Distributed Energy Resource and CAISO's Flexibility Needs

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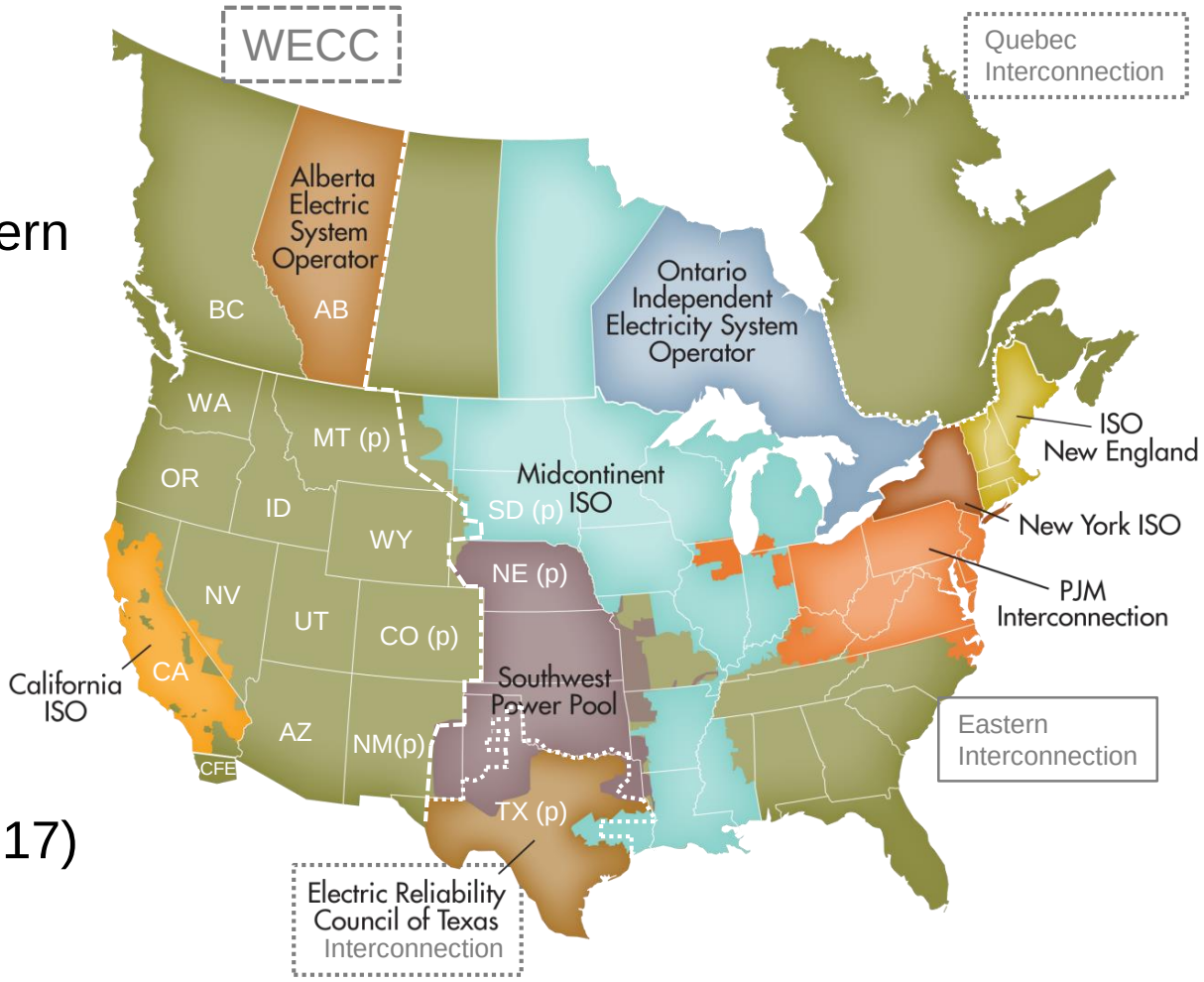
The California ISO

- 2/3 of the U.S. is supported by an ISO
- One of 39 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)



Industry in the midst of unprecedented change
- Driven by fast-growing mix of interrelated issues

