

Incorporating Renewables

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Regulation
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I. Drivers of renewable growth

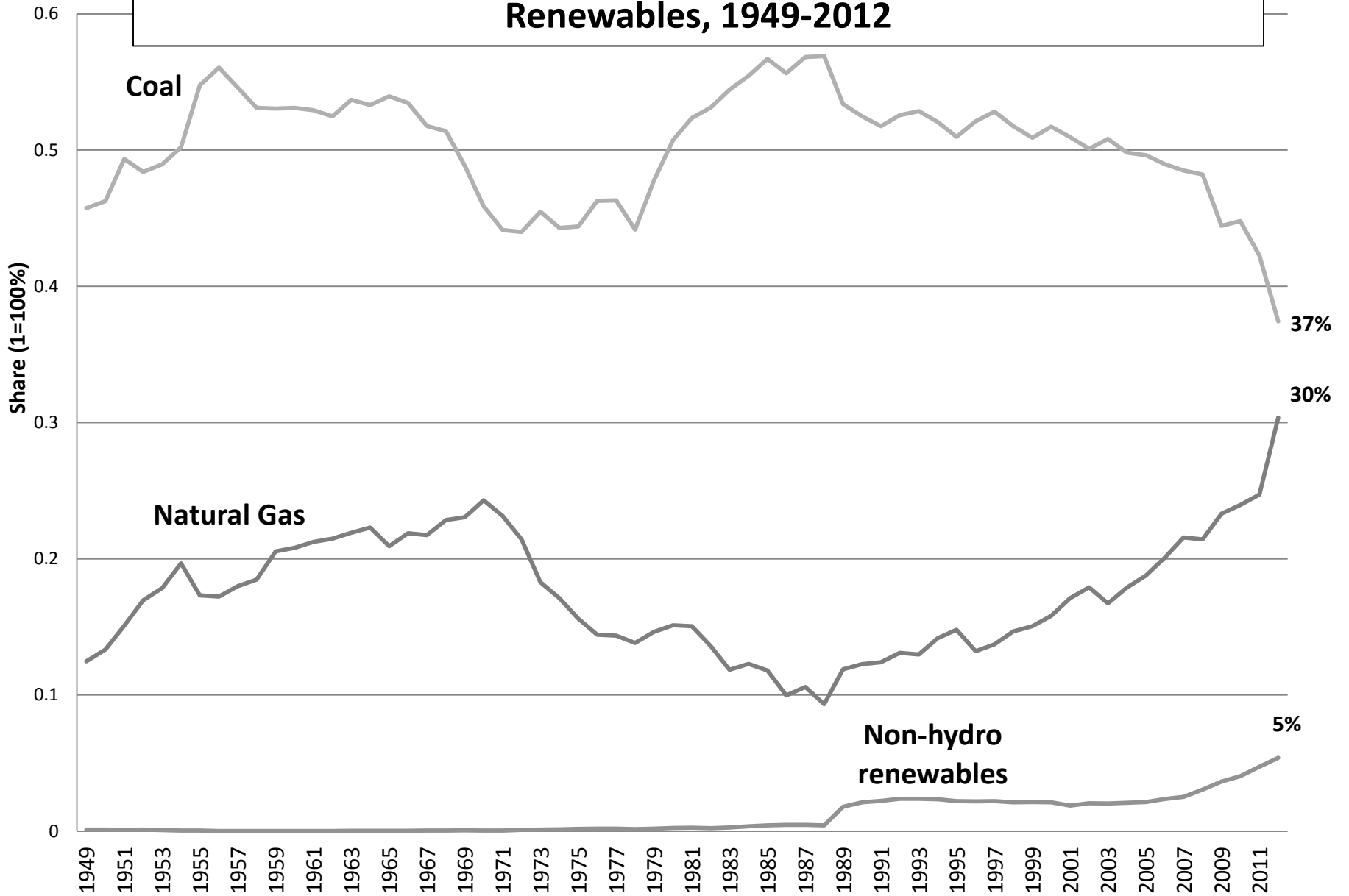
- Cost
- Policy

II. Integration Issues

- Grid
 - Compensation
 - Transmission
- Following options & ramping
- DG – distribution system

III. Tradeoffs

Shares of Electric Generation: Coal, Natural Gas, and Non-hydro Renewables, 1949-2012



I. Drivers of renewable growth

- Cost (tax credits?)

