natural gas, and propane gas system safety, and participates in transmission line planning (Weisenmiller 2013).

The California Energy Commission (CEC) has eight basic responsibilities, including forecasting future energy needs, permitting thermal plants larger than 50 MW, administering the Public Interest Energy Research program, setting the state’s appliance and building standards, supporting development of renewable energy through incentives authorized by the Public Goods Charge, planning for and directing the state’s response to emergencies, supporting the deployment of alternative and renewable fuel resources, and creation of the Integrated Energy Policy Report (Weisenmiller 2013).

The California Independent System Operator (CAISO) manages the flow of electricity across the high-voltage, long-distance power lines that make up 80% of California’s power grid (CAISO 2016c). CAISO facilitates the wholesale power market by forecasting demand and dispatching the lowest cost power plant to meet demand while ensuring enough transmission capacity is available to deliver the power (CAISO 2016c).

2.0 Key Historical Energy Events

Multiple factors led to the current energy and policy construct in California that focuses heavily on distribution side generation and demand management.

In the early 1990s, the economy was in a recession, California energy prices were 30–50% above the national average, and the trucking and telecommunications industries were seeming to benefit from deregulation with less reliance on regulation and more reliance on markets. It was in this context that California began considering electricity restructuring (Blumstein et al. 2002). In August 1996, the restructuring bill known as Assembly Bill (AB) 1890 passed the state legislature and was signed by the Governor. New wholesale power markets and customer choice programs began operating in April 1998.

As part of restructuring, the California Power Exchange and CAISO were formed. The California Power Exchange ran a commodity market for electricity, buying and selling power, and CAISO was responsible

for congestion management, providing ancillary services and real-time balancing (Blumstein et al. 2002). IOUs were strongly encouraged to divest half of their thermal units. Retail customers were allowed to switch from their existing utility to alternative retail providers.

The market and programs worked well for about a year and a half (EIA 2016b). However, beginning in the summer of 2000, California experienced serious energy supply problems, sharp increases in wholesale (and retail) electricity and natural gas prices, and isolated blackouts (Lutzenhiser et al. 2004). A shortage of supply due to market manipulation and other factors led to blackouts and an 800% increase in wholesale energy prices (Lutzenhiser et al. 2004). The California Legislature suspended electric choice in 2001. The level of deregulation retail choice in California is now limited. Few people have the opportunity of choosing a deregulated electricity option under the current rules enforced by the CPUC. However, California residential and commercial customers are still able to choose to get their gas supply from a utility or third-party supplier.

In January 2004, the CPUC issued a press release related to Rulemaking R.01-10-024 (CPUC 2002) that said,

Today the Commission took a huge step in assuring that California's consumers and businesses will not suffer another energy shortage. Through the framework we have adopted, we will promote environmentally sensitive resource choices (such as energy efficiency, demand response, and renewables)...and adopt a process to provide the public and all interested parties more open access to the Commission's decision-making on long-term power procurement (CPUC 2004).

The action in R.01-10-024 offered a variety of strategies including requirements for long-term resource adequacy plans, a loading order that favored energy efficiency, DR, and renewables above conventional supply and generation, and incentives for customer-owned and distributed generation. The seeds sown in R.01-10-024 following the California energy crisis continue to grow in current dockets and proceedings, including the Self-Generation Incentive Program (SGIP), which pays customers incentives for producing renewable energy. This program has been a major impetus for DER in the state.

Recent droughts and heat waves in California have also contributed to a policy environment focused on achieving climate and environmental goals.

3.0 Policy Environment

This section presents key policies in California that support and/or respond to power system transformation and increased deployment of DERs. It includes a table of the types of policies that support power system transformation and DERs and indicates which are present in California. Specific policies are then described, grouped in four key policy areas.

3.1 Policy Checklists

One purpose of this report is to provide a common basis for comparing energy policies between states. Table 2 summarizes key policies, programs, and requirements being implemented in states throughout the country that support and/or respond to power system transformation. Table 2 indicates whether or not these policies and programs are in place in California. Details for the important, key items are described below the table.

Table 2. Policy Checklist for California

| Policy | Comment/Description |
|--|---|
| Renewable Portfolio Standard (RPS) | Yes. Increased in October 2015 to 50% renewables by 2030. |
| Integrated Resource Plan (IRP) or Procurement Plan requirements | Yes. CPUC requires Procurement Plans be filed and coordinated with CEC and CAISO. |
| Distribution Resource Plan (DRP) | Yes. Required as of Oct 2013, Law AB 327 (PU Code 769). |
| Energy Efficiency Resource Standard | Yes. Enacted through AB 2021 in 2006. |
| Retail Deregulation | Suspended. Only gas and large-scale electric deregulation. |
| Wholesale Deregulation | Suspended. Only gas and large-scale electric deregulation. |
| Requirements for filing Smart Grid Plans | No. IOUs are required to submit DRPs, which are similar. |
| Net Metering | Yes. Updated net metering rules finalized 1/2016. |
| State climate goals or mandates | Yes. Reduce GHG emissions to 80% below 1990 levels by 2050. |
| Distributed generation goals or local generation goals | Yes. 75% of RPS must come from resources in California and/or in states connected to California. |
| State loading order | Yes. Established in State of California Energy Action Plan (CEC 2016c). |
| Cap and trade | Yes. Launched in 2013 in response to AB 32. |
| Public Purpose/Benefits Charge | Yes. Instituted in 1996; \$0.00263 per kWh. |
| State DER incentives (tax credits, grants, loans, loan guarantees, rebates, financing) | Yes. Multiple, including SGIP. |
| Time-varying pricing | Yes. Required for residential and commercial; default TOU pricing being developed. |
| Incentive based DR programs – mass market DR programs | Yes. Offered by utilities. California also has a Demand Response Auction Mechanism (DRAM). |
| Allows for Community Choice Aggregation? | Yes. Enabled through AB 117 in 2002. |
| Feed-in tariffs | Yes. Renewable Market Adjusting Tariff (ReMAT). |
| Community solar programs | Yes. IOU community solar program through Green Tariff Shared Renewables Program—current cap 600 MW. |
| Carbon limits on generating resources | Yes. Senate Bill (SB) 1368 – Emission Performance Standards. |
| Microgrid incentives | No. |
| Energy Storage Mandates | Yes. AB 2514 – CPUC target of 1,350 MW energy storage. |
| Voluntary renewable energy programs (renewable energy credits based) | Yes. Varies by utility. |
| Voluntary green tariffs for industrial customers | Yes. SB 793, approved Nov 8, 2015. |