Federal Election Impacts

Existing 50% goal

Gas Storage Challenges

NEW 100% goal

Community Choice

Grid Modernization

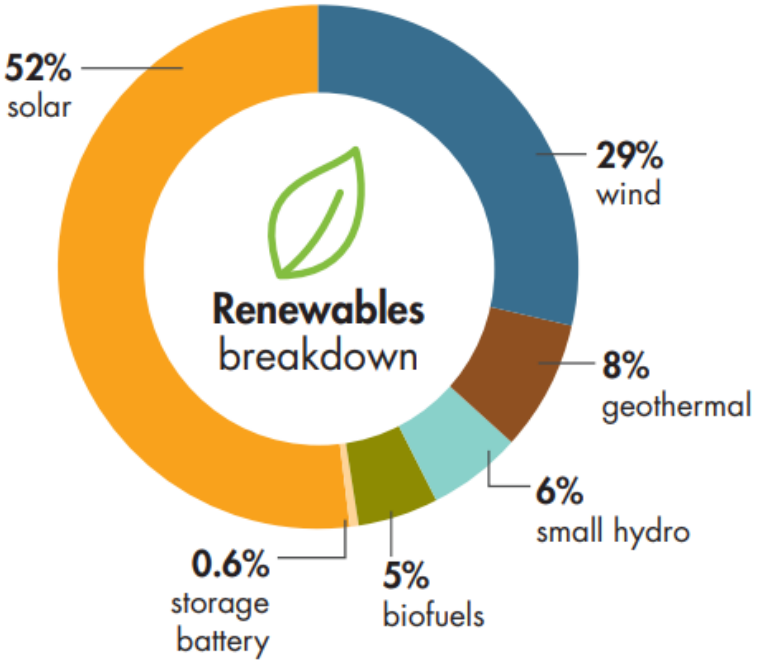
Regional Collaboration

Consumer-owned Power

Fossil Plant Retirements

Transmission & Distribution Systems Interface

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**

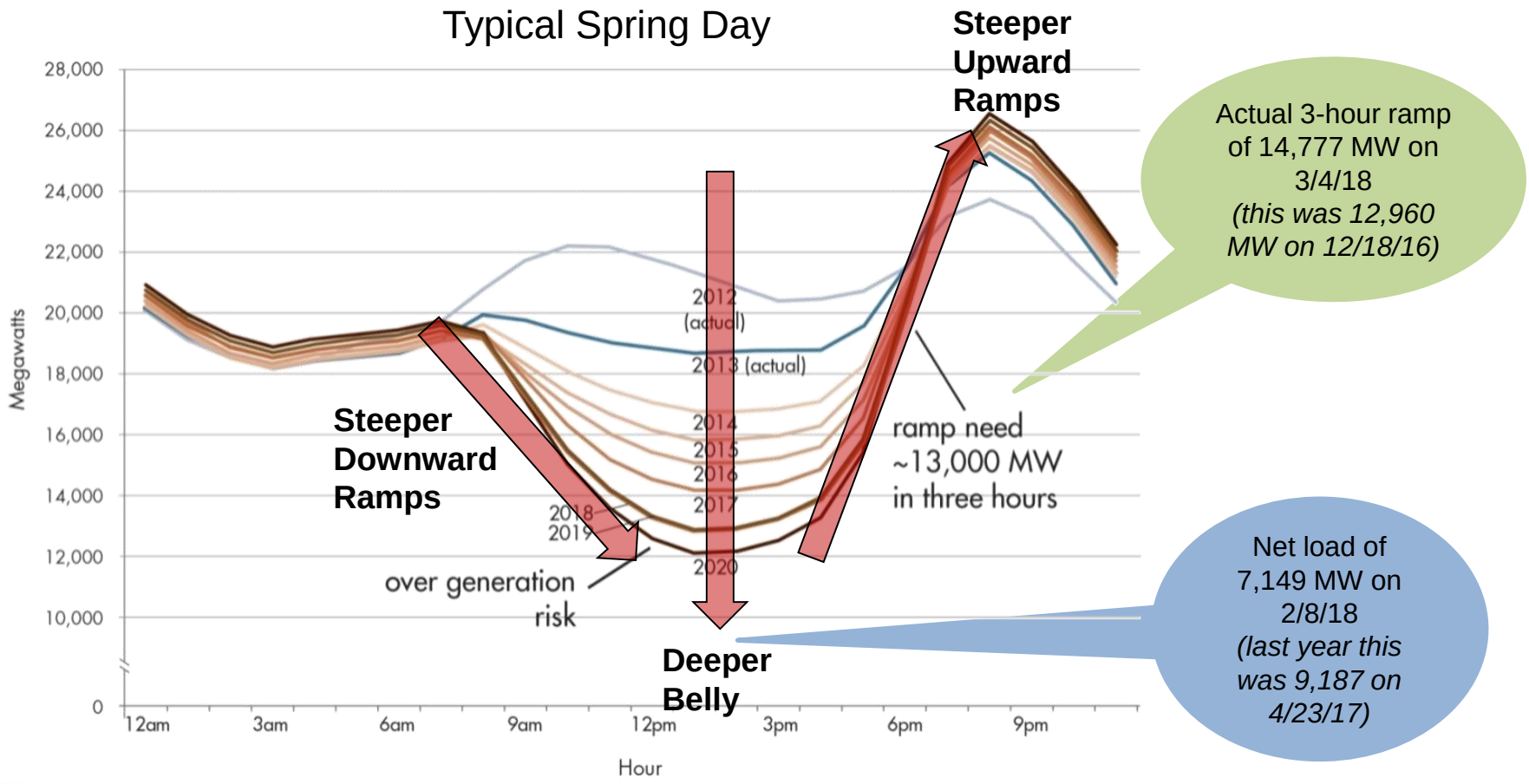
Renewables served demand
73.9% - May 26, 2018 at 2:12 p.m.

