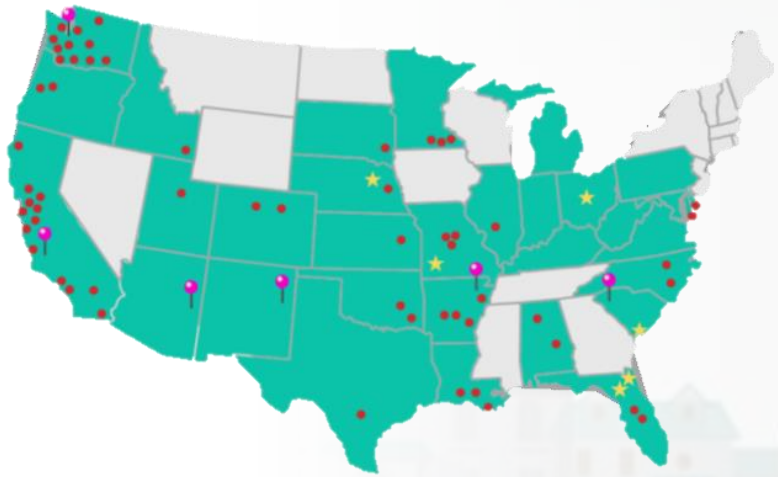
WHOLESALE ENERGY MARKET

WWU ENERGY SPEAKER SERIES

JUNE 4, 2024

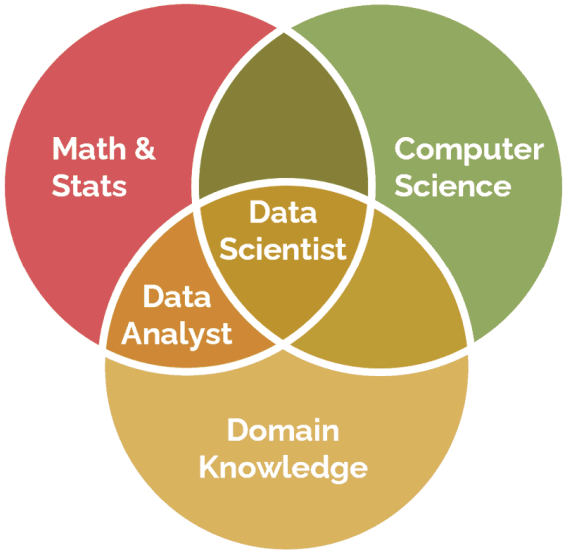
The Energy Authority

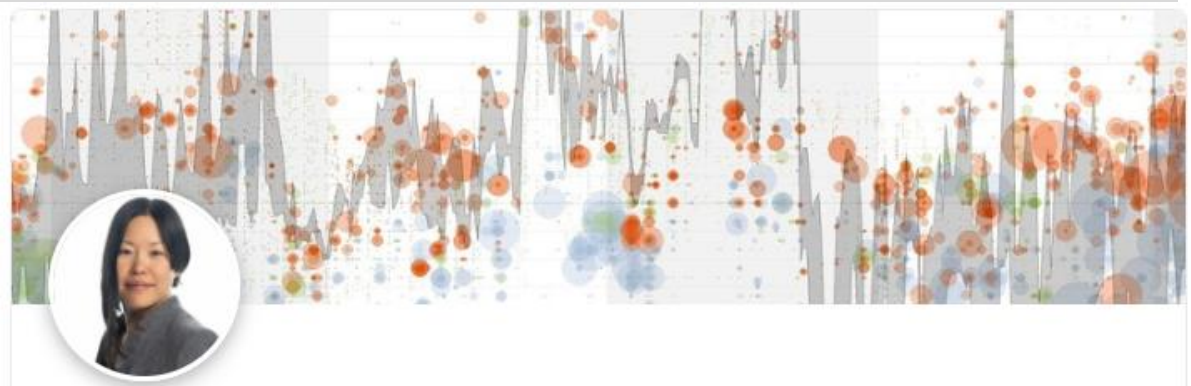
- Is public power-owned, **nonprofit** corporation
- Serves **60+ public utilities** nationwide for trading and portfolio management.
  - State and county utilities, municipal utilities, tribes, university regents, etc…
- In top 5 in trading volume since 2018.



Myself…

- Eina Ooka
  - Principal Data Scientist
    - Multivariate stochastic modeling
    - Time Series Forecasting
    - System Optimization (MIP)
  - 12 years at The Energy Authority





Eina Ooka
Principal Data Scientist at The Energy Authority
Bellingham, Washington, United States

The Energy Authority
https://www.linkedin.com/in/einaooka/

About

A principal data scientist specialized in forecasting, optimization, and stochastic modeling, from development to operation. Driven to learn and adapt new methodologies and focused on efficiently bringing customer-focused solutions to production.

~ Area of Expertise ~
Technical Project Management: Scoping, approach assessment, task and schedule management, critical thinking, communication. Agile methodology.
Machine Learning: Feature engineering, clustering, tree-based models, LSTM, CNN.
Operations Research: MIP, GA, logical decision models, ML/OR hybrid approaches.
Multivariate Stochastic Modeling: Gaussian process, Monte Carlo method, bootstrapping
Time Series Analysis: ARIMA, VARX, heteroscedasticity, outlier detection, seasonal and trend decomposition, hierarchical modeling
Programming: Python, R, SQL, git
Mentoring: Coaching through listening. Technical guidance. Organize knowledge-share.

~ Eina's GitHub page ~
https://github.com/einaooka (Conference presentations available).

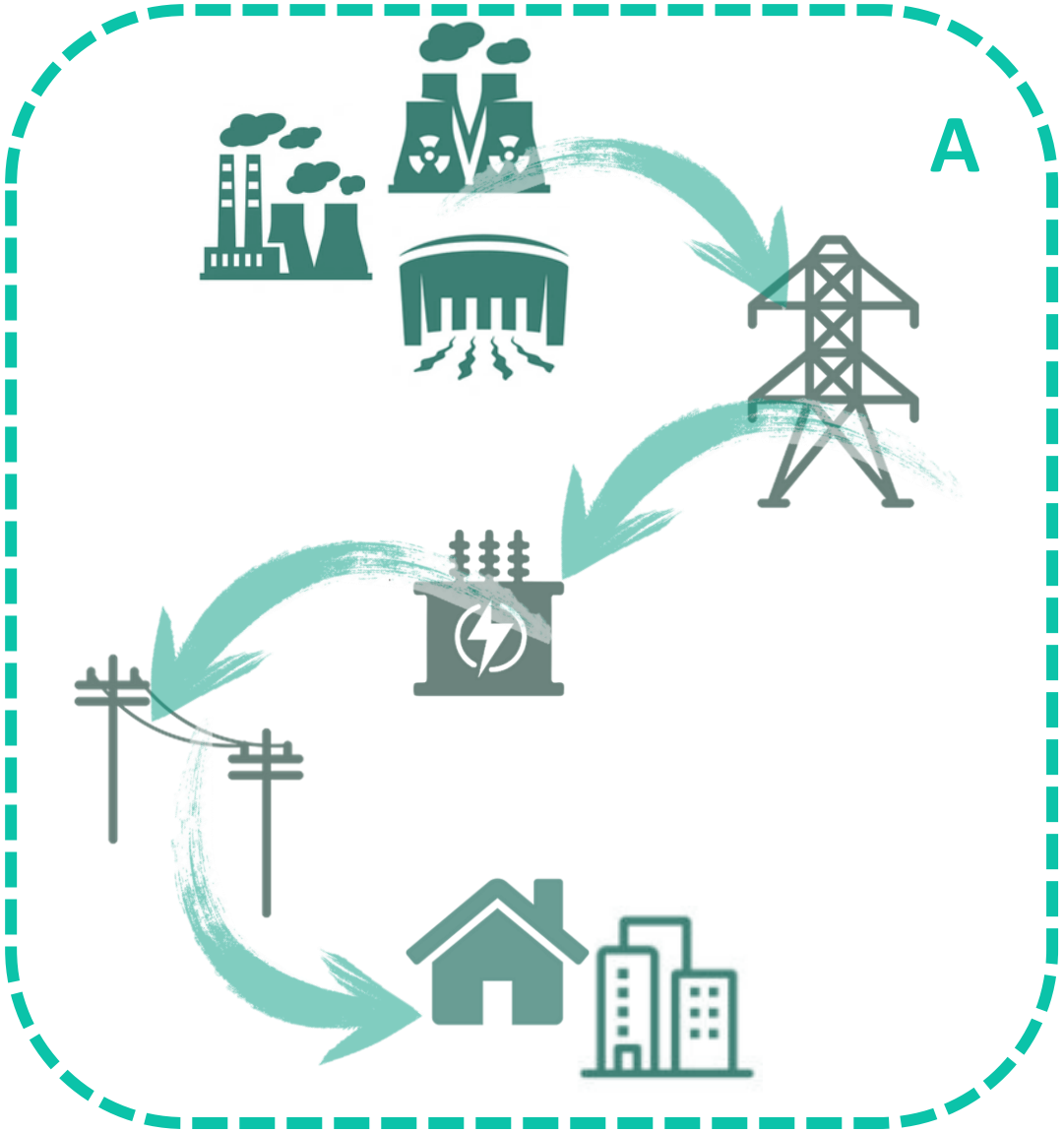
Agenda

- What are **wholesale energy markets**?
  - **History**: Vertical system to open markets
  - **Pricing Structures**: How to incentivize market participants to act in accordance with the societal goals
  - **Market Design** – How to build out enough capacity?
- How is the market changing?
  - **Renewables**
  - Extreme **weather** events
- How do utilities **manage market risks**?
  - Case Study: 2021 Texas Deep Freeze
  - Risk mitigation strategies

