Financing the efficient decarbonization of the power sector – key concerns:

1. Will wholesale spot energy market prices be sufficient to sustain the mix and quantity of clean resources needed to reliably balance supply and demand?

2. Will the range and volatility of these prices be sufficient to incentivize enough voluntary (to buyer and seller) contracts and hedges to support low-cost, high-volume capital sources (debt and equity) to support the build out of the volume and types of needed new clean resources?

3. Will the above processes (alone, with current capacity market constructs, or augmented by state clean energy mandates and incentives) be sufficient to incent the development and maintenance of what is really needed for decarbonization:

   - the lowest cost, most efficient mix of clean generation, flexible load and storage
   - that will reliably balance supply and demand, including massive electrification
   - in all likely demand and weather conditions
   - with ~ 90% reductions in power sector GHG emissions?

Many fear the answers are either “no”, “not likely” or “not well”. Hence we see a variety of proposals to add a new long-term market, designed to achieve these results, alongside existing short-term, LMP-based markets.

First, what would that look like?

We can visualize thanks to:

MINNESOTA'S SMARTER GRID

Pathways Toward a Clean, Reliable and Affordable Transportation and Energy System

Prepared By:

Vibrant Clean Energy, LLC

Prepared For:

McKnight Foundation & GridLab

July 31, 2018

Incorporating the kind of efficiencies we should expect from good markets:

- Complementary, co-optimized (by location, type and amount) to balance system every 5 minutes:
  - solar, wind, and existing clean resources,
  - flexible existing and electrified load,
  - new transmission, plus
  - the timely exit of heavy emitting fossil resources and
  - only the gas assets needed for residual balance.

- 80% economy-wide decarbonization with ~90% power sector decarbonization across entire interconnection by 2050.

- Comparative advantage, gains from trade and synergies rather than NIMBY / AIMBY policies and high levels of curtailment.

