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LCOEs and Renewables

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EIA LCOE/LACE Workshop

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EPRI Generation Options Report Provides Excellent Example of LCOE Use

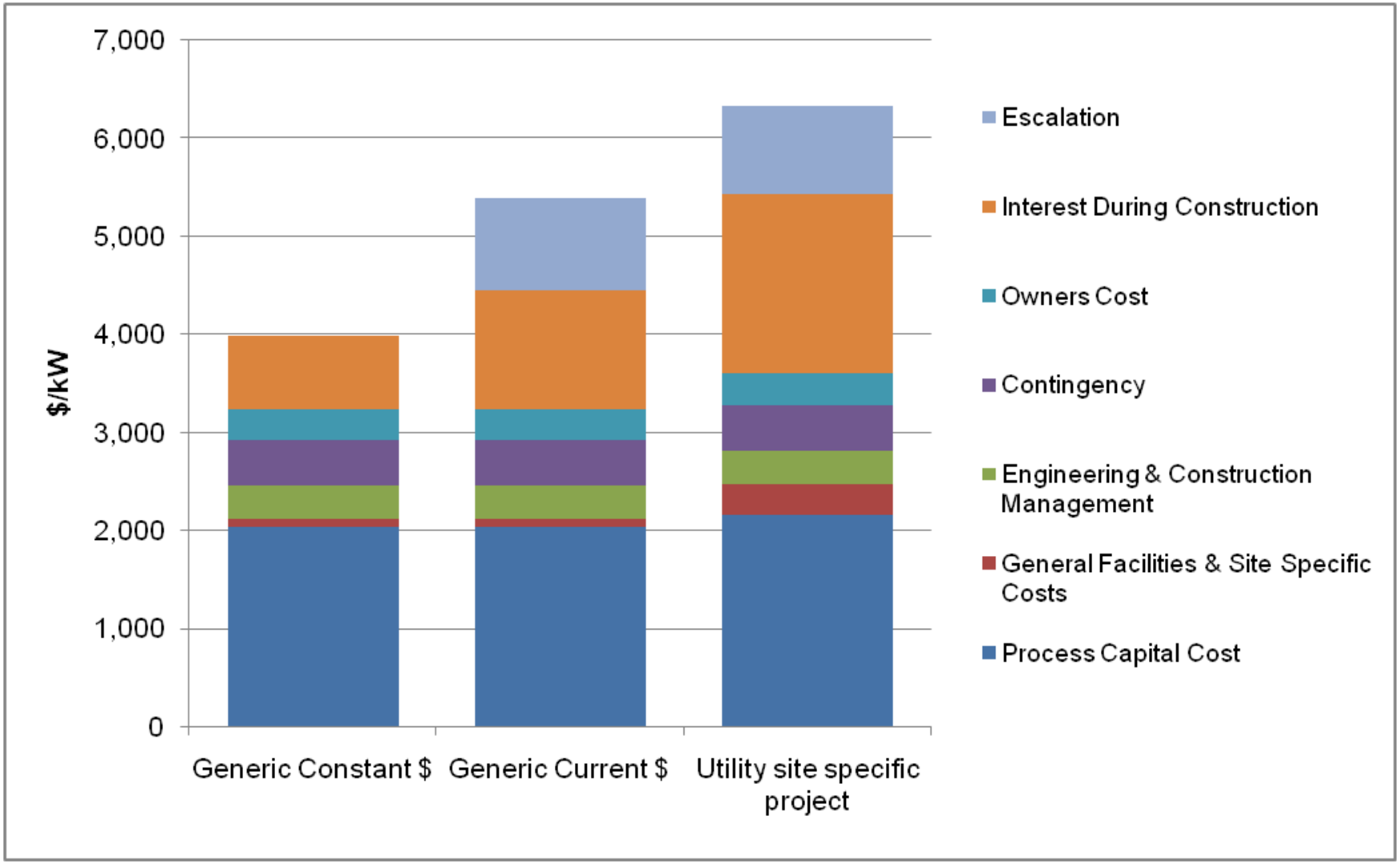
By Robin Bedillion of EPRI's Strategic Energy Analysis Group

Reference: EPRI Report 1026656
(free from EPRI.com, search for "1026656")

Levelized Cost of Electricity Analysis – Objectives

- Utilize EPRI capital cost data and methodologies to calculate levelized costs of electricity (LCOEs) in constant 2011 $
  - Incorporate key assumptions needed for calculations – capital cost, fuel cost, fixed and variable O&M, fuel type and energy content, capacity factor, cost of money
- Provide a generic basis for comparison of technologies for baseload and renewable generation
- Evaluate sensitivities of LCOE to potential CO_2 costs and other parameters

Magnitude of Cost Estimates* can be Very Different Site Specific vs. Generic Constant $, Current $



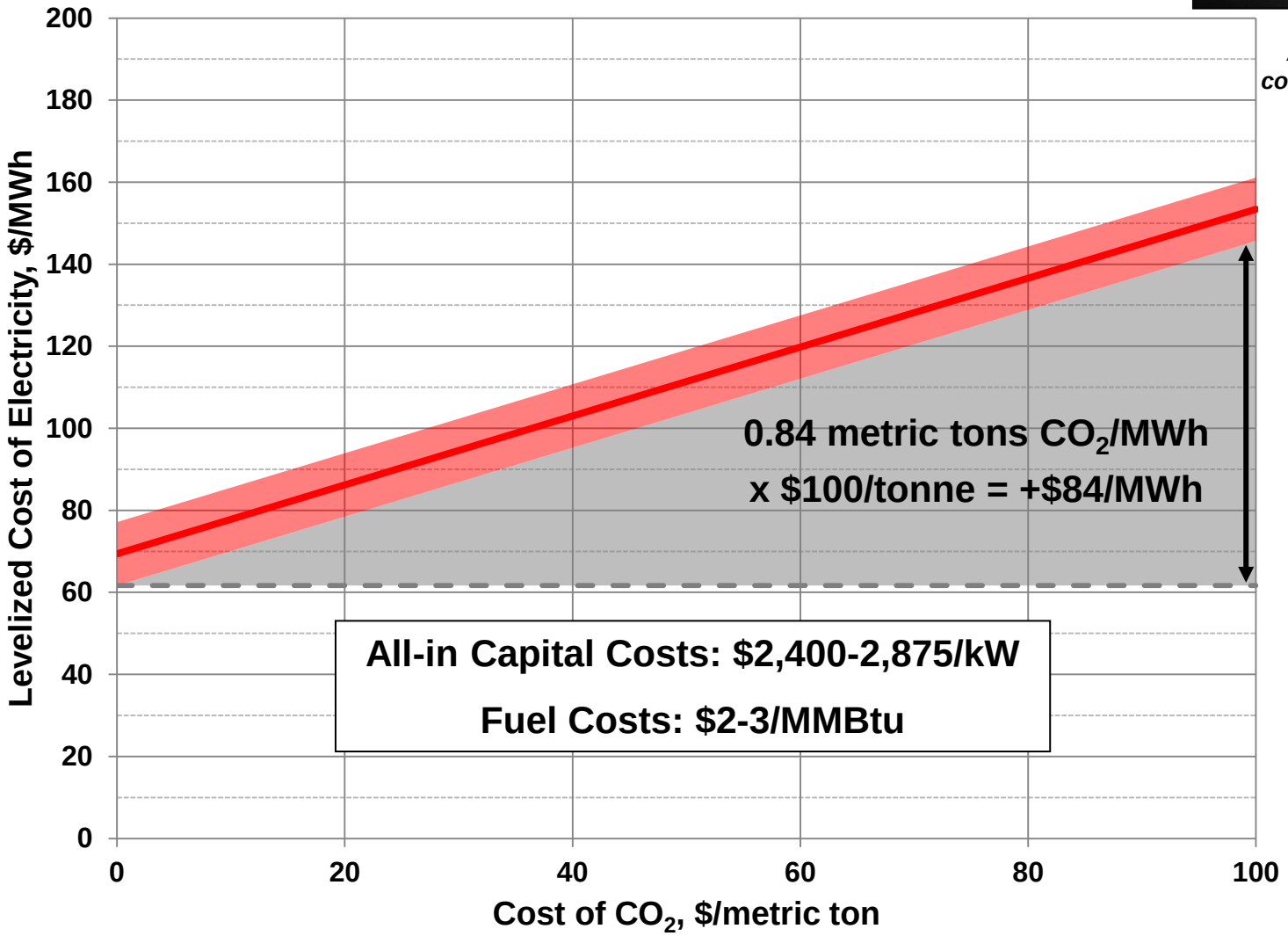
*** Data shown for illustrative purposes only**

Levelized Cost of Electricity Analysis – Assumptions

- All baseload technologies are assumed to have an 80% capacity factor, except for nuclear which has a 90% capacity factor.
- Non-dispatchable renewables assume a range of capacity factors based on a range of resource availability assumptions.
- No production or investment tax credits assumed for any technologies.
- No integration costs (e.g. costs associated with additional reserves, balancing, conventional generation cycling, etc.) included for non-dispatchable technologies.

Pulverized Coal (PC) – 2015

All costs are in constant Dec 2011$



LCOE is shown for high level comparison purposes. Actual plant investment decisions are affected by a number of other project specific considerations and caution should be used when comparing technologies based on LCOE. See Appendix A of report 1026656 for more details.

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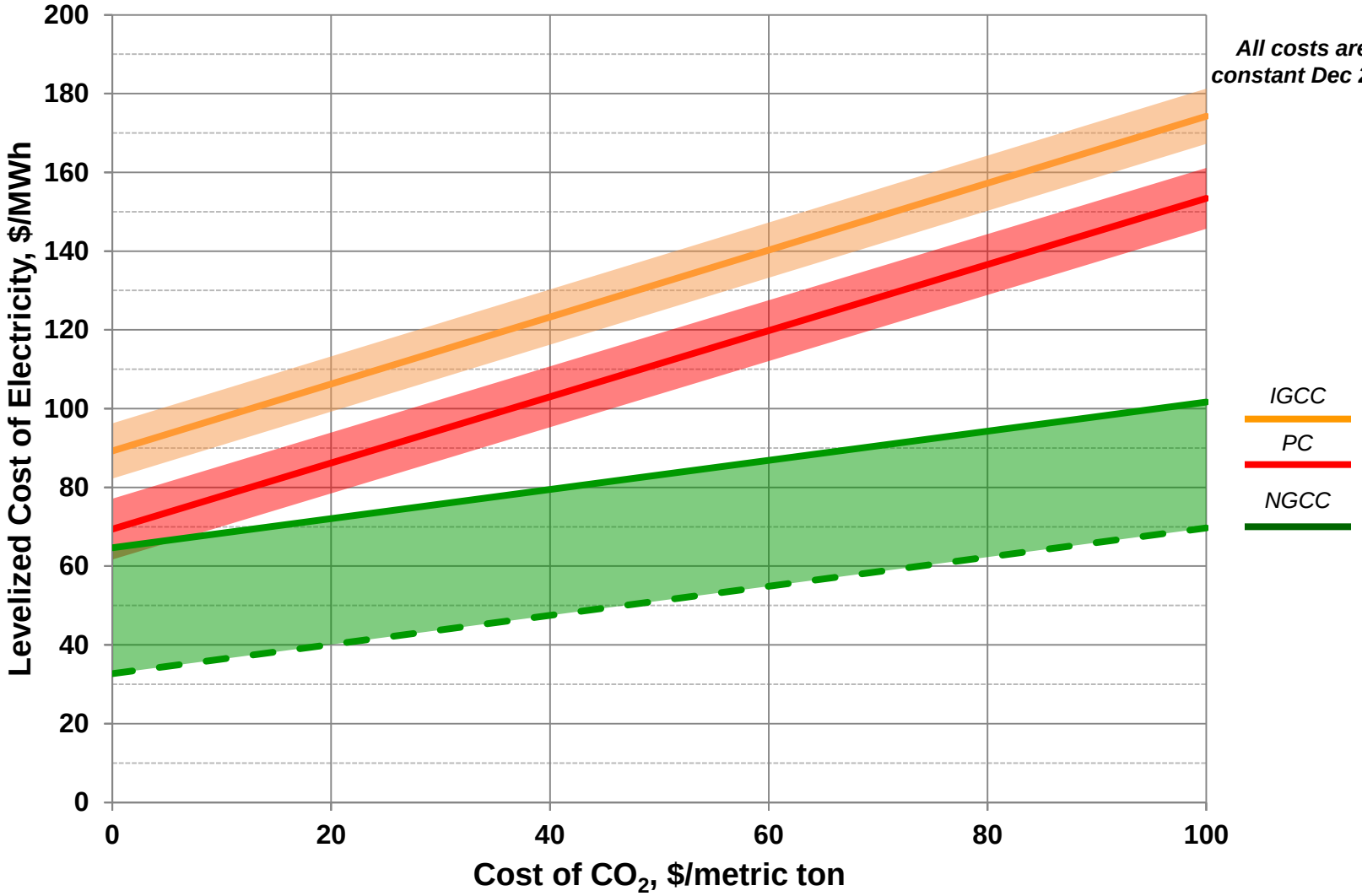
PC, IGCC, NGCC Comparison – 2015



