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ECON 366: Energy Economics

Topic 3.1: Electricity Basics

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Electricity Basics

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At the end of this section, you should feel comfortable answering all of these questions:

- What are the main sectors of the electricity industry?
- What do we mean by peak loads?
- What's a merit order?
- What is the difference between energy and capacity?

You should also feel (more) comfortable with (some) electricity units:

- kW, kWh, MW, MWh, volts, watts, amp, Hz

Why should you care about electricity?

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- Price volatility:
  - Electricity prices are an order of magnitude more volatile than oil or gas prices
  - Both supply and demand in Alberta affect us more than global or regional supplies and demands in oil and gas markets
- New technology:
  - Electricity is, arguably, changing faster than any other energy market
  - Alberta's electricity market is entering a period of market- and regulatory-driven transition
- Economics 101 in action
  - Nowhere else will you see supply and demand curves actually mapped out in real time determining prices as clearly as in Alberta's power market

Why should you care about electricity?

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- Application of other concepts you learned in 101, 102, 281, etc.
  - regulation of natural monopolies
  - collusion and oligopoly
  - externalities
  - capture theory

Volatility

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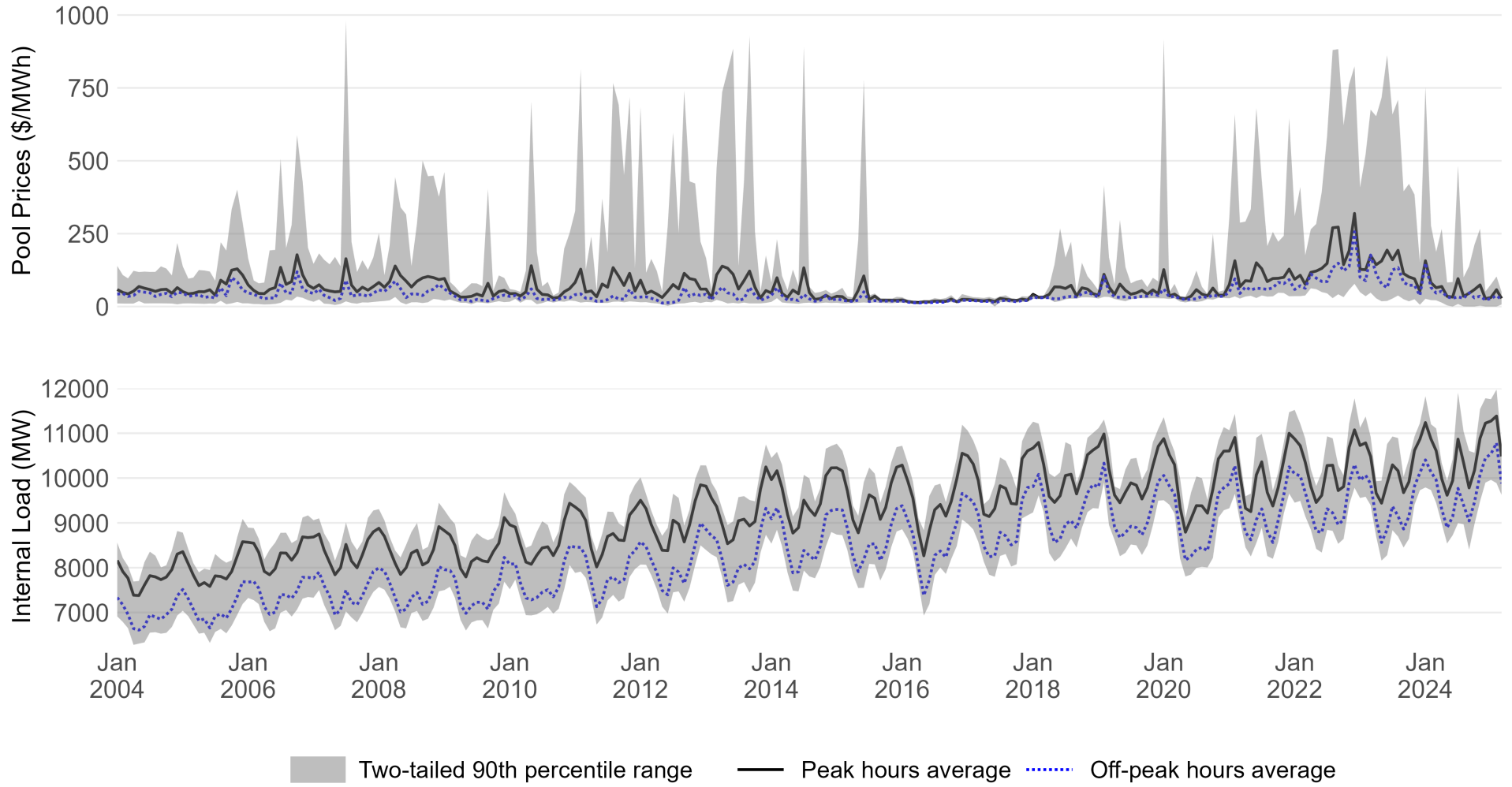

Economic Policies

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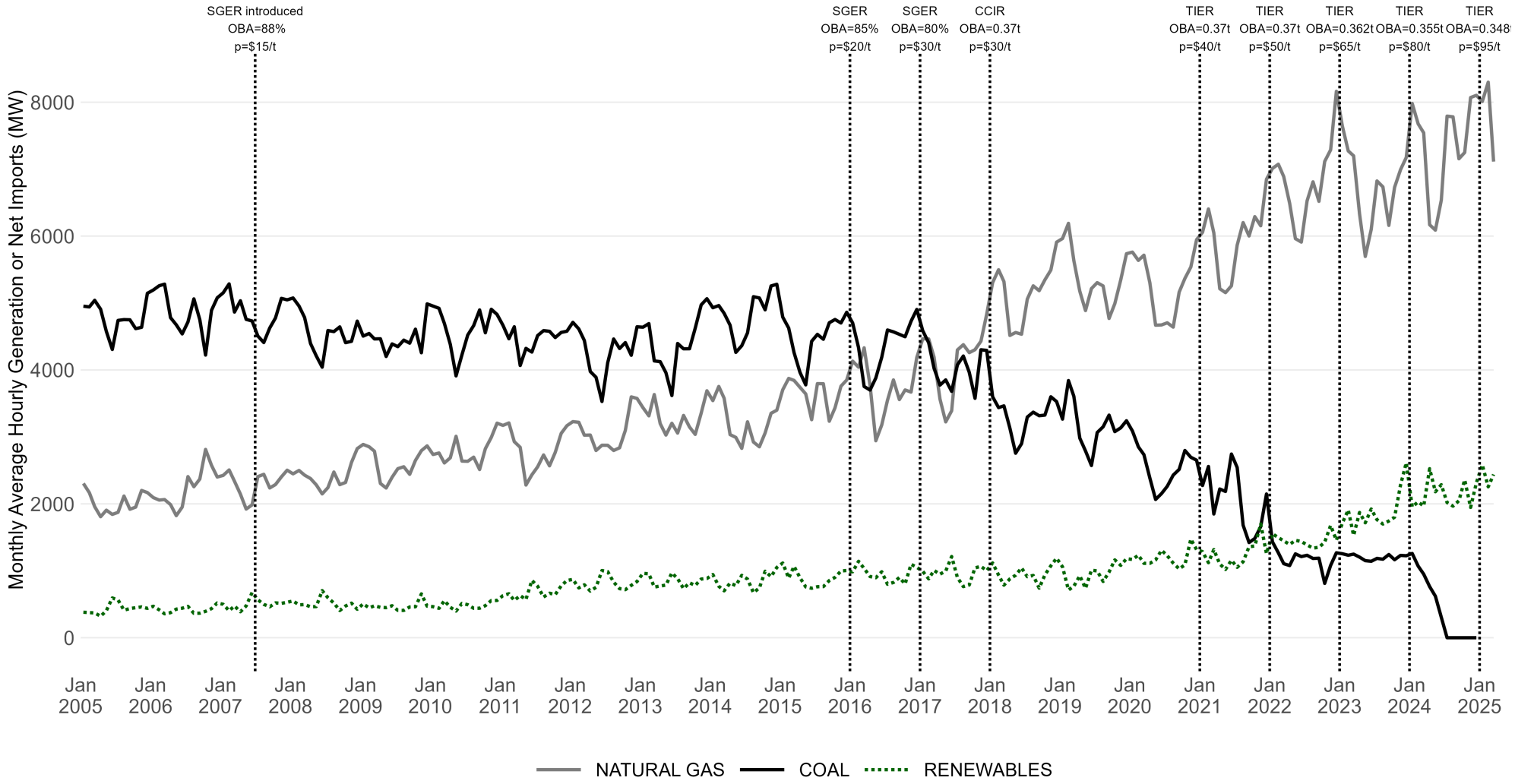

New Technology (Source: MPower)

