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Greetings,

Over the past year, the Board of Governors and Management of the California ISO have assessed the dynamics that are driving the development of a low-carbon, more decentralized electric service model. We began by interviewing over a dozen policymakers and energy industry leaders, each of whom shared their views on the tectonic changes unfolding in our industry, looking from now to 2030 and beyond. These experts also suggested actions that could help strengthen California's move to a highly reliable low-carbon grid. We incorporated these perspectives, along with those of the Board and ISO management, to create the attached draft vision document.

It is important to note that, while some of the trends and tasks that we have identified may affect California sooner or to a greater extent than other regions of the West, we deeply respect each state's prerogative to establish its own procurement strategy. It is with this in mind that we have assessed the reliability benefits and other positive impacts of deepening regional collaboration.

We will discuss the concepts behind this draft vision at the ISO's Stakeholder Symposium on October 19, 2017 and will subsequently welcome comments from stakeholders. Ultimately, the draft vision, together with your comments, will help inform our ongoing strategic planning process. Thank you for engaging in these important discussions.

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Discussion Paper

Electricity 2030

Trends and Tasks for the Coming Years

Prepared by the Board of Governors and Management of the California Independent System Operator Corporation
October 2017

Contents

Introduction

Decarbonize, Decentralize, Regionalize: Opportunities for evolving more secure, sustainable and affordable electric service

Three dynamics are driving California's transition to a clean energy economy. They unlock huge new opportunities—to improve public health and reduce greenhouse gases; to make electric service more resilient and secure; to reduce the long-term costs of energy use; and, by taking advantage of new technologies and integrating energy used in transportation and buildings with electricity, to put our entire economy on a dynamic and sustainable footing.

> **Decarbonize**: low-cost wind and solar resources, combined with advanced clean technologies, make it feasible to meet most of our energy needs free of the costs, risks and environmental damage of fossil fuels. By 2030, California could get more than two-thirds of its electricity from non-fossil, non-nuclear resources. By 2050, if we electrify much of the energy used in transportation, buildings and homes, a majority of the total energy used in the state can be provided by clean resources.
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> **Decentralize**: Solar power is generated on hundreds of thousands of rooftops, and is an effective complement to central station power resources. Local generation, together with smart meters, sensors, advanced IT and storage, create the infrastructure for local micro-grids. They offer business districts, campuses and neighborhoods in every part of the state a mode of reliable, resilient and secure electric service, and can be designed to disconnect from the main grid in case of large-scale disturbances. Decentralized distribution networks operate synergistically with the bulk power system, which provides access to low-cost, regional clean resources. Local power and big grid: both are necessary components of least-cost, least-impact electric service.
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> **Regionalize**: Sharing resources across the western U.S. reduces the number of power plants needed in each state, saving money and emissions. Collaboration improves reliability, drives down costs and minimizes transmission needs. And, as we rely on renewables to supply most or all of our electricity in every hour in every part of the state, we will require ready access to a much larger pool of wind, solar, geothermal, biomass and hydro resources than is available in California alone. Given diurnal and seasonal wind-solar output and weather patterns, trading these diversified resources benefits all states.

California's energy transition is well underway. State law and policies require a 40% reduction in GHG emissions below 1990 levels by 2030, on the way to 80% reductions in GHG by 2050; 50% of statewide electricity from renewables by 2030, with an additional large percentage supplied by local, decentralized clean generation; 50% improvement in energy efficiency, including increasingly stringent appliance and building standards; 1.5 million Electric Vehicles in service by 2025 (4 million by 2030); and introduction of Zero Net Energy Buildings by 2020. Together, these and other policies outline a trajectory for California's transition to a clean energy economy.

California policy goals address urgent needs. Toxic air pollution from fossil fuels harms our health and imposes huge costs on our economy, with people in low-income communities disproportionately affected. California has taken dramatic steps to reduce carbon emissions, along with SO_x and NO_x emissions, which are known to contribute to adverse health effects.

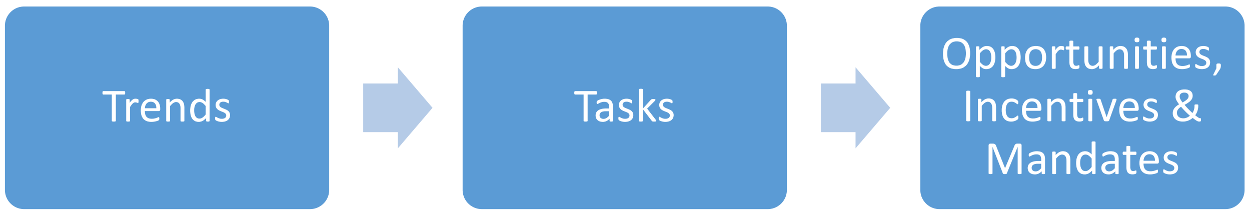
California's energy transition is an enormous modernization, job creation and investment program. Many fossil fuel plants in service today are old, inflexible and inefficient. Continuous advances in communications, computing and control technologies are improving the security and reliability of both central station plants and decentralized local grids. New energy management technologies can enable industrial facilities, businesses and homes to use energy much more efficiently.