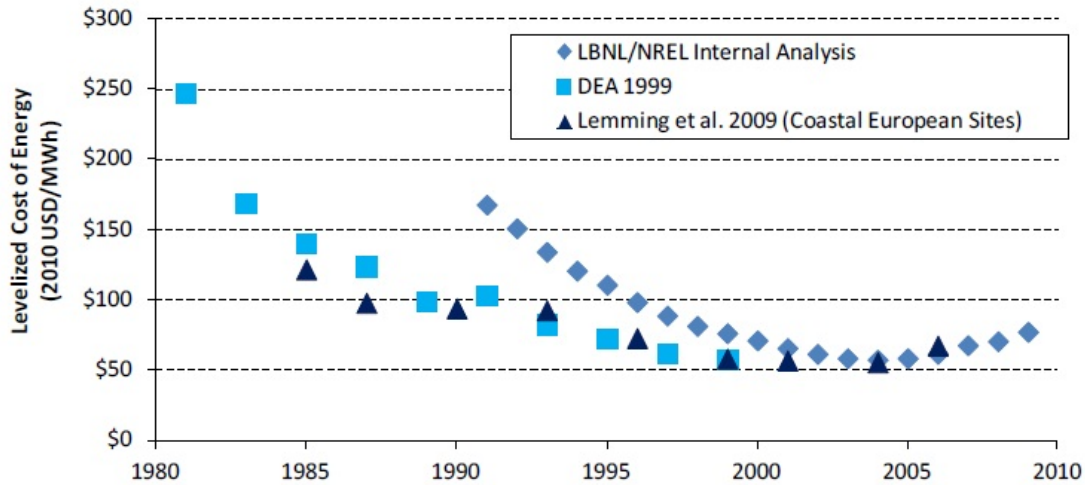
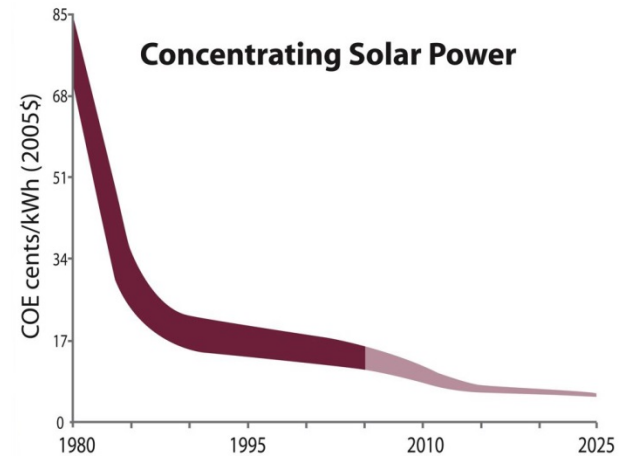
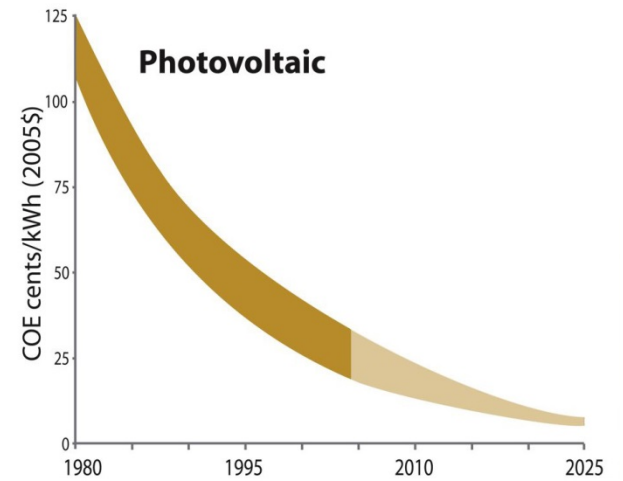


Figure ES-1. Estimated LCOE for wind energy between 1980 and 2009 for the United States and Europe (excluding incentives)

Sources: LBNL/NREL (internal analysis), Lemming et al. 2009, and DEA 1999



SOURCE: NREL

I. Drivers of renewable growth

- Policy

- Tax credits – PTC/ITC
- RPS change – CA, MN, NY
- EPA Clean Power Plan?



