


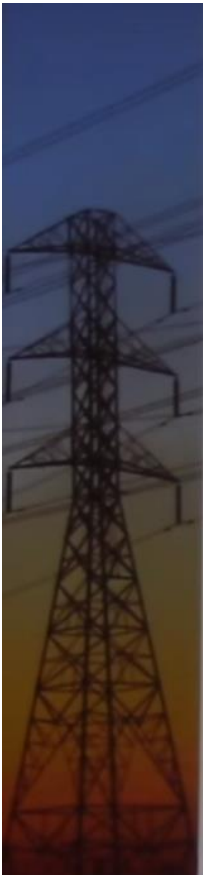
An Introduction to Operations

DayAhead and RealTime Operations in the Ca



Agenda

- 1.Introduction
- 2.Who Am I and What Do I Do
- 3.California ISO Overview
- 4.DayAhead Market
- 5.RealTime Market
- 6.Future of the CAISO
- 7.Q&A



Who Am I/What I Do

WHO:

I am a Senior Day Ahead Analyst for the Short Term Electric Supply Team within Pacific Gas and Electric's Energy Policy and Procurement division.

- B.S. in Mechanical Engineering from SDSU
- M. Eng. in Energy Systems Engineering from Lehigh University
- Lehigh Capstone Project: Micro Hydro for Acid Mine Drainage (PPL)

WHAT:

I am one of two primary hydroelectric power schedulers who bid, schedule and optimize our vast fleet of hydro resources into the CAISO markets.

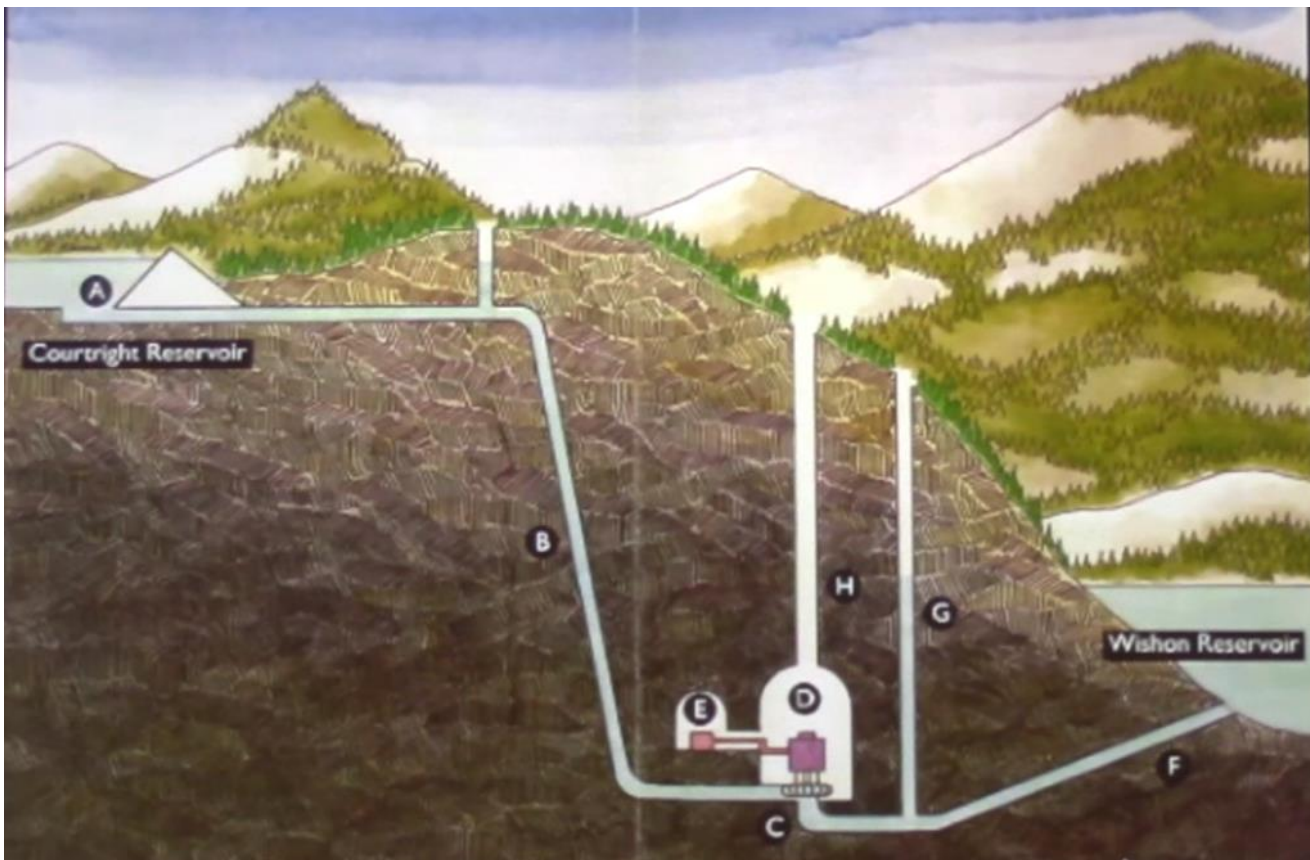
- Optimize our hydro fleet to determine whether to use water for the next day or hold the water for later use
- Bid and Schedule a diverse fleet of thermal, hydro, solar, wind, biomass and storage resources into the CAISO DayAhead market.
- Serve as a primary process improver within both the DayAhead and RealTime scheduling processes.



Who Am I/What I Do



Pumped Hydro is pumping water uphill to use later, we do this during pricing period to make money while also making money from the grid operators



Energy Procurement Operations

Safety, Reliability & Affordability

Day Ahead

- Price and load forecasting
- Daily optimization of diverse resource portfolio, including large complex hydro systems
- Schedules and bids power plants and retail customer load into the CAISO market

Real Time

- Responds to dispatch instructions across diverse portfolio fleet every 5 minutes
- Quickly reacts to rapidly changing operating conditions to ensure system reliability
- Oversees Alternative Headquarters / Emergency Preparedness

- Long Term Hydro Optimization
- Coordinate Generator Outages
 - Daily compliance
 - IT Systems Management
- Advise Long-Term Planning, Policy, and Procurement

Where is the pricing and load going to go today and tomorrow? We need to collect CAISO data that tries to maintain grid load at 60Hz



CAISO Overview

CALIFORNIA ISO ENERGY MARKETS



In the US, there are 9 Intermediate markets for bidding supply and demand for electricity, they are not-for-profits

California Independent System Operator (CAISO)

CAISO created in 1998 as the independent administrator of the electric transmission system and electric power markets



- 26,000 circuit miles
- 50,000 MW peak demand
- Supporting 30 million people
- Manages 80% of CA & small part of NV
- 28,000 Market Transactions/day

The California ISO



- Trading Hubs Divided Into Three Regions
- NP15 is PG&E
- ZP26 is PG&E and SCE
- SP15 is SCE and SDG&E

From a merchant and market standpoint that is purely financial, these are the trading hubs in CA that we trade in.