Modernizing the ways we produce and use energy can mitigate the public health and environmental impacts of current practices. Doing so will require billions of dollars of investment in cleaner, smarter technologies. Increasing energy productivity offers attractive returns on investment for both public and private capital. Today, solar power alone employs more than 70,000 Californians, and almost 500,000 have jobs in clean tech sectors. Carefully planned transition away from fossil fuels will create additional jobs in scores of disciplines, in every part of the state.

Transportation, buildings, electricity: the opportunities of a clean energy economy depend on addressing energy use holistically. Transportation accounts for 42% of California's carbon emissions (including emissions from oil refining); buildings about 35%; electricity generation approximately 20%. California cannot reach its GHG reduction goals without electrifying the fossil energy now used in buildings and vehicles. Doing so provides essential support for decarbonizing electric supply. Batteries in Electric Vehicles, electric heat pumps and other appliances, for example, can be flexibly dispatched to keep low-carbon electric systems balanced, while taking greatest advantage of weather-driven wind and solar output. The more of the economy we electrify, the easier and more affordable it becomes to manage total energy use.

About this document: California is setting its course for 2030 and 2050. Meeting current policy goals requires significant changes in regulatory policies and commercial practices. Meeting longer-term goals will require even more policy innovation and infrastructure investment—for example, to accelerate EV deployment, build public acceptance of electrifying building energy use, and create public support for development of a clean energy economy. Without a shared understanding of the challenges involved, there is real risk that investment can be misdirected, assets stranded, and major opportunities frustrated or lost.

We have identified eight trends likely to shape the transformation of the electric sector. With each trend, we also identified actions or tasks likely to help support movement toward the outcomes outlined in the trends. It is important to note that many of the actions suggested herein are not within the purview of the ISO. In those cases where lead authority lies with a state agency or other organization, we will support or otherwise collaborate with the appropriate entities to help find the best ways forward. The guiding questions accompanying each trend are intended to begin dialog about both the nature of the challenges and the policy solutions that California faces.



In developing this document the ISO interviewed energy industry executives, state policymakers, and national energy policy leaders. We thank them for the time and thought they contributed to this discussion. The ISO, however, bears sole responsibility for the articulation of the trends and tasks presented here.

This paper is intended to help focus discussion on both technical and policy issues involved in decarbonizing and decentralizing electric service. The ISO cannot, nor should not, lead this discussion alone. Electricity represents just one dimension of the transition to a clean energy economy. The Legislature, Governor, California Public Utilities Commission, California Energy Commission, California Air Resources Board, other agencies, industry, neighboring states and the public all have critical interests and perspectives for shaping this evolution. The ISO will engage with all these interests as we seek to fulfill our mission of operating the grid to ensure reliable electric service.

We look forward to working with policymakers, agencies and stakeholders to further develop a clear and broadly-supported view of a clean energy future—in California and across the region. The health and prosperity of western states are intertwined, and all of us stand to benefit from closer coordination and the sharing of resources.

Overview

8 TRENDS

1: Electricity is used far more efficiently.

2: Gas-fired generation declines significantly as the grid is modernized.

3: The system is shaped by the variable output of wind and solar resources.

4: Demand becomes as important as supply in balancing the system.

5: Electric service is increasingly decentralized.

6: The grid is coordinated regionally.

7: Transportation and building energy use is integrated with electric service.

8: Transition to a Clean Energy Economy creates new industries and jobs, benefitting all citizens statewide.

8 TASKS

1: Strengthen standards and incentives that promote efficient use of electricity.

2: Develop a comprehensive strategy for reducing reliance on fossil resources for power generation.

3: Re-orient regulatory policy to base system operation on non-fossil resources.

4: Develop a long-term strategy for enabling demand to provide essential grid services, like supply does today.

5: Develop a framework for coordinating decentralized electric service with the bulk power system.

6: Explore ways to share resources across the West for the benefit of all states.

7: Develop policies and programs to integrate transportation and building energy use with electric service.

8: Ensure consistent state policy direction sufficient to support sustained public and private sector investment in clean energy.