QUICK HISTORY

WHOLESALE ENERGY MARKETS

Grid Components



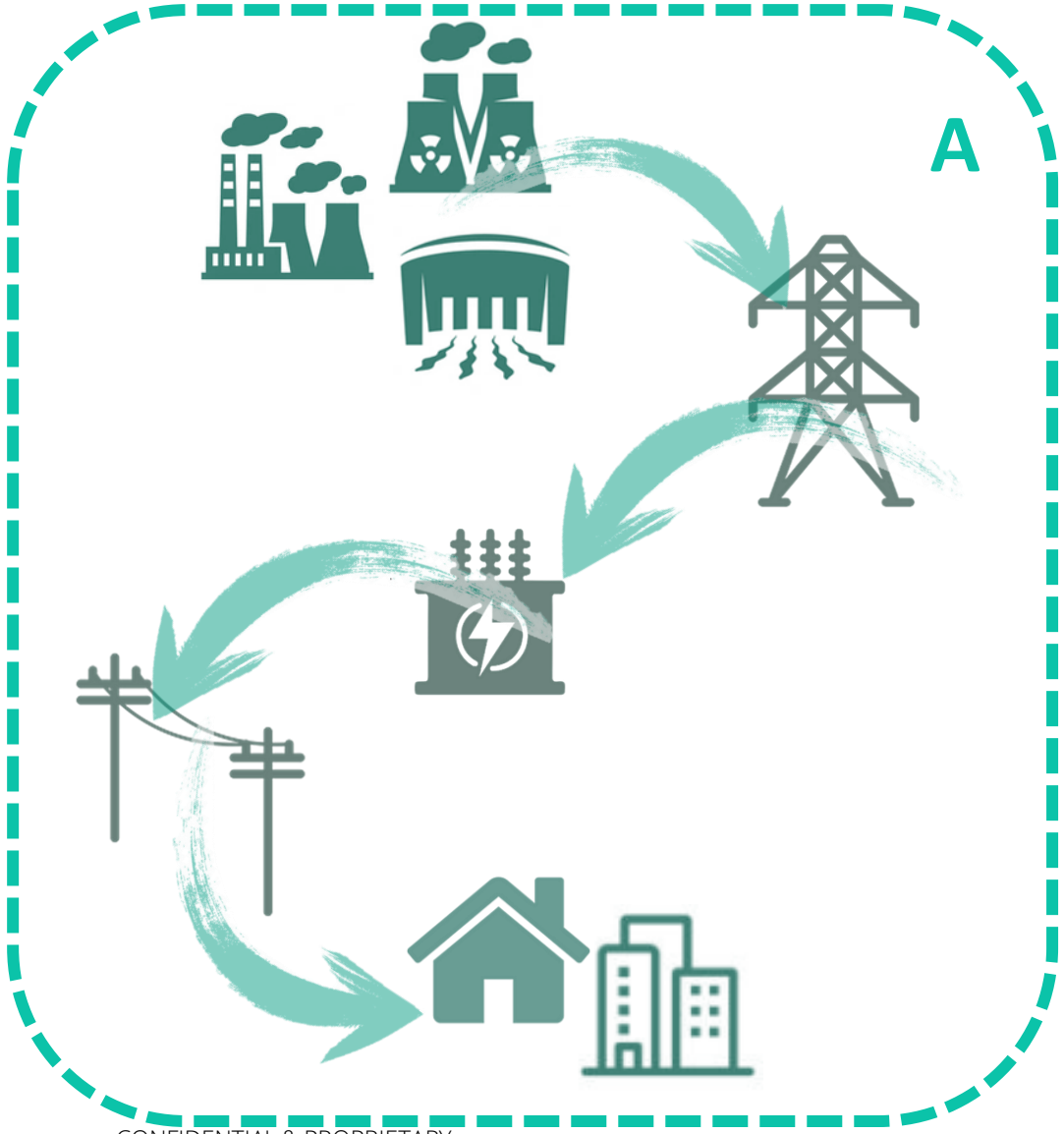
Generation

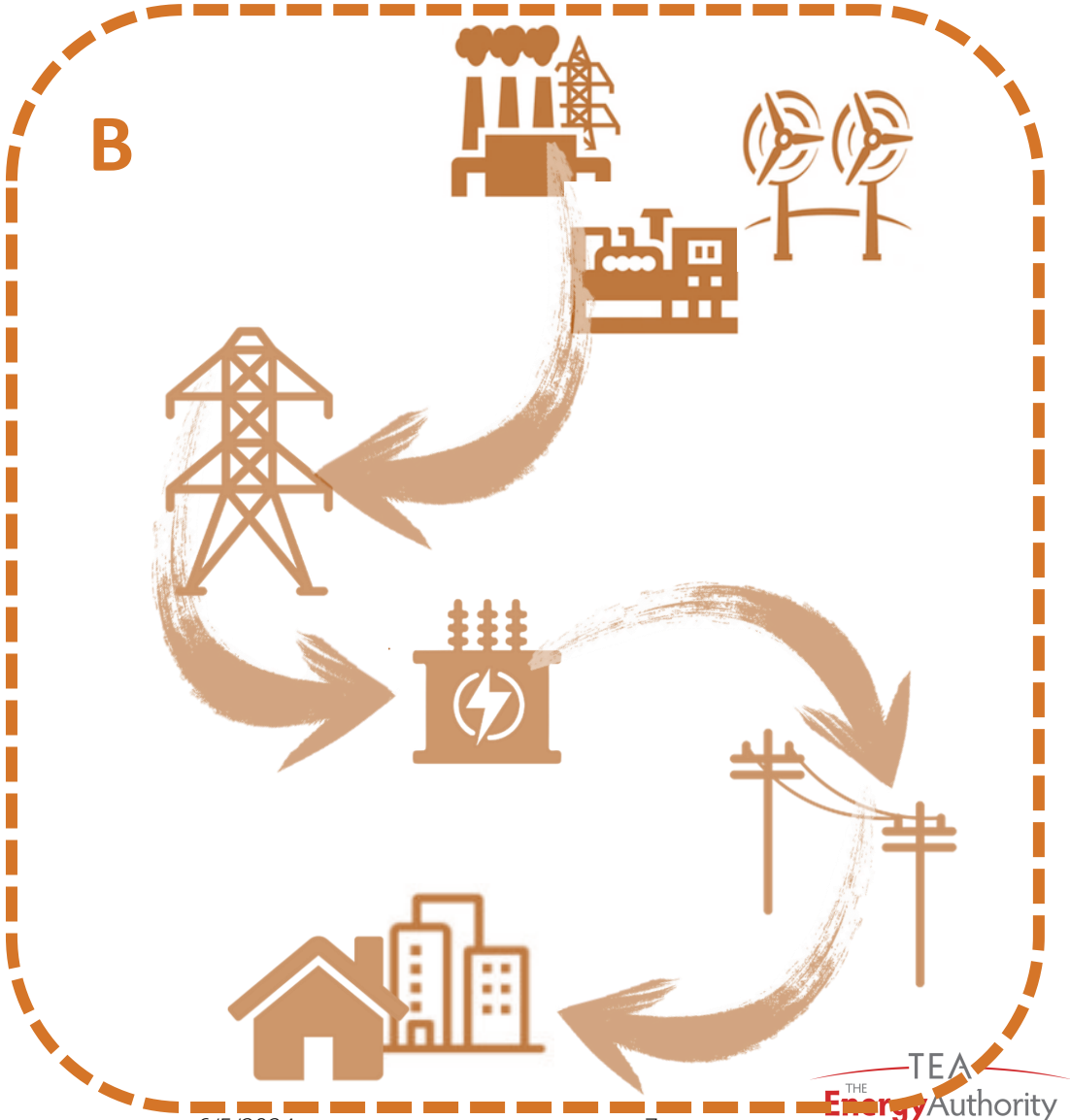
Transmission

Distribution

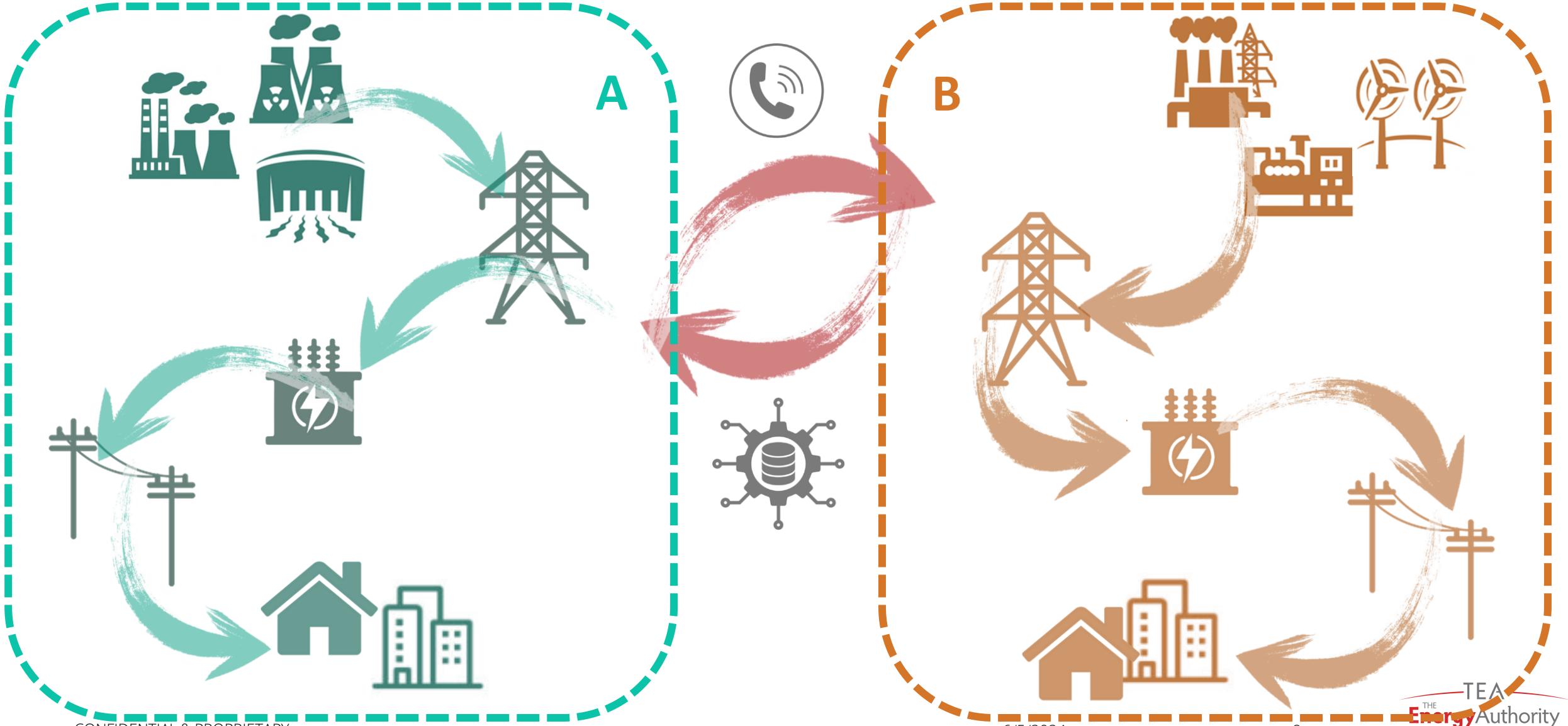
Load

Vertical Systems (before 80s)

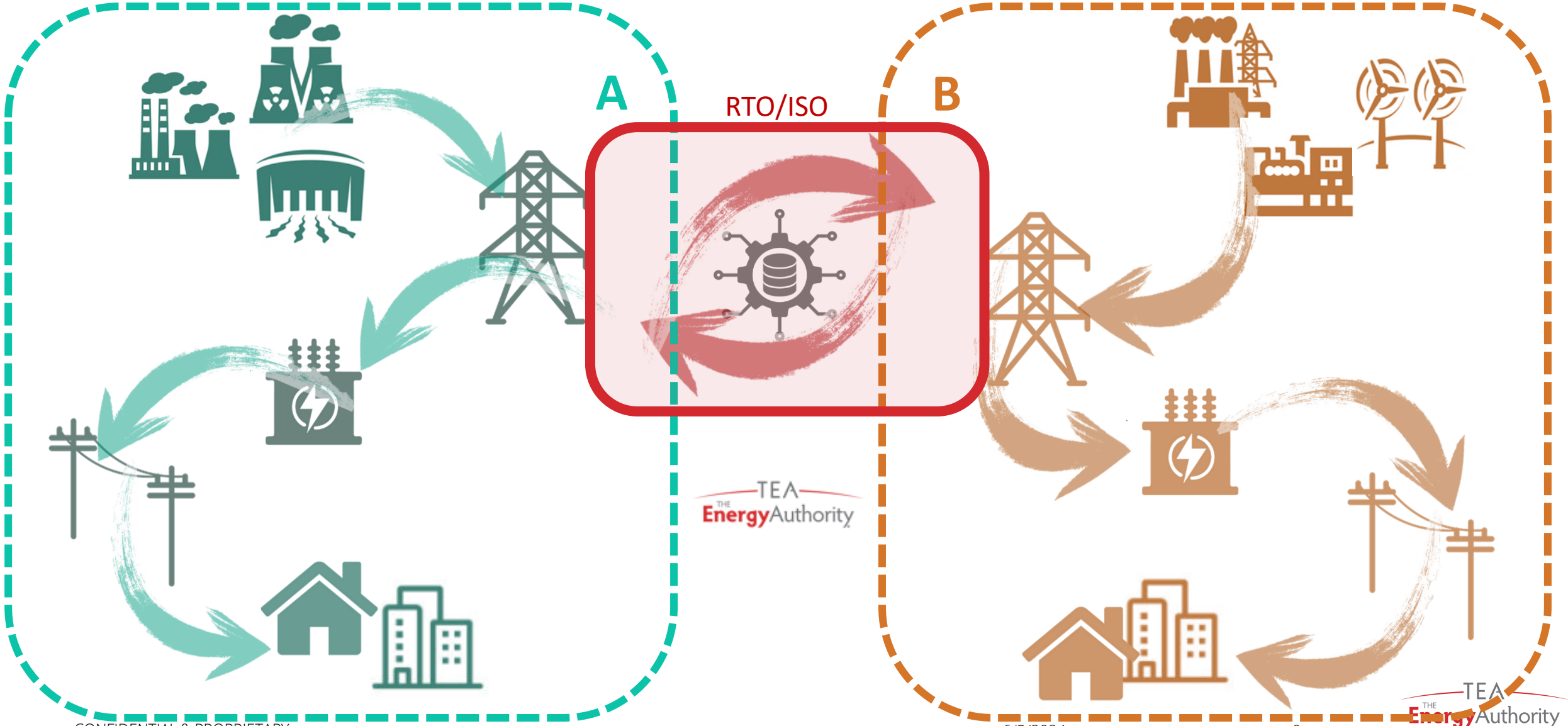




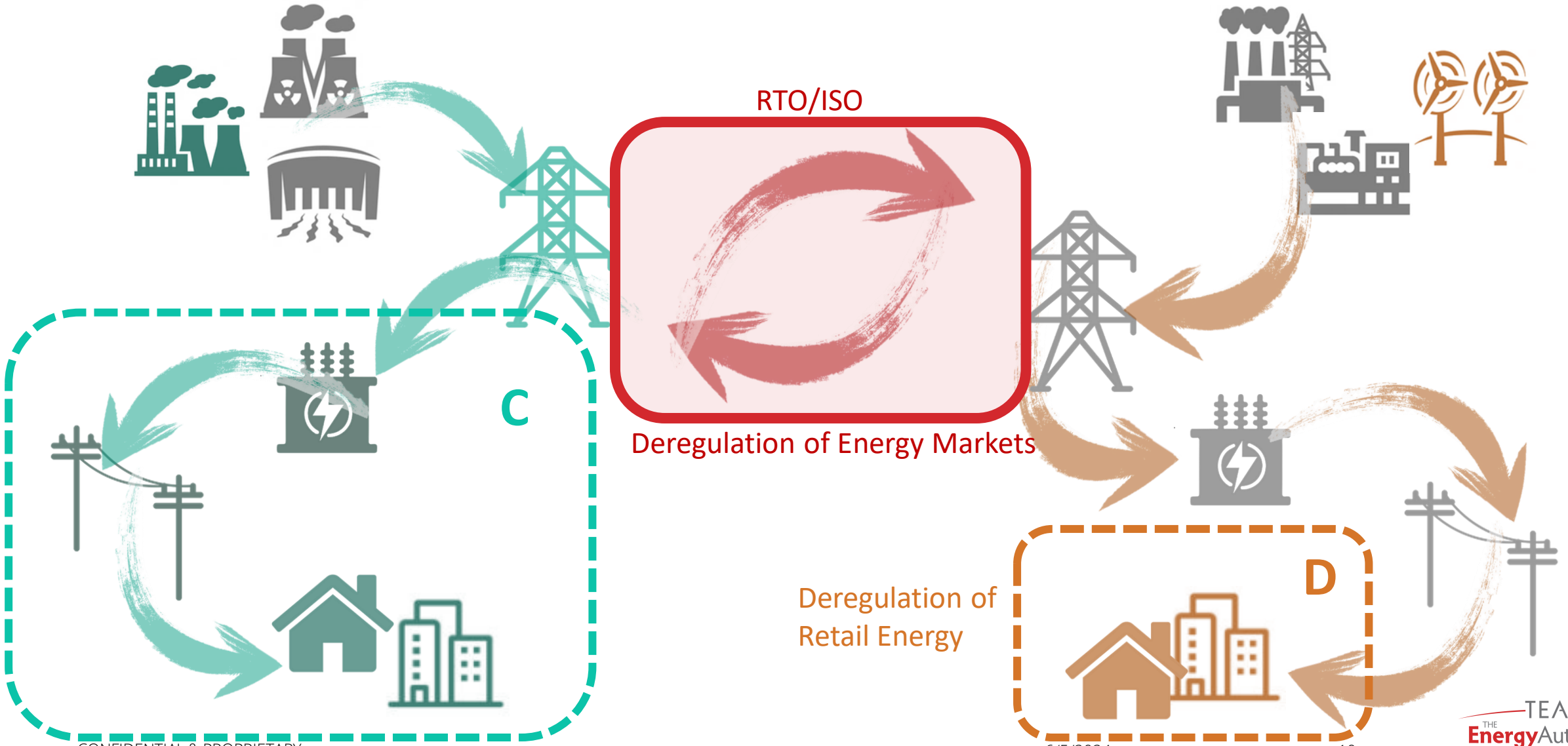
Deregulation & Open Market



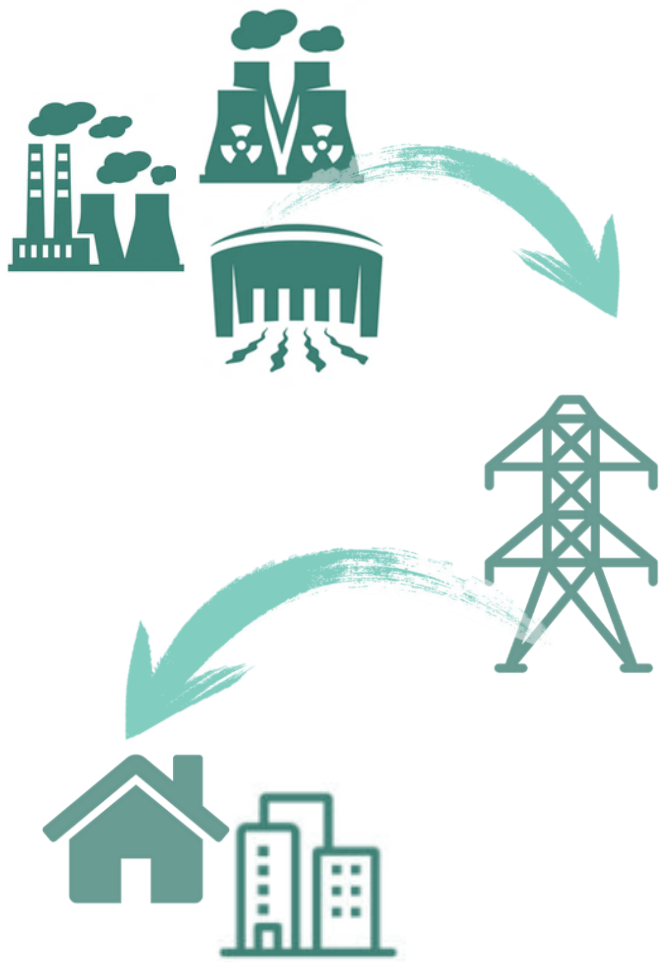
Regional Transmission Organizations (RTO) & Independent System Operators (ISO)

