Experiencia en el CAISO con la Integracion de Energias Distribuidas

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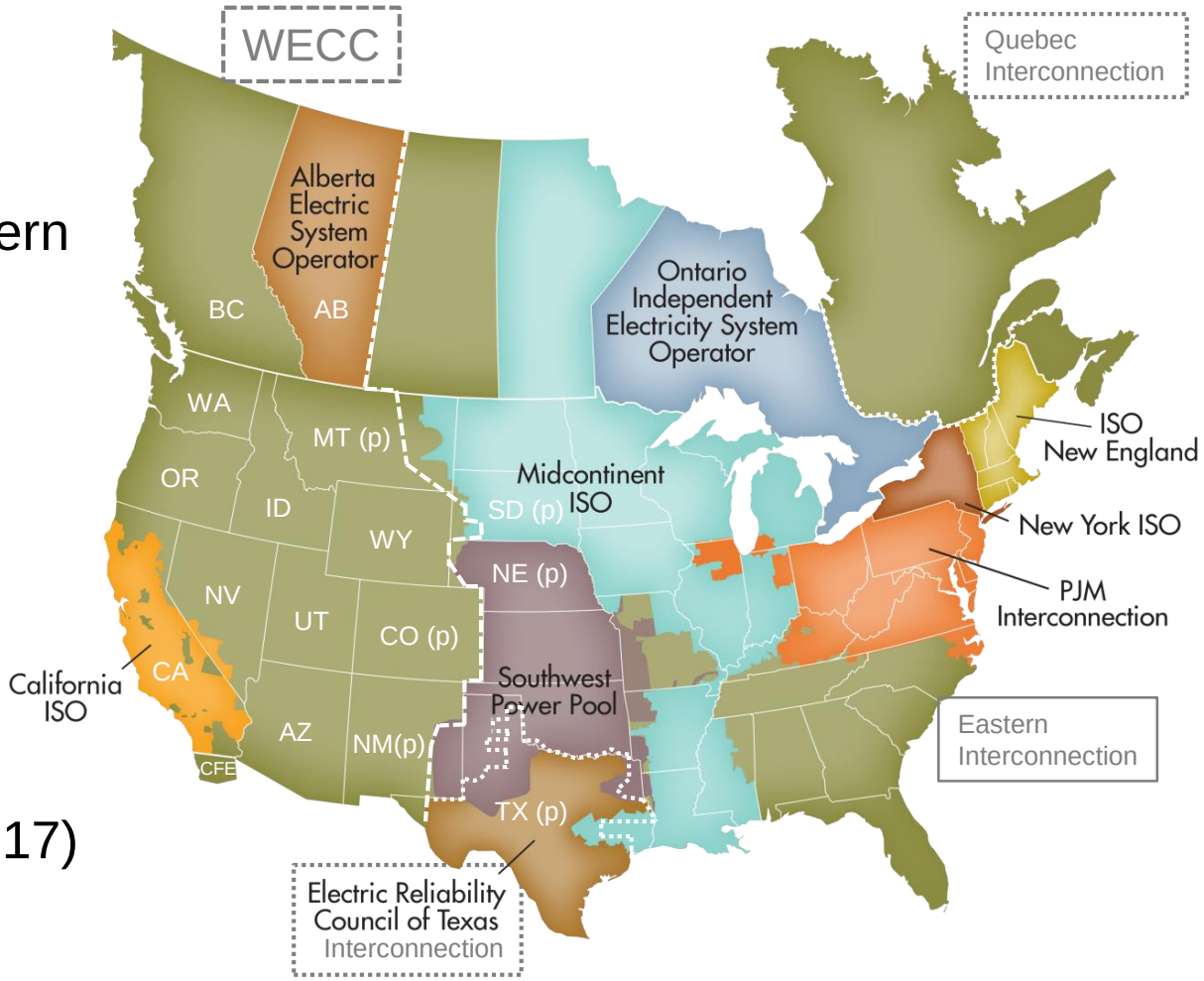
The California ISO

- 2/3 of the U.S. is supported by an ISO
- One of 38 balancing authorities in the western interconnection
- Serves 80% of CA & small portion of NV
- 26,000 miles of wires
- 27,000 market transactions per day
- $9.4 billion market (2017)

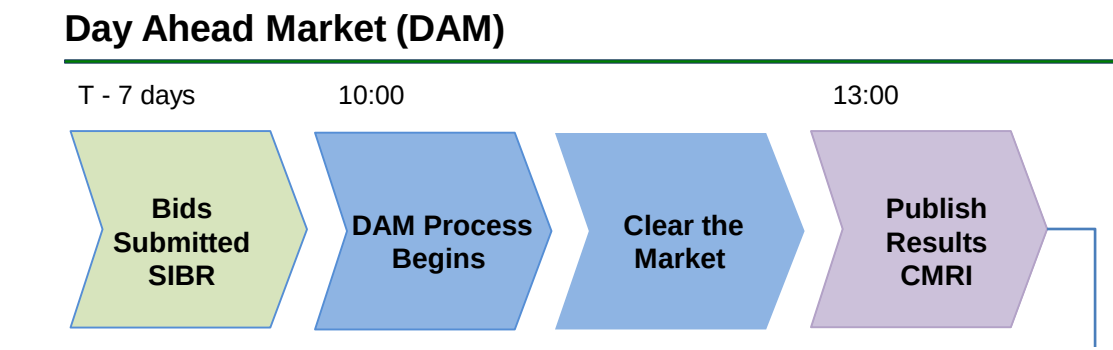


Key functions of an ISO

- Uses advanced technology to balance supply and demand every 4 seconds
- Operate markets for wholesale electricity and reserves
- Manage new power plant interconnections
- Plan grid expansions

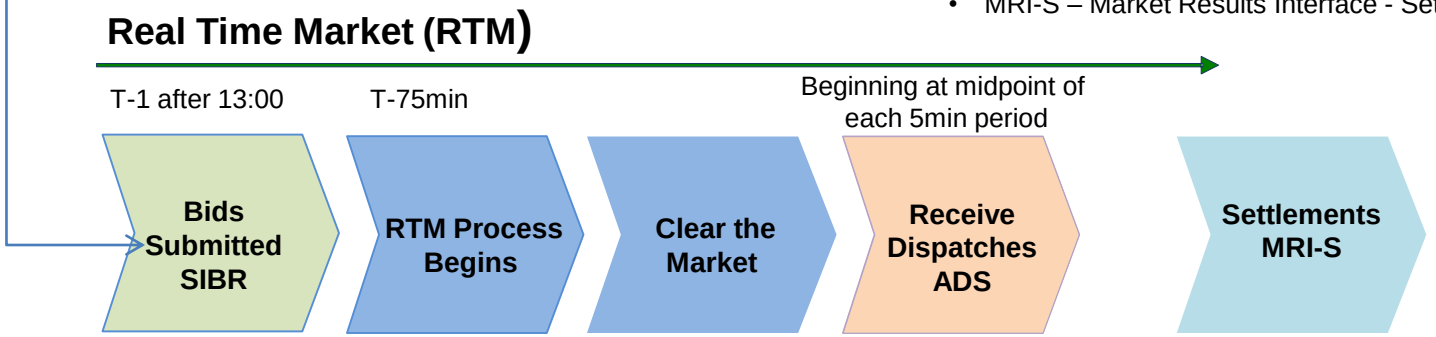
CAISO operates both day-ahead and real-time markets