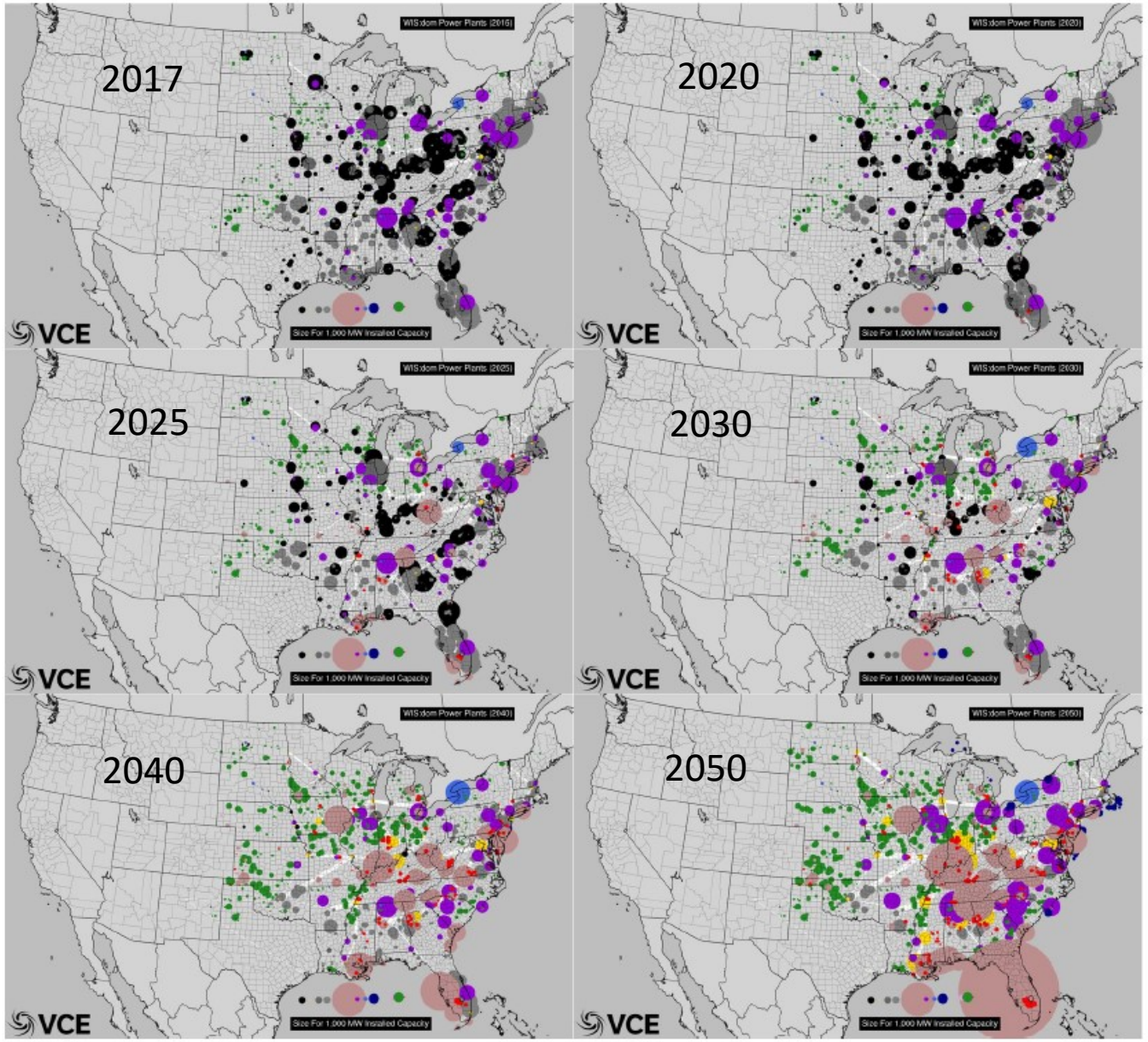