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Biomass – 2015

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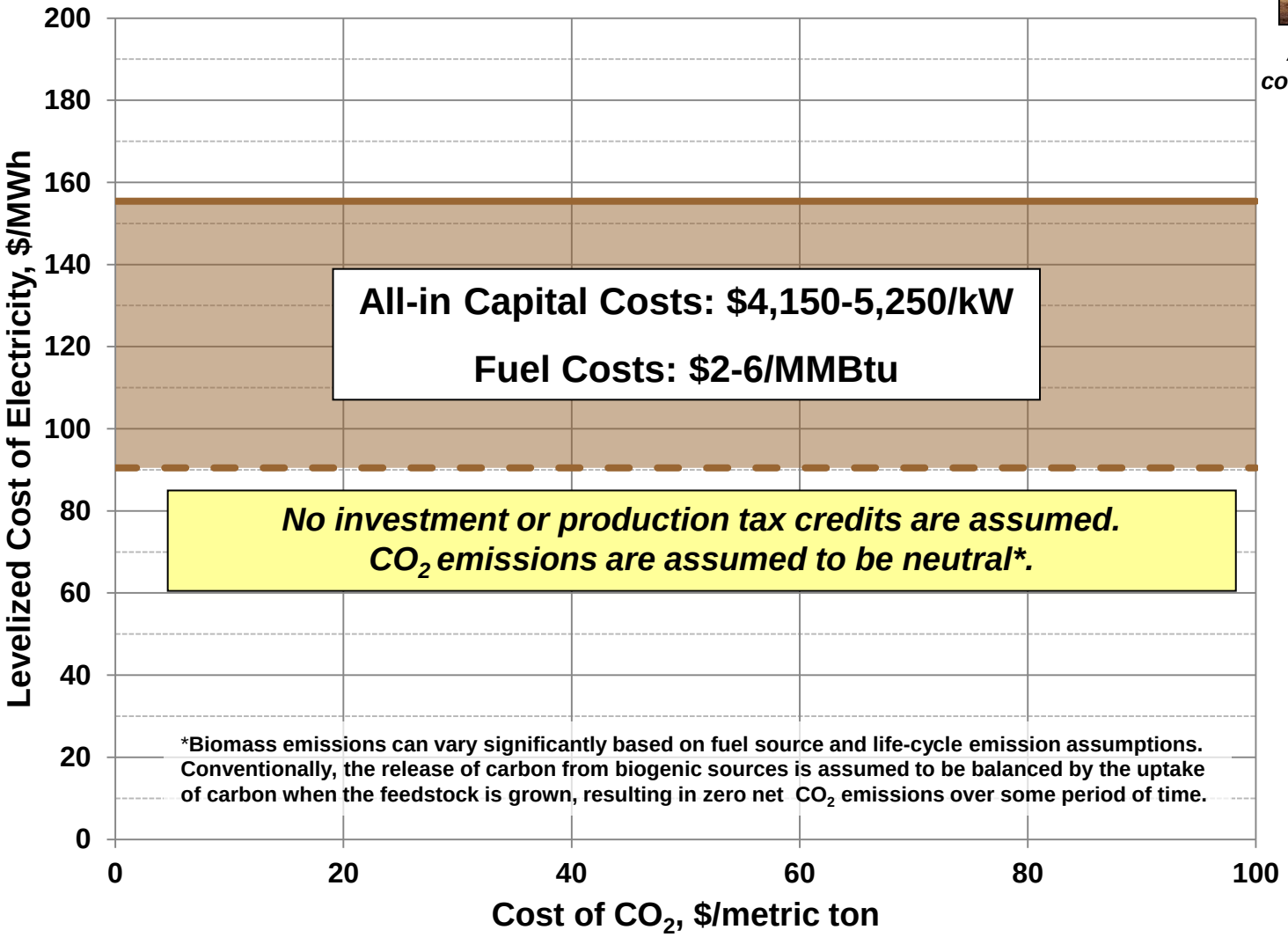

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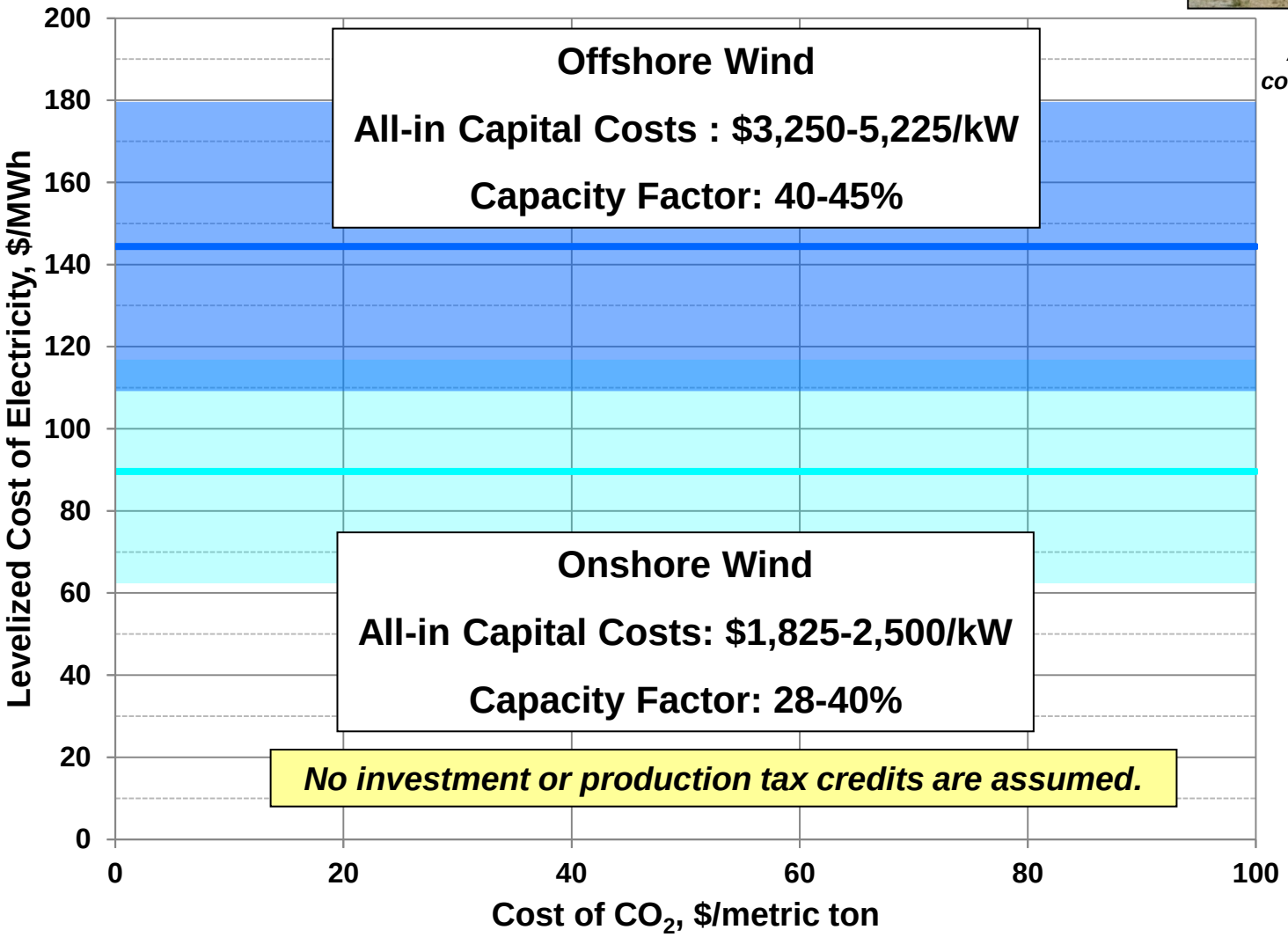
Wind – 2015



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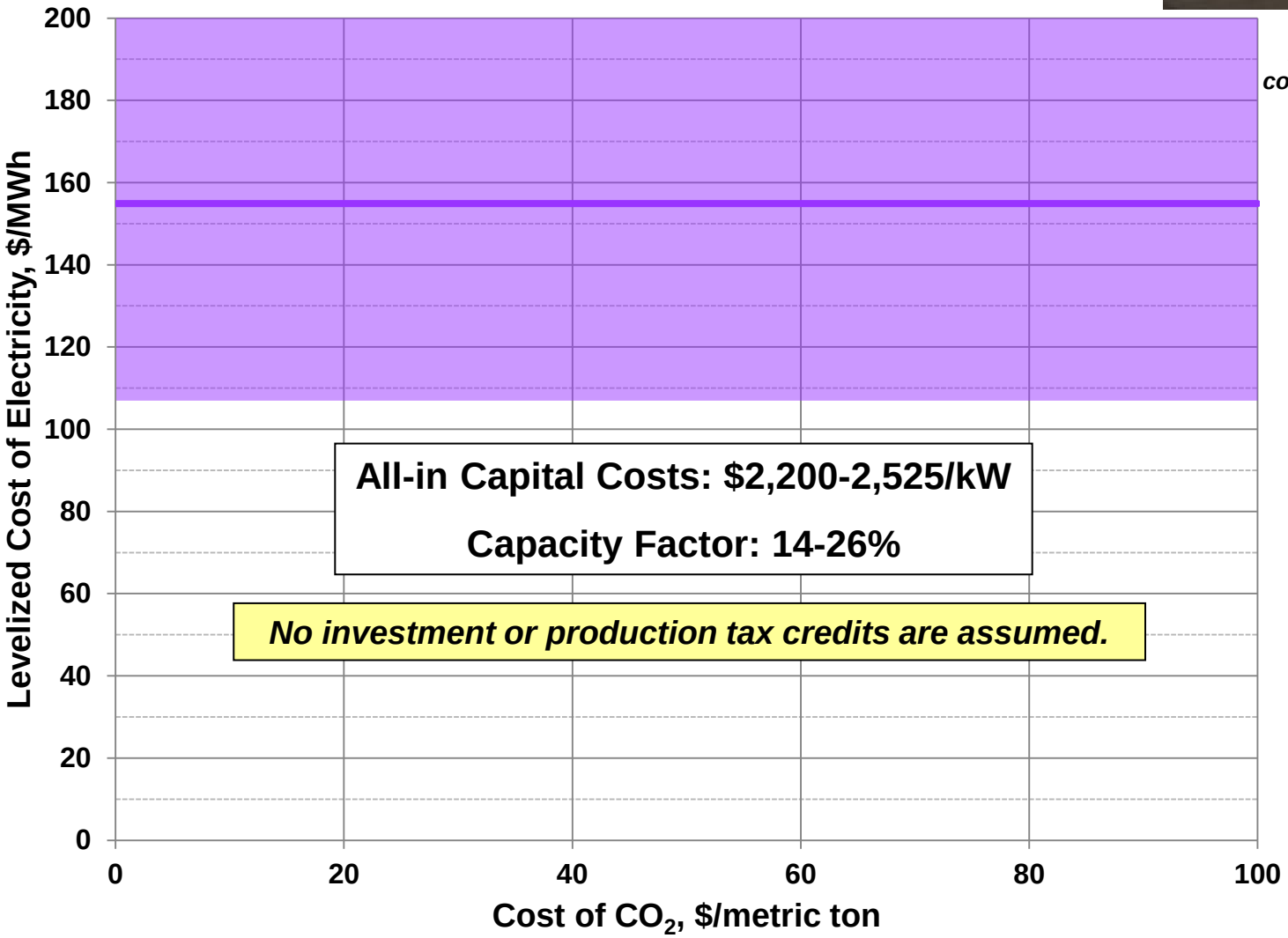
Solar Photovoltaic (PV) – 2015