Generation Portfolio

DIABLO CANYON NUCLEAR



COMBINED CYCLE (MSG)

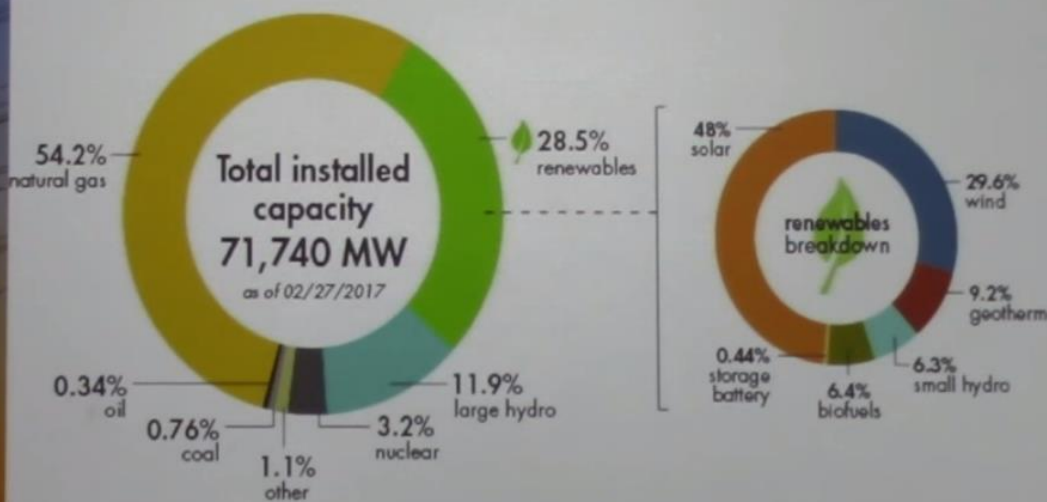


NATURAL GAS PEAKER UNITS



UTILITY SCALE WIND

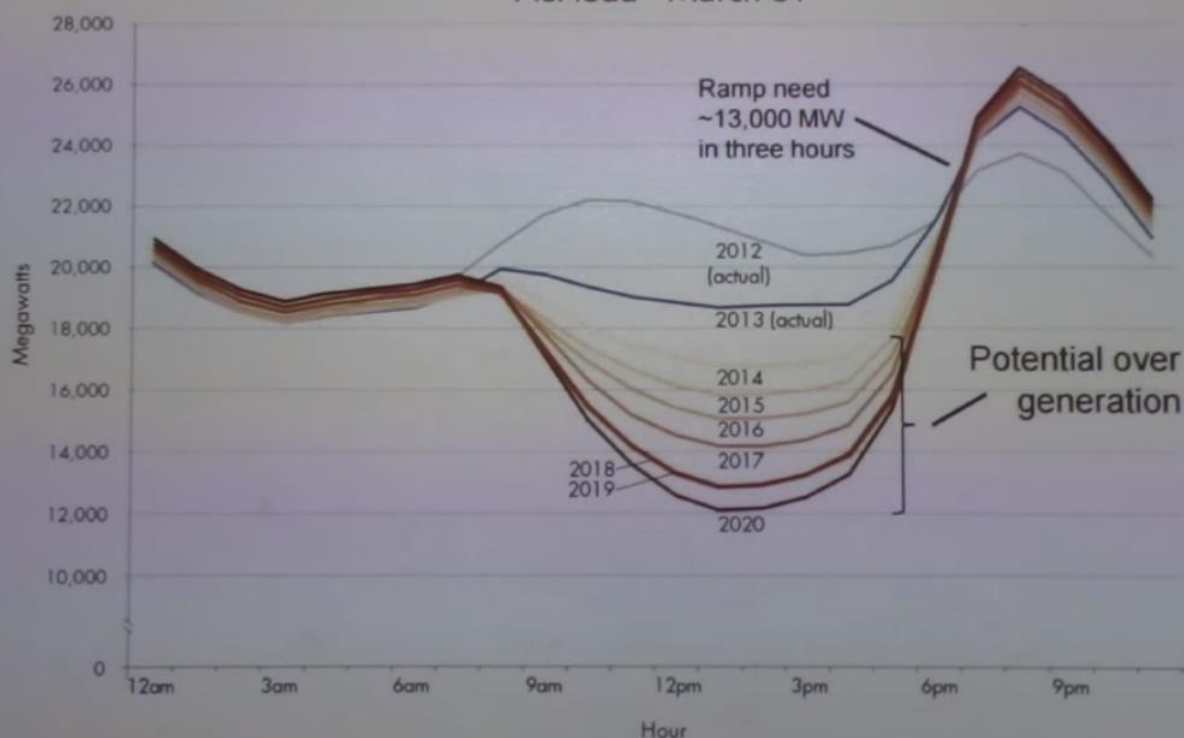
Generation Portfolio



Note: not all capacity is available for immediate dispatch due to outages or not being scheduled

This is an overview of CAISO in CA

Net load - March 31



The CAISO's Markets

Day Ahead (Integrated Forward Market)

- The CAISO's day ahead market provides market participants with the opportunity to contract financially for the buying and selling of energy and ancillary services for the following day.
- Includes both physical bids and virtual bids (financial only)
- Ancillary services are operating reserves (spinning/non-spinning) and regulation (up/down), and are procured as capacity held in reserve for real-time
- Creates foundation of resources to meet demand in Real Time

Day Ahead (Residual Unit Commitment)

- If scheduled capacity based on IFM results is less than the CAISO's forecast of demand, additional capacity is allocated