Trend 1: Electricity is used far more efficiently

- **By 2030, electricity is increasingly important.** Modern economies depend heavily on its reliable supply. Electrifying other energy uses is essential for meeting GHG reduction goals. Improving the productivity with which electricity is produced and consumed offers large economic and environmental benefits. By 2030, conservation and energy efficiency improvements are a social and cultural priority.
- **Energy management technologies and increasingly stringent building and appliance standards reduce building energy use statewide by 20%,** compared with projected levels of usage. This is equivalent to doubling energy saving from California's buildings, a goal set by Senate Bill 350.
    - **State programs and policies lead a long-term commitment to achieving large-scale energy efficiency savings.** Continuously updated building codes and efficiency programs encourage adoption of low-emission technologies in new construction and retrofit building projects.
    - **Performance-based efficiency solutions and data-driven decision-making** link incentive payments to measurable efficiency results. Energy benchmarking and disclosures help building owners and residents make informed decisions to invest in technologies such as LED lighting, heat pumps and building automation systems.
    - **Whole-house retrofits are cost-effective alternatives to electricity supply options.** Aggregated energy savings from installation of heat pumps, efficient windows, insulation and modern appliances in tens of thousands of buildings make building improvements equivalent to the cost of constructing new large-scale clean generating resources.
    - **Building energy efficiency is an integral part of routine property transactions.** The market value of buildings increasingly reflects their energy performance and environmental profile.
    - **A broad range of financial tools and products encourage self-sustaining private investments in efficiency.** The use of techniques such as on-bill financing and Property Assessed Clean Energy (PACE) loans is widespread.
- **Renters, low-income customers and disadvantaged communities are given access to energy efficiency gains**.
    - **Multifamily dwellings are much more efficient**, especially in water heating and distribution, space heating, lighting and landscaping. State programs remove critical barriers to investments in energy efficiency in multifamily housing, with programs tailored to different ownership structures; by resolving problems deriving from split payment of utility costs between owners and tenants; by addressing the limited availability of financing products; and by providing support for tenants having limited resources and knowledge about energy and property transactions.

  - **Low-income Californians take advantage of streamlined delivery of energy efficiency services**. Programs such as the Weatherization Assistance Program (WAP), Low-Income Home Energy Assistance Program (LIHEAP) and Low-Income Weatherization Program (LIWP) are incorporated into building owner eligibility for energy efficiency program incentives, increasing efficiency and reducing energy costs in multifamily buildings.

- **Distributed Energy Resources (DERs), layered system architecture and Microgrids increase options for reducing on-site electricity consumption.** Decentralized electric systems comprise home- and building energy management systems that interact with a local microgrid, as part of citywide or regional distribution system. Microgrids aggregate the power used in individual buildings in ways that reduce overall energy consumption. Improvements in distribution system planning help optimize the locational value of Distributed Energy Resources (DERs) to the grid. Combining distributed PV with other DERs at the building and community levels helps smooth short-term ramps in generation output, provides essential grid services to the local distribution grid and shifts oversupply to meet evening peak demand.

- **Controllable loads and thermal storage shift timing of electric use, reduce peak needs, reduce net energy use.** System operator ability to turn motors, pumps, air conditioners, freezers, electric water heaters and other appliances on and off for very short periods of time provides a low-cost, zero-emissions resource for balancing the system, with no effect on customer comfort or convenience. Thermal storage reduces peak needs by pre-cooling cold storage warehouses or freezers and by pre-heating water heaters at off-peak times. Ice storage uses off-peak electricity to make ice that later cools buildings during peak times. Such controllable loads employ the capabilities of many energy-consuming devices connected to the grid to greatly improve overall electric system productivity.

Task: Strengthen standards and incentives that promote efficient use of electricity

- Improve measurement and verification protocols to ensure energy efficiency programs meet or exceed demand reduction targets. Use program data to build public and political support for expanded focus on efficiency programs.
- Develop a long-term plan for statewide building energy efficiency upgrades, including supportive policies and financing mechanisms, beginning in low-income areas.
- Develop a Net Zero Energy Buildings implementation plan to meet requirements of California law.
- Develop policies and consumer education programs to support acceptance of direct load control of some appliances in new and upgraded buildings.
- Implement policies to incentivize retrofit of HVAC with combinations of heat pumps, ice storage, thermal storage and solar hot water.

Guiding Questions

1. How can state and local programs best be focused to make energy efficiency upgrades and savings benefits available to low-income Californians, including those living in disadvantaged communities?
2. How can policies unlock efficiency savings in multifamily housing? How can efficiency programs overcome the “split incentive” problem? Eighty-eight percent of multifamily households are renters; most pay utility bills but do not have control over building or equipment improvements that could lower them. Building owners typically pay for common area utilities (garage, lobby, landscape) but may not be able to influence tenant behavior that could help control costs.
3. How should the California ISO collaborate on the Integrated Resource Plan (IRP) to help prioritize the most effective procurement of efficiency, demand response and other clean programs over fossil energy supply options?