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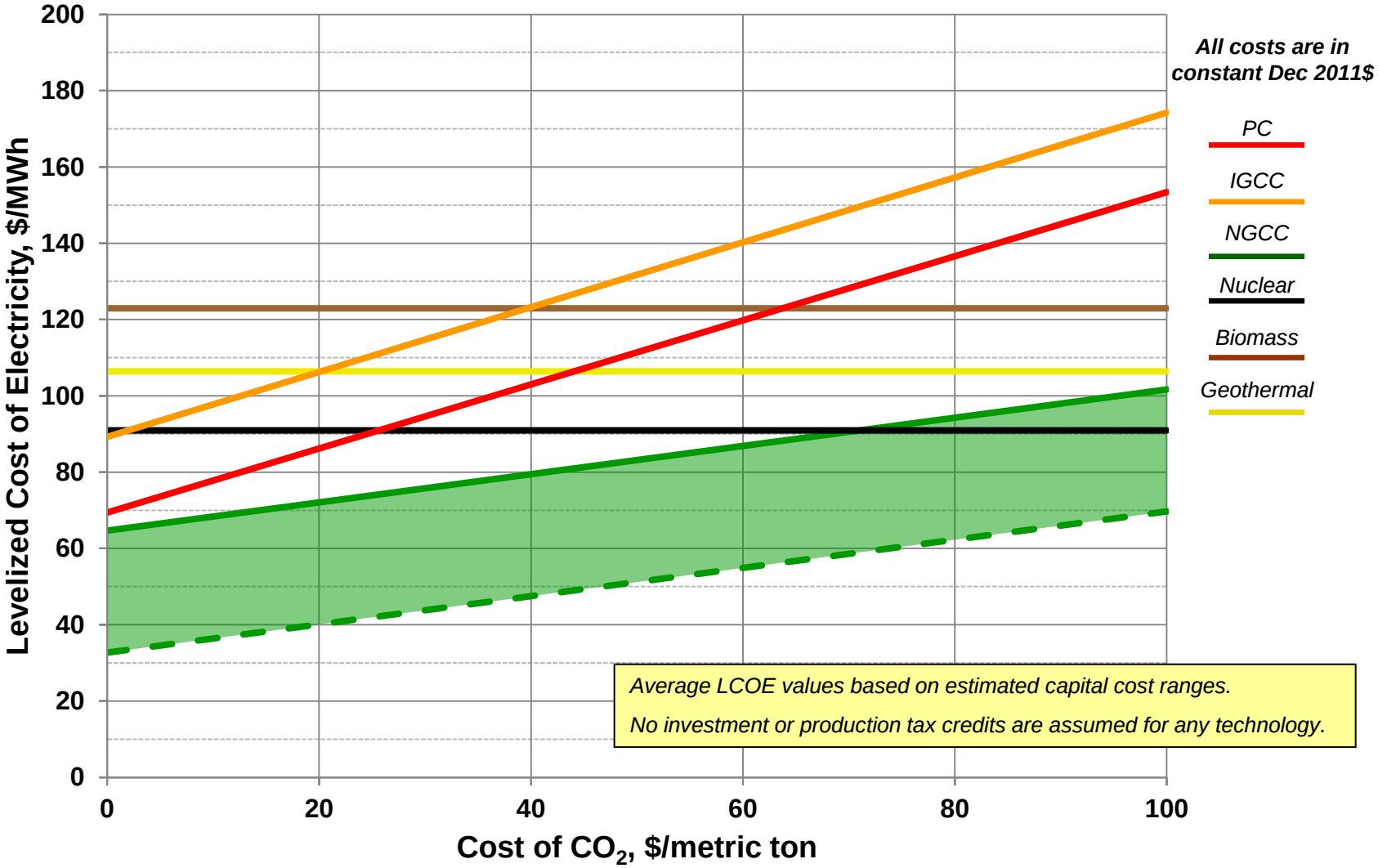
Comparative Levelized Costs of Electricity of Dispatchable Technologies – 2015



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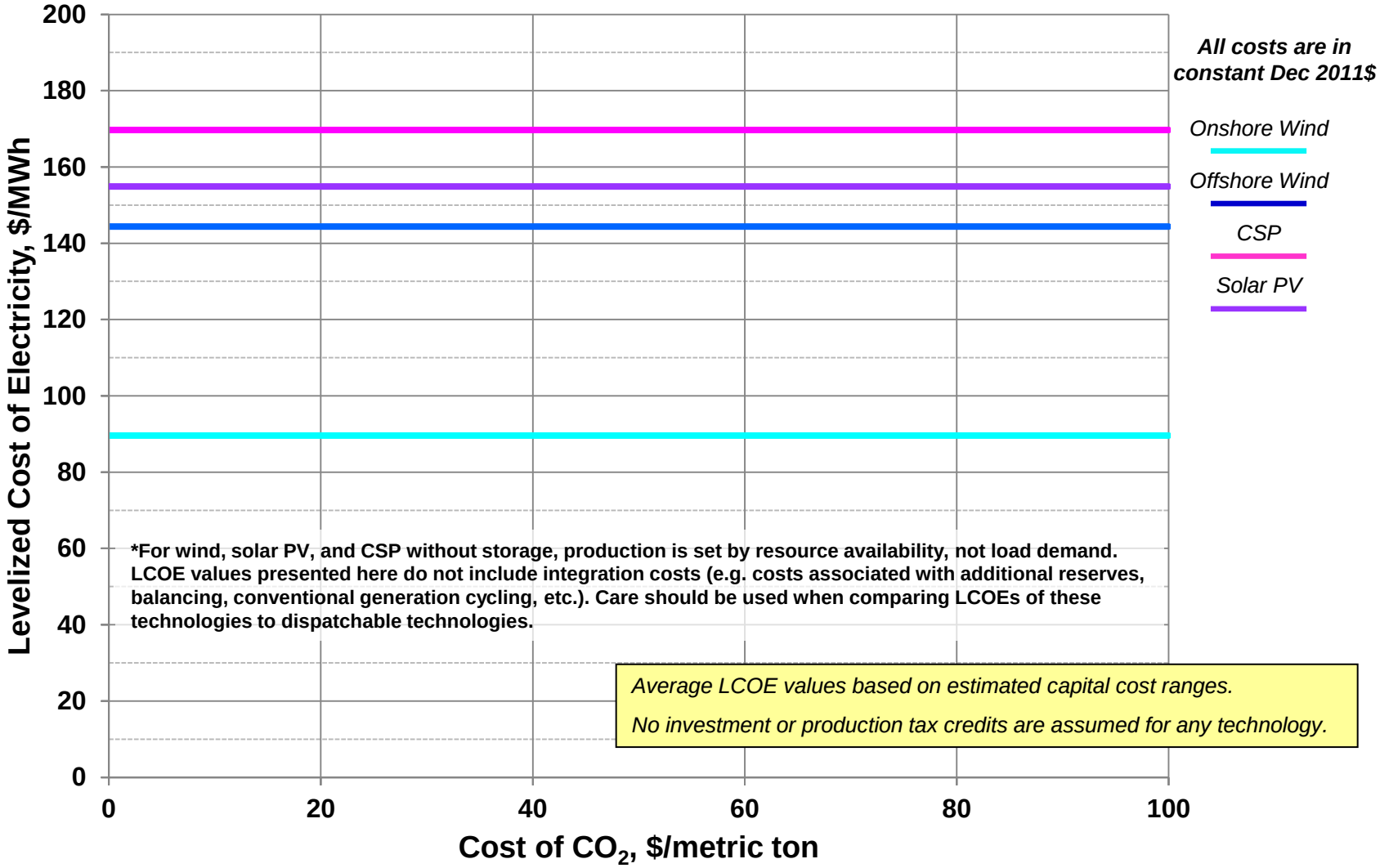
Comparative Levelized Costs of Electricity of Non-Dispatchable Technologies* – 2015



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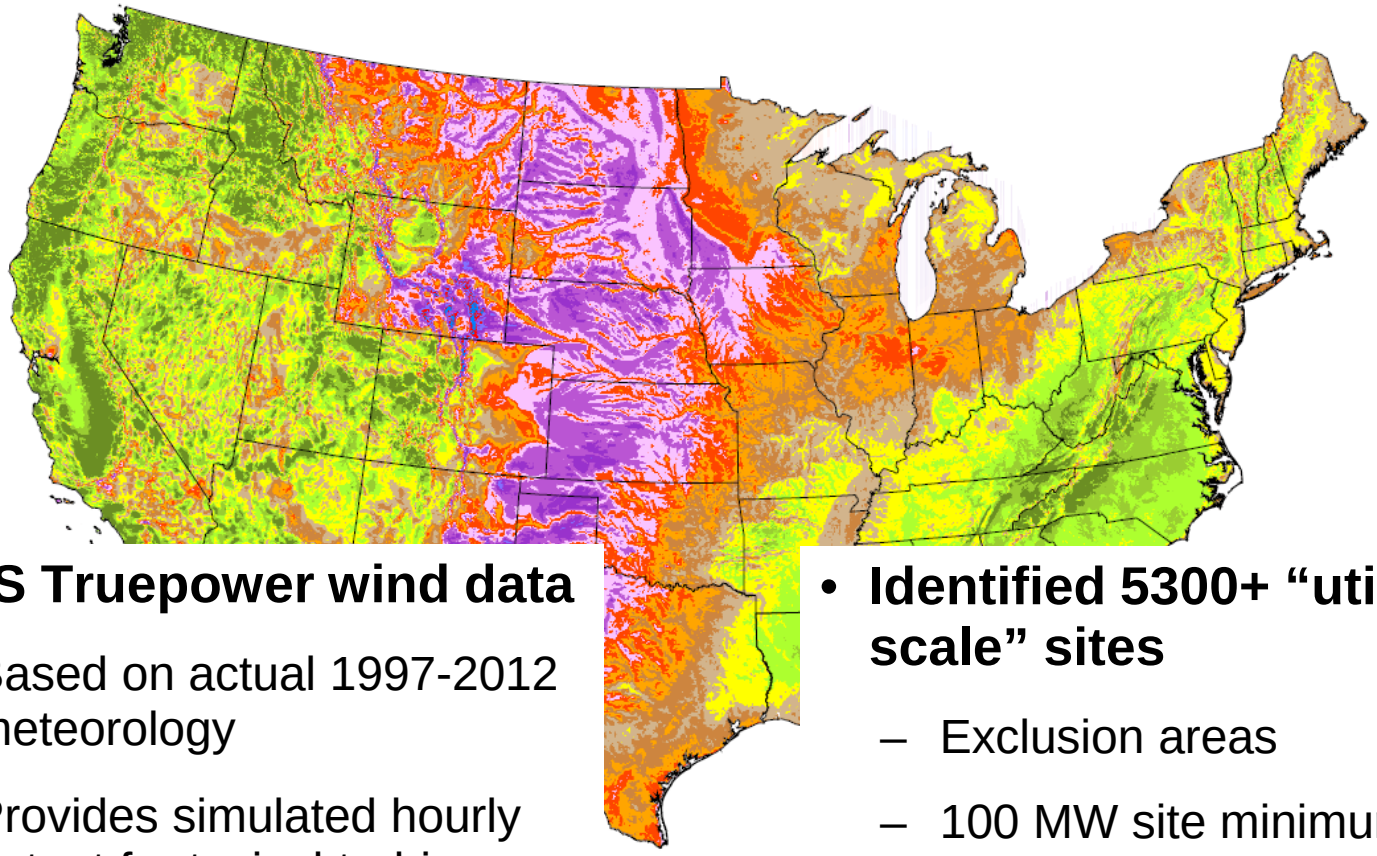
Observations on Value of Wind and Solar