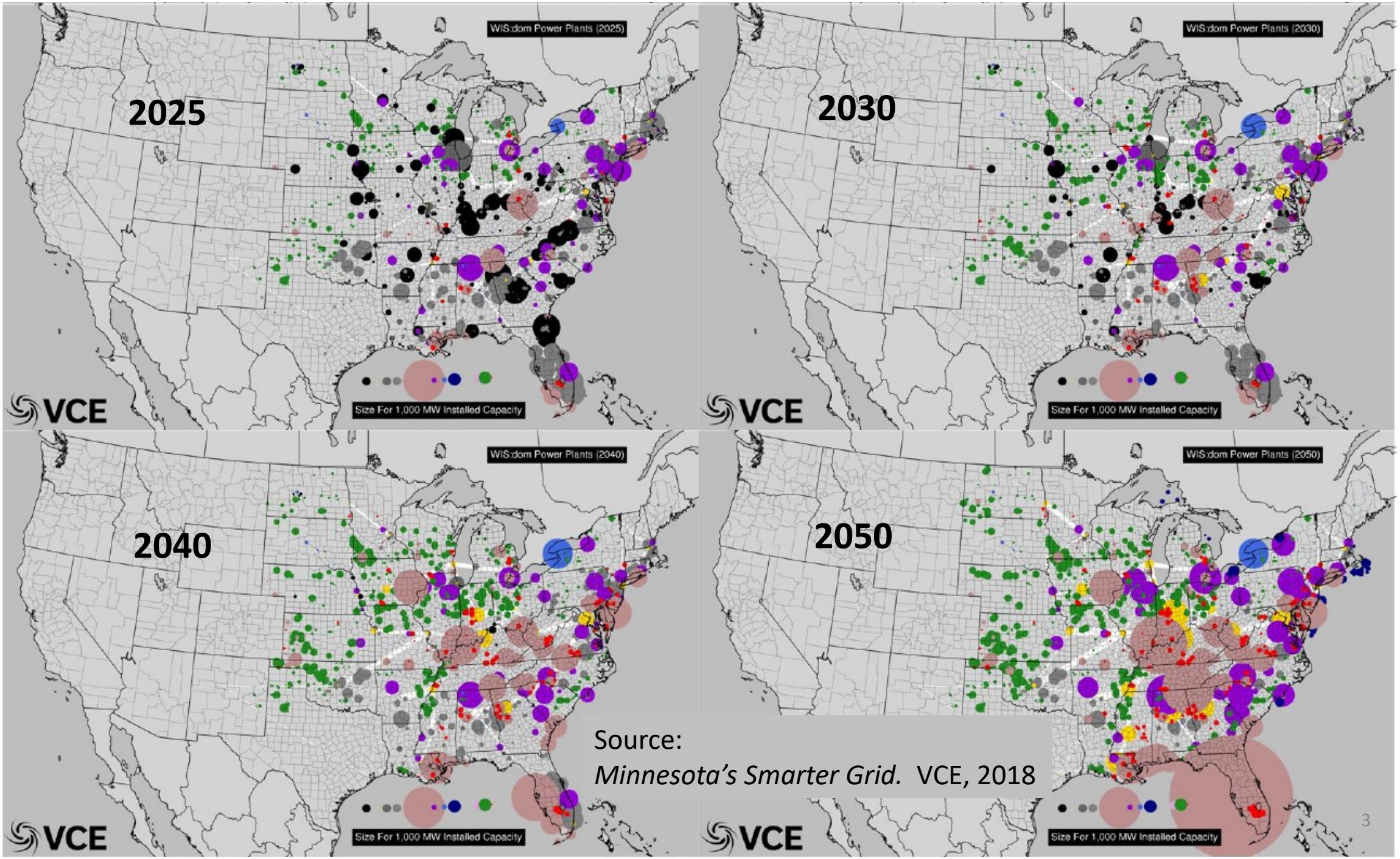