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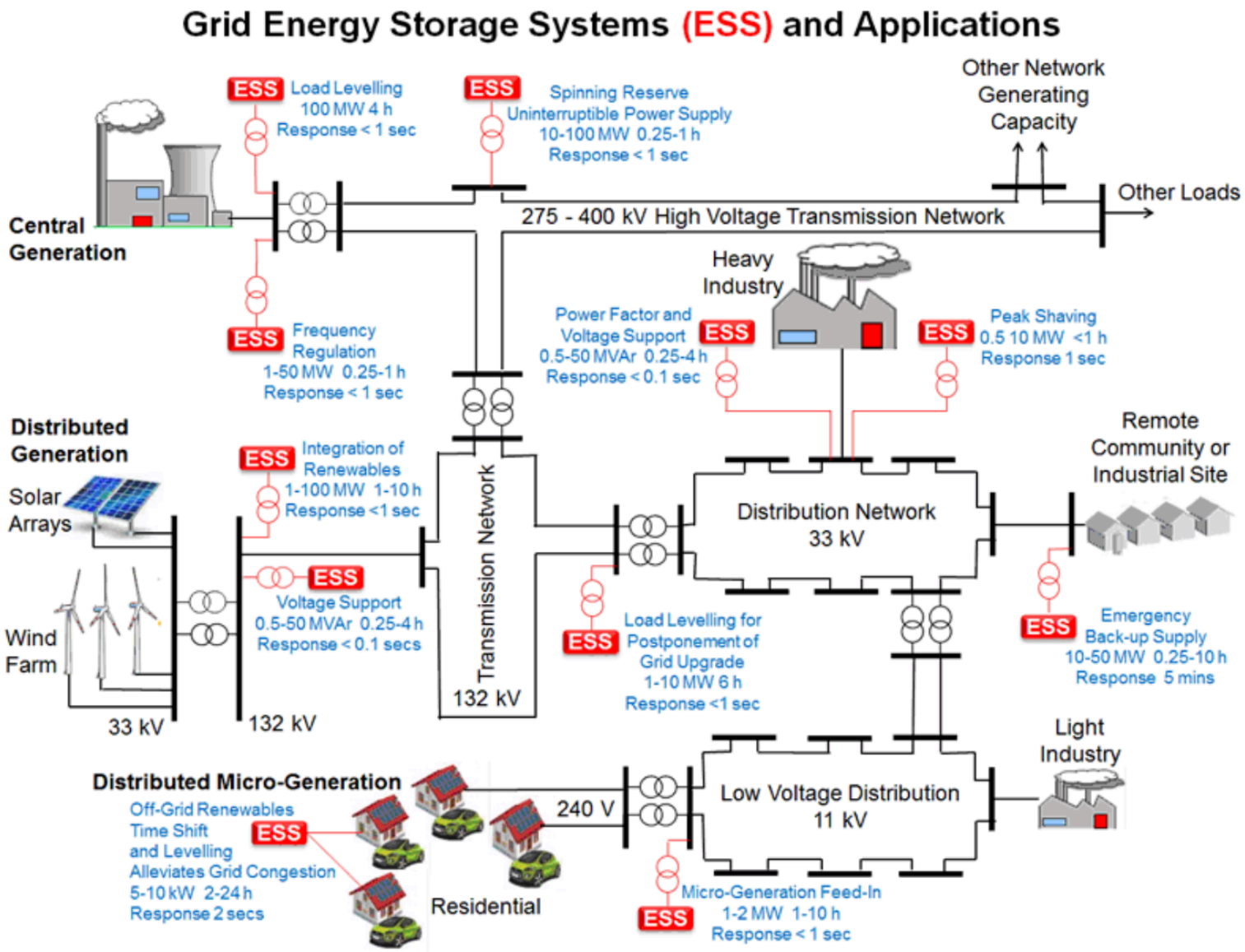

New Technology (Source: Brian Batholomew)

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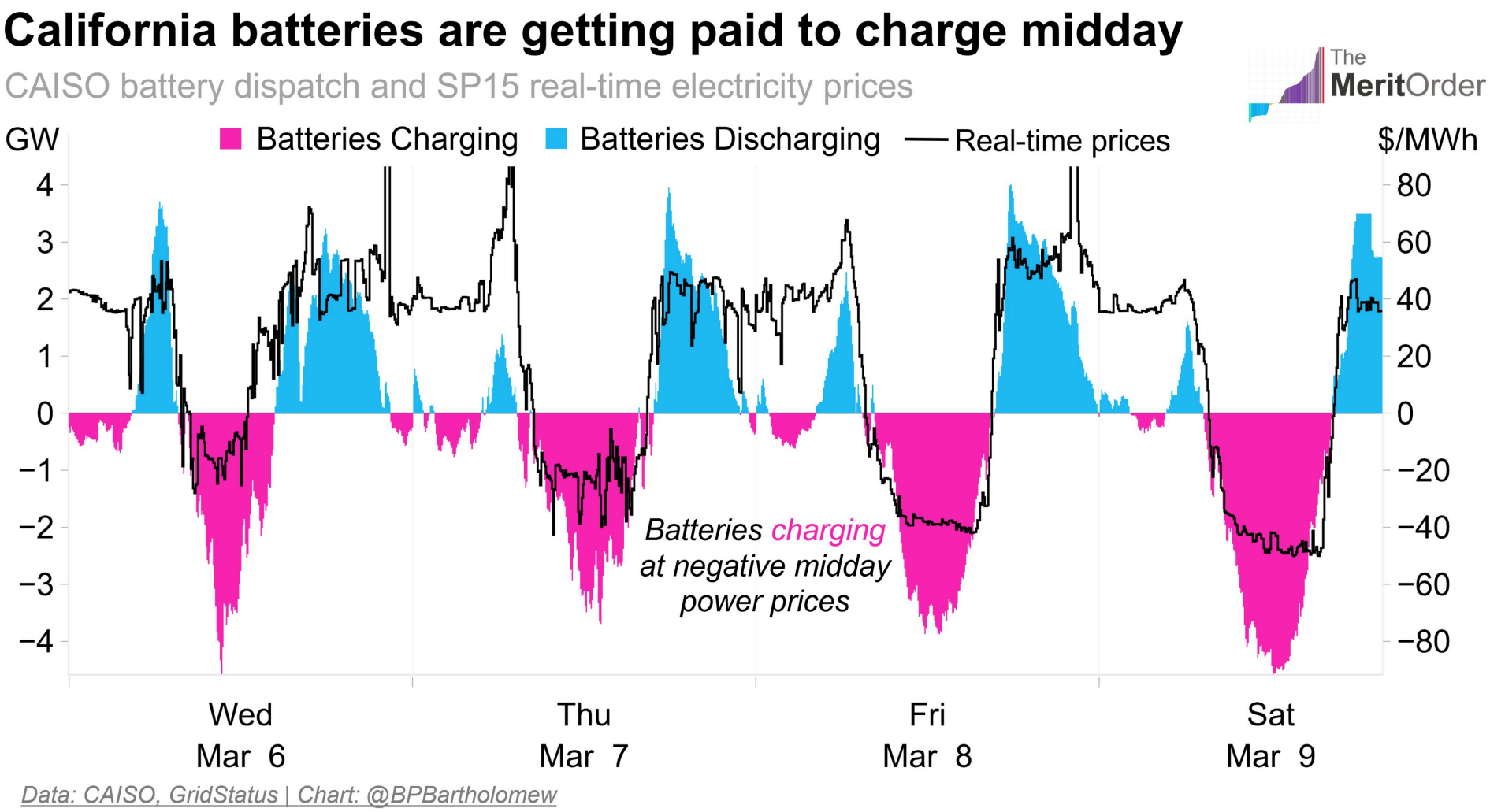

New Technology

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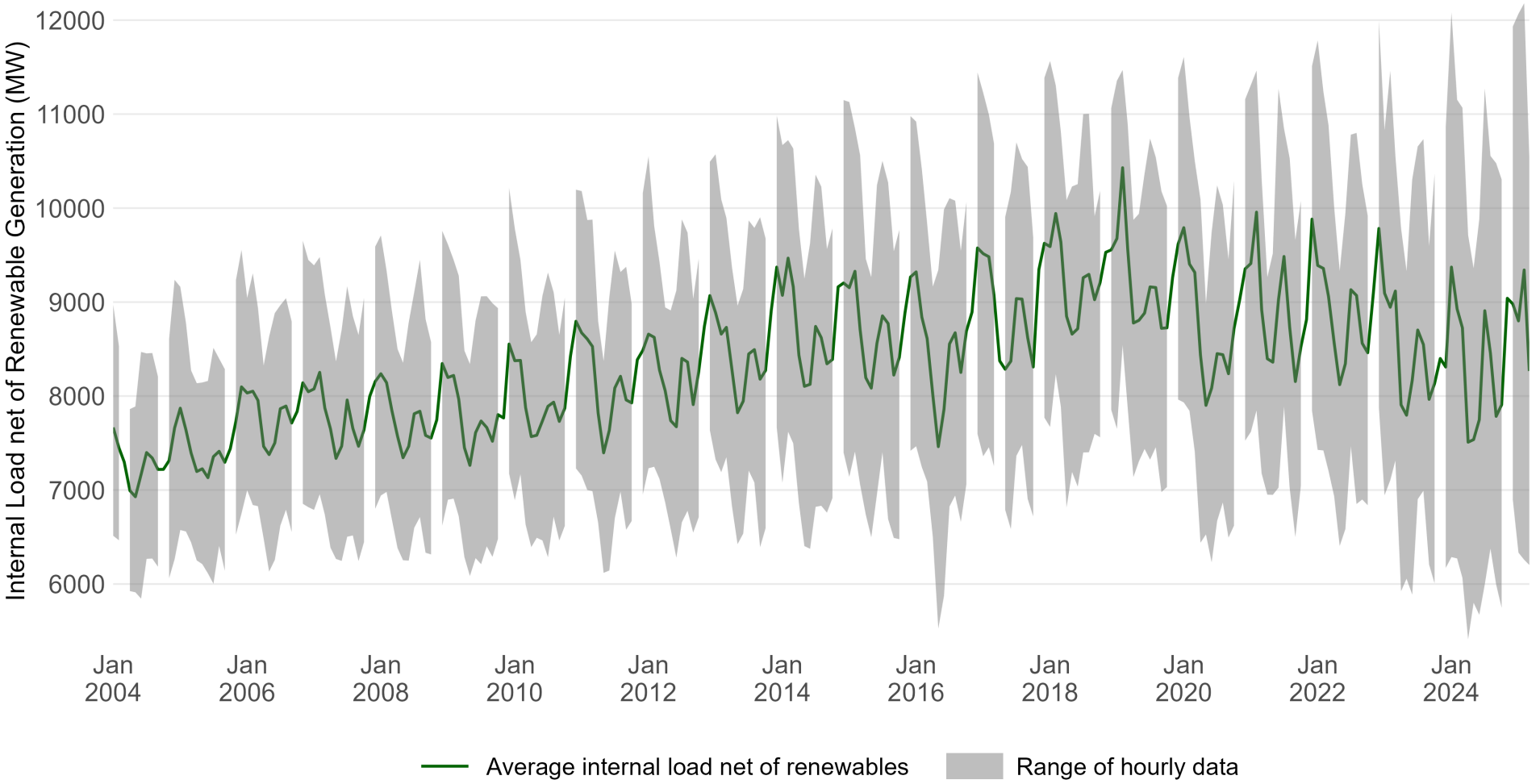

Econ 101 in Action!

