WELCOME to:

Power Operations & Planning Training

For Internal MWD Training

Guidelines:

- By default, all participants are on mute. If you would like to speak, please raise your hand by clicking the hand icon at the bottom of your screen.
- Feel free to use the Q&A box at the bottom of your screen to submit your questions to the panelists during the presentation. However, please note that questions will be answered at the end of the presentation.
- After the presentation, audio and camera use will be available for all participants to ask questions.

Sit back, relax and enjoy

Our intention is to provide support for MWD team members to better understand energy markets.

Part 1: MWD's "New Normal" in the CAISO Marketplace – Dyanne Kellough 8/13/21 1pm

Part 2: How the CAISO and Energy Markets work & How MWD participates in the CAISO – Scot Rolfe 8/27/21 1pm

Part 3: Why the CAISO needs Resource Adequacy Capacity & How Resource Adequacy works for MWD – Sal Heredia 9/10/21 1pm

Part 4: NERC Compliance & It's importance to MWD – Nayeem Mohammad Abdullah 9/24/21 11am

Managing Costs

$30,000,000

-

$70,000,000

Estimated amount budgeted annually for CRA Power Costs.

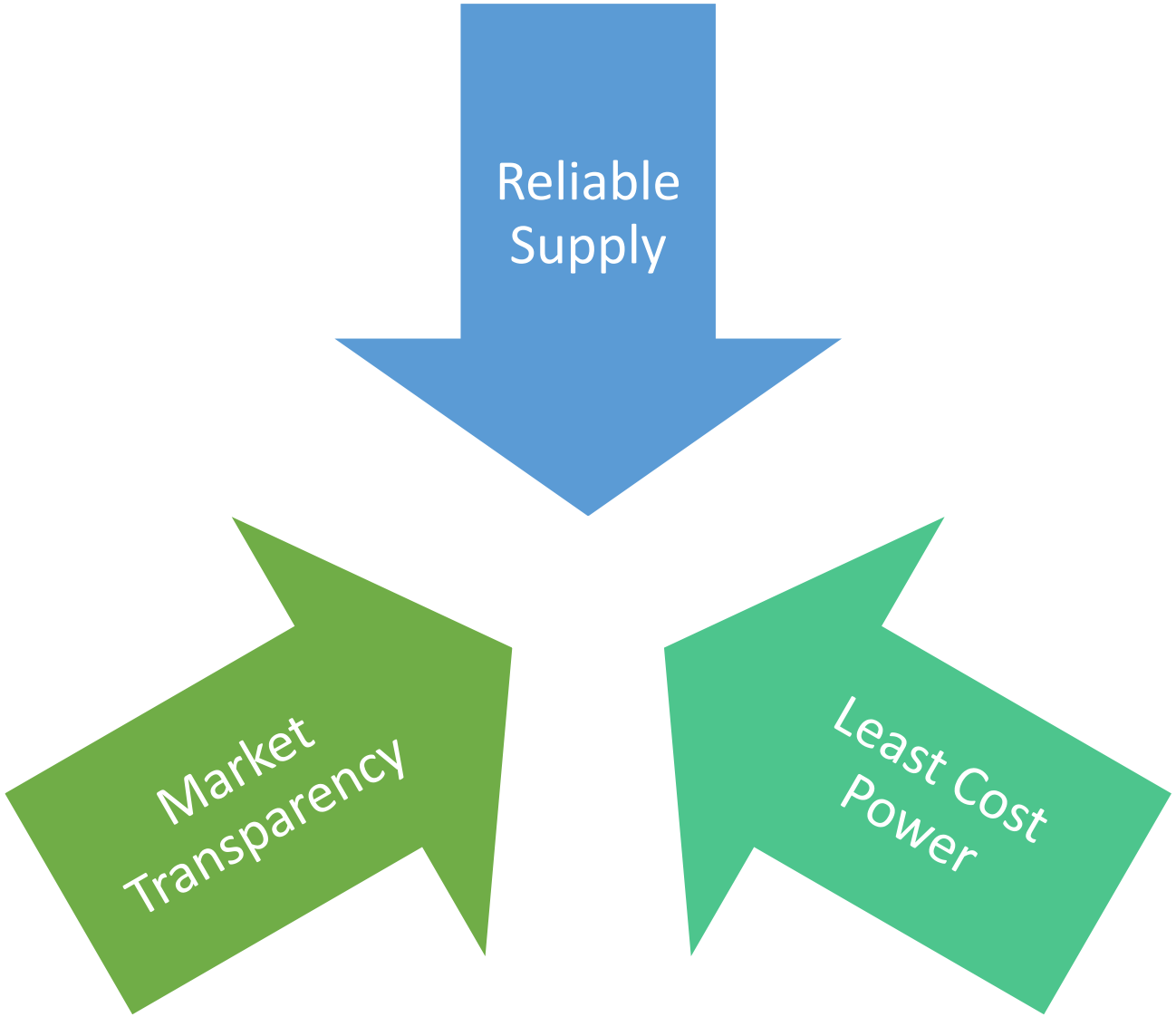
Energy Markets – CAISO and Natural Gas

Benefits of CAISO participation

CAISO Markets

Natural Gas Markets

Benefits of CAISO Participation



Reliable Power Supply for MWD

The CAISO provides a secure power supply for CRA pumping needs, regardless of the status of MWD's generation resources.

Reliability is maintained by:

- Meeting NERC and WECC reliability criteria
- Resource outage coordination
- Providing Ancillary Services that support the grid:
  - Regulation (Reg Up/Reg Down)
  - Reserve (Spin/Non-Spin)
  - Power Quality (Voltage and Frequency)

Lower Costs for MWD

- Full network model optimizes generation, transmission, import, and export dispatch in the daily, hourly, 15-minute, and 5-min markets, while minimizing losses and congestion.
- Liquidity – Market liquidity refers to the extent to which a market allows assets to be bought and sold at stable, transparent prices. **High liquidity means that there are a large number of orders to buy and sell in the underlying market.** This increases the probability that the highest price any buyer is prepared to pay and the lowest price any seller is happy to accept will move closer together. In other words, the bid-offer spread will tighten.

Transparency for MWD

Market transparency describes the extent to which the details of market activity are made public.

Market Rules are strictly enforced for all participants.

CAISO publishes the results of all markets, settled prices at all LMP's, components of LMP's(Energy Price, Losses, Congestion), Available Transmission Capacity and Utilization, etc.

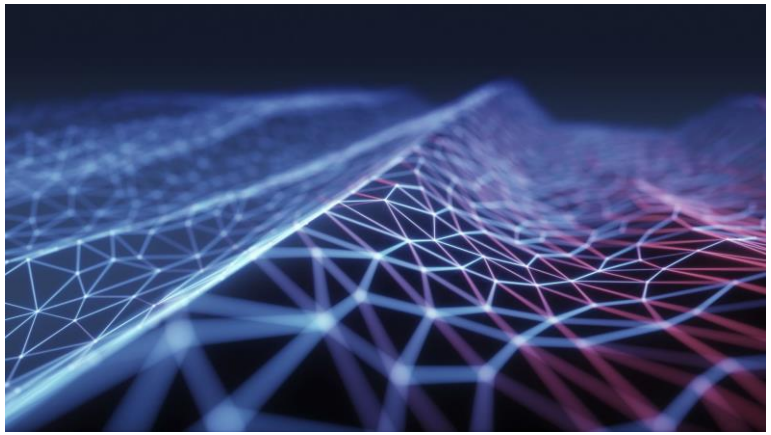
This aids in MWD's decision making for daily use of TOR's and related bilateral purchases in lieu of CAISO supply.

