



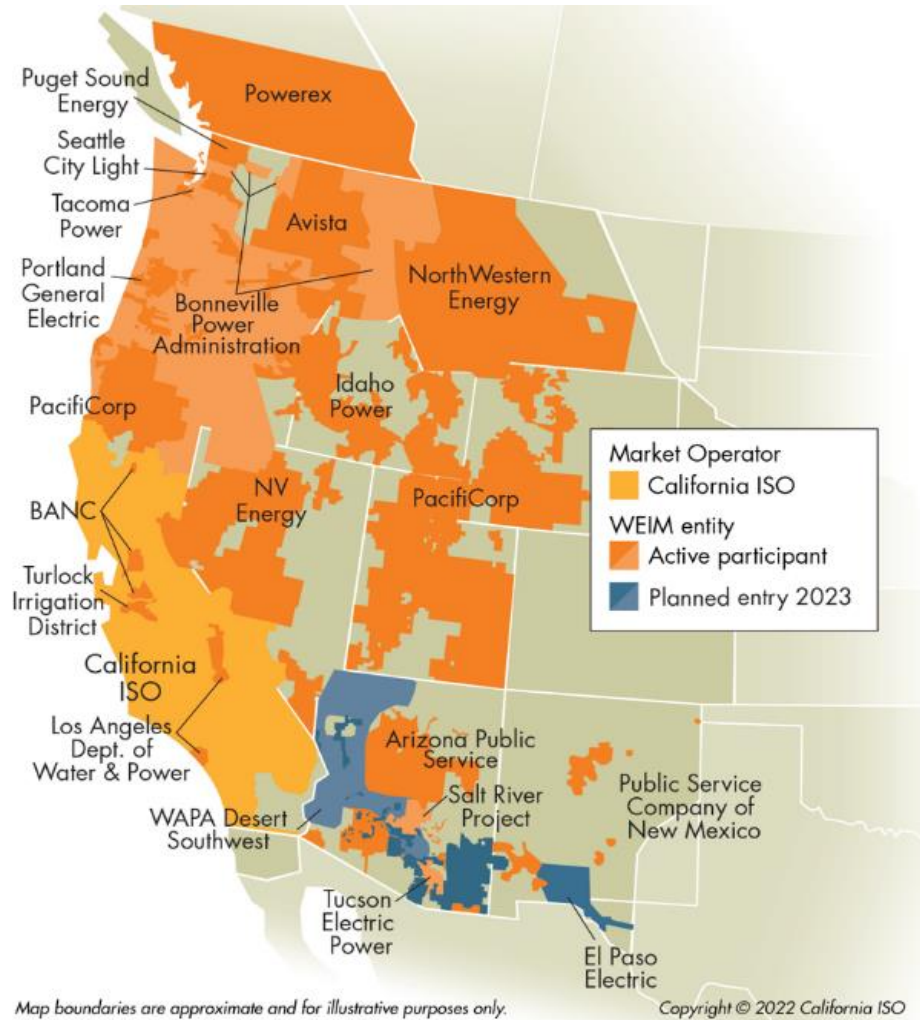
CAISO's Regulation Market

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October 15, 2022

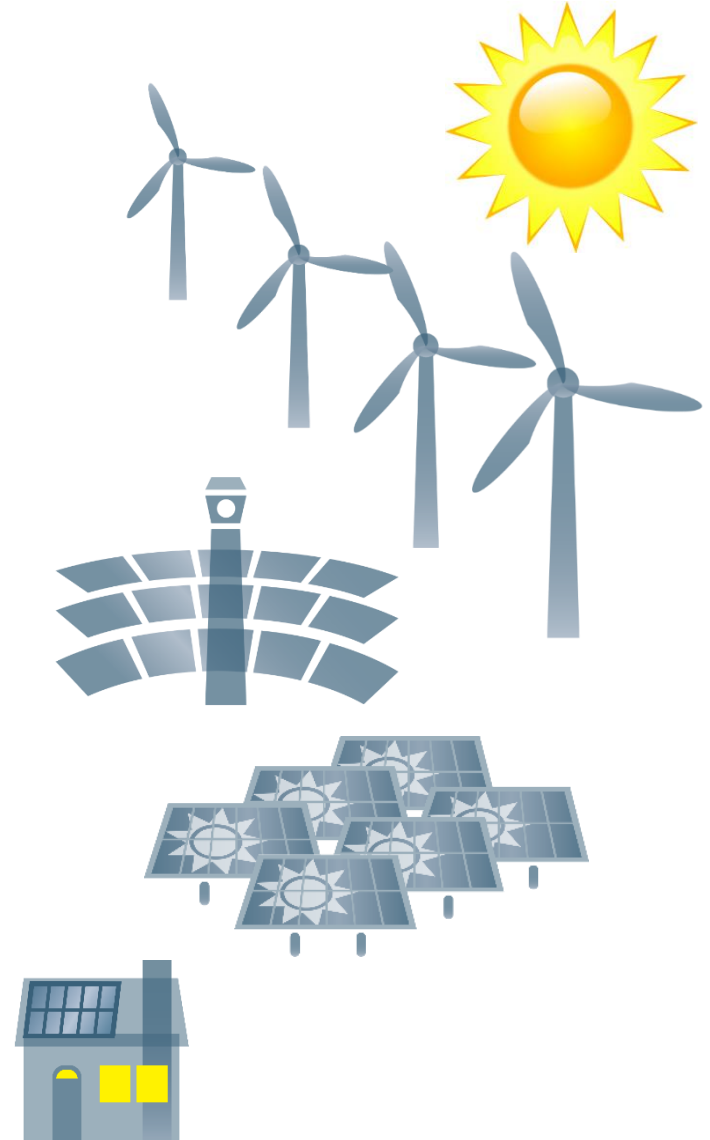
California ISO

- **Nonprofit** public benefit corporation
- Part of Western Electricity Coordinating Council
- Energy Imbalance Market covers 10 Western States and British Columbia with \$1.7 Billion of economic benefit so far
- **75,747** MW of power plant capacity
- **50,270** MW record peak demand (July 24, 2006)
- **>1,100** power plants
- **26,014** circuit-miles of transmission lines

