Challenges to Deep Decarbonization

July 11th, 2016
EIA Electric Capacity Expansion Modelling Workshop

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Commissioned by the Energy Innovation and Reform Project

Frequently Asked Question:

Q1: What produces electricity when wind doesn't blow and sun doesn't shine?

Q2: What *doesn't* produce electricity when wind *does* blow and sun *does* shine?

A) Unabated hydrocarbon power plant

B) Emissions free power plant

C) False Question -- Load shifting

Modest Decarbonization

Redundant Capacity

Limited Seasonally

Conclusion: Capacity planning should take into account the (seasonal) utilization of low carbon generators under deep decarbonization

$$\left[\frac{\$}{MWh}\right] \; Average\ Cost = \frac{Fixed\ Costs}{Production} + Variable\ Costs$$

1) General Decarbonization

$$Average\ Cost = \frac{Capital\ Costs}{Utilization} + Fuel\ Costs$$

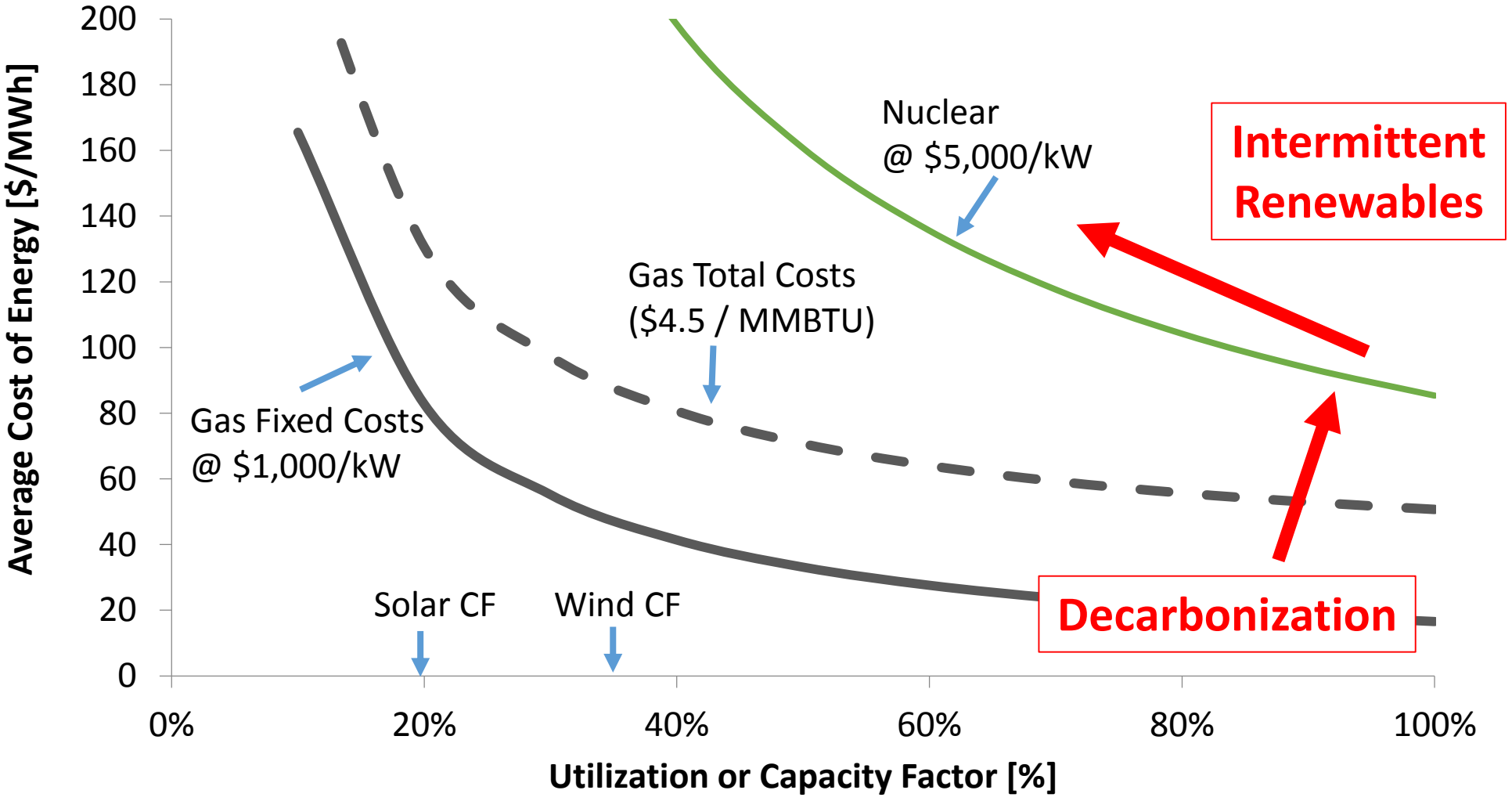
2) Intermittent Generation

$$Average\ Cost = \frac{Capital\ Costs}{Utilization} + Fuel\ Costs$$

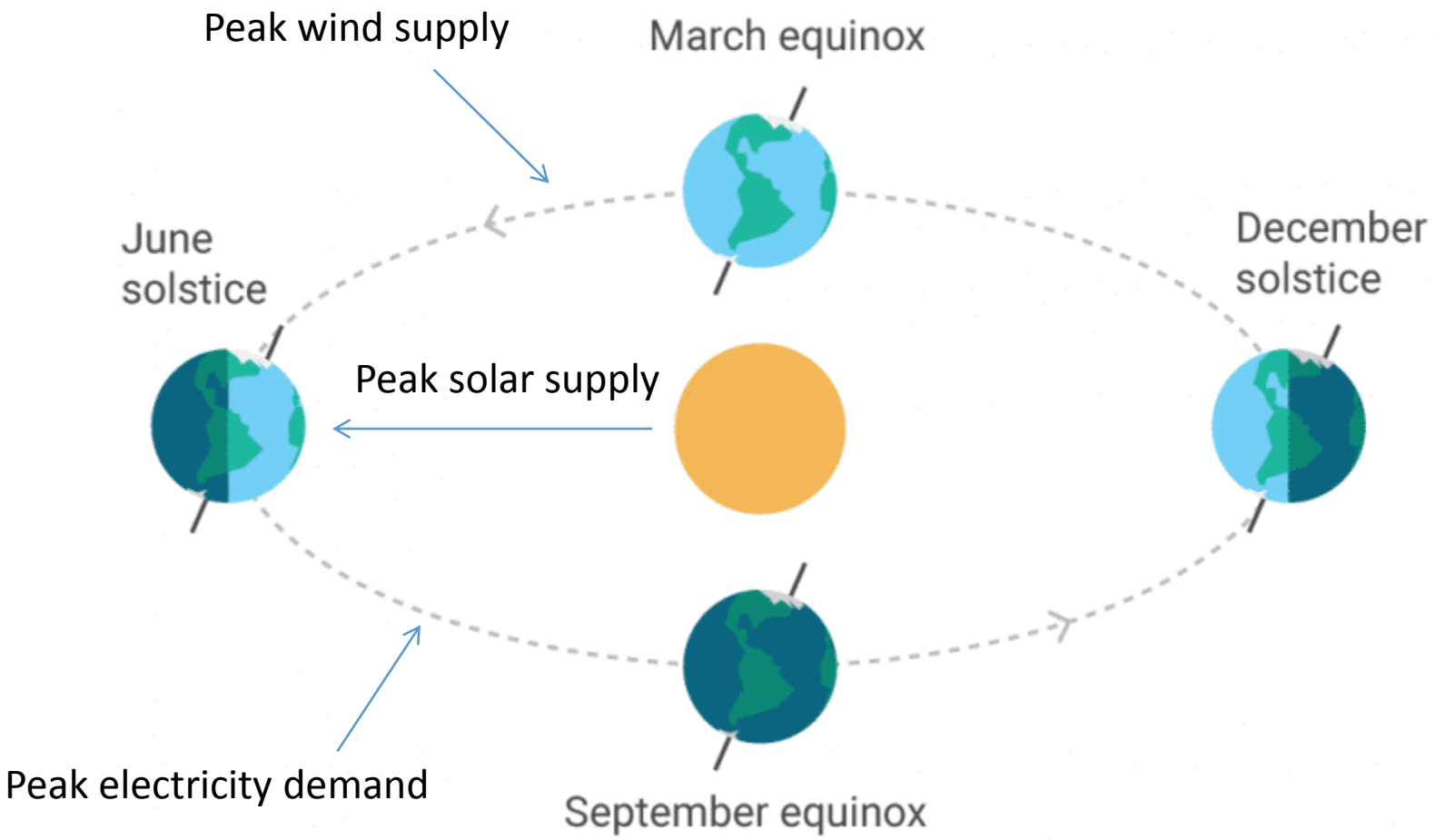
3) Intermittency Under Deep Decarbonization

$$Average\ Cost = \frac{Capital\ Costs}{Utilization}$$

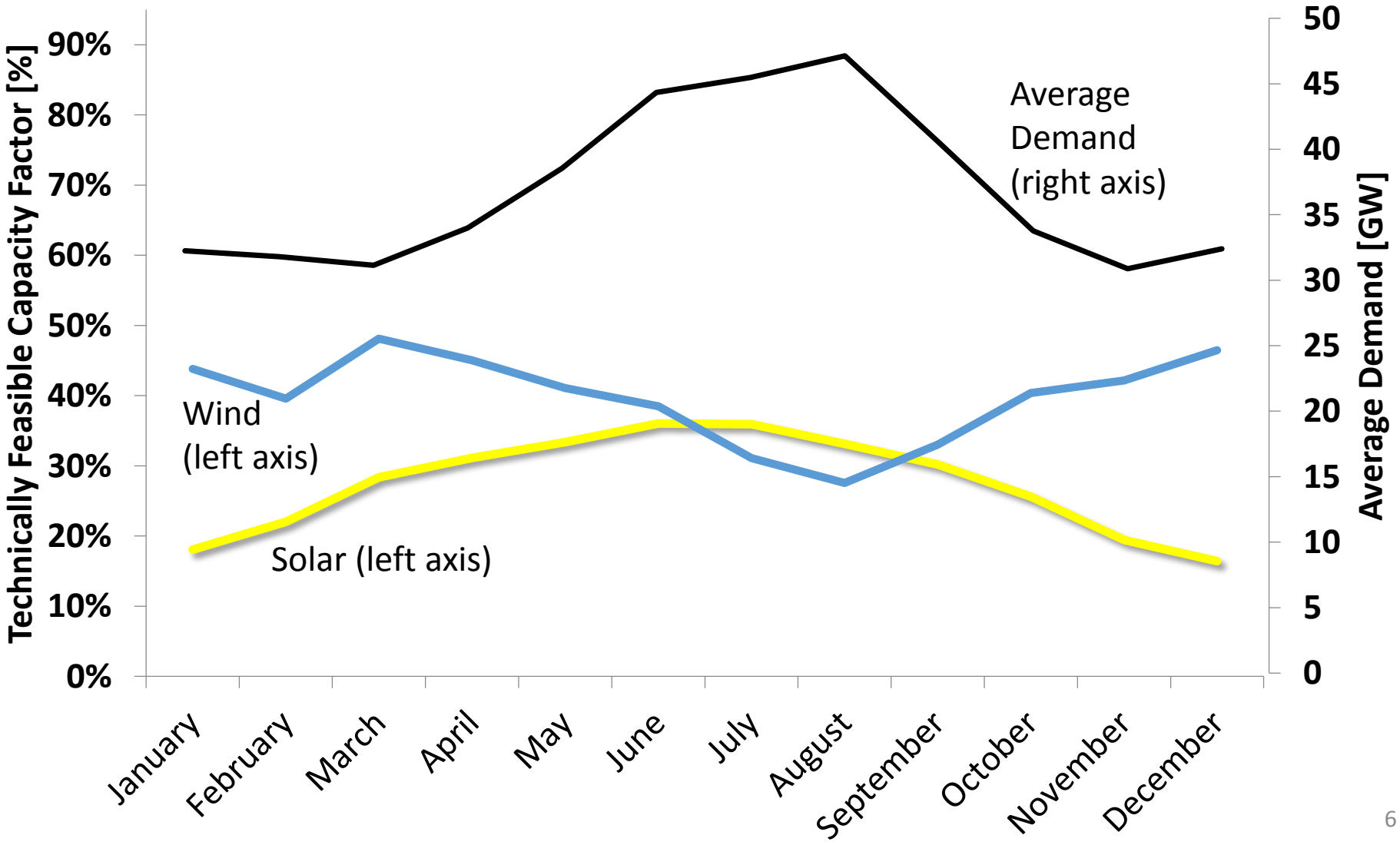
Cost of low carbon generators highly dependent on utilization



