NREL
NATIONAL RENEWABLE ENERGY LABORATORY





Current and Future Opportunities for Wind Power in the Southeast

Heidi Tinnesand, Owen Roberts, Eric Lantz

Utility Advisory Group – High Altitude Wind Resources and Technology
Charlotte, North Carolina
October 5, 2016

NREL/PR-5000-67354
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Looking into the Future and Flying on Instruments

Photo from Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/0/07/Six_flight_instruments.JPG

Qualifications and Caveats

This presentation contains data and analysis developed in the context of an ongoing research effort. Results presented are of a preliminary nature and subject to future change. Data and analysis presented are for reference purposes only.

Wind in the Southeast:

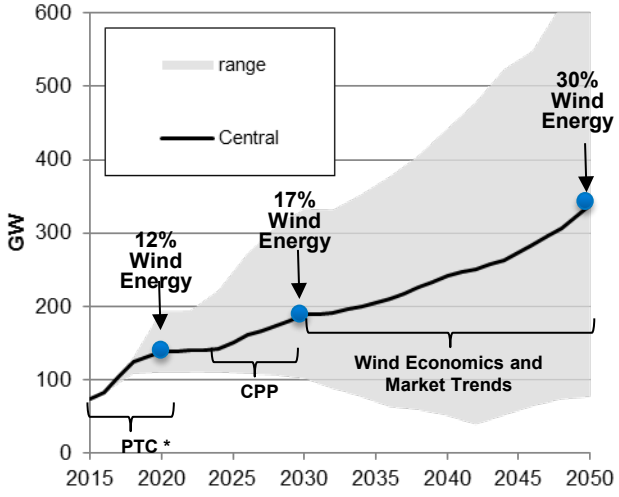
Where Are the Opportunities?

Wind Energy Opportunities

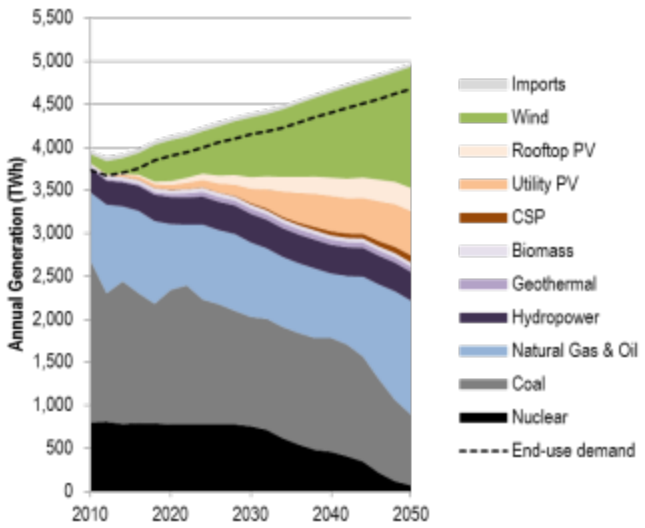
- Future carbon regulations
- Fossil fuel price volatility and variability
- New source of direct investment and economic development
- Increasingly cost-competitive resource
- Substantial regional forecast load growth.

Future National Wind Deployment: 2015 - 2050

Deployment Range and Central Scenario



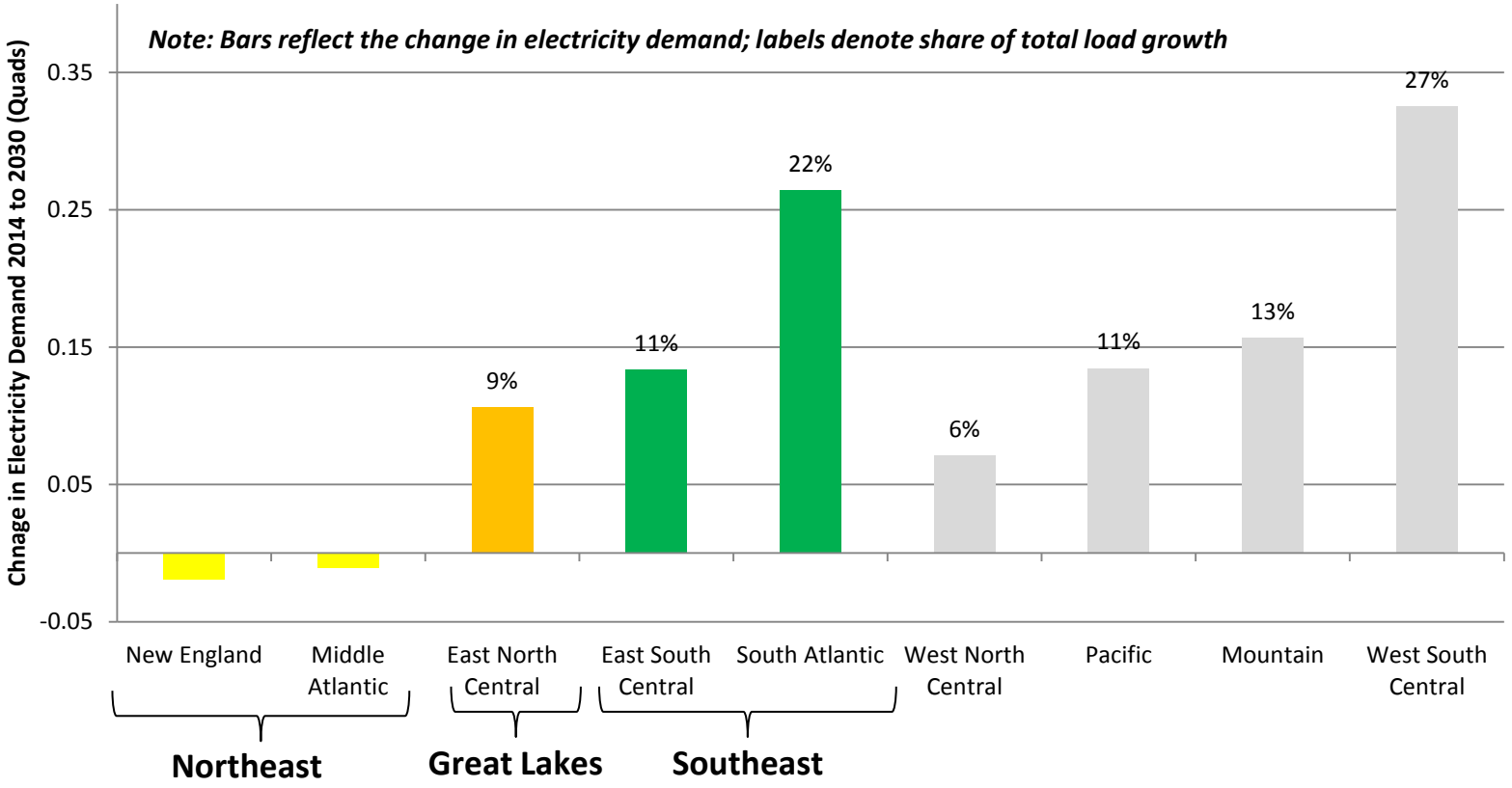
Central Scenario Electric Sector Generation Mix



**PTC modeling is based on 2-year 'under construction' window; transmission additions post-2020 are based on system economics.*

- In one wind-optimistic scenario, with delivered gas prices at approximately $5 - $6.50/MMBtu between 2020 and 2030, wind capacity steadily marches toward 200 GW by 2030.
- Post-PTC growth is supported by the Clean Power Plan (CPP) in the 2020s and by continued cost reductions for wind combined with increasing fossil fuel prices, growing demand, and retiring coal and nuclear after 2030.
- Natural gas and solar PV constitute the primary alternatives to wind power and also represent the resources most likely to be displaced by wind under more optimistic wind scenarios.
- Based on recent gas prices and other industry trends (e.g., continued PV cost reductions), there is substantial risk that wind deployment could fall to levels well below those projected under central conditions.

Forecast Demand Growth among Regions



Data Source: U.S. Energy Information Administration AEO 2016 Early Release

- Current estimates suggest that the Southeast could account for 33% of forecast (2030) electricity demand.
- Accessing these markets (via transmission or with locally sited wind projects) is likely a key element of continued future wind industry growth.