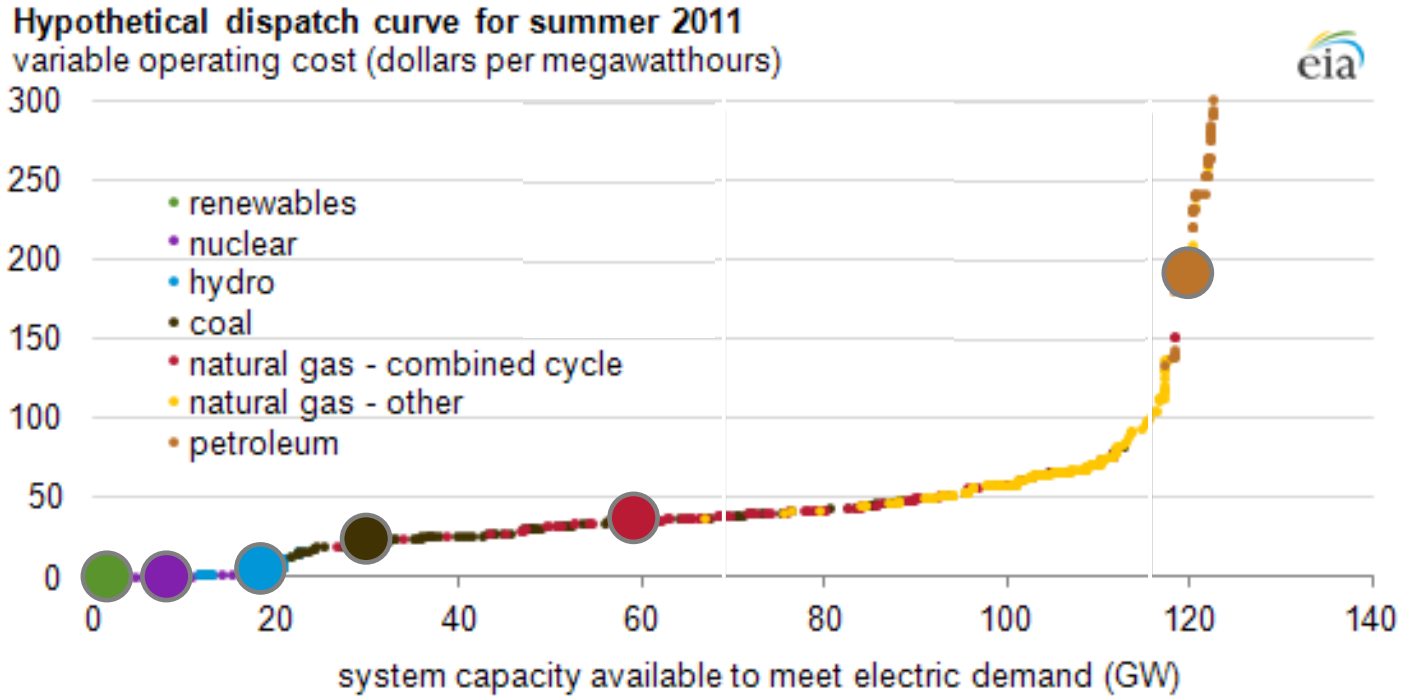


Utilities under Deregulated Markets



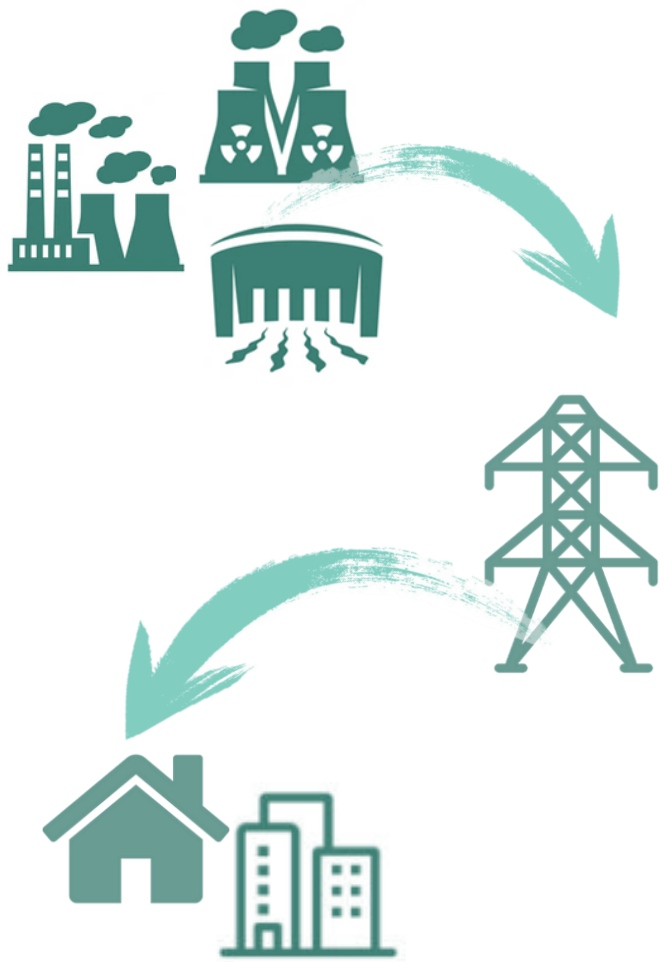
Marginal Resource & Marginal Prices

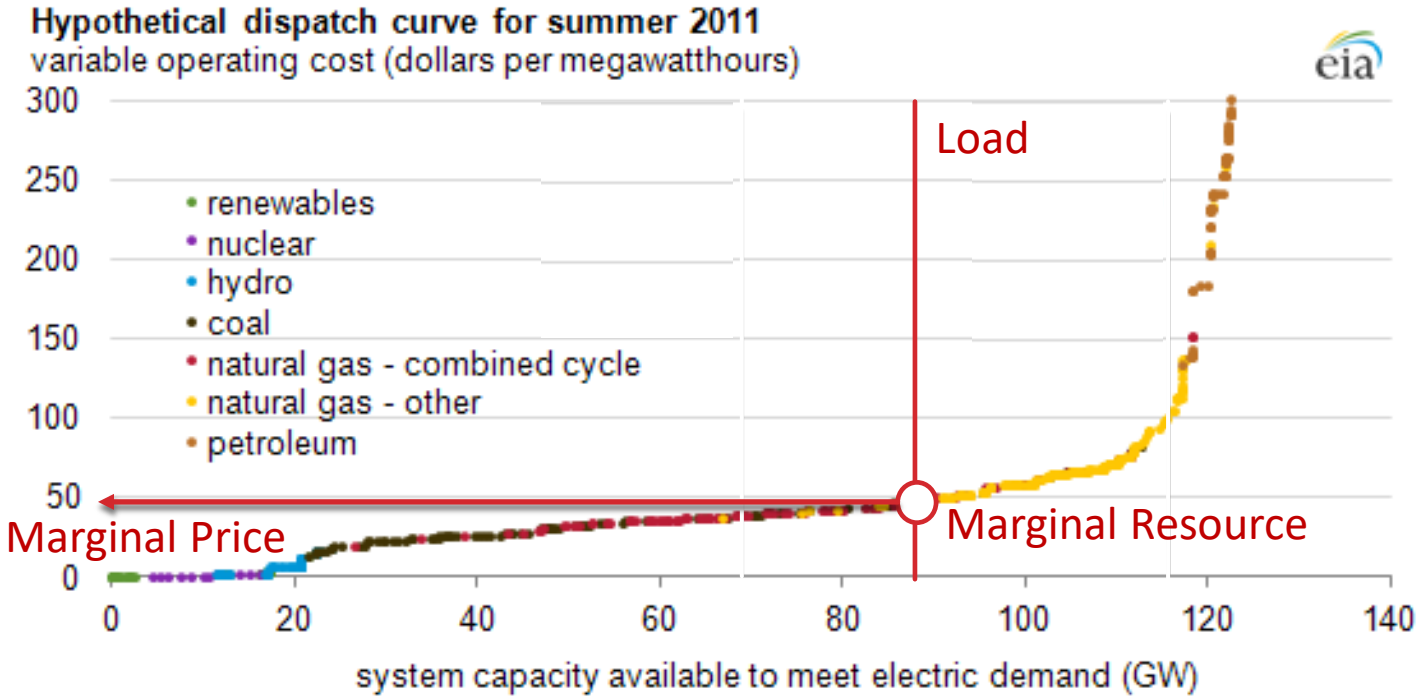




Source: https://www.eia.gov/todayinenergy/detail.php?id=7590

Marginal Resource & Marginal Prices

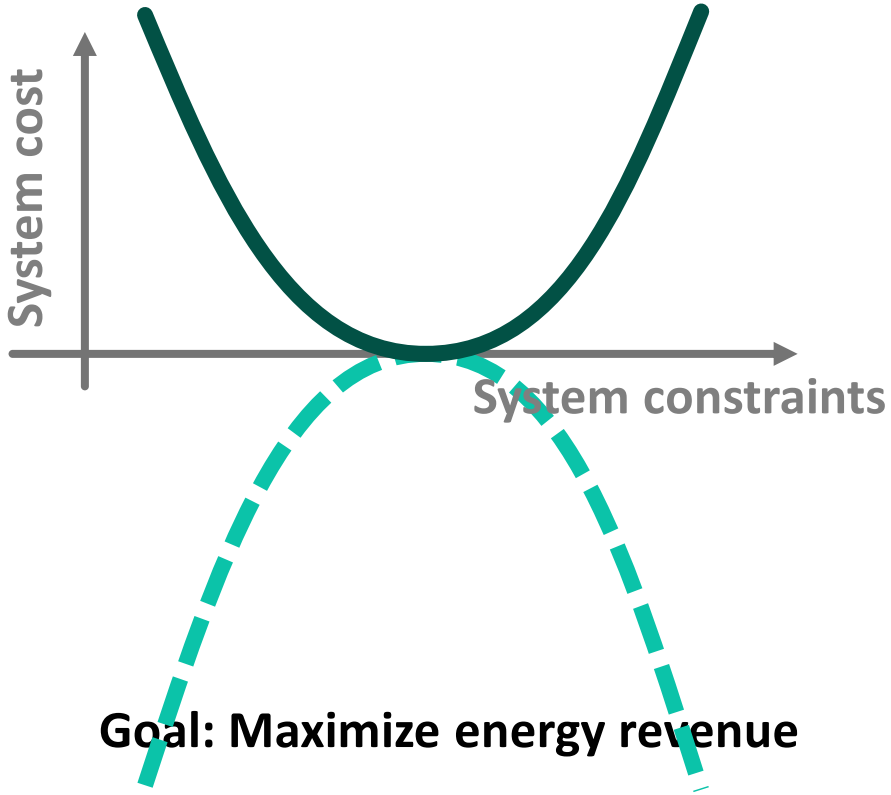




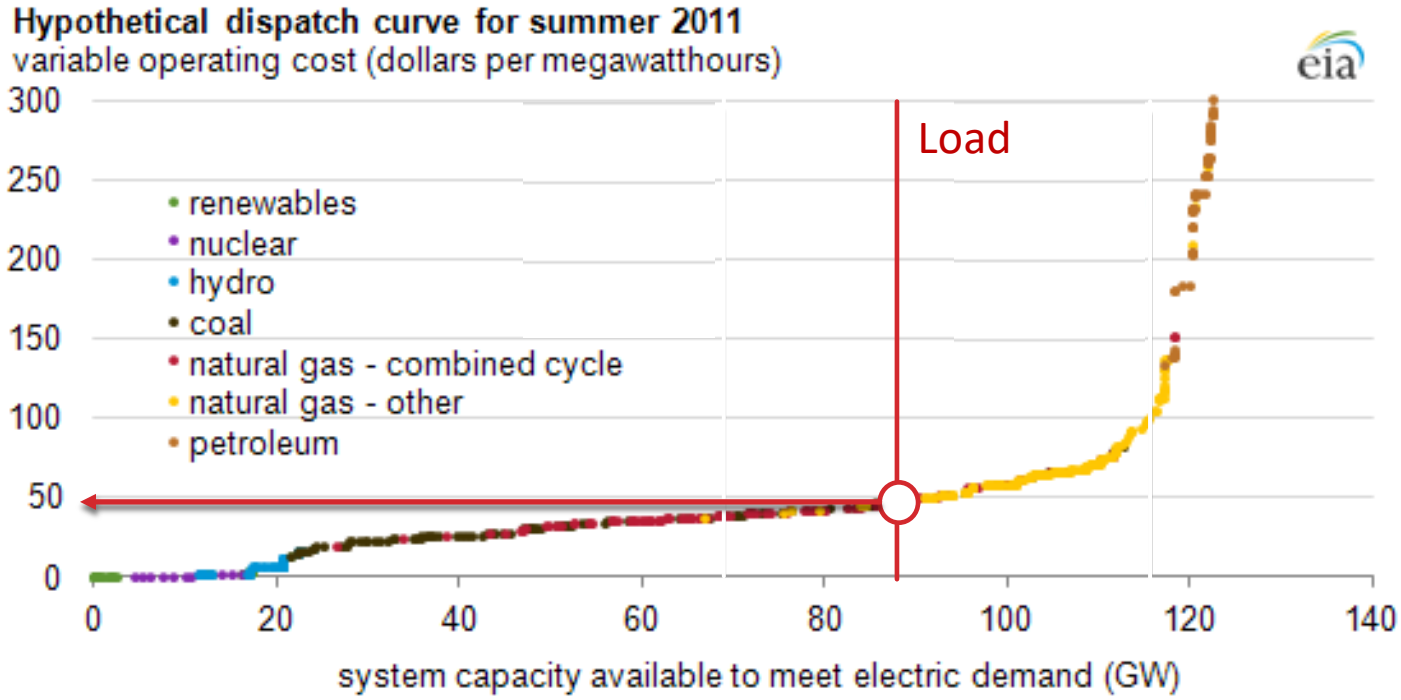
Source: https://www.eia.gov/todayinenergy/detail.php?id=7590