CAISO Markets

Day-Ahead vs Real-Time

Energy Clearing Price

Locational Marginal Price



Day-Ahead Market (DAM) vs Real-time Market (RTM)

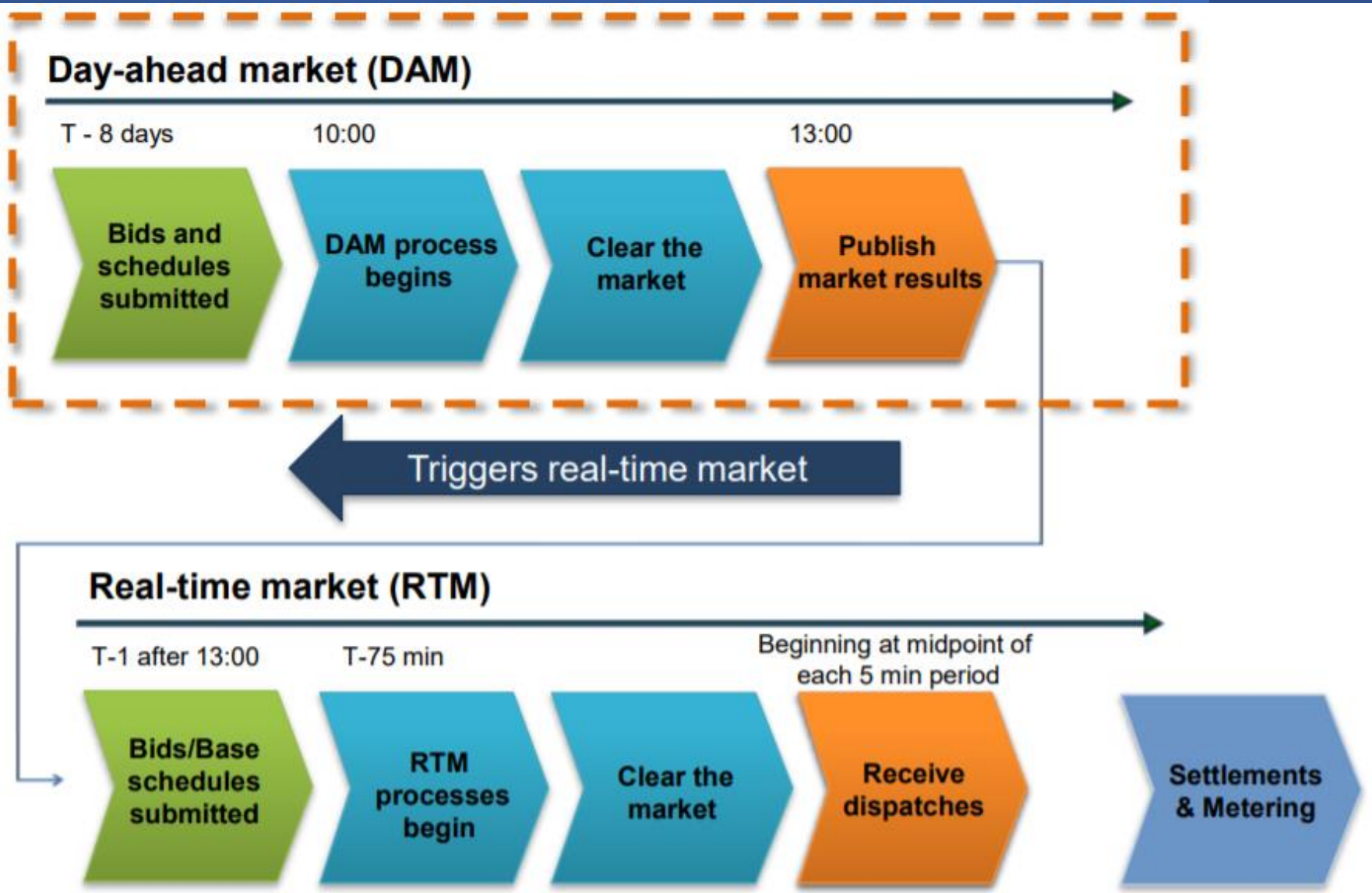
Adequate resources for a full day's operations are procured, confirmed and optimized by two markets to ensure reliability

Day-ahead market

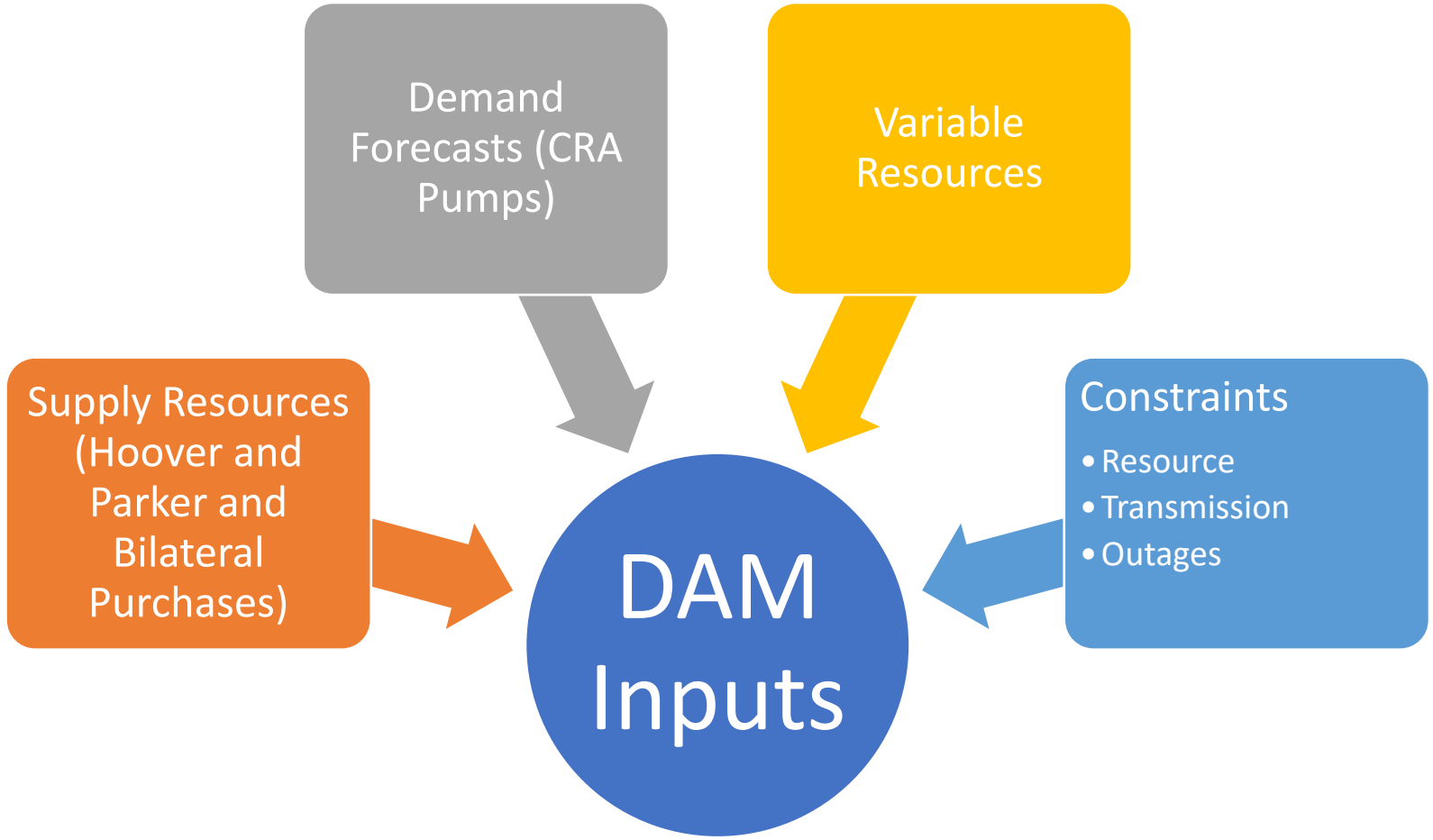
- *Ensures, a day in advance resources are available and deliverable in real-time*
- *Allow parties with bilateral agreements to schedule contracted supply/demand and offload excess supply as energy or Ancillary Services*
- *Secure pricing*