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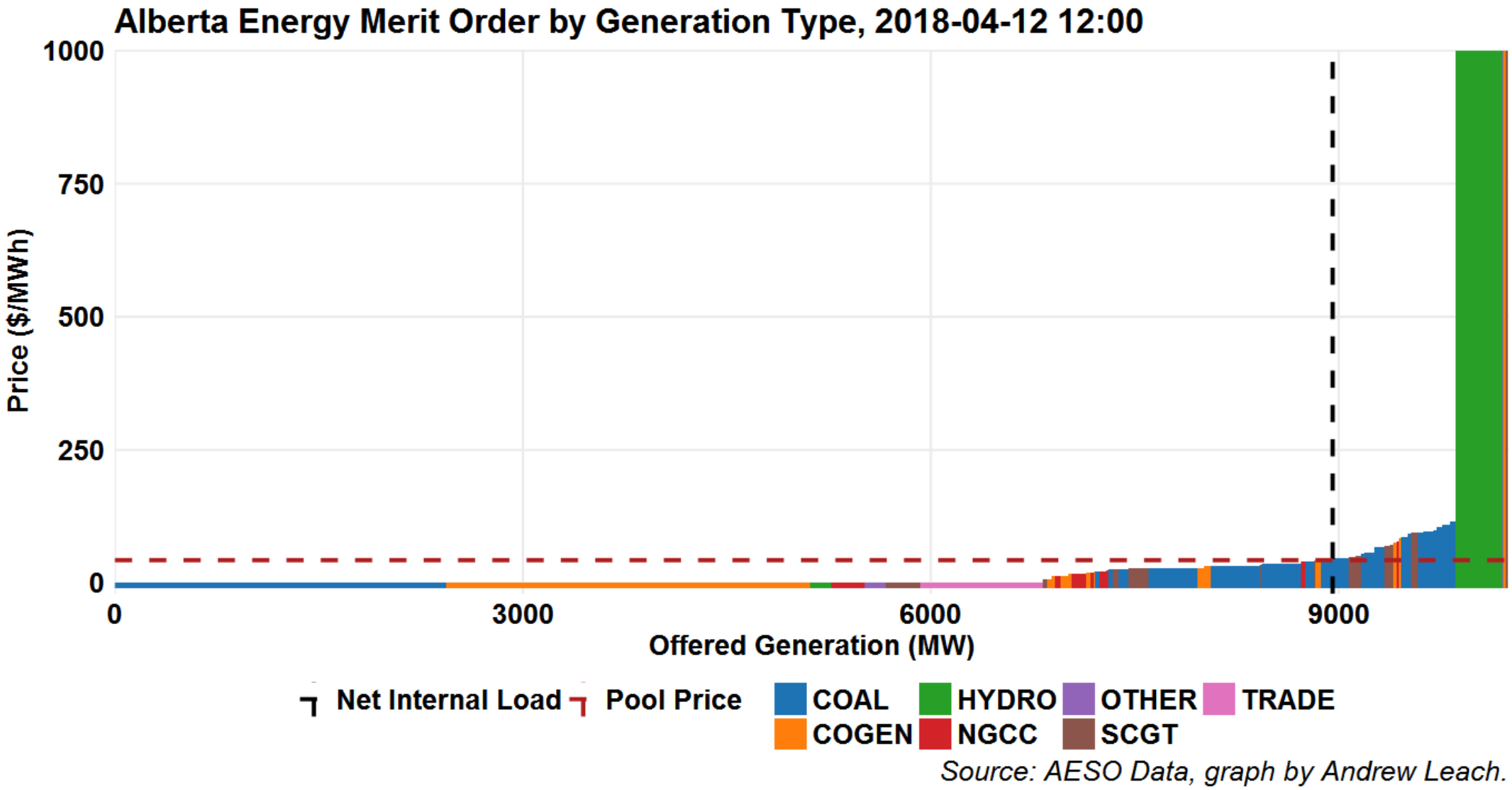

Source: AESO Data, graph by Andrew Leach.

Market Participants

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- Generation
- Transmission
- Distribution
- Ancillary Services
- Load (users)
- Storage
- Microgeneration

Market Regulation in Alberta

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- Generation is a competitive market
- Transmission is regulated on a cost-of-service basis
- Distribution (local wires) is regulated through performance-based regulation
- Ancillary Services is a competitive market
- Load (i.e. customers) may contract for electricity supply (i.e. retail is competitive)
- Storage (Still a lot TBD, but depends on the sector in which it's built)
- Microgeneration (free market for self-supply)

Energy units - electricity

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- Watts: measure of capacity (instantaneous production, installed capacity, or instantaneous demand)
  - Alberta system demand or internal load: e.g. 10,700 MW (megawatts or million watts)
  - Capital Power's Genessee 3 power plant has a nameplate capacity of 450 MW
- Watt hours: measure of energy (production or demand during a given period of time; i.e. flow through)
  - Production over a day, week, month, year
  - A 7.5W LED bulb on all day (24hr) uses 180Wh of electricity (.18kWh)
- Volts: measure of the electrical potential or the ability to convert charge to power (Watts=amps x volts)
  - Transmission lines: 150-765 kV
  - Distribution lines: 13,800 Volts
  - Household wiring: 120-240 (110/220) Volts

Usage in my house

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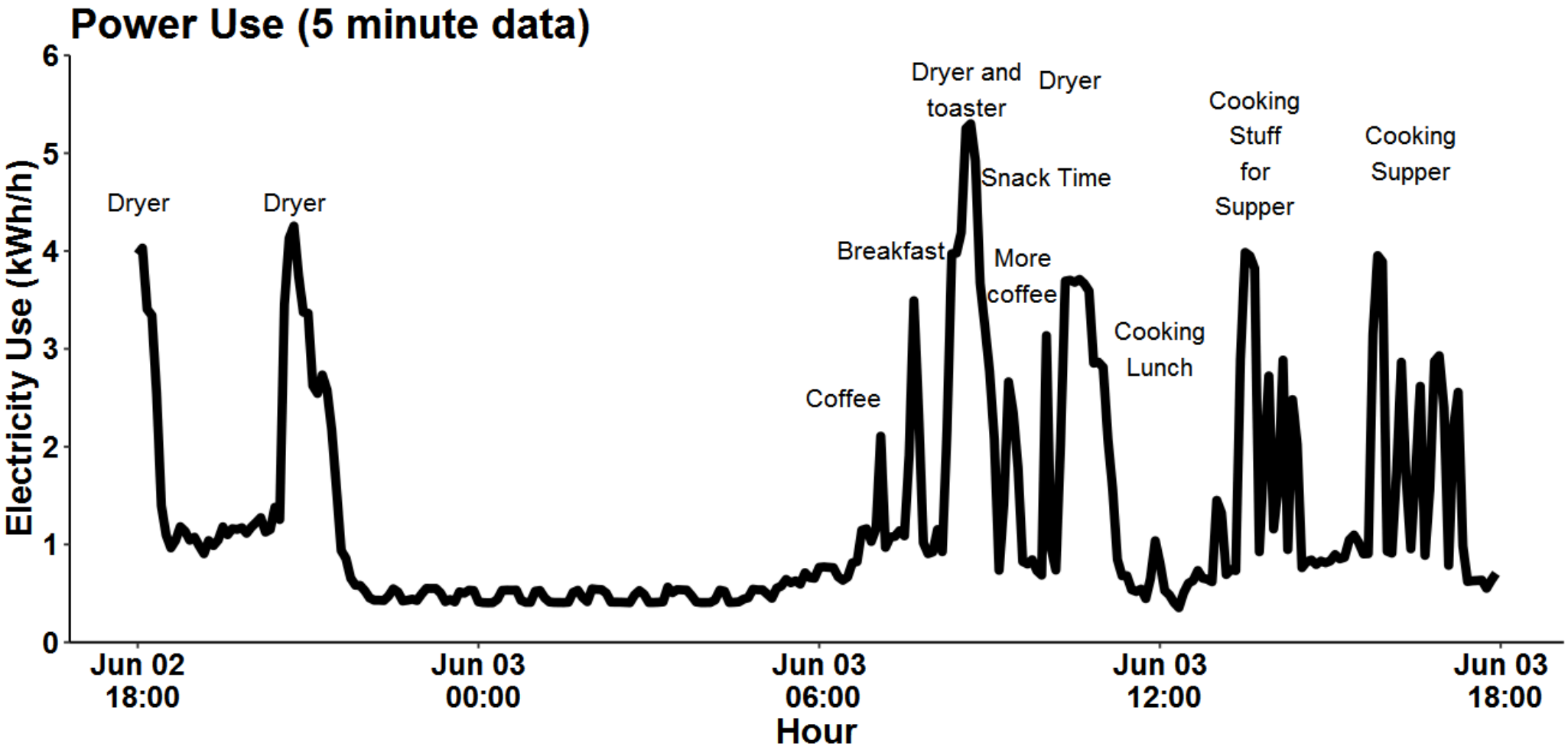