Matching Incentives

Goal: Reduce system cost



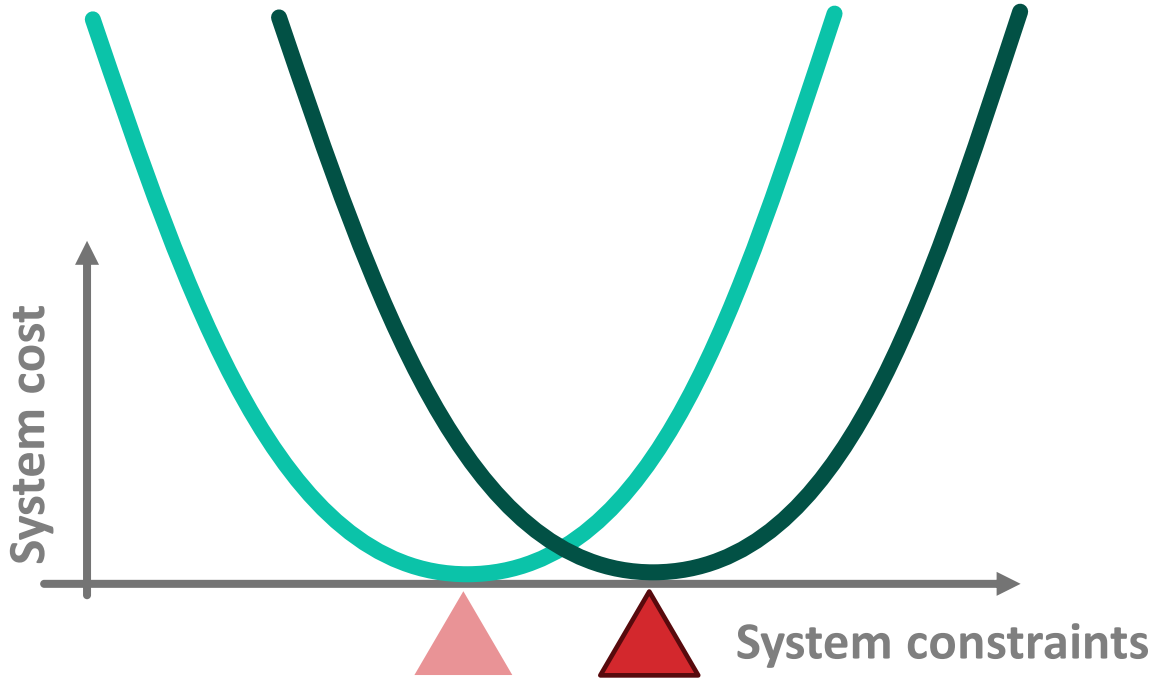
Goal: Maximize energy revenue

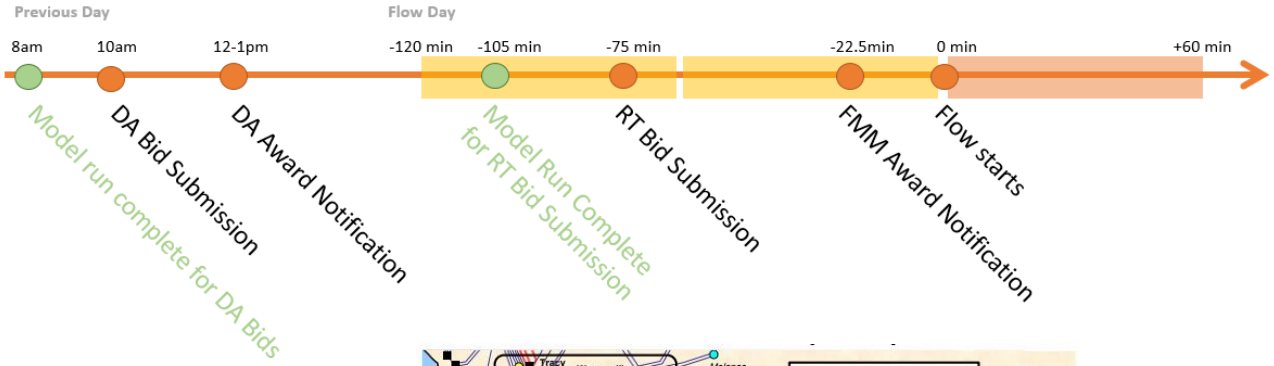


Source: https://www.eia.gov/todayinenergy/detail.php?id=7590

Day-Ahead vs Real-Time

Goal: Reduce system cost

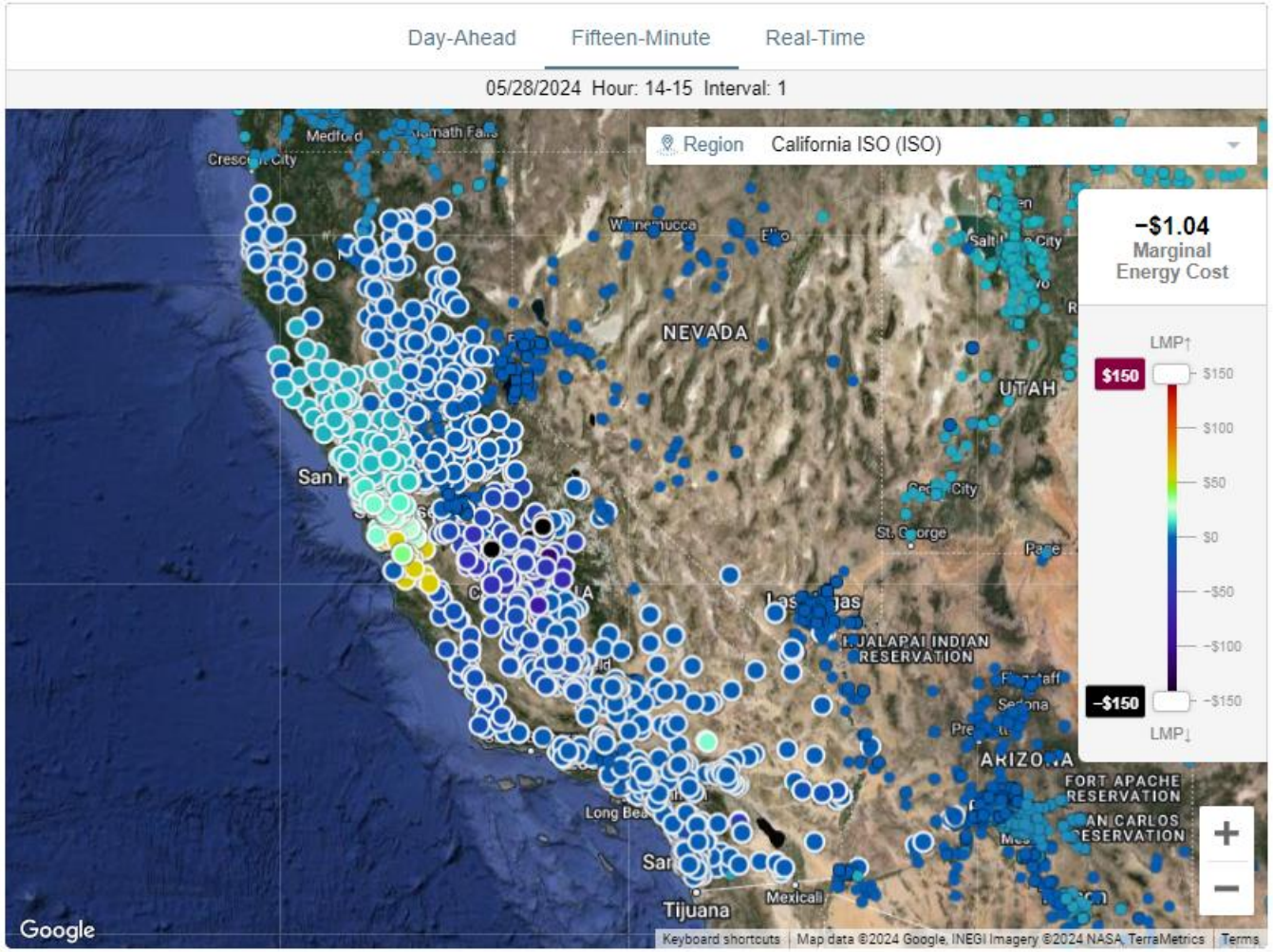




Source: https://www.caiso.com/documents/presentation-economicplanningstudyfinalresults.pdf

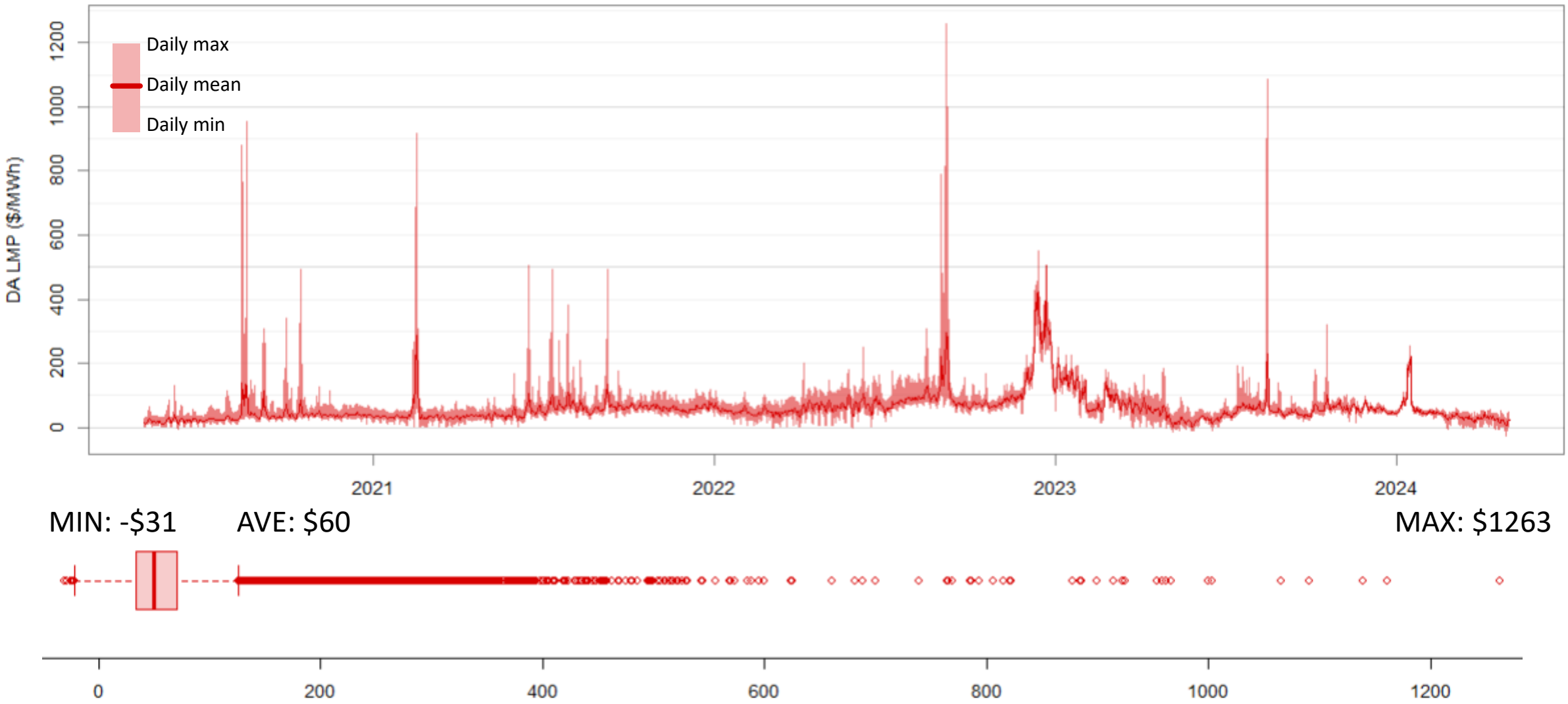
Locational Marginal Prices (LMP)

- Pricing at
  - **Every Gen/Load Node**
  - For
    - Every hour in Day-Head Market
    - **Every 5 min** in Real Time Market