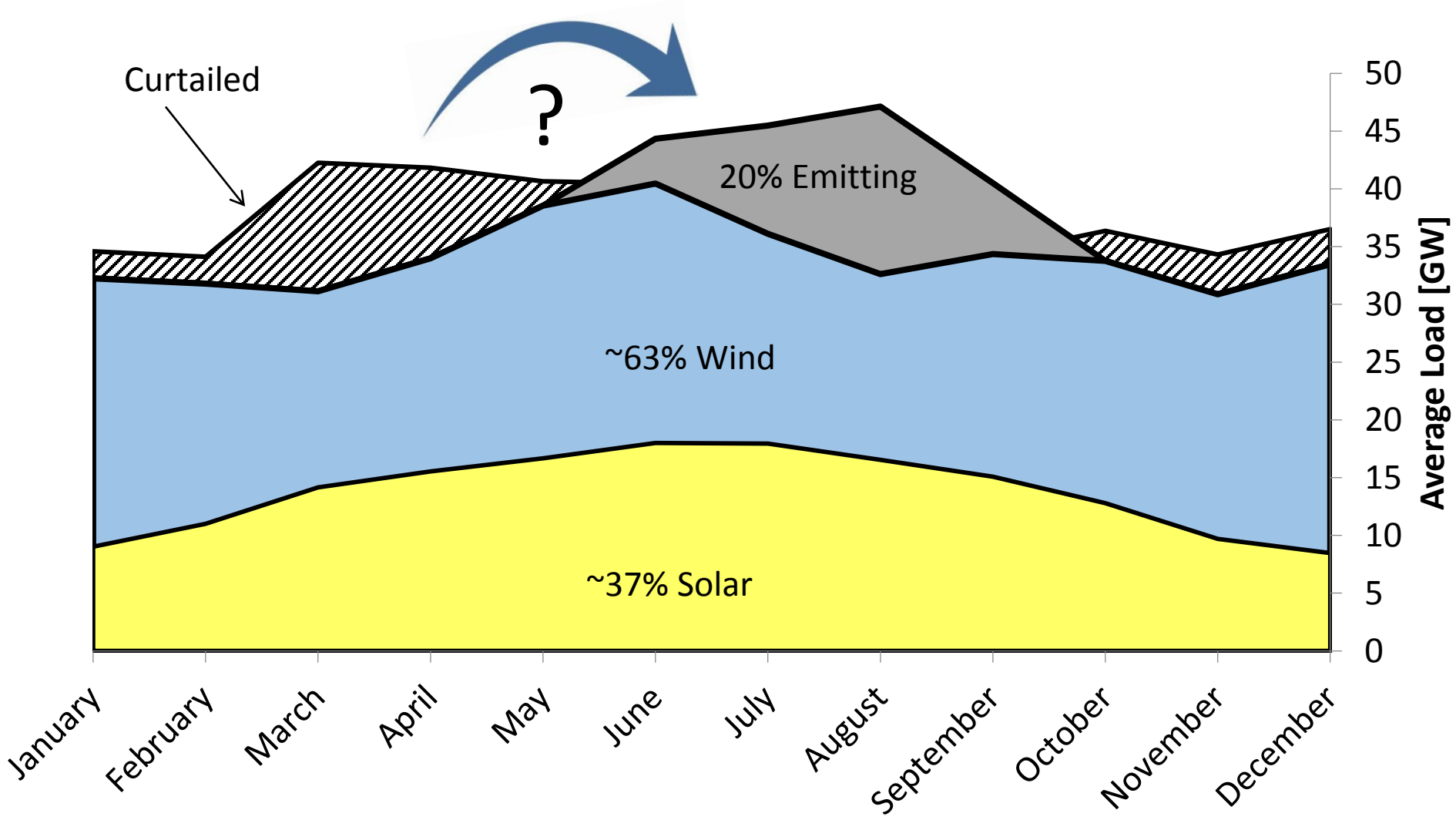
Seasonal Mismatch Between Supply and Demand



Seasonal Mismatch between Supply and Demand (ERCOT)



80% Renewable Energy (ERCOT) →
Seasonal Oversupply Implies Seasonal Storage



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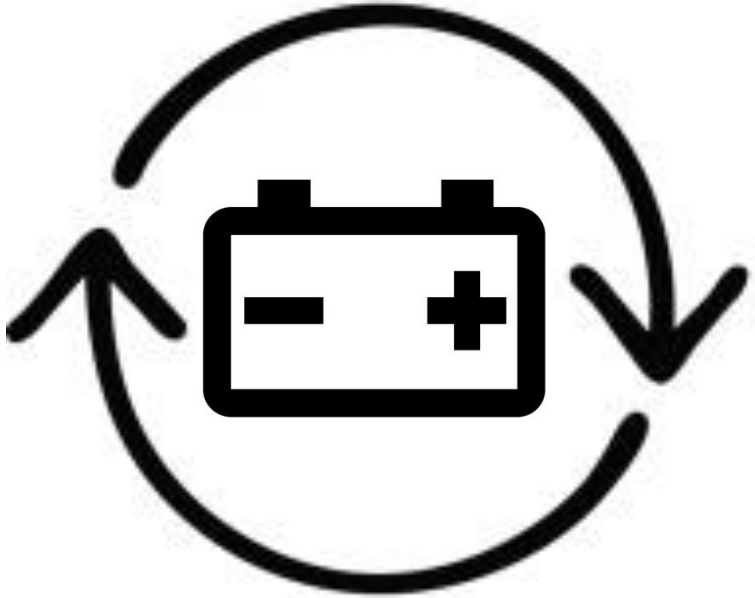