Table 3 provides a summary of proceedings related to distribution system operators, market animation, customer choice, and other important ongoing issues associated with regulation and the utility business model.

Table 3. Key Policy Initiatives and Proceedings Related to the Utility Business Model

| Explicit Statewide Initiatives or Proceedings Addressing: | Comment/Description |
|--|--|
| Distribution system operator or distribution markets? | Yes. In July 2015, CAISO approved a proposal whereby distributed energy resource providers (DERPs) can bid into CAISO. |
| Expanding customer services and choice | California DRPs required under AB 327 are also addressing this issue. |
| Market animation | Yes. CAISO’s June 15 decision regarding DRPs and the DRAM to allow for increased customer participation in energy markets. AB 117 allows for Community Choice Aggregation. |
| Fixed cost recovery/rate structure | Yes. Market animation is a driver behind DRP requirements and CAISO actions described above. |
| Reforming regulation / changes to utility business model | Yes. Addressed in response to AB 327 rate reform bill. |
| Reliability and resilience | Yes. Being addressed in the Integrated Demand-Side Resources (IDSR) Proceeding (R. 14-10-003) (CPUC 2015b). |
| | Yes. Being considered in DRPs. |

The sections below describe key initiatives and proceedings in California broken down into the following categories:

1. Policies that support **achieving environmental and climate goals**
2. Policies that promote **deployment** of DERs
3. Policies that support **reliability and integration** of DERs
4. Policies that promote **market animation** and support **customer choice**.

3.2 Policies That Support Environmental or Climate Goals

The primary policy drivers for DERs and power system transformation in California are statewide environment and climate goals. This section summarizes policies and programs in California primarily aimed at achieving those goals.

3.2.1 State of California Energy Action Plan Including Energy Resource Loading Order

In May 2003, the CEC, the CPUC, and the Consumer Power and Conservation Financing Authority (an authority now defunct) approved the first State of California Energy Action Plan (Energy Action Plan; CEC 2016c). The plan established shared goals and specific actions to “ensure that adequate, reliable, and reasonably-priced electric power and natural gas supplies are achieved and provided through policies, strategies and actions that are cost-effective and environmentally sound for California’s consumers and taxpayers” (CEC 2016c).

The 2003 Energy Action Plan spells out a loading order of energy resources to guide decisions made by the agencies. Energy conservation and energy efficiency are prioritized above all other resources. At the time of the passage of the Energy Action Plan in May 2003, the 2000–2001 California electricity crisis was fresh in memory. Elements of the Energy Action Plan were touted by the CPUC as ways to ensure that California would have no more energy shortages and that environmentally friendly resources would be prioritized above others.

3.2.2 GHG Emission Targets – California Global Warming Solutions Act of 2006

Assembly Bill AB 32, the California Global Warming Solutions Act, was passed in 2006. AB 32 requires the reduction of statewide GHG emissions to 1990 levels by 2020. In response, the California Air Resources Board developed a scoping plan that lays out specific programmatic measures that will be used to achieve specified emission reductions, including an RPS, energy efficiency, combined heat and power, and a statewide cap-and-trade program (ORA 2012).

The California Global Warming Solutions Act, along with the Energy Action Plan outlined in the previous section, set the stage for California’s rapid adoption of DERs and grid modernization in the ensuing years.

3.2.3 Renewable Portfolio Standard

California’s RPS is one of the most ambitious in the country. In October 2015, legislation passed that increased California’s RPS requirement to 50% renewables by 2030. This is up from the previous target of 33% by 2020 (CPUC 2016a). At least 75% of renewable resources must come from resources located within—and/or in states directly adjacent to—California. California’s RPS was originally established in 2002 under SB 1078. It was accelerated in 2006 under SB 107 and expanded in 2011 under SB 2. California is currently on track to meet RPS goals. The CEC estimates that close to 25% of electricity retail sales in 2014 were served by renewable energy. The current target is 25% by 2016 (CEC 2015a).

Figure 1 shows how California’s RPS targets have changed over time and California’s performance toward meeting those targets. This figure includes both in-state and imported renewable generation.