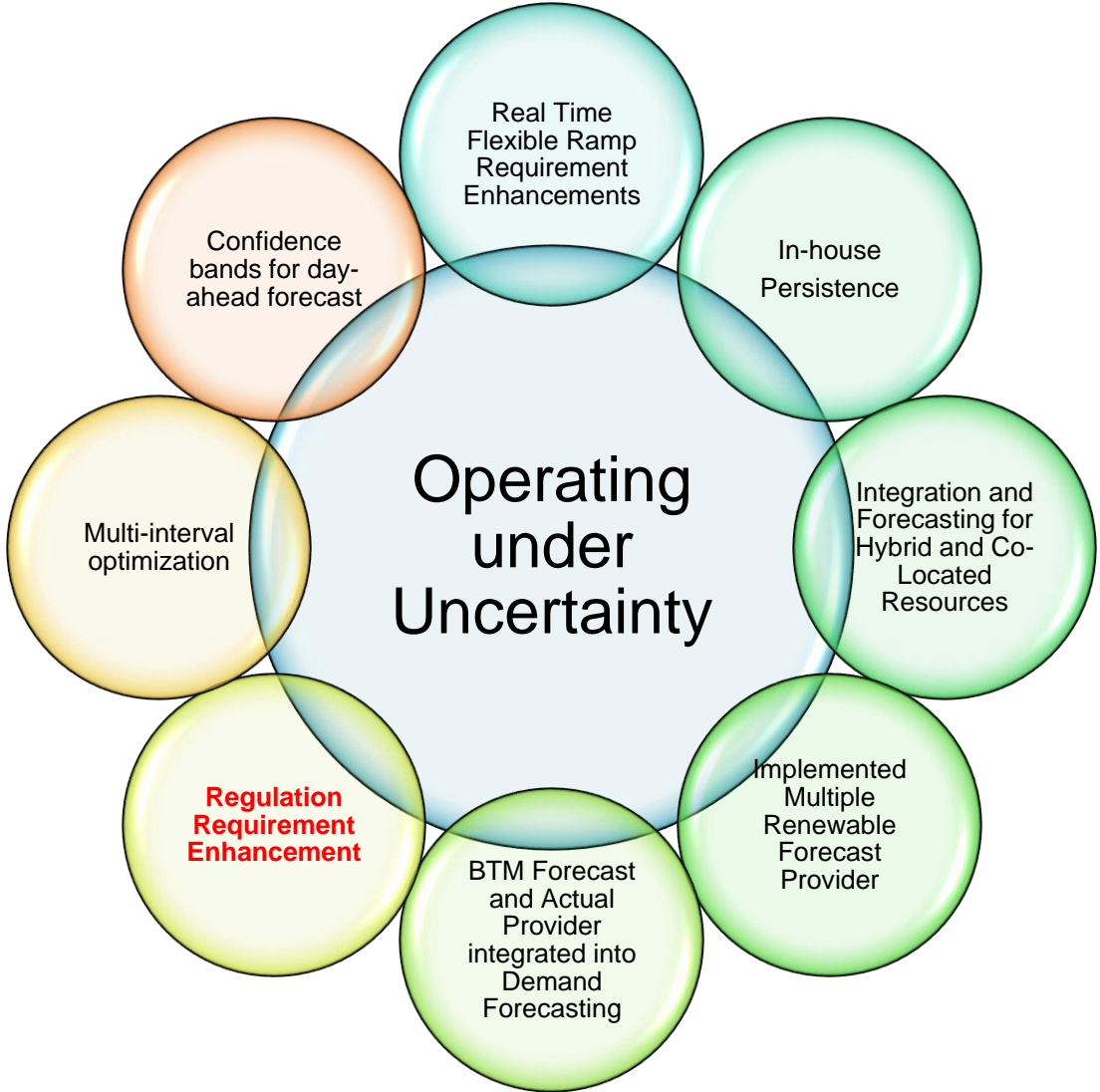


Major progress on meeting CA's renewable goals

- Currently Installed:
 - 21,000 MW of utility-scale renewables
 - ~11,000 MW of consumer rooftop solar
- Additional renewables:
 - 4,000+ MW additional utility-scale renewables by 2026
 - ~19,000 MW of consumer rooftop solar by 2030
- Projected 5000+ MW of storage and hybrid resources



Advancements to handle uncertainty in CAISO's market and system



CAISO Markets

Transmission-Right Markets

Day Ahead Market

Real-Time (EIM) Market



Monthly, seasonal and TOU intervals

Congestion Revenue Rights (Obligations)

Hourly intervals

Energy

- a) physical
- b) virtual

Mileage

Capacity

- a) Reliability
- b) Ancillary services
 - Spinning
 - Non Spinning
 - Regulation

15- and 5-minute intervals

Energy

Flex Ramp

Mileage

Capacity

- Spinning
- Non Spinning
- Regulation



Regulation is one of the four types of ancillary services (AS) in CAISO's markets



AS can be procured in real-time as conditions and needs change

- A 100 % of AS is procured in the day-ahead market
- AS can be procured only through the 15-minute market, not in the five minute market
- Although Operating Reserves needs may change, generally regulation requirements do not change in real time
- Incremental AS can be procured in real-time as conditions change
- AS awards can be blocked due to congestion concerns