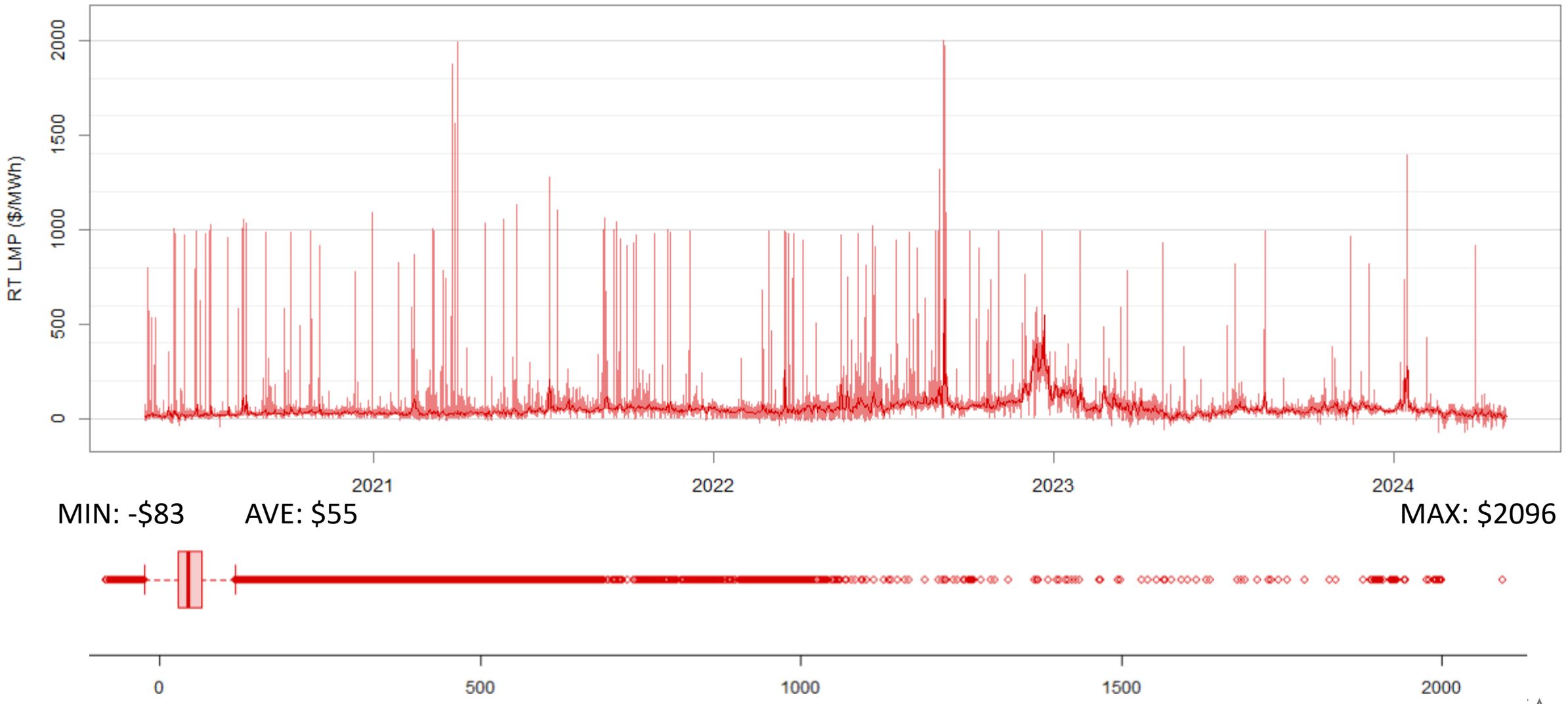


Source: https://www.caiso.com/TodaysOutlook/Pages/prices.html

Wholesale Energy Price: Day-Ahead California Hub LMP

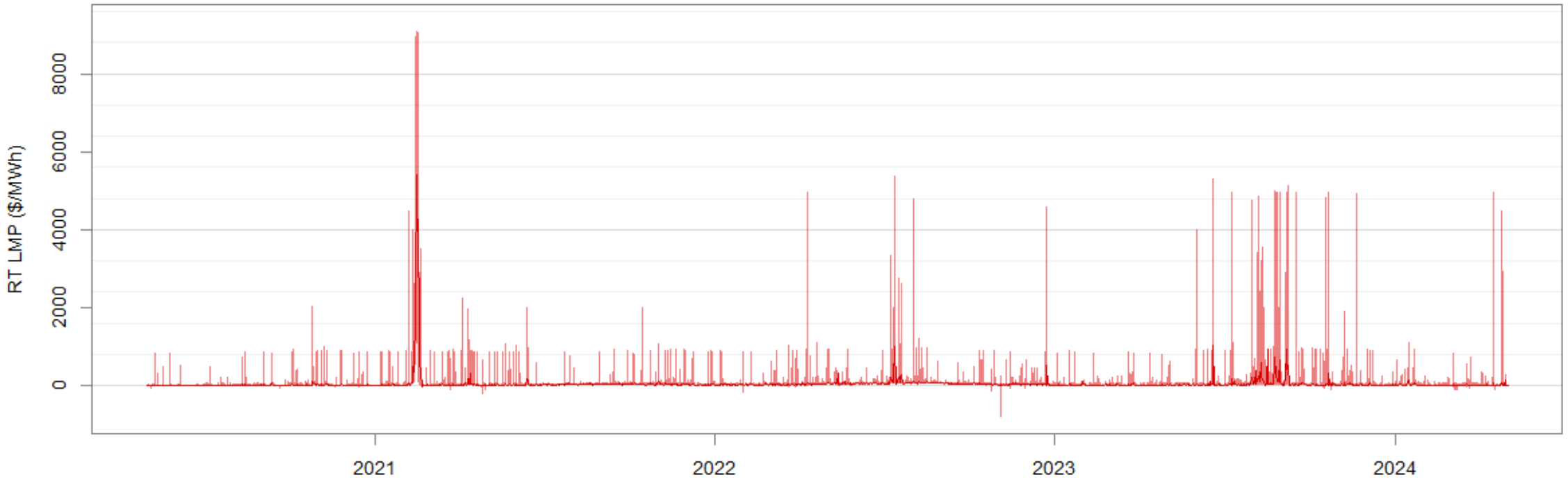


Wholesale Energy Price: Real-Time California Hub LMP

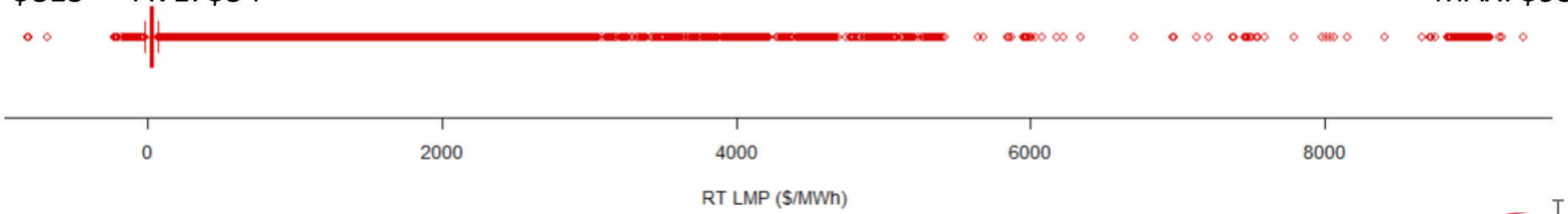


MIN: -$83 AVE: $55 MAX: $2096

Wholesale Energy Price: Real-Time Texas Hub LMP

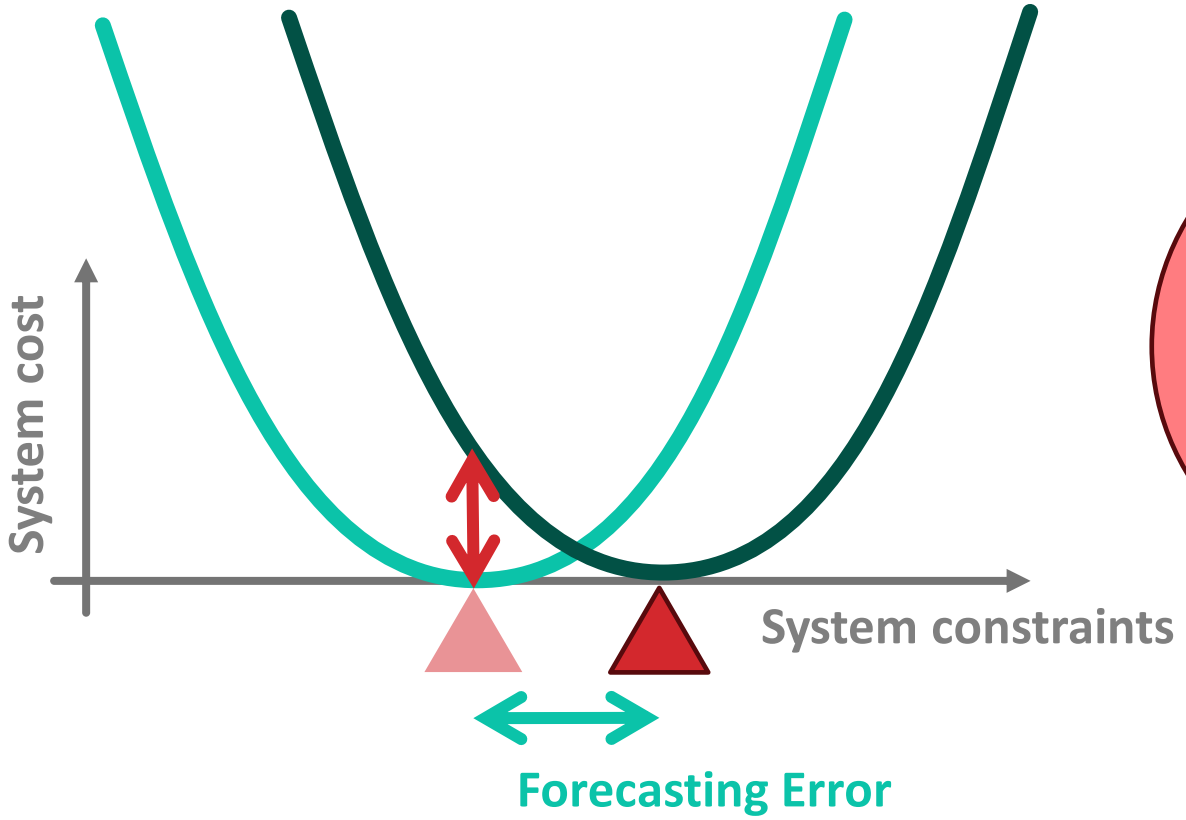


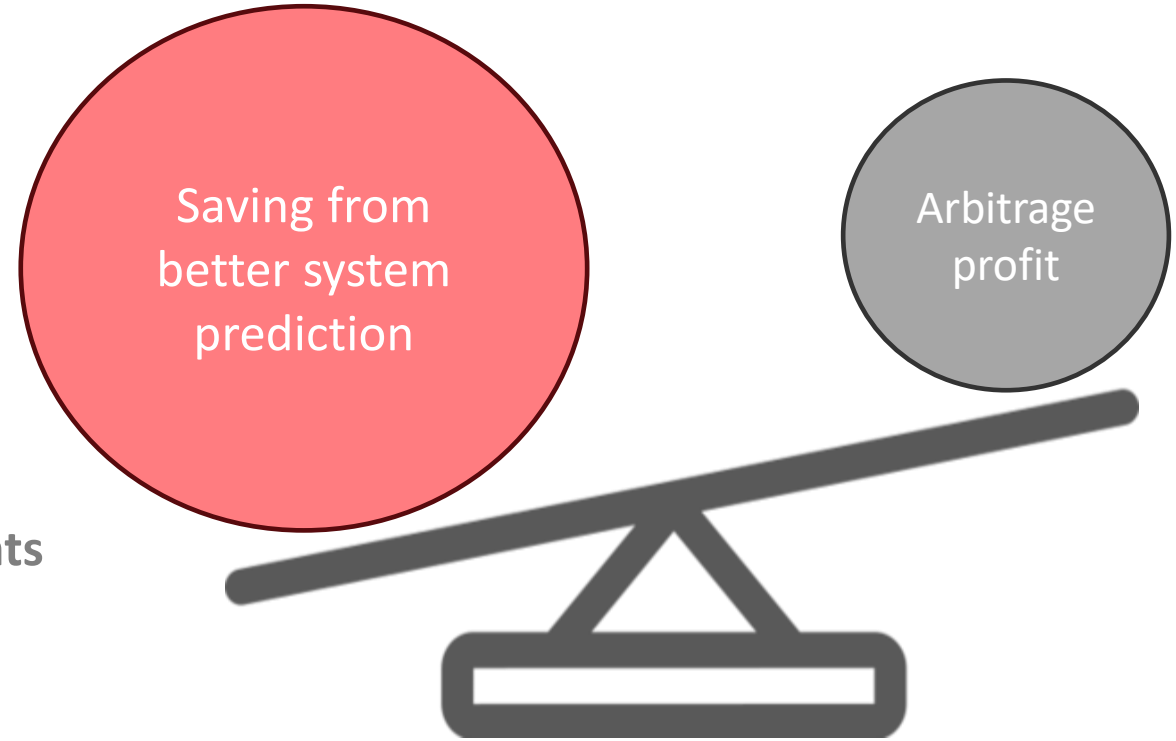
MIN: -$813 AVE: $54 MAX: $9352



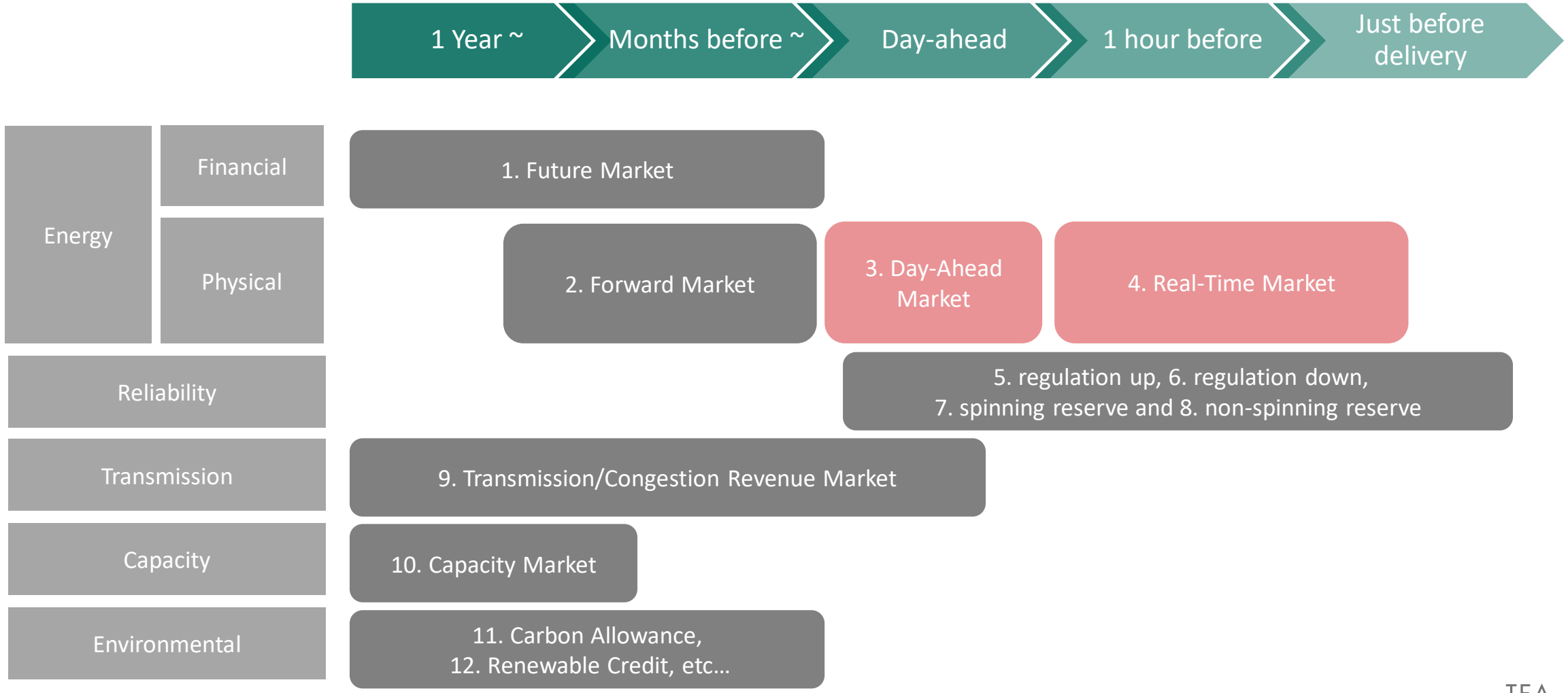
Virtual Bidding & Societal Benefit

- Market allows virtual bidding because:
  - Saving > Arbitrage profit





Wholesale Energy Markets

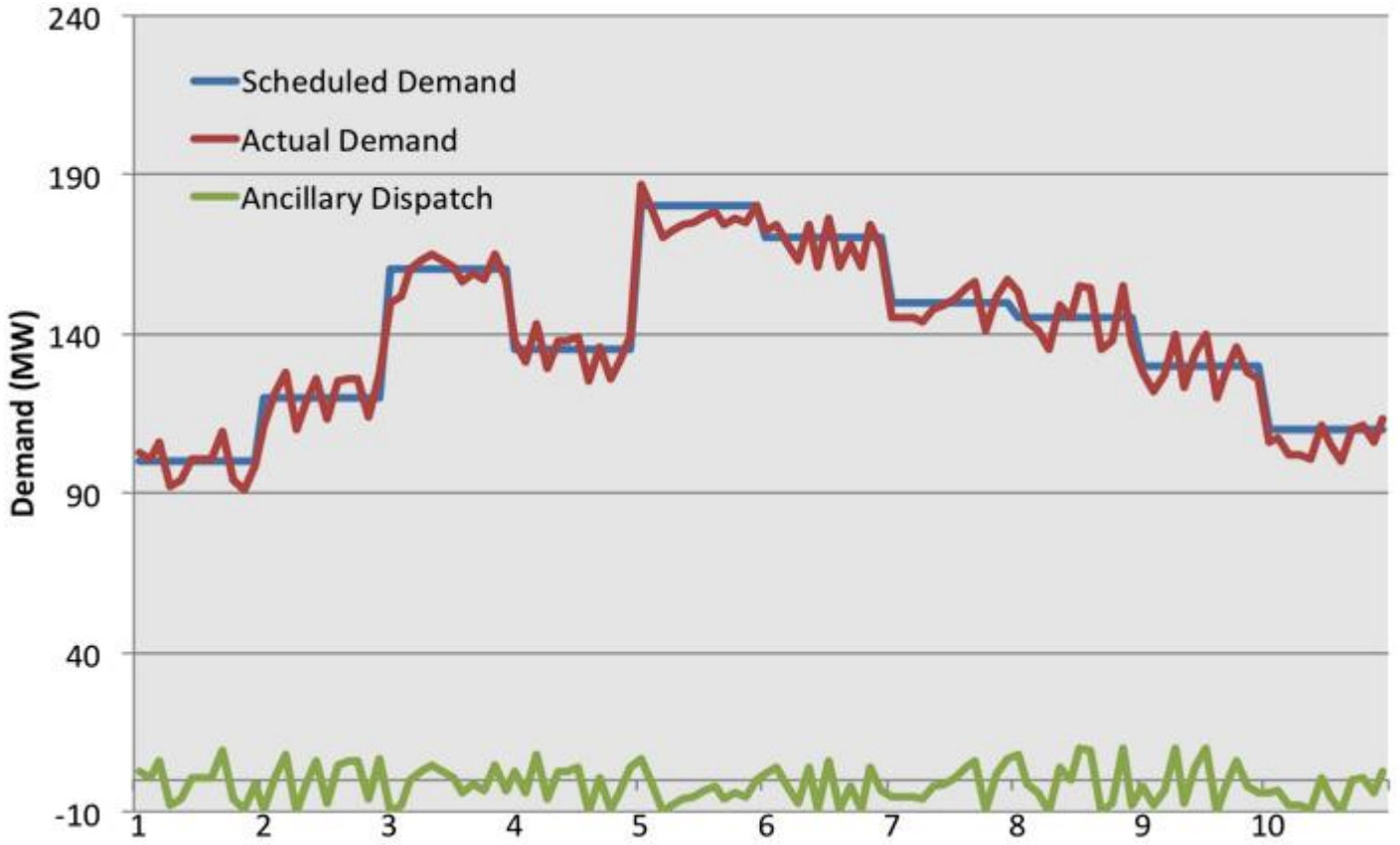


Ancillary Services Markets

Products

- Regulation Up
- Regulation Down
- Spin
- Non-spin
- Supplemental
- Black start

Regulation Services

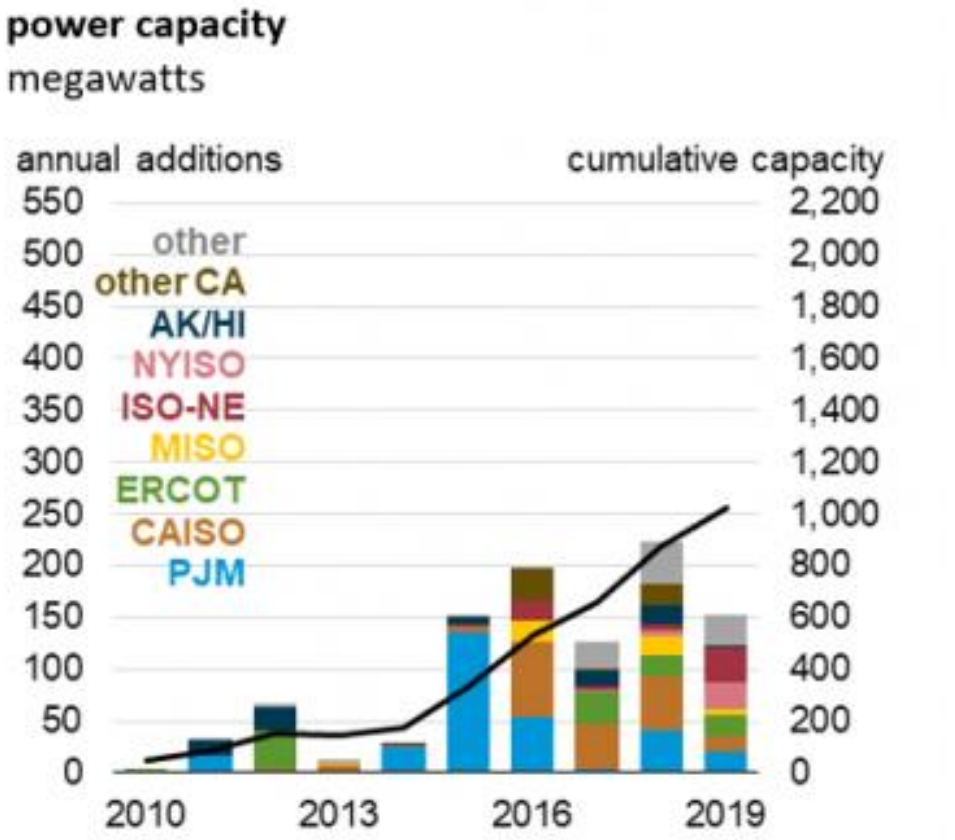


Source: https://www.e-education.psu.edu/eme801/node/702

Regulation & Battery

- PJM's battery-friendly market rules
  - → Short-duration battery build out
  - → Market saturation & price collapse

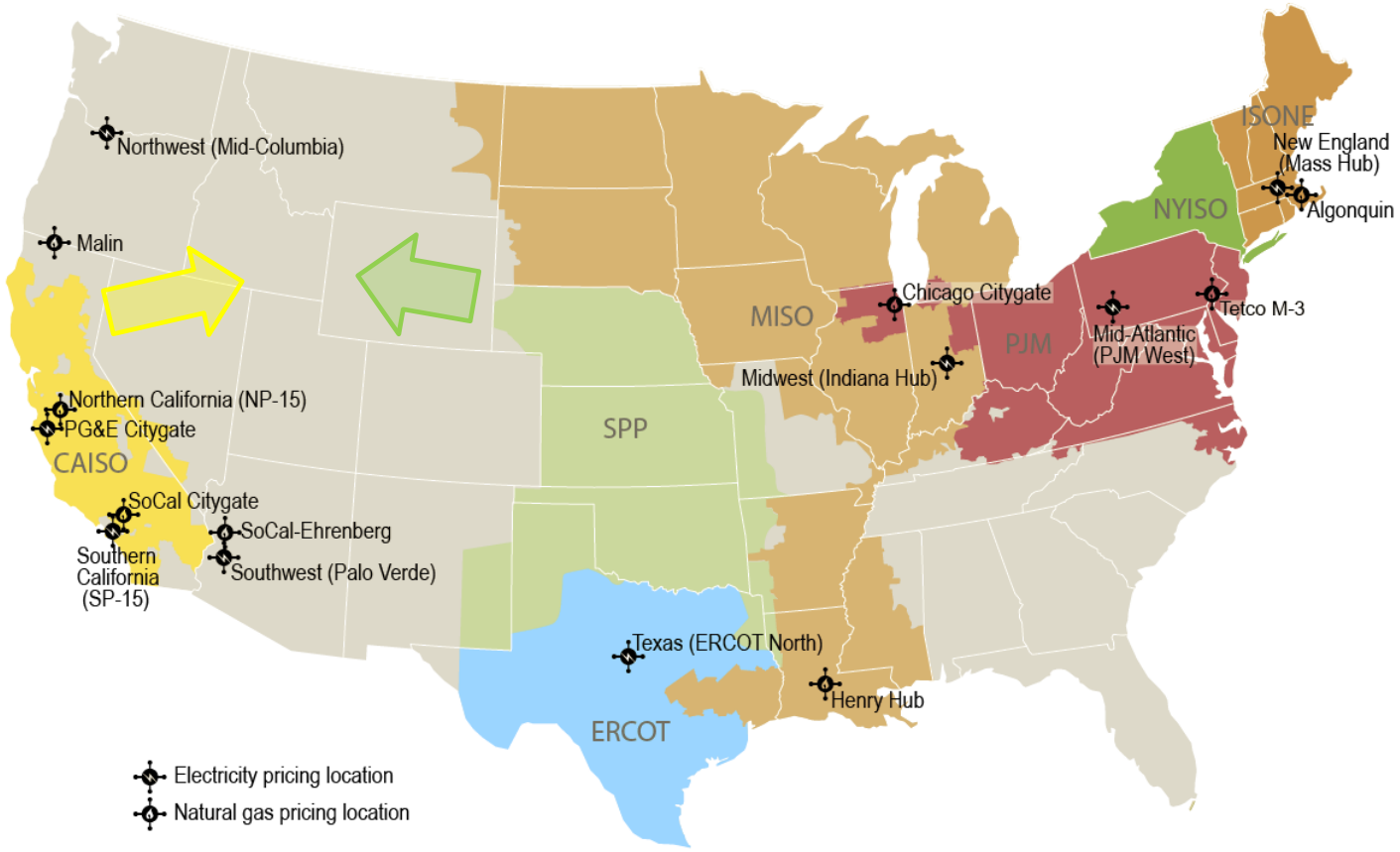
- Take Away from this:
  - Wholesale energy economics does matter
  - Market rules can make entry to market easier.
  - Careful market design is essential.
    - Over-promising of battery accommodation caused system challenges.