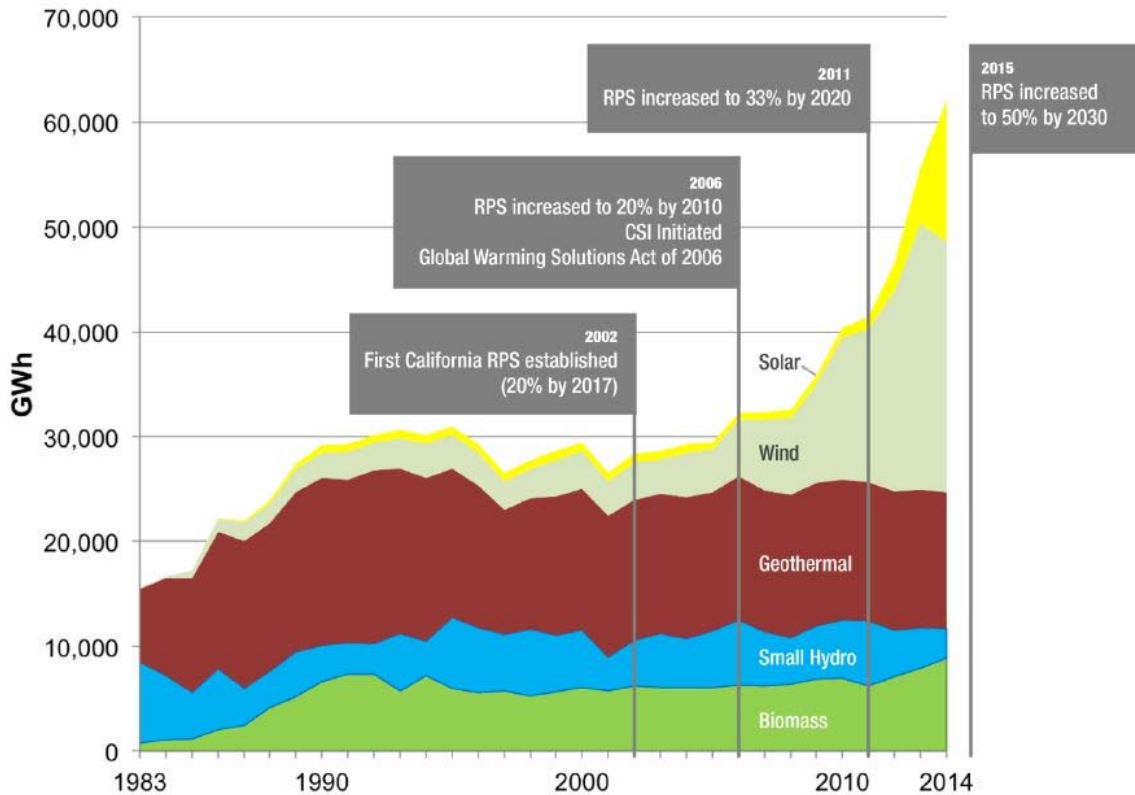


Figure 1. California’s Renewable Generation and RPS Targets (CEC 2015a)

3.2.4 Cap and Trade

In response to AB 32, the California Air Resources Board developed California’s Cap-and-Trade program. The Cap-and-Trade program is a key element of California’s strategy to reduce GHG emissions.

Launched in 2013, California’s Cap-and-Trade program is a market-based mechanism to lower GHG emissions (C2ES 2014). The program defines economy wide emission limits that are translated into tradable allowances. Each entity covered by the regulation has a requirement to acquire and surrender allowances in an amount equal to their obligation over the compliance period. Allowances are issued by ARB and distributed by free allocation and by sale at auctions. The supply of emission allowances decreases over time, reducing GHG emissions.

3.2.5 Emission Performance Standards

SB 1368, passed in 2006, limits long-term investments in base load generation by the state’s utilities to power plants that meet an emissions performance standard jointly established by the CEC and CPUC (CEC 2016d).

The CEC established a standard for base load generation owned by—or under long-term contract to—publicly owned utilities of no more than 1100 lb. CO₂ per MWh. This encourages the development of power plants that meet California’s growing energy needs while minimizing their emissions of greenhouse gases. New coal plants cannot meet the 1100 lb. CO₂ standard without significant carbon

capture and sequestration, which is not currently commercially available. Therefore, at present the emission performance standard essentially limits the use of coal as fuel in the state.

3.2.6 Electric Vehicle Executive Order

In March 2012, California Governor Jerry Brown issued Executive Order B-16-2012 to encourage zero-emission vehicles (ZEVs) in California. A long-term goal of reaching 1.5 million ZEVs on California's roadways by 2025 was established with specific milestones for 2015, 2020, and 2025. The 2015 goal is that California's major metropolitan areas will be able to accommodate ZEVs through infrastructure plans. The target for 2020 is that California's ZEV infrastructure will be able to support up to 1 million vehicles, and the goal for 2025 is 1.5 million ZEVs to be on California's roadways with easy access to infrastructure (CEC 2015b). California utilities and grid operators will need to ensure existing information, control, and sensing technologies are adequate to address increases in electric vehicles.

3.3 Policies that Promote Deployment of Distributed Energy Resources

3.3.1 Net Energy Metering Tariff

AB 327 required the CPUC to establish a rulemaking by December 31, 2015, to develop a replacement net energy metering (NEM) program. The rulemaking required by AB 327 resulted in a January 28, 2016, CPUC decision in which a successor net metering tariff was approved. The successor net metering tariff is much the same as the previous tariff, but with added interconnection fees. The added fees are significantly lower than those included in a draft version of the bill. A last-minute change removed fees NEM customers would have to pay for transmission (Corrigan 2016). NEM customers are also required to switch to TOU rates (B&V and SEPA 2016).

Under California's new NEM tariff, NEM successor customers with systems under 1 MW are required to pay a reasonable, preapproved interconnection fee. Utilities will propose the fee via Advice Letter based on actual historical interconnection costs. The one-time interconnection fee is likely to be approximately \$75–\$150. Customers larger than 1 MW will pay all interconnection fees and upgrade costs (CPUC 2016d).

In addition to NEM, California offers incentives to utility customers for DERs. Utility customers receive up-front cash incentives for solar electric systems and either up-front or performance-based rebates for wind turbines, fuel cells, and storage systems through the SGIP described below (ORA 2016b).

3.3.2 Self-Generation Incentive Program

California's SGIP has a long legislative and regulatory history. Originally created in 2001 in response to the California energy crisis, the SGIP provides monetary incentives for on-site distributed generation technologies. Qualifying technologies include wind, waste heat to power, fuel cells, pressure reduction turbines and advanced energy storage systems. Revisions were made to the SGIP in June 2016 and the SGIP incentive budget was divided into two categories: energy storage and generation. Energy storage will receive 75% of program funds, 15% of which will go to residential projects. Generation projects will receive the remaining 25% of funding, with 40% carved out for renewable generation (CPUC 2016b).