UCS

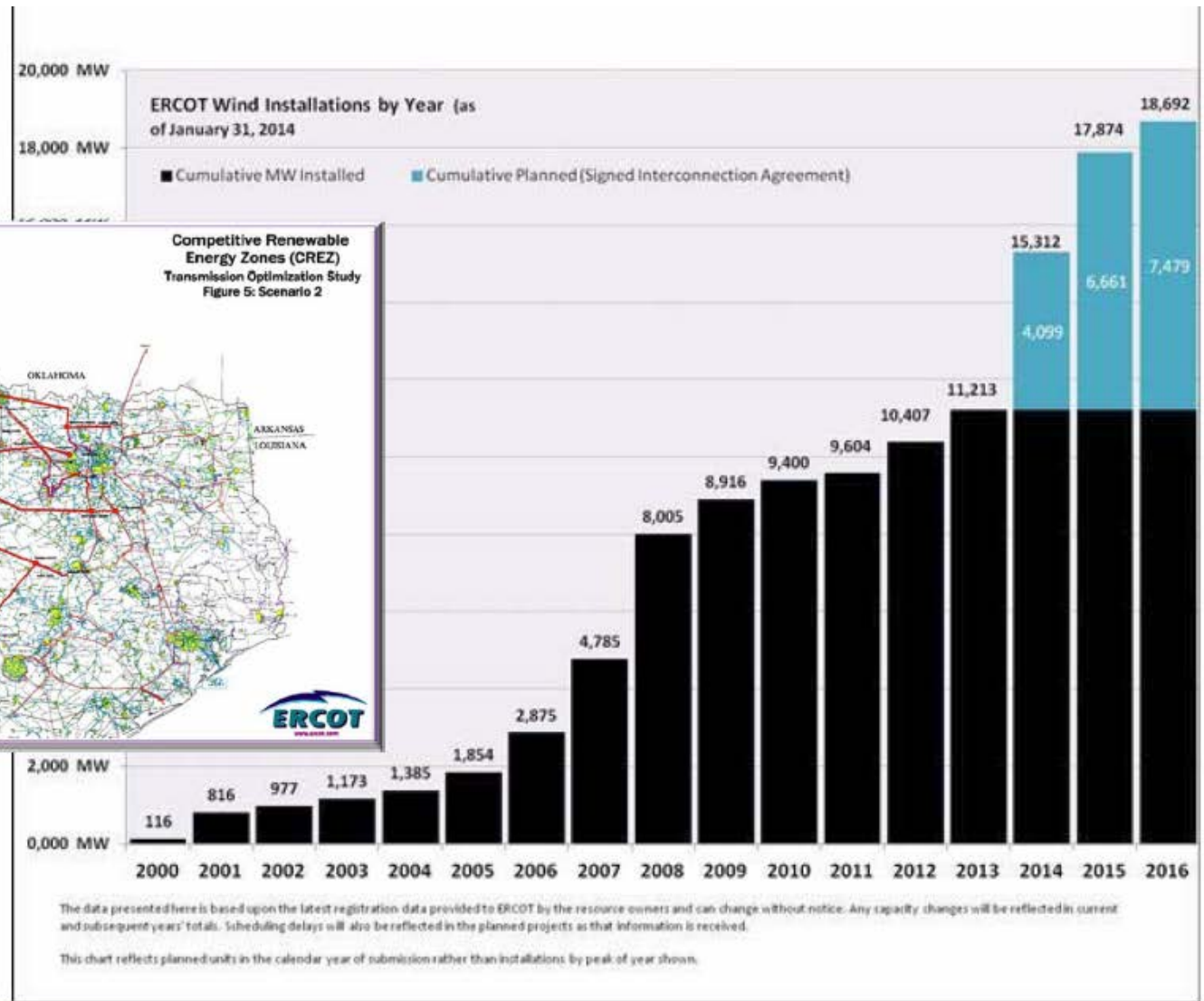
vs.