Record peaks

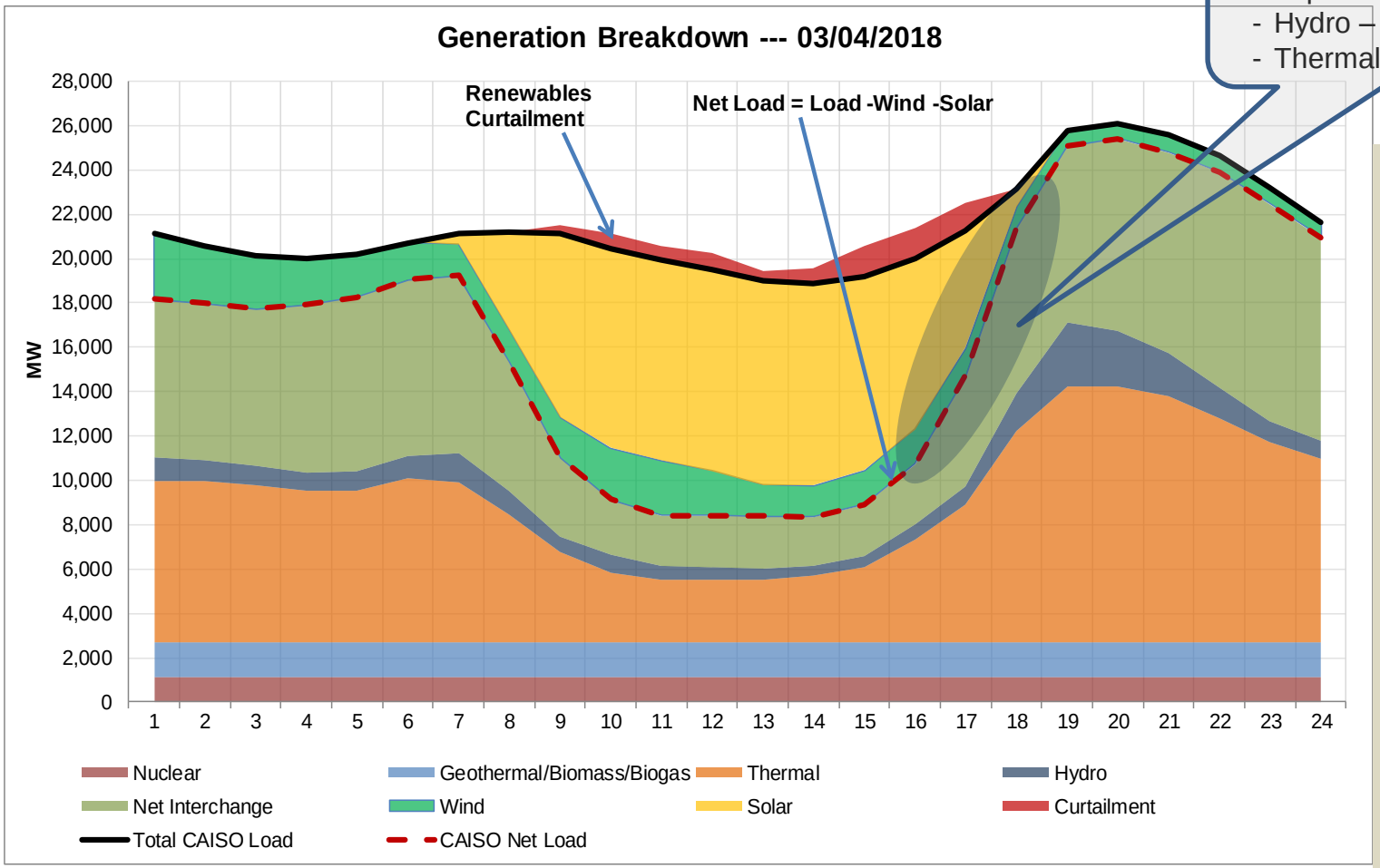
SOLAR (NEW)
10,735 MW - June 8, 2018, 12:33 p.m.