Source: SolarPeople system data via Neurio API, graph by Andrew Leach

Energy Prices

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- Electricity prices: expressed in power delivered over time
  - Cents/kilowatt-hour (c/kWh)
  - Dollars per megawatt-hour (\$/MWh)
- Levelized costs of electricity (supply costs) in \$/MWh
- Capacity costs are expressed in a cost per megawatt or cost of capacity
  - Genessee 3 cost approximately \$1.5 million/MW or \$1.50 per watt to build
  - Solar panel prices have declined to now lie under \$1/W of capacity
  - Balance of system costs imply that a solar system costs \$2-3/W of installed capacity
- Other prices matter for electricity markets as well
  - Renewable energy credits (usually prices in \$/MWh)
  - Emissions credits or permits (\$/tonne)
  - Capacity payments (\$/MW)
  - GHG or other emissions permits or credits (\$/tonne)

North American Electricy Regions (Source: Level 10 Energy)

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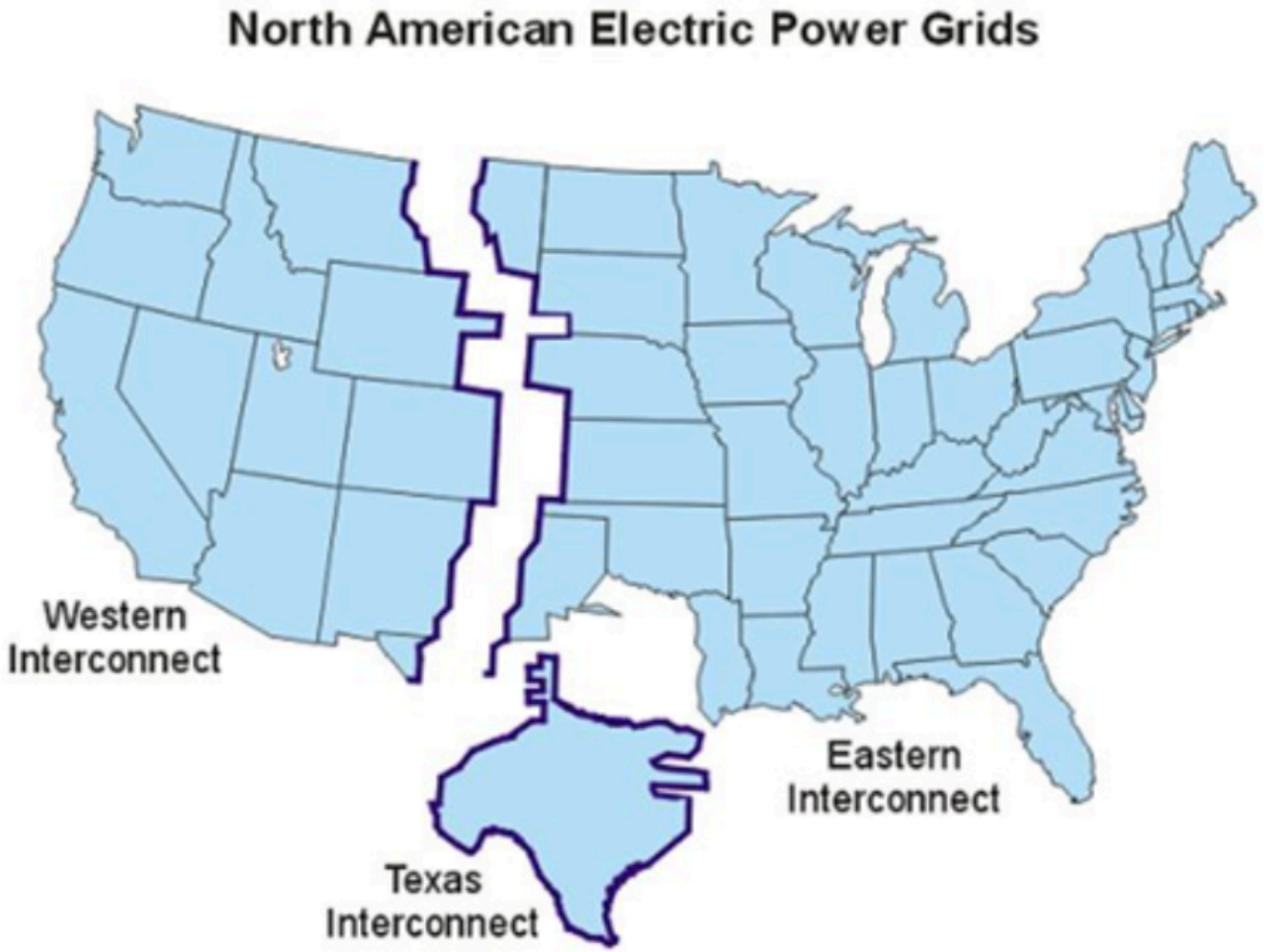

North American Electricy Markets (Source: Level 10 Energy)

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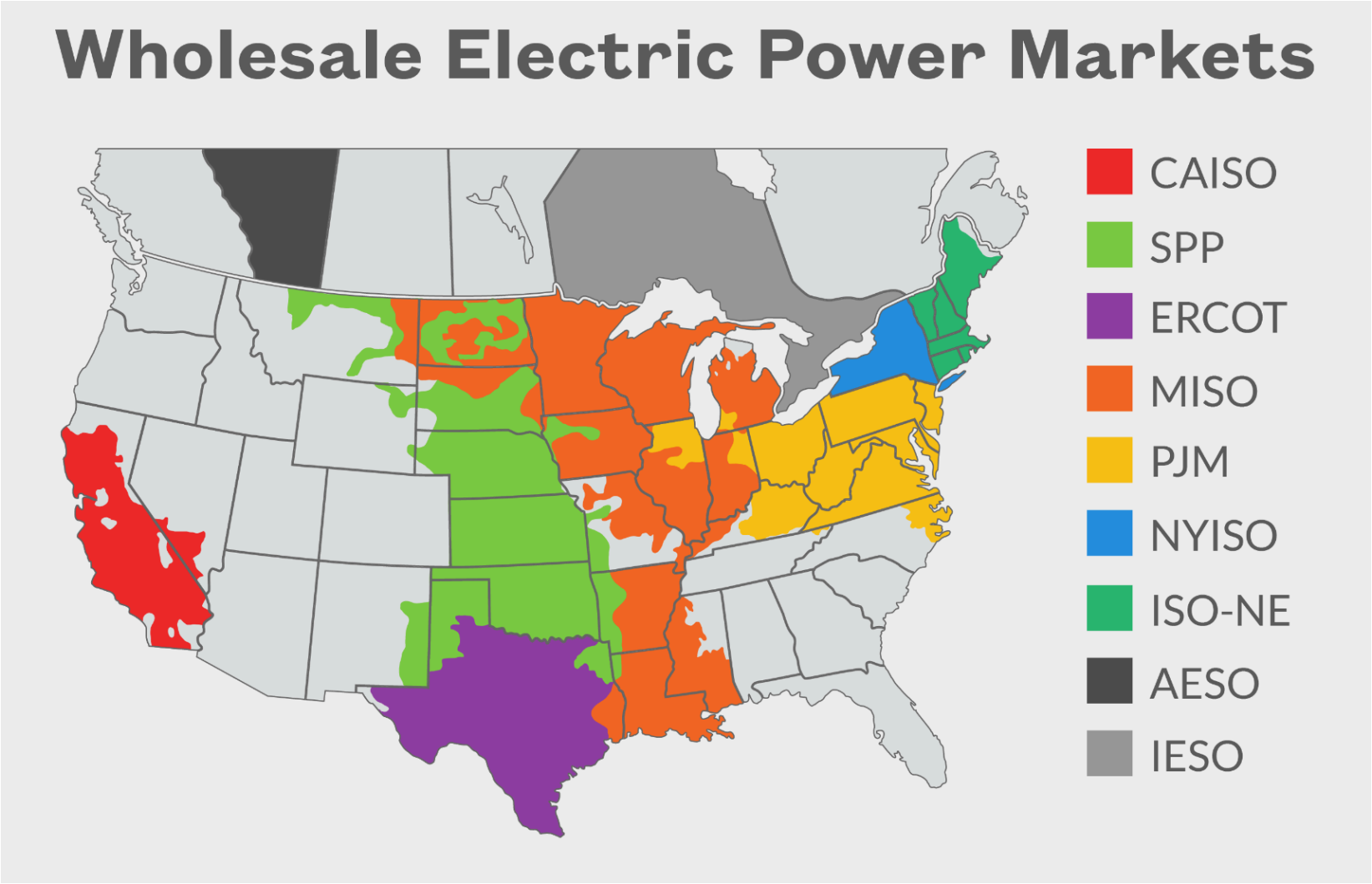