Real-time market

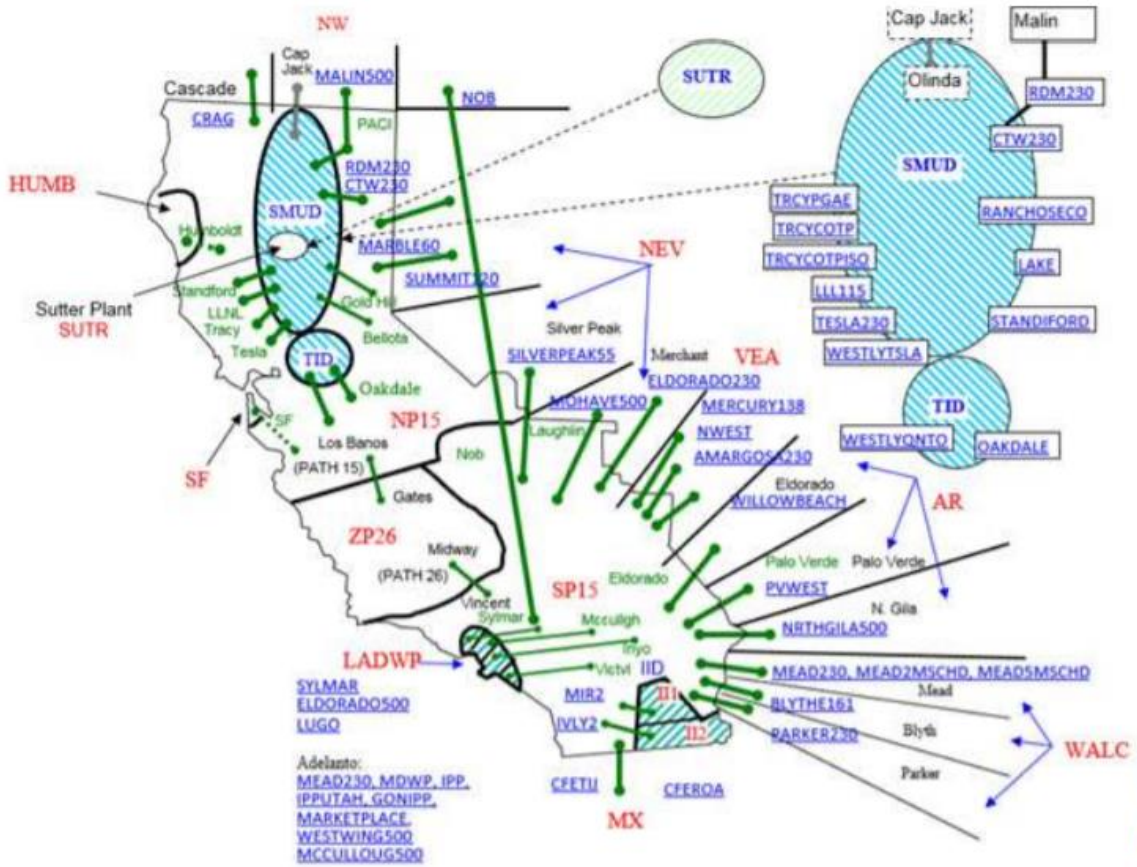
- *Hour ahead scheduling to enable import/export MWs*
- *Allows variable energy resources to submit energy forecasts and economic bids closer to financially-binding interval to increase bid accuracy*
- *Liquidates financial only bids*
- *Dispatches energy to meet instantaneous demand*


Day-ahead market (DAM)
T - 8 days
10:00
13:00
Bids and schedules submitted
DAM process begins
Clear the market
Publish market results
Triggers real-time market
Real-time market (RTM)
T-1 after 13:00
T-75 min
Beginning at midpoint of each 5 min period
Bids/Base schedules submitted
RTM processes begin
Clear the market
Receive dispatches
Settlements & Metering

Day-Ahead Market (DAM) Inputs



Full Network Model



The Full Network Model contains information such as:

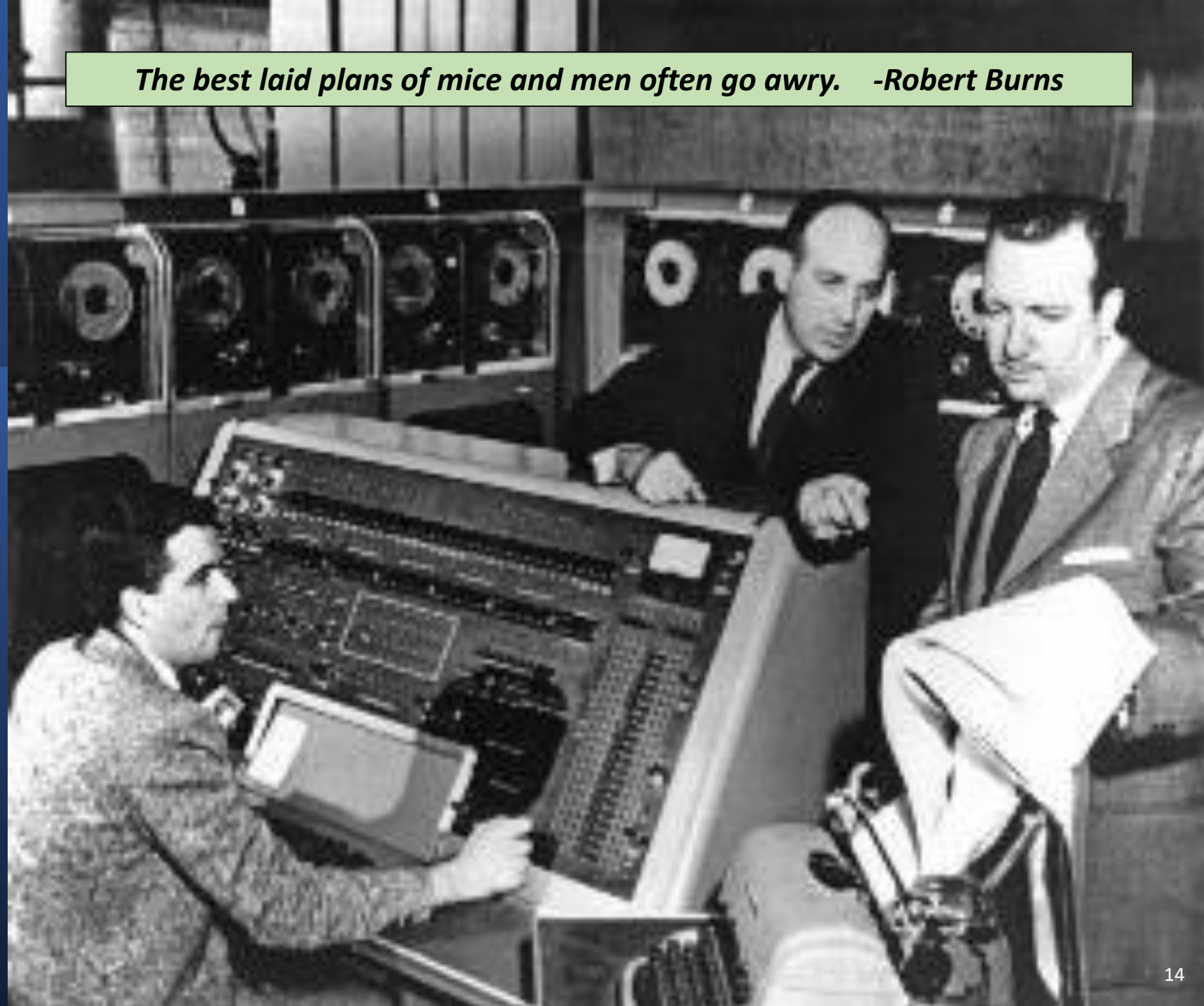
ISO and aggregated Resource IDs

Default and custom LAP areas

Ancillary service and trade hub regions

Imports and exports are modeled as injections at intertie scheduling points

DAM Market Optimization (Full Network Model)



Real-Time Market (RTM)

The RTM is how the CAISO manages deviations from the DAM results.

