Resource Adequacy Models and Low Carbon Power Markets

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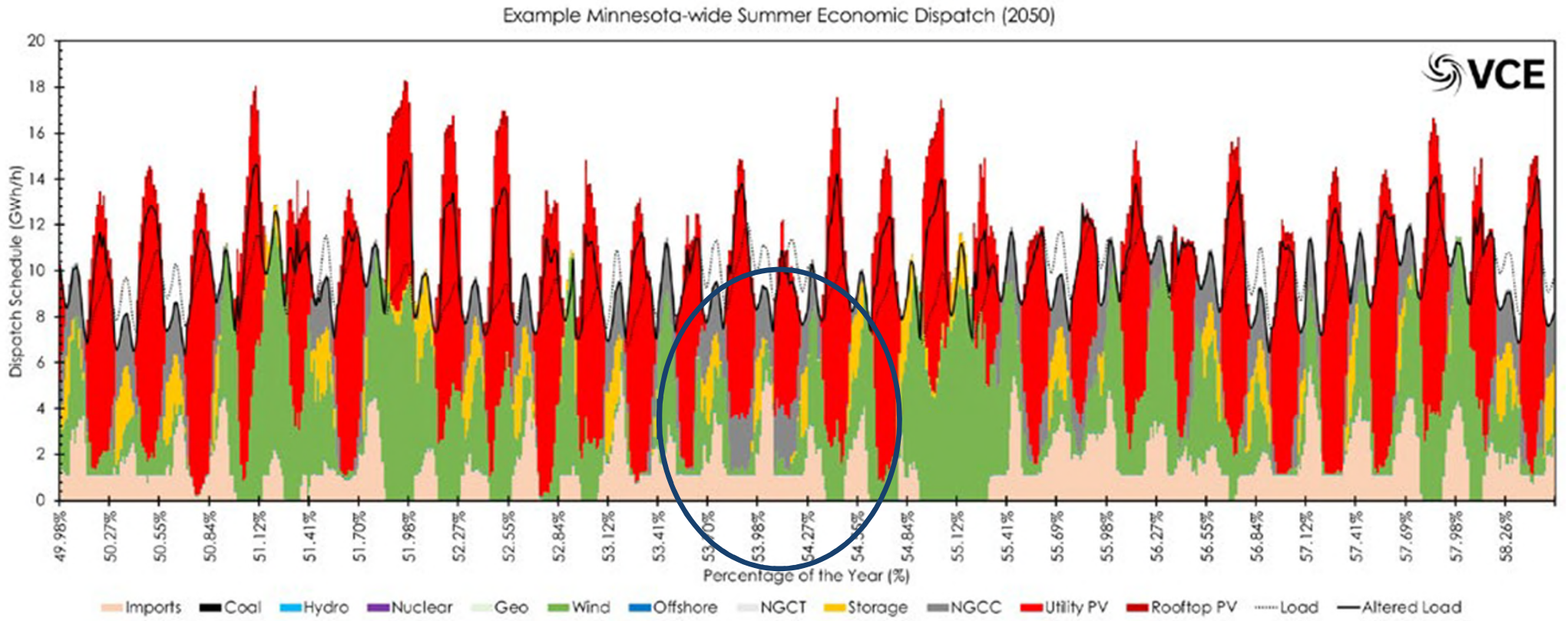
Grid Strategies disclosure

- Clients include renewable companies and associations, states, national labs, large energy consumers, environmental NGOs, transmission developers, transmission technology companies, foundations, universities (Columbia/Johns Hopkins Future Power Markets Forum).
- Gramlich bio: https://gridstrategiesllc.com/rob-gramlich/
- Mission: Low-cost de-carbonization through the reliable and efficient integration of clean energy into electric grids.
- Papers at https://gridstrategiesllc.com/articles-2/