Figure 46: The geographic siting of generation created by WIS:dom for the Eastern Interconnection Decarbonization scenario. The investment periods can be followed from 2017 in the top-left panel to 2050 in the bottom-right panel. The white lines represent the interstate transmission capacity. The thicker the lines the greater the capacity. The colors are (in order shown at bottom): black = coal, yellow = storage, dark grey = NGCC, light grey = NGCT, rose red = rooftop solar PV, purple = nuclear, light blue = hydroelectric, dark blue = offshore wind, pink = geothermal, green = onshore wind, red = solar PV.



Source:
Minnesota's Smarter Grid. VCE, 2018

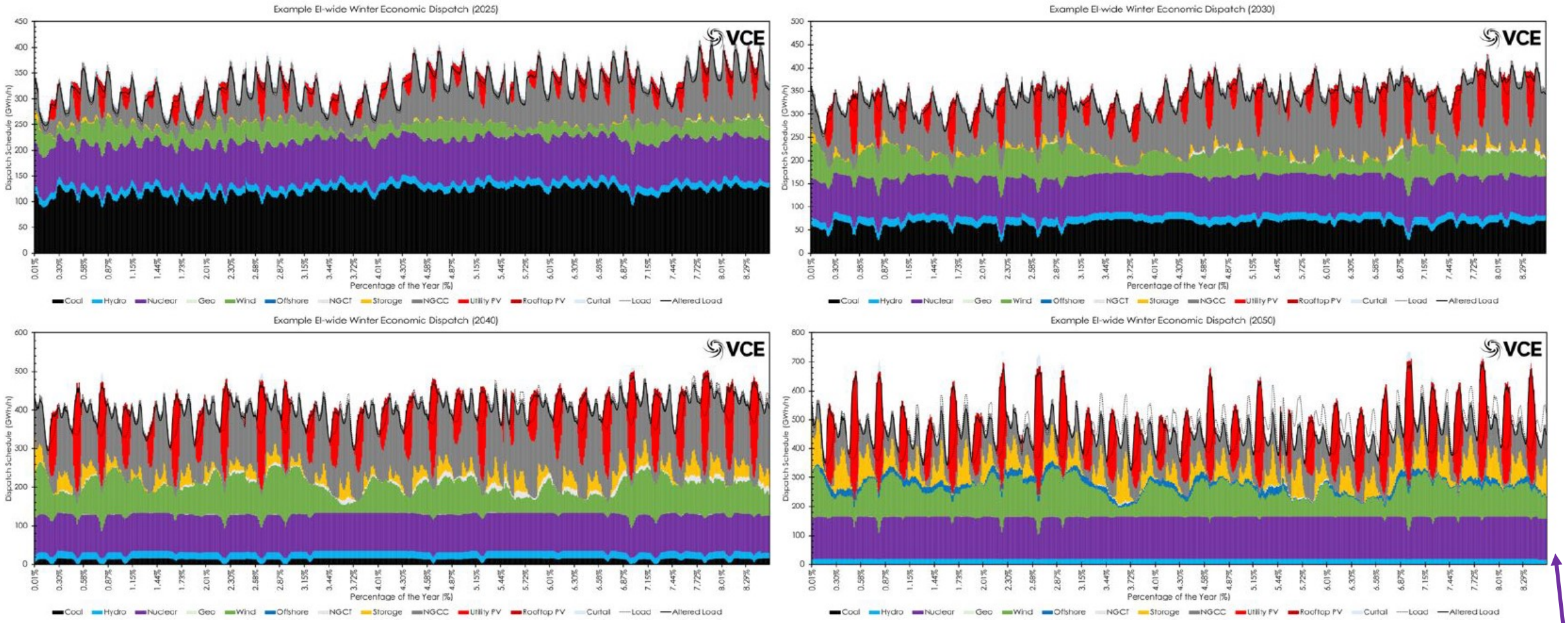
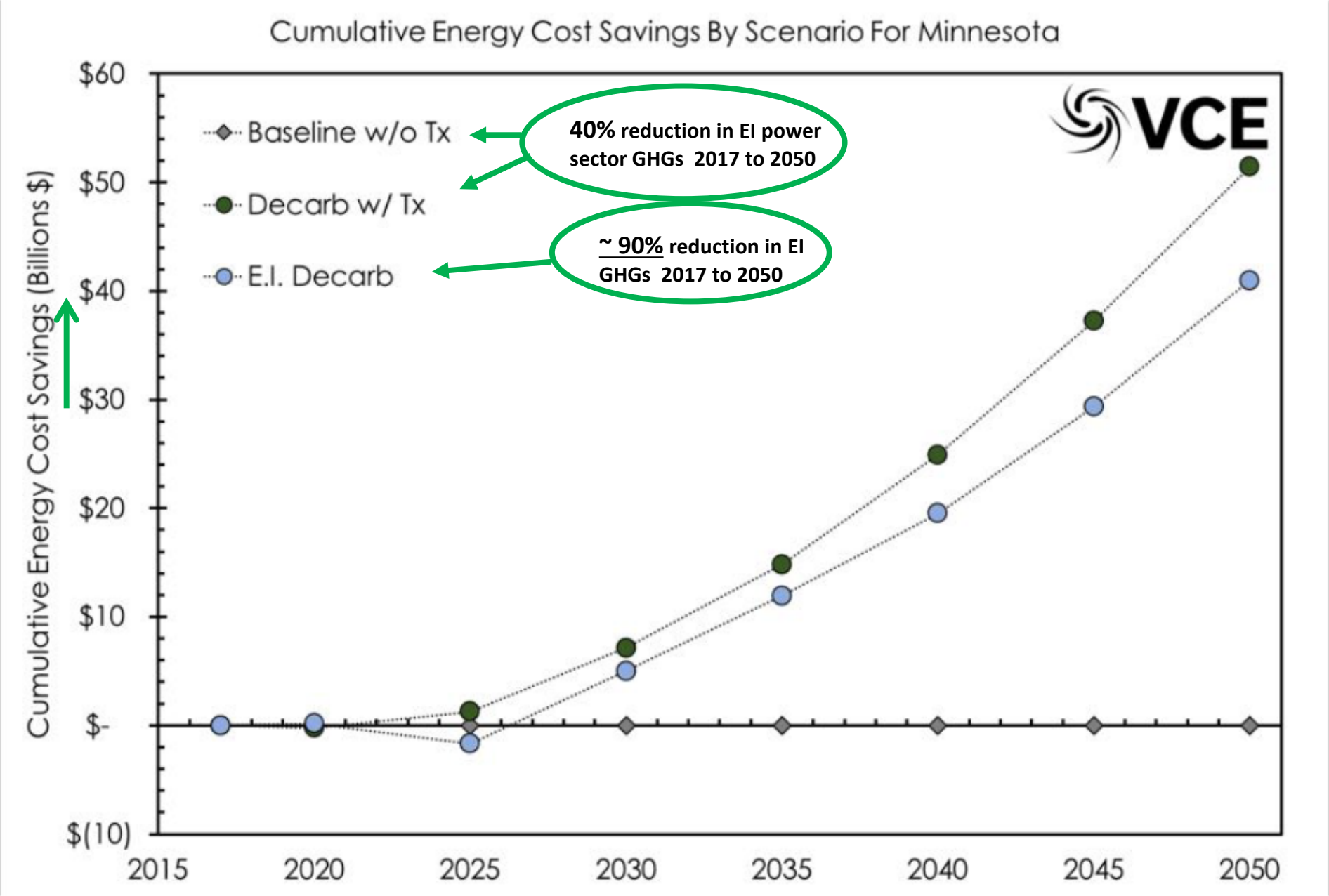


Figure 49: The economic dispatch over the month of January for the Eastern Interconnection.