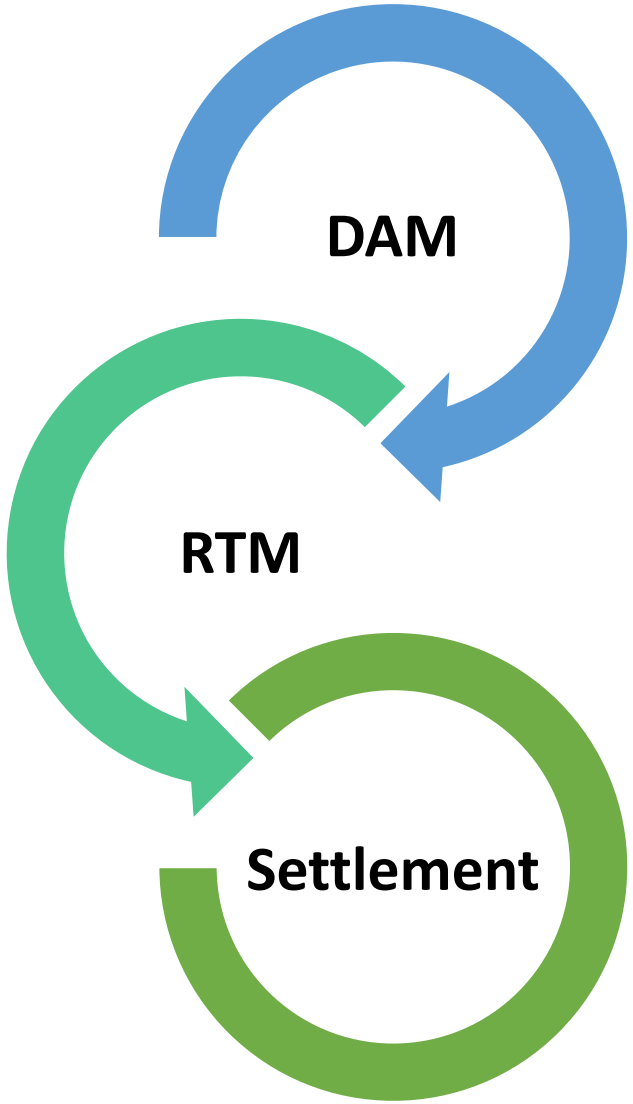
Maintenance and Repairs

Wildfires

Fuel Disruptions

Market Timelines important to MWD

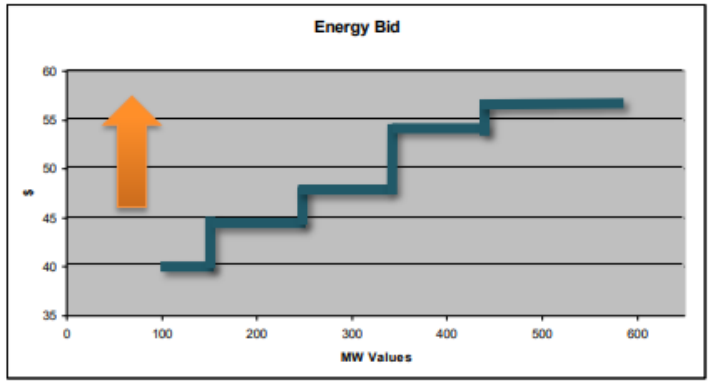
Timely information allows MWD to limit the exposure to fluctuations in market pricing between the DAM and RTM. *Make schedule changes before 10am!*



Economic Bids

Energy bids provide an economic signal indicating a participant's willingness to supply or purchase energy

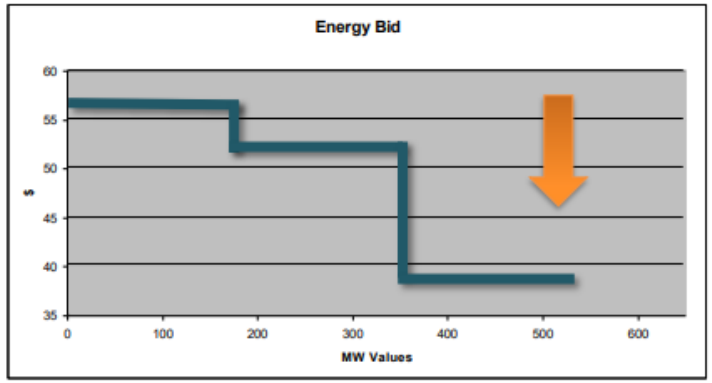
SUPPLY BID



generators and imports

The **higher** the price, the more they will **supply**

DEMAND BID



loads and exports

The **lower** the price, the more they will **buy**

Energy Market Clearing Price

Supply Offers

ID	Quantity (MW)	Cumulative Offers	Price ($/MWh)
A	100	100	$ 46.00
B	190	290	$ 47.00
C	150	440	$ 48.00
D	210	650	$ 49.00
E	200	850	$ 51.00
F	250	1100	$ 52.00
G	200	1300	$ 54.00
H	275	1575	$ 55.00
I	150	1725	$ 56.00
J	100	1825	$ 57.00

Demand Bids

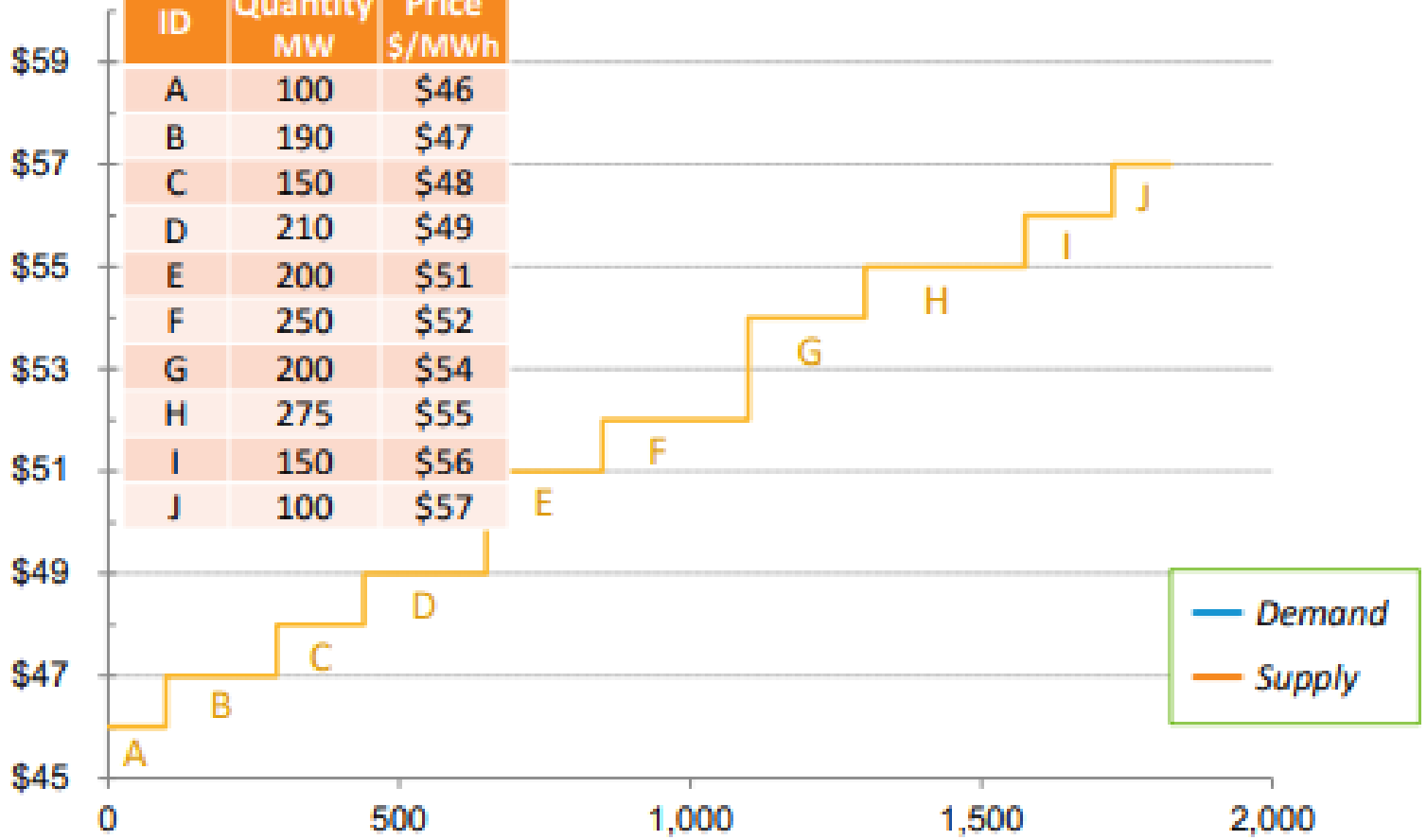
ID	Quantity (MW)	Cumulative Offers	Price ($/MWh)
K	100	100	$ 59.00
L	100	200	$ 58.00
M	250	450	$ 57.00
N	200	650	$ 55.00
O	150	800	$ 54.00
P	200	1000	$ 53.00
Q	150	1150	$ 51.00
R	200	1350	$ 50.00
S	200	1550	$ 49.00
T	125	1675	$ 47.00

Supply Offers

Offers to Sell (Supply)