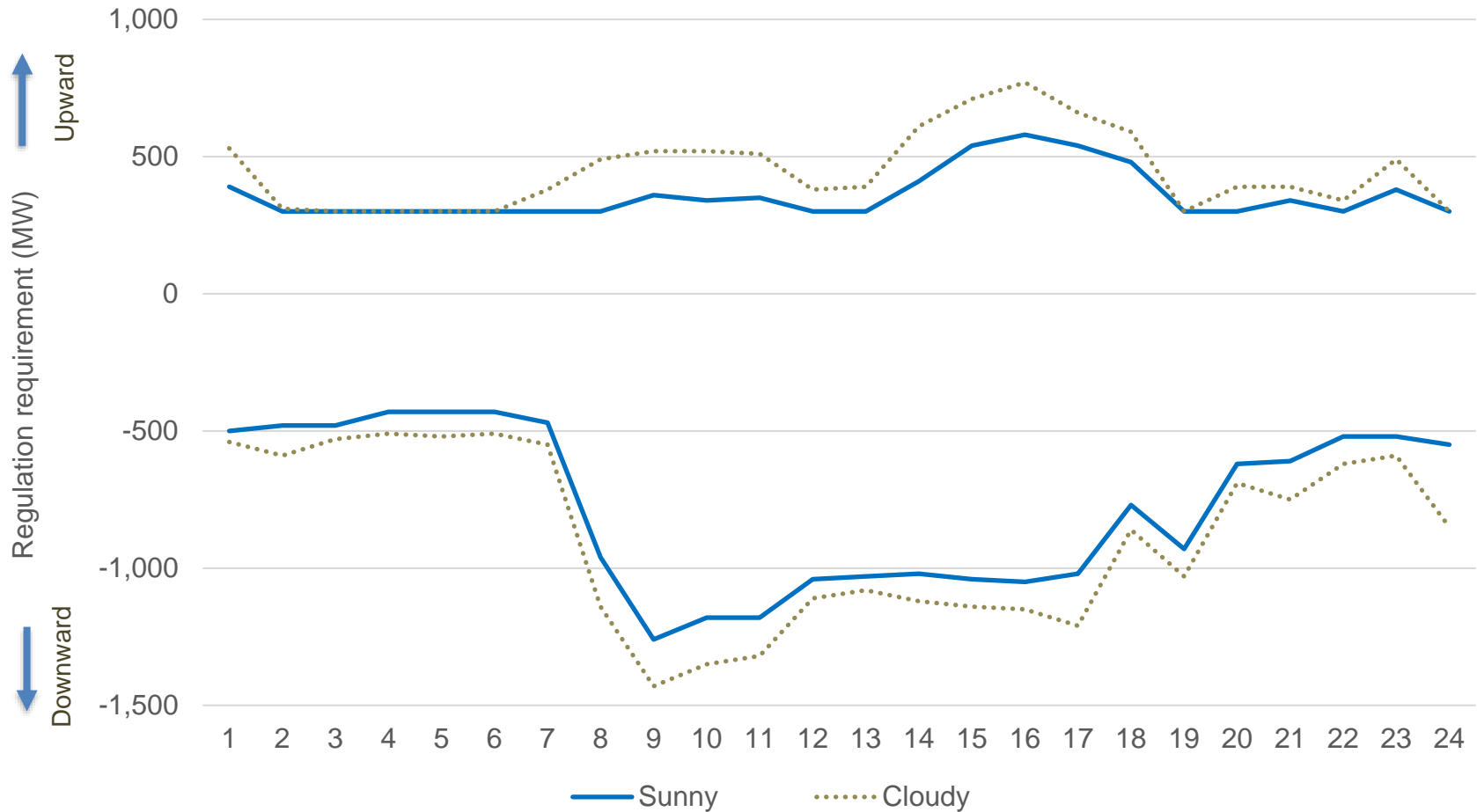
AS prices are optimally determined through the market clearing process

- Resources explicitly bid-in for regulation
- Regulation prices are set by bids and opportunity costs among market products
- When AS scarcity arises, market uses a demand curve to set prices, which are based on
 - type of service, and
 - level of scarcity