Resource Adequacy in a Low Carbon Future

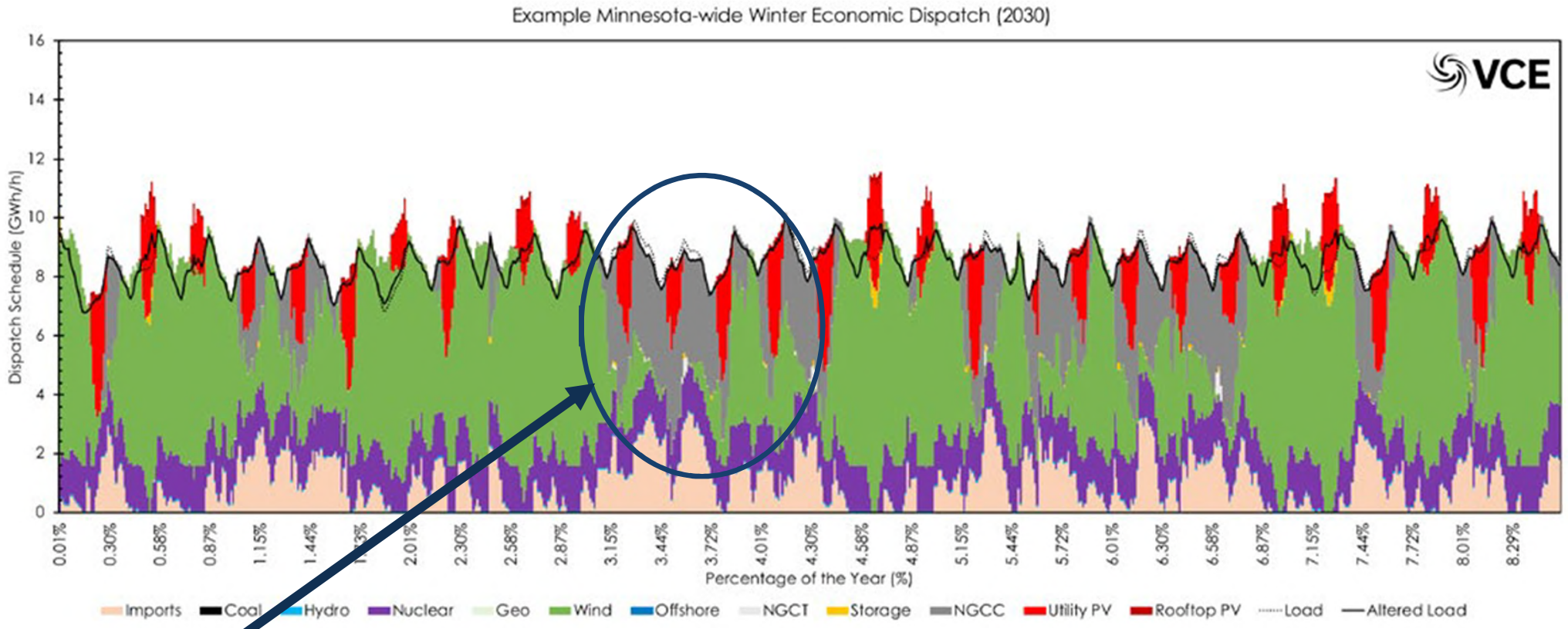
(the "what")



- High penetration (60-90 percent) renewable energy can be low cost and reliable

Chris Clack, Vibrant Clean Energy, https://www.mcknight.org/wp-content/uploads/Minnesotas-SmarterGrid_FullReport_NewFormat.pdf. See also E3, EFI, VCE, Brattle, Jenkins/MIT et al., Gridlab/UC Berkeley, NREL, LBNL, IEA, ESIG, other studies