Day-Ahead Forward Market

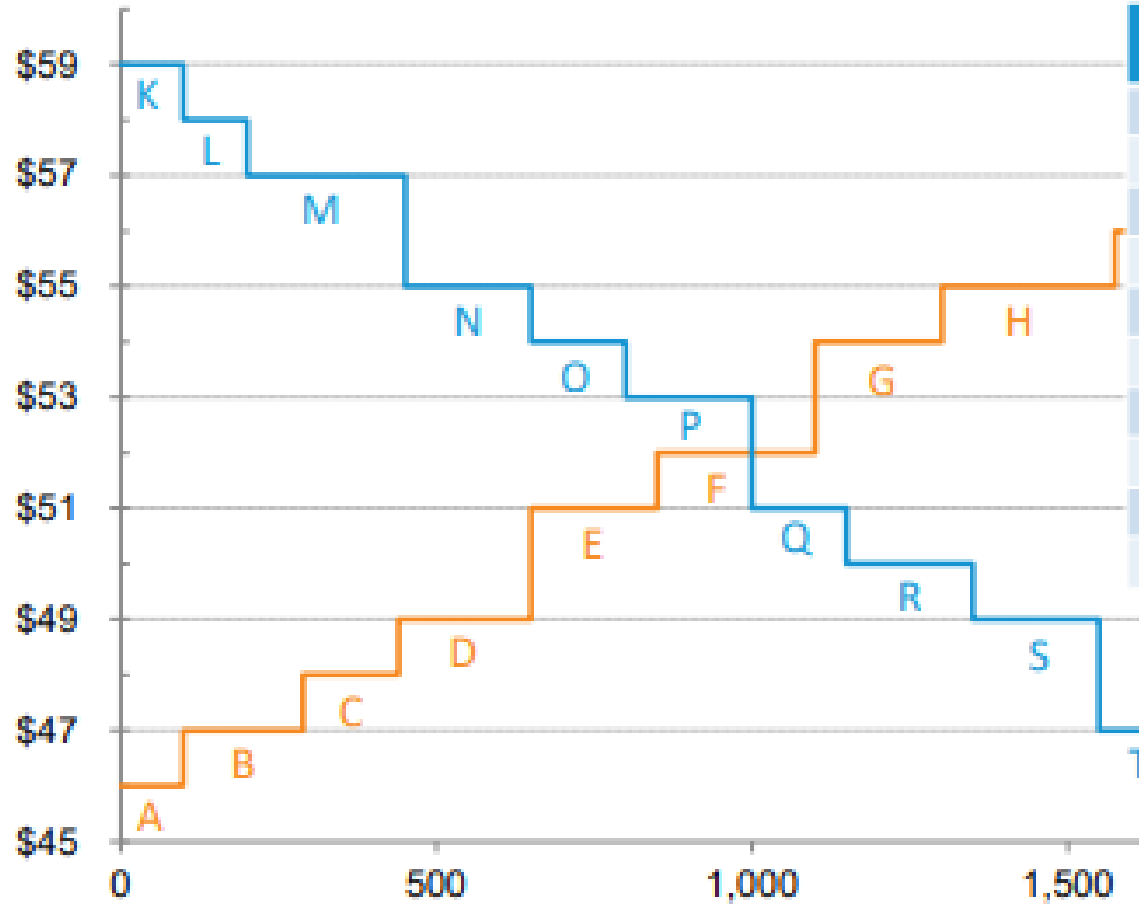
ID	Quantity MW	Price $/MWh
A	100	$46
B	190	$47
C	150	$48
D	210	$49
E	200	$51
F	250	$52
G	200	$54
H	275	$55
I	150	$56
J	100	$57



Demand Bids

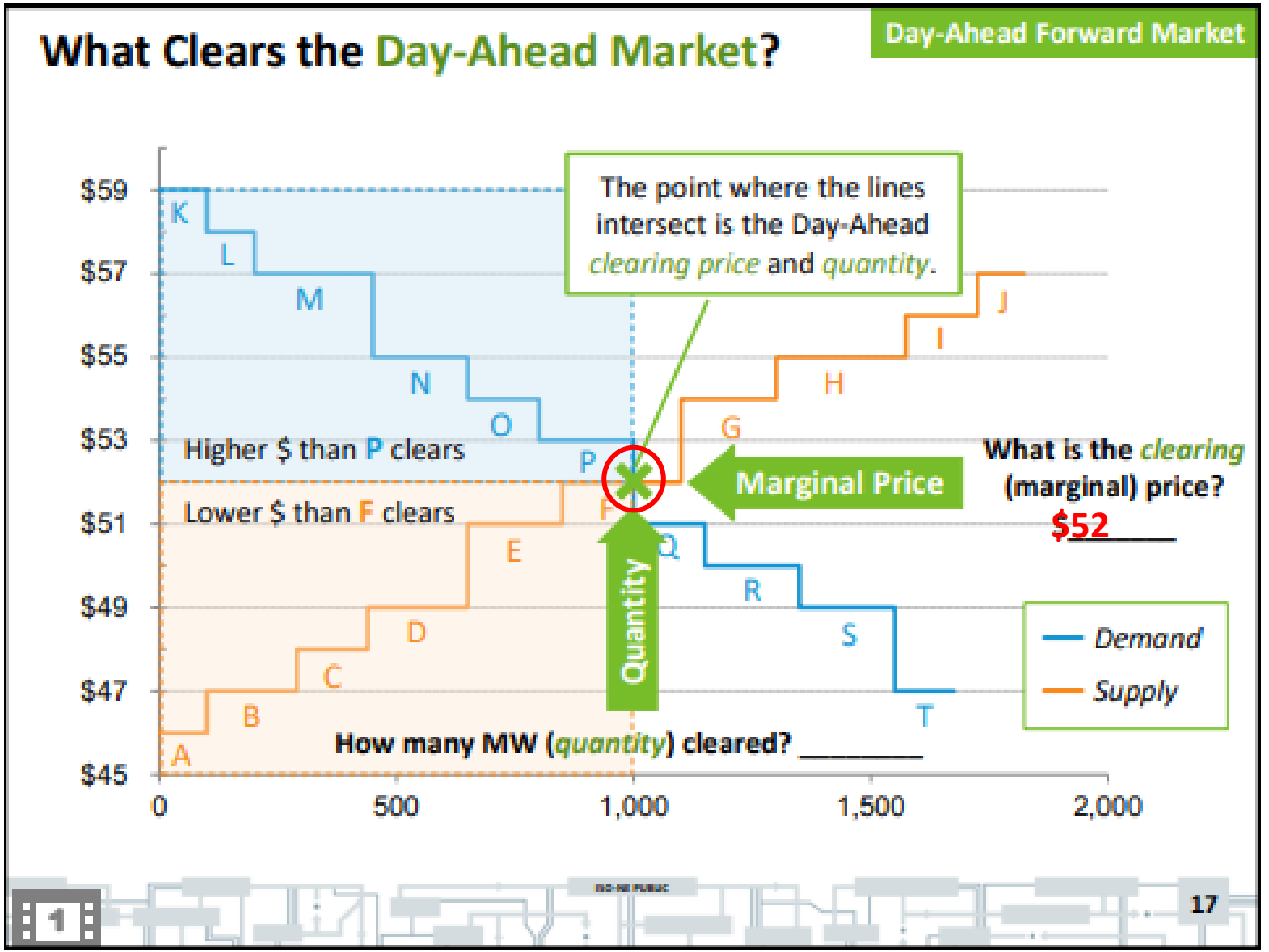
Bids to Buy (Demand)

Day-Ahead Forward Market



ID	Quantity MW	Price $/MWH
K	100	$59
L	100	$58
M	250	$57
N	200	$55
O	150	$54
P	200	$53
Q	150	$51
R	200	$50
S	200	$49
T	125	$47

Market Clearing Price of Power



ID	Quantity (MW)	Cumulative Offers	Price ($/MWh)
A	100	100	$ 46.00
B	190	290	$ 47.00
C	150	440	$ 48.00
D	210	650	$ 49.00
E	200	850	$ 51.00
F	250	1100	$ 52.00
G	200	1300	$ 54.00
H	275	1575	$ 55.00
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O	150	800	$ 54.00
P	200	1000	$ 53.00
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R	200	1350	$ 50.00
S	200	1550	$ 49.00
T	125	1675	$ 47.00

Self-Schedules

Self schedules are also known as “price takers”