Changes in Wind Turbine Technology – Up to Today

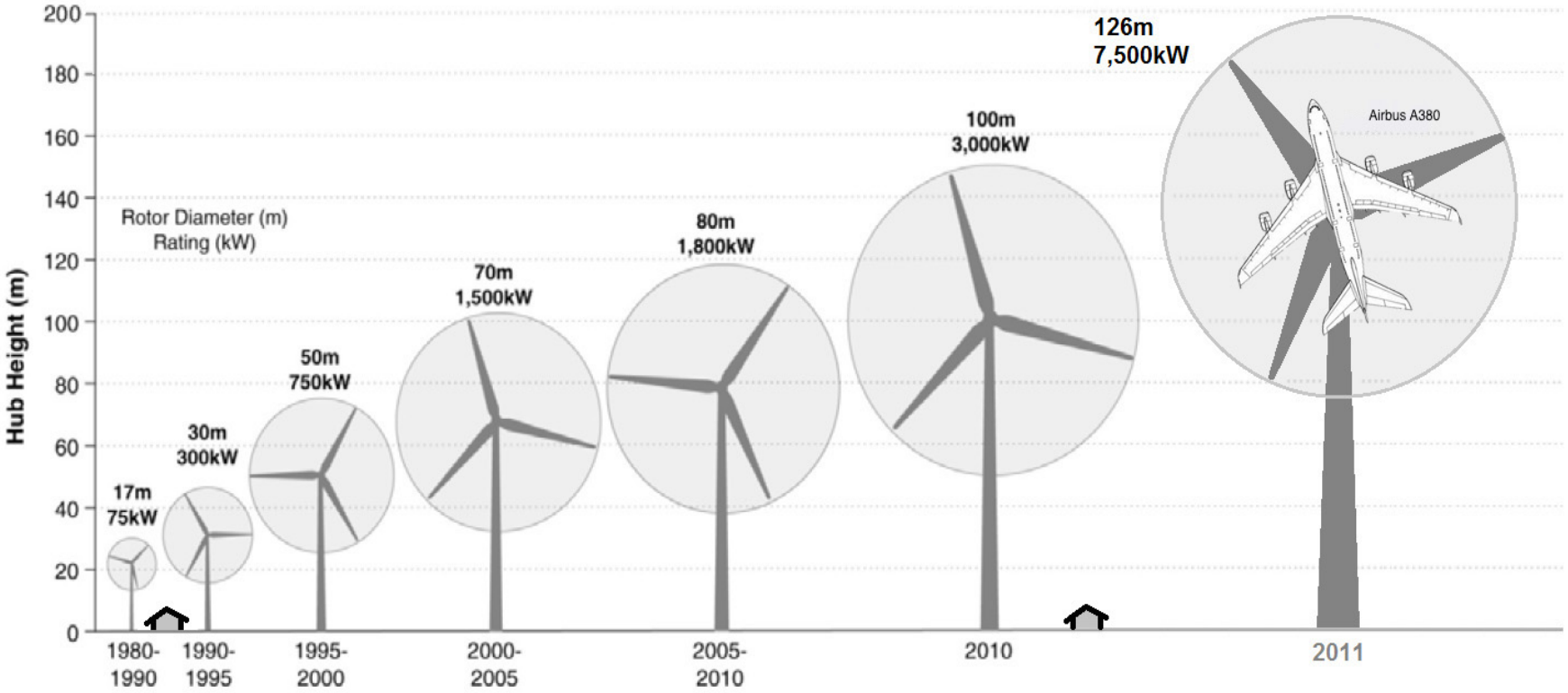
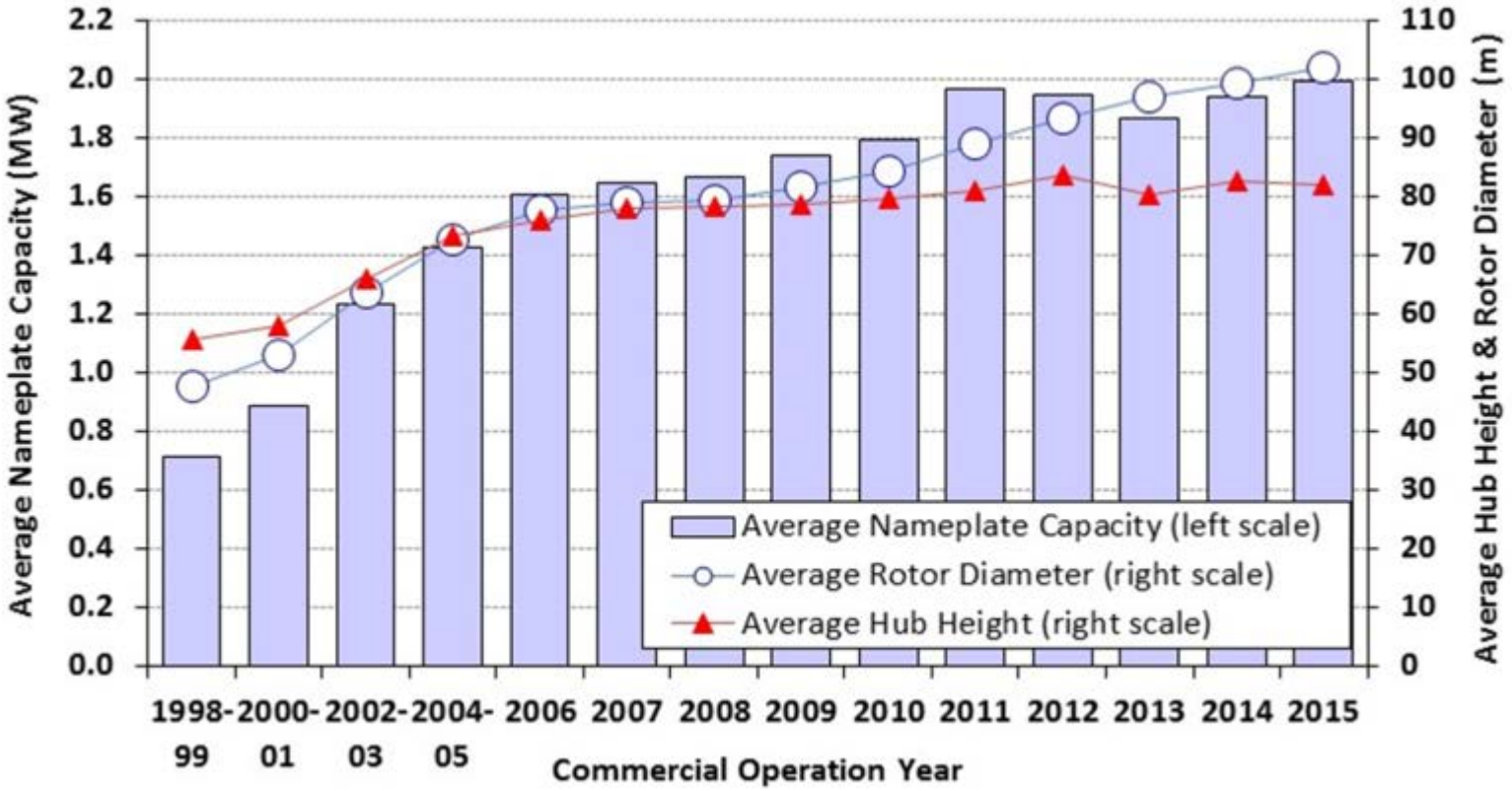


Photo courtesy of NZWEA, http://www.vox.com/2016/6/1/11820920/concrete-wind-turbine

Historical Wind Power Innovation Trends



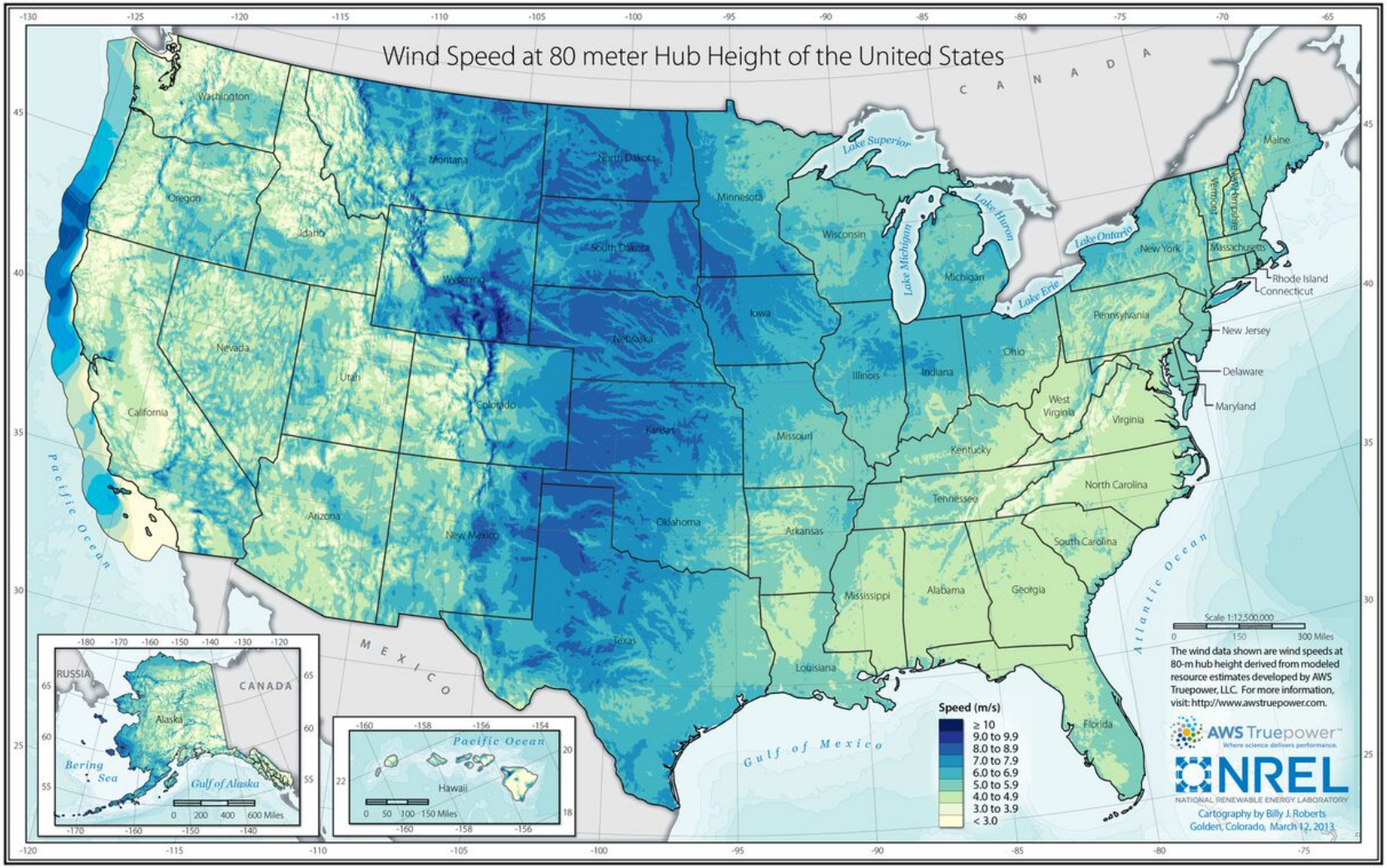
Source: Lawrence Berkeley National Laboratory (2015 data are preliminary)

- Future sources of innovation are anticipated to be similar to historical trends and enable continued turbine scaling or "tall wind."
- Specifically, continued rotor-diameter growth, increased hub heights, and increased nameplate capacity are all anticipated to be key elements of continued cost reduction.
- Manufacturing, logistics and balance of plant, and whole plant optimization improvements will also be important.

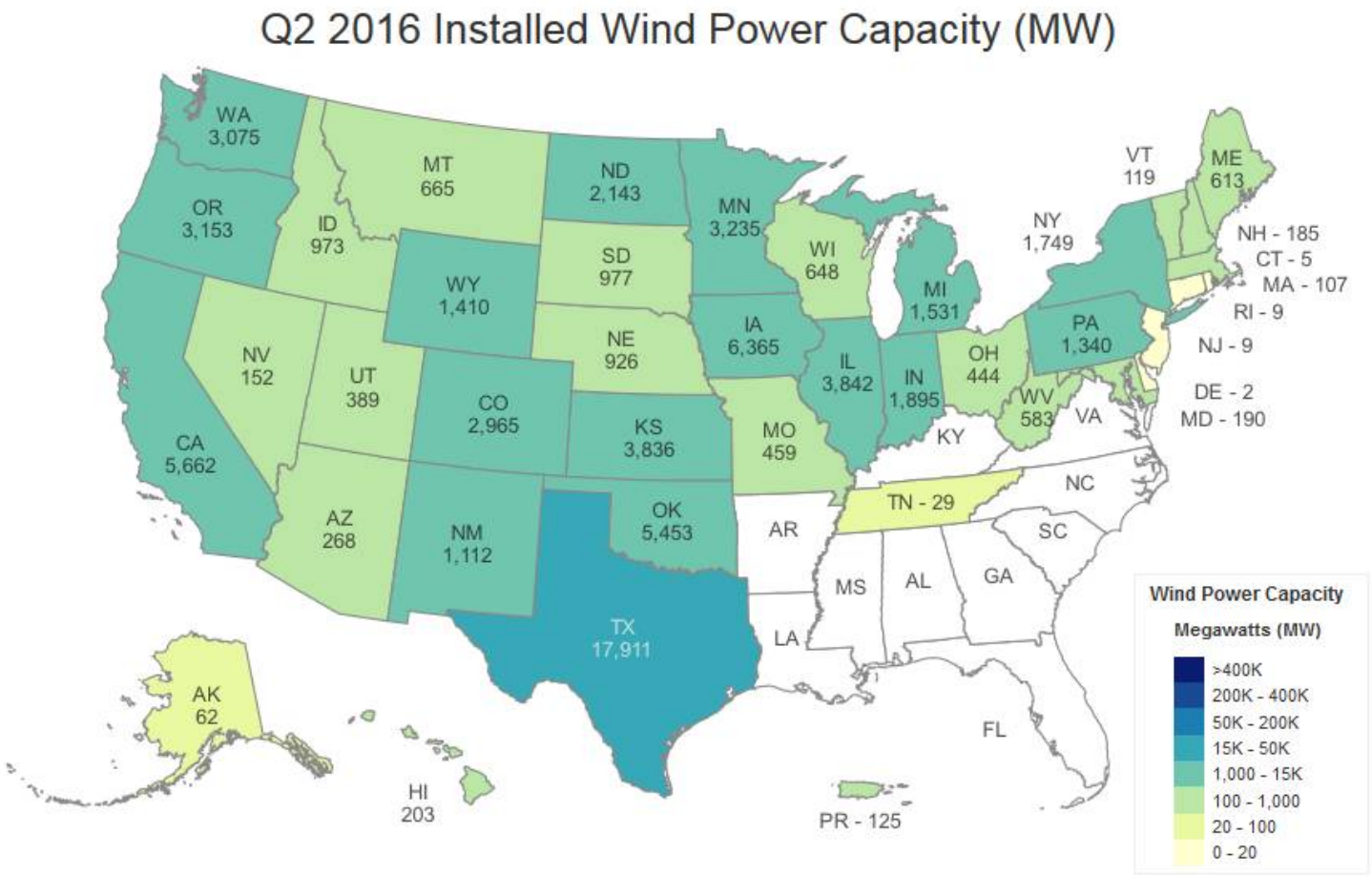
Current Status of Wind in the United States:

80-m Hub Height

United States Wind Speed Map



Installed Wind Capacity, End of 2Q2016



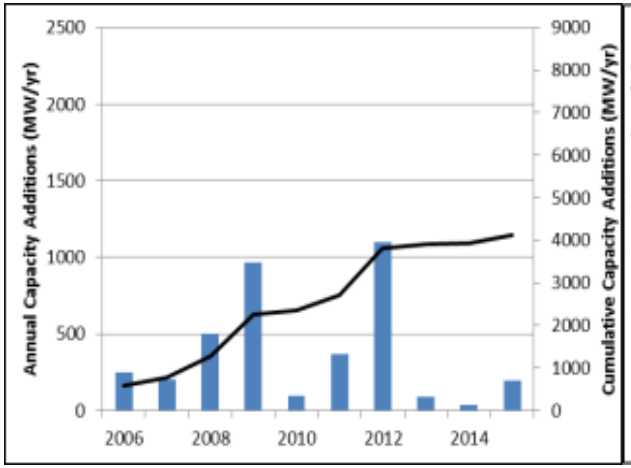
Total Installed Wind Capacity: 74,819 MW

Source: American Wind Energy Association Q2 2016 Market Report

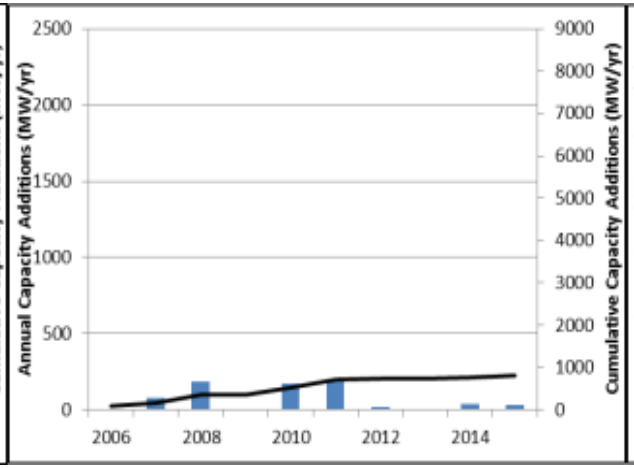
Focus Region Trends: 2006 - 2015

Historical Wind Power Deployment

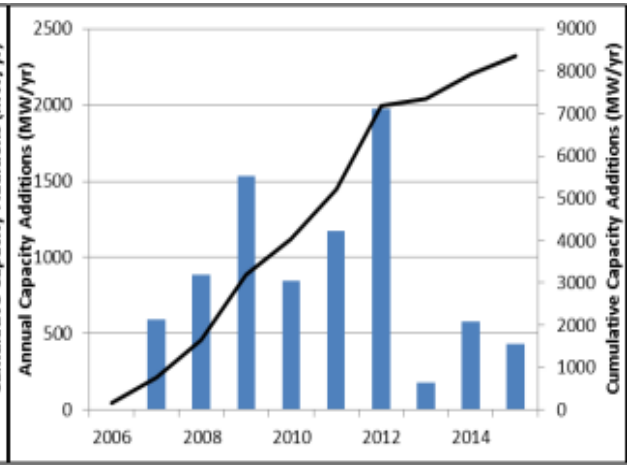
Northeast



Southeast



Great Lakes

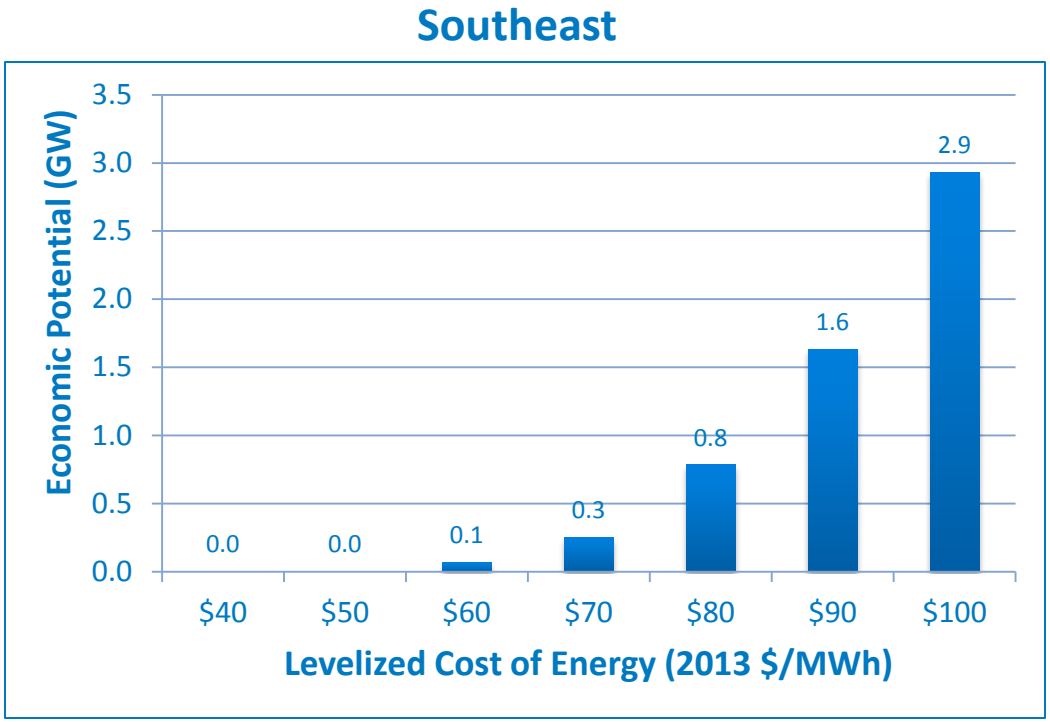


Data acquired from WINDExchange. n.d. Washington, D.C.: U.S. Department of Energy. Accessed April 2016, energy.gov/eere/**wind/windexchange**

The Southeast has yet to witness sustained growth, but development interest persists as technology costs continue to fall.

Current Resource Cost Status

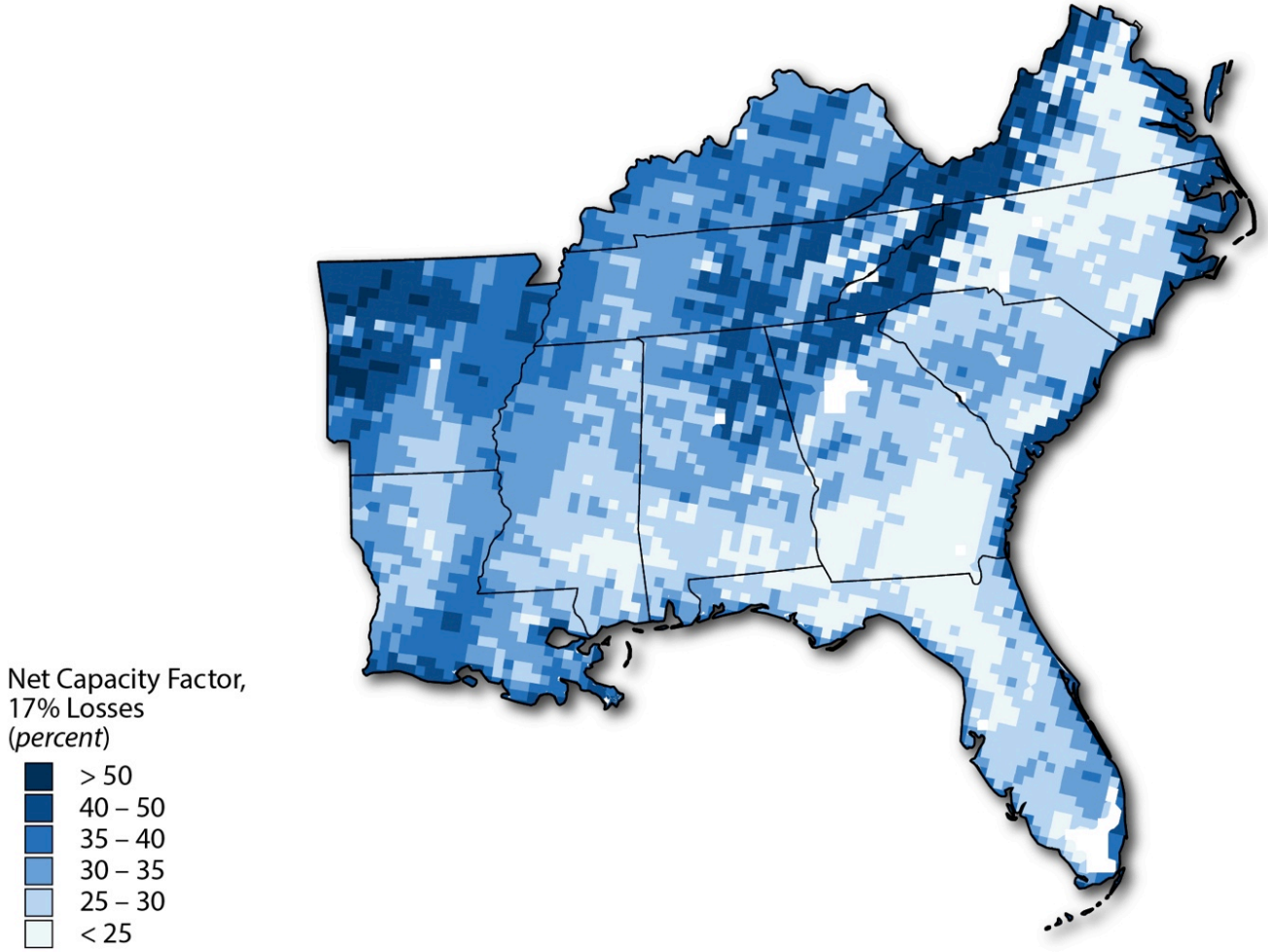
Wind Power Quantity at or below LCOE Cost Thresholds (PTC Not Included)