Resource Adequacy Focus

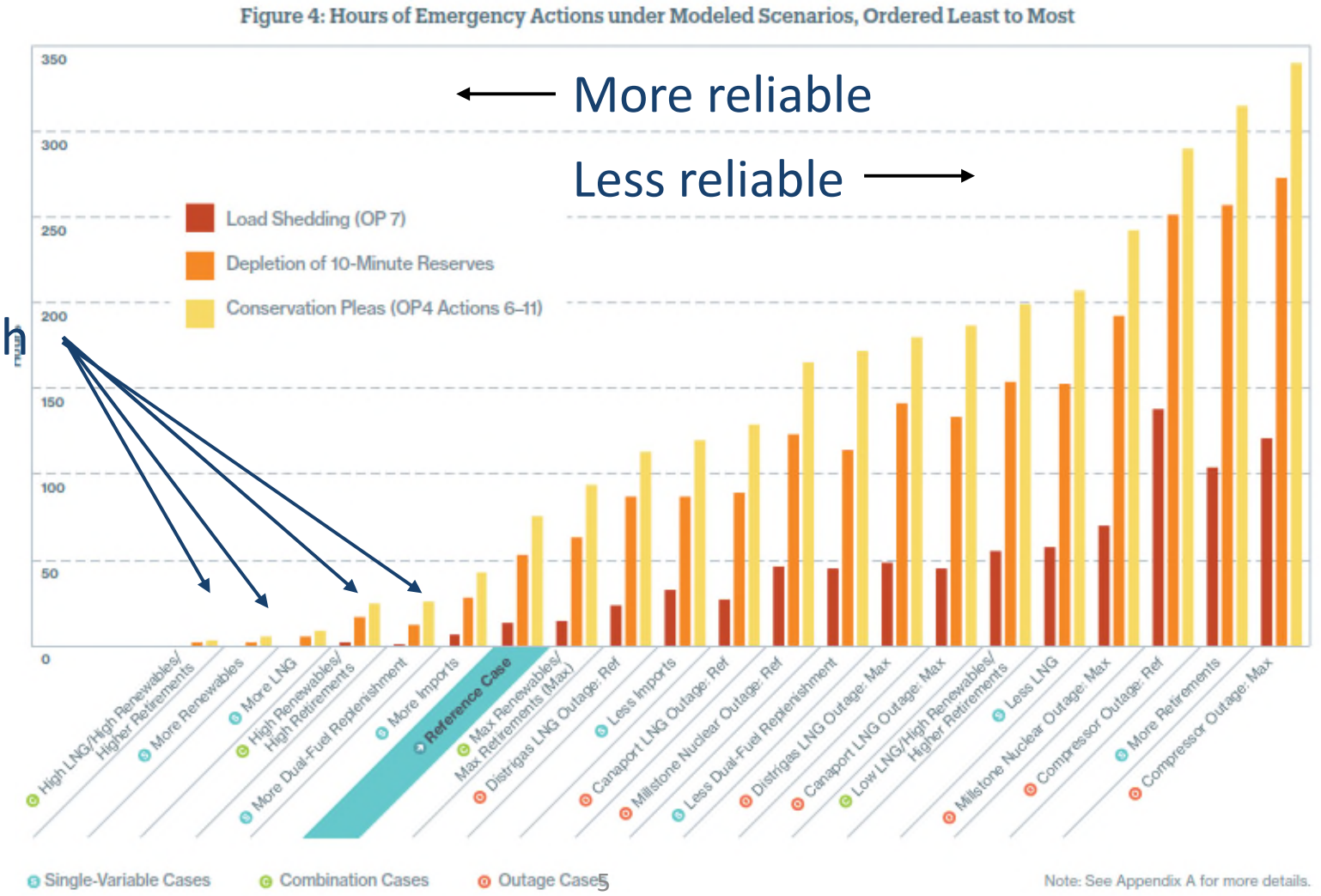


- Multi-Day periods of low wind+solar, usually winter. Not peak load.
- Served by contracted imports and firm resources. Not traditional reserve margin/“capacity”

Source: Clack, VCE, Minnesota/Eastern Interconnection study. See also E3, EFI, VCE, Brattle, Jenkins/MIT et al., Gridlab/UC Berkeley, NREL, LBNL, IEA, ESIG, other studies