Victor Niemeyer

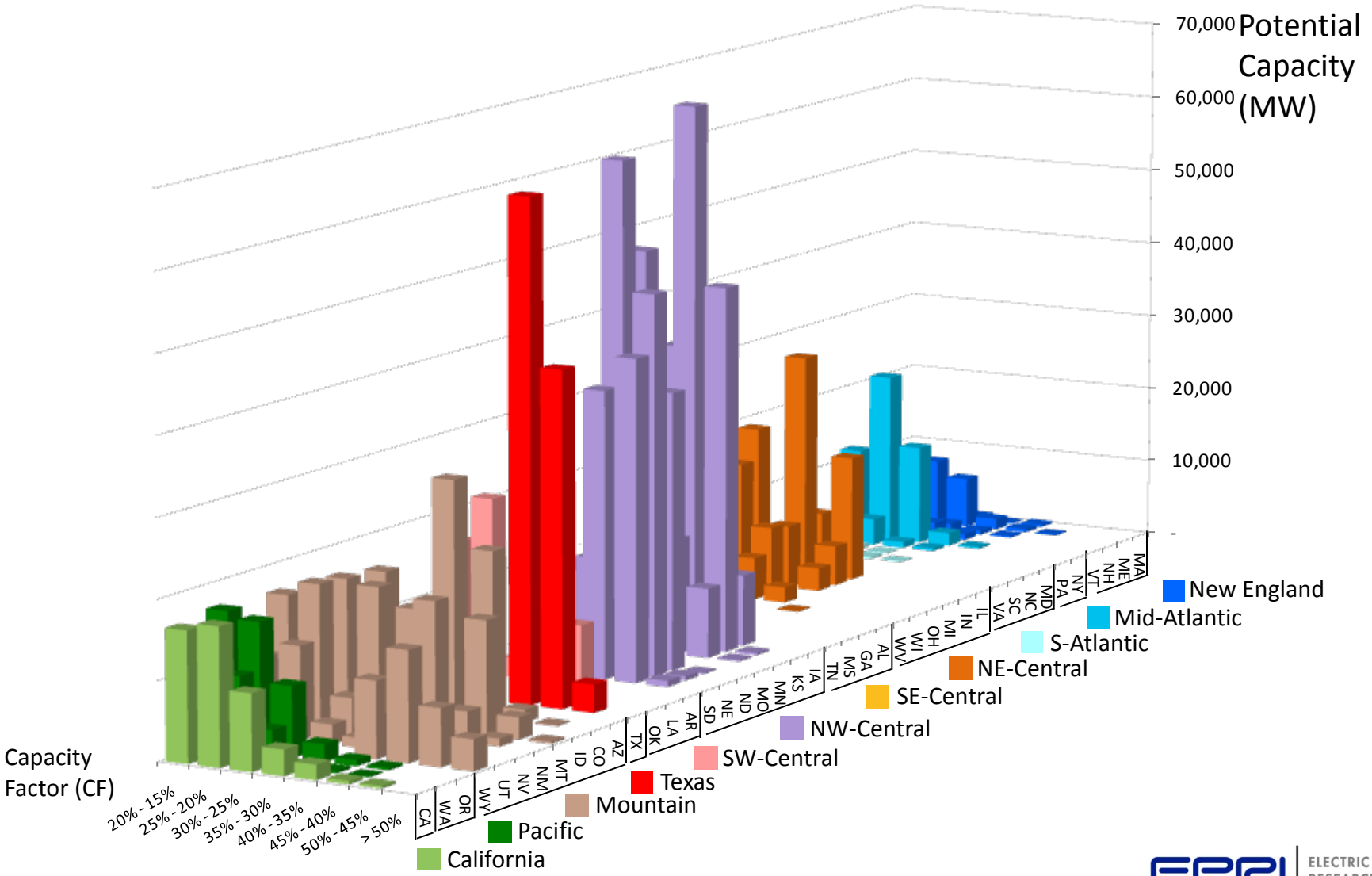
AWS Truepower Data Set: Capturing the Location and Variability of Wind



- **AWS Truepower wind data**
  - Based on actual 1997-2012 meteorology
  - Provides simulated hourly output for typical turbines (80/100m height, 1.5-2.0 MW)

- **Identified 5300+ "utility-scale" sites**
  - Exclusion areas
  - 100 MW site minimum
  - Distance to grid
  - Terrain/wake effects