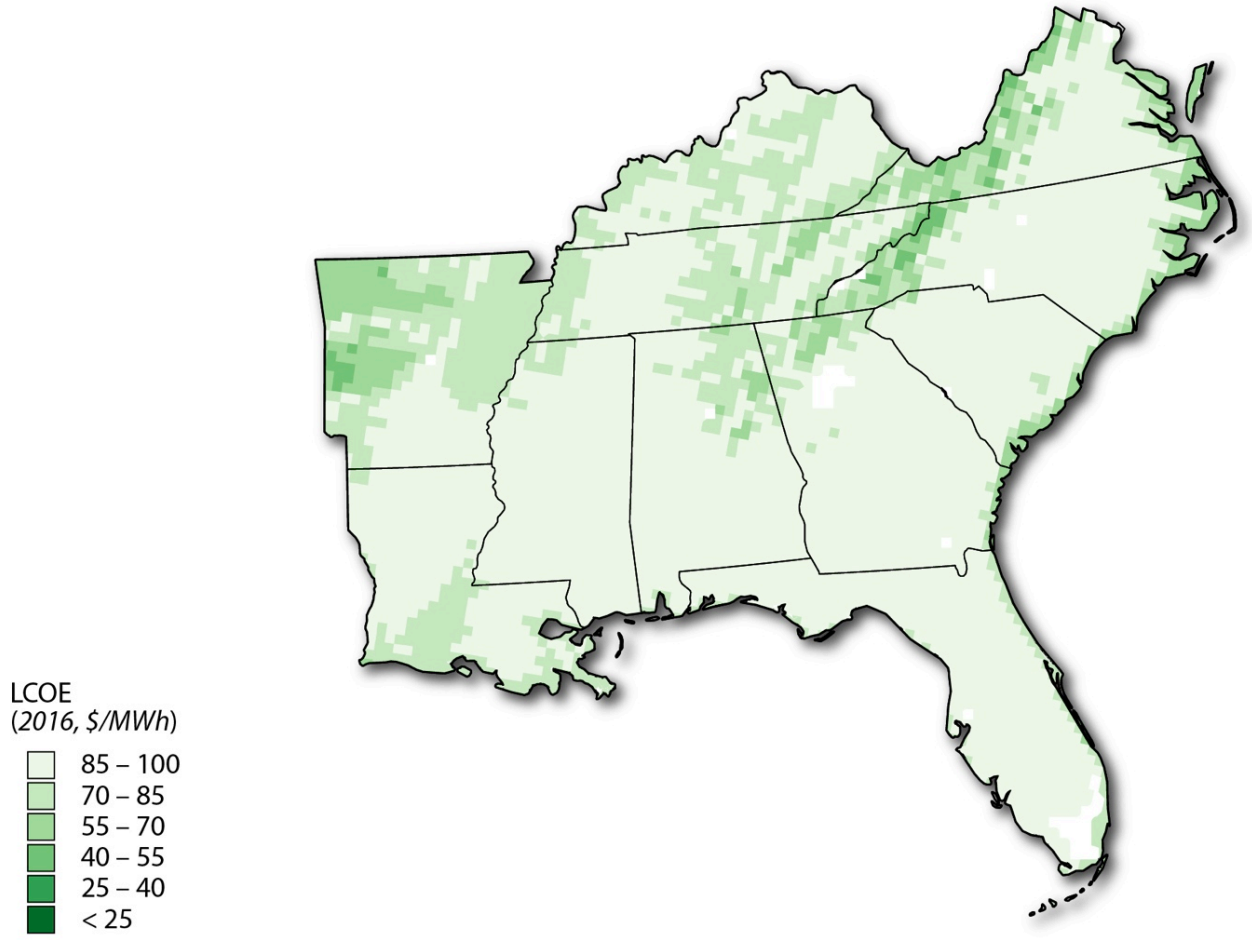
Estimated wind power costs include regional capital cost factors and intra-regional transmission "spur lines."

The Southeast is estimated to have approximately 2.9 GW that could compete with prices of $100/MWh and 0.8 GW that could compete with prices below $80/MWh.

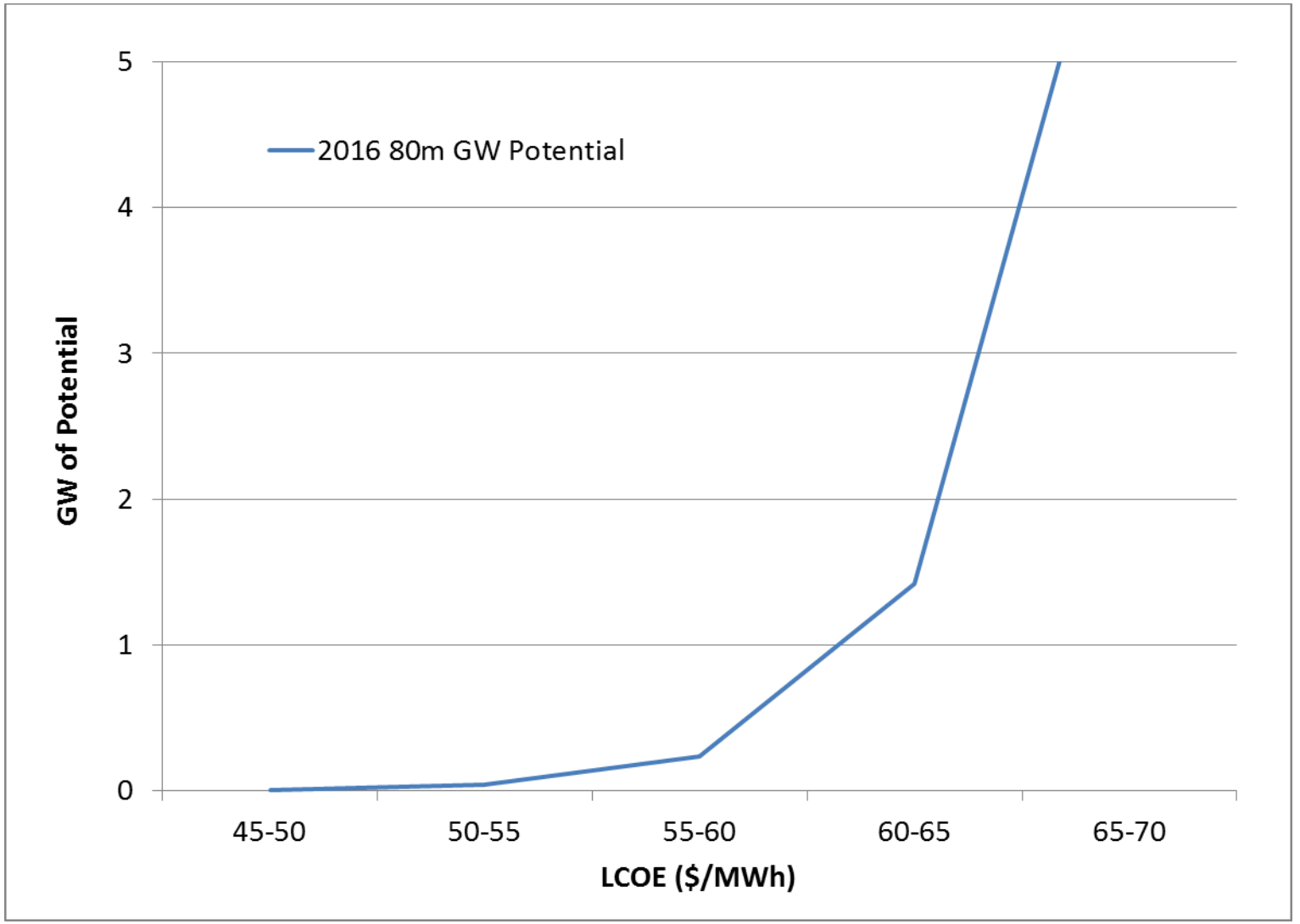
Capacity Factor at 80m ~3.5-MW Turbine



2016 LCOE Map at 80m ~3.5-MW Turbine



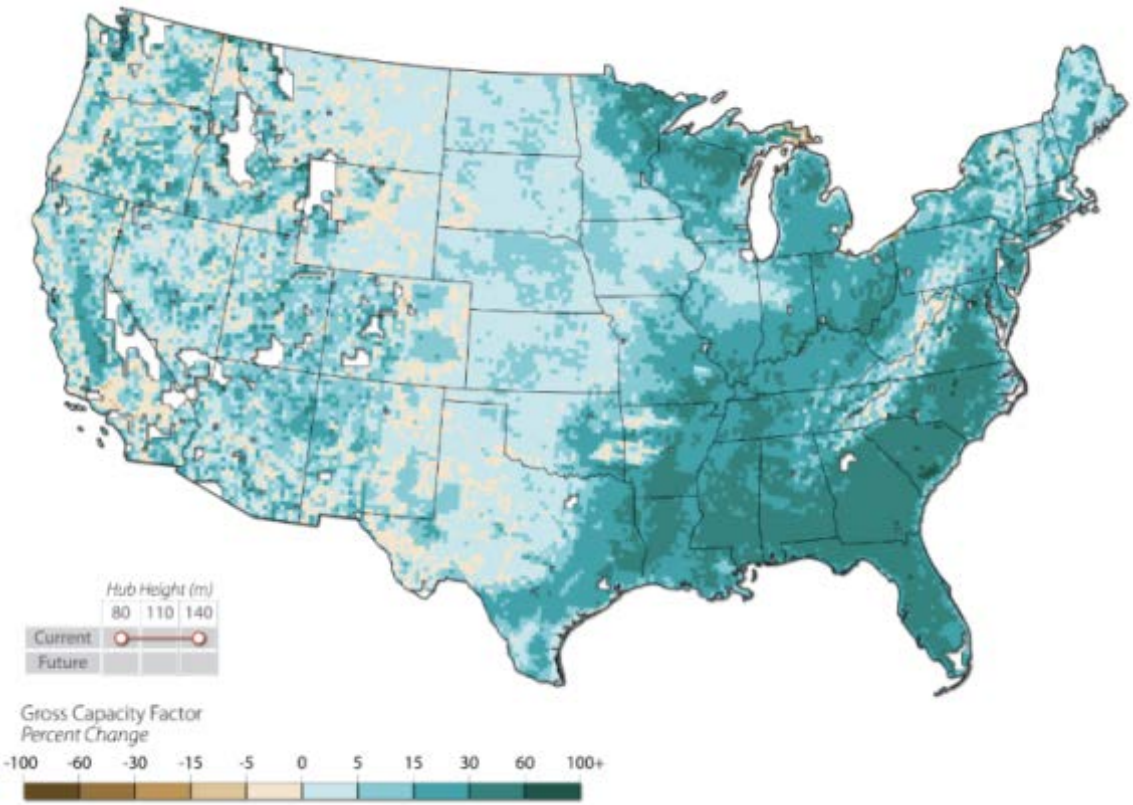
2016 Potential Capacity (GW) at 80m ~3.5-MW Turbine



Near Future Outlook:

110-m/140-m Hub Height

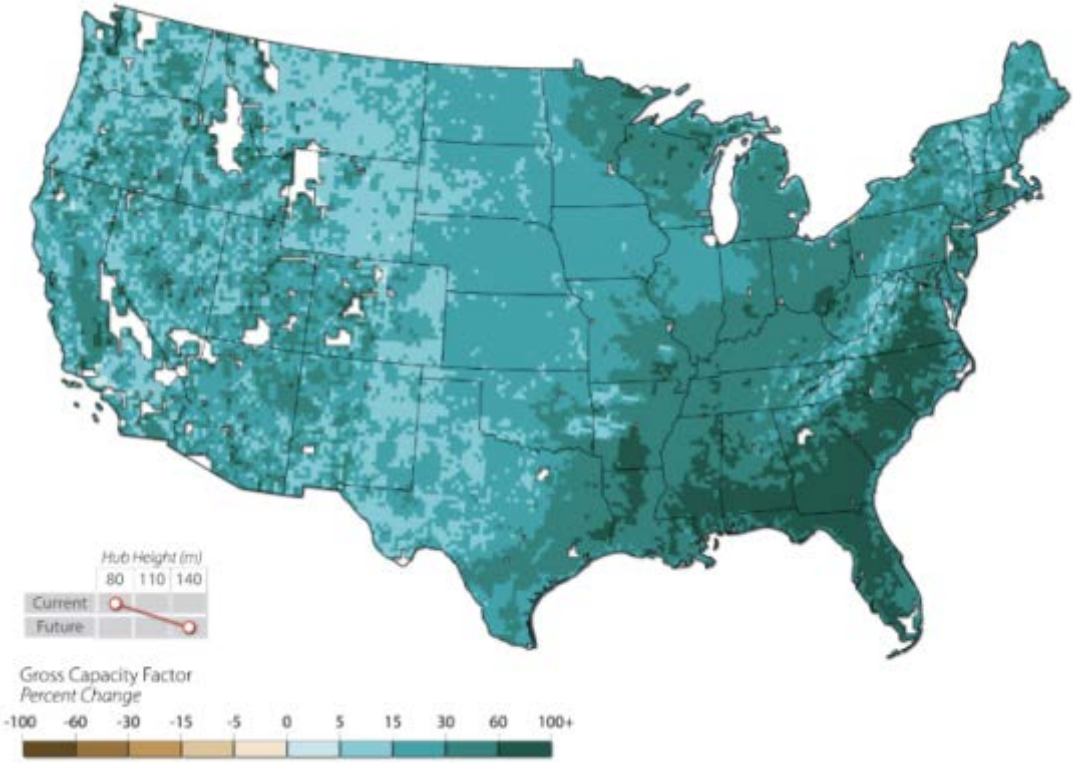
Potential Impacts on Capacity Factor from Tall-Tower Innovations



Underlying resource data are from AWS Truepower Mesoscale modeling. Data reflect the change in gross capacity factor when going from 80m to 140m based, with no other changes to turbine technology.