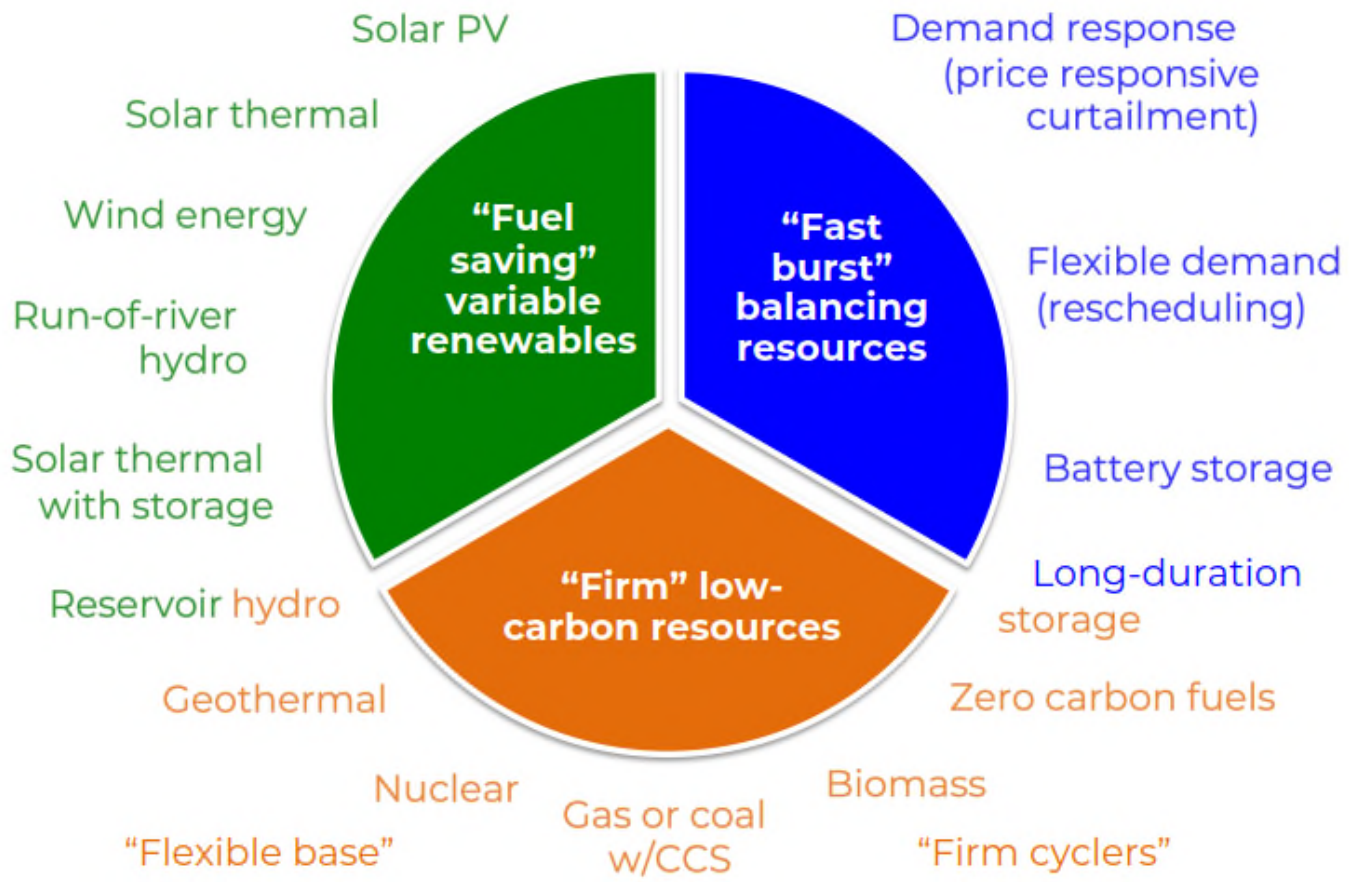
Renewable + Firm + Imports
Similar to Fuel Security in ISO-NE

Most reliable:
High renewables with firm + imports



ISO-NE Operational
Fuel Security Analysis

Reliable Carbon-Free Portfolio



Plus transmission-enabled imports

Since scarcity occurs at different times in different regions

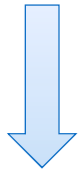
Sepulveda, N., Jenkins, J.D., et al. (2018), "The role of firm low-carbon resources in deep decarbonization of electric power systems," Joule 2(11).