Trend 2: Gas-fired generation declines significantly as the grid is modernized

- **By 2030, gas generation is used mainly when clean resources are not available**. Renewables and distributed resources provide the majority of electricity in most hours. Energy efficiency gains reduce net demand for electricity, even as transportation and building energy use is increasingly electrified.
    - **The gas generation fleet is modernized**. Older gas generation is retired, retrofitted or replaced with resources that start and ramp quickly and can operate at very low loadings. Flexible gas units are incentivized to provide essential services. Gas fleet modernization reduces renewables oversupply conditions and curtailment risk.
    - **A managed process phases-out gas generation.** An exit strategy and phase-out timeline for gas generation retires the least flexible resources first, and minimizes risk of newer, more valuable fossil assets becoming stranded. Incentives for early retirement, upgrades or replacement with non-fossil technologies help manage phase out of the fossil units. Multi-year Integrated Resource Planning guides the managed phase-out process.
    - **The wholesale energy market ensures financial viability of gas-fired generators that remain necessary**. Appropriate pricing of non-energy Essential Reliability Services and removal of price caps help gas-fired generators that operate only a small number of hours to remain financially viable.
    - **Biofuels play a larger role in the thermal generation fleet:** An increasing number of fast-start conventional resources are converted to use biofuels instead of fossil fuels.
- **Local resource needs are mainly met by non-fossil technologies:** Local capacity reliability needs are met largely by non-fossil technologies and resources, including distributed energy resources and local microgrids with storage. Voltage support technologies and distribution system upgrades increase imports of renewables into local areas. Standards for coordinating distribution system and transmission system operations enhance both local and system reliability.
- **New technologies enhance transmission and distribution system capabilities.** Transmission and distribution system upgrades address or eliminate local constraints that have previously required operation of fossil resources. Fast-acting automated devices divert flow away from constraints, smart inverter technology provides voltage support and stability, and synchro-phasor monitoring devices identify stressed conditions and trigger schemes to self-heal potential network stability vulnerabilities.

- **Regional sharing of flexible resources reduces the need for gas-fired generation**. Regional cooperation enables the sharing of flexible resources across much of the West. Operational and planning decisions take advantage of coordinated use of regional hydro resources and associated storage capabilities. Revised grid operational policies remove bottlenecks in order to maximize sharing of flexible resources.

Task: Develop a comprehensive strategy for reducing reliance on fossil resources for power generation

- Develop a reliability-based plan for operating the grid with a majority of non-fossil resources. Embed this plan in IRP-based procurement, in order to minimize the risk of conventional generating assets becoming stranded.
- Identify the obstacles to supplying all, or almost all, local capacity reliability needs with non-fossil resources. Develop a strategy for removing those obstacles. Align IRP with transmission and distribution system planning to prioritize non-fossil solutions.
- Establish a timeline for orderly phase-out of non-critical gas-fired generation. Develop market mechanisms to ensure the financial viability of remaining gas generators, as those units operate fewer and fewer hours.
- Implement policies that require all resources to operate flexibly, and conventional generators to have fast start, fast ramping and low Pmin capabilities.
- Determine the constraints that must be addressed to permit the use of biofuels as dispatchable resources.
- Coordinate deployment of local smart grids and storage, Demand Resources and other fast response technologies to address local and system reliability issues.
- Develop regional capacity planning and regional system operation to maximize use of non-fossil flexible resources across the West.

Guiding Questions

1. What are the major obstacles to meet local reliability capacity needs with non-fossil resources? How can those obstacles be removed?
2. What kinds of market mechanisms can ensure the financial viability of gas-fired generators as they run fewer and fewer hours? How do infrastructure financing models need to adapt to a paradigm of reduced reliance on fossil resource?
3. What changes in ISO and CPUC policies and practices can best align transmission planning and procurement to promote deployment of the most reliable and cost-effective grid solutions?
4. What are the constraints on use of biofuels in electricity generation? What are the limits of a sustainable biofuel supply? What infrastructure upgrades would be required to access and biofuels for electricity generation?

Trend 3: The system is shaped by the variable output of wind and solar resources

- **By 2030, California gets more than two-thirds of its electricity from non-fossil, non-nuclear resources**. Electric supply revolves around the variable output of wind and solar resources, with gas generators running mainly to fill gaps in clean power supply.

    Renewables supply an increasing share of Essential Reliability Services, including Primary Frequency Response, regulation, voltage support and spinning reserves, all of which had previously been supplied by fossil, nuclear and hydroelectric power.