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

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



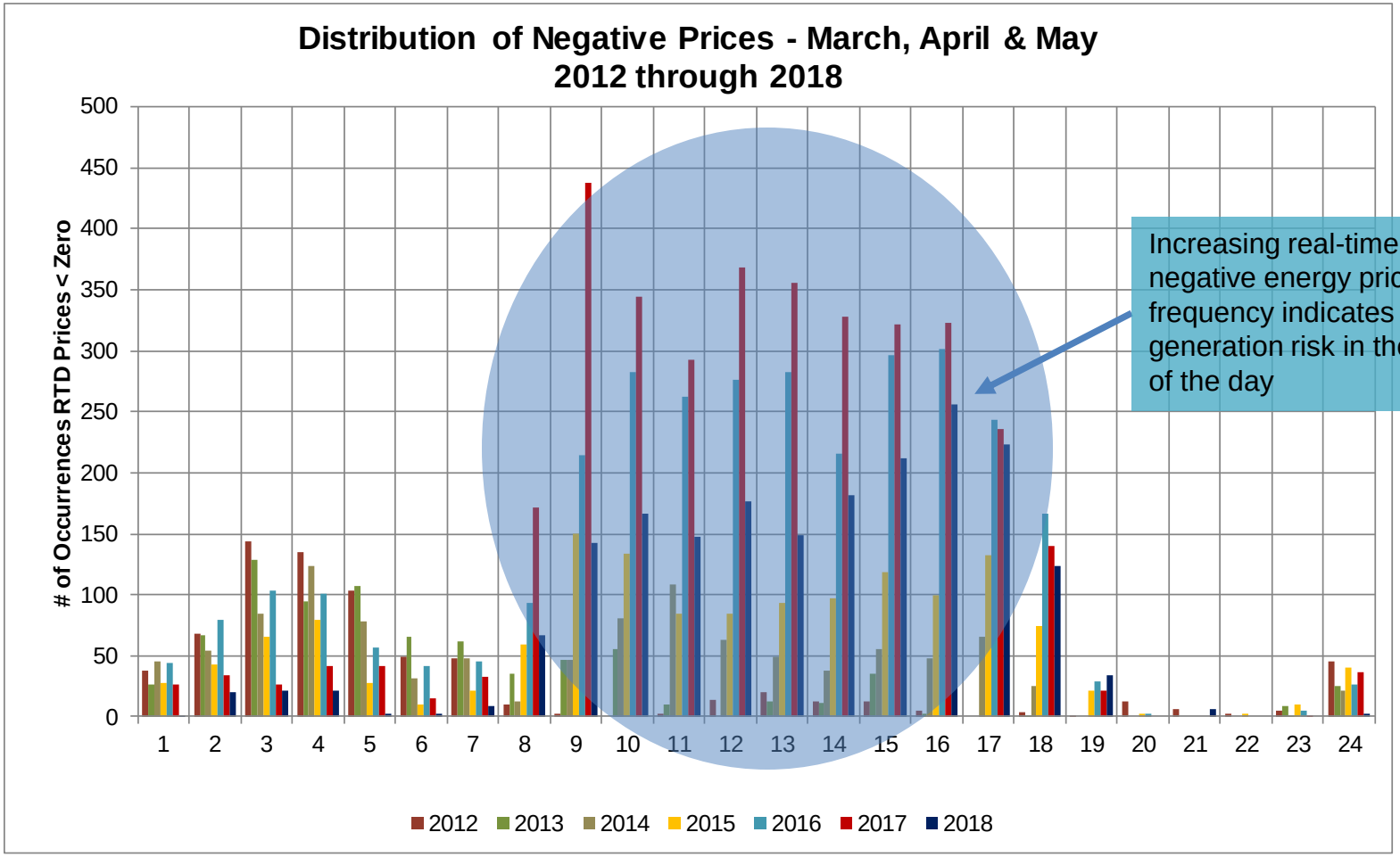
On Sunday, March 4, 2018 the maximum 3-hour upward ramp was 14,777 MW