Models of Resource Adequacy (the "who" and "how")

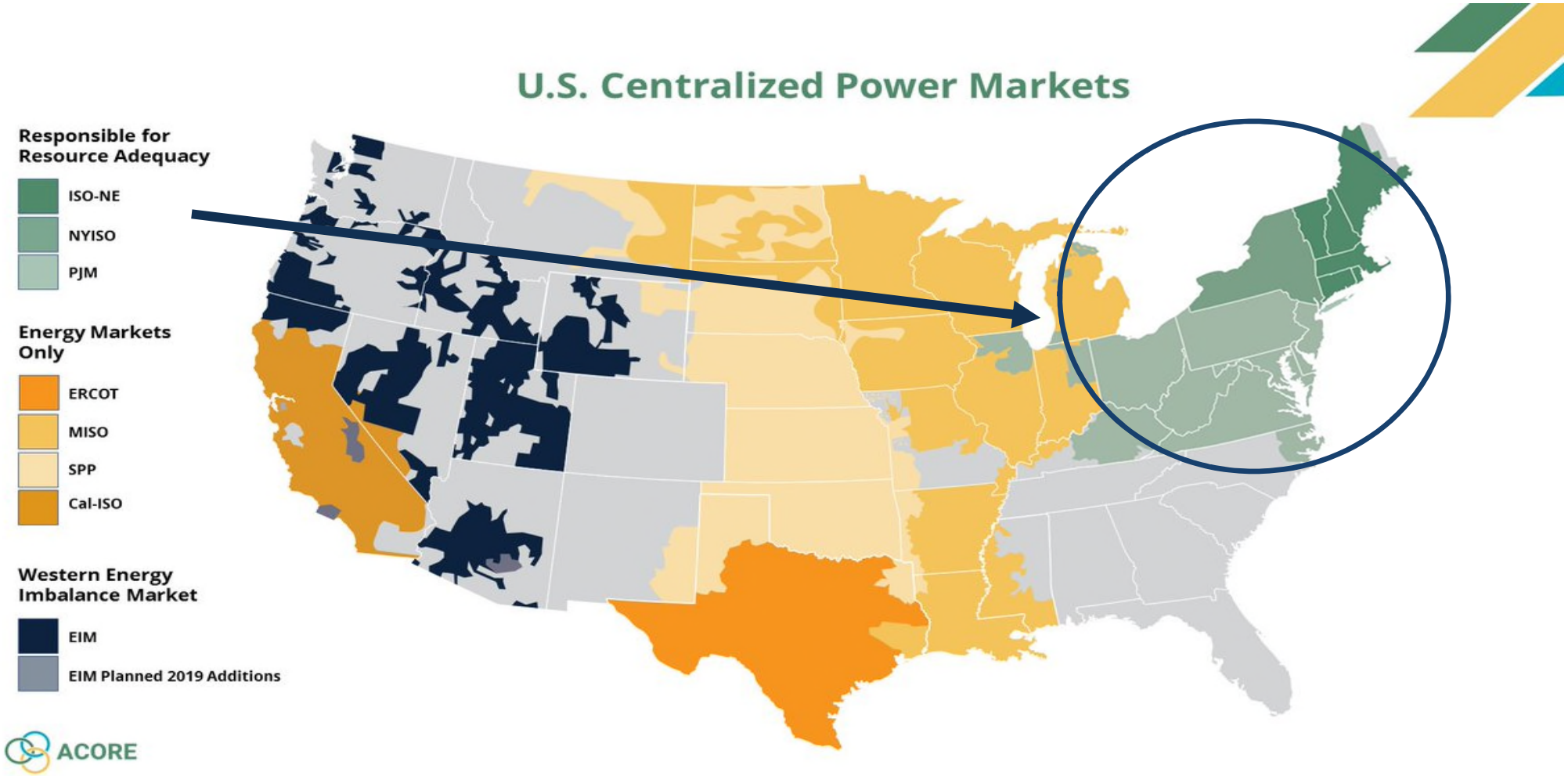
1. Current construct with broad MOPR
2. Eliminate broad MOPR
   a. Courts, future FERC 206, ISO 205 filing.
3. PJM's Fixed Resource Requirement (FRR)
4. Voluntary Residual Capacity Market
5. LSE responsibility with vertically integrated utility & RTO (MISO, SPP)
6. LSE responsibility with competitive generation and retail markets (CA, ERCOT, Australia)