Electricity Sector: Regulatory characteristics

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- Rate-regulated or or state-owned utilities
  - EPCOR (legacy) or BC Hydro
  - PG & E in California
- Competitive markets
  - Energy only markets: ERCOT and Alberta
  - Energy and capacity markets: MISO, PJM
- Real-time vs day-ahead prices: PJM and others have day-ahead market and then a real-time differences market
- Many other design characteristic differences between restructured or competitive markets

Alberta Wholesale Energy Market Design

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- Energy-only market (single price, $/MWh)
- Real time, spot pricing, no day-ahead market
- Single node
- Capacity market was contemplated, but not pursued

Ancillary services:

- separate, competitive market for operating reserves, transmission-must-run, load-shed and black start

Alberta Transmission

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- Regulated monopoly within a service area
- Congestion free (no nodal pricing) across the province
- No transmission rights
- Paid for (mostly) by load (consumers)

Nodal Pricing Example (Source: CAISO)

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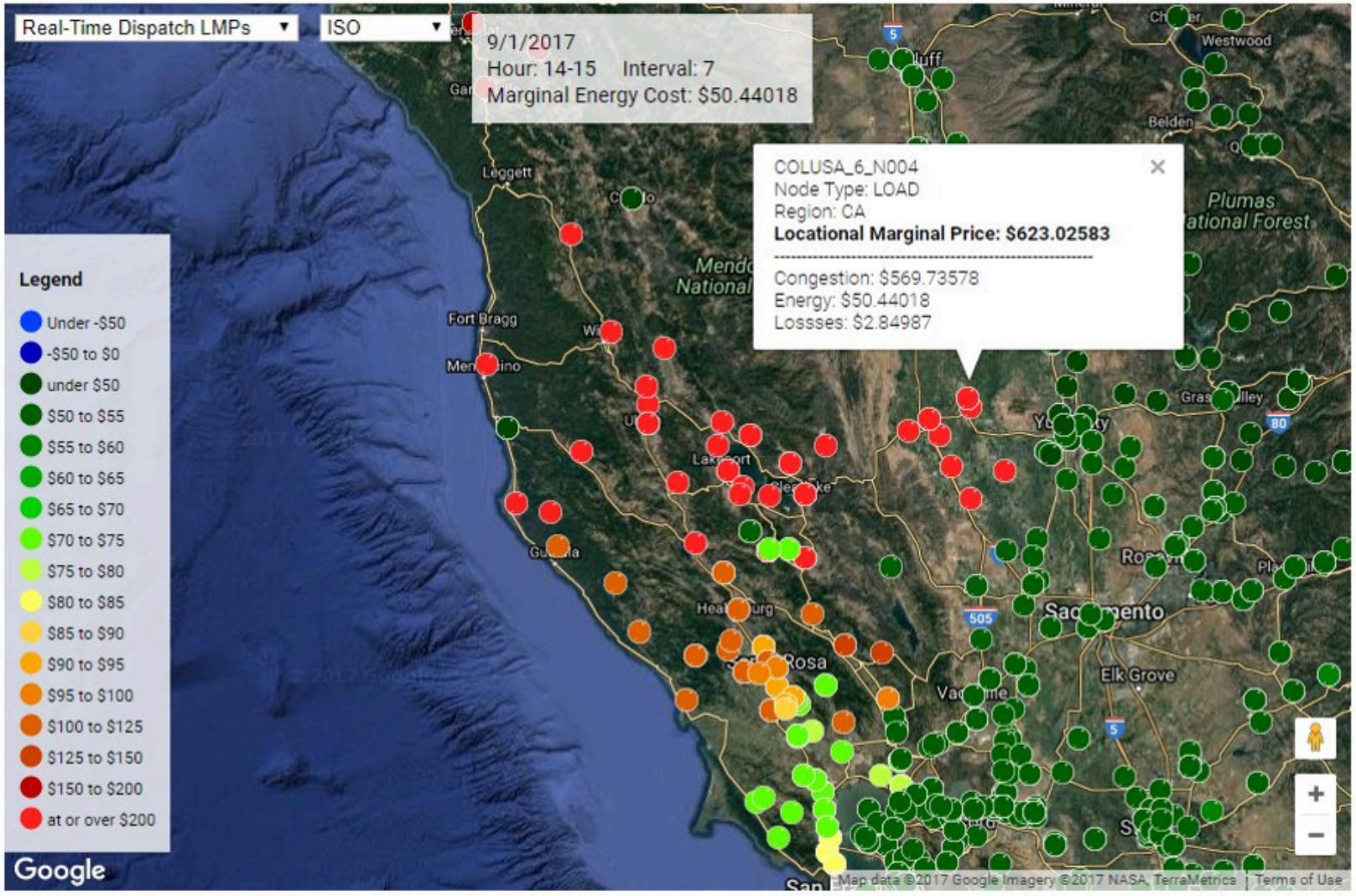

The Alberta Wholesale Market

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- Suppliers place offers of power at particular price
- Generators must offer, must run
- Demand-side bids placed for power with a maximum price
- Supply offers are sorted from low to high
- Demand offers are sorted from high to low
- Marginal price is set at the price which equates supply and demand - economics 101 at work!
- Import and renewable supply is bid-in at \$0, but everyone receives the market price
- Export demand is bid-in at \$999, so they do not set the price directly but pay the marginal price
- Renewables default offer at zero
- Consumer default bid allows AESO to go up merit order to meet observed demand

Econ 101 in Action!

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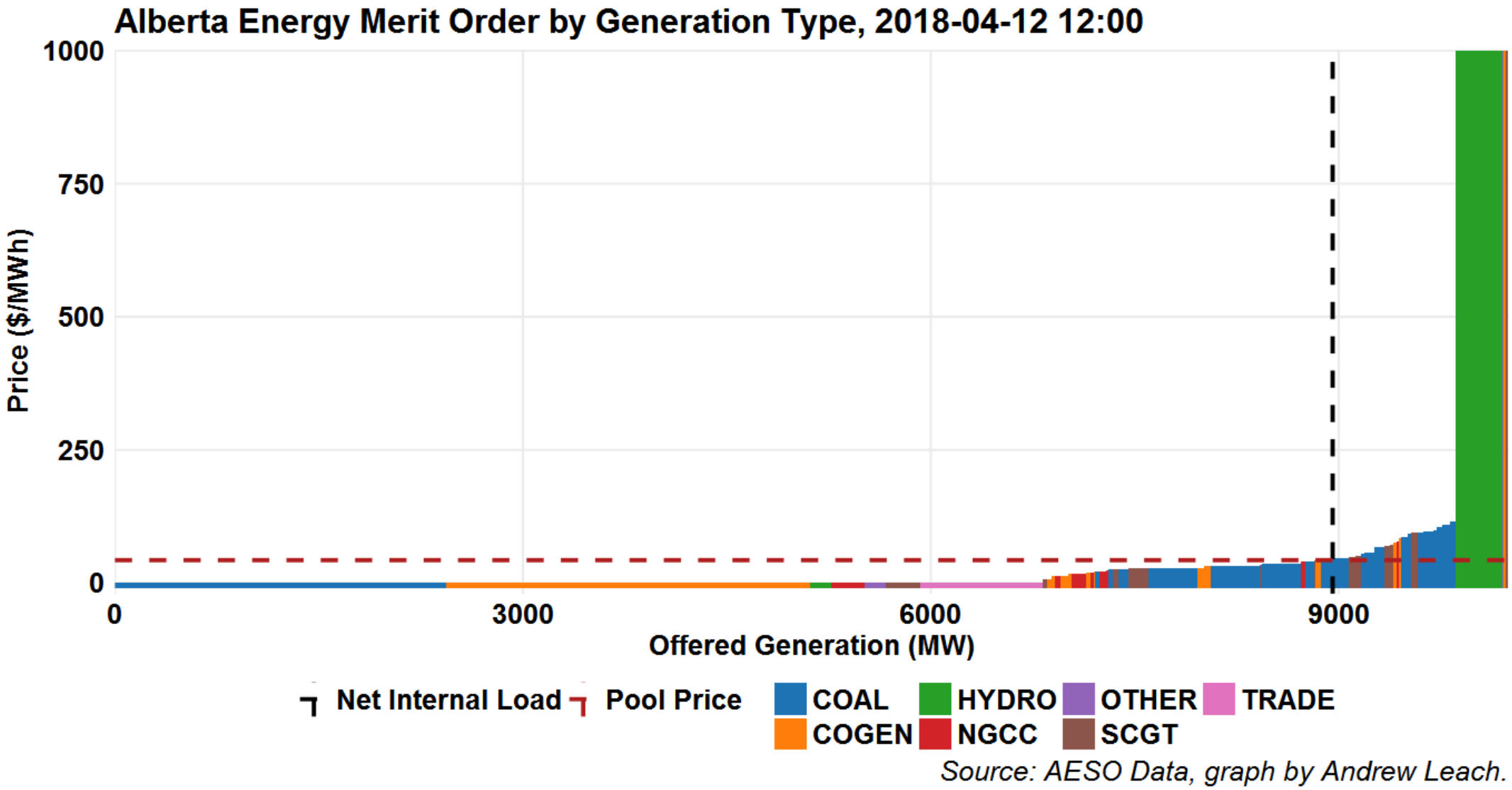

Source: AESO Data, graph by Andrew Leach.

Econ 101 in Action!