Location of wind resource by state and CF



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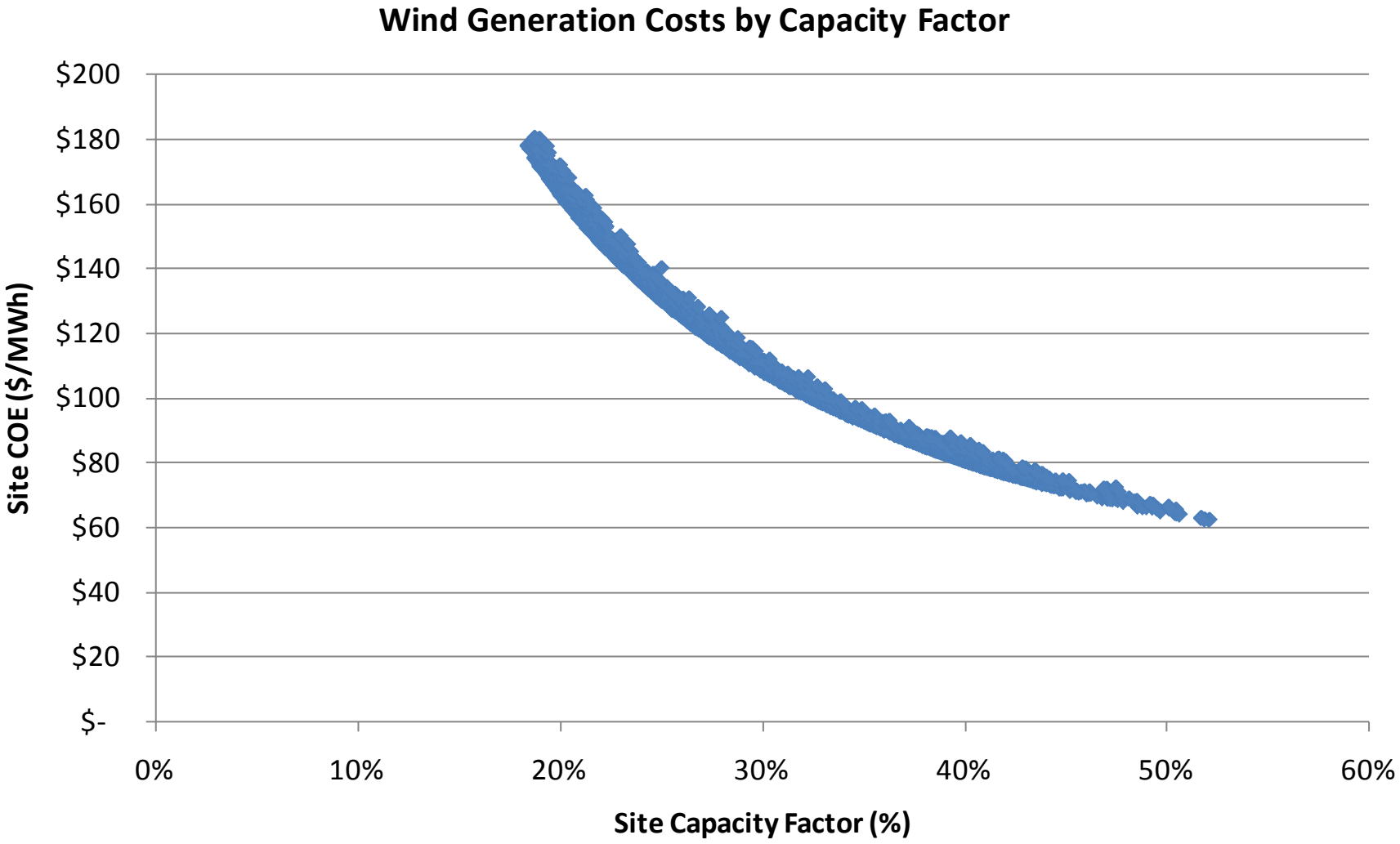
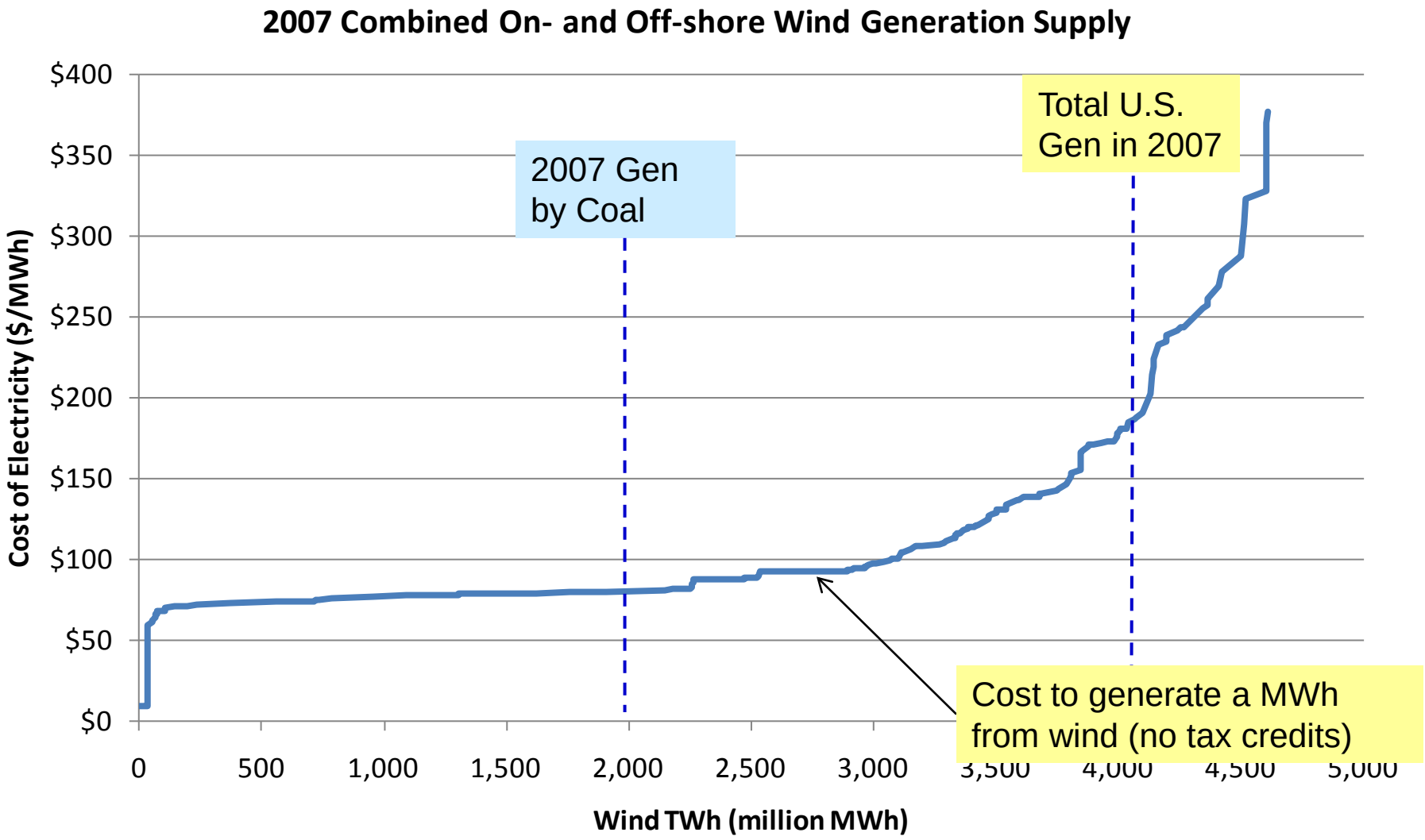
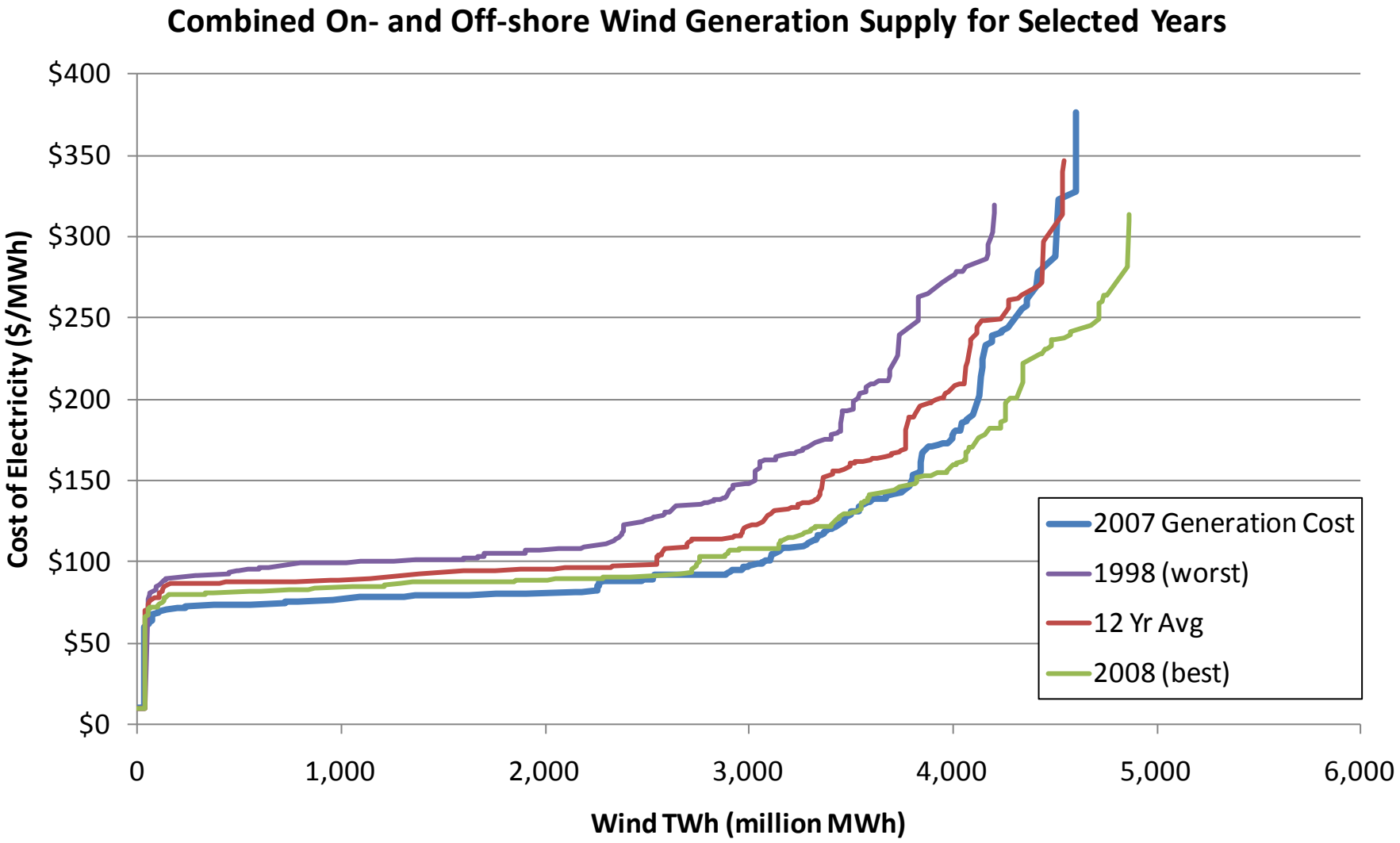
Site Capacity Factors Drive Average Costs of Generation; Distance to Grid is Secondary



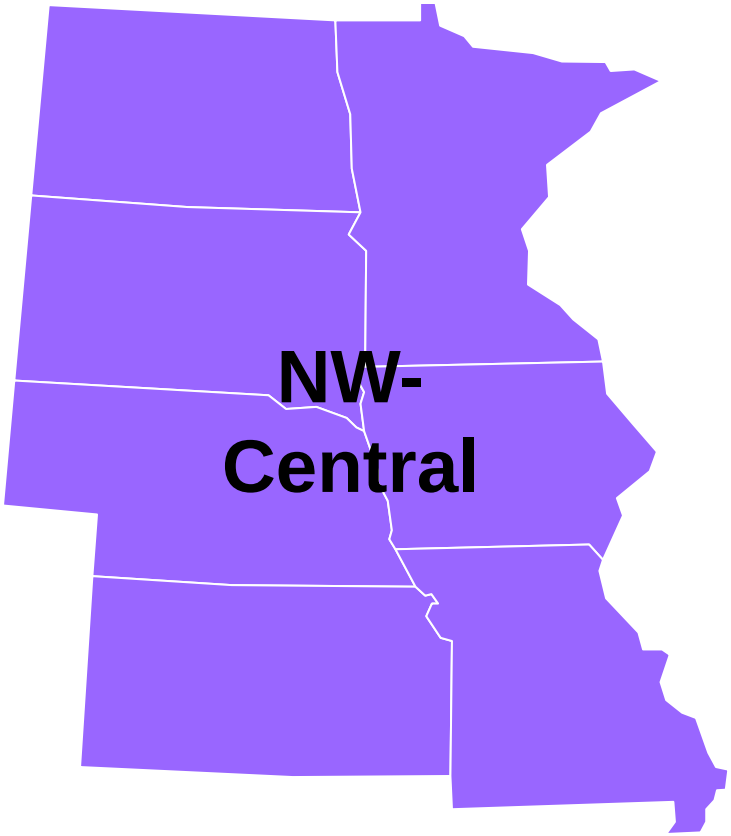
EPRI Wind Resource Assessment from Truepower Shows Vast Generation Potential