Real Time

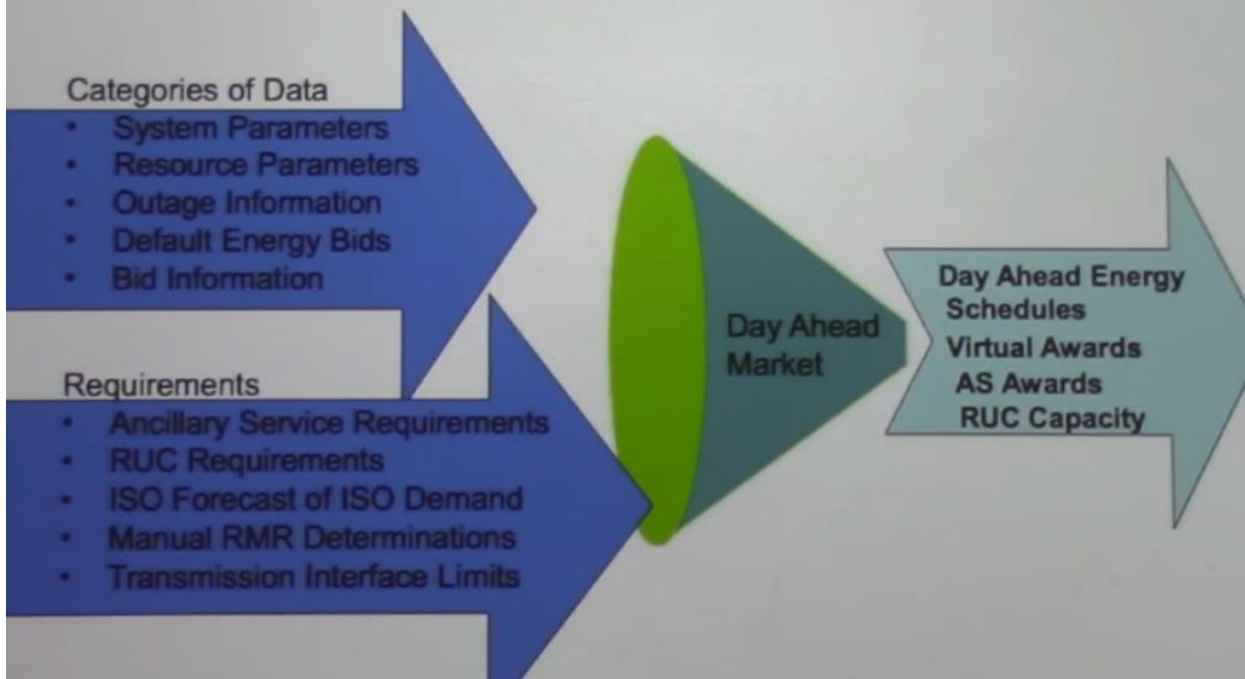
- Incremental resources bid or scheduled into the CAISO market 75 minutes before electrons flow
- Resources committed or de-committed based on CAISO estimates of load
- Includes interties and CAISO system resources
- Schedules awarded every 15 and 5 minutes



The DayAhead Market

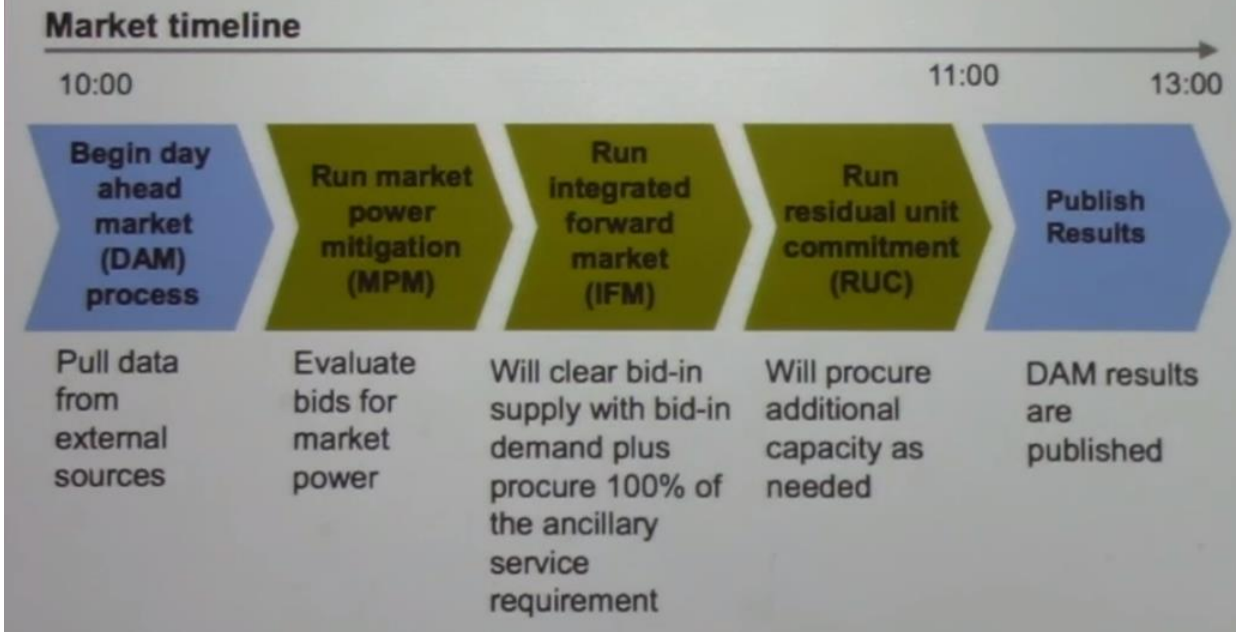
CALIFORNIA ISO ENERGY MARKETS

DayAhead Process



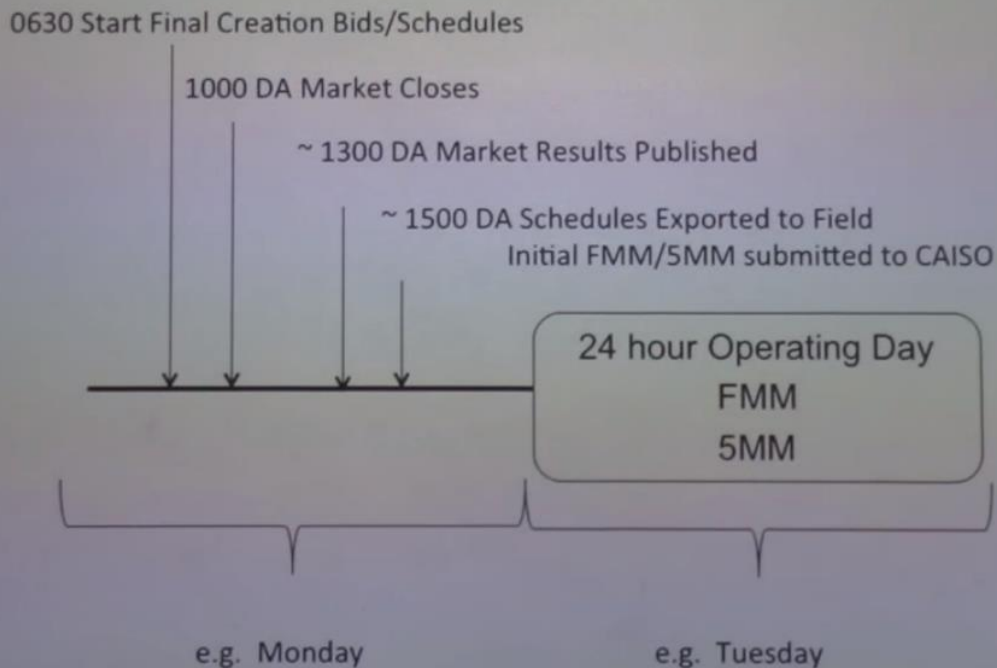
We usually send all our energy bids, information like outages for every unit to the ISO. The ISO then runs network model and get the day-ahead generation schedule for each generating unit that is purely financially binding.