Market Timeline:

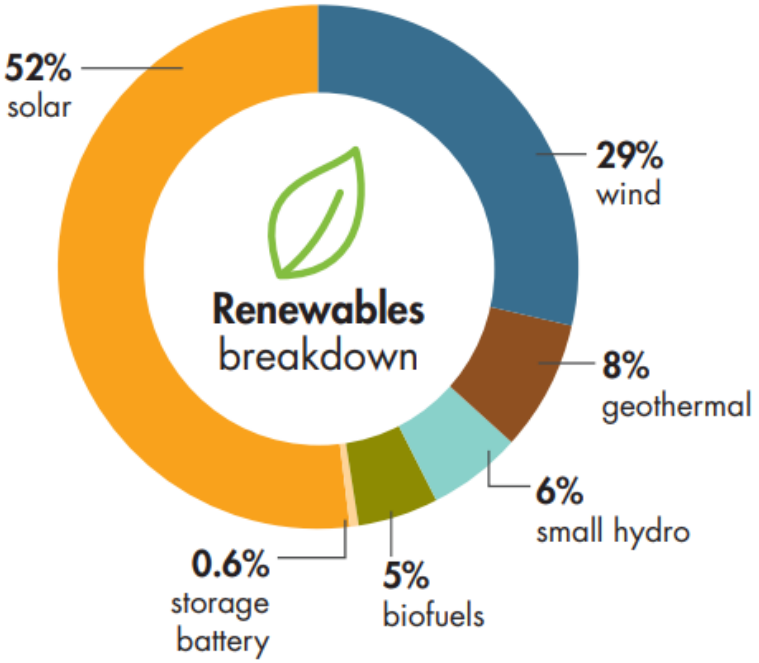


Applications:

- SIBR - Scheduling and Infrastructure Business Rules
- CMRI – California ISO Market Results Interface
- ADS – Automated Dispatch System
- SLIC – Scheduling and Logging for ISO of California – Outages
- MRI-S – Market Results Interface - Settlements



ISO renewable resource mix



	Megawatts
Solar	11,482
Wind	6,295
Small hydro	1,238
Geothermal	1,790
Biofuels	1,013
Storage battery	134*
TOTAL	**21,952**

Renewables served demand
73.9% - May 26, 2018 at 2:12 p.m.

Record peaks

SOLAR (NEW)
10,735 MW - June 8, 2018, 12:33 p.m.

WIND (NEW)
5,193 MW - June 8, 2018, 9:04 p.m.

Major progress on meeting CA's renewable goals

- Currently installed:

  22,000 MW of large-scale renewables
  + 6,000 MW of rooftop solar
  28,000 MW

ISO renewable resource mix

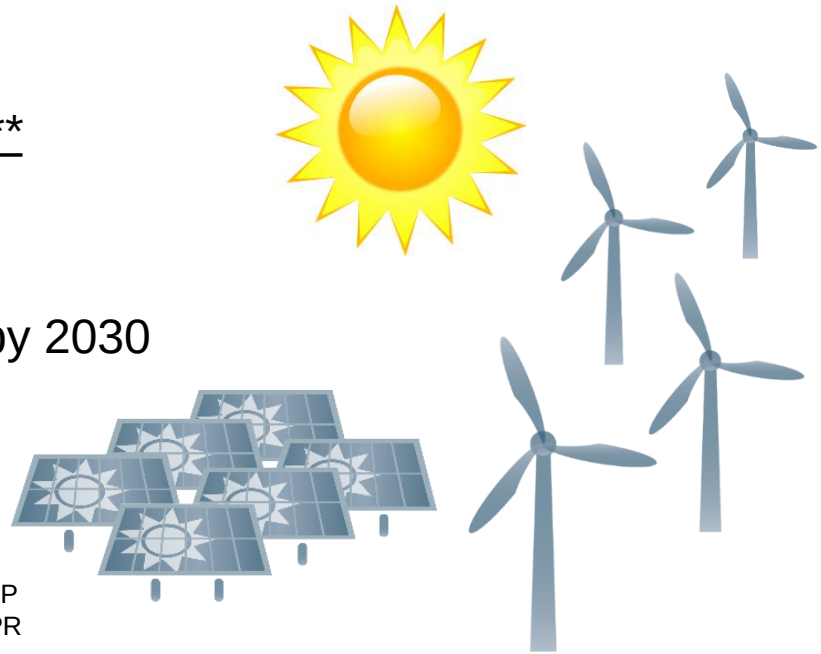
Solar	11,863
Wind	6,467
Small hydro	1,238
Geothermal	1,785
Biofuels	1,002

- Additional renewables by 2030:

  3,300 MW for 50% RPS *
  + 11,400 MW of consumer rooftop solar **
  14,700 MW

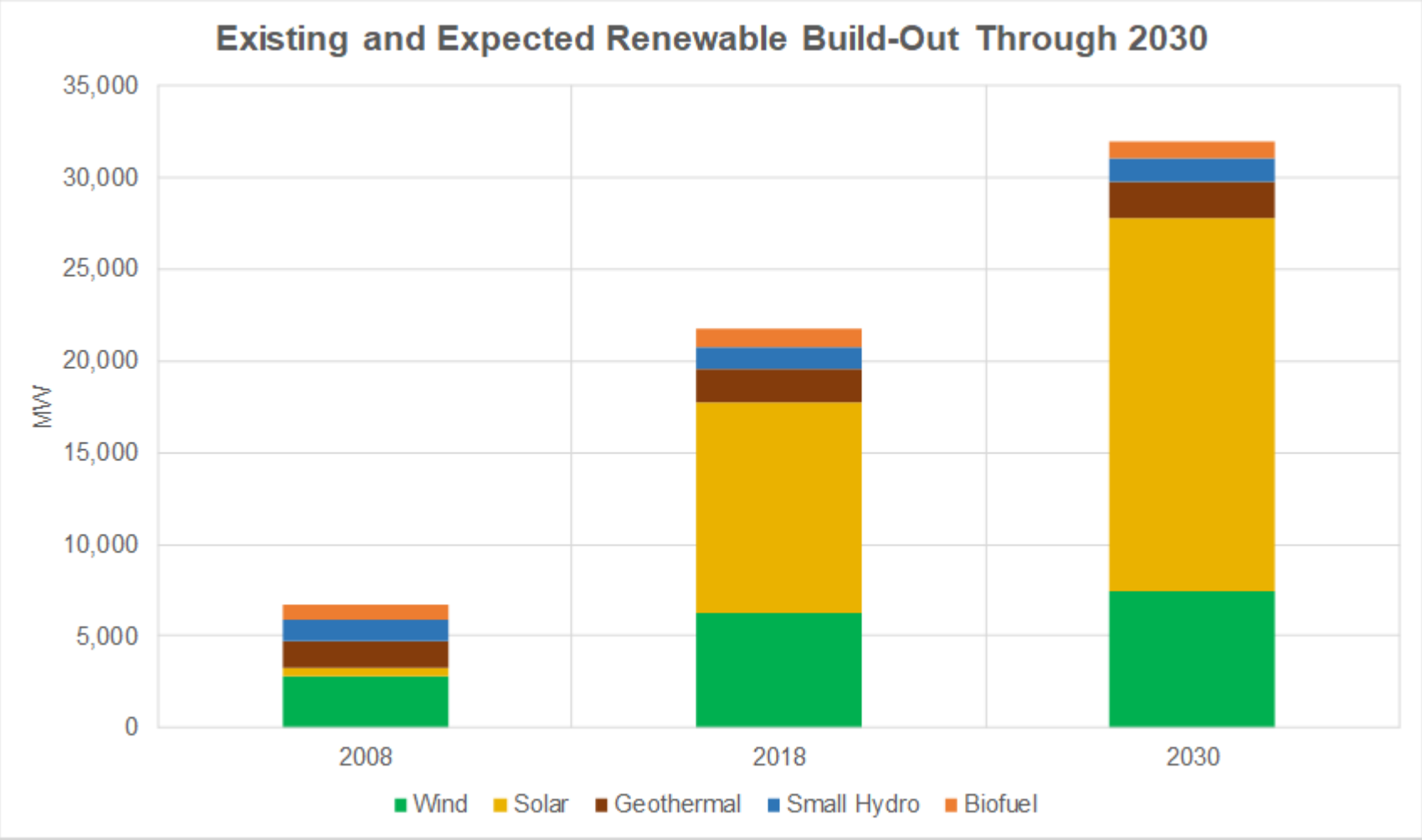
- Approx. **42,000 MW** installed renewables by 2030