3.3.3 Integrated Demand-Side Resources Proceeding

The Integrated Demand-Side Resources (IDSR) Proceeding (R. 14-10-003) (CPUC 2015b) deals with the regulatory framework and ratemaking treatment of DERs. The IDSR proceeding is extensively intertwined with the Distribution Resource Planning docket. On Aug. 13, 2015, CPUC Commissioner Mike Florio issued a proposed decision in IDSR proceeding stating the scope of the proceeding was expanded to a) focus on the integration of demand-side resources in a holistic way that includes not only what the utilities offer to customers but also what customers offer the utility, and b) consider the adoption of localized incentives and what methodology should be used in determining such incentives (CPUC 2015b). One goal of the IDSR rulemaking is to develop and adopt a regulatory framework for addressing distributed energy and demand-side resources. (CPUC 2015b)

On April 4, 2016, CPUC Commissioner Mike Florio offered a proposal for comment that would give an incentive for utilities to contract with distributed generation. IOUs would earn a return on equity for contracting with distributed generation, just as they currently do for investments in utility infrastructure and distribution infrastructure. This would remove part of the disincentive for utilities to support distributed resources (Raphael 2016b).

3.3.4 Feed-In Tariff

In California, IOUs with 75,000 or more customers are required to make a standard Renewable Market Adjusting Tariff (ReMAT) available to their customers. Though initially created in 2008, revisions in late 2012 expanded the ReMAT program to a cumulative 1 GW target (750 MW for the general ReMAT program, and 250 MW for the bioenergy ReMAT program). Eligible utilities are responsible for a portion of the cumulative totals based on their proportionate sales (EIA 2013).

Obligated utilities must offer 10-, 15-, or 20-year contracts for their share of the program goal set at a market-based tariff rate. The initial rate will be set according to California's renewable auction mechanism results, but may be adjusted up or down if applications fall above or below incremental program targets. A wide range of renewable generation systems—up to 3 MW in size—are eligible for this program. Any customer-generator who sells power to the utility under this tariff may not participate in other state incentive programs (DSIRE 2015).

3.4 Policies that Support Reliability and DER Interconnection

3.4.1 Distribution Resource Planning

The CPUC developed policies between 2001 and the present that promoted DERs located within the IOUs' distribution systems. California policy makers recognized that the design and operation of the distribution system was a bottleneck preventing more penetration of DERs. In an attempt to streamline and simplify the processes for interconnecting to the distribution grid, California policy makers required utilities to develop and submit distribution resource plans (DRPs), reflected in AB 327 (PU Code 769). CPUC R.14-08-013 contains policies, procedures, and guidelines for DRPs (CPUC 2015a).

AB 327 requires DRPs to evaluate locational benefits and costs of distributed resources on the distribution system and to propose or identify standard tariffs, contracts, or other mechanisms for the deployment of cost-effective distributed resources. The DRPs must also identify barriers to the deployment of distributed resources.

California's three large investor-owned utilities—PG&E, SCE, and SDG&E—submitted their first DRPs in July 2015.

3.4.2 Energy Storage Mandates

Pursuant to AB 2514, the CPUC established energy storage mandates. A target of 1350 MW of energy storage was set. Utilities submit energy storage procurement plans to the CPUC for approval every two years, with the first procurement period beginning in 2014. Procurements increase incrementally every two years. SCE, PG&E, and SDG&E must procure a total capacity of 1325 MW by 2020 at an estimated cost of \$1–3 billion (ORA 2016a). Three classes of storage are defined: transmission connected, distribution connected, and customer side. Utilities are not allowed to own any more than half of the energy storage they procure, which should pave the way for high levels of growth in merchant storage and customer-sited and -owned energy storage systems. (St. John 2013)

3.4.3 Smart Inverters

California's Rule 21 is the distribution grid interconnection rule for DER devices that fall under CPUC jurisdiction. The CPUC adopted recommendations for updating the technical requirements for inverters in DERs on December 18, 2014, which established new standards for advanced inverters under Rule 21. Under this rule, California's IOUs must install advanced inverters by Dec. 31, 2015, or 12 months after the date that the Underwriters Laboratory approves new certification standards regarding the items below:

- default voltage ride-through settings
- anti-islanding protection for new voltage ride-through settings
- frequency ride-through settings
- dynamic volt/VAR operations requirements
- ramp rate requirements
- reconnection by soft-start methods.

A CPUC decision in June 2016 expanded on the previous Rule 21 decision for smart inverters and clarified the interconnection process for energy storage systems. Both smart inverters and energy storage systems can help manage higher penetration of DERs.

3.5 Policies that Support Market Animation and Promote Community Choice

Another driver in California's power system transformation and promotion of DERs is supporting additional market participants and enabling customer choice. This section summarizes key initiatives that support those ends.

3.5.1 DERs and DR Participating in Wholesale Market via CAISO

In July 2015, CAISO approved a proposal to allow aggregated DERs to participate in the California wholesale energy market as long as they are aggregated together to meet CAISO's 500 kW minimum participation requirement (Troutman Sanders 2015). This decision will allow DERPs to be a new class of grid market players (St. John 2015a). Aggregated DER portfolios will be allowed to bid into wholesale

markets beginning in late 2016 (B&V and SEPA 2016). Utilities and other companies will be able to purchase and consolidate output of rooftop solar systems, batteries, and electric vehicles from multiple homes or commercial systems and then bundle those into a power supply product to be sold into the independent system operator (ISO) electricity market.

California PUC Docket 13-09-011 created a Demand Response Auction Mechanism (DRAM) designed to allow customer battery storage and electric vehicles, among others, to participate in wholesale markets for demand management as long as they are part of an amassed 100 kW of energy reduction. In January 2016, California utilities revealed winning bids in the first auction to consider DR as a capacity resource. Utilities acquired more than 40 MW from a wide range of vendors (Walton 2016; St. John 2016).

