

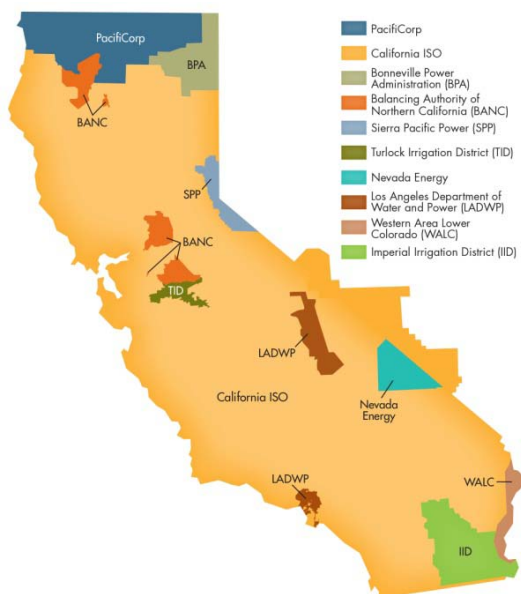


California Independent System Operator

History and Geography of California ISO

The California Independent System Operator (CAISO)¹ was established as a non-profit corporation in 1998 to operate the transmission system. CAISO is responsible for maintaining and enhancing reliability, establishing and overseeing competitive wholesale electricity markets, and planning the power system for California's future electrical grid. As of September 2012, CAISO dispatches approximately 58,700 MW of generating capacity over about 25,800 miles of the state's transmission lines, providing electric service to 30 million people or about 80 percent of California (Exhibit 1).² An all-time peak demand of 50,270 MW was set on July 24, 2006.

Exhibit 1 California ISO market area



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Similar to other ISOs, a primary function of CAISO is to facilitate the energy markets in its service area, maintain minute-to-minute reliable electricity service in a cost-effective manner, manage wholesale markets, and develop bulk power system planning processes. CAISO operates the electricity (energy, capacity, and ancillary services) markets to serve load and meet reserve obligations with the lowest-cost resources possible. It has designed a locational market structure to ensure that transmission capability is used efficiently and that energy prices reflect the marginal cost of providing the service at each location. While the wholesale electric energy cost includes capacity and ancillary services to ensure reliable supply of power, as seen in Exhibit 2, the majority of the electricity price in CAISO is dominated by energy cost (i.e., the cost of generating power, which includes fuel costs, operation and maintenance for generators, and reimbursement for the capital cost of generators).

¹ Many of the technical terms used in this primer are defined in a companion *Glossary for Power Market Primers*.

² California ISO. (2012). *Annual Report: State of the Grid – September 4, 2012*. Retrieved on December 3, 2012, from <http://www.caiso.com/Documents/2012StateoftheGrid.pdf>

³ California ISO. (2013). *The ISO Grid*. Retrieved on March 28, 2013, from <http://www.caiso.com/about/Pages/OurBusiness/UnderstandingtheISO/The-ISO-grid.aspx>

Exhibit 2 CAISO average wholesale electricity price 2009, 2010, and 2011 (\$/MWh)⁴

Price	2009	2010	2011
Energy	\$ 37.70	\$ 39.53	\$ 35.78
Ancillary services	\$ 0.39	\$ 0.37	\$ 0.62
Total	\$ 38.09	\$ 39.91	\$ 36.39

CAISO Products and Services

CAISO manages competitive markets that provide energy services and reliability services through a day-ahead energy market, hour-ahead energy market, real-time energy market, congestion revenue rights (CRR), and an ancillary services market. In 2011, these markets aggregated billings of over \$8.3 billion (energy market \$8.2 billion and ancillary services \$139 million).⁴

Energy Market

CAISO's main role as an ISO is to coordinate an energy market throughout the service area, which consists of facilitating the continuous buying, selling, and delivery of wholesale electricity, providing dispatch requests to generators, and acting as a data clearinghouse. In addition to acting as a clearinghouse for bilateral power contracts, CAISO manages a **day-ahead** market, an **hour-ahead** market and a **real-time** market for power delivery. In each market CAISO "clears the market," i.e., coordinates which generators will operate, at what time, and at what price to meet electricity demand. The price of electricity is based on the cost of bringing the next marginal unit of electricity on line at a specific location throughout the California control area. This method of calculating electricity price is called locational marginal pricing (LMP).