- 2018 system peak range:
  24,553 MW - 46,424 MW



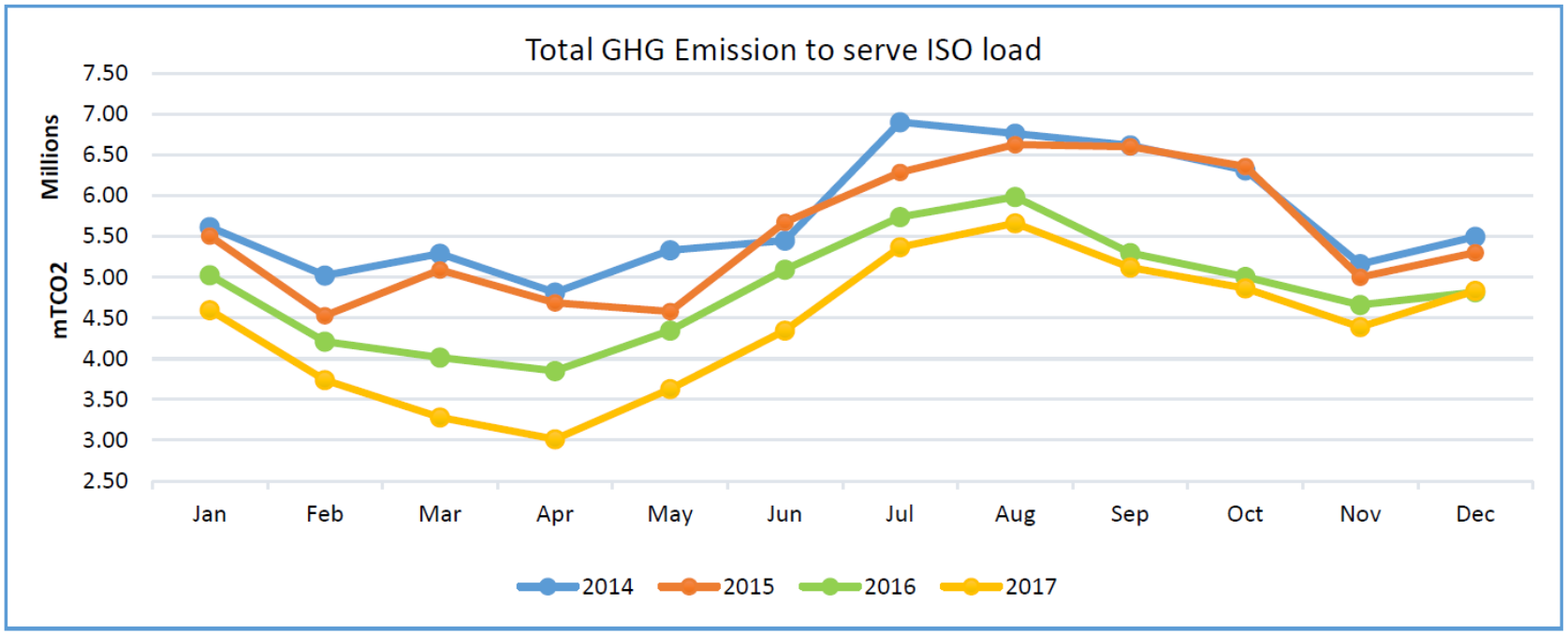
* 2018 CPUC IRP
** 2017 CEC IEPR

Growth of renewables to achieve 60% by 2030 is expected to be largely solar

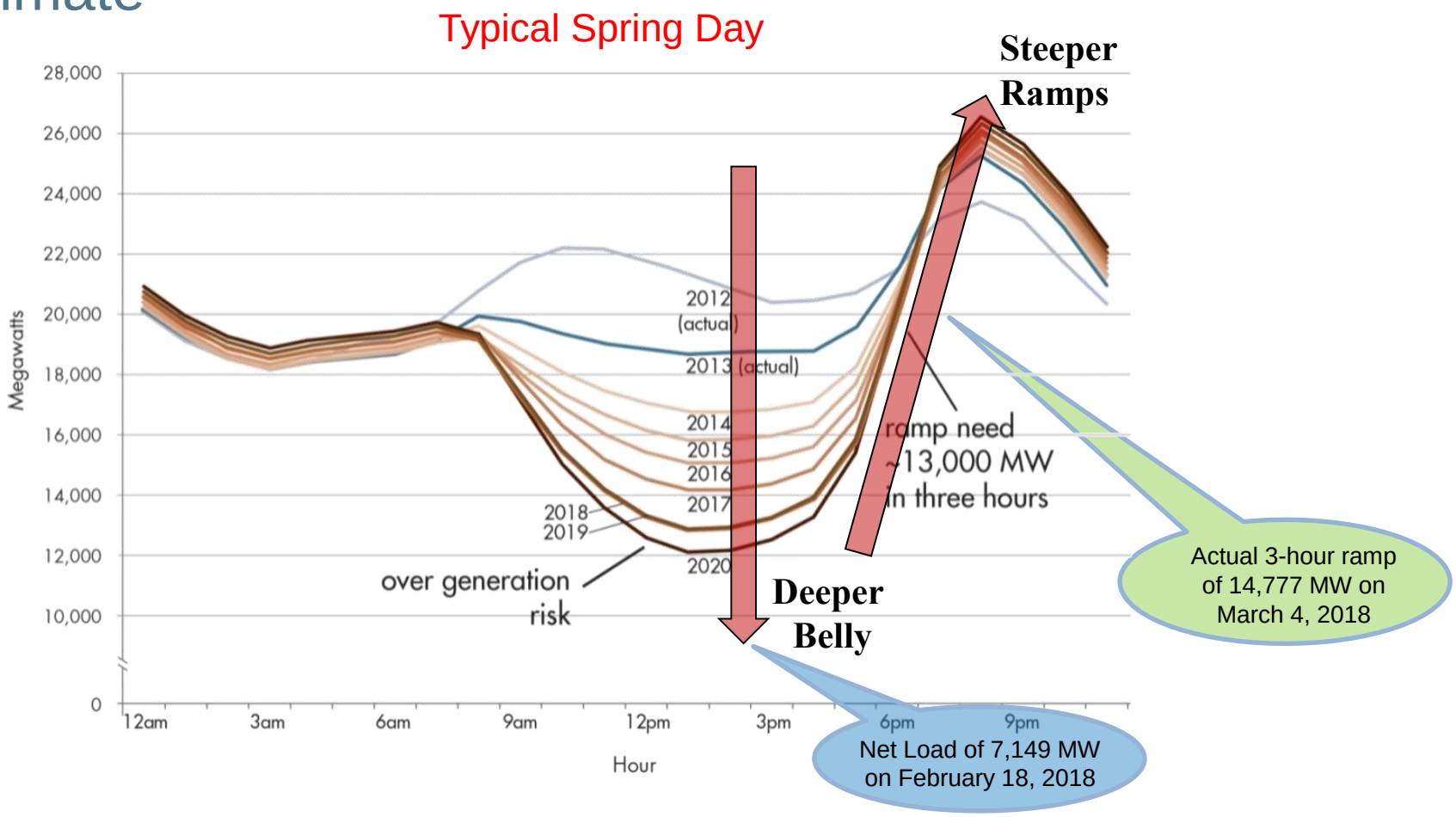


CAISO GHG emissions reduced by 23% since 2014

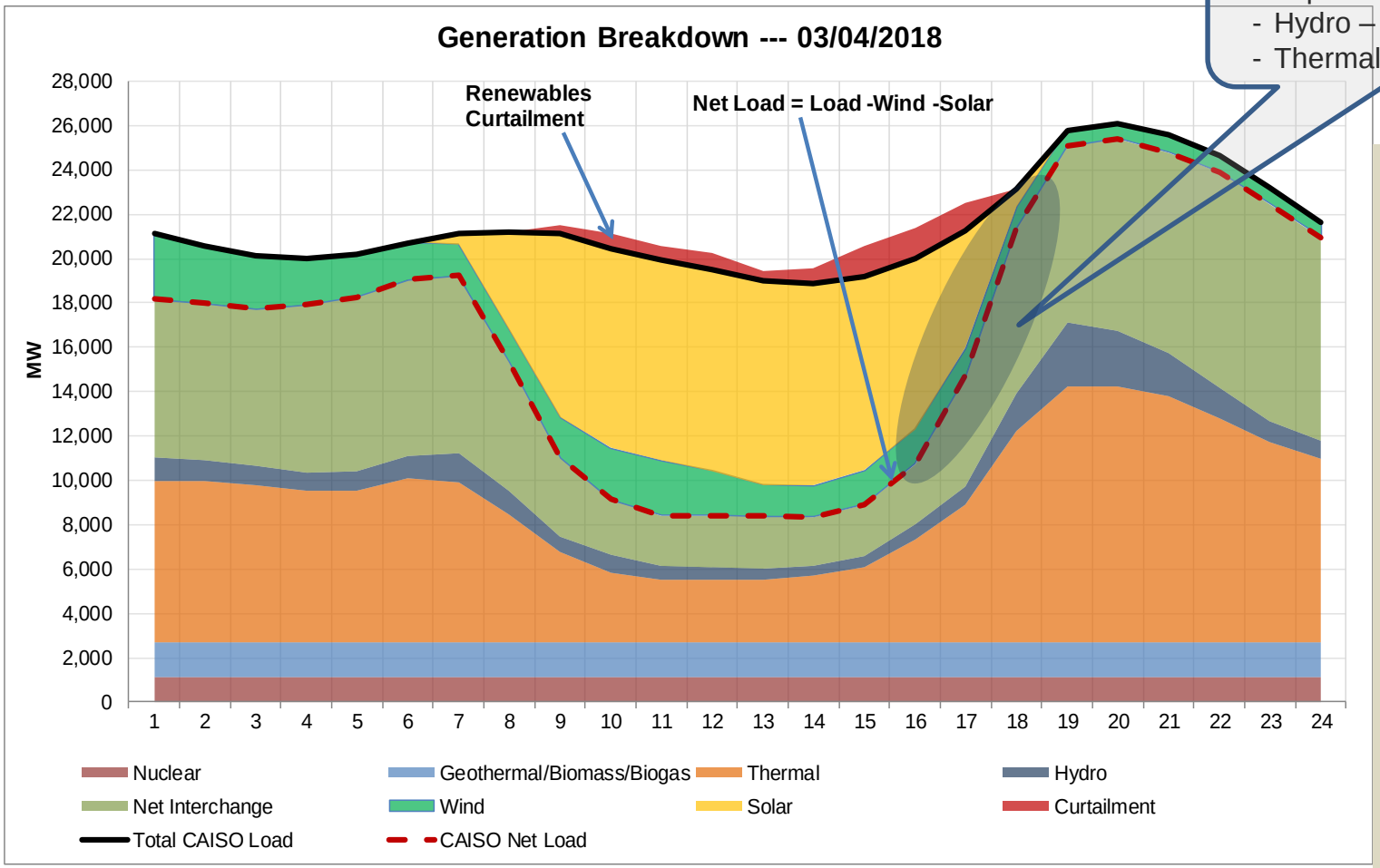
YTD (January - December) million mTCO2	2014	2015	2016	2017
GHG Emission to serve ISO load	68.78	66.24	58.05	52.85