3.5.2 Community Choice Aggregation

Passage of Community Choice Aggregation (CCA) enabled greater customer and community choice in California. CCA was authorized in California by Assembly Bill 117 (AB 117). CCA allows cities, counties, and groups of cities and counties to provide electricity to the aggregated electric load of the residents, businesses, and institutions within their jurisdictions.

Under CCA, the California IOUs continue to deliver power over their transmission and distribution lines, but an aggregator purchases power on behalf of its customers and provides the power to customers. All customers within a CCA's territory have the option of buying electricity from the CCA or remaining as generation customers of the IOU by exercising their rights to opt out of the CCA program (CEC 2009).

Figure 2 shows the extent of CCA in California, including where it is in service, where it is ready to launch, where technical feasibility studies are completed or in process, and where options are being explored.



Figure 2. Community Choice Aggregation Status (Raphael 2016a)

3.5.3 Expansion of the Energy Imbalance Market

CAISO launched a real-time energy imbalance market (EIM) to capture reliability and renewable integration benefits by sharing and economically dispatching a broad array of resources. PacifiCorp was the first participant in the EIM in November 2014 and Nevada Energy joined in 2015. Arizona Public Service and Puget Sound Energy plan to join the EIM in 2016. Portland General Electric plans to join in 2017, and Idaho Power Company plans to join in 2018.

The EIM automatically balances supply and demand every 15 minutes, dispatching the least-cost resource every five minutes. The participation of more utilities results in a wider portfolio of resources in the market leads to potentially reduced costs of energy and capacity. The expanded EIM captures the benefits

of geographical diversity of load and resources (CAISO 2016b). Figure 3 shows a map of California ISO and utilities currently participating or planning to join the EIM.

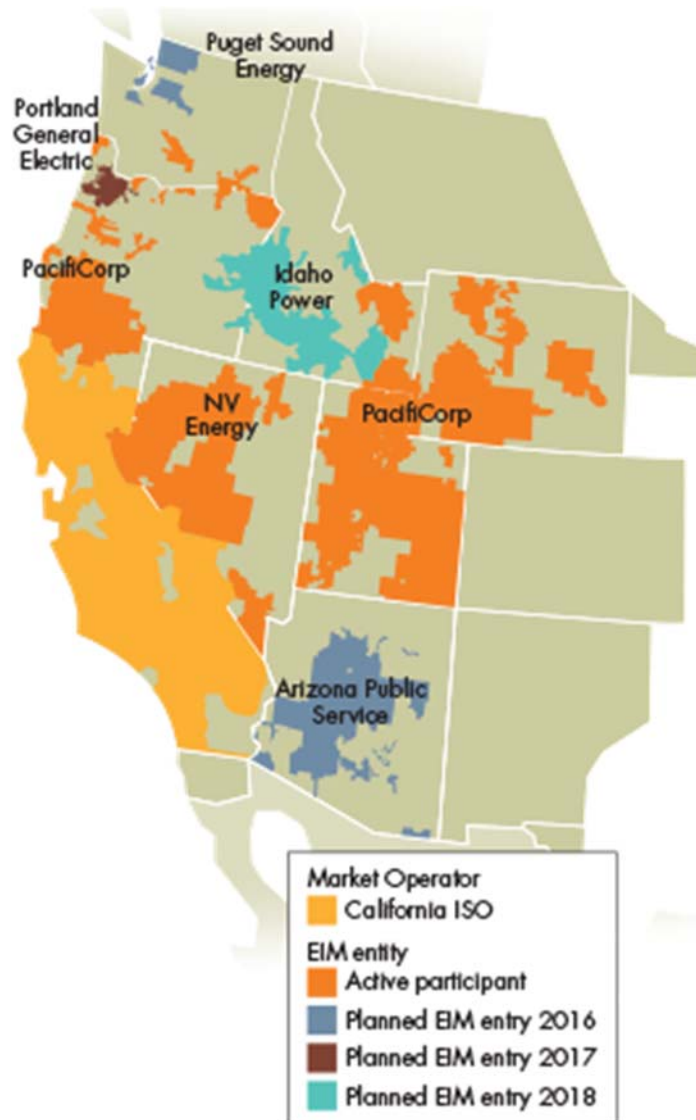


Figure 3. Map of Existing and Future Participants in the EIM (CAISO 2016b)

4.0 Changing Resource Mix

This section of the report describes key changes in California’s resource mix over the last 15 years. These changes in resources have been influenced by the policies and programs detailed in previous sections. California’s resource mix has shifted toward renewables and away from coal and nuclear between 2000 and 2014, while natural gas generation in the state has remained about the same. Increases in renewable generation, sited on both the transmission and distribution systems, create the need for smarter and more responsive grid components to keep the system balanced and reliable.

4.1 Coal

Figure 4 shows the yearly amount of electricity generated by coal in California. In-state coal generation is shown along with direct coal imports to the state. Direct coal imports have been reduced from nearly 30,000 GWh in 2005 to less than 15,000 GWh in 2014. Policies such as the Global Warming Solutions Act of 2006 (AB 32), emissions performance standards passed in SB 1368 (CEC 2016d), the RPS, and cap and trade have favored non-emitting or lower emitting resources over coal and have contributed to the decrease of coal energy in the state.