Note "nuke resurgence" with output largely flat despite 60% VRE energy

Source: *Minnesota's Smarter Grid.* VCE, 2018

Efficient configuration leads to ***lower costs*** than assumed BAU pathway!



Key price and revenue sufficiency problems we anticipate with short term energy markets and their implications:

1. Growing share of VRE with minimal marginal costs depresses power prices when VRE output exceeds demand, plus a growing share of flexible load and storage with low opportunity costs during short periods when demand exceeds VRE output.

   → Direct market-based fixed cost recovery will need to occur in hours when demand exceeds VRE output, and outside of periods with ample storage and flexible load to meet temporary shortfalls of VRE output.

2. Scarcity (to the extent allowed by policy makers) will focused in hours when many VREs are unavailable due to *protracted* periods of low / no wind or sunshine..

   → Thus it will have to happen increasingly during periods of scarcity, when much (especially local) VRE is offline due to lack of the underlying energy source. VRE, storage and flexible load don't always run in merit!

3. There are few competitive LSEs that are creditworthy, even if they want to contract with resources to cover such market shortages and scarcity price risks.

   → Even with enough scarcity prices to drive voluntary hedging at compensatory levels, there won't be enough contracts to cover all new and existing clean energy resources with fixed cost recovery at risk due to the above risks -- many VREs, potentially nuclear.

4. Voluntary bilateral contracting to cover load will focus on technologies that can best serve load during such periods, with little or no sun and wind and when batteries are discharged and low-cost flexible load is flexed.

   → Such voluntary contracting is likely to be for resources that are always available at a low cost during such periods – e.g., diesel or gas reciprocating engines, gas turbines and gas fuel cells.

5. LMP prices (even if they are sufficient to incent enough contracts to cover all needed resources are not likely to be sufficient to get the right region-wide mix of VRE, transmission, flexible load, storage and existing clean energy technologies needed to minimize the cost of decarbonizing.

   → A regional, multi-state optimization process (planning and policy design or bid-based optimization) plus long term competitive contracts *coordinated with LMP market* to assure efficient mix, good risk allocation, cost control, revenue sufficiency and low risk finance.

Common core elements among our long-term market proposals:

1. **Qualified resources selected in long term procurement process awarded PPAs** or other assurance of fixed cost recovery, subject to performance. Specific purpose is to address revenue sufficiency and price risk barriers to deployment and low cost finance.

2. **Voluntary participation by resources, with costs allocated to load.** Resources may choose short-term only market or bilateral contracts instead. Load must participate in long term market, but could do so through a self-supply option (e.g., by using qualified resources.)

3. **Long term markets linked and coordinated with short term LMP-based market.** Two proposals use short term market to balance fixed long term contract energy schedules, the other treats long term contracts like tolls and uses short term markets to dispatch all resources.

4. **Incremental procurement through periodic tranches** to support innovation and avoid path dependence.

5. **Greater coordination and integration with clean energy and climate policy.** One proposal depends on policy makers to determine mix, profiles and locations, the other two give policy makers and stakeholders feedback on the optimal solutions and tradeoffs among their objectives regarding clean energy, reliability, customer cost, etc.

6. **Incremental implementation and market development pathways.** All three proposals envision their long term market evolving incrementally out of existing market and policy structures, without the need for major legislative and market rule changes first.