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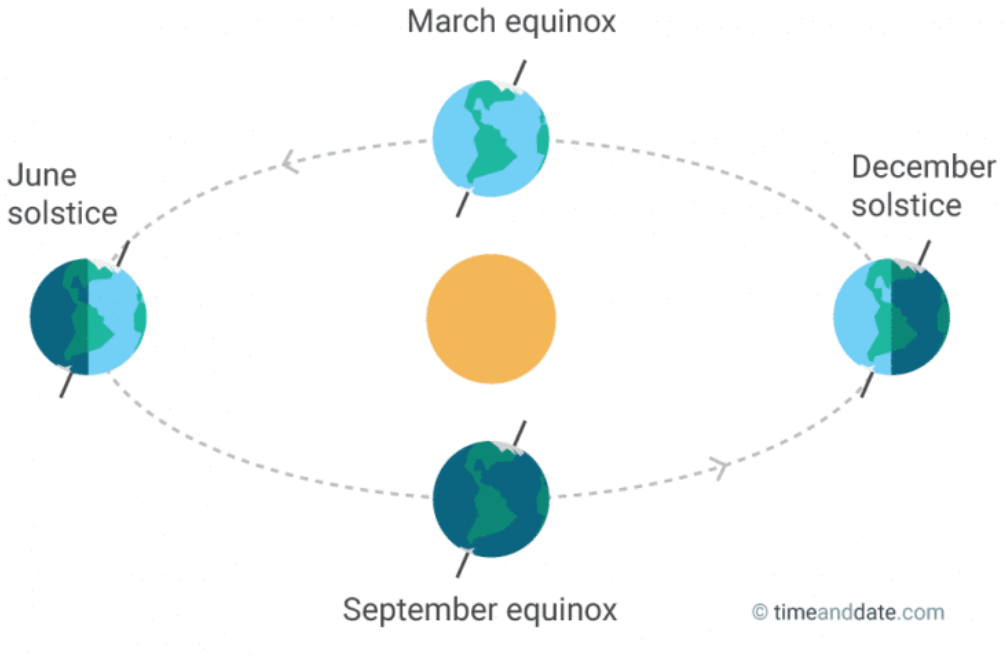
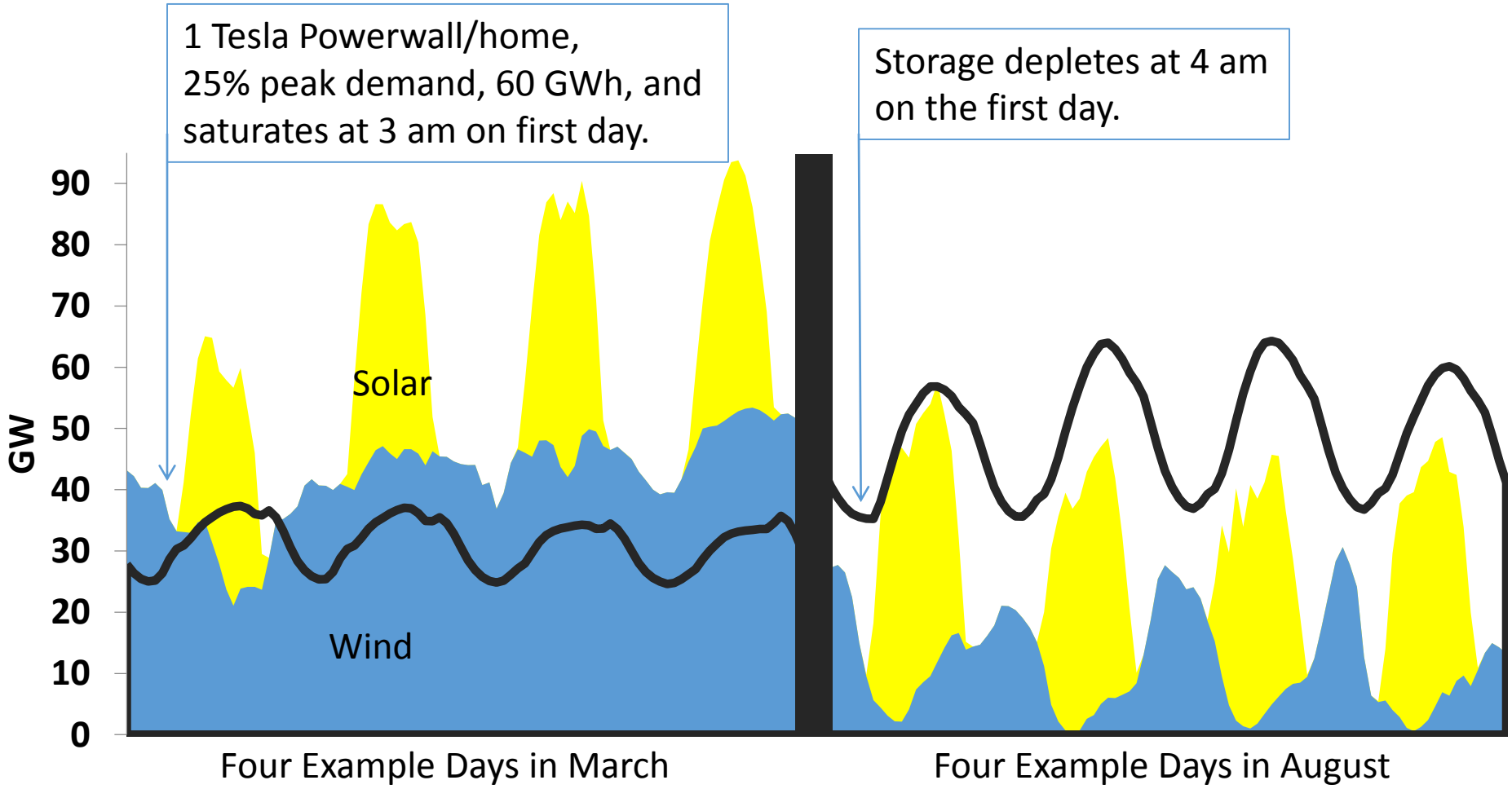