DayAhead Process

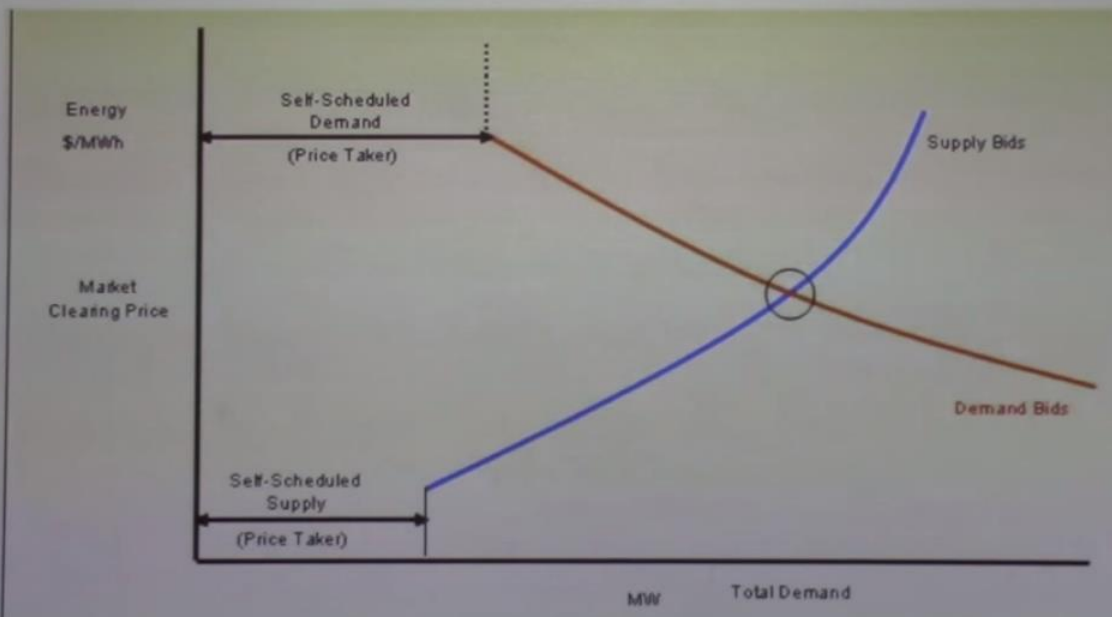


We need to submit all our production schedule for the next day to CAISO by 10AM so that they can make their day-ahead generation schedule in the IFM with results published at around 1PM.

Day Ahead Market - Timeline

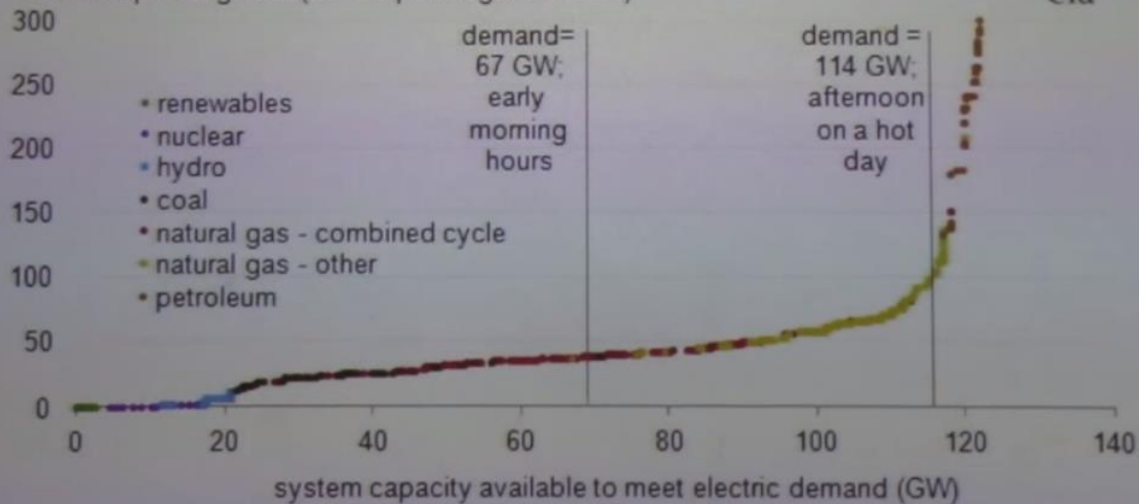


Supply and Demand



Example Energy Resource Bid Stack

Hypothetical dispatch curve for summer 2011
variable operating cost (dollars per megawatthours)

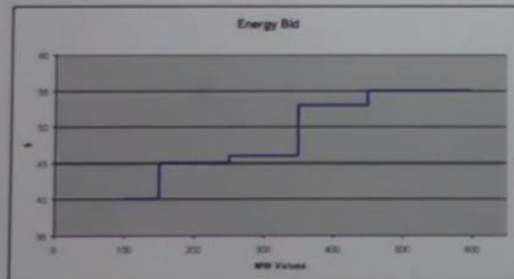


Example Energy Resource Bids

Provides the CAISO an economic signal when what participant is willing to accept or pay for energy in the Day Ahead Market

SUPPLY

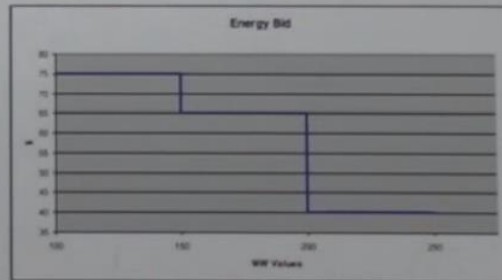
Up to 10 segments,
monotonically INCREASING



Supply Resource

DEMAND

Up to 10 segments,
monotonically DECREASING

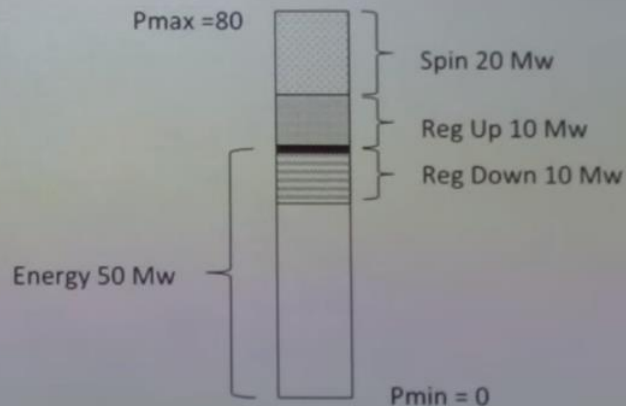


Demand Resource

CAISO Markets

•Energy and A/S Products

- Energy
- RUC (Residual Unit Commitment)
- Regulation Up
- Regulation Down
- Spin
- Non-Spin