Source: U.S. Energy Information Administration, 2019 Form EIA-860, *Annual Electric Generator Report*

Markets & Market Designs

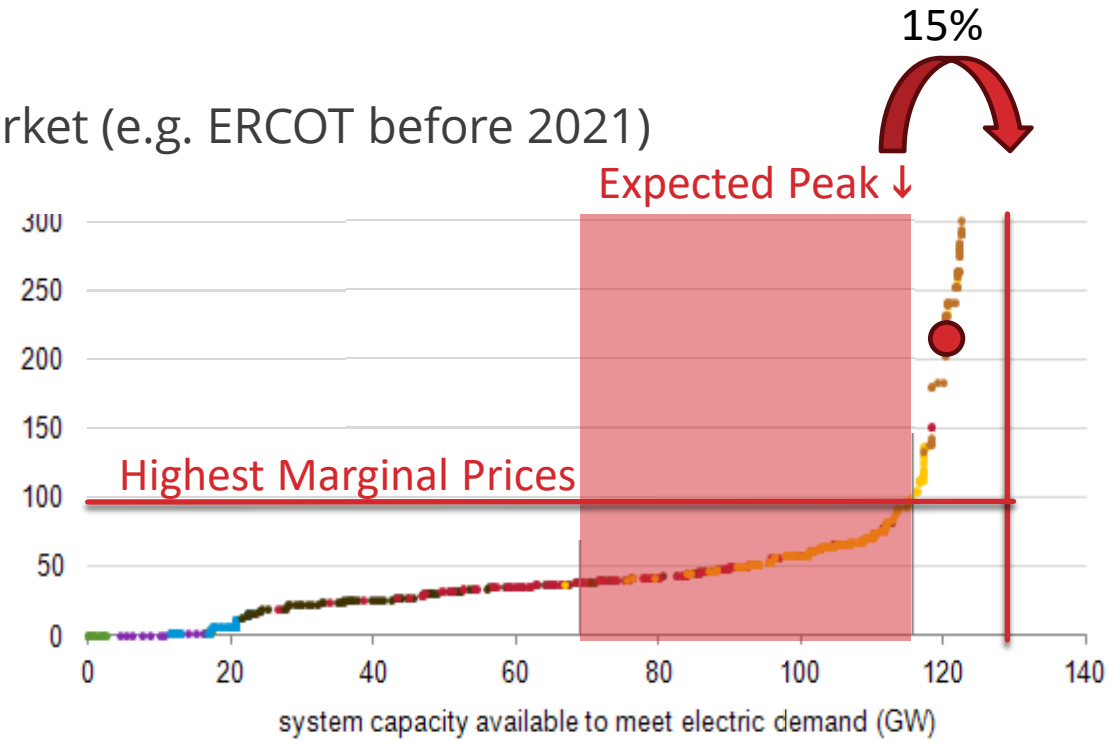
Selected price hub locations for wholesale electricity and natural gas reported by Intercontinental Exchange



Note: Colored areas denote Regional Transmission Organizations (RTO)/Independent System Operators (ISO)
Source: U.S. Energy Information Administration based on Ventyx Energy Velocity Suite

Incentives for Reliability

- Reserve margin needed for reliability: 15 ~ 20%
- Approaches
  - Put obligation to load-serving entities to procure capacity (e.g. CAISO)
  - Capacity Market (e.g. PJM)
  - Send high pricing signal to build more in Energy Market (e.g. ERCOT before 2021)
- Complications
  - Reliability issues for wind & solar
  - Quick ramping capacity
  - Locational needs
  - Hour of the day
  - Fairness



Institutional Goals

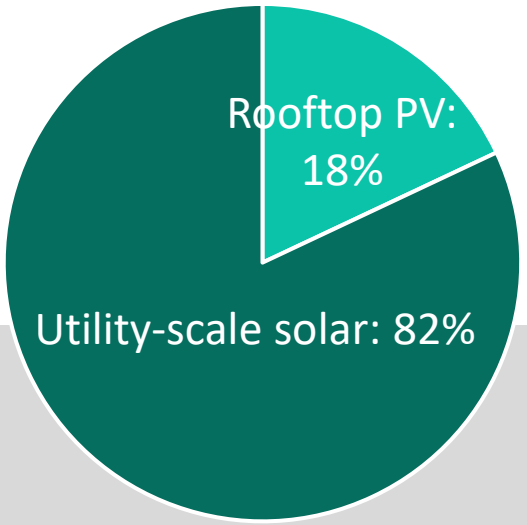
- **Public Utilities**
  - Reliability
  - Affordability
  - (Promote green and efficiency initiatives)

While
- Meeting all regulations
- Making defendable future investments
- Adopting to changing market

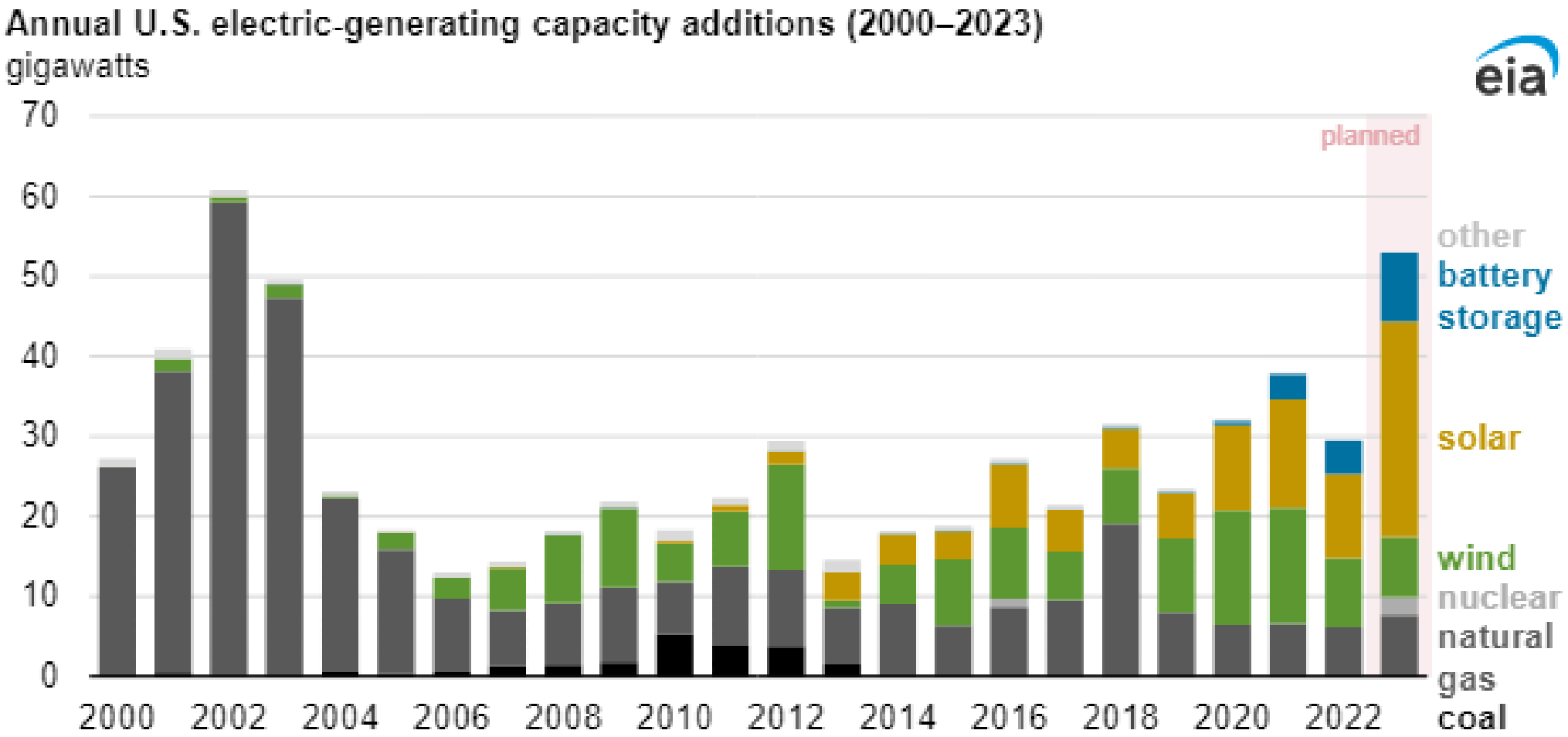
- **ISO/RTO**
  - Reliability
  - System efficiency to keep cost down
  - Implement fair market rules for all market participants

- **Policy Makers**
  - Larger societal goals
    - Green initiative (RPS)
    - Carbon initiatives (allowance market, tax)
    - Distributed Energy initiatives (FERC 2222)
    - Etc…

IMPACT OF RENEWABLES

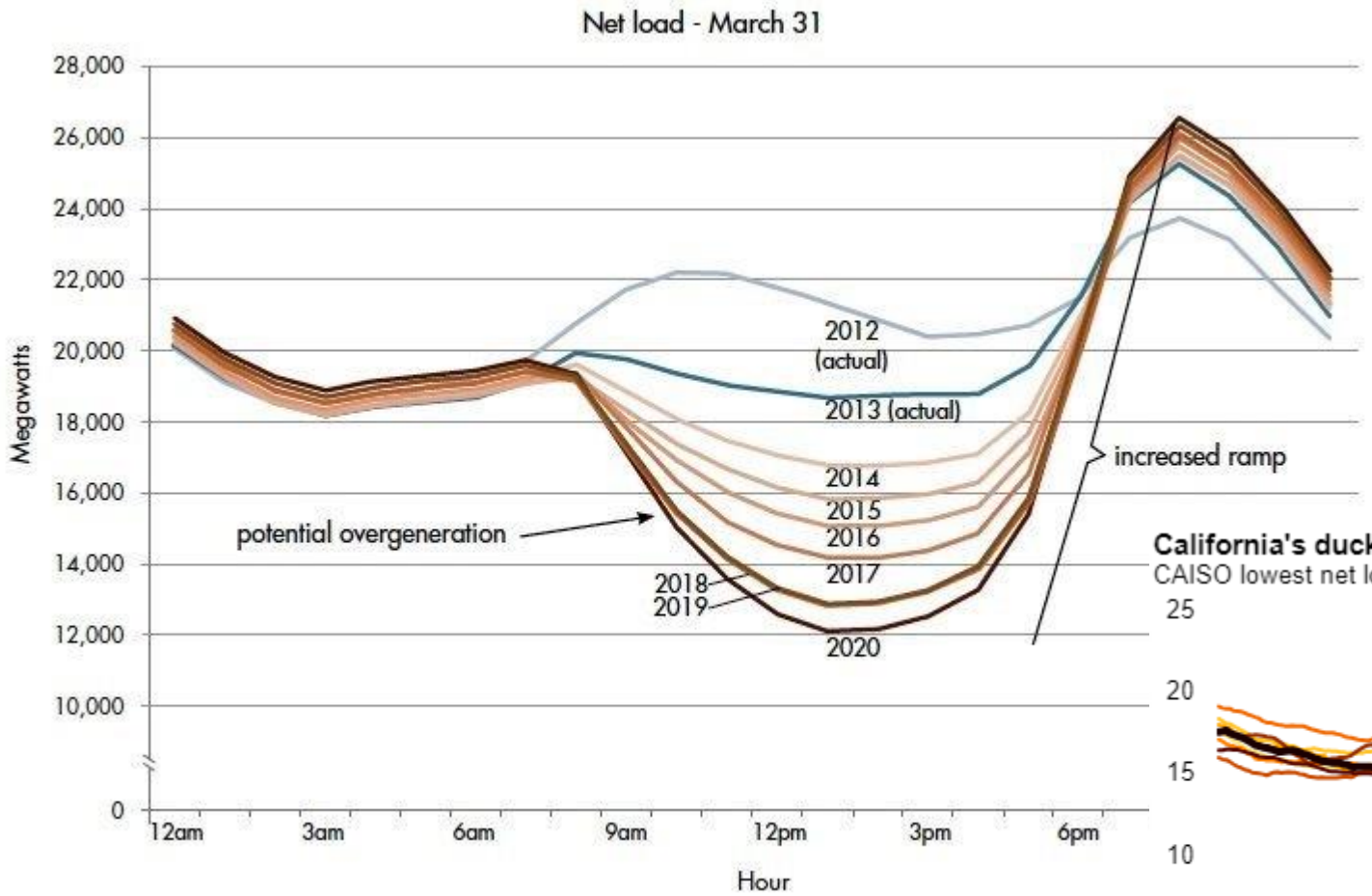


What does it take to incorporate Renewables?