Utilization Maximizing Combination of Wind and Solar for 80% Low Carbon Energy



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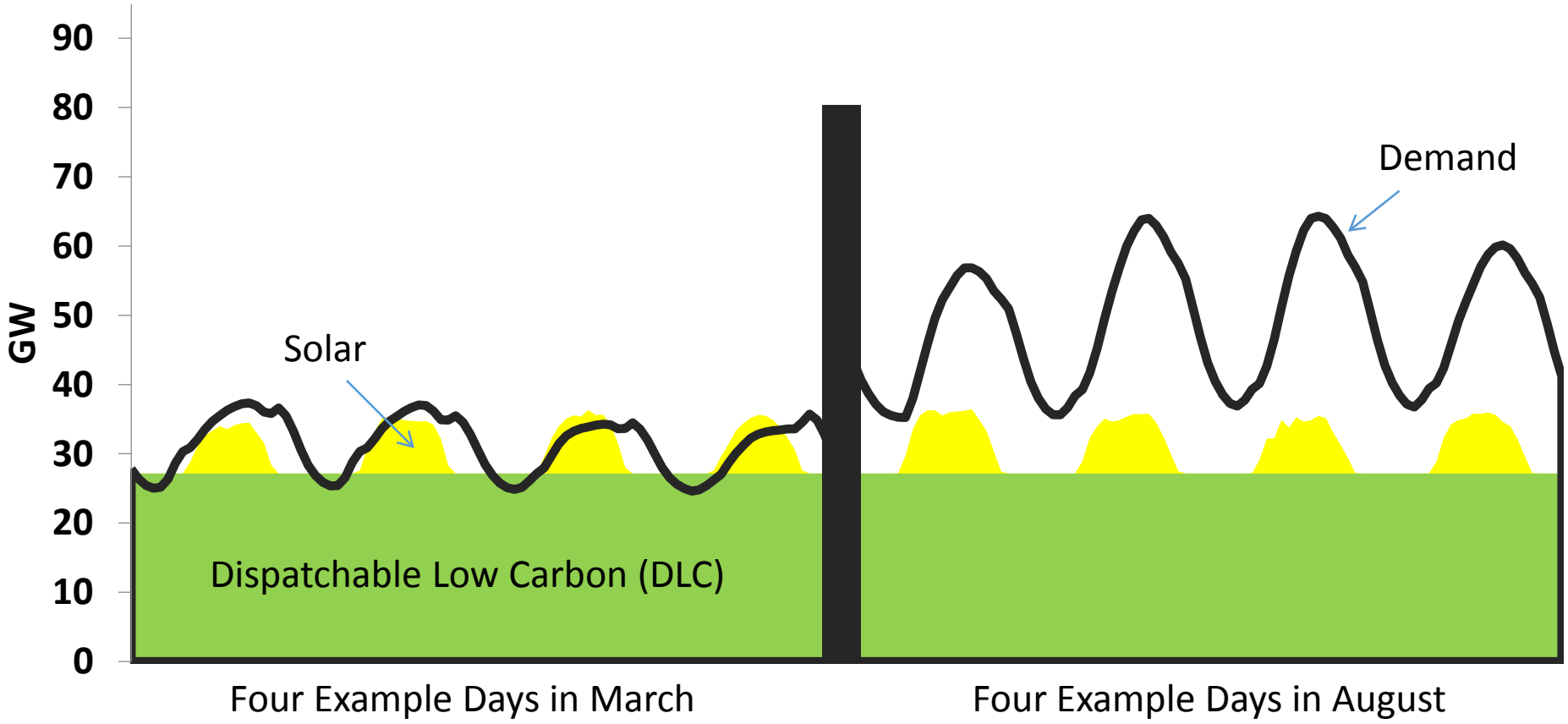
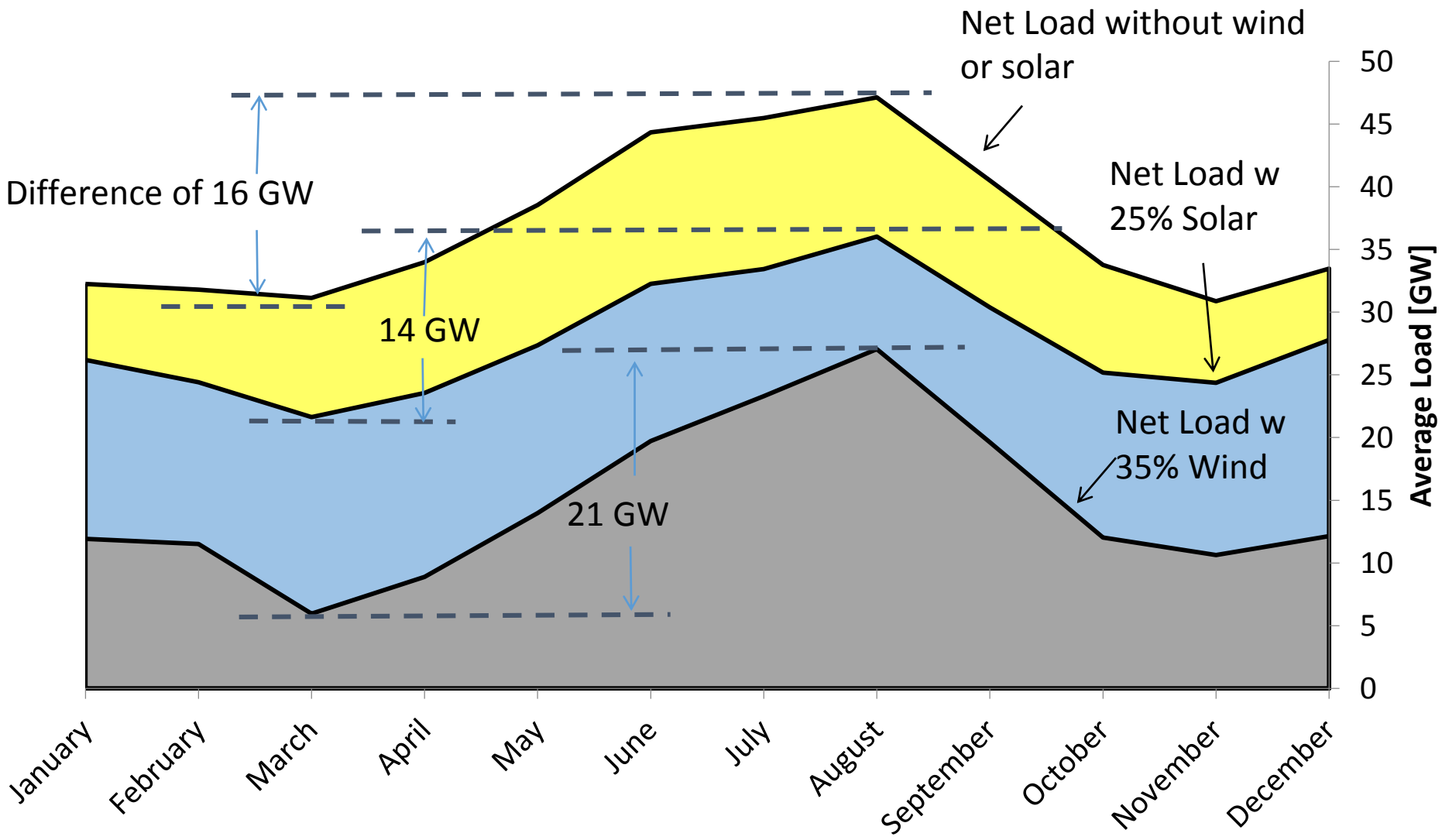


