

## **Mercados Descentralizados**

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#### **California ISO facts**

Nonprofit public benefit corporation

As a federally regulated nonprofit organization, the ISO manages the high-voltage electric grid in California and a portion of Nevada

**52,061** MW record peak demand (Sept. 6, 2022)

**\$20+** billion annual market (2022)

**224.8** million megawatt-hours of electricity delivered (2020)

**75,747** MW power plant capacity Source: California Energy Commission

1,119 power plants Source: California Energy Commission

## $\begin{array}{c} \textbf{32} \text{ million people served} \\ \text{One of } \textbf{9} \text{ ISO/RTOs in North America} \end{array}$





#### **Evolution of markets**

Centralized DispatchUnit commitment and merit order dispatch

#### Introduction of markets –Least cost dispatch

• Nodal markets/sophisticated optimization

#### Decarbonization of the grid

 Penetration of renewable resources – Introduction of uncertainty

#### Storage resources

• Introduction of more uncertainty

#### Less centralized markets

 Rooftop resources, DER resource, Vehicle integration – Introduction of more uncertainty



#### **Standard Market Design**





#### **Standard Market Products**





#### **Standard Market Features**

Multi-interval optimization based on MIP techniques

Co-optimization among market products

AC-power flow consideration in congestion management

Dynamic ramp rates

Multi-stage model for combined cycles

Energy limited resources and opportunity costs



## Markets are evolving towards less central but more non-deterministic environment

Different products and procedures are developed to "factor in" uncertainty

Weather variables introduce uncertainty to multiple variables in the power system, including

- Load
- Renewable production
- · Behind the meter
- Reliability services

CAISO still uses a deterministic market clearing process with deterministic inputs



## Variability poses a great forecasting challenge which results in uncertainty in market and systems operations







#### **Over 50% of renewables is price responsive**





### **California ISO Behind-the-Meter Solar**



CAISO Total Values: <u>https://efiling.energy.ca.gov/GetDocument.aspx?tn=236297-6</u> <u>http://www.caiso.com/InitiativeDocuments/Final2023FlexibleCapacityNeedsAssessment.pdf</u>

Rooftop solar is not connected to the high-voltage transmission system, but they affect the ISO's markets and grid operation. Rooftop solar is expected to produce up to 19,000 MW by 2030.



**Territory and Location** 





### Demand Forecast is more challenging due to significant levels of **Behind the Meter Solar**

BTM Solar Forecast Updates vs. Actual 7000 750 6500 ₹ 6000 500 MM 5500 250 5000 Mar 03 06:00 Mar 03 00:00 Mar 03 06:00 Mar 03 12:00 Mar 03 18:00 Mar 04 0 DT

Load Forecast Movement due to BTM Solar





#### Net load varies significantly day-to-day and minute-to-minute



🍣 California ISO

#### Markets can be technology agnostic when considering new technologies

Renewable forecasts are generated and consumed every 5 minutes

Renewable resources can economically bid

Renewable resources are optimally dispatched in the market like any other type of generation resource

Renewable resources receive and must follow operating instructions

Ancillary services requirements consider the impact of renewable resources

New flexible ramping product to handle uncertainty of renewable resources



#### New market products to handle uncertainty explicitly

- Secures ramping capability in the fifteen-minute market and real-time dispatch
- Accounts for upward and downward ramping needs
- Compensates resources who provide ramping and charges those that consume ramping capability
- Procures ramping capability for uncertainty when expected value greater than cost
- Aligns cost allocation with those who benefit from additional ramping capability to meet net load uncertainty





### **Continuous need for more accurate forecasting tools**





### Uncertainty impacts both market and operations across areas





#### Managing power through new technologies and consumer programs





- As more renewable energy is integrated on the electric system, oversupply conditions often occur during the middle of the day
- To avoid curtailment, excess renewable energy must be stored
- Several new technologies and consumer programs have been developing including:
  - Storage/batteries (ISO is agnostic to resource technology)
  - Demand response
  - Time-of-use rates
  - Hydrogen fuel
  - Offshore wind and wave technology
  - Underground compressed air
  - Electric vehicles



# The advancement of new technology is changing the markets landscape. The case of explosive growth of storage resource:



Regulation has saturated the regulation market



# Rapid growth in storage technologies will require enhanced market design to support market participation

- Expected to have 5,000 MW of renewable + storage by 2024
- Use-limited batteries
   required complex models
- Advanced forecasting techniques needed to consider the type of configuration

Hybrid vs. Co-located	Definition	Forecasting / Dispatch
Hybrid POI Limt 100MW Boteru Batteru	A Generating Unit, with a unique Resource ID at a single Point of Interconnection, with components that use different fuel sources or technologies.	<ul> <li>No aggregate forecast for hybrid</li> <li>Hybrid expected to follow dispatch</li> </ul>
Co-located	A Generating Unit with a unique Resource ID that is part of a Generating Facility with other Generating	<ul> <li>VER component will be forecast</li> <li>VER dispatched rules</li> <li>Battery will dispatched and state of charge managed</li> </ul>







#### A suite of solutions are necessary



**Storage** – increase the effective participation by energy storage resources.



Western EIM expansion – expand the western Energy Imbalance Market.



**Demand response** – enable adjustments in consumer demand, both up and down, when warranted by grid conditions.



**Regional coordination** – offers more diversified set of clean energy resources through a cost effective and reliable regional market.



**Time-of-use rates** – implement time-of-use rates that match consumption with efficient use of clean energy supplies.



**Electric vehicles** – incorporate electric vehicle charging systems that are responsive to changing grid conditions.



**Renewable portfolio diversity** – explore procurement strategies to achieve a more diverse renewable portfolio.



Flexible resources – invest in fastresponding resources that can follow sudden increases and decreases in demand.



#### Price formation is core to any market and poses ongoing challenges

- Price signal under scarcity conditions
- Price formation with high penetration of low- or zero-cost resources (renewables)
- Uplift costs and extended locational marginal prices
- Distributed energy resources, and demand response and demand modifiers