Considerable Year-to-year Variation in National Wind Energy Supply

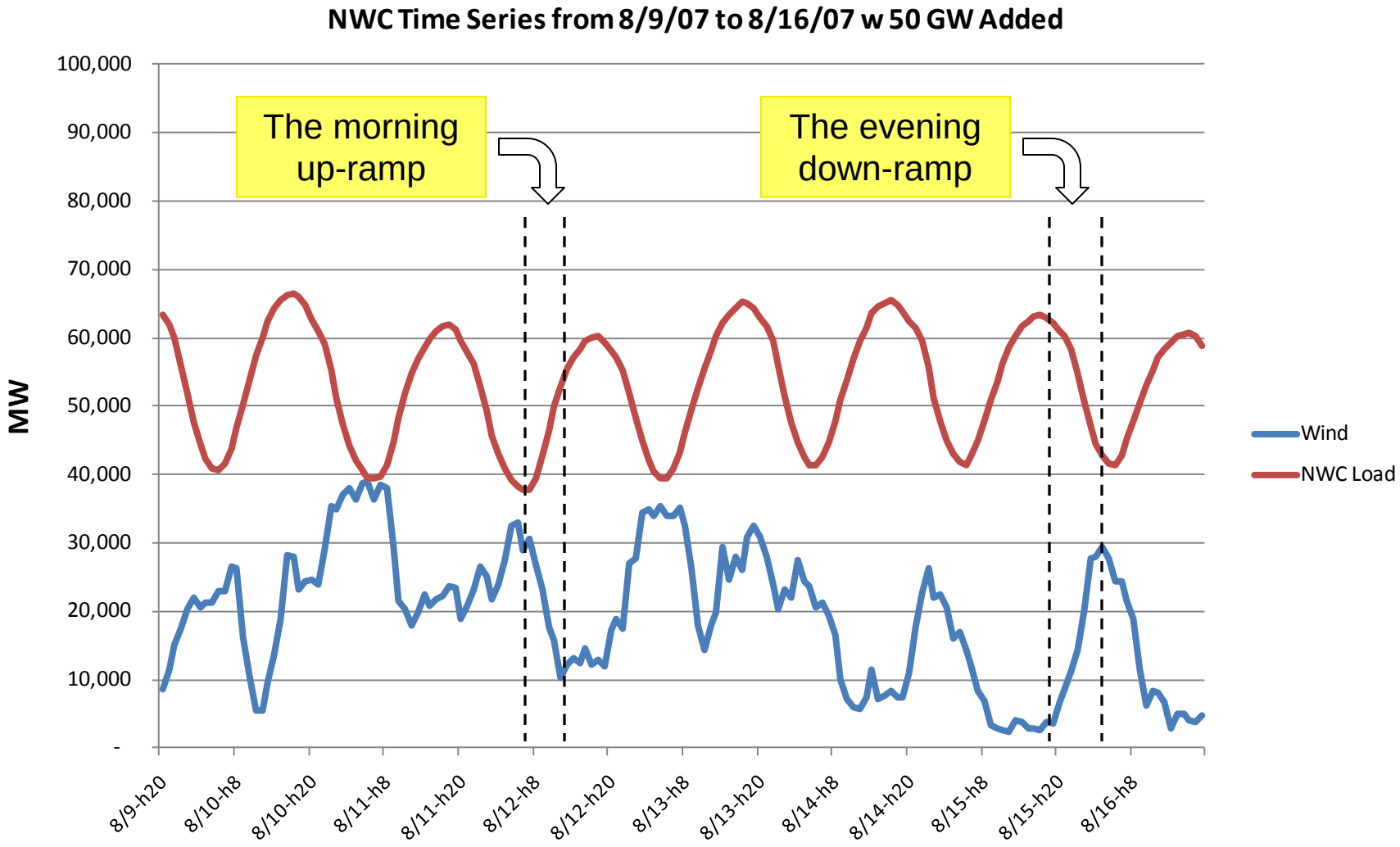


Example Analysis for NW-Central Region

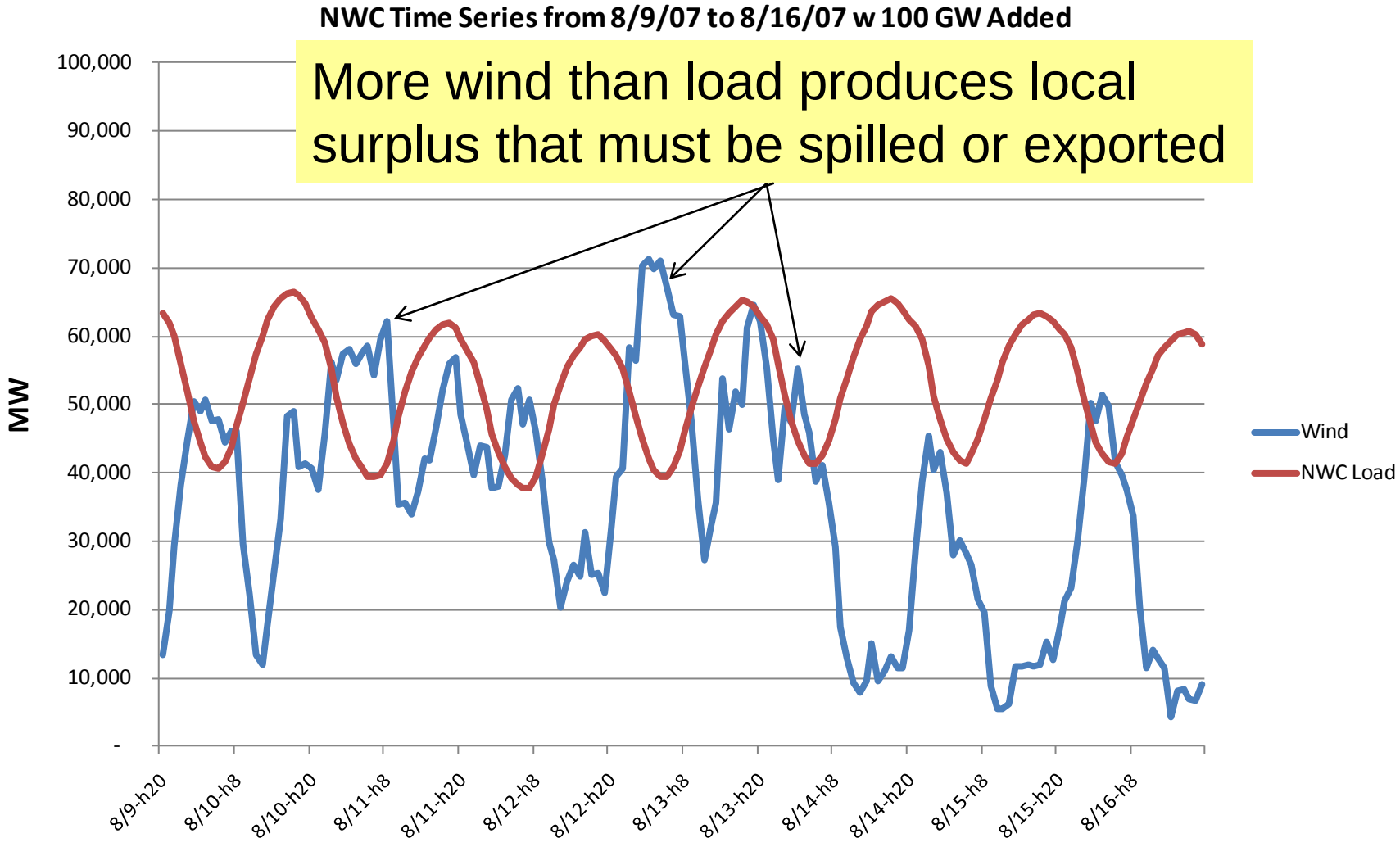


- State hourly load data for 2007 from Energy Velocity
- Hourly loads and wind output synchronized so driven by same 2007 meteorology
- Add 50 GW new installed wind capacity within region
- Rank sites by capacity factor, build best sites first

Anti-correlation of Wind with Load Creates Ramping Issues (50 GW example)



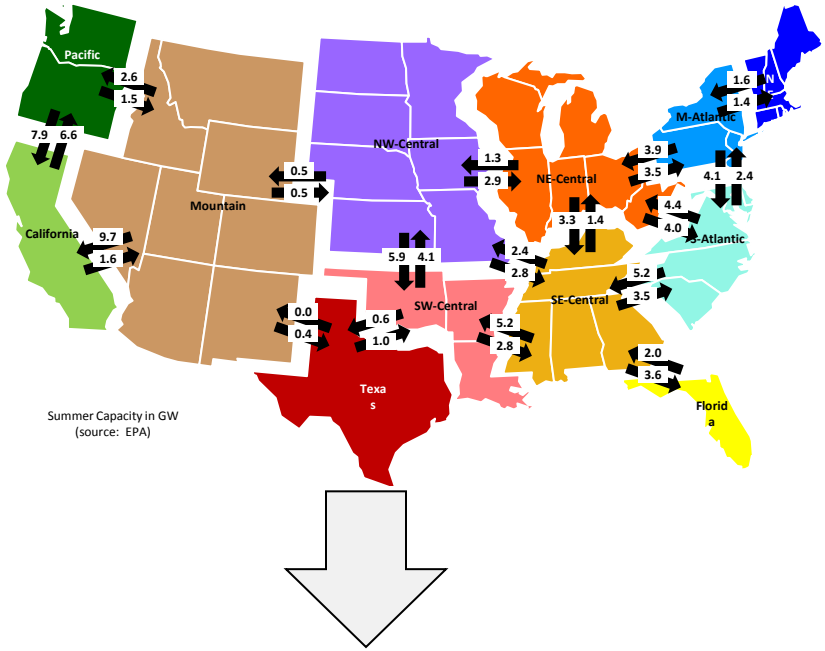
Anti-correlation of Wind with Load Also Forces Diminishing Returns to Wind Additions: 100 GW



Modeling Provides Preliminary Realistic Assessment of Wind's Strategic Potential

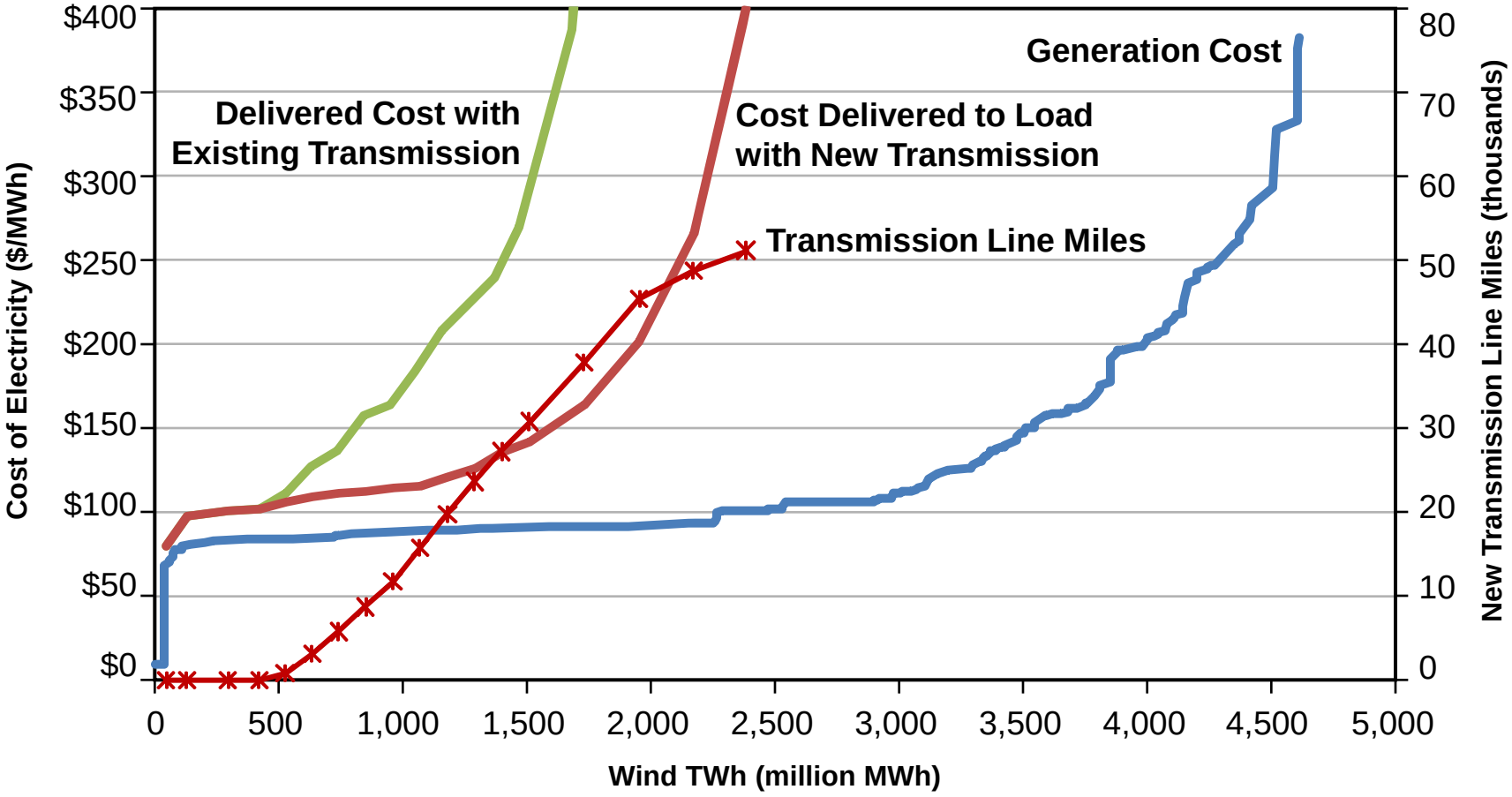
- Simultaneous regional 8760 hourly loads and potential wind for 2007
- Existing mix of generation and transmission capability
- New wind turbine costs
- New transmission costs

REGEN Optimization



Mix of wind and transmission investment and operating decisions to minimize cost of delivering wind to serve load

National Wind Energy Potential Supply Curves* (including delivery costs)