Seasonal Version of "Duck Curve": Variation in Seasonal Demand Exacerbated by Renewables

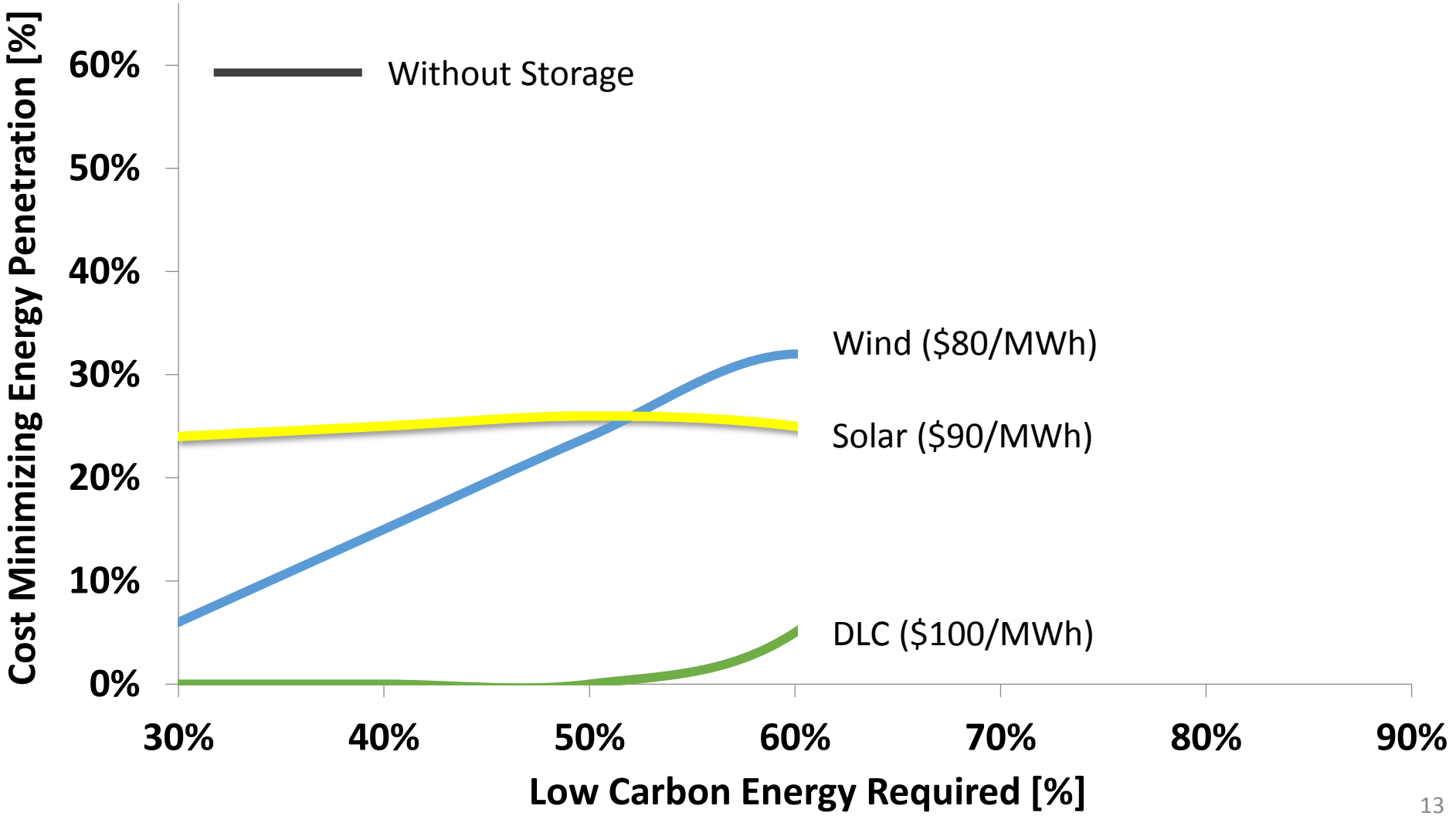


Which Combination of Wind, Solar, and DLC Minimizes Costs?