Source: https://www.eia.gov/todayinenergy/detail.php?id=55719

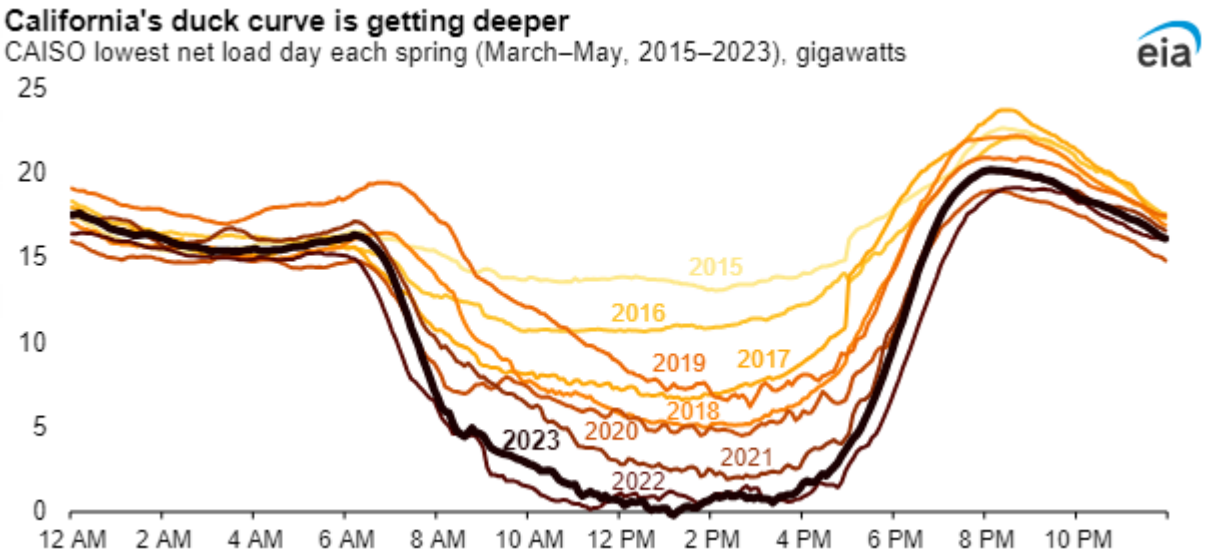
Duck Curves



Source: https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy

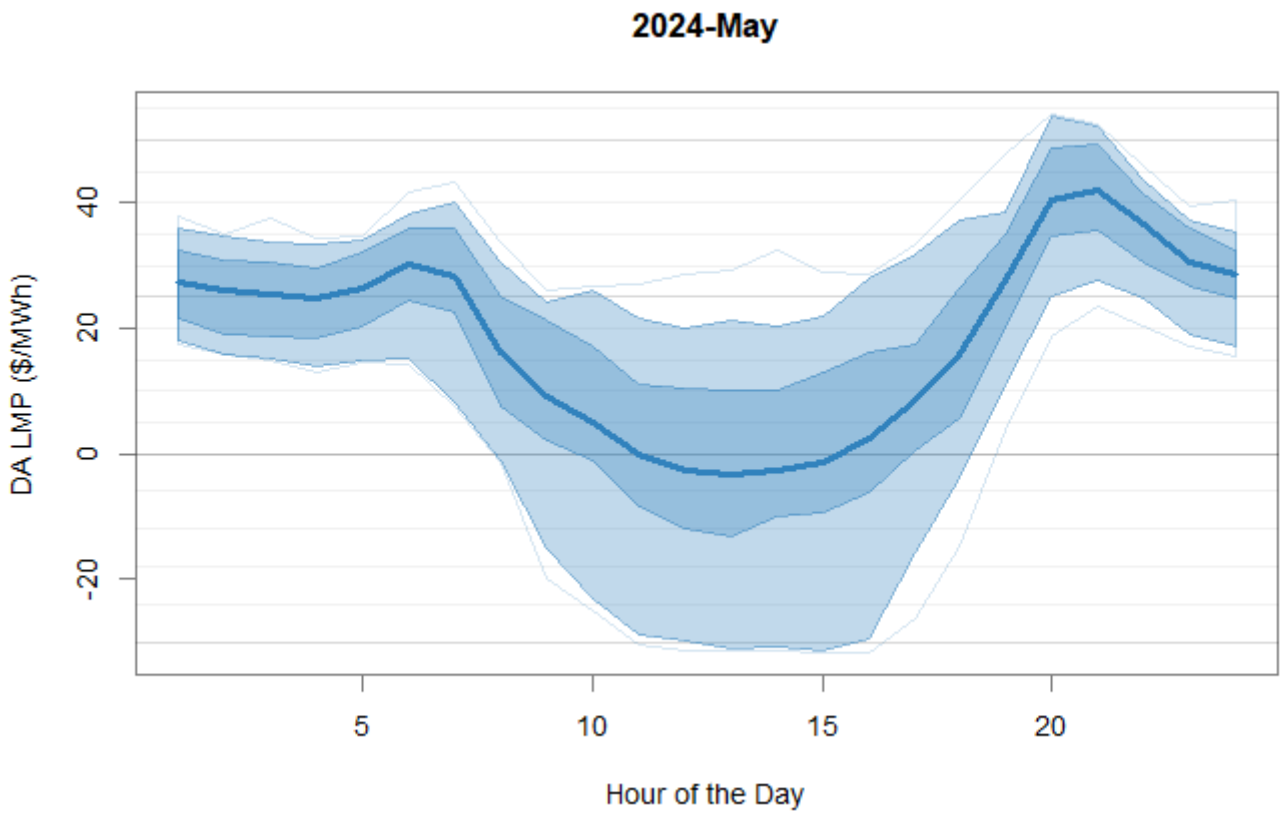
←Projected in 2014

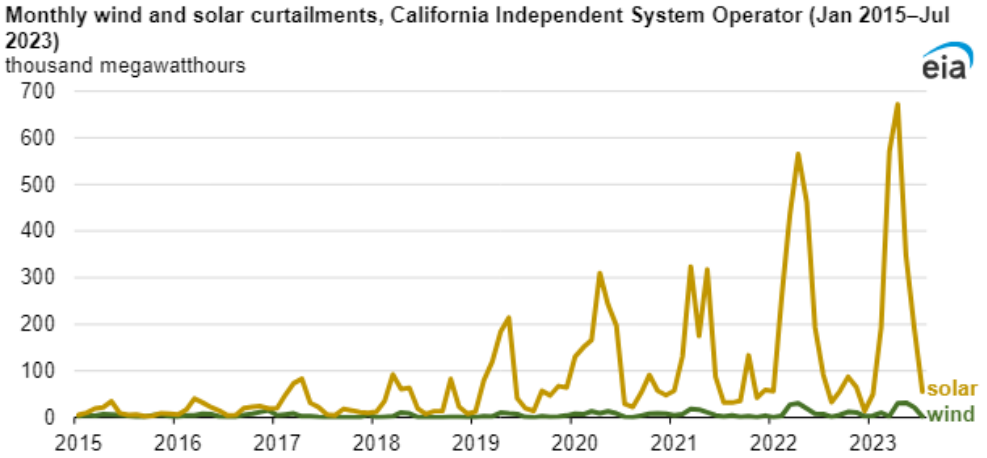
↓ What happened so far



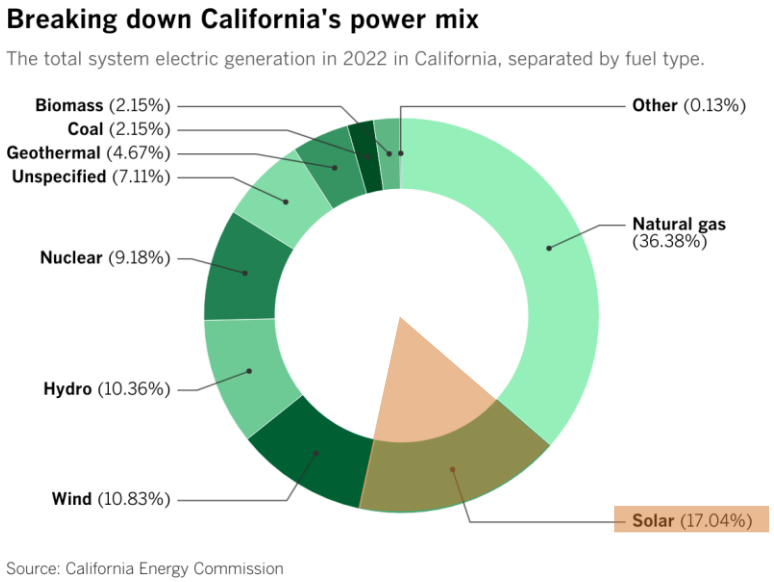
Source: https://www.eia.gov/todayinenergy/detail.php?id=56880

Negative prices & Solar Curtailment



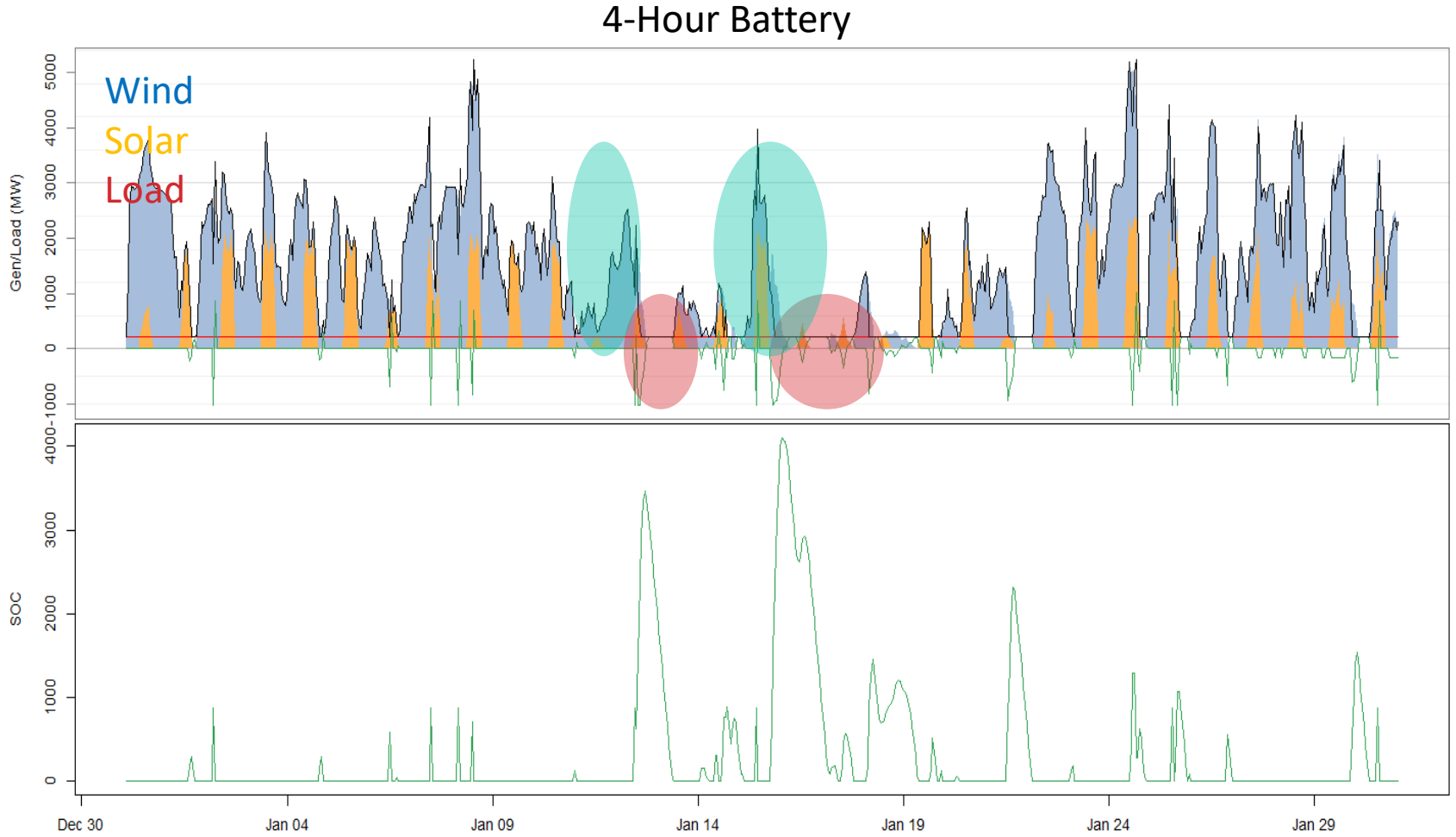


Source: https://www.eia.gov/todayinenergy/detail.php?id=60822



Source: California Energy Commission

What does it take to be 100% renewable?



Required Renewable Capacity to Meet Flat 200 MW Load

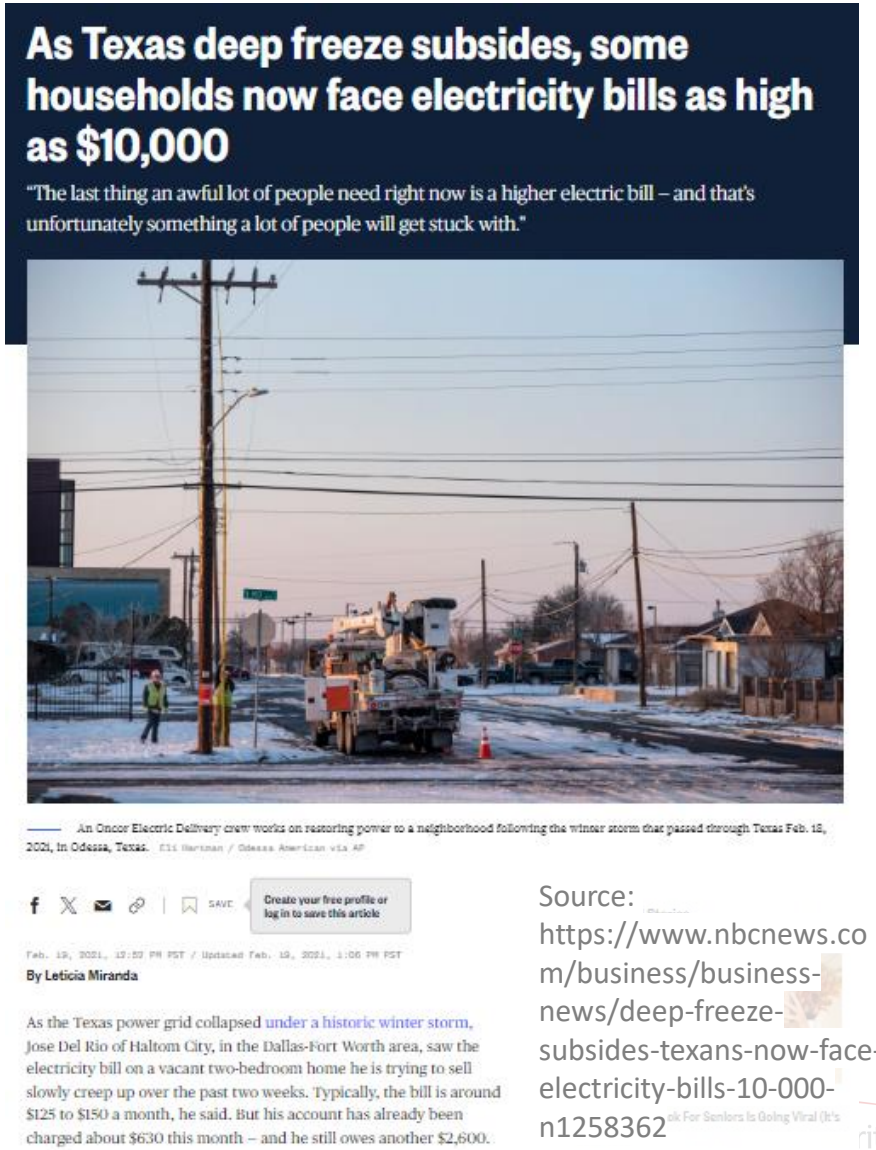
Duration	Battery	Solar	Wind
4	1184%	1847%	1112%
8	697%	832%	1112%
16	359%	397%	1112%
24	239%	386%	1112%
72	138%	165%	1112%

RISK MANAGEMENT

Case Study: 2021 Winter Storm Uri

- Key Events
  - Unprecedented Winter Storm Uri (-10°F for a week).
  - Unwinterized assets froze
    - Gas pipelines
    - Variable generation
    - Thermal generation
  - Texas as an Island grid
  - Skyrocketing wholesale fuel and energy prices
  - Deregulated retail, passing wholesale price directly to consumers

- Results
  - One utility with an expected annual fuel costs was ~$170 mil, paid $102 million for fuel just during the week.
  - Another utility had to take a loan to pay off Uri, adding $2 to every bill for all rate payers for 28 years.



As Texas deep freeze subsides, some households now face electricity bills as high as $10,000

"The last thing an awful lot of people need right now is a higher electric bill – and that's unfortunately something a lot of people will get stuck with."

An Oncor Electric Delivery crew works on restoring power to a neighborhood following the winter storm that passed through Texas Feb. 18, 2021, in Odessa, Texas. Eli Hartman / Odessa American via AP

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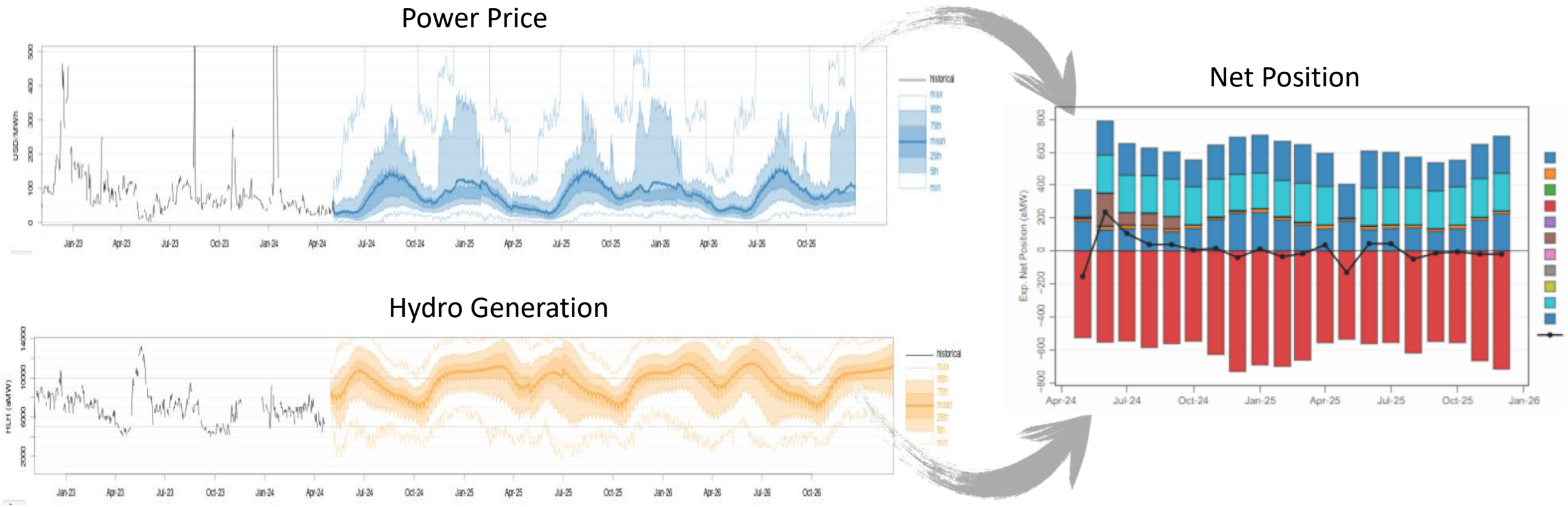
By Leticia Miranda

As the Texas power grid collapsed under a historic winter storm, Jose Del Rio of Haltom City, in the Dallas-Fort Worth area, saw the electricity bill on a vacant two-bedroom home he is trying to sell slowly creep up over the past two weeks. Typically, the bill is around $125 to $150 a month, he said. But his account has already been charged about $630 this month – and he still owes another $2,600.