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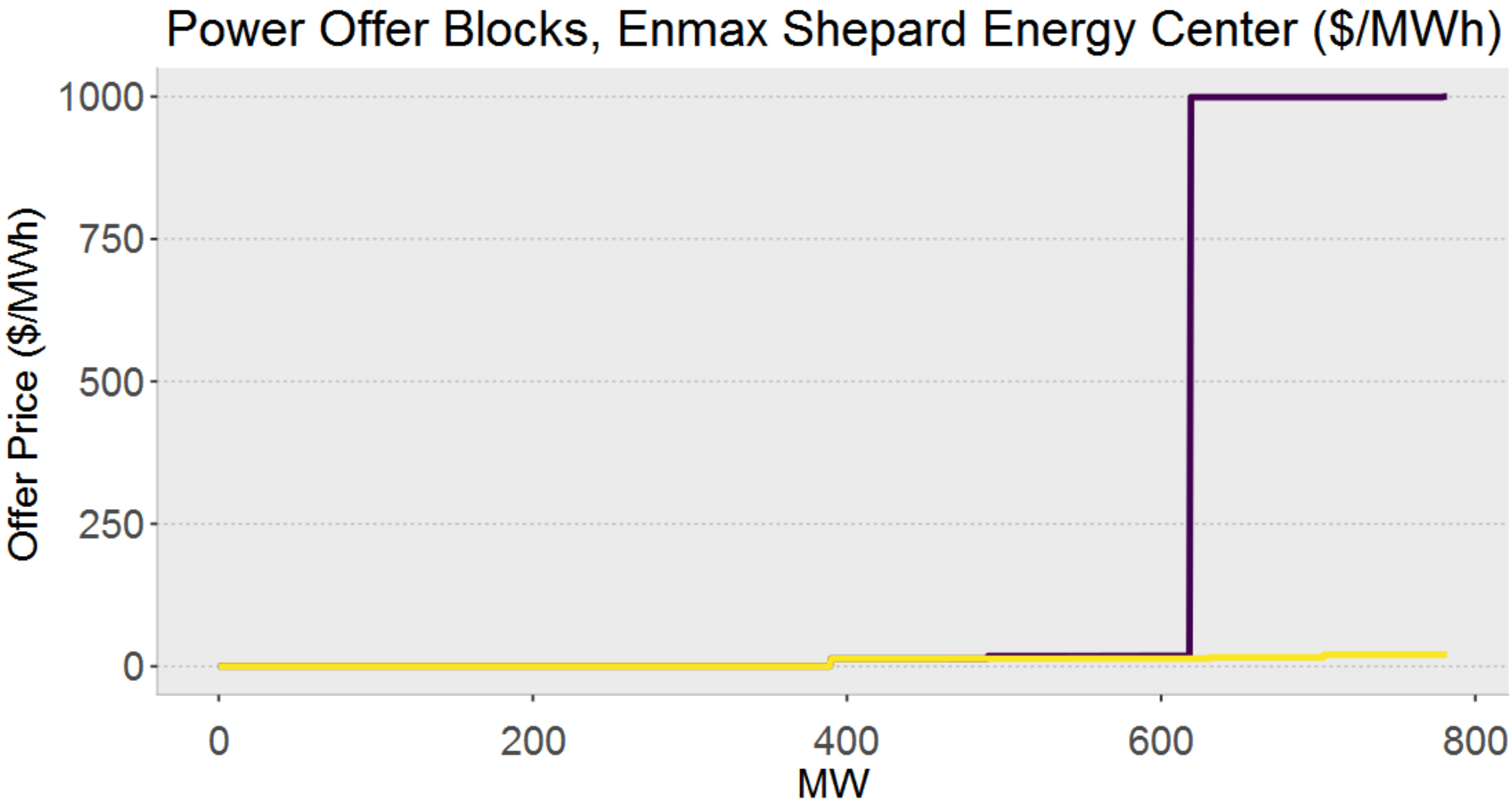

Equilibrium Supply

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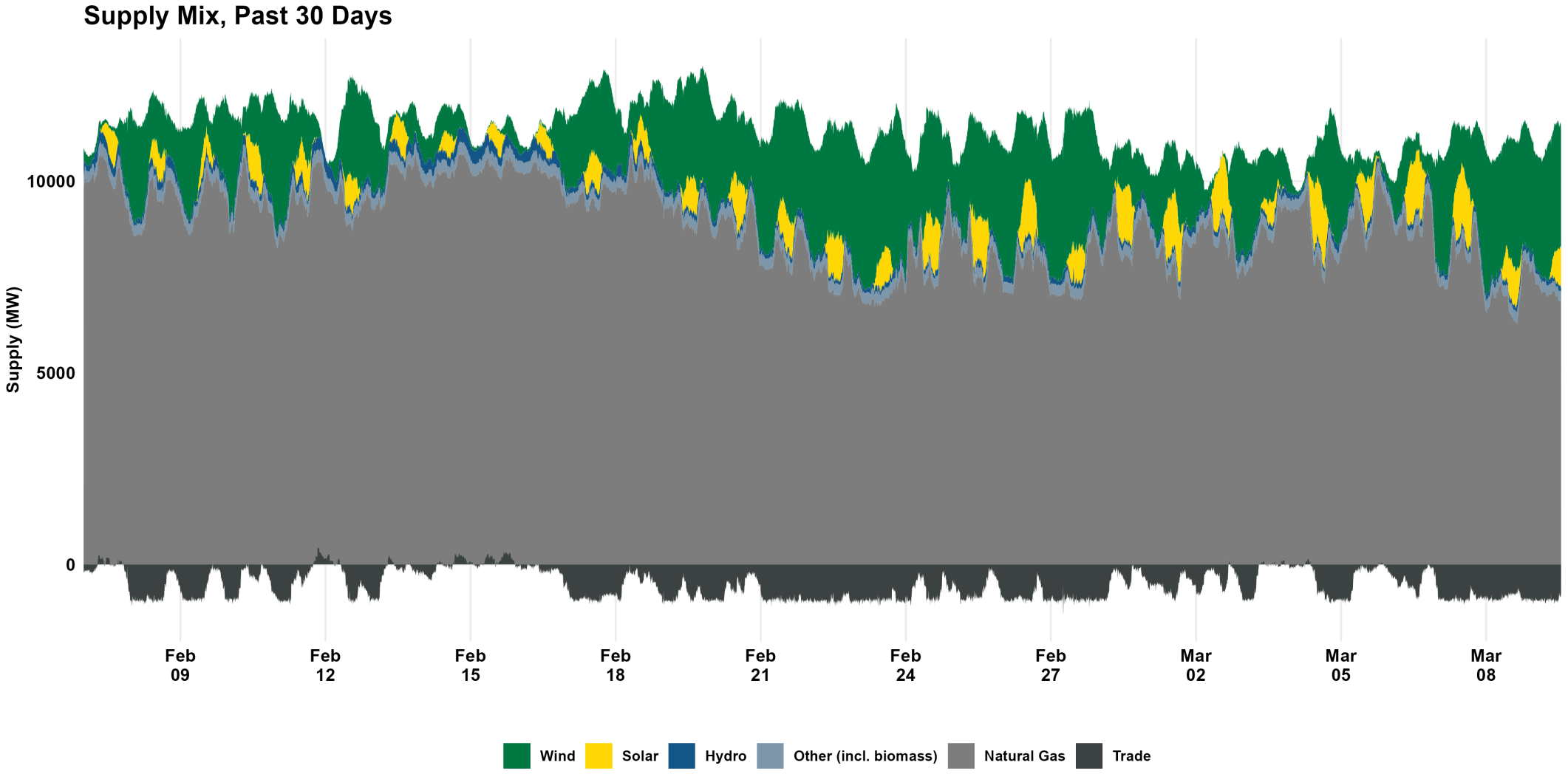