Typical DA Merchant Operations

Renewable Bidding / Optimization

- To economically bid/schedule renewable resources into CAISO markets

Unit Commitment & Economic Dispatch Models

- Dispatch resources prior to CAISO DA market

Curtailment Models

- Optimize curtailment rights on must take resources

Import Scheduling Models

- Optimize imports rights

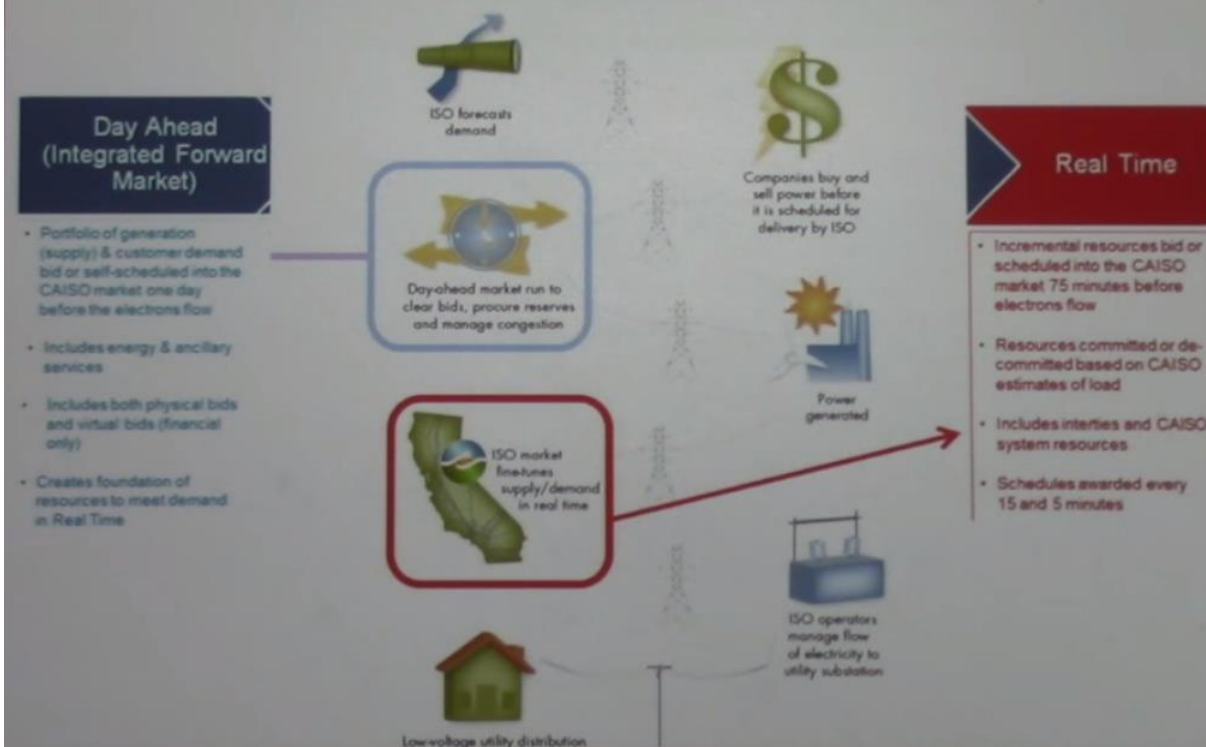
Demand Response Bidding Optimization

- Economically bid DR resources into CAISO markets

Battery Optimization

- Bidding Strategy

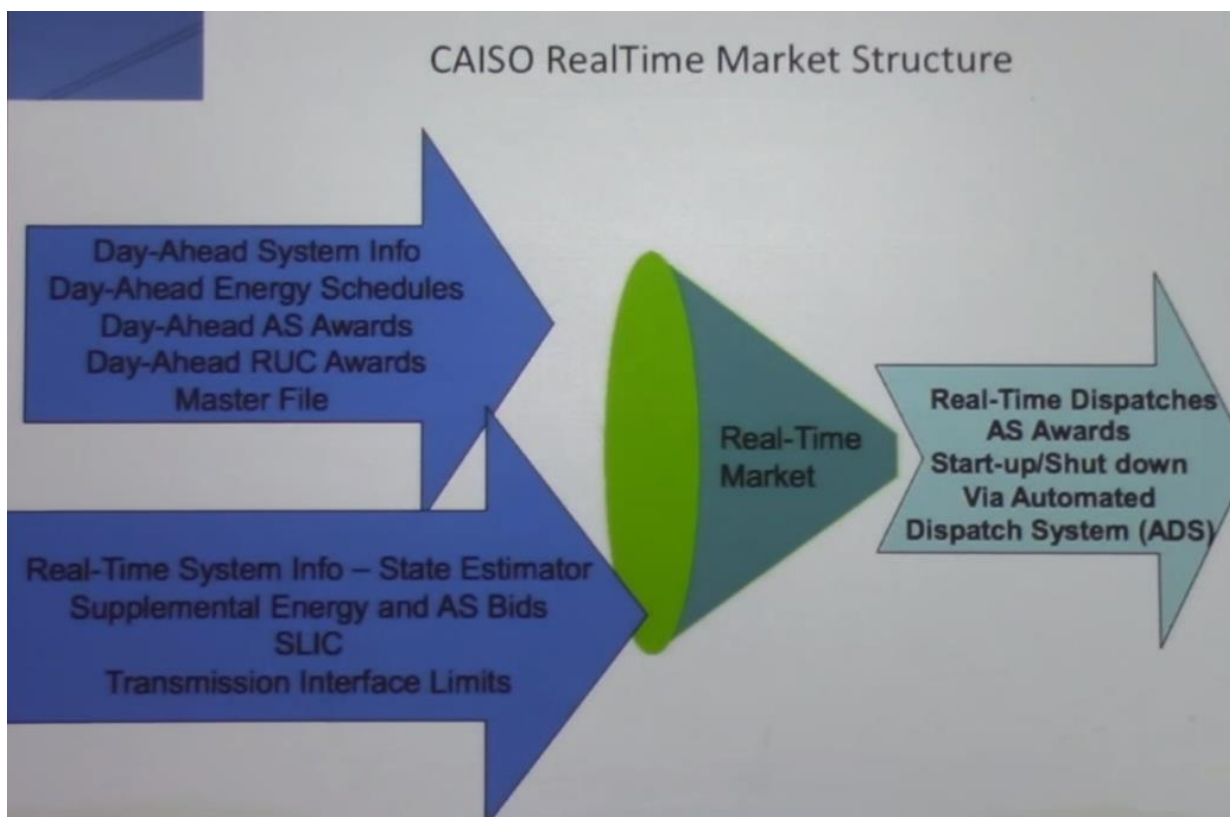
How power flows in California





The RealTime Markets (15 Minute and 5 Minute)

CALIFORNIA ISO ENERGY MARKETS



All the day-ahead information from the 1PM generation schedule become inputs for the real-time market structure

CAISO Energy/Ancillary Service Markets

15 Minute Market (FMM)

- Runs every 15 minutes
- Bids due 75 minutes before the operating hour
- FMM Energy and Ancillary Service schedules and prices
- Financially binding only

5 Minute Market (RTD)

- Runs every 5 minutes
- Same bids as used in FMM
- Produces 5MM Energy schedules and prices (No A/S)
- Physically binding