NERC

“EPA’s proposal falls short of the national renewable energy generation levels that the U.S. Energy Information Administration (EIA) projects would occur in 2020 under a business-as-usual approach; the proposal’s 2030 results are only marginally higher than the EIA’s projections ...”

NERC (2014): “The EPA’s ... projections [of non-hydro renewables growth] exceed the Energy Information Administration ...forecast [and] its own forecast ...”

ERCOT, individual days in March 2014: almost 10MW wind = 30% of load



Parts of MISO – wind averaged 25% of load for a week

I. Drivers of renewable growth

II. Integration Issues

- Grid
 - Compensation

FERC Order 764 on VERs:

- ISO/RTO Compliance plans
- DIRs -- Dispatchability?

I. Drivers of renewable growth

II. Integration Issues

- Grid
 - Compensation
 - Transmission
 - Wind integration studies assume significant investment in transmission
 - Cost allocation challenges → PJM vs. MISO experience

I. Drivers of renewable growth

II. Integration Issues

- Following options & ramping

Bentek Study

NREL, Eastern Wind Integration Study

NREL, Western Wind & Solar Integration Study

PJM Study

MISO Study

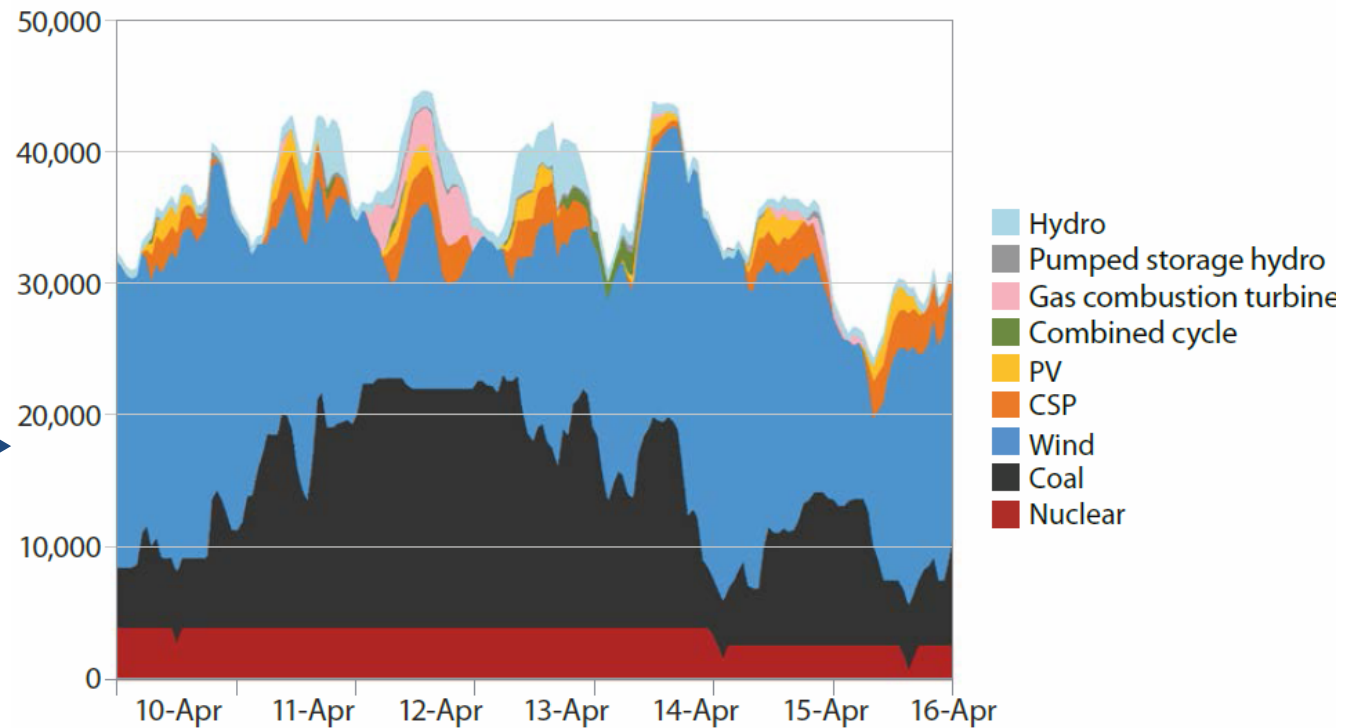


Figure ES-1. WWSIS-1 dispatch for the most challenging week of 3 years of data analyzed

Notes: PV, photovoltaic; CSP, concentrating solar power

- I. Drivers of renewable growth
- II. Integration Issues
- III. Tradeoffs – Cycling & Emissions