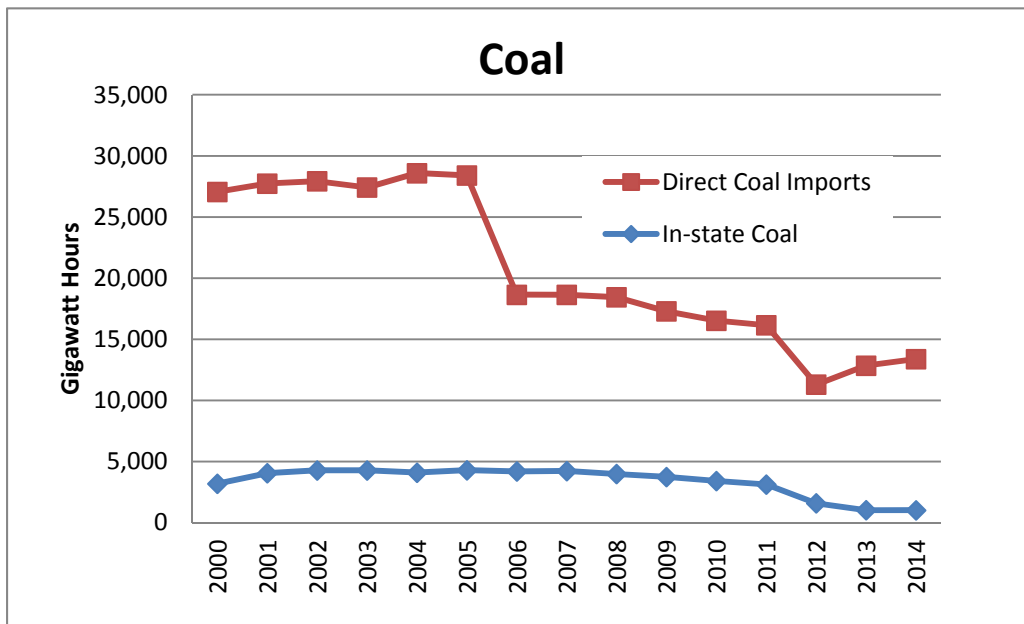


Figure 4. Coal-Based Power in California between 2000 and 2014 (CEC 2016e)

4.2 Natural Gas

Figure 5 shows yearly natural gas electricity generation in California between 2000 and 2014. Natural gas generation in California has fluctuated at or below 120,000 GWh over the past 15 years.

In October 2015, a blowout in a well at the Aliso Canyon underground natural gas storage facility operated by Southern California Gas Company (SoCalGas) created a natural gas leak that lasted until February 2016. The leak released an estimated total of 97,100 metric tons of methane gas into the air and created the largest known anthropogenic point source of methane in the United States (Conley et al. 2016). SoCalGas was prohibited from injecting any new gas into Aliso Canyon until inspections are completed by numerous federal and state agencies. Short-term implications of this incident include concerns about the ramping capacity of the existing gas and electric system for contingency recovery and to follow the fluctuations in renewable generation during the summer of 2016 (CAISO 2016a). It is unknown what, if any, long-term implications of the Aliso Canyon leak will be on natural gas generation in California.

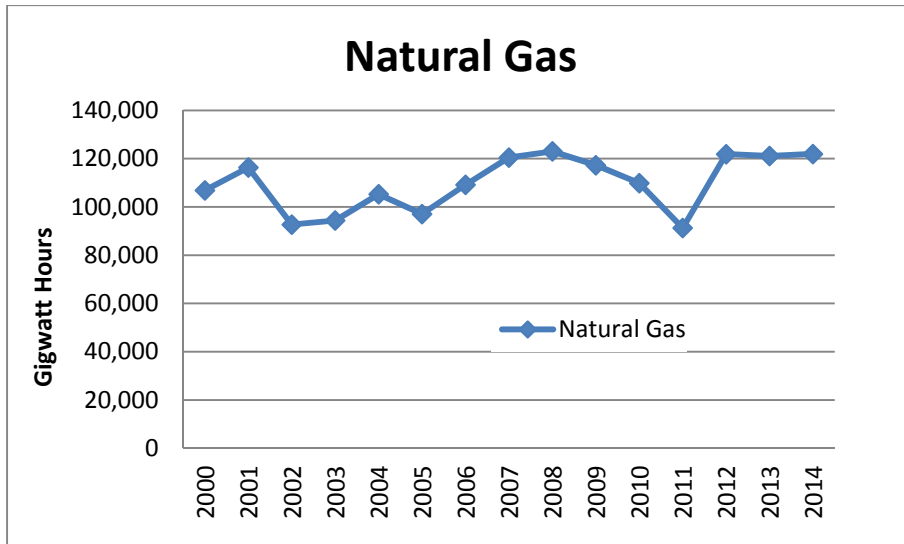


Figure 5. Natural Gas Electricity Production in California (CEC 2016e)

4.3 Nuclear Energy

Figure 6 shows total yearly nuclear electrical generation in California between 2000 and 2014. Nuclear energy generation in the state has been reduced from nearly 45,000 GWh hours to less than 20,000 GWh. This is largely due to the shutdown of the 2150 MW San Onofre Nuclear Generating Station in 2012. The operating license for California’s only remaining nuclear power plant, Diablo Canyon, will expire in 2025. PG&E has applied for a 20-year extension to this license that is currently under review (ORA 2016c).