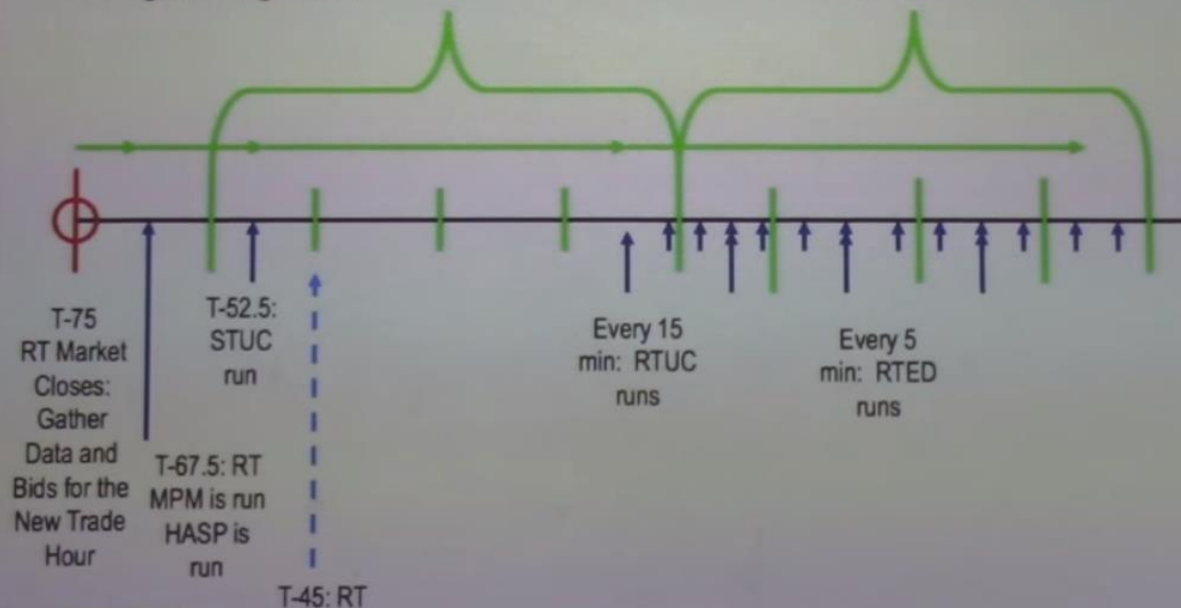
Dispatch Types

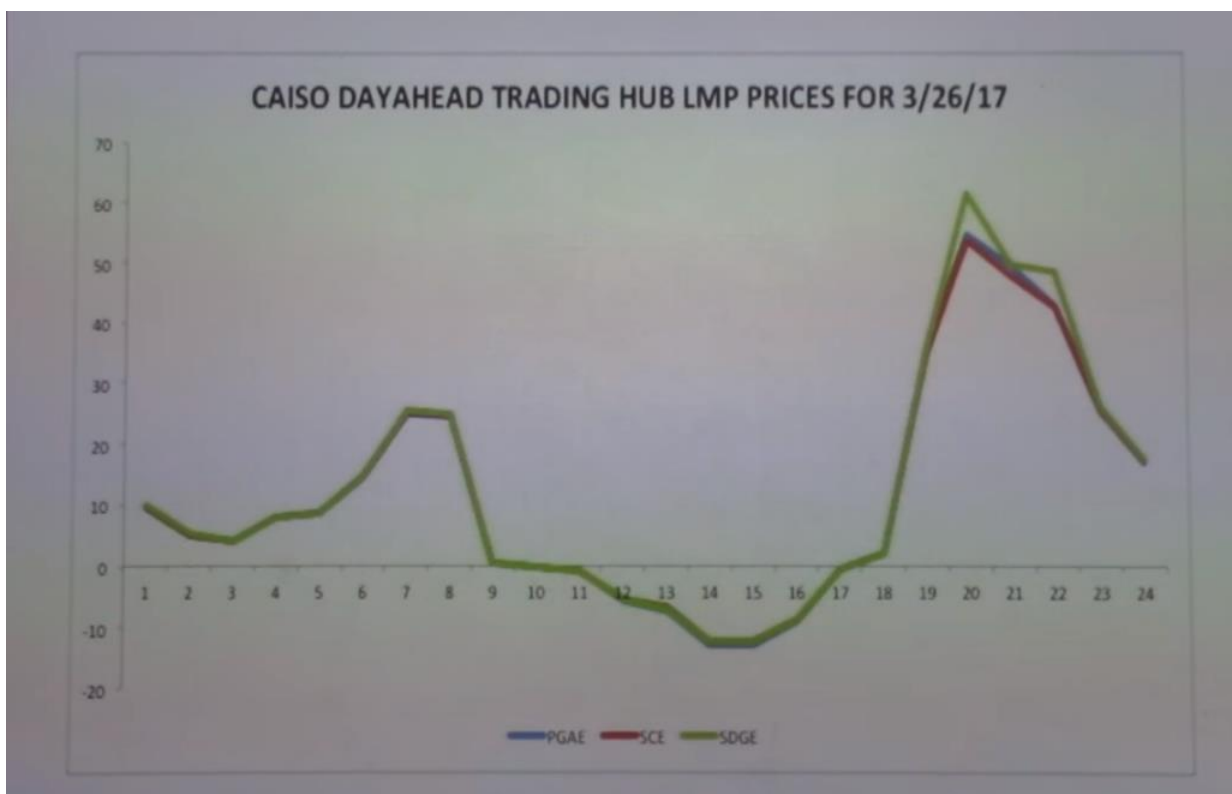
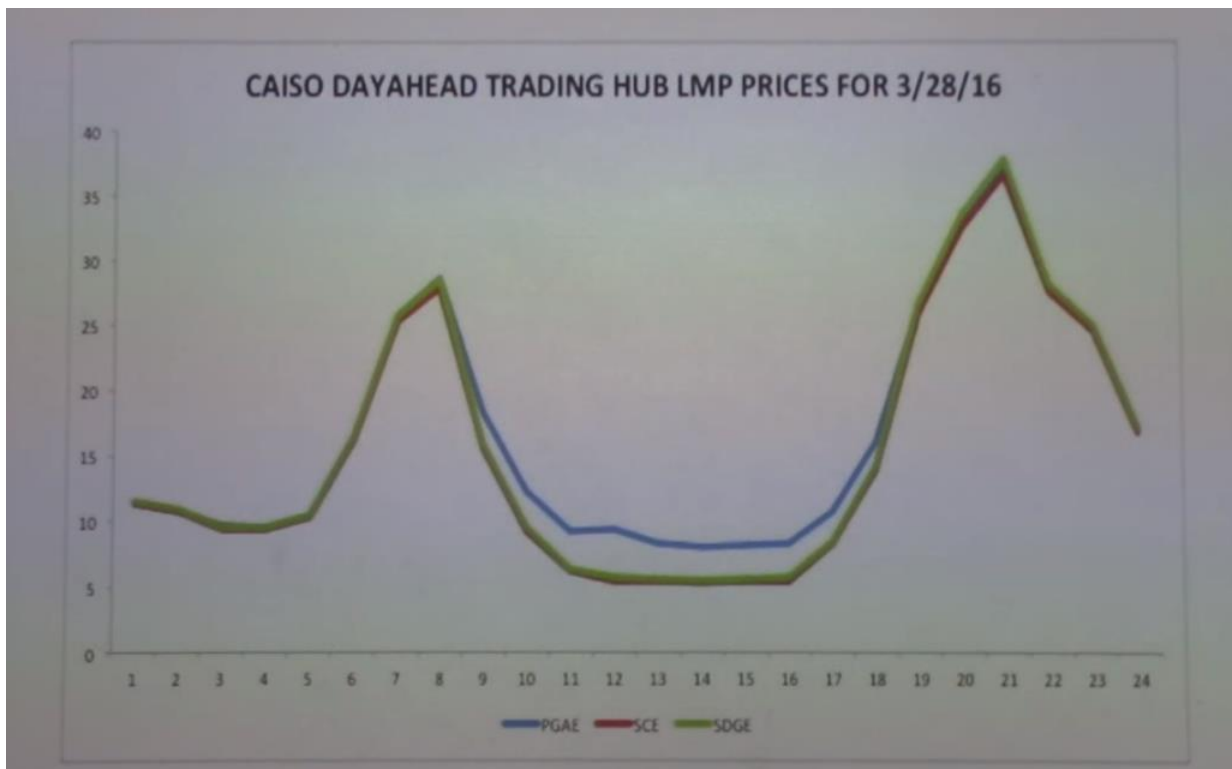
- Economic
- Contingent
- Exceptional
- Manual