Source: AESO Data, accessed via NRGStream

Equilibrium Supply

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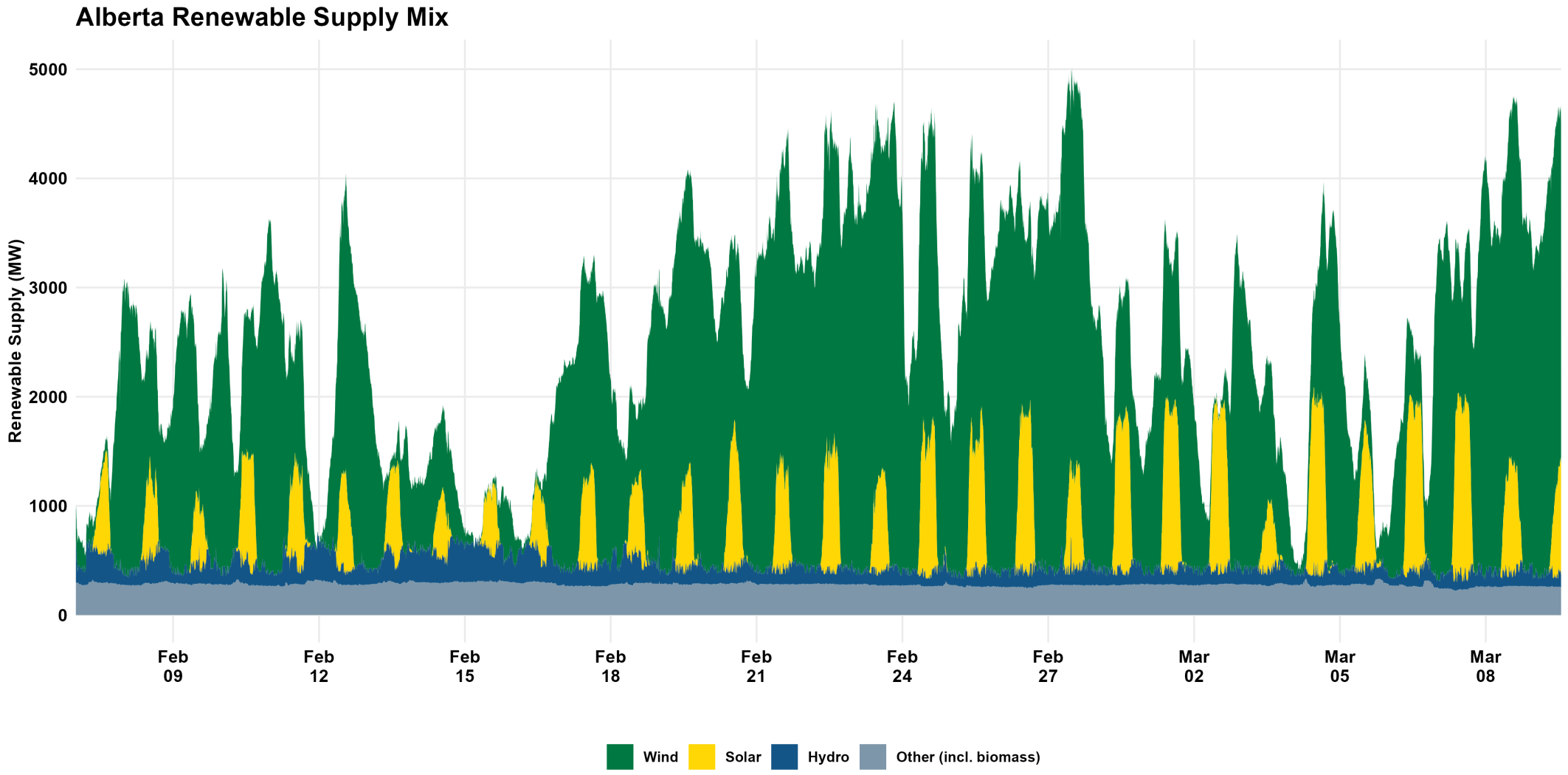

Source: AESO Data, accessed via NRGStream

Demand side of the market

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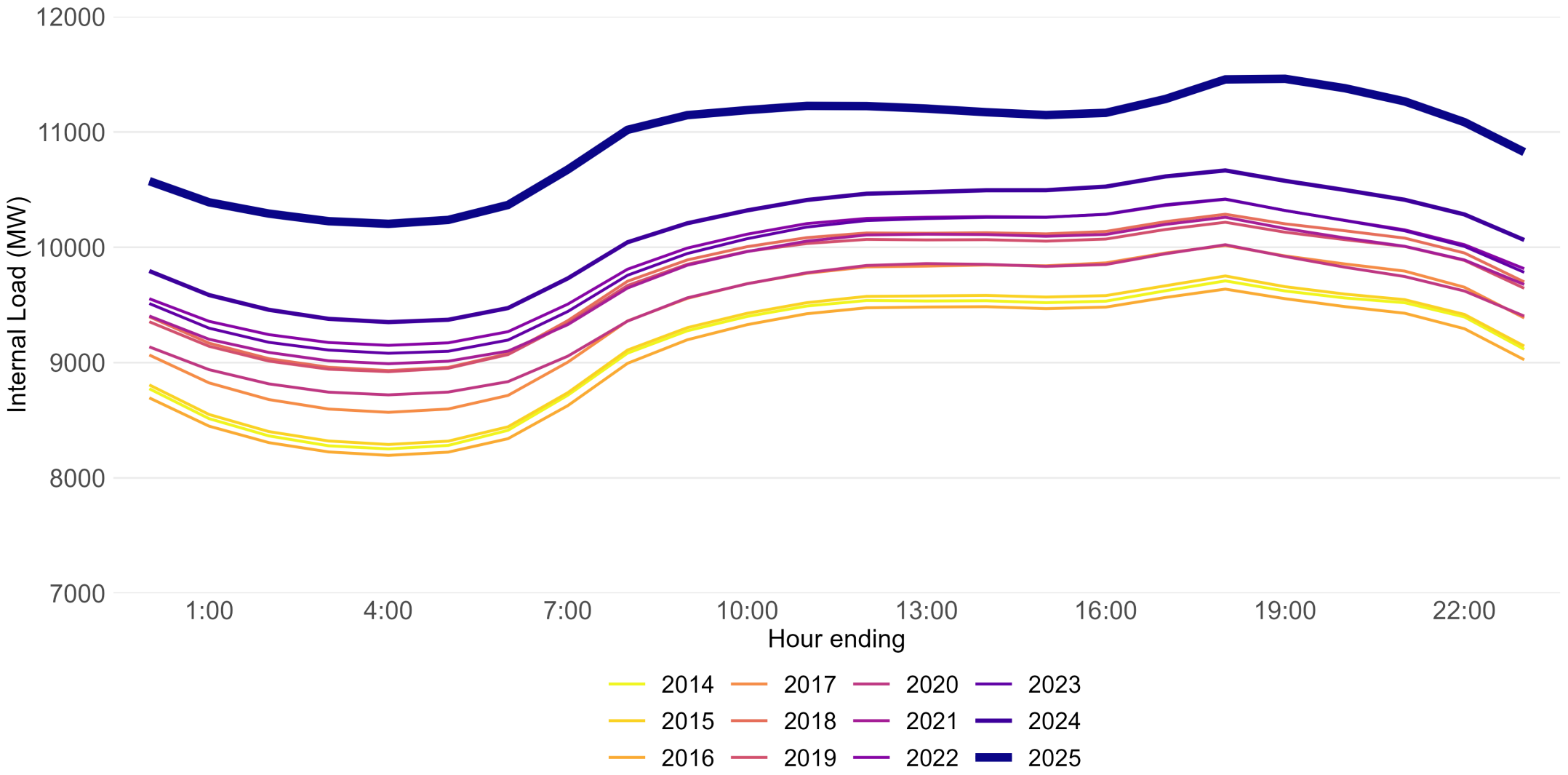
Year	2023	2022	2021	2020	2019	2018	2017
Total AIL (GWh)	86,293	86,572	85,214	83,115	84,925	85,330	82,572
Average AIL (MW)	9,851	9,883	9,728	9,462	9,695	9,741	9,426
Maximum AIL (MW)	11,572	12,193	11,729	11,698	11,471	11,697	11,473
Minimum AIL (MW)	7,873	8,110	7,976	7,579	8,024	7,819	7,600
Average system load (MW)	6,951	7,061	6,946	6844	7,027	7,287	7,220

Demand side of the market



Demand side of the market

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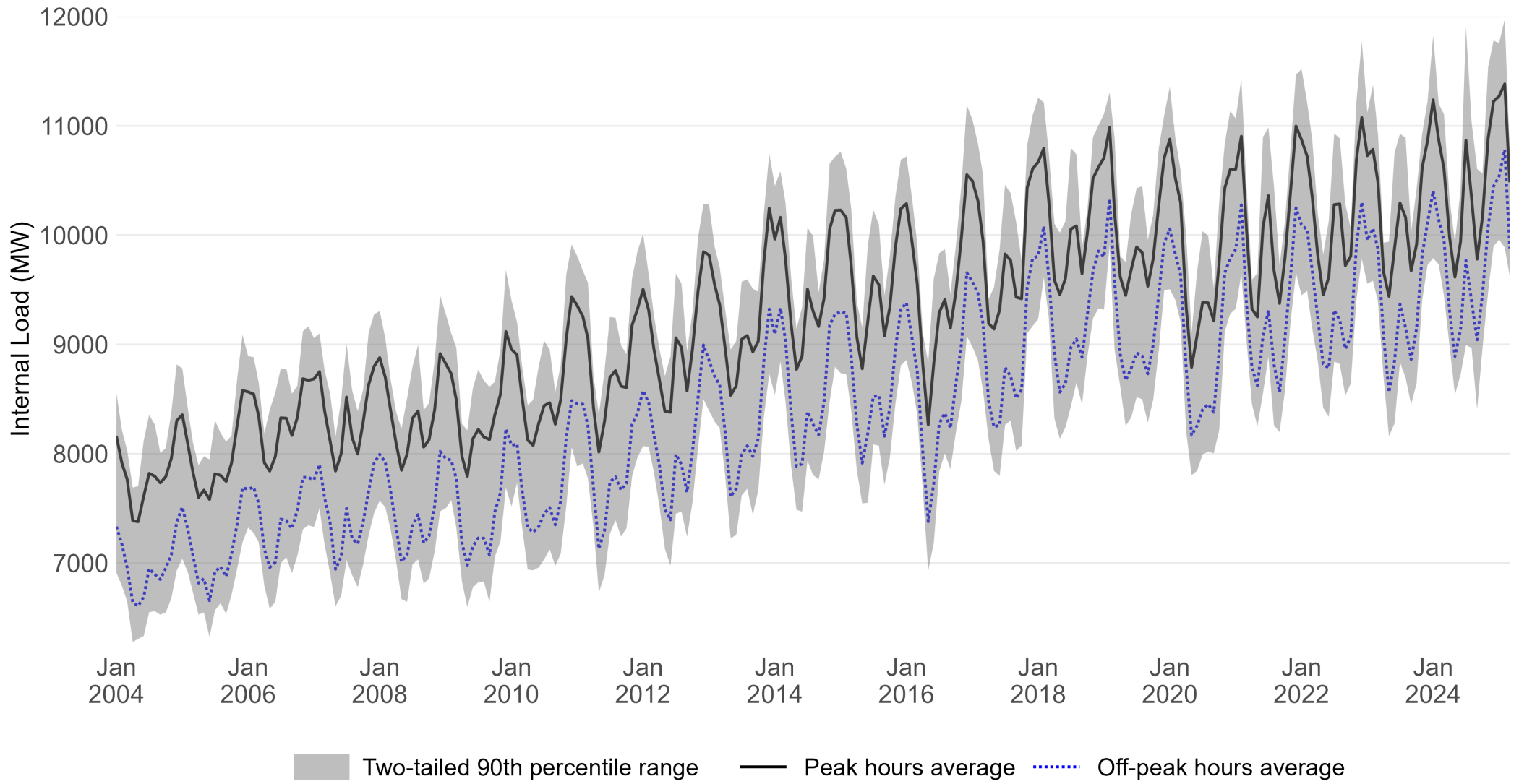