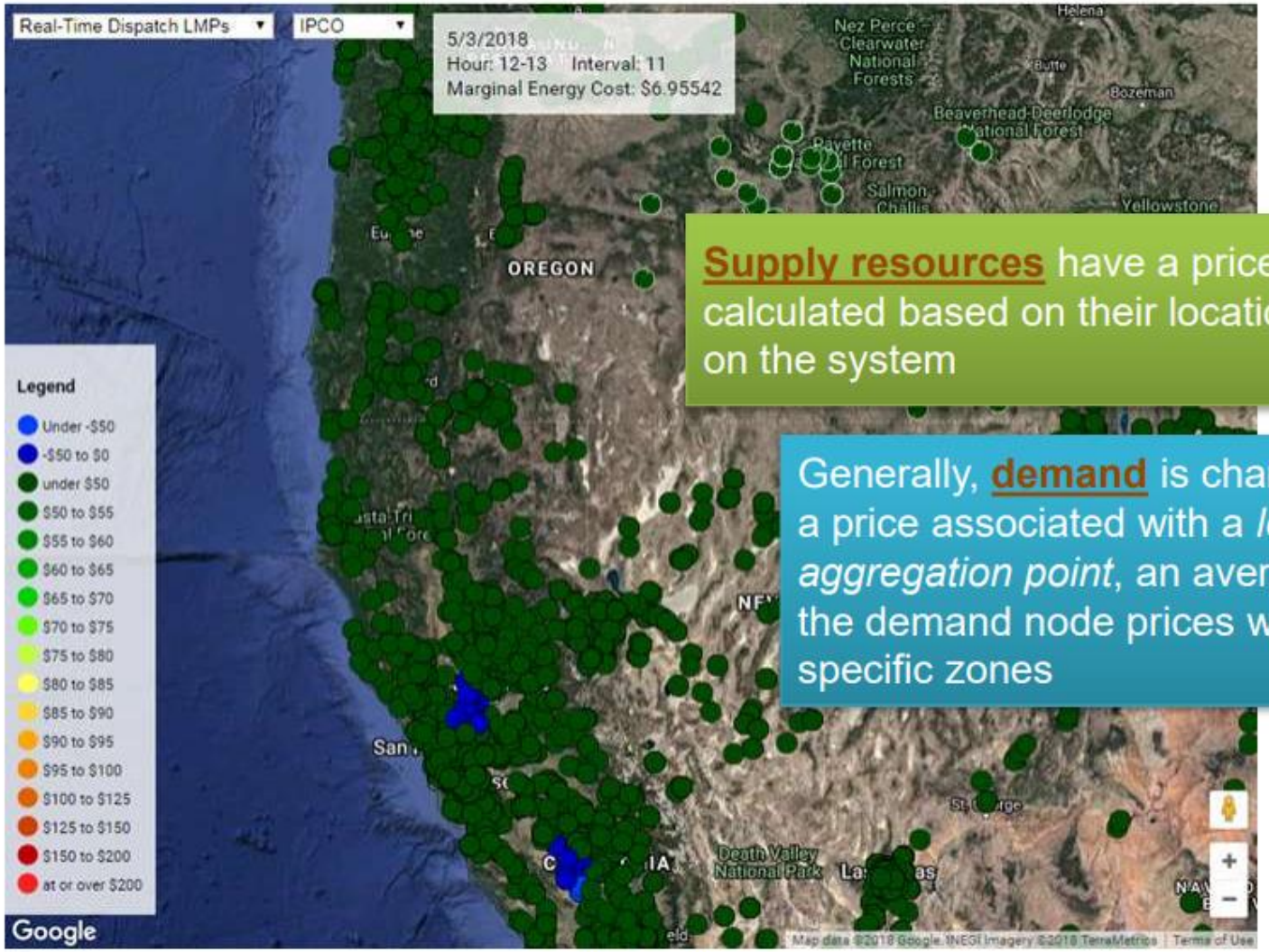
SUPPLY SELF SCHEDULE

Informs the ISO that the SC is willing to run its generator regardless of the price

DEMAND SELF SCHEDULE

Informs the ISO that the SCS is willing to buy a certain quantity of supply, regardless of the price, to serve its load

There are thousands of price nodes throughout the system



Supply resources have a price calculated based on their location on the system

Generally, **demand** is charged at a price associated with a *load aggregation point*, an average of the demand node prices within specific zones

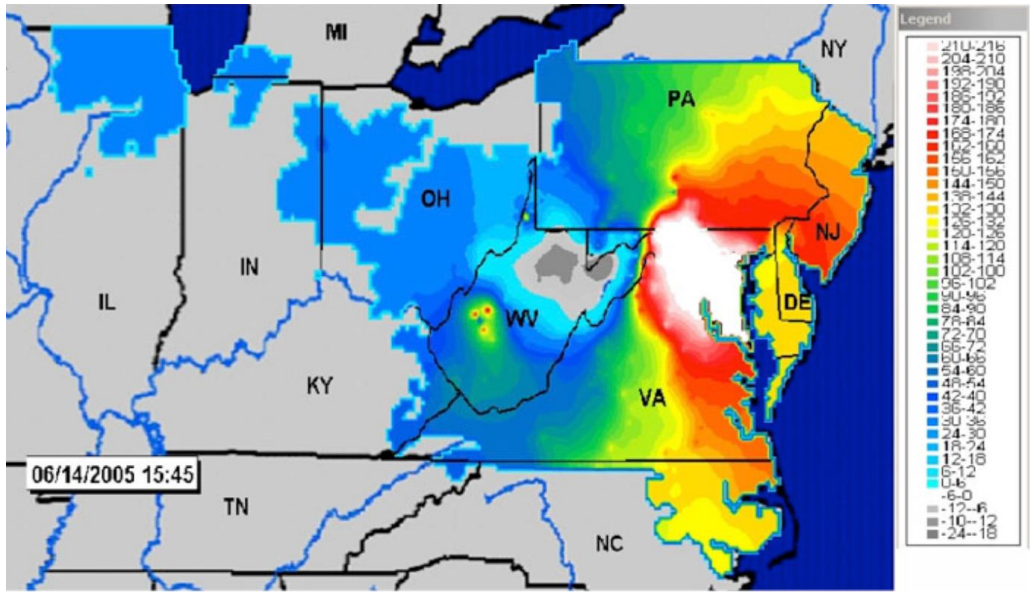
Locational Marginal Price

Locational Marginal Price (LMP) - The marginal cost ($/MWh) of serving the next increment of Demand at that PNode consistent with existing Transmission Constraints and the performance characteristics of resources.

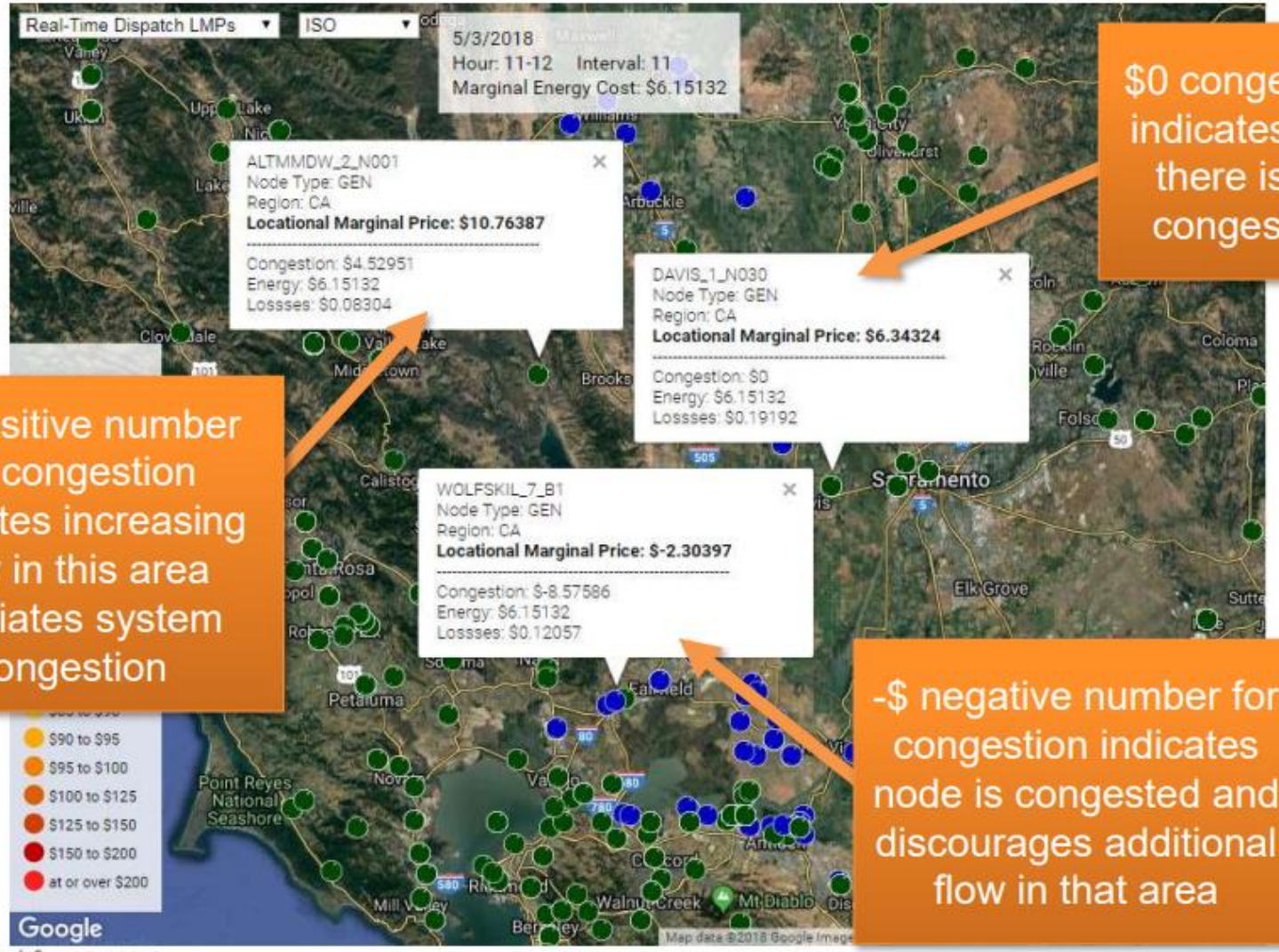
An LMP is composed of 3 elements:

- Energy Price
- Losses
- Congestion

An LMP is calculated for every generating node and every load zone during the optimization process.



Congestion may result in higher or lower prices



$0 congestion indicates that there is no congestion

+$ positive number for congestion indicates increasing flow in this area alleviates system congestion

-$ negative number for congestion indicates node is congested and discourages additional flow in that area

Importance of LMP's to MWD

- MWD has supply resources (Hoover and Parker) that are scheduled as imports and get paid at MEAD and PARKER LMP's.
- MWD has 4 load node LMP's (Gene/Intake, Eagle, IronMtn, Jhinds), which are priced differently than Mead and Parker.
- We could potentially be paid much less for our generation than we are paying for the same amount of power at our pumps.
- Transmission Ownership Rights (TOR's) help mitigate this risk.

Natural Gas Markets

IMPORTANCE OF NATURAL GAS

HOW NATURAL GAS PRICING TRANSLATES TO POWER PRICING

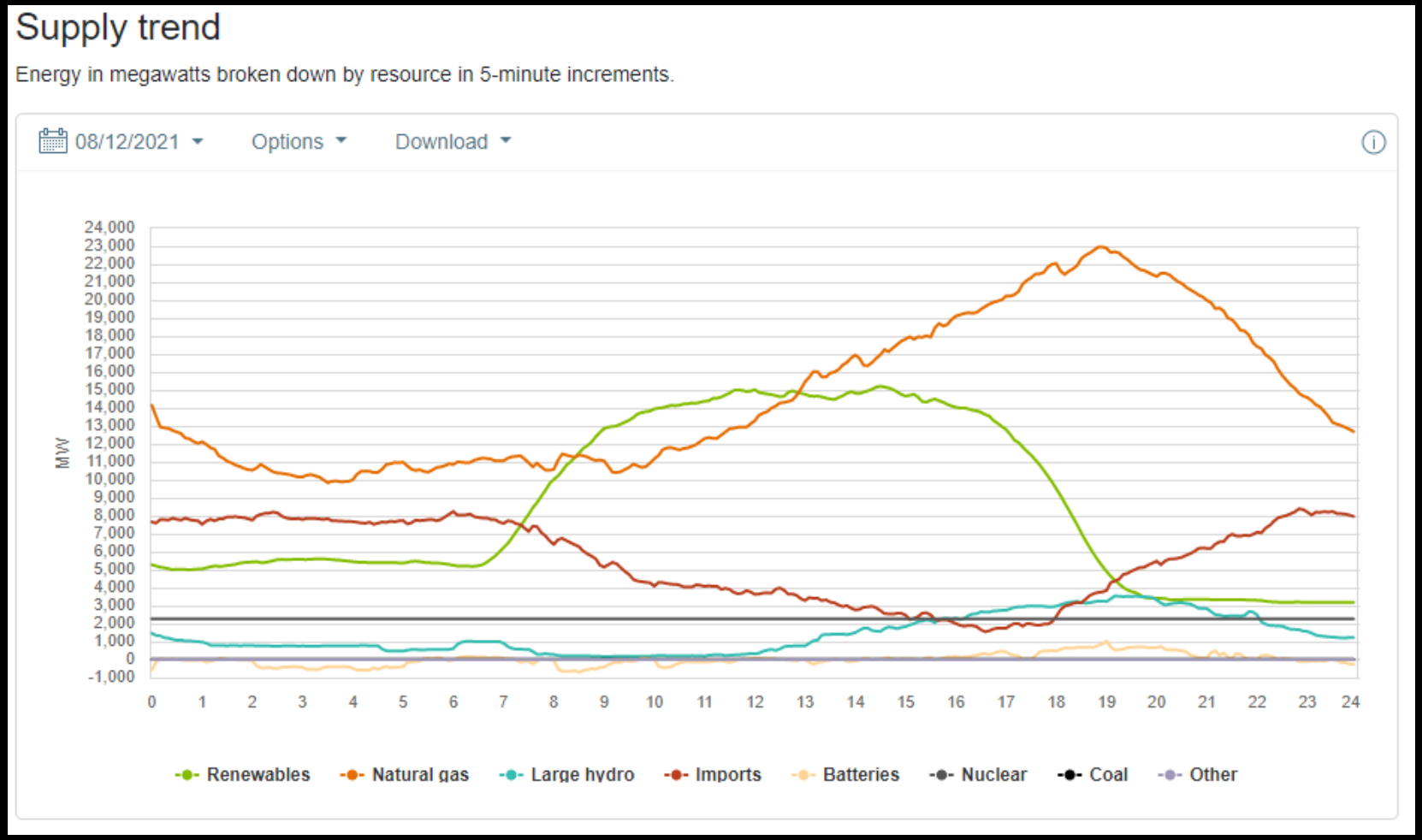
Natural Gas as a Fuel

Fuels over 50% of generation in CAISO

Additional from Imports

Flexible Capacity

August 12, 2021 CAISO Resource Mix



Natural Gas becomes Power

Gas generation is priced in the CAISO Day-Ahead Market based on its variable costs, the majority of which is its fuel cost, natural gas.

Bid Price ($/MWh) = (Daily Gas Price ($/MMBtu)
* Unit Heat Rate (MMBtu/kWh))
+ Variable O&M costs ($/MWh)
+ GHG Compliance costs ($/MWh)

Inputs:
Daily Gas Price at Socal Citygate = $7.23
Unit Heat Rate = 7.061 MMBtu/kWh
Unit Variable O&M = $2.37/MWh
GHG Compliance cost = $10.00/MWh

Calculation:
Bid Price ($/MWh) = (7.23*7.061)+2.37+10.00

Results:
Bid Price ($/MWh) = $63.42

Comparison of Power and Gas Markets

There are several differences in how gas and power are traded each day.

Operating Day

- Power - midnight to midnight
- Gas - 10am to 10am

Hourly Products

- Power – Heavy-Load Hours (HE 7 to 22), Light-Load Hours (HE 1-6, and 23-24)
- Gas – Entire Operating Day

Summary

MWD benefits from participation in the CAISO, who provide us with least-cost, reliable power in a robust marketplace.

The CAISO markets are complex, but they provide us with many tools to manage risks in our power portfolio.

Natural Gas is an important component of the CAISO power markets, because it fuels a large amount of generation.