CAISO RealTime Market Structure

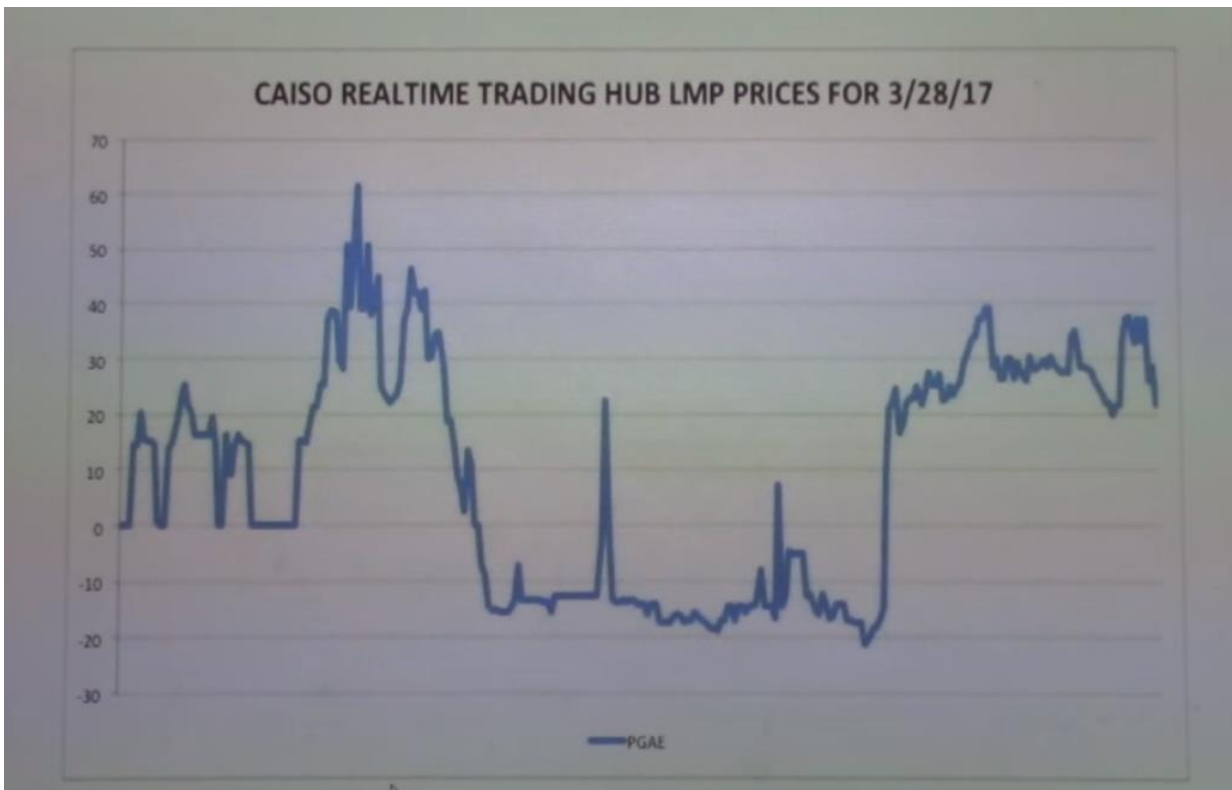
Real Time is a continuous process:
Looking at a single hour:

New Trade Hour





Having day-ahead prices moving into negative territory is a result of generators that are generating power for a negative amount, like renewables/solar units.



Prices in the real-time market really fluctuate to reflect the rapid changes in supply and demand of power going forward.

California ISO @California ISO • Aug 08

#ISO set a new historical solar peak of 8352 MW at 12:17pm on Sunday, August 7th, 2016. #CleanEnergy #RenewableEnergy

California ISO @California ISO • Feb 24

#ISO set new all-time #solar generation peak of 8792 MW at 1:42 pm, 2/24/17. Last peak of 8545 was set on 9/14/16 #cleanenergy

California ISO @California ISO • Mar 1

Another #ISO #solar generation peak of 9044 MW set at 1:46 p.m today, replacing previous all-time peak of 8792 on 2/24 #renewables

California ISO @California ISO • Mar 2

#ISO sets new all-time #solar peak of 9066 MW today at 10:07 am. Previous peak was 9044 MW on 3/1. #renewableenergy

