Mr. Steve Berberich, California ISO

President and CEO of the California ISO

1. **What makes your energy system unique and different from any other?**

Because the California ISO grid covers the majority of the state of California, our system is transforming to support the state's leading environmental policies of the nation, including ambitious renewable energy targets of 60% by 2030, and 100% of retail load served with zero-carbon resources by 2045, aggressive greenhouse gas reduction goals, and elimination of once-through-cooled conventional resources. Maintaining reliability while supporting these environmental goals requires thoughtful and innovative ways to plan and operate the system. The policies will reshape the generation mix of the system, pose new technical challenges and create opportunities in the expansion and operation of the system.

The California ISO system is unique because of high renewable penetration, predominantly from wind and solar resources. Integrating renewable resources require creative solutions to operate the system through a market mechanism.

For example, key characteristics: geographic features, fuel mix & generation mix, performance specifications, compliance of market mechanisms with energy system control, network topology (extension, voltage levels etc.).

California, and more generally the U.S. Western Interconnection, is fortunate to have a geographically and technically diverse mix of energy resources, including significant amounts of hydropower, wind, solar, and geothermal resources. Leveraging this diversity using a coordinated, planned grid and applying efficient market mechanisms that value not only energy and capacity, but also resource capability will be the key to successful operation and control of the system.

2. **What is the impact of these peculiarities on your energy system management & control? What is the structure or hierarchy of your energy system management & control?**

As the system and resource capability becomes more distributed and variable in nature, the system control and complementary market system have to adapt to be able detect issues and automatically respond more quickly to emerging vulnerabilities, while relying on a broader set of resources than traditionally have been used to maintain reliability. This includes finding ways of using the new resource mix, including leveraging distributed energy resources to provide reliability services.

3. **What are the recent challenges that arise from the operation of your energy system? How do you address them? What problems do they help to pinpoint?**

The main operation challenge facing our system is posed by increasing amounts of renewable integration, with more than 11,000 megawatts (MW) of utility solar generation, and more than 6,000 MW of utility wind generation. The challenges of managing those fast-rising amounts are then compounded with more than 5,000 MW of behind-the-meter solar generation. The primary challenge arises with the required flexibility of the system to absorb the variability and steep ramps produced by the daily profile of solar generation; a second challenge to tackle is the oversupply condition arising during midday hours when solar production reaches its maximum level and requires minimum level of production prior to starting the upward ramp to meet the evening peak. These operational challenges were predicted by the Duck Curve beginning in 2014, but the situation has surpassed projections.

4. **How are market mechanisms embedded in your energy system management & control?**

The California ISO system fully integrates the operation of the system with a market clearing process. The market mechanism enables the efficient operation of the system through market products and signals. Similar to other ISOs in the US, the ISO has locational marginal pricing energy markets that operate day-ahead and in real-time for imbalances. The real-time market operates on a fifteen and five-minute basis that provides operational instructions to resources, including unit commitments and energy dispatches. In addition to balancing supply and demand, the market provides for reliability needs through ancillary services such as regulation and operating reserves as well as for flexible ramp capacity and congestion management of the transmission system. As the system transforms, the market mechanisms and control system must adapt and expand to align market incentives and expand the set of controls, including the use of potentially increasing amounts of distributed energy resources.

5. **What are the main approaches to your energy system development?**
    A. **For example, main directions of investment flow: networks, generation, modernization, renewables etc. Have these trends changed in the past 10 years?**

Over the past decade, the California ISO has planned and built its transmission system to reliably integrate the large amounts of renewables being developed to meet RPS targets. This has resulted in about $7 billion in new rate-payer funded transmission development. Achieving the newly established state goals of 60% RPS by 2045 may require additional transmission investment. The California ISO is coordinating with the California Public Utility Commission (CPUC) to determine the

optimal portfolios of resources and transmission needed to meet the 2045 goals. Infrastructure planning needs to identify and embrace a broader set of solutions than historically has been available. These new solutions must recognize the potential role of demand response, energy storage and variable resources.

The ISO has also approved major transmission upgrades to address the cost of transmission congestion. The ISO operates a nodal price energy market, which provides transparency on the costs and source of grid congestion. The ISO uses historical data on congestion costs as well as prospective modeling of future congestion in its planning process to consider possible cost effective solutions to alleviating transmission constraints. While the ISO planning process allows for merchant transmission development – in which a merchant develops transmission in exchange for receiving congestion revenues -- this option is rarely used, while almost all transmission upgrades are funded through regulated rates charged to demand and exports on the ISO system.

B. How does ISO participate in long-term planning of energy system development?

The ISO plays a leadership role in local and regional planning to support state policies. Specifically, the ISO develops a 10-year transmission plan each year that identifies the transmission needed to meet reliability, economic, and policy needs over the coming decade. This plan is approved by the ISO Board of Governors, and ultimately any new transmission must also obtain approval from state siting authorities, typically the CPUC.

What is the mechanism to support decision making for regulating investment flows in the industry?

We have developed a structured planning process that considers the reliability, economic and policy objectives. New generation development is typically driven by procurement directives from the CPUC.