The duck turns 10 years old: Actual net-load and 3-hour ramps are about four years ahead of the CAISO's original estimate



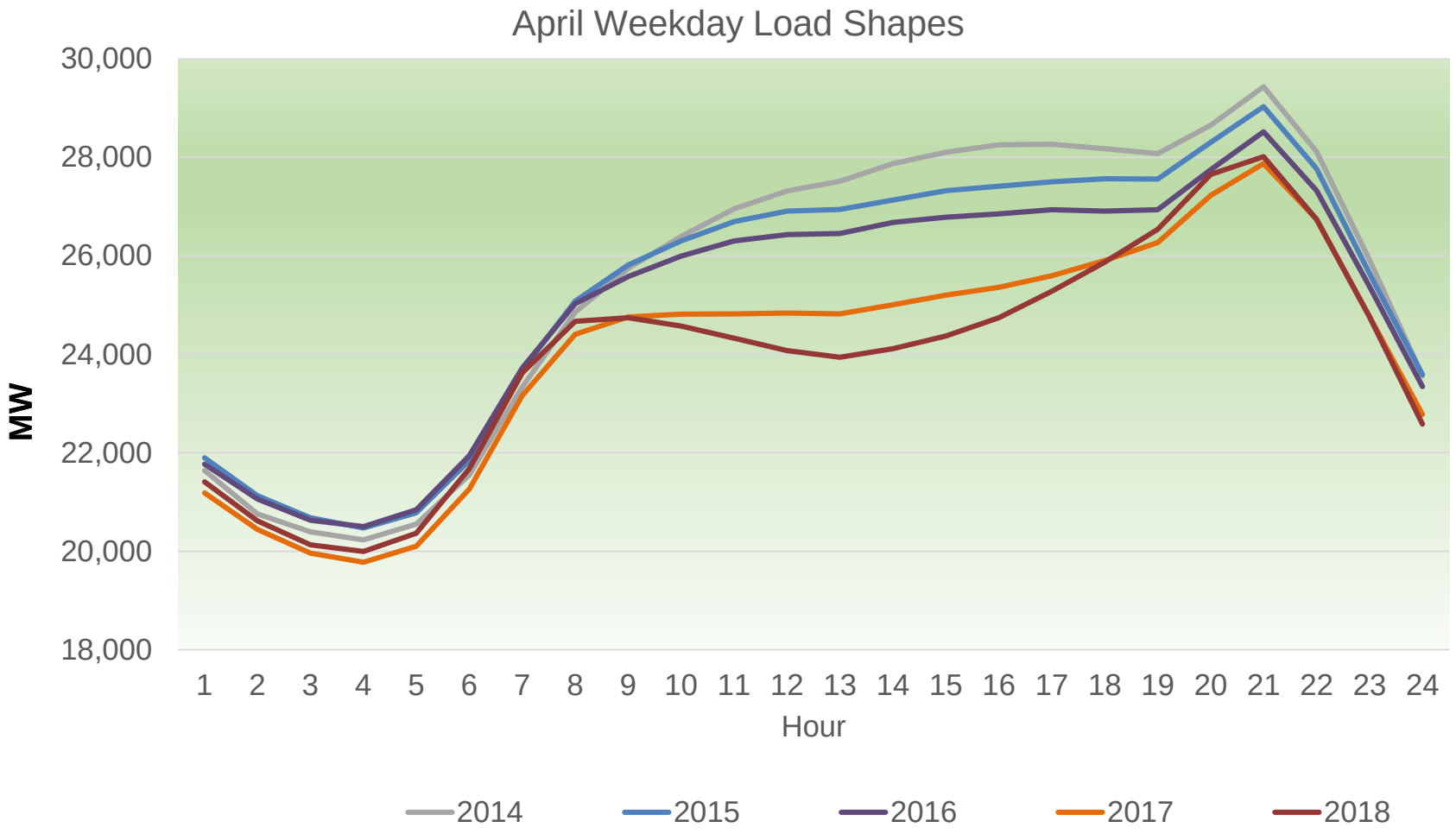
On Sunday, March 4, 2018 the maximum 3-hour upward ramp was 14,777 MW