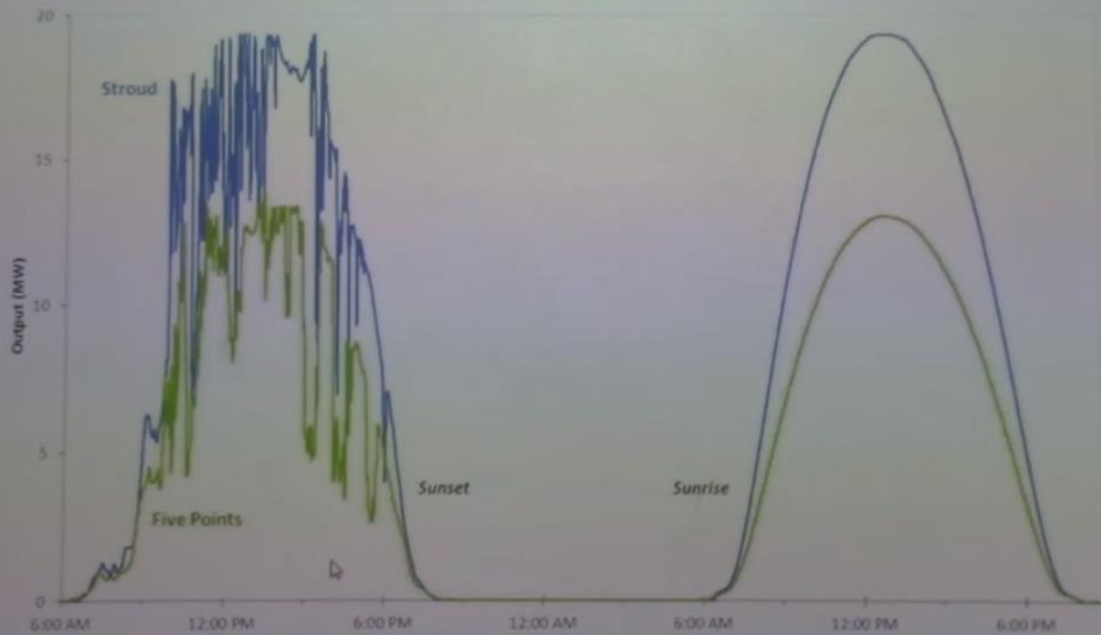
Solar Intermittency

Cloudy days are much more challenging to manage for solar

Output of Stroud and Five Points Solar Plants

July 19, 2012: Cloudy Day

July 20, 2012: Clear Day



These are causing problems for us regarding us knowing what we should generate, what we should bid, and what we should schedule.

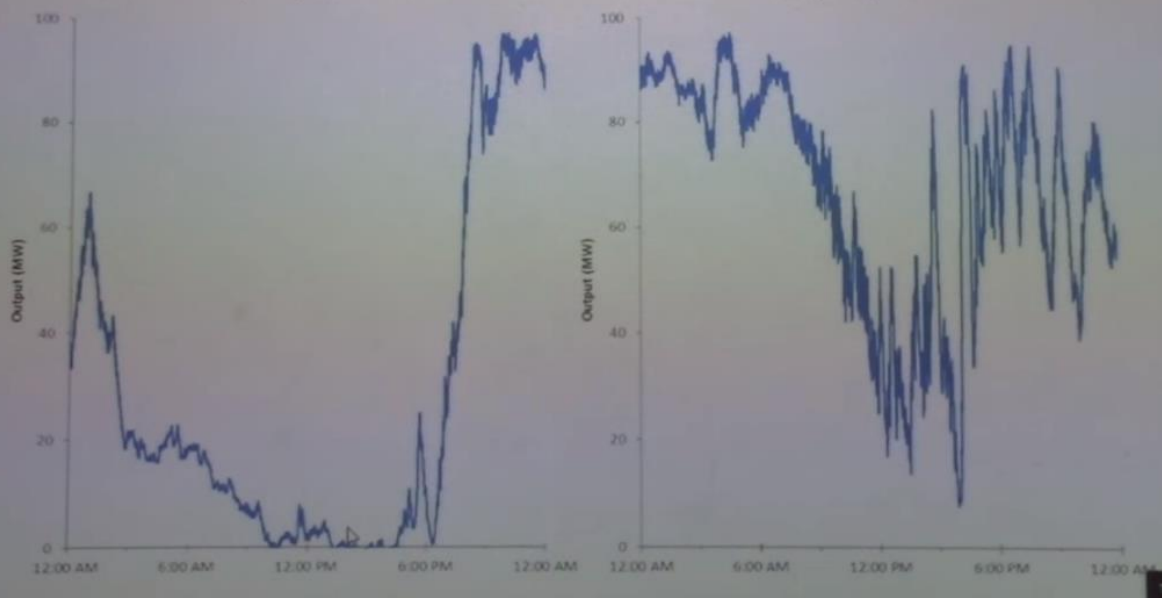
Wind Intermittency

Day-to-day variation in generation output can be significant

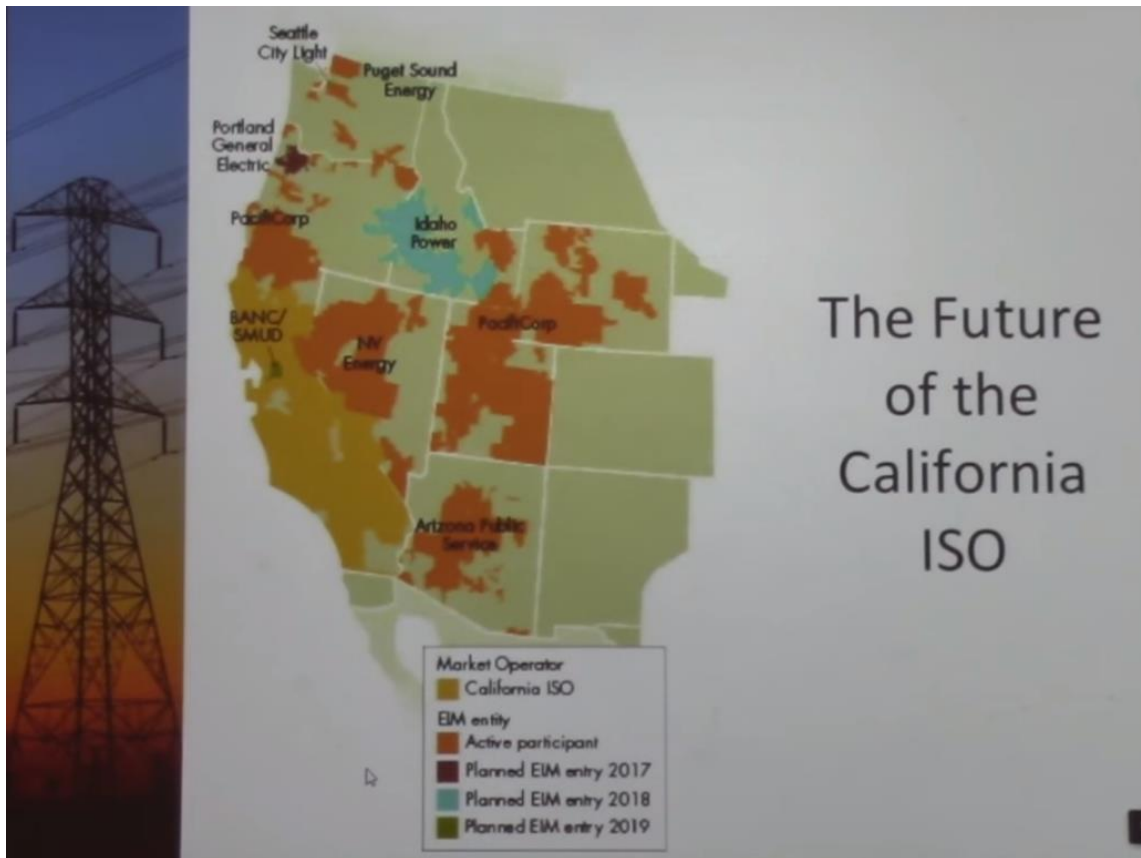
Output of Hatchet Ridge Wind Farm

April 15, 2013

April 16, 2013



This is part of what causes power variability on the grid.



Since 2016, CAISO is now creating the EIM for taking over the balancing of supply and demand for the above region so that CA can send out excess power to other grids to keep it balanced for the 5-minute interval power production. States can agree to take excess power from CA during negative pricing periods and make money and power.