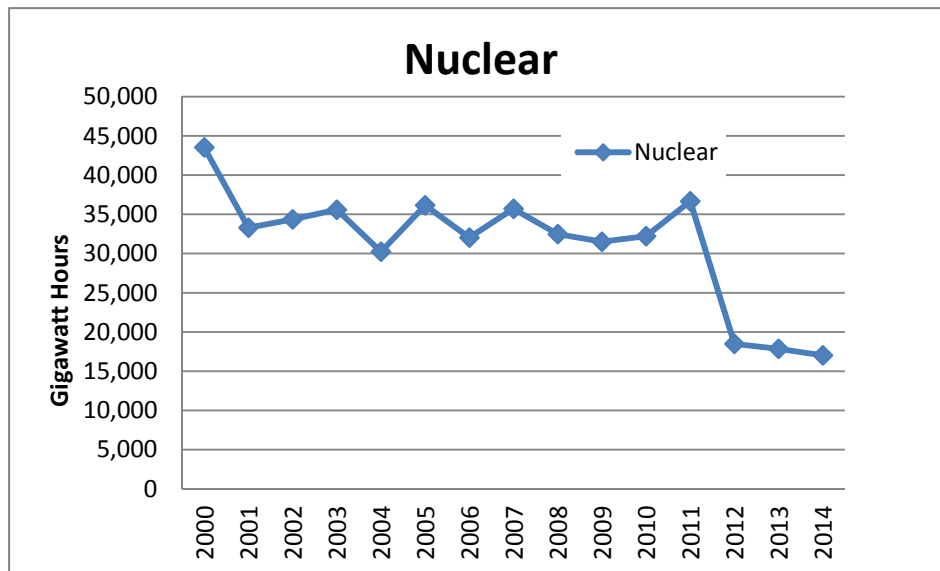


Figure 6. Nuclear Electricity Generation in California (CEC 2016e)

4.4 Renewable Energy

California has experienced substantial growth in renewable energy generation over the last five years. Figure 7 shows the annual renewable energy generation in California between 2000 and 2014. Total renewable energy generation in the state increased from just below 25,000 GWh in 2000 to nearly 45,000 GWh in 2014. California is ahead of schedule for meeting RPS requirements. The CEC estimates that close to 25% of electricity retail sales in 2014 were served by renewable energy, whereas the current target is to meet 25% by 2016.

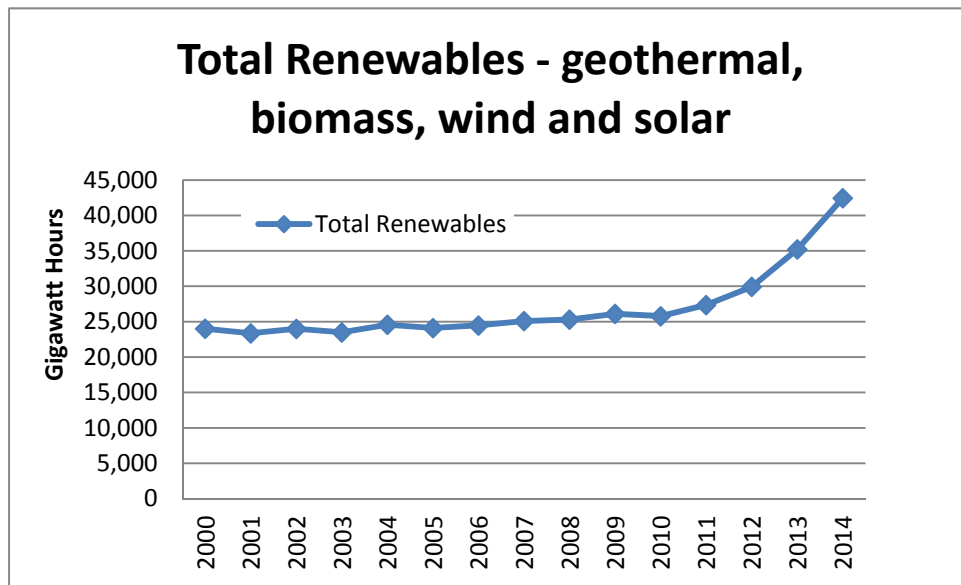


Figure 7. Total Renewable Energy Generation in California (CEC 2016e)

5.0 Challenges

5.1 Operational Challenges

CAISO created future scenarios of net load curves that show the difference between forecasted load and expected electricity production from variable generation resources. CAISO created curves for every day of the year from 2012 to 2020 to illustrate how net loads vary with changing grid conditions (CAISO 2013). Net loads are the amount of energy that must be provided by the utility/ISO. Net loads at any point in time are calculated as the customer demand for energy minus the amount of energy being produced locally. Figure 8 shows the projected net load curves from 2012 to 2020 for March 31. This figure is commonly referred to as the “duck curve,” and shows the need for steep ramping resources between about 5 p.m. and 8 p.m. The curve also shows the risk of overgeneration, which can occur as long-start resources take time to come online before they can support ramps in demand. Overgeneration can also occur in the middle of the day when demand is low and solar production high (CAISO 2013).

The challenges associated with the duck curve center around acquiring cost-effective, flexible resources that can support the natural diurnal pattern of solar power generation and addressing the risk of overgeneration. The rapid integration of renewable resources creates operation challenges for the ISO, including short, steep ramps, overgeneration risk, and decreased frequency response.