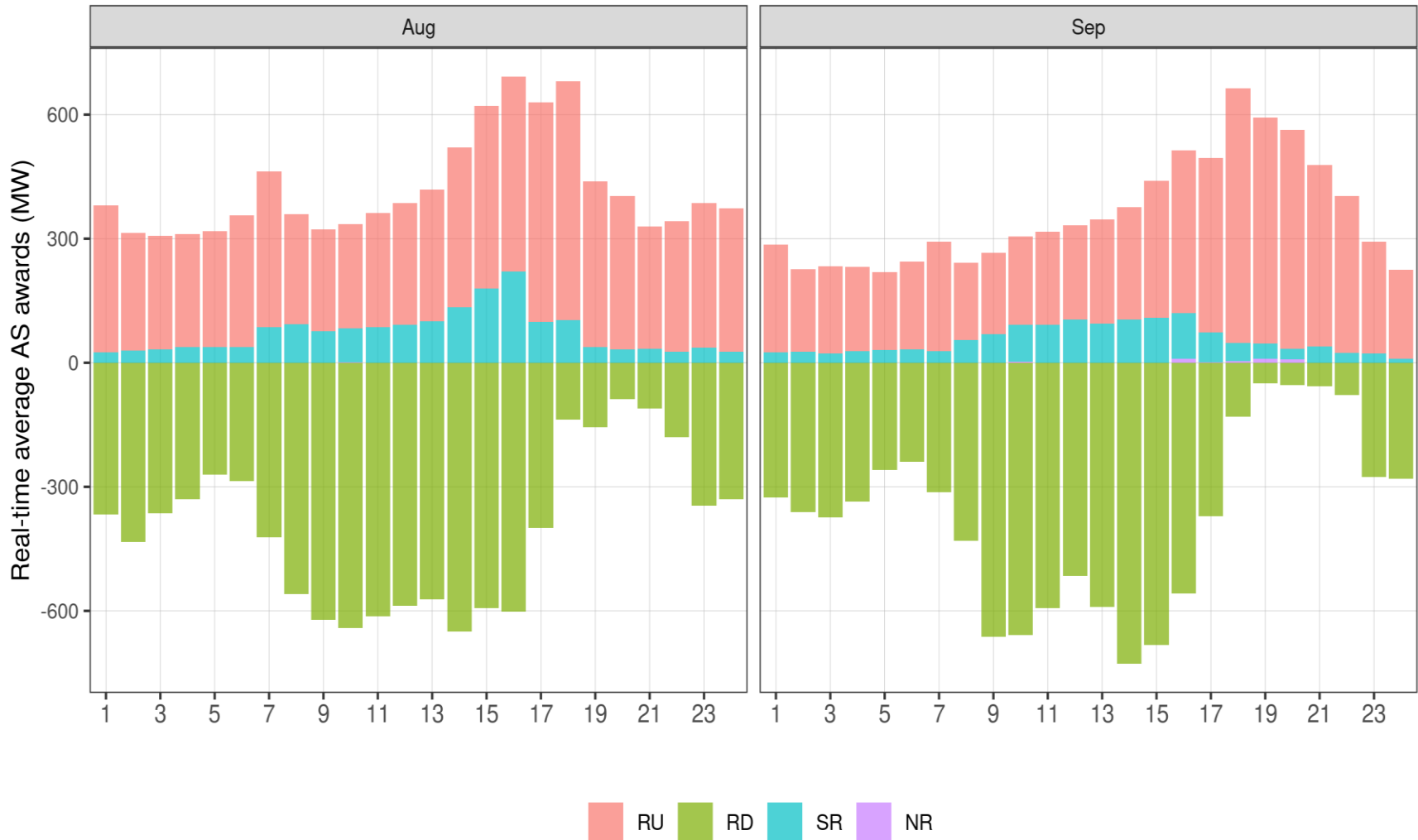
Determination of Regulation requirements

- Legacy requirements used to be a flat profile of 350 MW
- With integration of renewable resources, CAISO estimates regulation requirements by calendar month
 - Assess of requirements based on historical use/need of regulation
 - Gather a data sample based on last 30 days and same month of last year
 - Build a histogram per hour of the day
 - Use a confidence interval (*i.e.*, 95th) for sunny days and a higher level for cloudy days
- Operators may adjust as needed based on other operational concerns