    Oversupply of mid-day solar generation is resolved by a combination of measures, including exports, market bidding by renewable generators, storage, and use of electricity in transportation and buildings.

    - **Ready access to a much larger pool of wind, solar, geothermal, biomass and hydroelectric resources than is available in California** helps supply all electrical characteristics necessary for reliable electric service in every hour in every part of the state**.** Regional grid operation also creates major reliability and environmental benefits and cost savings.

    - **All resources, including renewables, gas and customer demand, provide the operational flexibility needed to integrate large amounts of wind and solar power.** Electricity generated from wind and solar depends on the weather. Ability to adjust output or operating requirements quickly helps provide system flexibility and ramping needs.

- **Beyond the RPS.** By 2030, grid operation and regulatory policy incorporates all clean resources on a comparable footing, including rooftop PV, large hydro and biomass, as well as wind, solar, geothermal and storage. New Power Purchase Agreements require renewables to bid into the market and compensate them for providing Essential Reliability Services (ERS) as well as energy and capacity.

- **Portfolios of diverse clean resources that reduce flexibility needs become least cost as PV capacity value declines**; geothermal, biomass, storage and voltage support technologies complement wind and solar to ensure reliable system operation.

Task: Re-orient regulatory policy to base system operation on non-fossil resources

- **Focus Integrated Resource Planning** on solving for least-cost, least-regrets, cross-sectoral GHG reduction. Develop new tools to guide procurement of resource portfolios capable of meeting grid reliability needs. Ensure that procurement takes advantage of least-cost clean energy supply from out-of-state resources.

- **Accelerate implementation of Time of Use rates** and Demand Response programs designed to better align electricity use with renewable energy output and to minimize system flexibility needs.
- **Develop new Power Purchase Agreements** that require renewables to, and compensate them for providing Essential Reliability Services, Ancillary Services, energy and capacity, and that require market bidding by all resources.
- **Stimulate industry innovation** to improve the capabilities of geothermal, wind, solar, biomass and storage technologies to provide flexible output, ERS and increasingly sophisticated grid services.

Guiding Questions

1. What constraints limit meeting Local Capacity Resource needs with non-carbon resources?
2. To what extent can Primary Frequency Response substitute for mechanical inertia in ensuring reliable system operation?
3. To what extent can non-carbon resources supply Essential Reliability Services, including spinning and non-spinning reserves?
4. What market products and associated pricing structures are necessary to support the transformation from fuel-based energy markets to capability-based products?

Trend 4: Demand becomes as important as supply in balancing the system

- **Load becomes increasingly flexible and controllable.** Widespread adoption of application- and internet of things-based technologies help consumer loads actively respond to grid conditions, in ways virtually unnoticeable to consumers.

- **Distribution system resources enhance grid operation.** Over 10,000 MW of controllable supply and demand exists on distribution systems statewide. DSOs/ESPs manage residential, commercial, and industrial devices and EVs to provide essential grid services and converge power demand with clean resource supply.

- **Electric Vehicles comprise the bulk of new car sales and represent a significant share of cars on the road in California.** Smart-charging and time of use incentives enable electric vehicles to provide thousands of megawatts of controllable demand. Spurred by state policies, private companies, cities and counties collaborate regionally and re-think transportation to go beyond a one-for-one substitution of individually-owned EVs for fossil-fuel vehicles, reducing emissions per vehicle miles traveled and increasing intensity of use per vehicle through new mobility business models and a variety of investments in urban planning, zoning and public transit infrastructure.

- **Electrification of many energy uses provides controllable load.** Electrification of transportation, residential, commercial and industrial building energy use and some industrial processes reduce carbon emissions while providing essential grid services, including fast-response flexibility for load following and frequency regulation and utilization of renewables oversupply.

- **Customers become "prosumers."** All customers—residential, commercial, industrial, agricultural and public agencies—take advantage of options for managing their electric needs. Building energy management systems and Demand Resource aggregators reduce costs and provide grid services without active customer involvement. Rooftop and community solar provides local generation without customer involvement. Microgrids incorporating battery storage and automated controls create options for improving resilience and security of local electric service. Other customers take advantage of opportunities to provide and be paid for services to the distribution operator and, in many areas, to engage in peer-to-peer transactions through local distribution-level markets operated by the distribution utility or DSO.

Task: Develop a long-term strategy for basing electric service on demand as much as supply

- Develop and implement data security and data privacy standards covering all customer energy use.