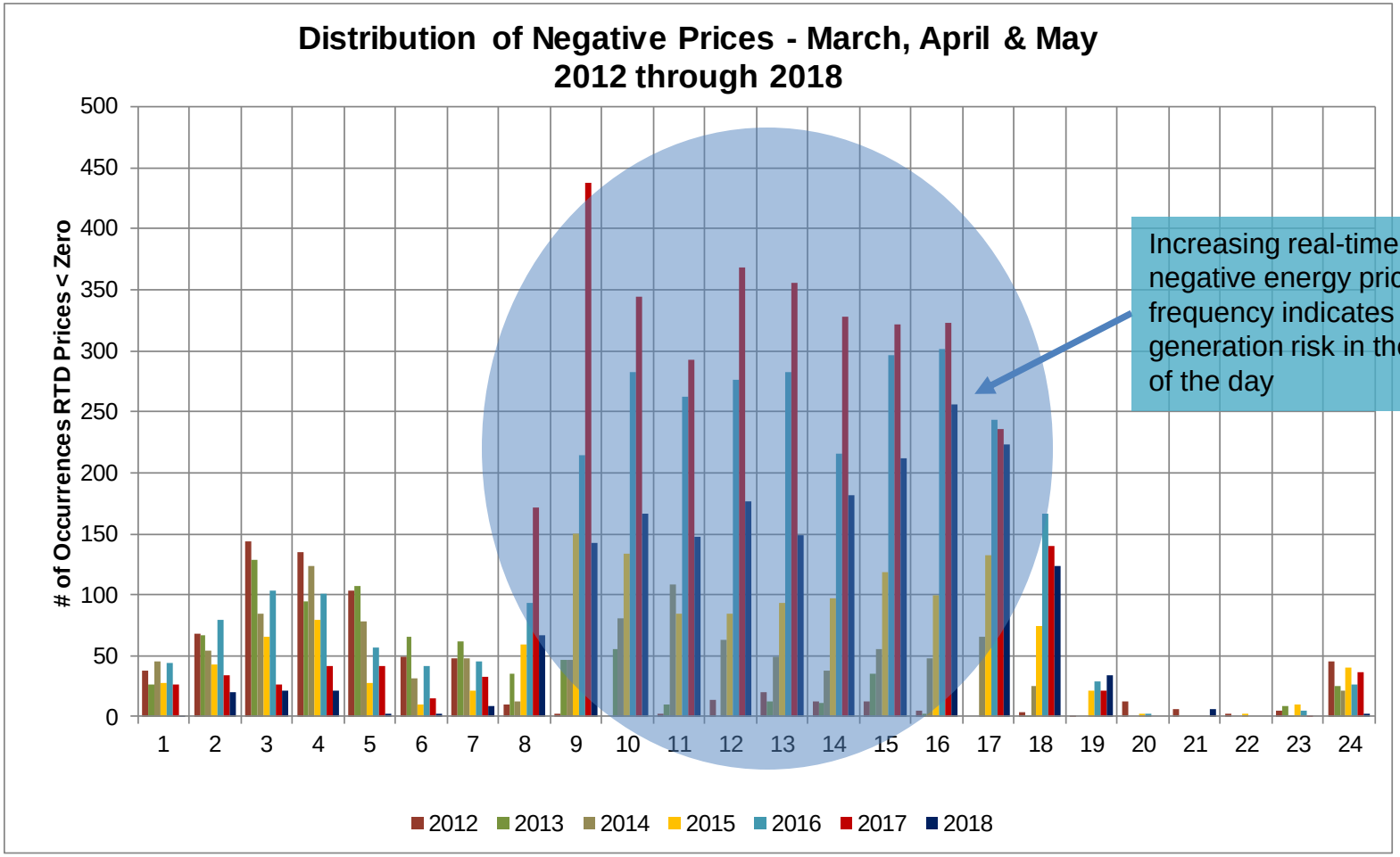
3-hr, 14,777MW ramp met by:
- Import ~ 36%
- Hydro – 15%
- Thermal – 49%

- The CAISO markets economically optimized resources both internally and externally to meet demand
- Imports may or may not be available when needed to meet evening ramps
- Internal resources makes up about 64% of ramp
- Cannot rely on wind to meet ramps

Historical Load Shapes



New price patterns incentivize innovation in responsive demand and storage



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.

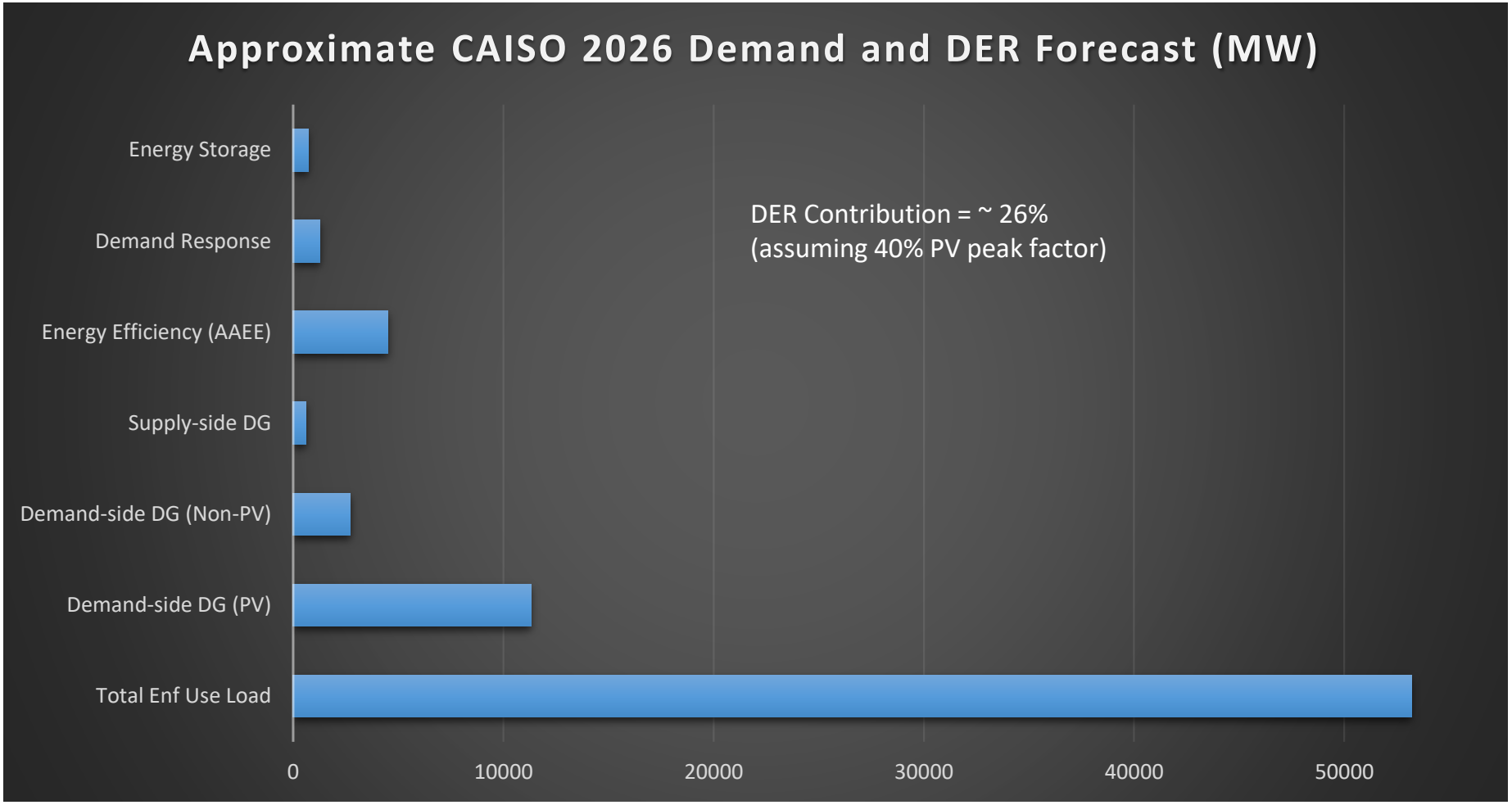
Flexible resources – invest in fast-responding resources that can follow sudden increases and decreases in demand.

DER Types (NERC Reliability Guideline)

- **Utility-Scale Distributed Energy Resources (U-DER):** directly connected to the distribution bus or through a dedicated, non-load serving feeder.
- **Retail-Scale Distributed Energy Resources (R-DER):** Offset customer load. Include residential, commercial, and industrial customers.