- Eastern U.S. regions have the most to gain from taller towers, based strictly on moving to higher hub heights.
- *Note: Individual site conditions may differ from those suggested by larger mesoscale resource data trends.*

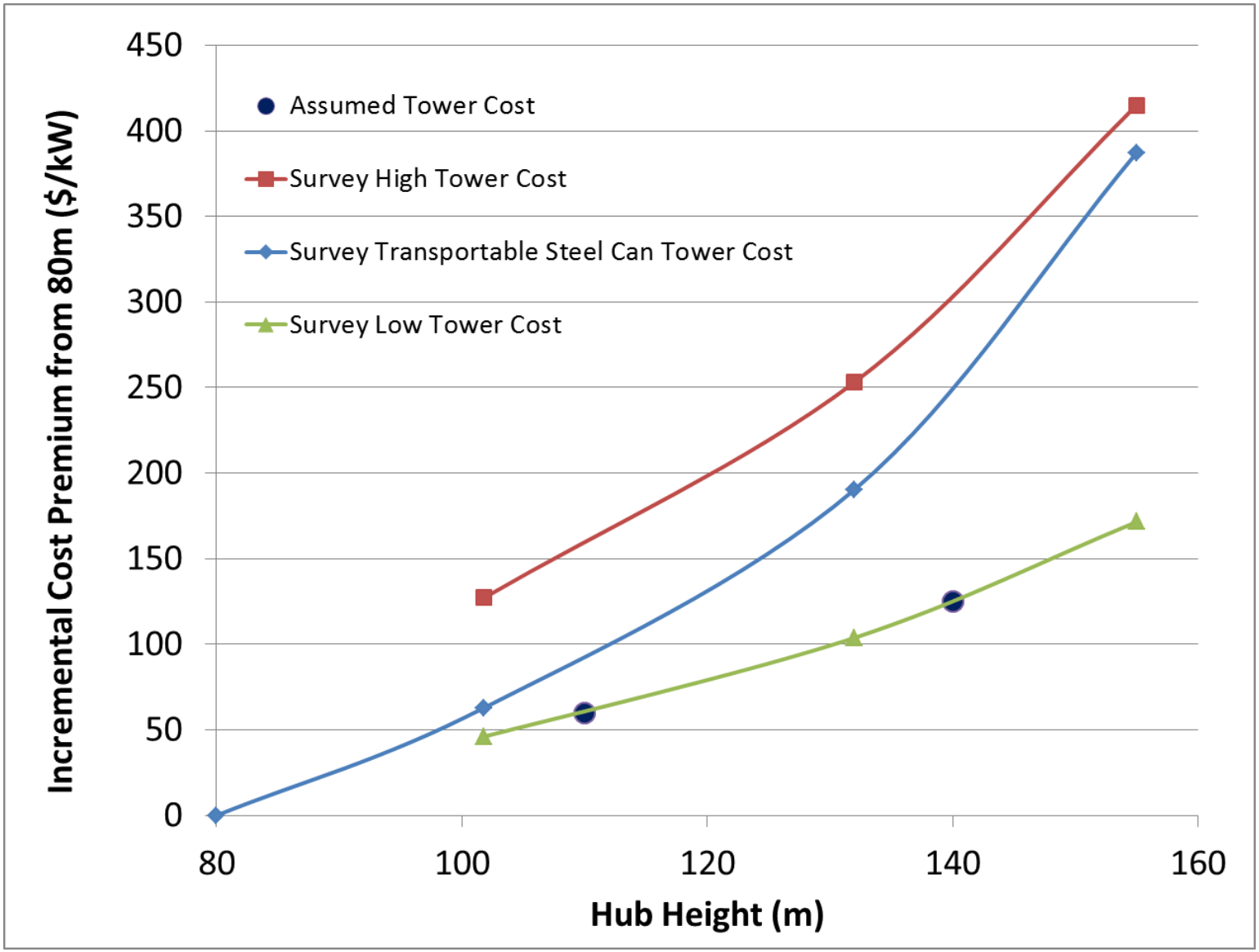
Potential Impacts on Capacity Factors from Tall Tower and Rotor Innovation



Underlying resource data are from AWS Truepower Mesoscale modeling. Data reflect the change in gross capacity factor when going from 80 m to 140 m with continued growth in rotor diameters (e.g., 122 m for IEC Class III turbines).

- Portions of the Southeast and Great Lakes could see capacity factor improvements approaching 100% (i.e., near doubling of capacity factors) as a function of higher hub heights and larger rotors.
- Although somewhat smaller on a percentage basis, improvements in the wind belt are also non-trivial.

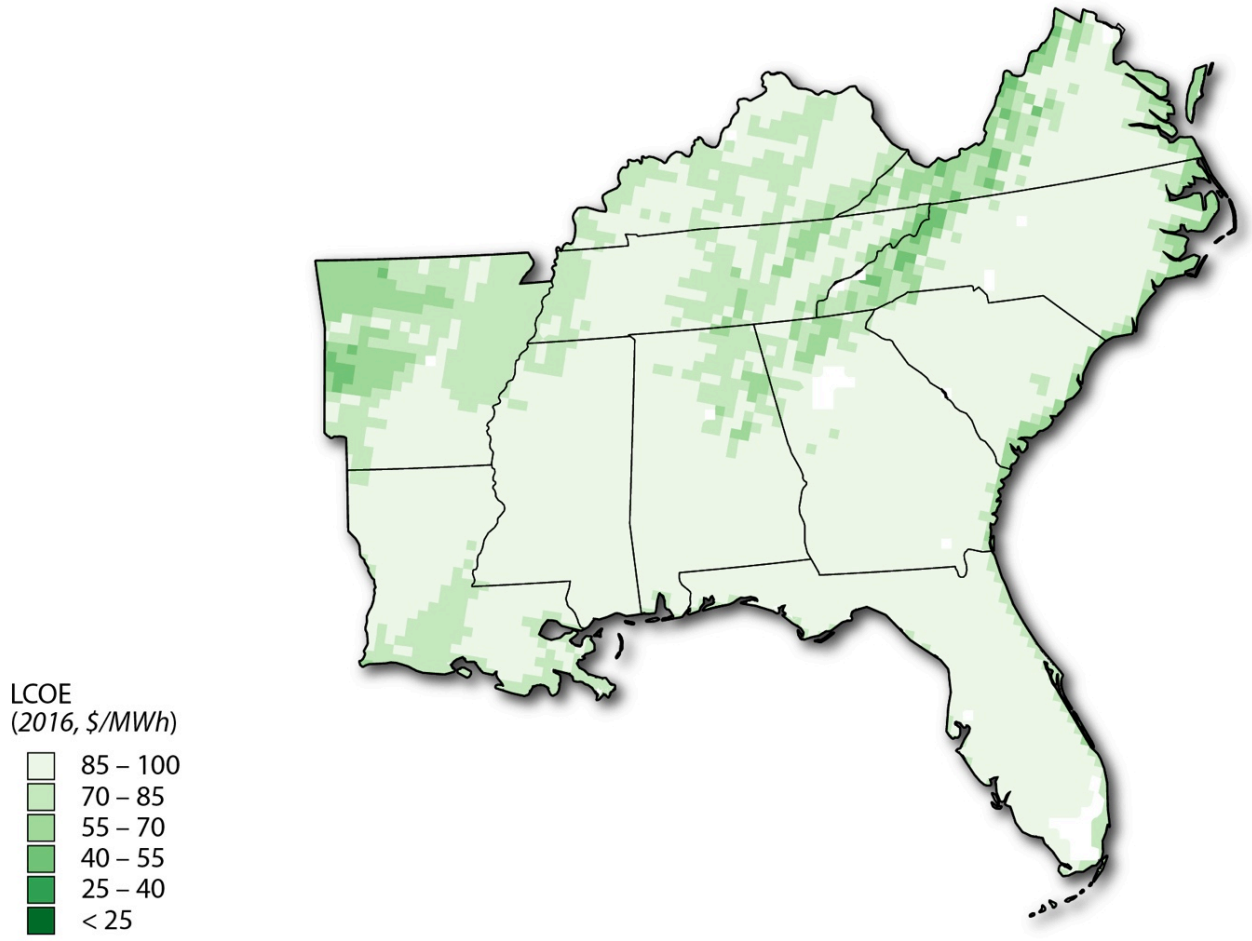
Tall-Tower Cost Assumptions



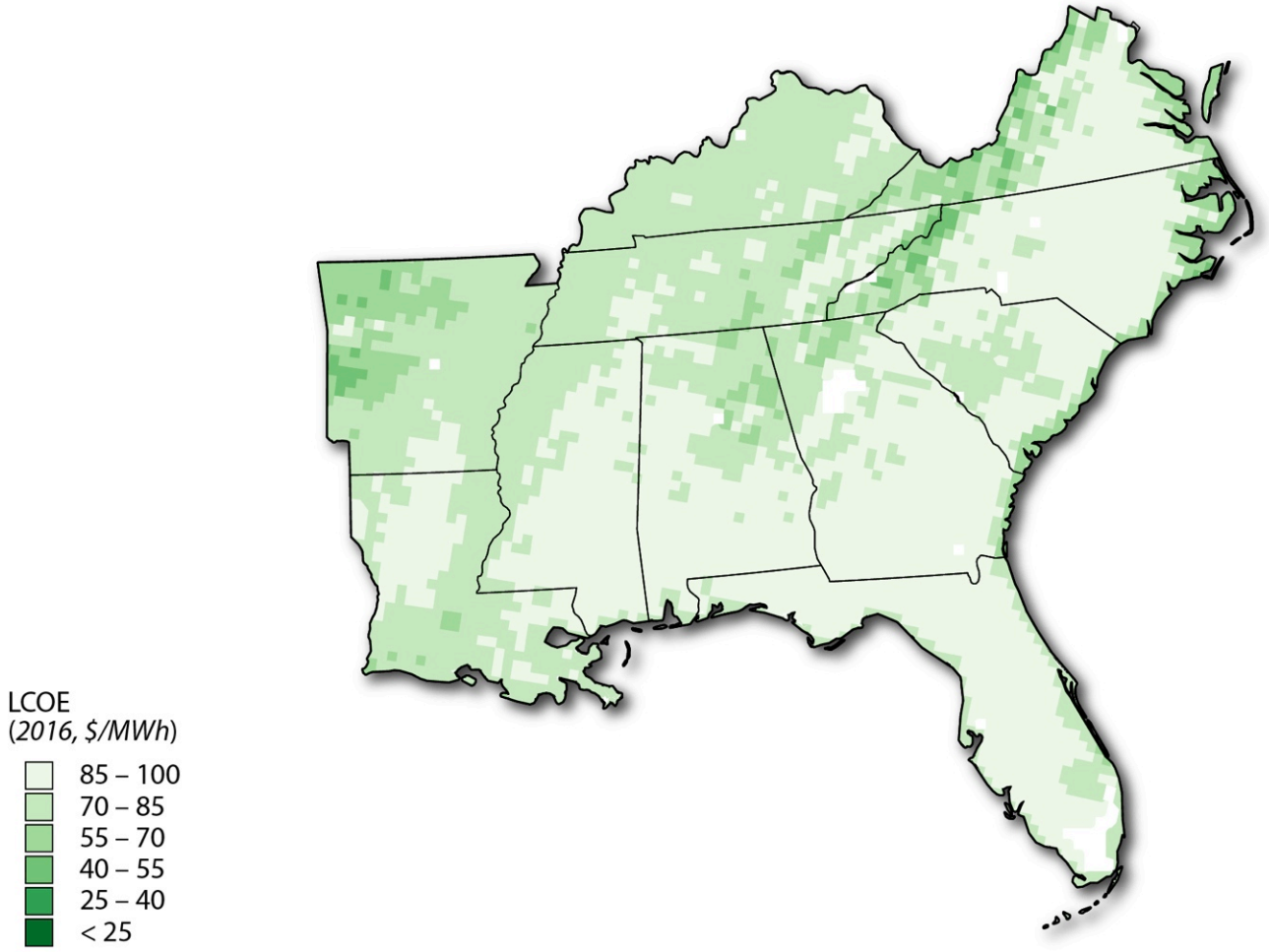
Tall-Tower Cost Assumptions

- Incremental costs for taller towers were estimated.
- Technologies considered include conventional transportable steel can towers, hybrid concrete/steel towers, full concrete, and spiral welded towers.
- Costs assume a ~3.5-MW turbine nameplate for cost scaling.
- Cost increase from 80 to 110 m ~$55-$70/kW.
- Cost increase from 80 to 140 m ~$125-$200/kW.