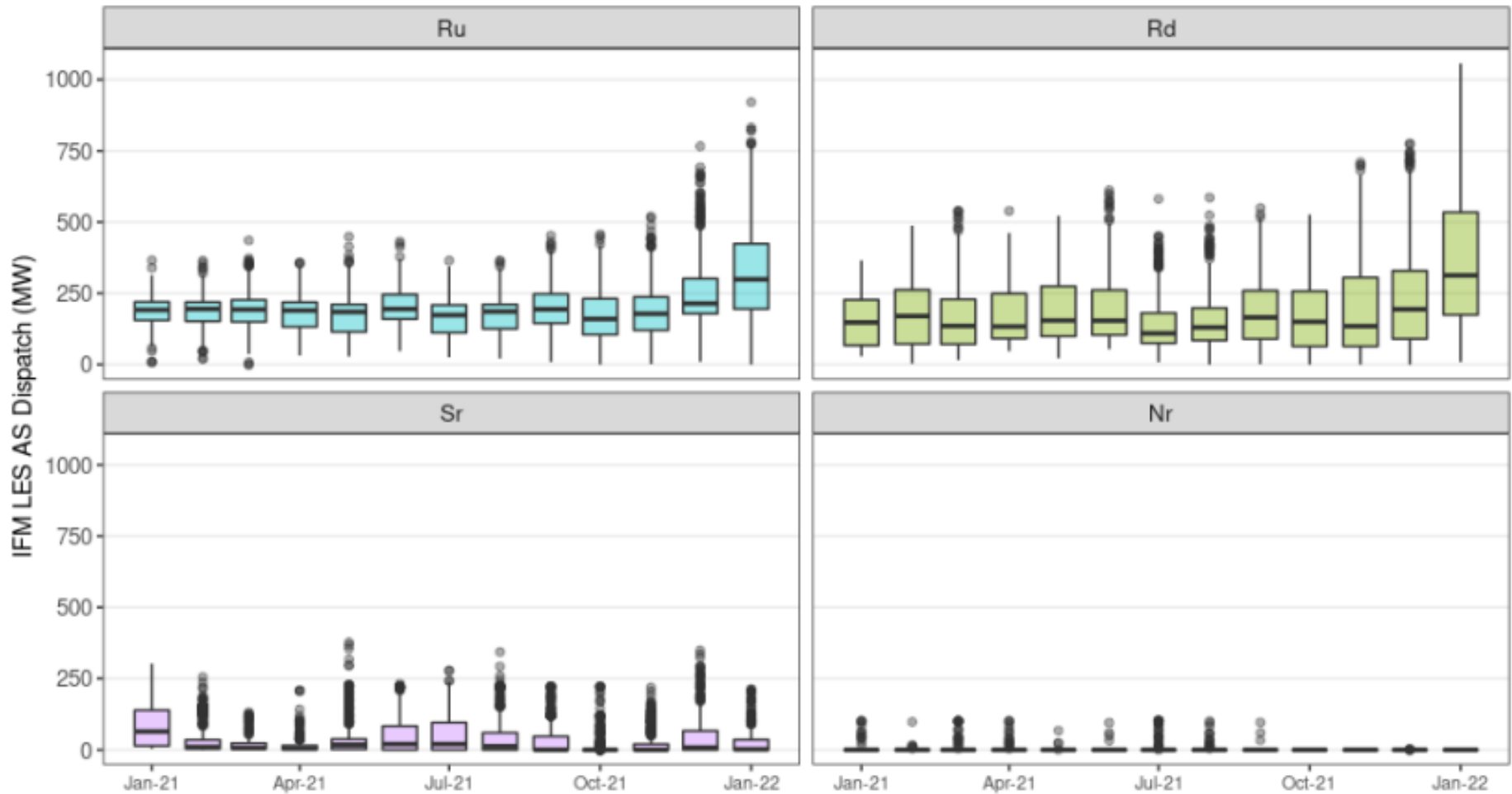
Sample of regulation requirements for a non-summer month



Integration of storage resources has changed the dynamic of the regulation market



Monthly AS dispatch for storage resources shows an increasing trend of regulation procurement



Storage resources have saturated at times the regulation market by providing capacity in excess of regulation requirements