1) Scale wind, solar, or DLC output within an Excel-based, hourly economic dispatch model using hourly (8760) demand from ERCOT

2) Assume:
   - Value of reliability or Equivalent load Carrying Capability (ELCC) @ $330/MW-day
   - Wind LCOE @ $80/MWh, ELCC starting at 25%
   - Solar LCOE @ $90/MWh, ELCC starting at 50%
   - DLC LCOE @ $100/MWh, ELCC of 95%

Contribution of Generators Dependent on Decarbonization Desired



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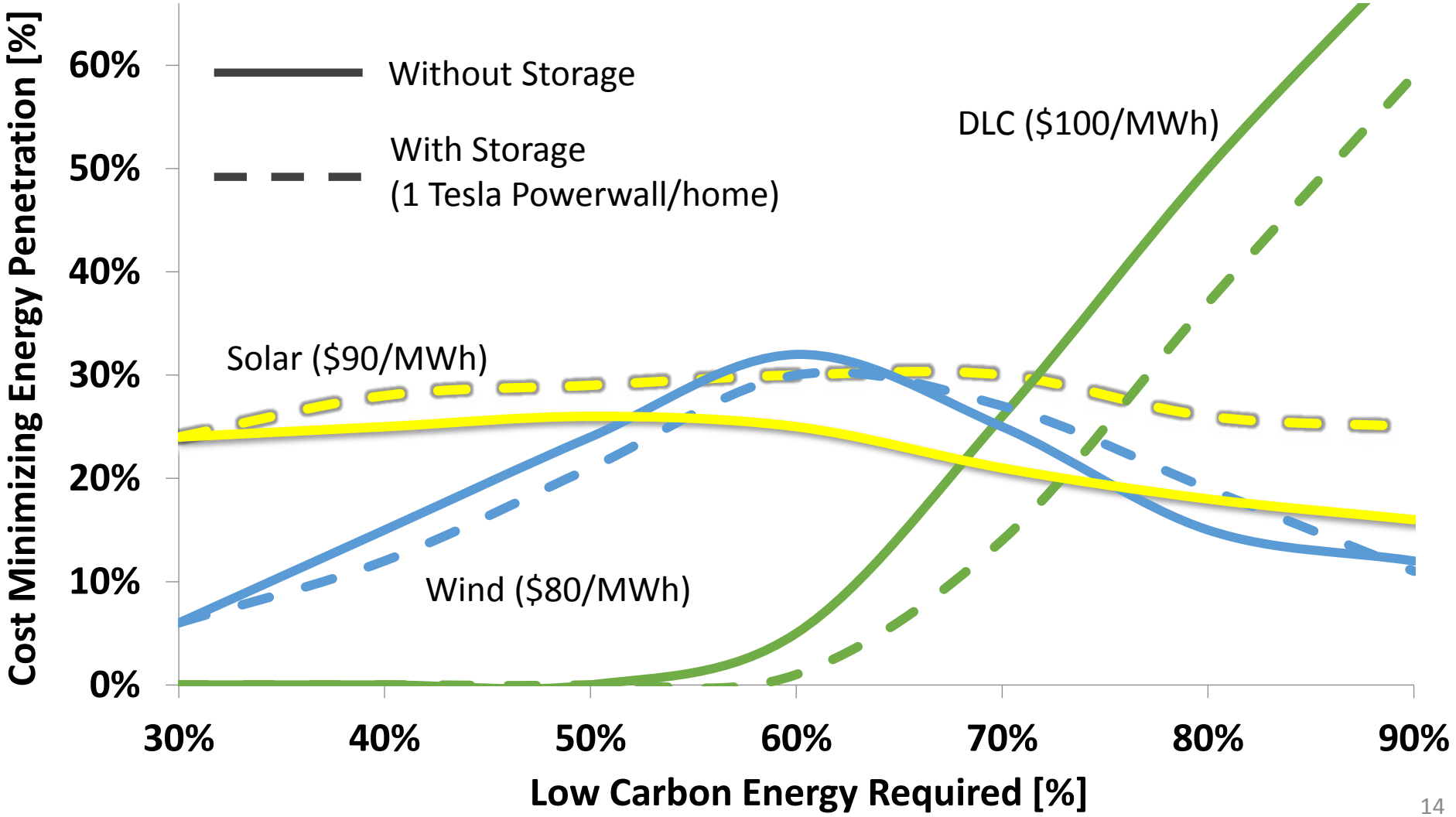
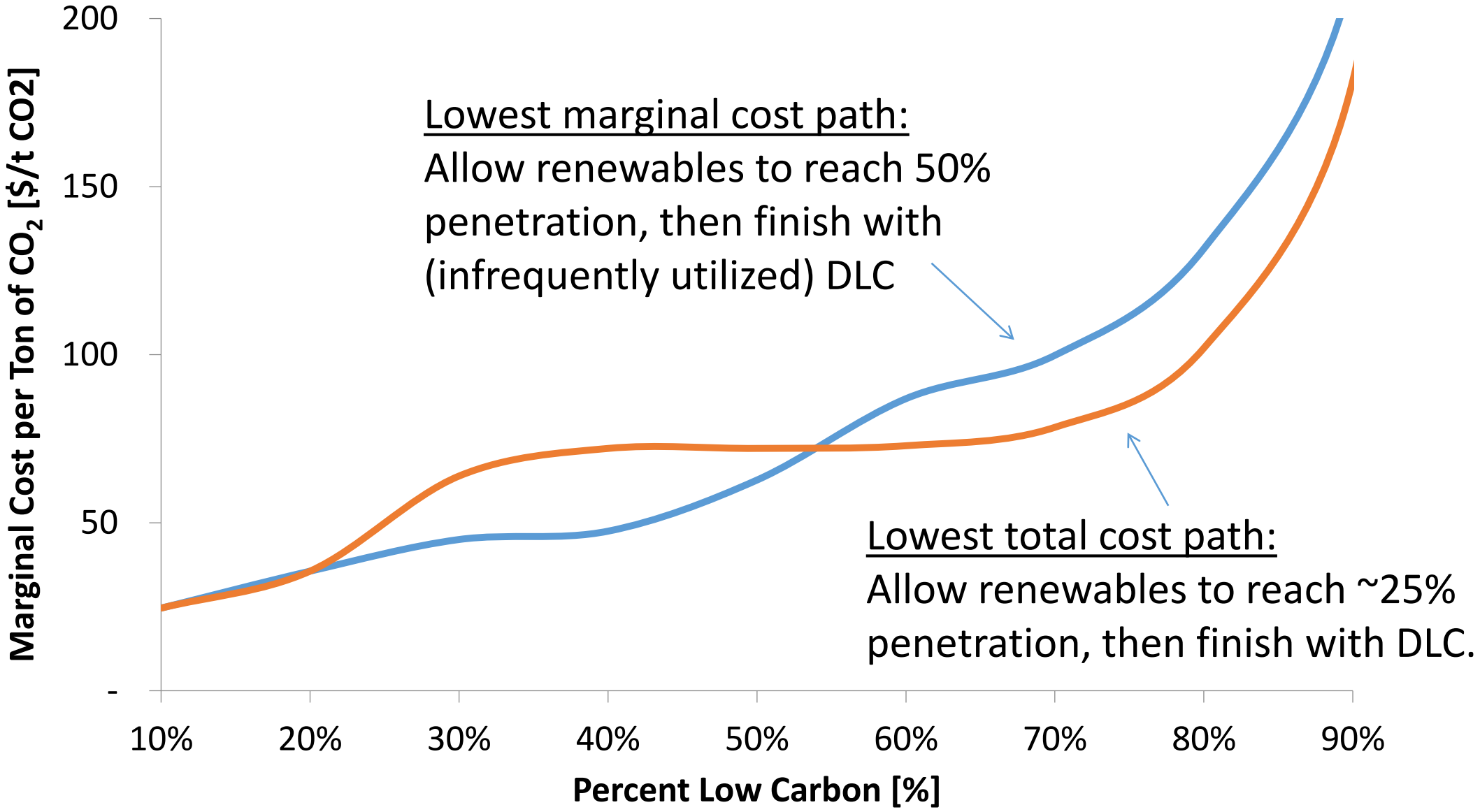