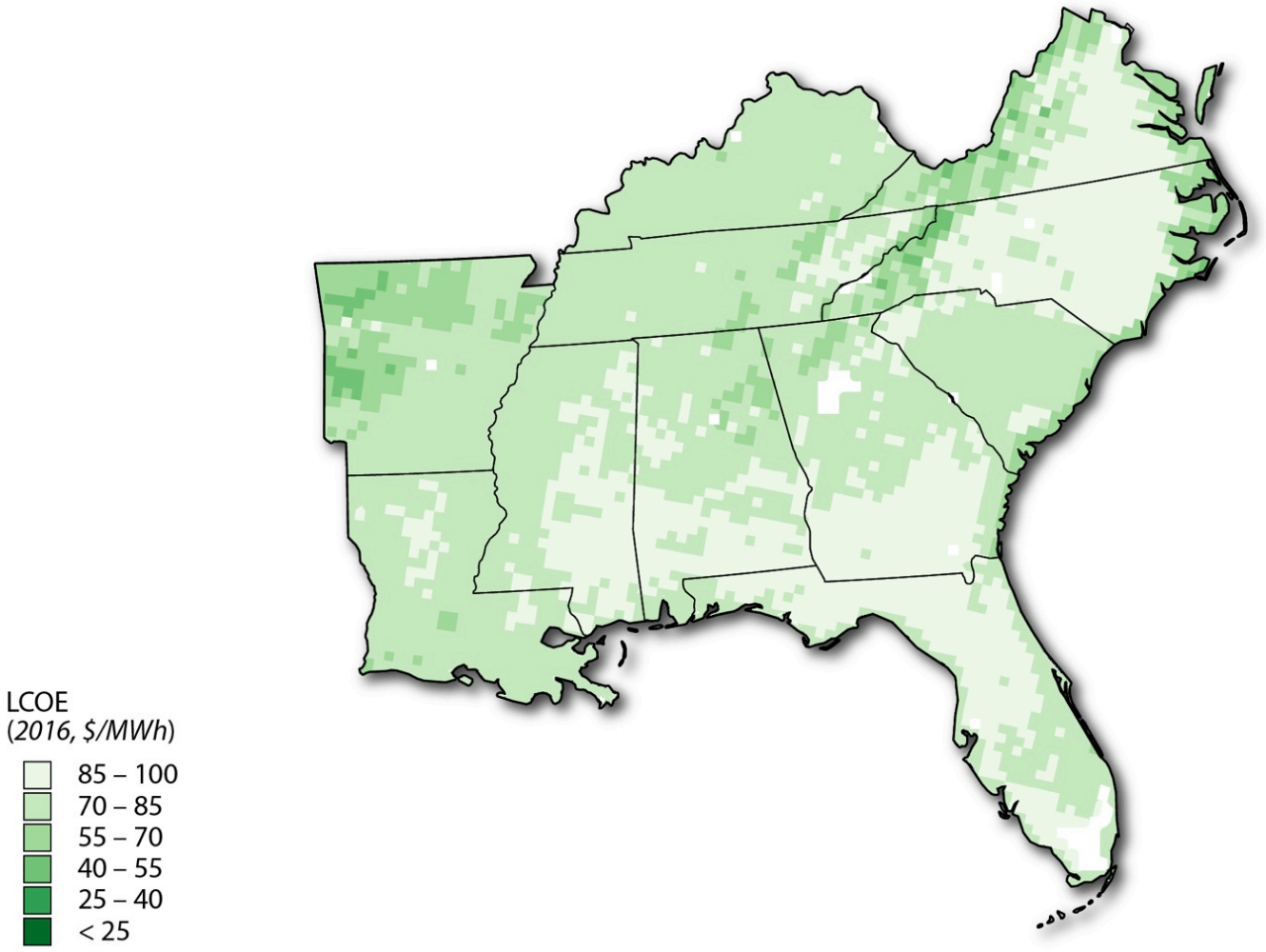
2016 LCOE Map at 80 m – Quick Flashback



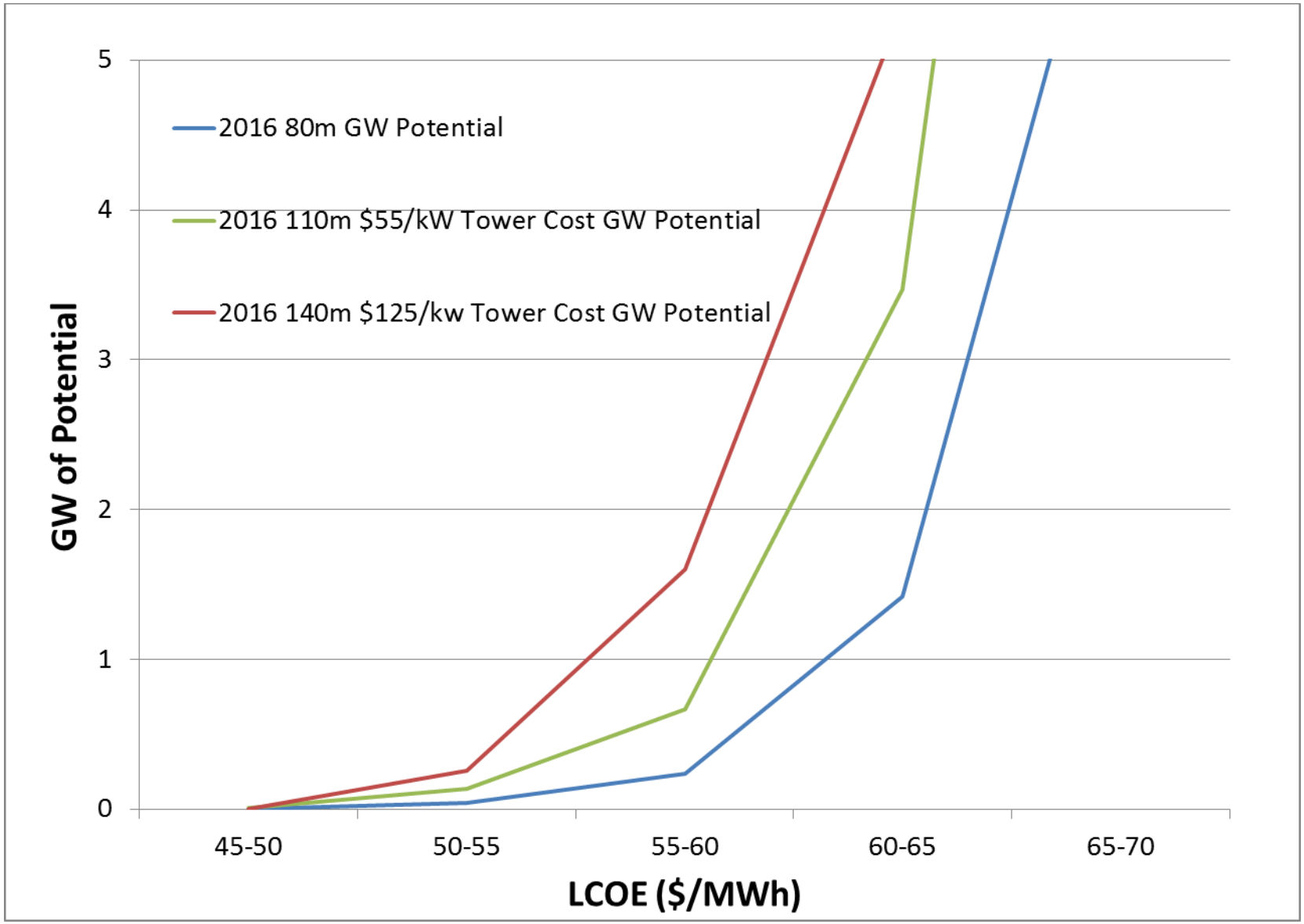
2016 LCOE Map at 110 m



2016 LCOE Map at 140 m



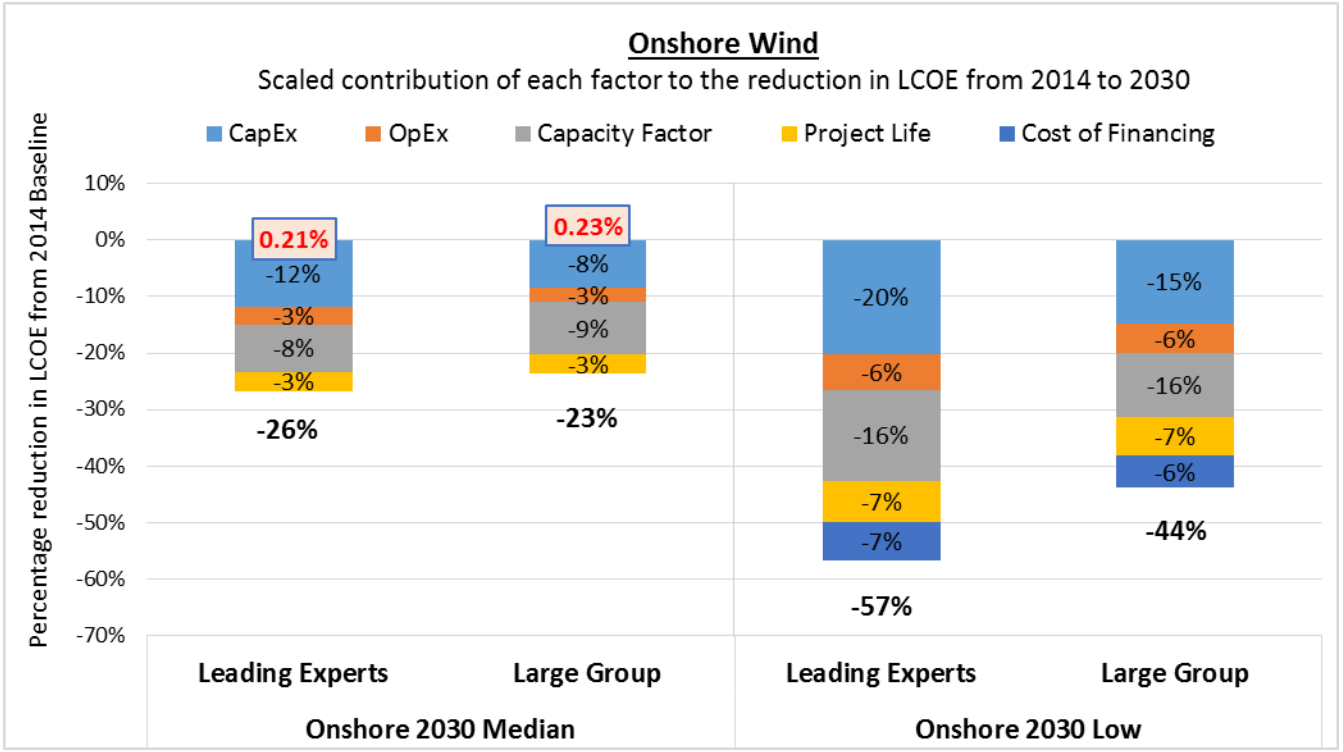
2016 Capacity Potential 110-m and 140-m Towers