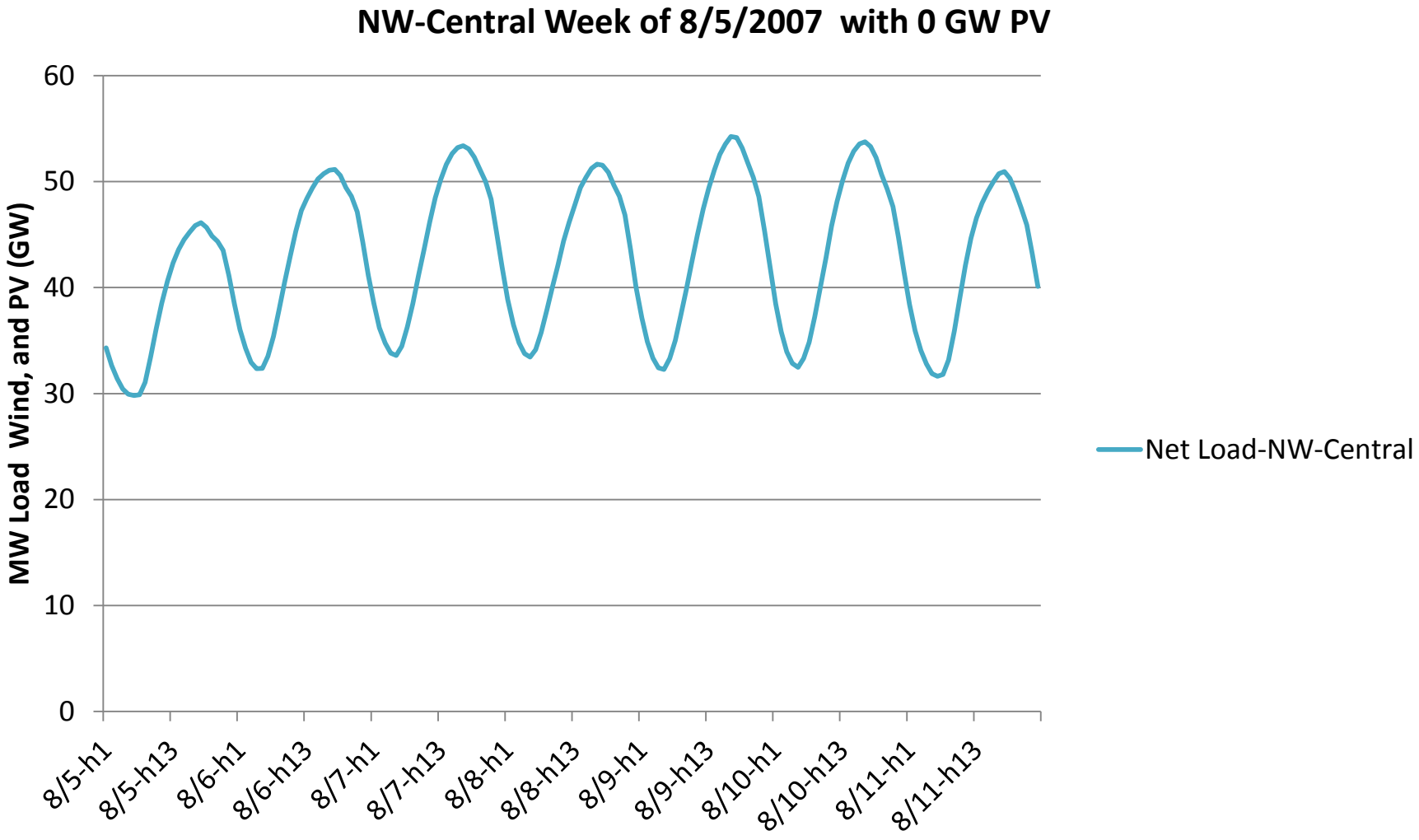


*EPRI – AWS TruePower National Wind Energy Supply Curves

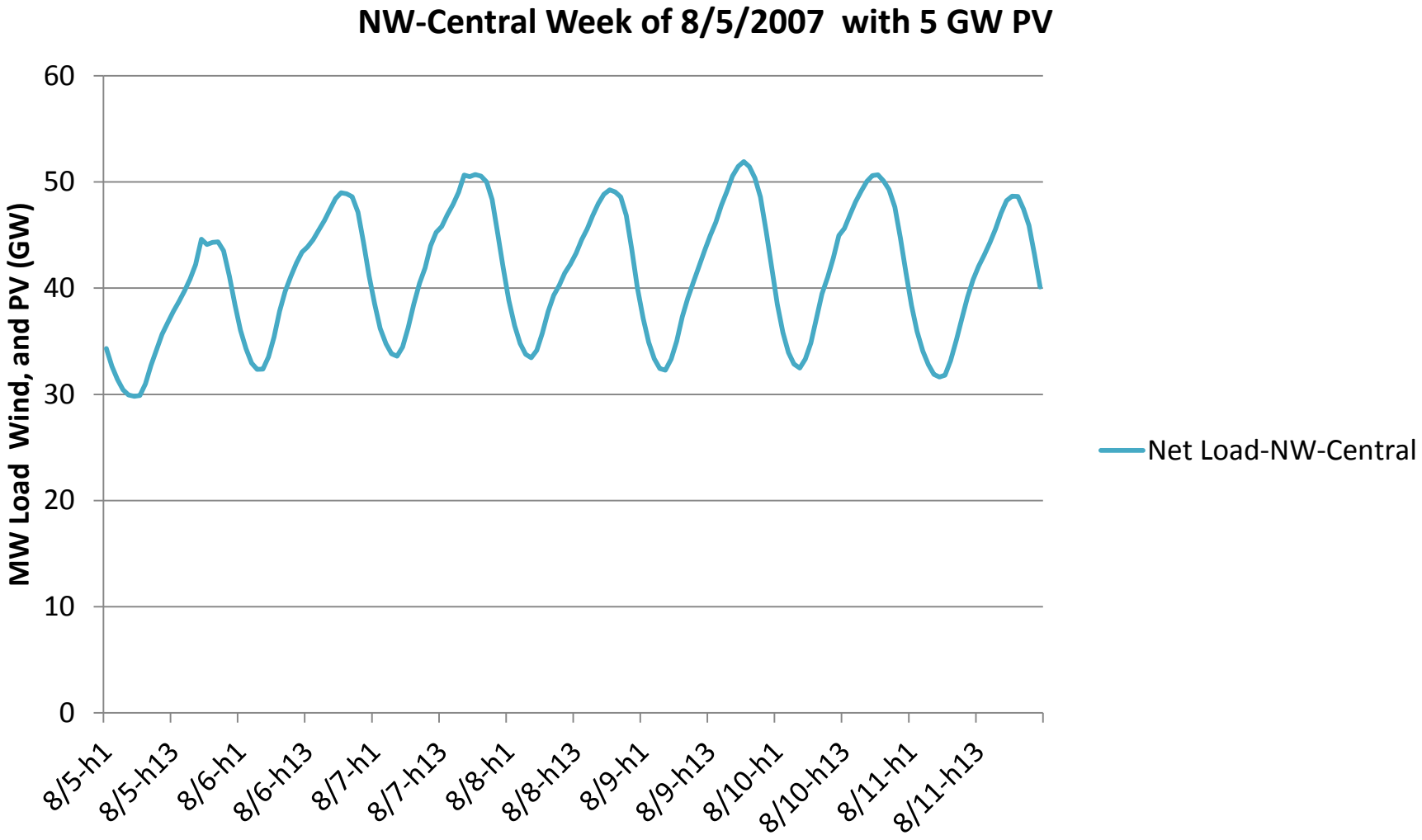
Following Example Shows Similar Diminishing Returns for Large Penetrations of Solar

- Same NW-Central region (MN, ND, SD, KS, IA, NE, MO)
- Hourly loads from Energy Velocity
- Solar and wind shapes from AWS Truepower
- Plots show net load with additions of 0 to 20 GW of solar PV
- Sensitivity case shows 20 GW of PV with 20 GW of wind

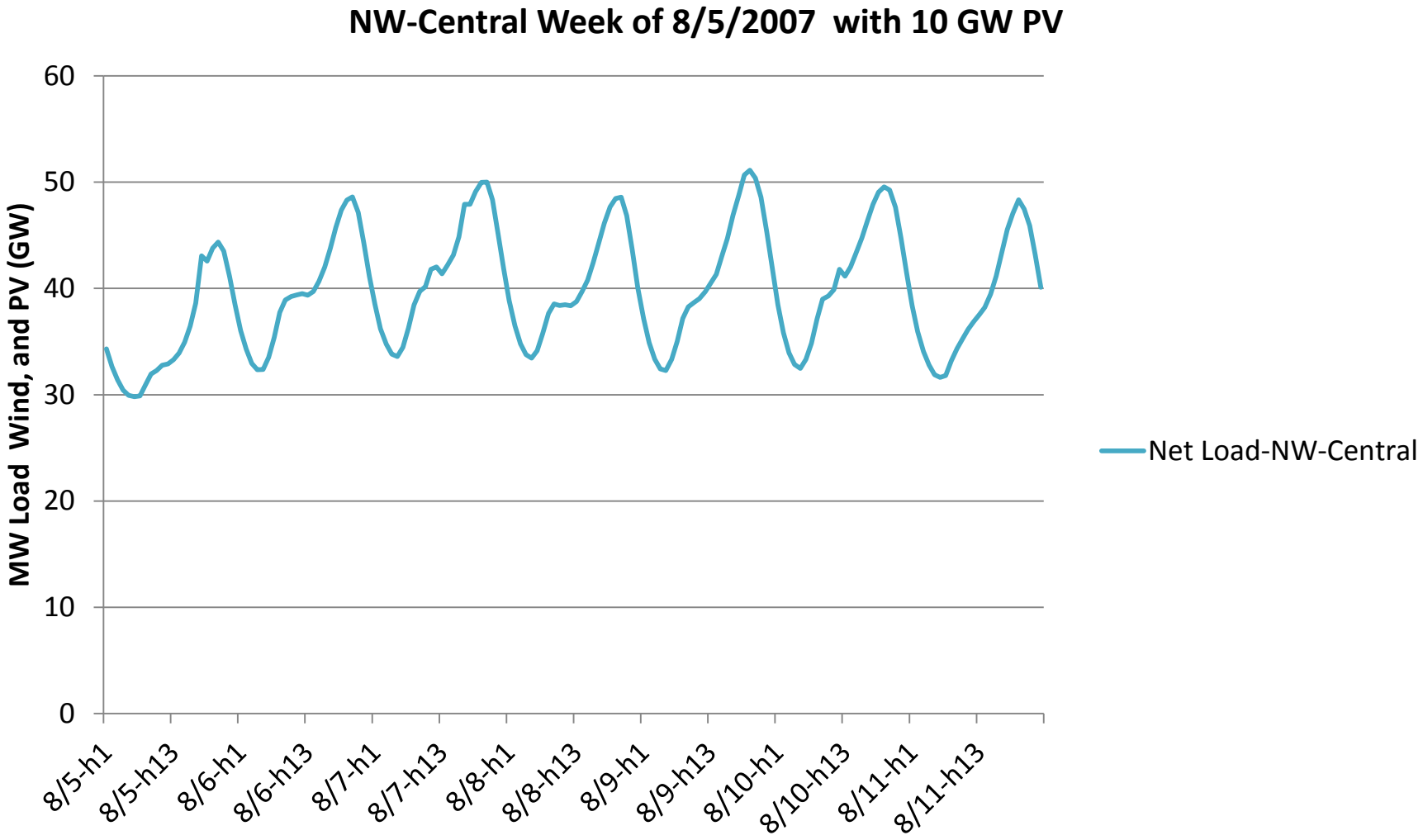
2007 Peak Day Net Load with No Solar PV (Reference Case)