Links to ISO Training Presentations

- www.caiso.com
- http://www.caiso.com/Documents/WelcomeToTheISO-ParticipantSlides_ToolKit.pdf
- https://www.iso-ne.com/static-assets/documents/2018/10/iso-101-handbook-2019-10-10-web-version.pdf

Questions

Glossary

- CAISO – California Independent System Operator
- NERC – North American Electric Reliability Corporation
- WECC – Western Electricity Coordinating Council
- Bilateral Transaction – a transaction between two parties not involving the CAISO
- Liquidity - Market liquidity refers to the extent to which a market allows assets to be bought and sold at stable, transparent prices.
- MMBtu – One Million British thermal units, a measure of heat content that is the standard for natural gas
- Mcf – One Million cubic feet. A volumetric measurement of natural gas. Sometimes used interchangeably with MMBtu.
- Heat Rate (HR) – measurement of efficiency for heat conversion to electricity in a generating unit. The lower the number, the more efficient a unit. MBtu/kWh or MMBtu/kWh.
- Locational Marginal Price (LMP) - The marginal cost ($/MWh) of serving the next increment of Demand at that PNode consistent with existing Transmission Constraints and the performance characteristics of resources.
- MW – Megawatt, a measure of power capacity. One million watts.
- MWh – Megawatt per hour. A volumetric measurement of power delivered in one hour.

Why does the CAISO exist?

FERC Orders 888 & 889 (1996)

Transmission Owners (Utilities) must begin allowing 3rd party access to their transmission lines.

Transmission Owners must post non-confidential market-related information online accessible by ALL market participants

FERC Orders 888[1] & 889[2]

The Commission's goal is to remove impediments to competition in the wholesale bulk power marketplace and to bring more efficient, lower cost power to the Nation's electricity consumers.

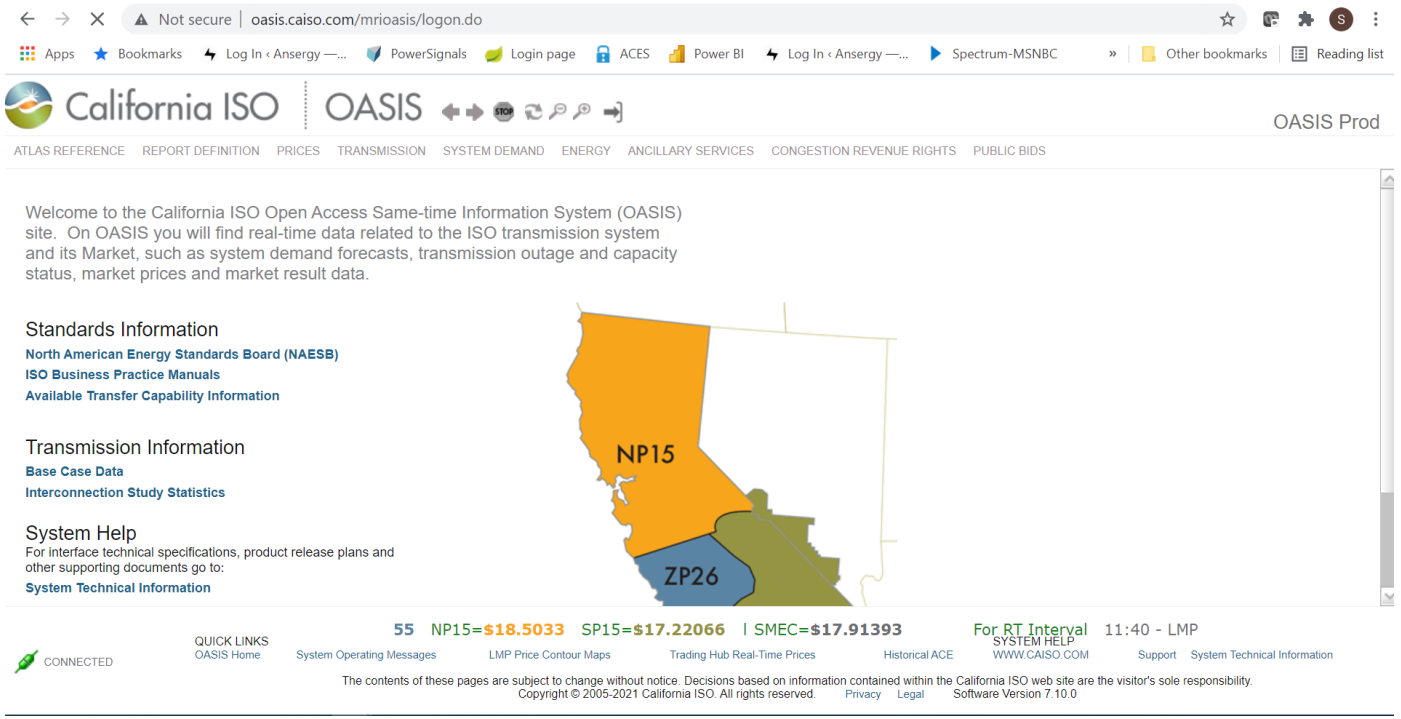
- **FERC 888 -** Requires all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce:
  - To have on file open access non- discriminatory transmission tariffs that contain minimum terms and conditions of non-discriminatory service.
  - Permits public utilities and transmitting utilities to seek recovery of legitimate, prudent and verifiable stranded costs associated with providing open access and Federal Power Act section 211 transmission services.
- **FERC 889 -** requires each transmission owner to make available an Open Access Same-time Information System (OASIS), an electronic bulletin board that will be available on the Internet.

1 - https://www.ferc.gov/industries-data/electric/industry-activities/open-access-transmission-tariff-oatt-reform/history-oatt-reform/order-no-888
2 - https://www.ferc.gov/industries-data/electric/industry-activities/open-access-transmission-tariff-oatt-reform/history-of-oatt-reform/order-no-889-1#

Impartial, Non-Discriminatory Access

The CAISO is a non-profit, public benefit corporation.

- The CAISO acts as a “middle-man” for facilitating transactions, buying 100% of all power generated by it’s participants, and re-selling that power to all Load-Serving Entities (LSE’s).
- Provide participants with equal access to all non-confidential market-related information via https://oasis.caiso.com/.



CAISO Regulation and Oversight

The ISO adheres to strict oversight

FERC

Regulated by the Federal Energy Regulatory Commission

- Regulates the interstate transmission of electricity, natural gas and oil

NERC

Compliant with the North American Electric Reliability Corp

- Regulates the North American grid through the adoption and enforcement of reliability standards

WECC

Members of the Western Electricity Coordinating Council

- Coordinates bulk electric system reliability in the geographic area known as the Western Interconnection

What does the CAISO do?

Reliability

Infrastructure Planning

Market Operations

CAISO Reliability

The ISO is a grid operator and market operator

grid operator

maintains reliability by:

- balancing supply and demand
- operating transmission system within limits
- ensuring grid is secure in case of a contingency event
- orchestrating restoration in case of a system outage

market operator

supports reliability by providing:

- a larger operational footprint
- cost minimization to balance supply and demand
- non-discriminatory grid access to supply and demand
- price transparency reflective of system conditions
- compensation for grid services

CAISO Infrastructure Planning

- Long Term Transmission Planning
  - Generator Interconnection - provide cost estimates for new projects to interconnect to the grid
  - Identify transmission projects needed to meet changing supply vs. demand balance and related power flows.

- Resource Adequacy
  - Ensure each LSE has enough supply to meet peak demand

CAISO Market Operations

- ***Market processes and products*** - The California wholesale market operates as other commodity exchanges do and is composed of interrelated processes.
- ***Network and resource modeling*** - Accurate network modeling supports efficient market operations.
- ***Outage management*** - Accurate and complete outage scheduling is vital to reliable operation of the transmission system.
- ***Interchange scheduling*** - Interchange scheduling contracts energy delivery.
- ***Metering and telemetry*** - Accurate metering of electricity generated or consumed provides key data inputs for accurate settlement calculations.
- ***Settlements*** - Quick and accurate settlements help markets function.
- ***Transmission operations*** - Our operations reporting, coordination and maintenance efforts help keep the lights on for nearly 32 million people in our control area.
- ***Power contracts bulletin board*** - Find market participant offers to buy or sell power on a long-term basis.
- ***Reports and bulletins*** - Special reports and audits published by the ISO can help keep you up-to-date on our markets and operations.
- ***Market monitoring*** - The ISO Department of Market Monitoring keeps a close watch on the efficiency and the effectiveness of the California ISO markets.