- Design and implement sustained educational campaigns to explain new electric service options, the central role of demand in low-carbon electric systems, and the importance of two-way information flows between customers and system operators. Establish goals for building public acceptance for control of some energy end uses by system operators.
- Adopt policies and rate structures that enable customers to become active prosumers and to be compensated for providing services to distribution and transmission system operators, aggregators and other customers. Ensure such policies do not negatively affect customers opting not to participate as prosumers.
- Encourage DSOs to adopt business models that accelerate development of responsive demand.
- Encourage the Demand Resource industry to develop fast-response passive technologies and to increase managed load under contract, across all customer classes. Incent LSEs to increase reliance on Demand Resources with enforceable targets.

Guiding Questions

1. What practices and regulations must be removed, replaced or adapted to enable a broader range of customer demand to provide grid services?
2. How can data security and customer data privacy be protected as electric service evolves to rely more and more on two-way information flows?
3. What are the most effective ways of building public understanding of and support for making portions of customer energy use controllable by system operators?
4. What are the most effective ways for Demand Resource aggregators, DSOs and Energy Service Provider to earn public trust? What safeguards are needed to ensure new service providers are responsive, responsible and accountable?
5. How will adoption of consumer storage devices change customer engagement?

Trend 5: Electric service is increasingly decentralized

- **Widespread deployment of local solar generation and new technologies change the structure of electric service**. By 2030, local generation accounts for more than 25% of California electric supply. Solar power generated on hundreds of thousands of rooftops is a secure source of electricity that complements large central station power plants. Local generation, together with smart meters, sensors, advanced IT and storage, create the infrastructure for local smart grids. They promise business districts, campuses and neighborhoods in every part of the state reliable, resilient and secure electric service, and are capable of disconnecting from the main grid in case of large-scale disturbances.
    - **Solar generation costs continue to fall**, and financing options make local solar generation available to all customers. Community solar projects enable renters and low-income families to take full advantage of locally controlled clean power.
    - **Falling battery costs and IT technologies encourage formation of local microgrids**. Neighborhoods and commercial and industrial complexes combine local generation and storage into resilient networks that operate independently of the main grid in case of emergencies.
    - **Electric vehicles and sophisticated building energy management technologies enable customers to become prosumers** who both take power from and provide electrical services to the grid. Distributed Energy Resources (DER) and Demand Resources provide an increasing share of the services needed for reliable system operation.
    - **New entrants compete with utilities to provide new electric service offerings.** Energy management companies, new financing models and advanced technologies expand customer choices for the supply electric/energy services. Competition among distribution utilities and non-utility energy service providers drives down costs while improving service quality.
    - **Community Choice Aggregation (CCA) proliferates**. As local governments adopt renewable energy and decarbonization plans, 50% or more of California consumers receive electric service from Community Choice Aggregators, city- and county-based organizations formed specifically to provide clean energy services. By 2030, renewable resources supply upwards of 70% of CCA load.

- **Distributed Energy Resource (DER) and decentralization strengthen distribution grids, minimize need for new high-voltage transmission**. Distribution system upgrades facilitate bi-directional flows between local generation and the bulk electric system. Growth of local generation changes energy flow patterns, reducing congestion on existing transmission lines and minimizing need for new, large-scale transmission.

- **Distributed Energy Resources (DER) complement regionalization of the bulk electric system.** Locally-generated power and Demand Resources increase the resilience and security of electric service. The bulk power system provides access to low-cost, regional clean resources. Growing reliance on renewable resources increases the value of sharing regional differences in diurnal and seasonal wind-solar output. Local power, big grid: both are necessary components of least-cost, least-impact electric service.

Task: Develop a framework for coordinating decentralized electric service with the bulk power system.

- Support accelerated adoption of national standards that define Transmission-Distribution interfaces, system architectures and the scope of responsibilities of both local and system-wide grid operators.
- Encourage utilities and DSOs to adopt Energy Service Provider business models.
- Allow non-utility providers to compete with utilities to meet customer energy needs.
- Upgrade distribution grids to enable two-way flows of power and information in ways that facilitate development of DER and local microgrids.

Guiding Questions

1. What policies can best encourage and support monopoly distribution utilities to adopt energy service provider business models?
2. What policies are necessary to ensure that state energy and climate goals can be achieved as electric services is decentralized?
3. What safeguards are necessary to ensure decentralized service meets highest standards for safety, reliability, and customer support and supplier accountability?
4. What standards can ensure that decentralization of electric service advances grid modernization?
5. How should the evolving decentralization be incorporated into the transmission planning process?