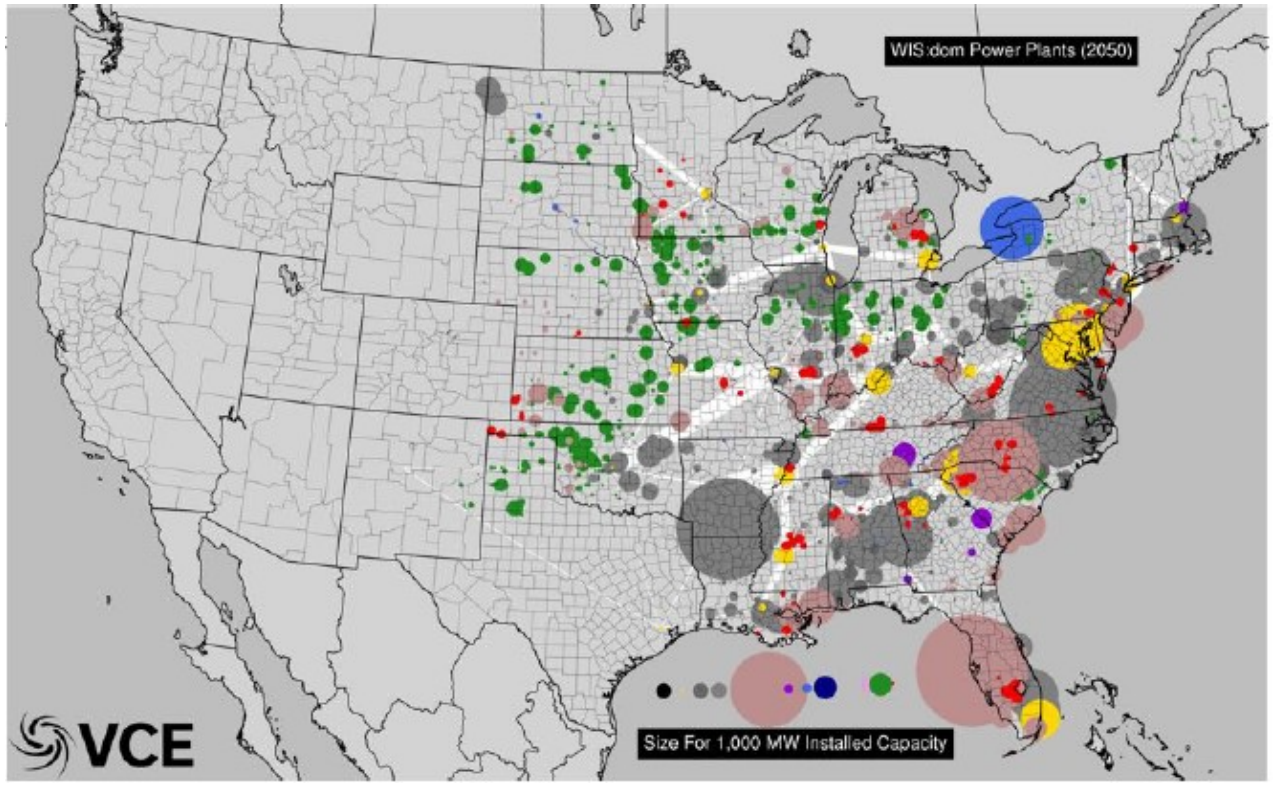
Major variables:

a. **Portfolio optimization:** through the competitive market process or from outside policy makers?

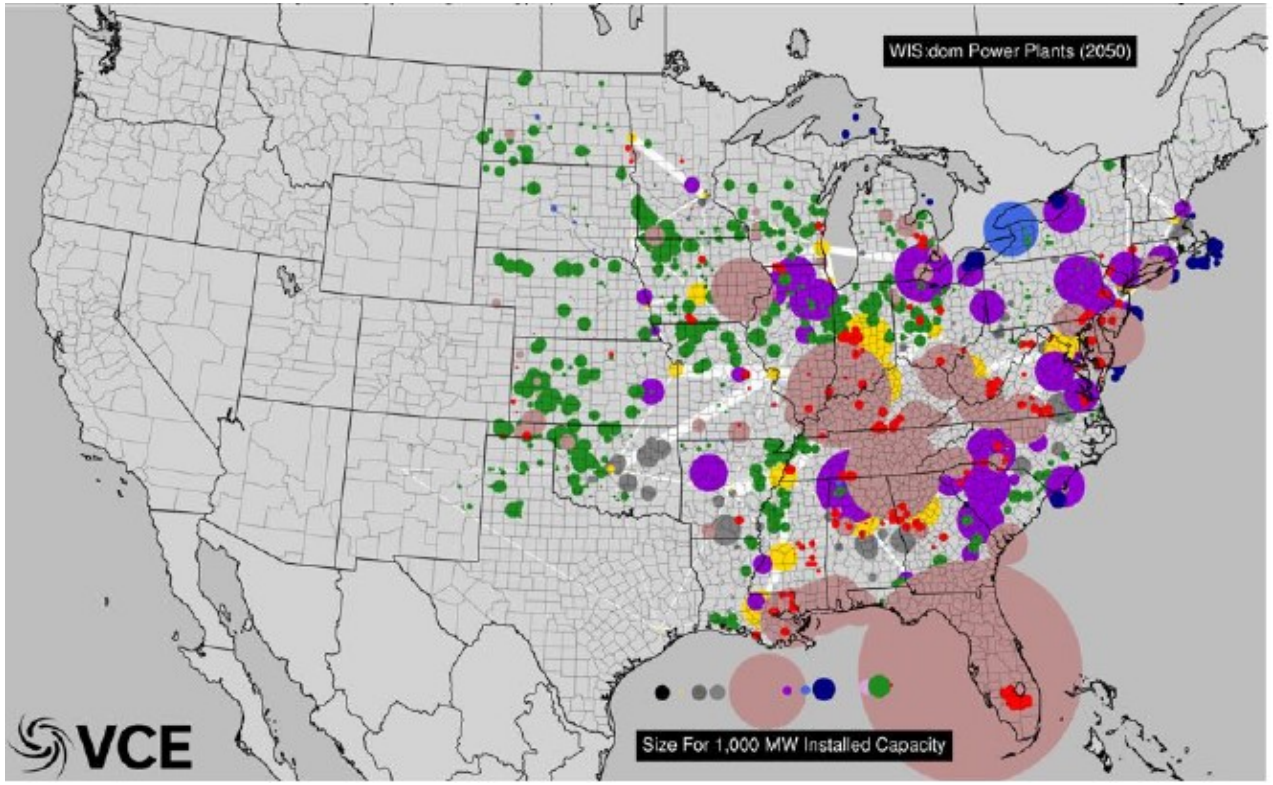
b. **Long-term market product:** firm “years-ahead” energy schedules balanced by short-term market, or toll-like “capabilities” contracts dispatched through short-term market?