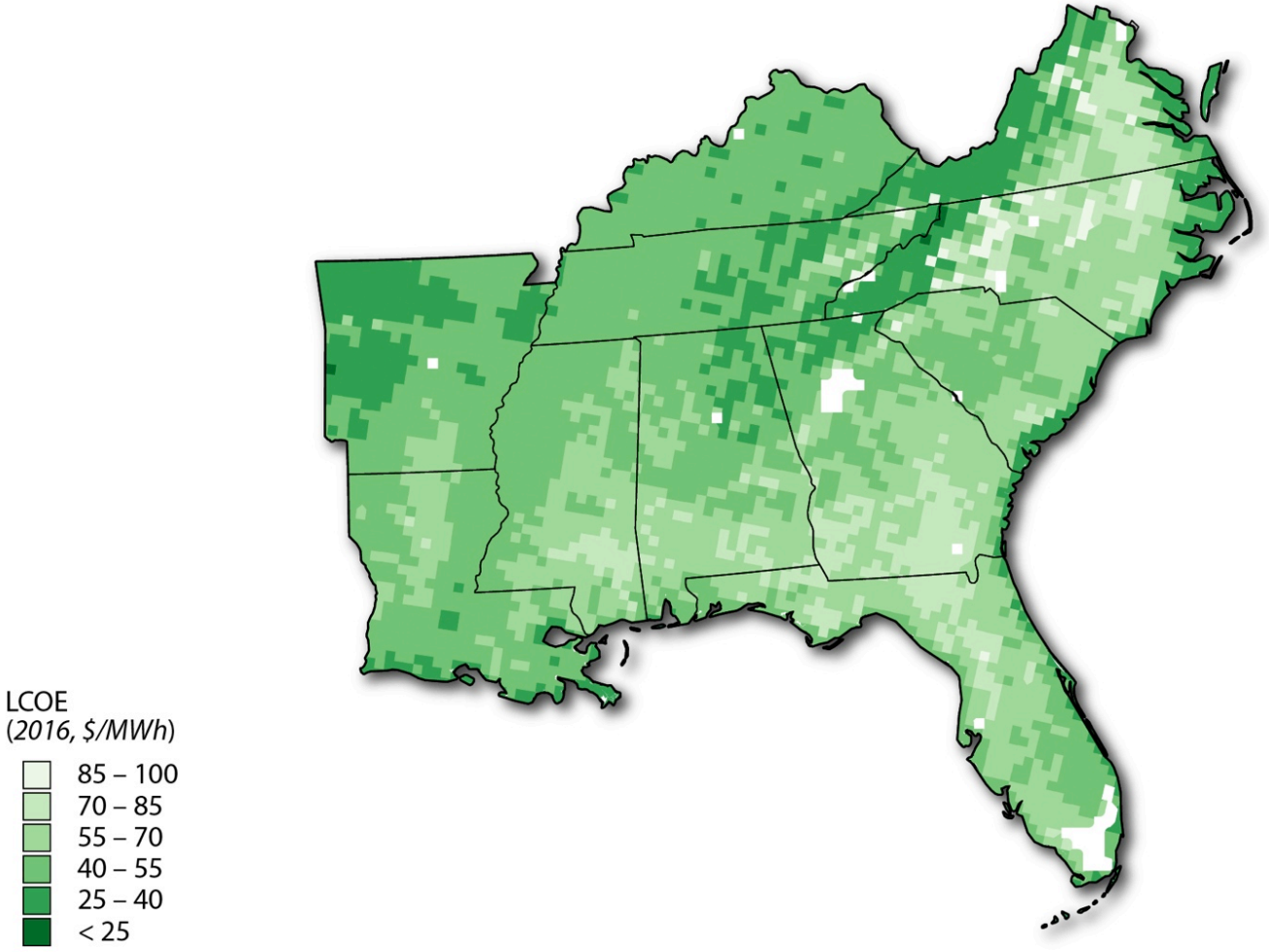
Future Cost Reductions:

2030 and Beyond

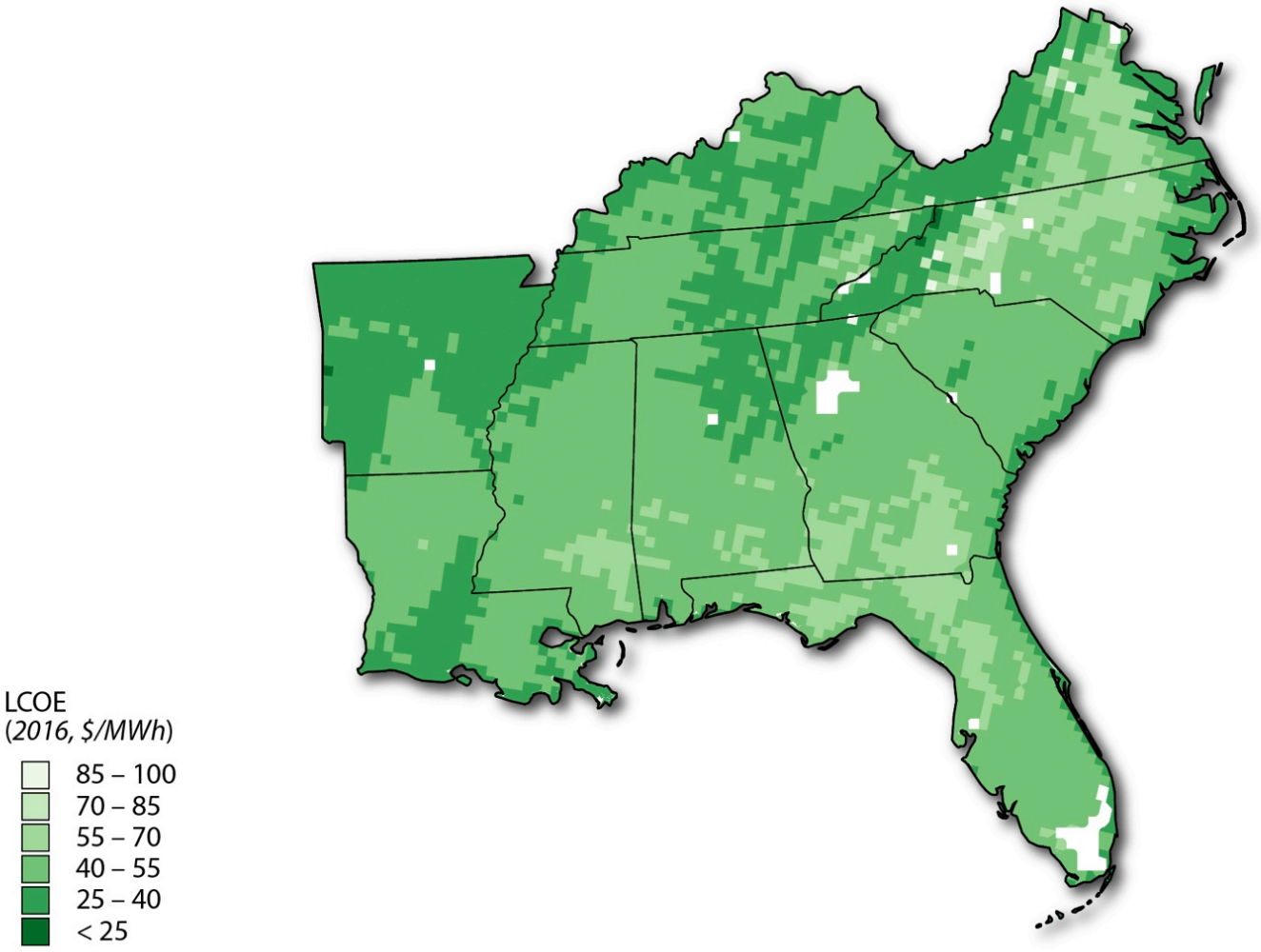
Assumptions for Future Technology



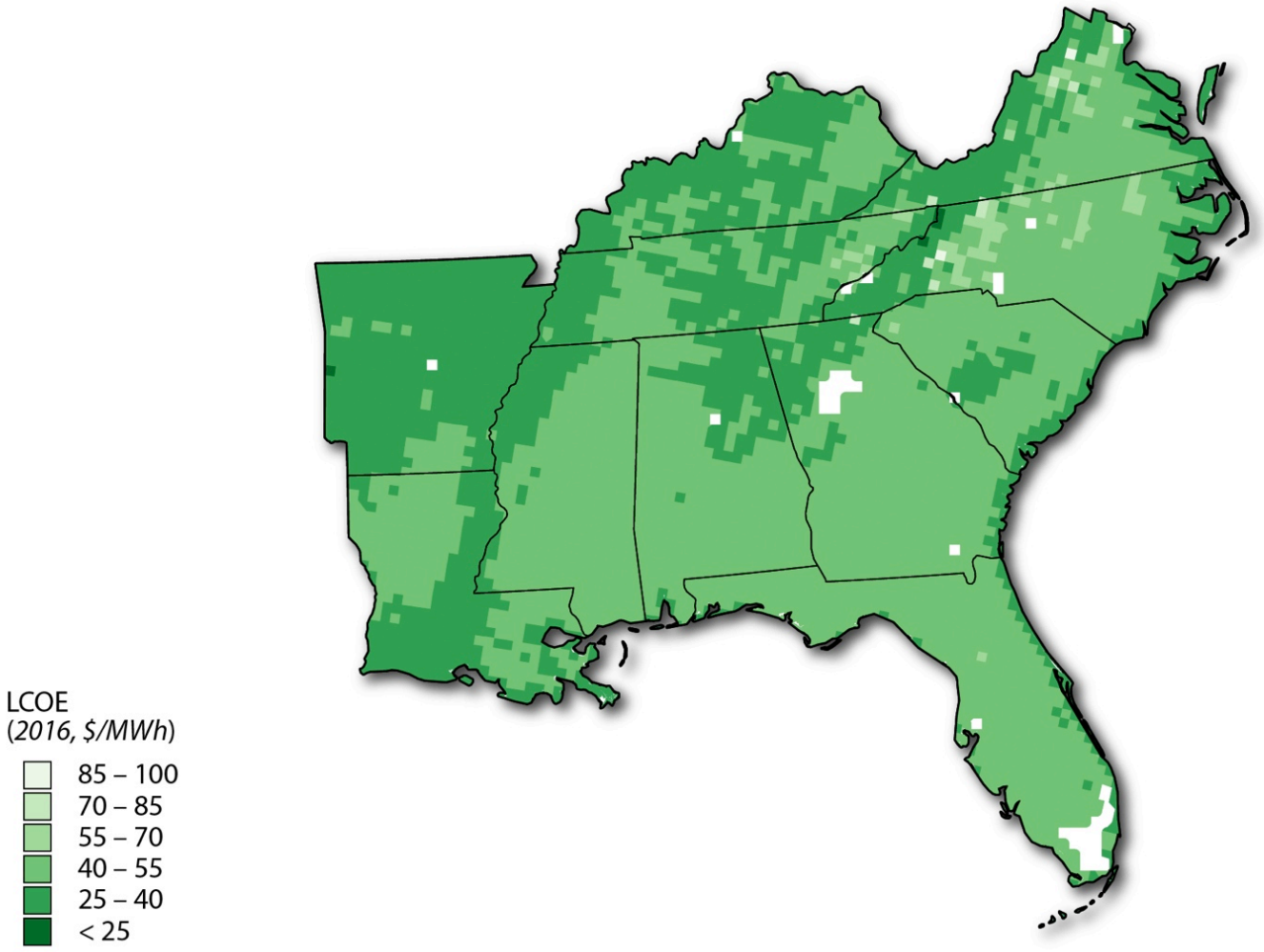
2030 LCOE Estimates at 80 m



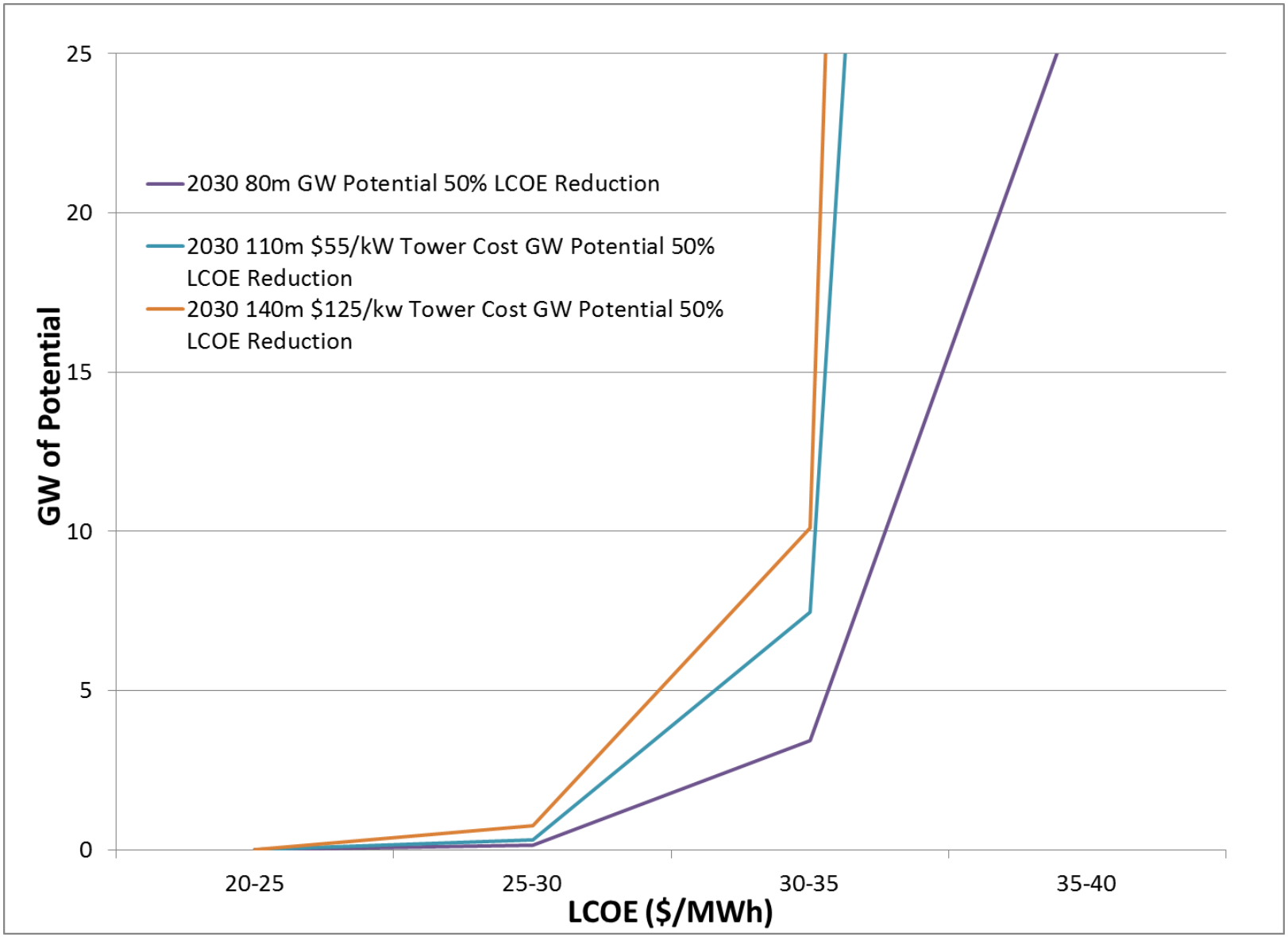
2030 LCOE Estimates at 110 m



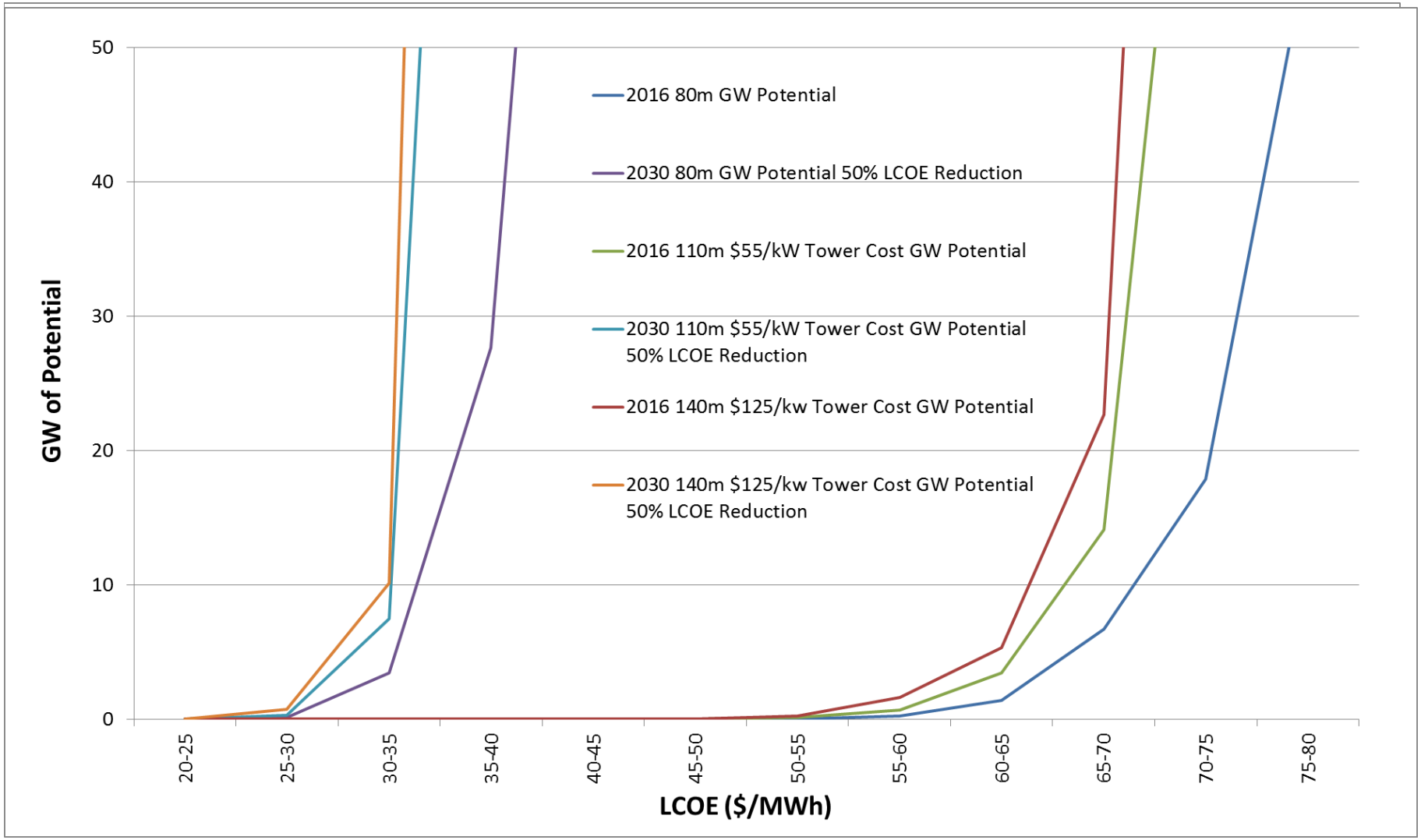
2030 LCOE Estimates at 140 m



2030 Capacity Potential with 50% Reduction in LCOE



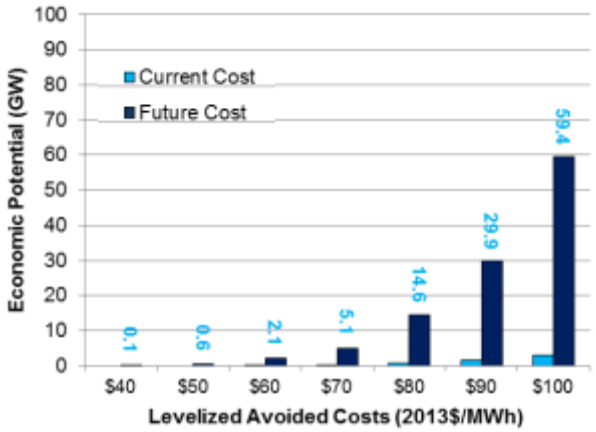
Comparative Look at Capacity vs. LCOE, 2016 vs. 2030



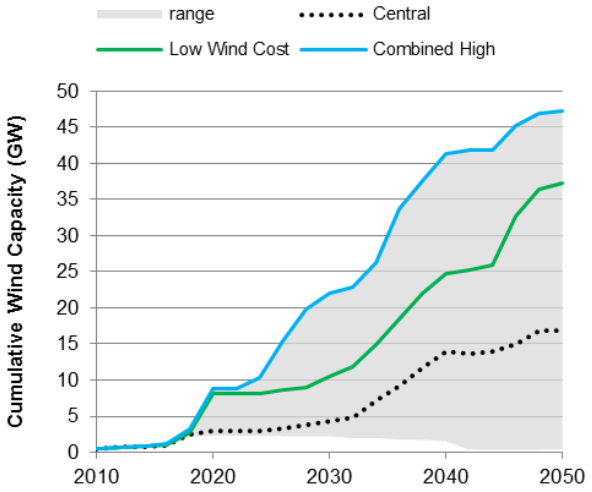
Focus Region Market Potential: 2015 - 2050

Future Wind Power Demand by Region in Specific Scenarios

Southeast



Estimated wind power costs include regional capital cost factors and intra-regional transmission "spur lines"



Combined High = Low Wind Cost (NREL ATB), High Natural Gas Prices (AEO 2015), and High Electricity Demand (AEO 2015)

- Wind technology innovation is an essential component of scenarios that see wind deployment growth in these regions; the relatively higher deployment scenarios require technology innovation and additional favorable conditions such as high gas prices and high load growth.

- Scenarios that limit transmission and emissions trading (under the CPP) also tend to increase demand in these regions, particularly in the Southeast.

Future Needs

- More resource data
- More resource validation
- Apples-to-apples comparisons of delivered COE estimates for Midwest wind
- Apples-to-apples comparisons of delivered solar PV costs
- Evaluation of capacity value for offshore wind, land-based wind, and PV.

Conclusions

- Wind works in the Southeast today at 80 m in some small pockets – and developers are starting to develop.
- Even more development is possible when you move to 110-m/140-m towers.
- If costs for tall towers decrease, there are more options for sites to develop.
- Tall wind innovations (including increased hub heights, larger rotors, and larger nameplate capacities) are anticipated to remain important drivers of future cost reductions and are particularly important for the Southeast.
- Focusing on aggressive technology innovation, the Southeast could see demand for 9 GW of new capacity by 2030.

Thank you!

Heidi Tinnesand
Engineer, NREL
heidi.tinnesand@nrel.gov
720-390-8784

For further information, contact:

Owen Roberts
owen.roberts@nrel.gov

Eric Lantz
eric.lantz@nrel.gov