More federal role

Less federal role



Who is responsible for Resource Adequacy: Where it is the RTO/ISO under FERC



3. Fixed Resource Requirement

PJM option

- RTO still defines, enforces capacity rules
- Option in PJM tariff for load to bypass central auction and procure capacity bilaterally.
- State could put the obligation on utility, or state agency, or competitive retailers if they wish
- Significant interest now
  - MOPR would not apply, reducing costs
  - Replaces capacity demand curve with reserve margin—procures less, saves money.
- Market power mitigation
  - Generation market power: FERC regulation of bilateral contracts?
  - Utility buyer monopsony power: state rules re affiliate favoritism
- Can rely on generation competition, non-utility IPP generation, or not.

4. Voluntary Residual Capacity Market

Early RTO capacity markets

- RTO still define, enforce
- LSEs procure through bilateral contracts or through voluntary central auction—they can choose either, or a mix
- Like early capacity markets, the central market would be an option, not obligation
- Penalties ultimately financial, as with all models

5. LSE responsibility, vertically integrated utility & RTO

MISO, SPP

- RTO serves backstop function
- RA largely driven by state commission-overseen utility Integrated Resource Planning processes

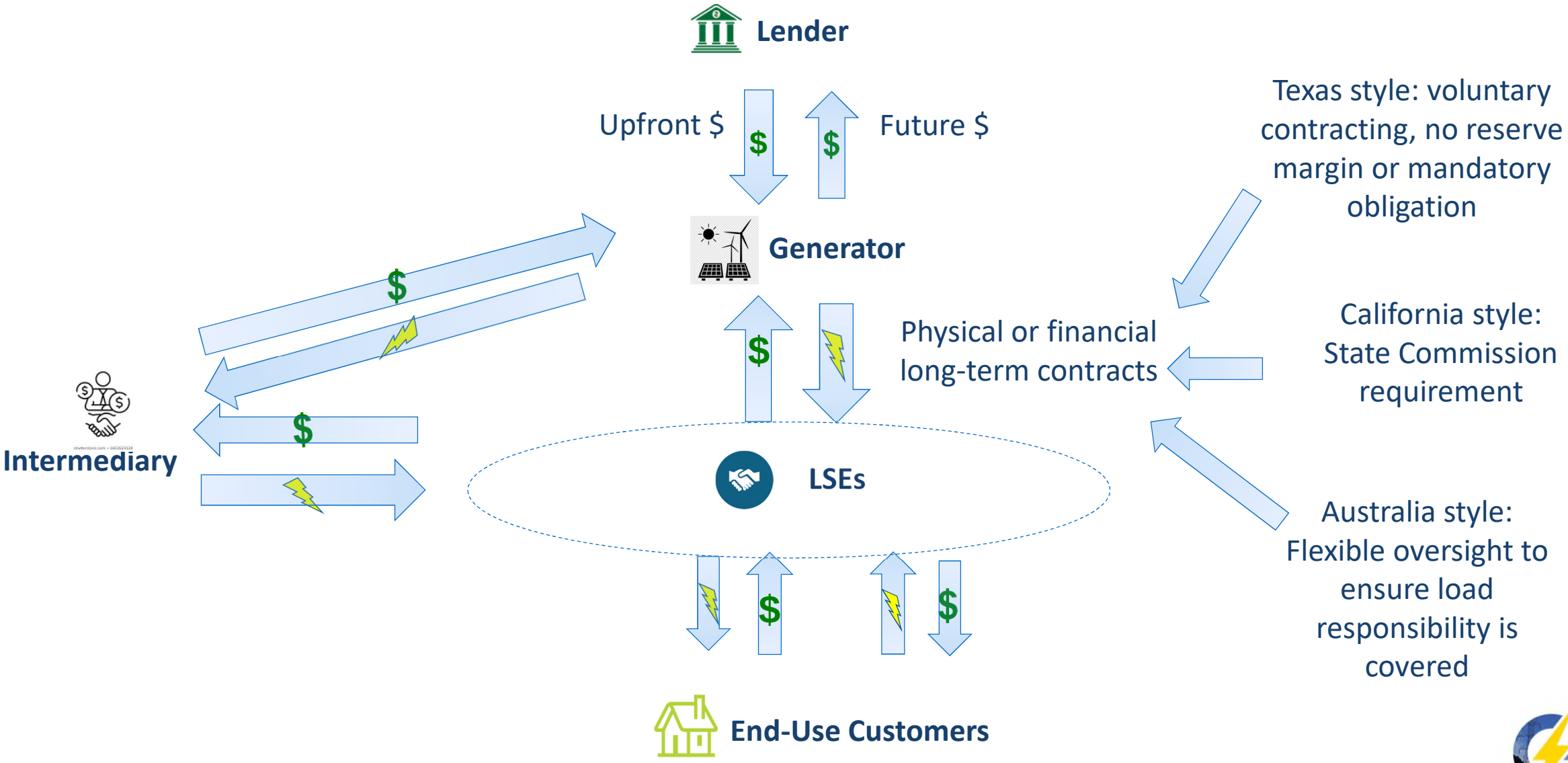
- SPP variant
  - States set the reserve margin through the Regional State Committee
  - Similar to New York NYSRC but in multi-state context
  - This model can be considered states “taking back” RA if states get to set RA standard and various rules

6. LSE Responsibility with competitive generation and retail markets