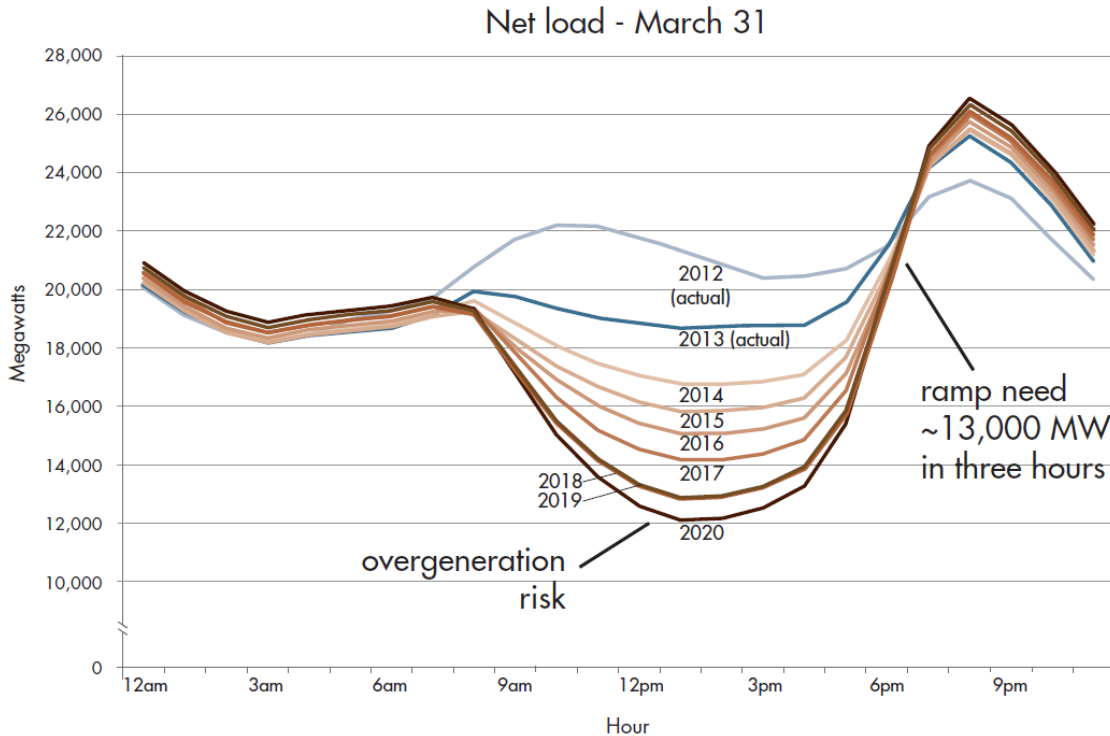


Figure 8. The Duck Curve showing Net Load Curves for March 31 (CAISO 2013)

5.2 Reliability and Safety Concerns

California utilities were required to submit DRPs to the CPUC in June 2015. In their initial DRP submittals, utilities expressed concerns about a number of reliability-related issues associated with increasing numbers of DERs on their systems. Of particular concern was relying on DERs to address distribution capacity and reliability needs. Prior CPUC decisions required distributed generation to provide physical assurance when acting as an alternative to distribution system upgrades (CPUC 2016c). Uncertainty and concerns about the capacity of the system to accommodate and integrate DERs were also expressed in DRP filings, and questions were raised as to how to best harmonize DERs to meet market and local reliability needs (CPUC 2016c). Reliability and DER integration were also of concern for utilities at the interface between the transmission and distribution systems.

One utility expressed concerns in DRP filings with worker safety and a lack information about DER equipment needed for workers to safely respond to emergencies. (CPUC 2016c)

5.3 Forecasting and Models

California utilities expressed concerns about predicting DER adoption and potential impacts on grid reliability and safety in initial DRP filings.

Utilities also expressed that there was a lack of detailed modeling of multiple DER technologies and behind-the-meter resources needed to ensure customers realize the value of their investment in DERs. In general, there was concern about lack of a common model of information and processes (CPUC 2016b).

5.4 Regulatory – Tariffs, Interconnection, and Rate Reform

In their initial DRP submittals in 2015, utilities expressed concerns with the interconnection request process. It was suggested that the interconnection request process should be revised to handle the growing number of DER interconnection requests and that interconnection tariffs need to accommodate emerging technologies. Concerns were also expressed about permitting and the flexibility needed for a speedy regulatory approval processes for DERs (CPUC 2016c).

One utility noted in their initial DRP submittal that rates are needed that are fair, transparent, and avoid cost shifts. Investor confidence is critical to the success of the new framework for utility distribution planning. It was suggested that current policies that allow a subset of customers to avoid paying for the value they receive from the distribution system and grid undermines investor confidence and therefore the financial health of the distribution system (CPUC 2016c).

The traditional utility business model emerged during a time of growing sales and large centralized assets. Energy policies in California and elsewhere are moving toward policies that promote energy conservation and more distributed assets. This transition has implication for rates and how they are calculated and designed as well as for the traditional utility and regulatory business models generally. California’s experience with revenue decoupling for energy efficiency, which is intended to ensure utilities retain expected earnings even as energy efficiency programs reduce sales, may be a model that is expanded and built upon for DERs going forward.

5.5 Valuation and Pricing

Historical distribution system planning fails to articulate the value of DERs temporally and spatially in the distribution system. California policy makers recognize the need to understand value temporally and spatially and ultimately to design programs and rates that incentivize DERs where they are most valuable. Utilities and regulators will continue to define and characterize locational benefits and locational marginal pricing for DERs.

5.6 Data Management and Sharing

As more and more data from smart meters and DERs become available, new challenges arise around managing, protecting, and when appropriate, sharing that data. DER providers, such as SolarCity and Advanced Microgrid Solutions have indicated they need utility data to help guide their investments to align with utility needs. (St. John 2015b) Extensive data from the state’s AMI meters provide data analytics opportunities and challenges.

6.0 Conclusions

Increasing levels of DERs and the associated market and grid transformations taking place in California have been driven by forward-looking and proactive legislative mandates focused on renewable energy and GHG emissions reduction that are being implemented via regulatory channels. Distribution Resource Planning requirements are one of the key efforts supporting grid integration of increasing levels of distributed resources.

Market animation is key to California’s emerging transformation. Demand response and distributed renewables will soon be able to participate in CAISO energy markets as a result of legislation and

rulemakings by CAISO. Communities in California can elect to provide their own power to their communities (via existing utilities' distribution systems) through Community Choice Aggregation.

California's proactive renewable and climate targets serve as a foundation for distributed renewable energy incentive programs and a cap-and-trade emissions trading program that is one of the few in the United States.

California's resource mix has shifted toward renewables and away from coal and nuclear between 2000 and 2014, while natural gas generation in the state has remained about the same.

Key challenges going forward are operational risks presented by high levels of renewables on the grid and transmission/distribution seam issues, ratemaking and utility business model challenges, questions about how to value and price DERs, data management and sharing, predicting and planning for DERs, permitting and interconnection, and reliability.

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