The day-ahead market clears both energy and ancillary services markets for each hour of the operating day by matching energy demand bids at each LMP node and by operating reserve requirements throughout the system with the generators' ability to provide power taking into account physical limiting factors such as transmission capacity and the generators' scheduled maintenance. The market opens seven days prior to the operating day and closes the day before the operating day.⁴

The hour-ahead market pre-dispatches non-dynamic (fixed) imports or exports about 45 minutes prior to the start of the identified hour of operation (i.e., the hour in which a fixed level of export and import will be provided for the entire hour). The hour-ahead market considers all real-time schedules and bids from resources inside and outside of the CAISO and the forecast of real-time demand during the identified hour of operation.⁴

The real-time market procures energy and ancillary services, and manages congestion in real-time. The real-time market opens at 1:00 p.m. prior to the operating day and closes 75 minutes prior to the identified hour of operation (i.e., the hour in which the generator proposes operating and providing the electricity). It uses the final day-ahead and hour-ahead schedules and re-dispatches the generators every five minutes based on the current demand and the generators' bid prices—with the lowest-cost resources dispatched first.⁴

Ancillary Services Market

CAISO facilitates an ancillary services market to ensure the reliability of electricity production and transmission. The ancillary services include operating reserve (spinning and non-spinning reserve) and regulation (regulation up and regulation down).

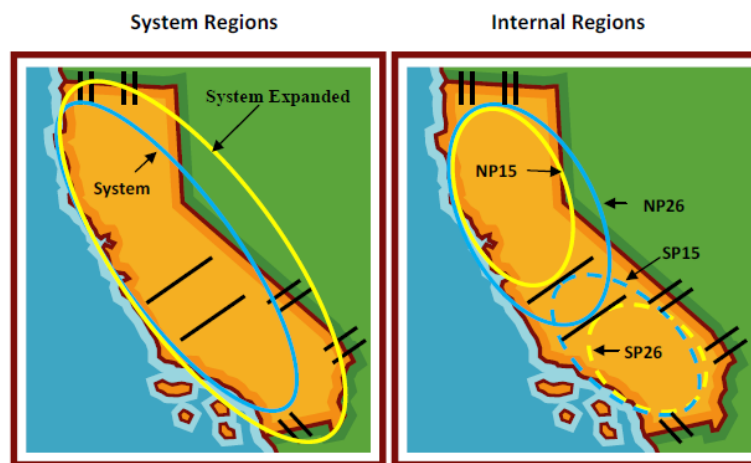
⁴ California ISO. (2012). *2011 Annual Report on Market Issues and Performance*. Retrieved on December 3, 2012, from <http://www.caiso.com/market/Pages/MarketMonitoring/MarketIssuesPerformanceReports/Default.aspx>

The operating reserve service provides backup generation in the event of a system contingency such as unexpected failure of generators, transmission lines, or other electrical equipment. The spinning reserve must be from units that are on-line and can provide additional output within 10 minutes. The non-spinning reserve must be from resources (generation units or demand response resources) that are able to synchronize with the grid and provide output within 10 minutes. Both spinning and non-spinning capacity can be bid as non-contingent or contingency-only, where the contingency-only can only be used to avoid a system contingency.

The regulation service allows CAISO to manage small changes in the system's electrical load by increasing (up regulation) or decreasing (down regulation) the generators' output by sending a control signal to adjust the power output. The up and down regulation requirements are set and provided independently. The regulation up is provided by generator units that can quickly increase the power output in response to automated signals from CAISO. The regulation down is provided by generator units that can quickly decrease the power output after receiving the automated control signal from CAISO.