ERCOT, Australia, California

- Responsibility on Load-Serving Entities
  - LSEs can manage both demand and supply arrangements
  - Applies at all times and places of load, not just peak
  - Competitive retail suppliers, municipals, coops, IOU, Community Choice Aggregators
- States ensure LSEs are credit-worthy and all parties have incentive and ability to procure needed power to serve their customers
  - State commissions have licensing authority, can make sure retailers are equipped to perform this essential aspect of providing electricity service to retail customers. May require legislation.
- LSEs procure long term power under bilateral PPA contracts
  - Most transactions in bilateral markets. PPAs priced at average cost of competitive new unit. Often intermediaries take long position.
  - Low cost financing achieved through multi-year PPAs
- Spot market low volume, for unexpected surplus/shortfall exchange
  - Energy at each time and location with LMP
  - Reliability Services--technology-neutral products competitively procured by ISO
  - During scarcity, value based (VOLL, not generator operating cost) pricing serves as a penalty for under-procurement, attracts flexible DR and storage resources

How LSE-based RA leads to generation investment



Summary RA functions

System Operator (SO) vs state/local lead

	MISO	CAISO	SPP	ERCOT	PJM	NYISO	ISO-NE
Set reqmt	State&local	SO and local	State&local	n/a	SO	State	SO
Enforce on load	State&local	State&local	State&local	n/a	SO	SO	SO
Enforce on gens	State and SO	SO	State&local	n/a	SO	SO	SO
Central auction	Yes	none	none	none	Yes	Yes	Yes
Resource credit	State&local	State&local	State&local	n/a	SO	SO	SO
Backstop procurem't	n/a	SO	n/a	n/a	n/a	n/a	n/a