- Distributed Energy Resources may include:
  - Distributed Generation – in front or behind the meter
  - Energy Efficiency – load modifier embedded in load forecast
  - Demand Response – demand or supply side
  - Energy Storage – can be modeled as supply or demand side
  - Electric Vehicles

DER in numbers



CAISO's markets are supporting the growth of distributed generation

- When supported by markets, it presents an opportunity for California technology companies

- DER can offer benefits/services to customers, distribution system, and transmission grid:
  - Energy storage can help mitigate oversupply and add flexibility
  - Demand response can reduce the need for conventional resources
  - Micro grids allows participation in ancillary services markets

- Our markets support:
  - Charging and discharging of storage
  - Distributed generation aggregations
  - Distribution-side heterogeneous aggregations of demand and other assets

The four corners to a successful integration of Distributed Resources

Load Shaping

Reliable Operations

Economical fesibility

Resource Adequacy

Distribution connected resources are becoming an increasingly important part of the resource mix

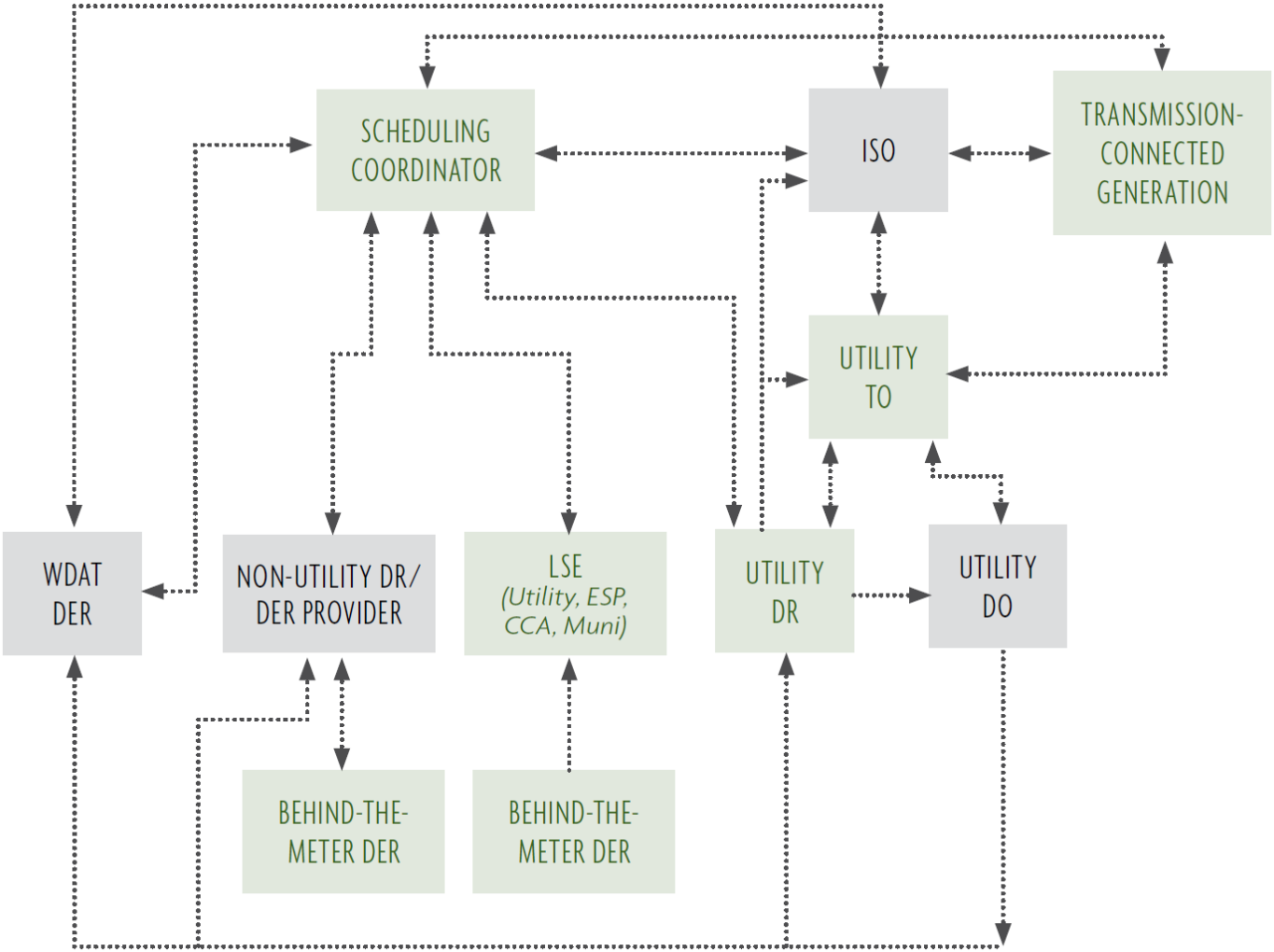
- Significant growth driven by state policies, emerging cost-effective distributed technologies and evolving customer preferences
- Opportunities for DER are expanding: DER can offer benefits/services to customers, distribution system, and transmission grid (i.e., ability to “sell up”)
- Integrating DER into CAISO markets will:
  - Help lower carbon emissions
  - Provide operational benefits

Multiple Use Applications

CAISO has several models for participation of distributed energy resource (DER)