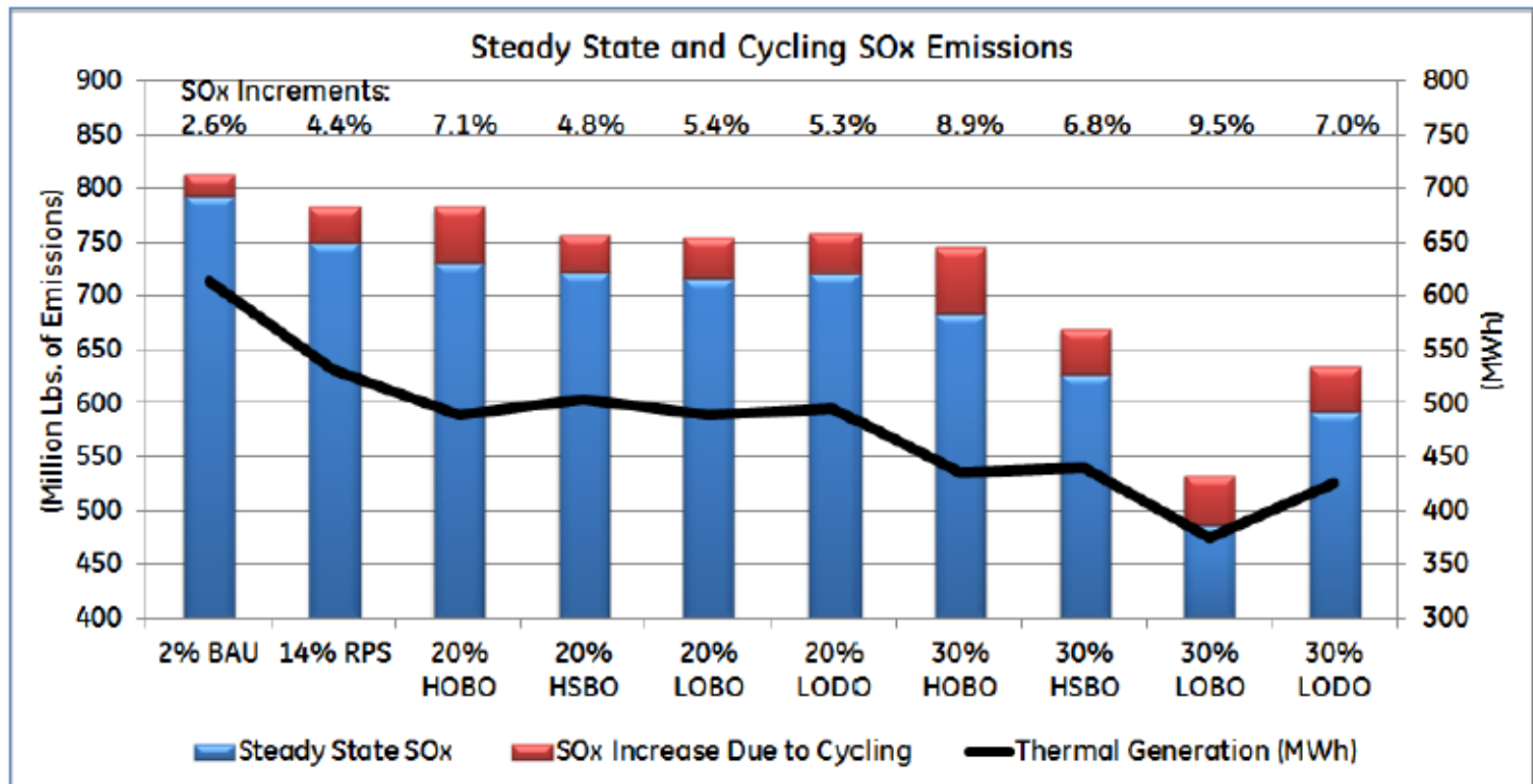


Figure 18: SOx Emissions for Study Scenarios, With and Without Cycling Effects Included

Source: PJM Study

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What role will CCGT play in the grid of the future?