c. **Geographic scope:** Regional, multi-state process (with necessary federal involvement) to best capture configuration efficiencies, or potentially just a new kind of state level RPS?

40% decarb 2050 (BAU)



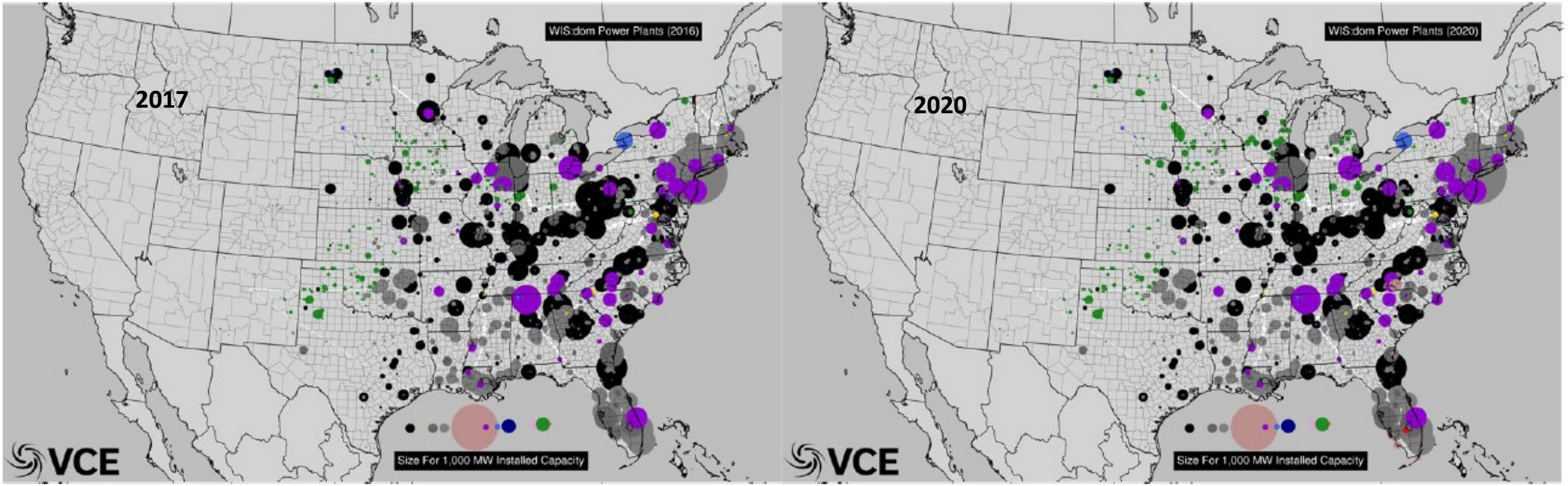
80% decarb 2050



This?

Or this?

Source: *Minnesota's Smarter Grid*. VCE, 2018



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Source: *Minnesota's Smarter Grid.* VCE, 2018