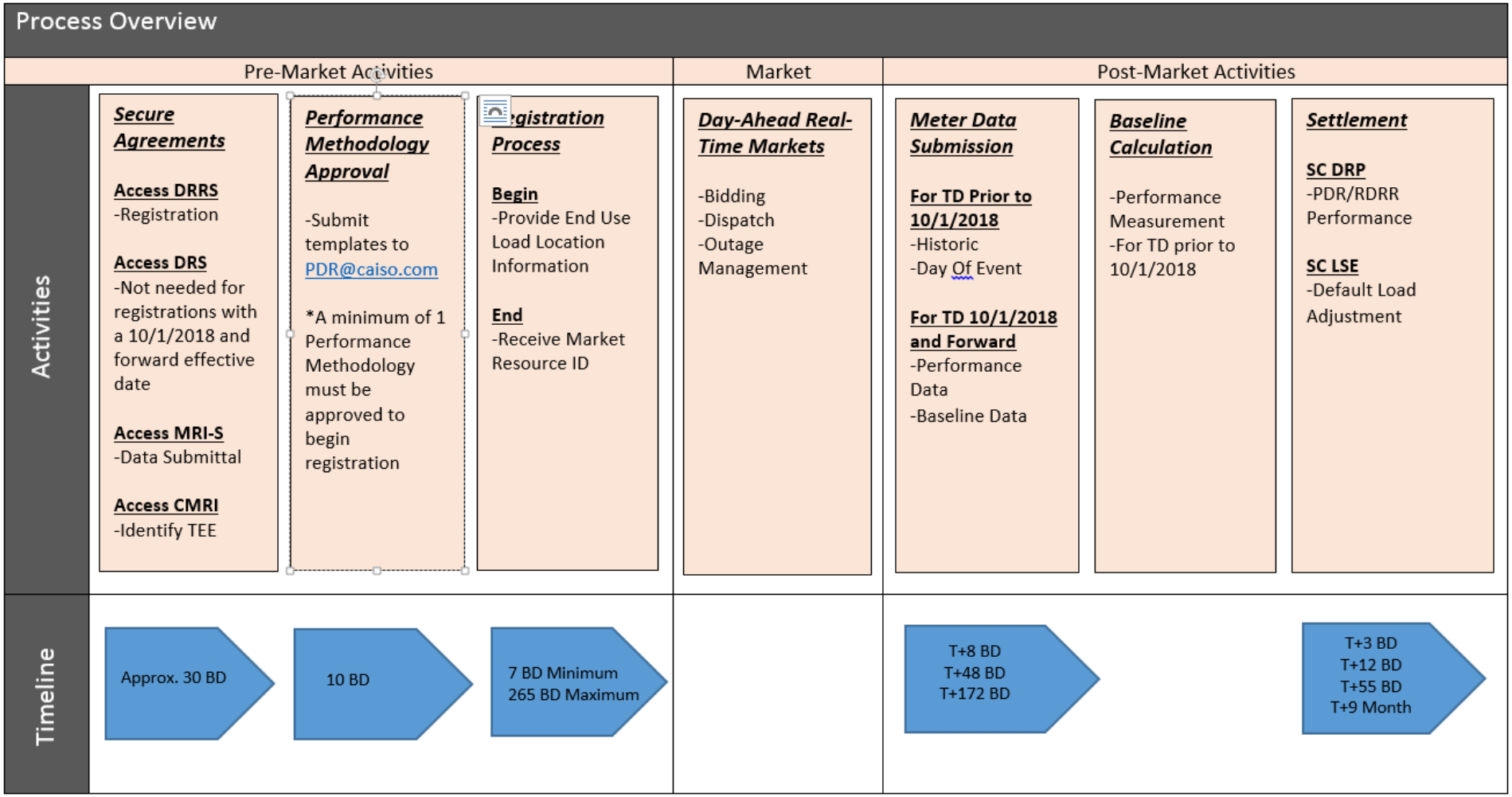
- Proxy Demand Resource, 2010 (PDR) – Distribution
  - Leverages on standard model of generating resources
  - Supplier can aggregate multiple end-use customers to create a virtual supply resource
- Non Generator Resource, 2012 (NGR) – Transmission & Distribution
  - Designed for a resource that can vary between consuming & producing energy (e.g., storage, V2G)
  - The non-generator resource (NGR) participation model recognizes a seamless operation between generation and load
- DER Provider, 2016 (DERP) - Distribution
  - Create a pathway for DERs to be aggregated and meet .5 MW minimum participation requirement
  - Allows aggregations from resources in front of and behind the end-use customer meter

Typical flow of Demand Response Programs*



* Report on Coordination of transmission and distribution operations in a high distributed energy resource electric grid

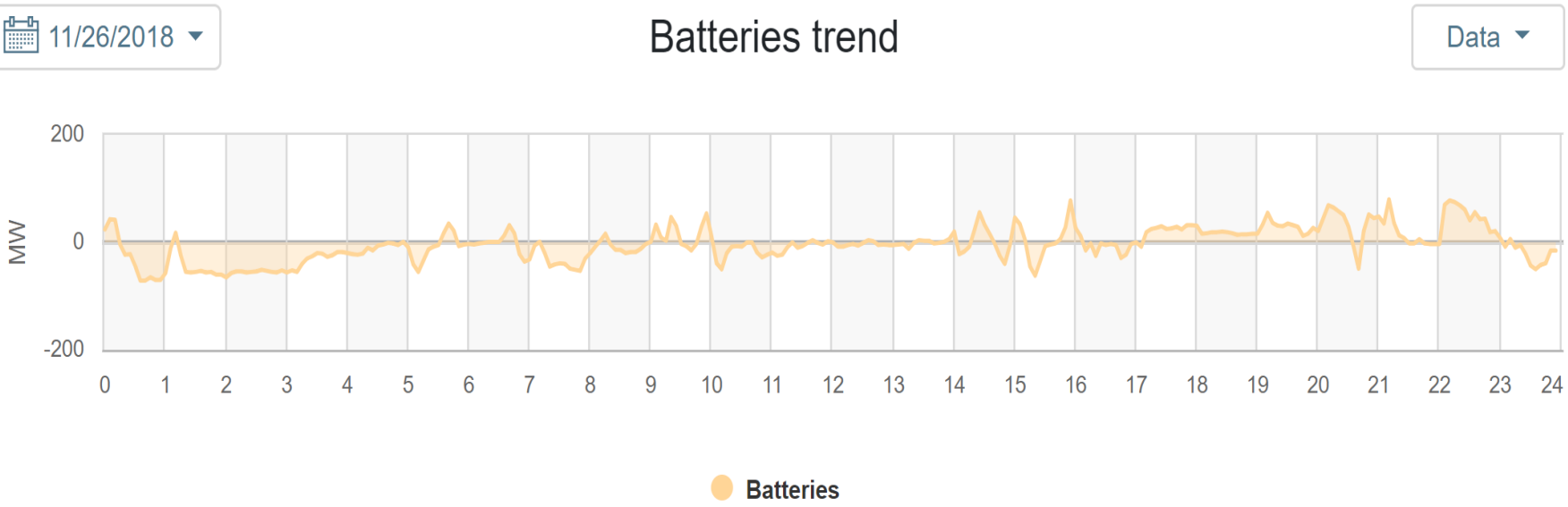
Demand Response process in the ISO's markets



2018 Enhancements contain four proposal elements recently approved by the Board of Governors

1. New bidding and real-time dispatch options for proxy demand resources (PDR)
2. Removal of the single load serving entity (LSE) aggregation requirement
3. New load shift product for behind the meter (BTM) storage
4. Measurement of behind the meter electric vehicle supply equipment (EVSE) load curtailment

Batteries provide great flexibility to the operation of the system



Brewing challenges for the integration of Distributed Resources

- Limited projection and forecasting of conditions
- Lack of situational awareness, observability and controllability
- Coordination between the Transmission and Distribution sides