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

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.

The ISO, First Solar and NREL demonstrated how a 300 MW solar PV plant can provide essential reliability services

	Test	Performance
Ramping	• Ramp its real-power output at a specified ramp-rate	
	• Provide regulation up/down service	
Voltage	• Provide reactive power support in various modes - Control a specified voltage schedule - Operate at a constant power factor - Produce a constant level of MVAR - Provide controllable reactive support (droop setting) - Capability to provide reactive support at night	
Frequency	• Provide frequency response for low frequency and high frequency events - Control the speed of frequency response - Provide fast frequency response to arrest frequency decline	

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

The ISO has several models for energy storage and distributed energy resource (DER) participation

- Proxy Demand Resource, 2010 (PDR) – Distribution
  - Supplier can aggregate multiple end-use customers to create a virtual supply resource
  - May involve other DER types behind customer meter, but will not be settled in market for net energy injection to the system (load offset only)
- 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

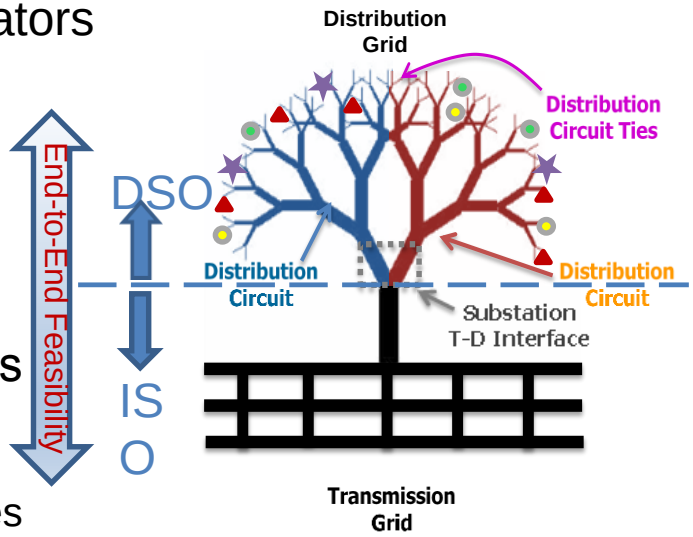
Industry transformation is driven from the bottom up

- DER growth is driven by customer demand & adoption

- The new paradigm features
  - Substantial local supply to meet local demand
  - Multi-directional, reversible flows on distribution system
  - Multi-use DER provide services to customers, distribution and transmission domains
  - New challenges for distribution operations, planning & interconnection

Rapid DER deployment spurs the need for enhanced coordination at the T&D interface

- Diverse end-use devices and diverse owners/operators affect:
  - Load shapes, peak demand, total energy consumption
  - Energy flows, voltage variability, phase balance
  - Variability and unpredictability of net loads and grid conditions
- CAISO "sees" DER as if located at T&D substations
  - No ISO visibility to distribution grid conditions/impacts
  - Distribution utility is unaware of DER bids and dispatches
- DER providing services to customers and the distribution system affects the T&D interfaces
  - Need accurate operational forecasting and local management of DER variability to ensure end-to-end feasibility



New control and coordination needed at the T-D Interface

In summary, planning for future needs to include impact of high DER penetration

- Enhanced operations coordination at Transmission–Distribution interfaces
  - Communication
  - Technology to streamline coordination
- Resource visibility and modeling
  - Real-time aggregate metering
  - Dynamic distribution of resources
- Forecasting
  - Quantity and location of resources
  - Enhance load forecast methods

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