Conclusion: Capacity planning should take into account the utilization of future generators under deep decarbonization



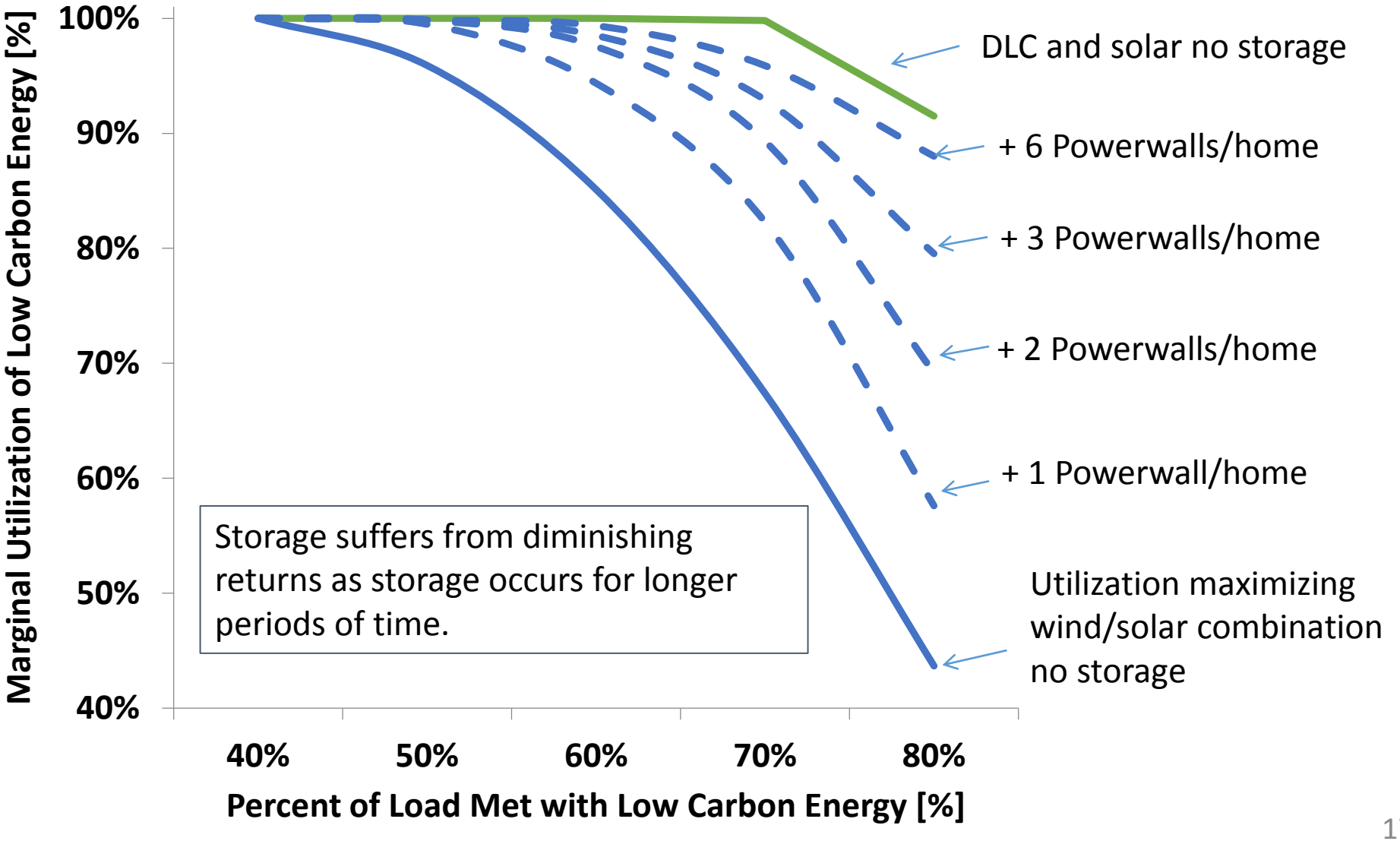
"…Find ways to promote strategies that will scale up to the ≥ 90% emissions reductions that will be needed to stabilize the climate. … The success of today should not become the burden of tomorrow."

-- M. Granger Morgan in PNAS (2016)

Subsequent deep decarbonization

Overreliance on intermittent generation

Storage suffers from diminishing returns



Electricity Service: Power at a certain time, reliably