Trend 6: Regional Coordination Supports Efficient Grid Operations

- **By 2030, Regional System Operators (RSOs) improve reliability and reduce costs and emissions across much of the western U.S.** Sharing resources across state lines enables unneeded power plants to retire, makes low-cost power available everywhere and increases security of supply. Annual savings of regional operations exceed $1 billion for California alone.
- **Peak load diversity and resource sharing reduces costs, emissions.** Across the region, utilities' peak loads occur at different times of the day and in different seasons. Resources not needed in certain hours or seasons in one part of the region are used to meet needs elsewhere, reducing the number of power plants required to meet aggregate regional needs.
- **Regional markets improve liquidity, drive down costs and ease access to all resources.**
    - **Electric supply is optimized by market bidding.** Security-Constrained Economic Dispatch replaces bilateral contracts and point-to-point transmission to make greater use of existing transmission assets and minimize the need for new transmission. Competitive market bidding results in the most efficient resources and lowest prices for meeting system needs in every hour, as demonstrated by the Energy Imbalance Market.
    - **Regional markets facilitate access to the huge supply of clean resources across the western U.S., reducing costs and emissions.** Clean resources with very low variable costs drive down system average costs. Trading oversupply of low-cost wind and solar output benefits all customers regionally. Coastal states get Mountain state solar output an hour earlier each morning; Mountain states get coastal solar an hour later each afternoon. Mountain state wind output complements diurnal and seasonal timing of coastal wind regimes.
- **Procurement remains each state's prerogative**, as established in the Federal Power Act. Cooperative planning among state commissions, LSEs, and RSOs optimizes meeting Resource Adequacy needs on a regional basis. States review and approve Load Serving Entities' specific procurement plans, which are informed by state and local needs. State procurement processes deliver electrical capabilities needed for reliable system operation, including flexibility, ramping, frequency response and Essential Reliability Services.
- **Grid modernization takes advantage of new technologies to improve reliability and reduce costs and emissions.** Fast response Demand Resources and precise wind and solar inverter output improve system control. Advanced sensors and communications, computing and control technologies provide self-healing capabilities to improve system resiliency. Day-Ahead market bidding and Security-Constrained Economic Dispatch

enhance visibility into system conditions to avoid operational problems and support proactive grid management.

- **A significant number of western balancing authorities are consolidated** into RSOs, improving operational control of generation and transmission region-wide and eliminating seams between different balancing areas. RSOs eliminate internal transmission charges, reducing the costs of accessing regional resources. Aggregating wind and solar output across the region facilitates large-scale use of clean resources and reduces flexible capability requirements.
- **Regional markets help states meet individual policy goals.** Because RSOs have no authority to set procurement policy, states determine the mix of resources they deem appropriate to meet their needs. Emissions tracking and accounting systems enable states to verify actual emissions results.

Task: Pursue regional collaboration opportunities

- Strengthen and expand the Western Energy Imbalance Market.
- Collaborate with entities across the region to ensure that all have ready access to low-cost clean resources.
- Ensure that regional planning and operations respect individual state environmental policies.
- Implement a region-wide emissions tracking and accounting system.

Guiding Questions

1. How should states evaluate the potential benefits of regional markets and regional electric system operation against pressures to maintain current practices?
2. How can states best coordinate infrastructure planning to inform investment decisions and ensure access to low cost regional resources?
3. How can RSO operation respect differing state environmental policies?

Trend 7: Transportation and building energy use is integrated with electric service

- **By 2030, electricity powers an increasing share of transportation, building heating and cooling and industrial processes.**
  - **Electric vehicles (EVs) rapidly replace internal combustion engine vehicles.** EVs represent the bulk of new car sales and a significant percentage of cars on the road. Different forms of on-demand mobility services, including autonomous and non-autonomous electric cars and light duty vehicles, are as popular as individual automobile ownership in urban areas, particularly for younger people and seniors.
  - **Public transportation is increasingly electric-driven.** Electric buses and delivery vans displace diesel fleets and smaller, multi-passenger EVs provide flexible, shared “pop-up” urban last-mile transportation. By 2030, Phase 1 of California’s High Speed Rail project, powered entirely by electricity, serves 20-30 million passengers annually, reducing the costs and emissions of automobile and airline traffic.
  - **New buildings employ a range of clean energy technologies for heating, cooling and cooking**. Existing buildings are gradually retrofitted to replace gas space and water heating with solar thermal technology, heat pumps, and electric or solar water heating and ice storage for cooling.
  - **Many industrial processes rely on electricity alone or supply electricity to the grid from efficient combined heat and power (CHP).** Re-engineered industrial processes reduce overall energy consumption and take advantage of zero marginal cost renewable electricity. Industries not able to completely convert to electricity use renewable fuel sources such as biomethane and solid biomass, and waste heat is used for electricity generation or district heating and cooling.
- **Electrification expands controllable loads which become resources for reliable, low-cost system operation**
  - **Electric vehicles provide a large volume of widely dispersed and dispatchable storage capacity.** Intelligent electric vehicle charging—at homes, workplaces or via public charging infrastructure—absorbs excess renewable generation, helps to reduce peak electricity demand during peak periods, and helps to optimize use of electrical system assets. Charging and discharging EV batteries provides a low-cost, low-carbon resource for balancing the system, and together with time-of-use pricing, makes the grid more flexible and resilient and able to utilize higher levels of renewables. Energy stored in geographically dispersed EVs is available to provide power during emergency situations.
  - **Repurposed second-life EV batteries** provide a low-cost source of storage capacity for homes, commercial and industrial microgrids and grid-scale applications.