An ancillary service market clearing price received by each unit for each service provided is calculated as a sum of regional ancillary services shadow prices. The regional ancillary services shadow prices reflect the cost of providing the next available MW of the service inside of a region. There are ten different regions: NP15, NP15 expanded, NP26, NP26 expanded, SP15, SP15 expanded, SP26, SP26 expanded, system, and system expanded (Exhibit 3). For example, the ancillary service market clearing price for a service provided in the SP26 region is equal to a sum of regional ancillary service shadow prices for SP26, SP26 expanded, system, and system expanded regions.

Exhibit 3 Ancillary services market regions



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Note: the expanded internal regions will include any inter-ties with one end in the unexpanded region.

Congestion Revenue Right (CRR)

The CRR market provides a financial instrument for market participants to hedge against congestion costs in the system and they are settled in the day-ahead market only. In the absence of any transmission constraints, all LMP nodes would price at the lowest priced generation resource. However, there is not enough physical transmission to deliver electricity from low-cost resources to the place demanding the electricity at all times. Thus, some nodes will, by necessity, use power from higher cost resources and therefore the LMP at that node will be higher. The difference in LMPs between two nodes that is

⁵ California ISO. (2011). *2010 Annual Report on Market Issues and Performance*. Retrieved on March 28, 2013, from <http://www.caiso.com/Documents/2010AnnualReportonMarketIssuesandPerformance.pdf>

attributable to the transmission constraints multiplied by the transfer amount is called “congestion cost” or “the cost of congestion” because, but for the lack of transmission capacity, a lower-cost resource would be used to meet demand. A CRR can be thought of as a “reservation” for access to a specific transmission path (e.g., between LMP nodes) for a specific timeframe, but does not actually correspond with a physical right to deliver energy. Rather, a CRR will create a revenue stream (or charges) based on the difference between two day-ahead LMP prices at specific times.

Transmission Planning

CAISO is responsible for maintaining the operations and reliability of the grid in its service area and, as such, conducts periodic reviews of grid adequacy. It conducts an annual transmission planning process to identify necessary grid expansions. In addition, it provides support to generation interconnection.

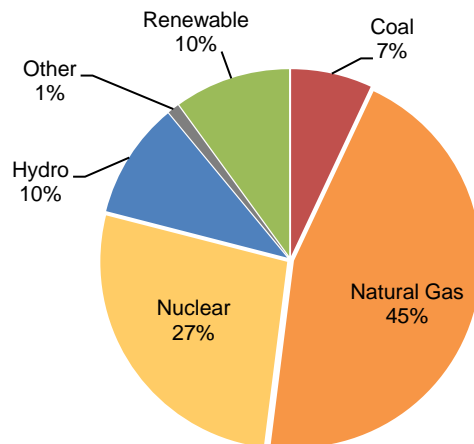
Capacity Market

CAISO does not have a centralized capacity market. It relies on a resource adequacy program established by the California Public Utilities Commission to provide sufficient generation capacity. Load-serving entities are responsible for contracting for capacity services above the anticipated demand (115 percent of the forecasted peak demand) in their service area for each month. This process is conducted on a year-ahead basis.

CAISO Generation Profile

While CAISO does not own or directly operate power generation facilities, it is responsible for managing scheduled outages for maintenance and maintaining reliable electricity service at the lowest cost possible, as provided by the different generators on the system. Thus, to maintain reliability, CAISO continually evaluates the fuel mix of generation assets in the region. As seen in Exhibit 4, the majority of the region’s power comes from natural gas and nuclear generation facilities.

Exhibit 4 California ISO generation (MWh) by fuel type (2011)⁶



⁶ ABB Velocity Suite. (2012). *Velocity Suite Database: Power/Regional Report Analysis/ISO Region/California ISO*. Retrieved on December 3, 2012, from <https://velocitysuite.globalenergy.com/Citrix/MetaFrame/site/default.aspx>