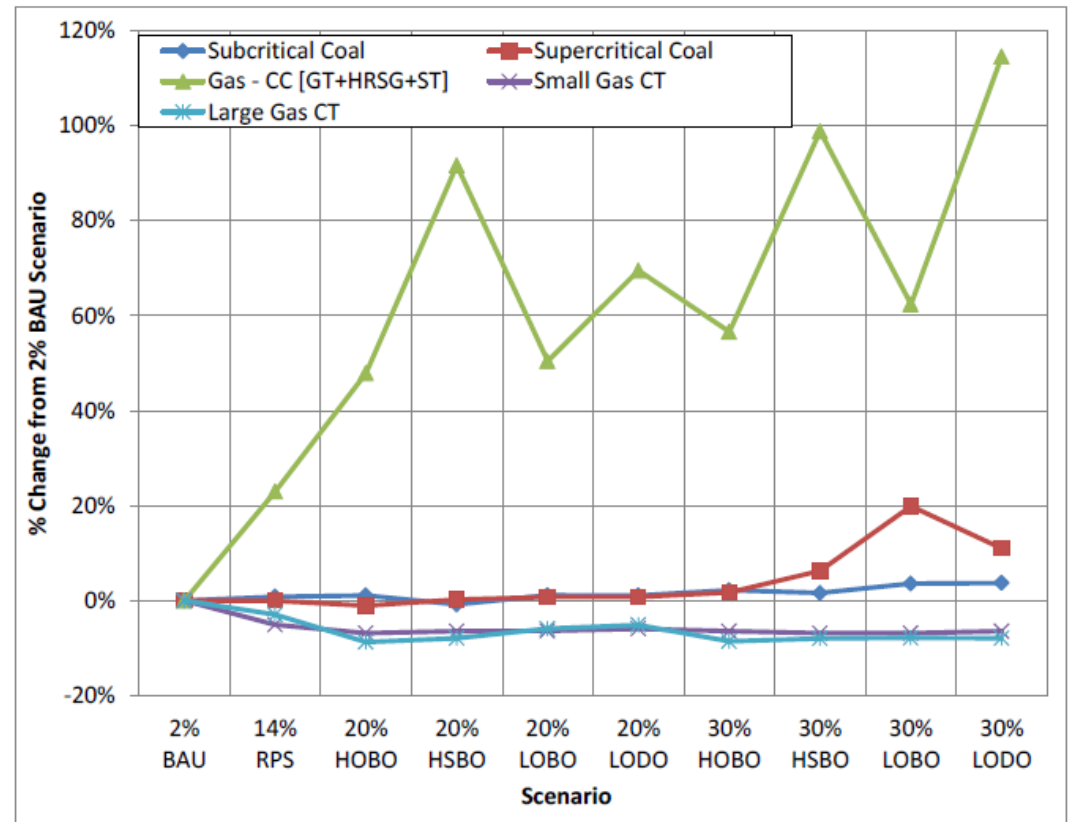


Figure 16: Net Effect on Cycling Damage Compared to 2% BAU Scenario

Source: PJM Renewables Integration Study, 2014

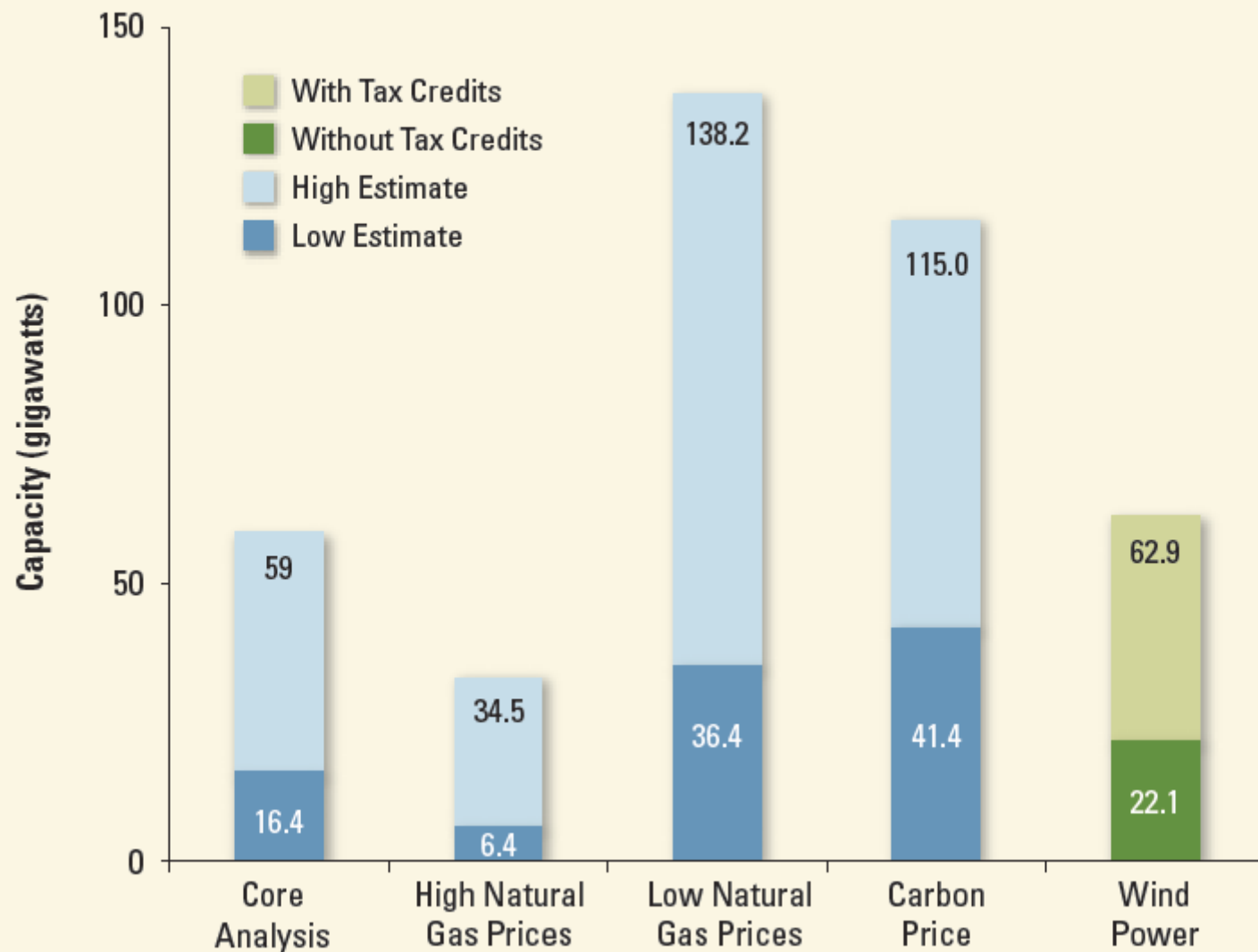
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1. Cheap natural gas + more wind and solar → lower marginal costs of production
2. This increases importance of network delivery constraints (gas and electricity), which increase scarcity, and LMPs
3. THEREFORE, network improvements are prerequisite to cleaner electricity mix
4. Is storage a magic bullet? Only if it is relatively inexpensive.

Figure ES-3. Coal Generating Capacity Deemed Ripe for Retirement under Alternative Scenarios



Source: Union of Concerned Scientists, 2012