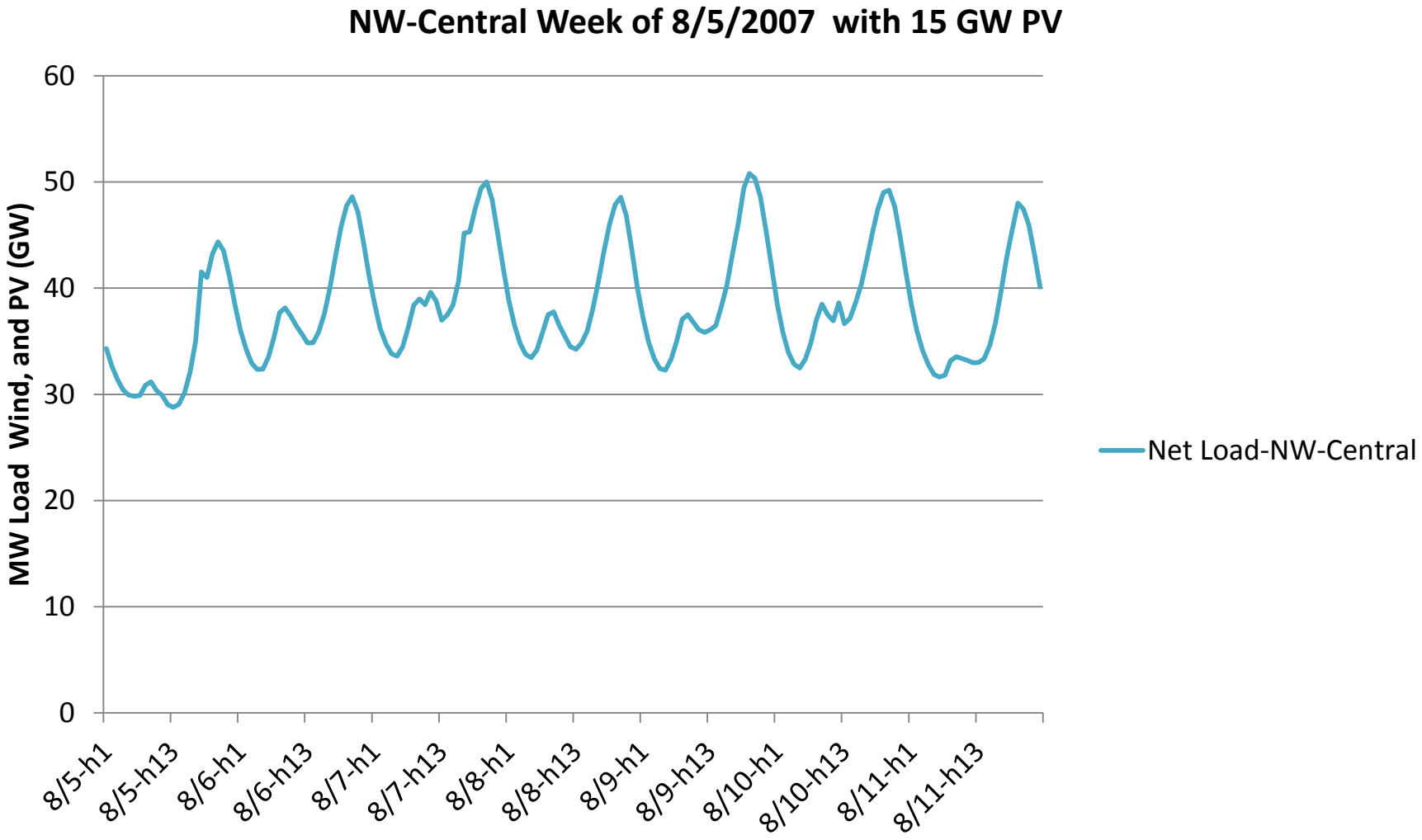
Peak Day Net Load with 5 GW of Solar PV (peak and energy reduction)



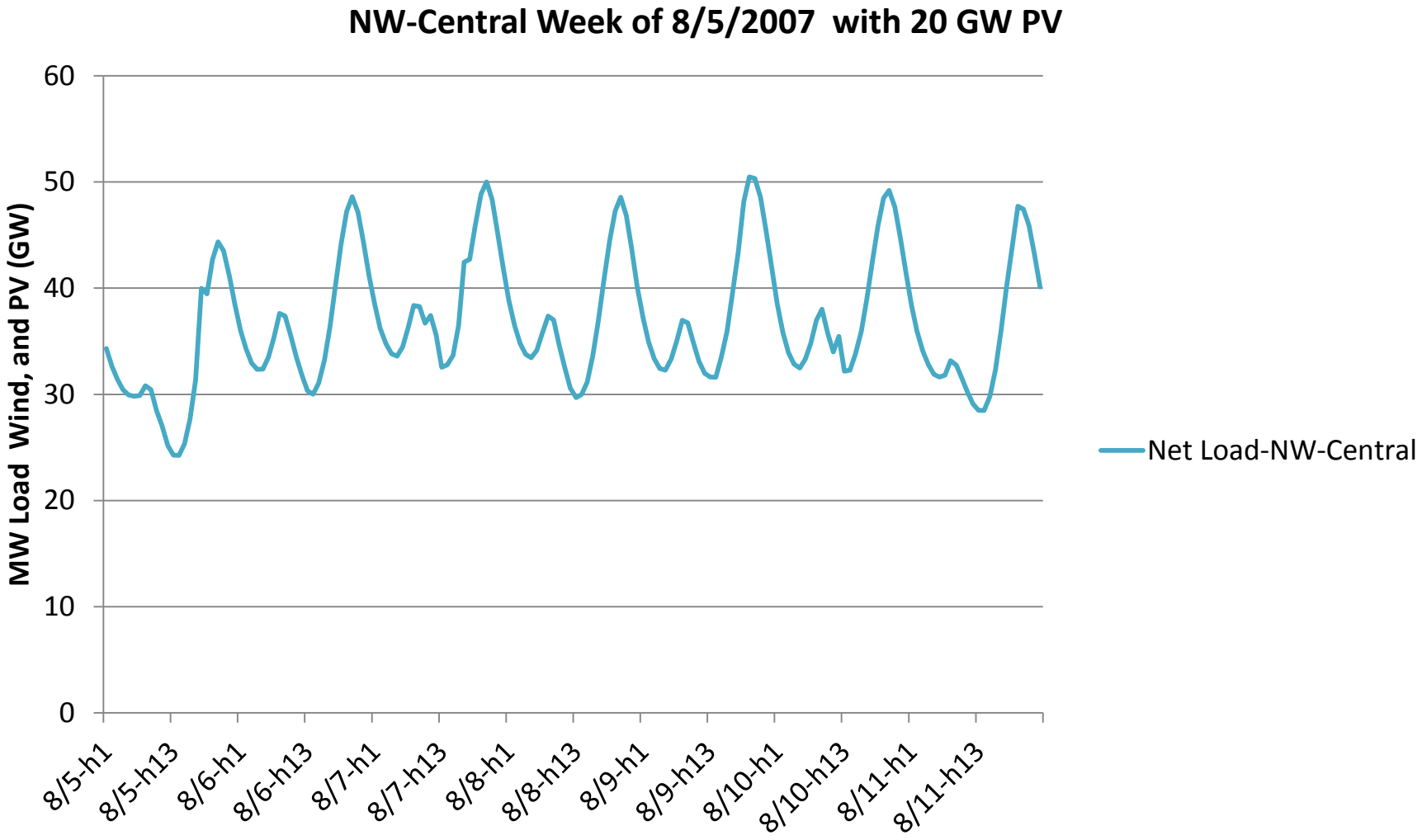
Peak Day Net Load with 10 GW of Solar PV (peaks getting “spiky”)



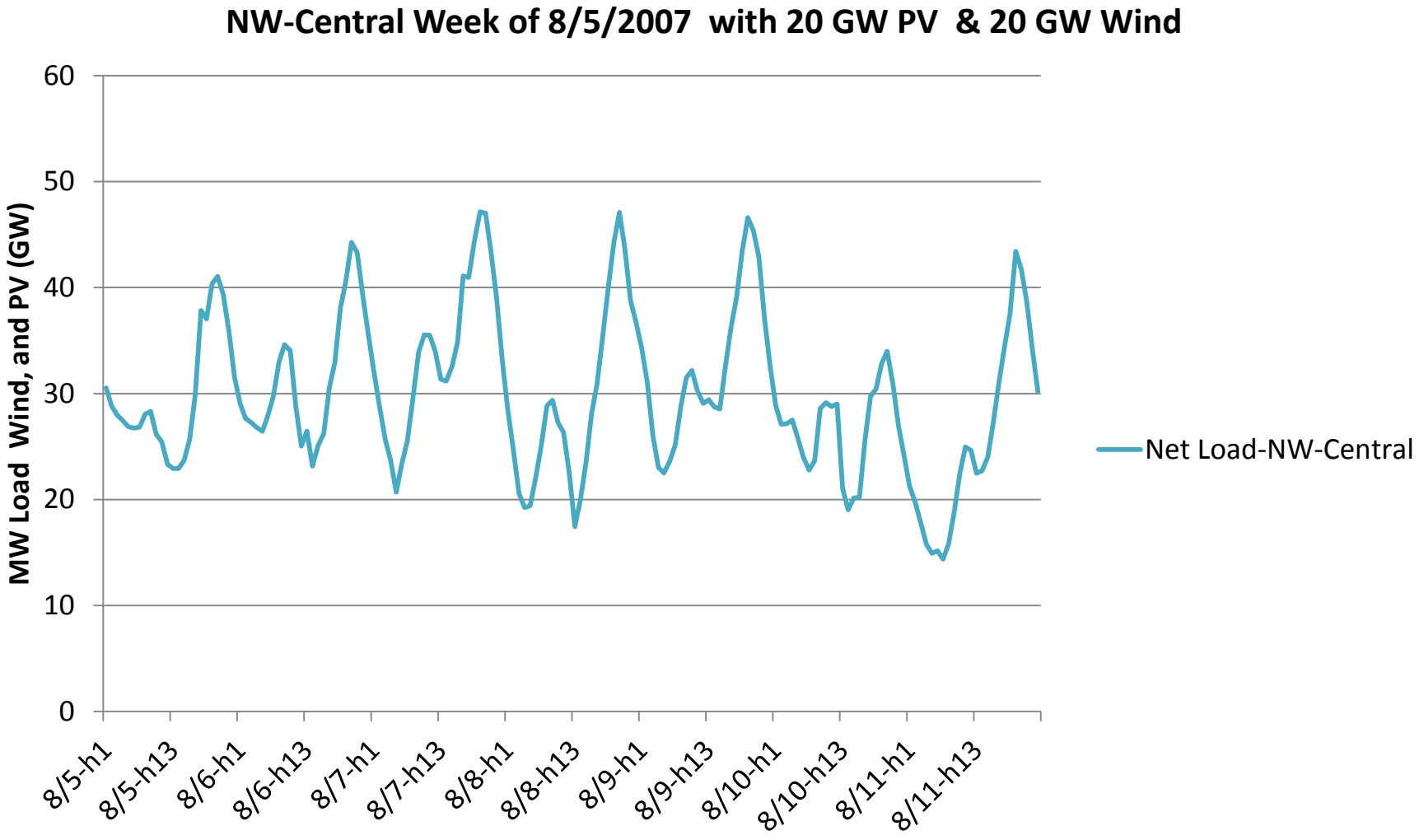
Peak Day Net Load with 15 GW of Solar PV (no further peak reduction)



Peak Day Net Load with 20 GW of Solar PV



High Penetration of Wind and Solar Lead to Extreme Variability and Limited Peak Synergy



Observations

- LCOEs useful for ball park estimates of costs, but numerous embedded assumptions mean “caveat user”
- Wind and solar provide “shaped energy” whose value can be usefully summarized by LACE, but diminishing returns to wind/solar at policy-relevant levels of penetration means LACE estimates are not constants
- Good reasons for using power system simulation models in policy analysis (e.g., NEMS, IPM, US-REGEN, Haiku)
- LCOE, LACE, and the simulation models aren’t perfect
- But they all can be useful

Together…Shaping the Future of Electricity