- **Commercial and industrial building energy management systems help balance the grid** much like peaker plants did in the earlier part of the 21st Century. Employing combinations of stationary battery storage, advanced heating and cooling systems, automated load control technologies and data analytics, buildings provide grid services while improving productivity and comfort of building occupants.

Task: Develop policies and programs to integrate transportation and building energy use with electric service

- Shift state planning across all sectors to be based on total energy use, including both direct and indirect use of fossil fuels and electricity used for all purposes. A holistic approach to energy use is a prerequisite for meeting energy productivity and GHG reduction goals.
- Track and report total energy use, both for the direct and indirect use of fossil fuels and electricity, and develop and incorporate energy use reduction targets into state plans.
- Develop educational campaigns explaining the rationale and benefits of approaching energy use holistically, targeting, especially, business and public sector leaders.
- Develop government and utility/ESP incentive programs and support mechanisms sufficient to bring millions of EVs into service by 2025, including accelerated, widespread deployment of vehicle charging infrastructure, financial and credit support for new electric vehicle acquisition and incentives for shared or pooled use of electric vehicles.
- Establish rules and technical standards for wide-scale participation in distribution system and wholesale electricity markets by behind-the-meter resources such as EVs and buildings.
- Establish the sustainable potential of using biomass for energy purposes, including transportation fuels and process heat.
- Establish and implement building standards for Zero Net Energy and all-electric buildings.

Guiding Questions

1. Which agency or agencies should guide the shift in California energy planning to tracking and reporting total energy use on an integrated, holistic basis, rather than separated into electricity use and non-electricity energy use?
2. What key design elements will enable state government and utility incentive and support programs to accelerate adoption of Electric Vehicles? What funding sources are available to incentivize rapid EV adoption, in all transportation sectors?
3. What programs and incentives are required to expand daytime EV charging infrastructure at workplaces and multifamily dwellings? How can EV owners who do not have access to at-home charging be served?

4. What data analytics and control protocols and technologies are required to allow fleets of EVs and behind the meter stationary storage to provide local distribution and wholesale grid services?

Trend 8: Develop ways to enable everyone to contribute to, and benefit from, the transition away from fossil fuels

- **Clean energy goals create hundreds of thousands of new, well-paying jobs across the entire economy.** In 2016, nearly 500,000 Californians work in clean energy and cleantech areas of the economy, with 70,000 employed in the solar industry alone. By 2030, momentum to expand California's clean energy economy creates more than two million jobs in all regions of the state.
    - Building materials, demand and supply technologies, storage, sensors, communications and control, architecture, urban planning, education and public relations, environmental remediation and many more disciplines will be mobilized as clean technologies displace fossil fuels
- **Phase-out of fossil generation improves air quality and public health**, especially in low-income communities where many fossil generating plants are located. Procurement of increasingly sophisticated clean energy resources enables gas-fired generating plants located in constrained load pockets to retire. Progressive electrification of car, bus and truck transportation and fossil fuel use in buildings and by industry reduces criteria pollutants and improves air quality.
- **Community solar programs** and associated financing extend benefits of locally controlled clean generation to all California communities.
- **Energy efficiency retrofit programs and multifamily housing construction standards focused on low-income communities** extend energy efficiency savings benefits to renters and people living in disadvantaged communities.

Task: Ensure consistency of state policy direction sufficient to support sustained public and private sector investment in clean energy

- Establish long-term electrification goals for all sectors, to complement and support existing energy efficiency and GHG reduction goals.
- Quantify and promote energy productivity, pollution reduction and clean energy investment opportunities in all sectors.
- Establish investment priorities by potential for funding to accelerate transition to a clean energy economy.
- Develop policies to ensure distribution system upgrades, CCAs and development of local microgrids benefit all classes of customers, statewide. Implement targeted policies ensure efficiency upgrades and retrofits benefit renters and low-income families.
- Develop and fund worker retraining and transition assistance programs for coal, oil and gas-dependent communities.

Guiding Questions

- Which investment opportunities promise the largest returns in moving to clean energy?
- How can investor confidence in clean energy projects be strengthened?
- What regulations and standards are necessary to ensure that clean energy programs benefits all customers, in every part of the state?