Source: https://www.nbcnews.com/business/business-news/deep-freeze-subsides-texans-now-face-electricity-bills-10-000-n1258362

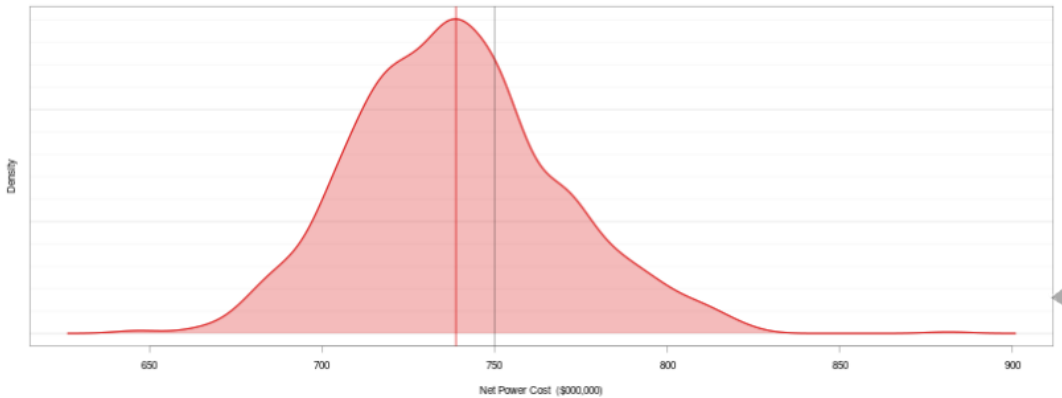
Quantifying Risks

- Multivariate Stochastic model that captures market, load and generation behaviors with associated covariates.

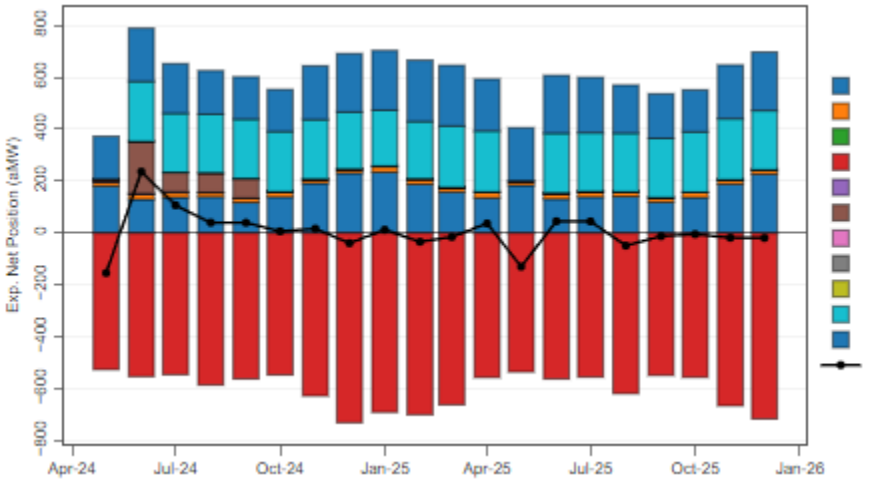


Quantifying Risks

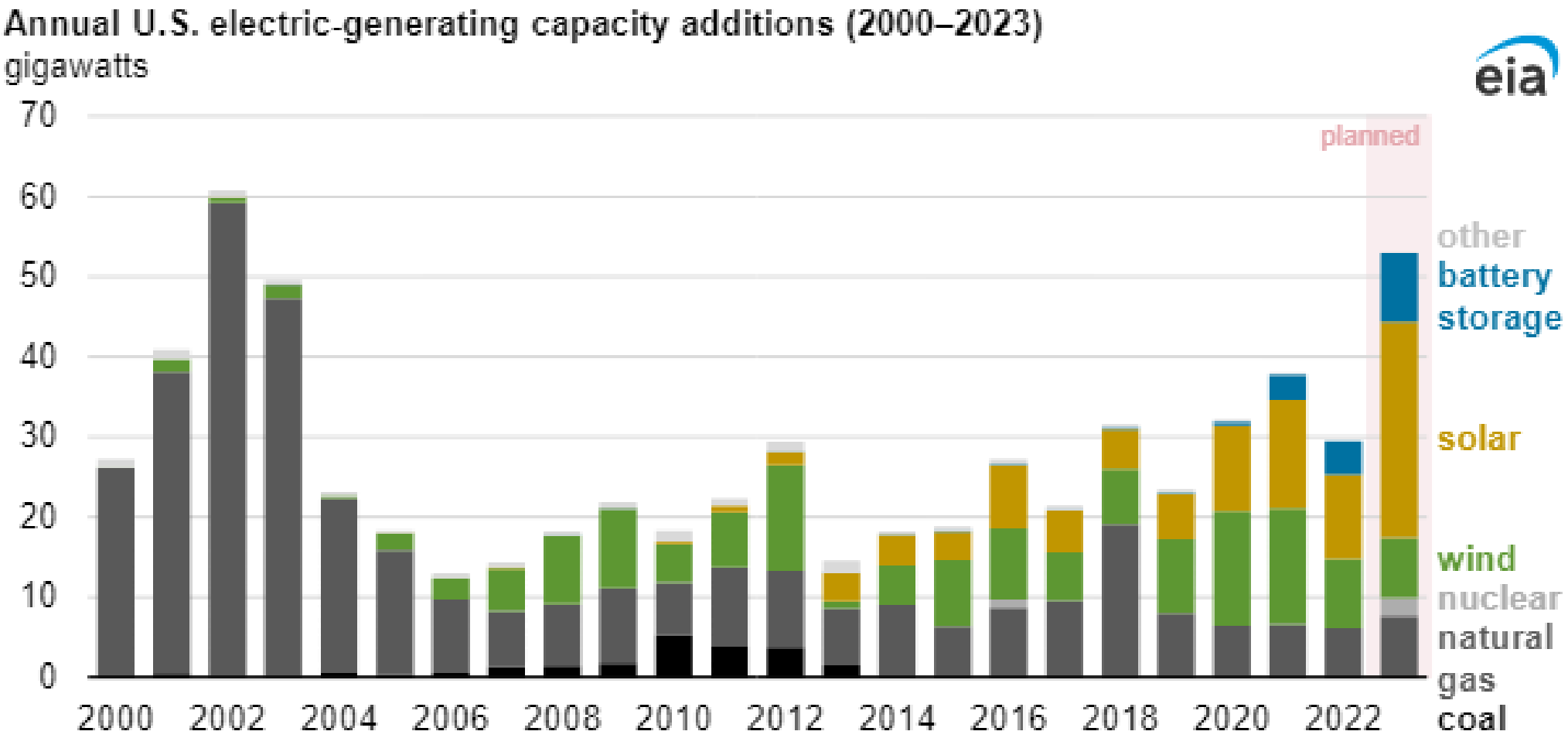
- Multivariate Stochastic model that captures market, load and generation behaviors with associated covariates.
- Use this for:
  - Setting budget
  - Setting appropriate cash reserve for extreme events
  - Hedging analysis
  - Scenario analysis for bad water years, etc…



Expected Net Position



Lastly…



Source: https://www.eia.gov/todayinenergy/detail.php?id=55719

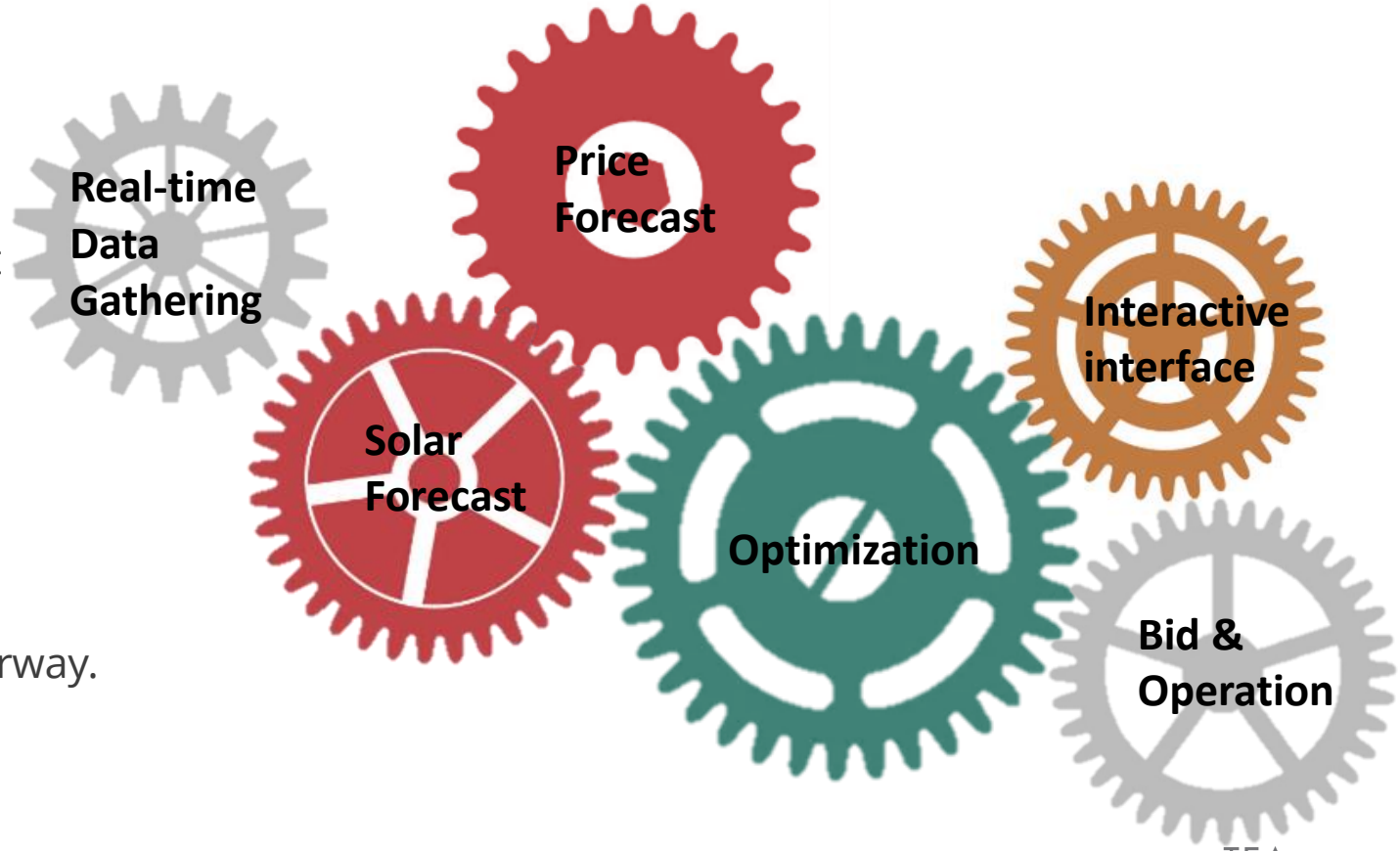
Thank you!

Contact:
eooka@teainc.org

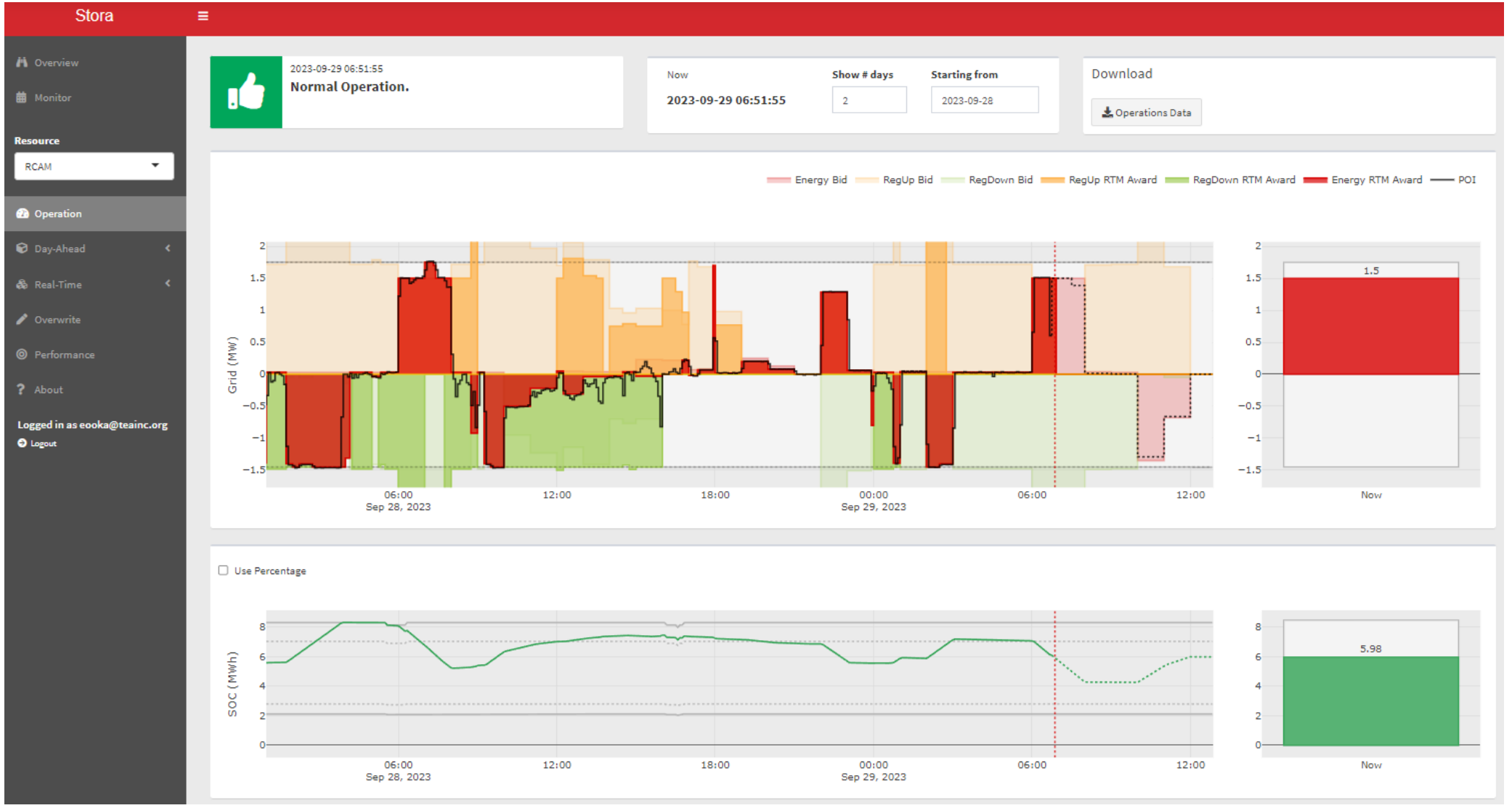
APPENDIX

What is Stora?

- **Operational Optimization Application for Storage & Hybrid Resources**
  - What does it do?
    - Process live operational data
    - Forecast market, gen and native load
    - Optimize operation
    - Formulate bids & submit to the market
    - Provide user interface
  - For which resources
    - Front- or behind-the-meter
    - Standalone, co-located or hybrid
    - Operational in CAISO. SPP model underway.



STORA UI


Stora
Overview
Monitor
Resource
RCAM
Operation
Day-Ahead
Real-Time
Overwrite
Performance
About
Logged in as eooka@teainc.org
Logout
2023-09-29 06:51:55
Normal Operation.
Now
2023-09-29 06:51:55
Show # days
2
Starting from
2023-09-28
Download
Operations Data
Energy Bid
RegUp Bid
RegDown Bid
RegUp RTM Award
RegDown RTM Award
Energy RTM Award
POI
Grid (MW)
06:00
Sep 28, 2023
12:00
18:00
00:00
Sep 29, 2023
06:00
12:00
1.5
Now
Use Percentage
SOC (MWh)
5.98
Now