6. What are the regulatory problems ISO faces in the industry? How do you address them?

As the transformation of California ISO's electric grid continues to include more renewable and distributed energy resources, there is a risk that infrastructure and technology changes will outpace changes to regulations. Our relationships with regulatory authorities at both the federal and state level are critically important to ensure we can advise them on how grid conditions may impact their regulatory decisions and oversight as well as the need to modify their regulations to address emerging issues.

7. What is the role of the Demand Response mechanism in your energy system?

What is your understanding of DR potential? In case DR is not introduced yet do you plan to introduce it?

The ISO roadmap to advance demand response and energy efficiency builds upon California's progressive policies enabling non-polluting distributed energy resources such as microgrids, rooftop solar, electric vehicles and energy storage facilities. The ISO envisions these resources contributing to the low-carbon, flexible capacity needed to maintain real-time system balance and reliability underpinning the integration of renewable energy. Currently, the ISO enables the participation of demand response in our system by having a market mechanism for demand response to bid into the market; these demand response resources help balance the supply and demand of the ISO system.

In recent high load peak days, the ISO has estimated demand response helped shave the peak load by about 300 MW. The ISO market also has a reliability demand response market product in which demand response can be deployed during system emergencies, allowing it to help manage issues by effectively reducing load.

8. **In recent years traditional approaches in the industry are strongly influenced by new technologies. How does your energy system management & control adapt to these changes?**

The ISO has developed and evolved its market mechanisms to recognize and break down barriers to allow and incentivize demand response and more distributed energy resources in general to participate in the market. The California ISO has been a world leader in developing innovative ways for distributed energy resources, particularly behind-the-meter resources such as energy storage, to participate in the wholesale energy market. The ISO recently adopted a distributed energy resource provider model that allows for the aggregation of multiple sources of distributed energy resources having different locations and technologies to participate as a single resource in the ISO market. The ISO has also expanded its performance validation options for demand response resources to also include directly metering a behind the meter storage device that serves as the source of demand response for the host customer.

9. **Integration of new resources into conventional energy mix is widely discussed at present. Is it of high priority to you?**

The ISO fully embraces the integration of renewable and distributed resources. During the last decade, the ISO system has integrated a large amount of wind and solar resources, shifting the generation mix of the system and posing new operational and market challenges and solutions.

What types of new resources have you adopted already?

How do you address the issue of system operation & management with these new types integrated into your energy system?

In addition to wind and solar resources, the ISO uses other renewable technologies including geothermal, biomass, small hydroelectric and battery storage. In order to efficiently integrate new technologies into the system, the ISO has developed new policies and market and compensation mechanisms, such as policies to support the economical participation of renewable resources into the markets, new market products like flexible ramp product to properly compensate resources for the services provided to the system, and state-of-the-art modeling of resource and market features to appropriately reflect the physical characteristics and limitations of resources such as batteries.

10. **The concept 'Power System of the Future' is gaining increasing acceptance in the world energy industry. How you approach this concept?**

The concept of an expanded set of resources and innovative solutions on the horizon must be leveraged to operate the Power System of the Future. These include the new renewable resources, storage, distributed energy resources, along with leveraging emerging technology concepts, such as IoT, Power Electronics and Controls, and new transactional mechanisms like block chain.

11. **Which innovative solutions are being looked at in your company to address the future challenges of the power grids of the future (e.g. Storage, Smart Inverters, Bit Chains, etc…)**

With the high levels of renewable resources connecting to the system, the ISO is collaborating with market participants and research organizations to enable renewable resources to provide reliability services such as upward and downward regulation. The ISO successfully tested the ability of photovoltaic solar resources to provide regulation, which opens the door to renewable resources being part of the solution for the challenges posed by their integration.

Regional diversity is another fundamental solution the ISO is pursuing. A wider regional energy imbalance market in the western US is creating benefits. Since November 2014, adjacent balancing authority areas have been working with the ISO to participate in a Western Energy Imbalance Market , enabling all participating areas to unlock the rewards of optimizing the use of resources in a larger footprint and taking advantage of regional diversity.

12. **What business models and regulatory changes are necessary to ensure the economic viability of the power system of the future**

In addition to breaking down barriers to regional coordination to enhance efficiency and reliability, the following needs to occur:

- All resources need to be calculated not just on their capacity and energy value, but on the capabilities the resources provide and on the location of the resource. As the marginal price

of energy shifts downward to reflect zero-marginal cost resources with no fuel cost increases, certain reliability standards must be met. Resources that can provide these reliability capabilities must be compensated for the essential services.

- Alignment of retail rates and wholesale market structure would provide incentives for end users and distributed energy resources to participate in the operation of the power system of the future. This also requires coordination between distribution system operators and transmission system operators.

- As consumers' choices increase and utility models transform into the transportation, distribution, and metering services sectors, there needs to be clear responsibility for ensuring the necessary capacity, and capability secured to operate the power system in a reliable manner. There may be different models for ensuring this, but long-term investment in the power system that supports low carbon policies need to be in place, so that the power system continues to operate at an efficient cost to consumers while maintaining reliability standards.

13. **How do you address the power grid reliability and resiliency needs in the context of a highly decentralized and low carbon power system?**

A suite of solutions is needed to enable the reliable and resilient operation of our system under the changing paradigm of a low-carbon grid. These solutions include developing market mechanisms to incentivize and integrate new technologies and renewable resources.