Equilibrium Prices

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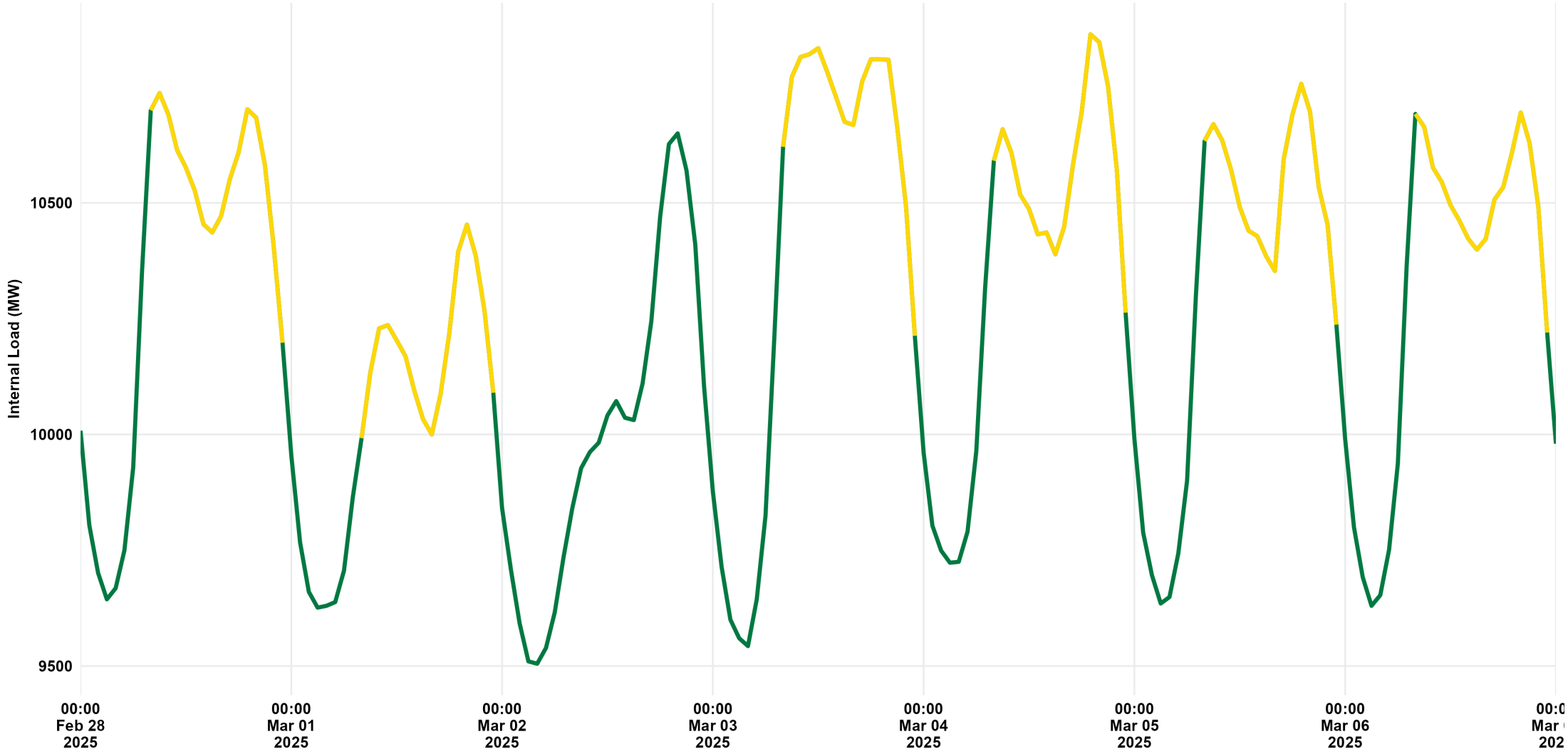
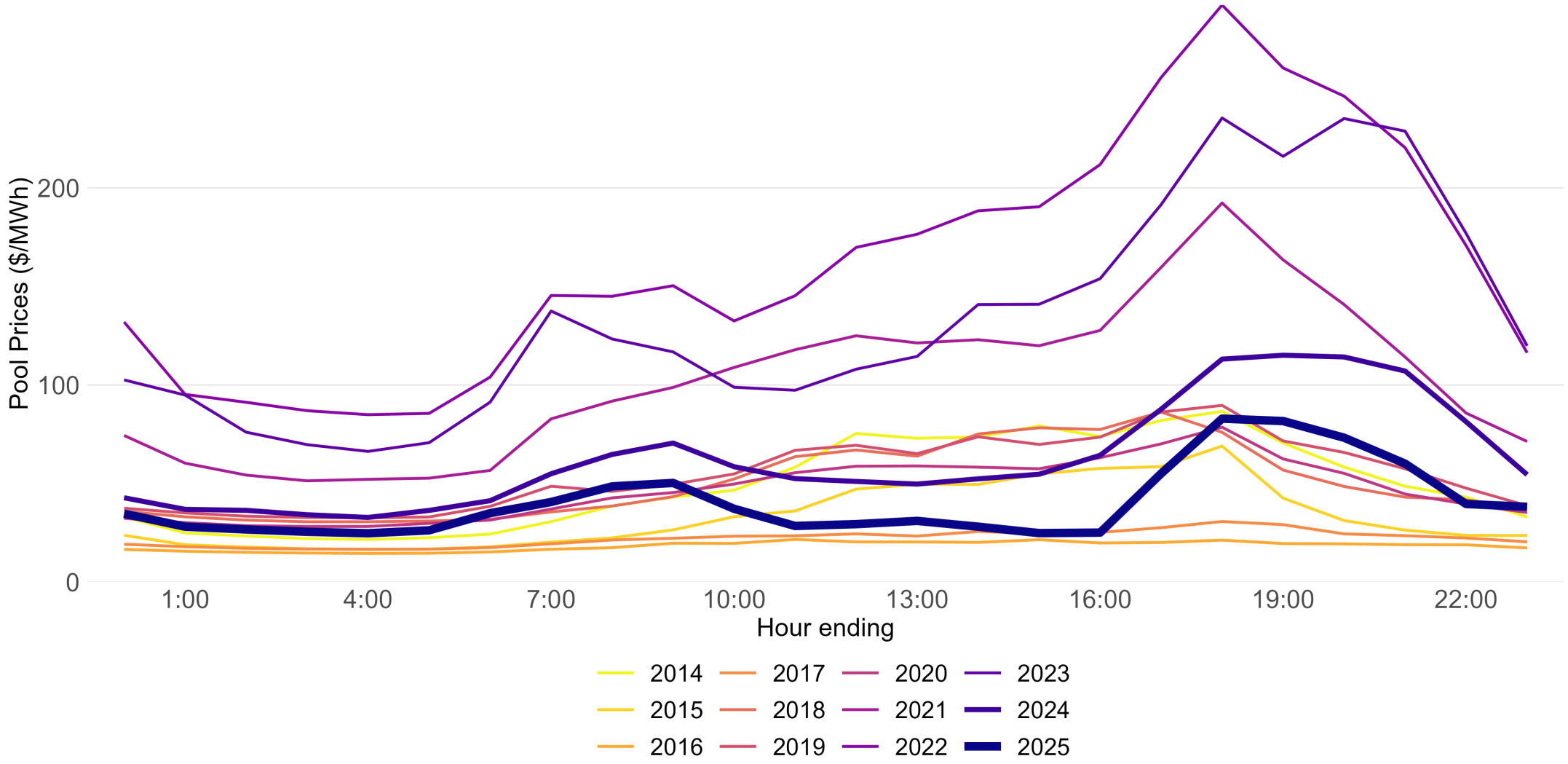


Equilibrium Prices



What is considered on-peak, off-peak? What's a super peak?

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- The AESO uses four different time blocks: on-peak, off-peak, AM super peak, and PM super peak
- Time definitions generally use *hour ending*, e.g. 5 p.m. to 6 p.m. is HE18 (HE=hour ending 18:00)

The four different time blocks are:

- On-peak: HE 8-23
- Off-peak: HE 1-7 and HE 24
- AM super peak: HE 6-8
- PM super peak: HE 17-24 in November, December and January and HE 18-24 in all other months

AESO uses these 7 days of the week. My graphs count Sundays and holidays as off-peak.

Up Next

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- generation mix here and elsewhere in Canada
- plant costs
- plant revenues
- levelized cost of electricity (equiv. supply costs)
- challenges of renewable integration
- market power and market power mitigation (see here)
- distribution and transmission regulation
- government policies (GHG and renewable procurement)