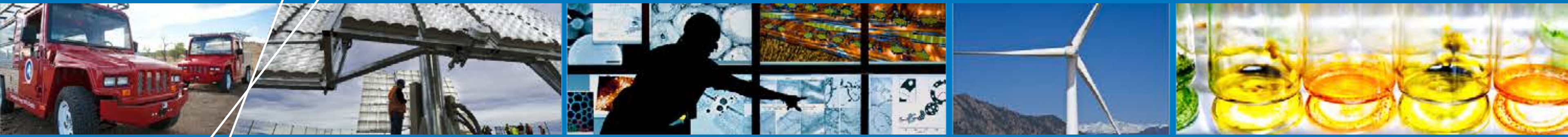
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Land-Based Wind Turbine Transportation and Logistics Barriers and Their Effects on U.S. Wind Markets



American Wind Energy Association (AWEA) WINDPOWER 2014 Conference

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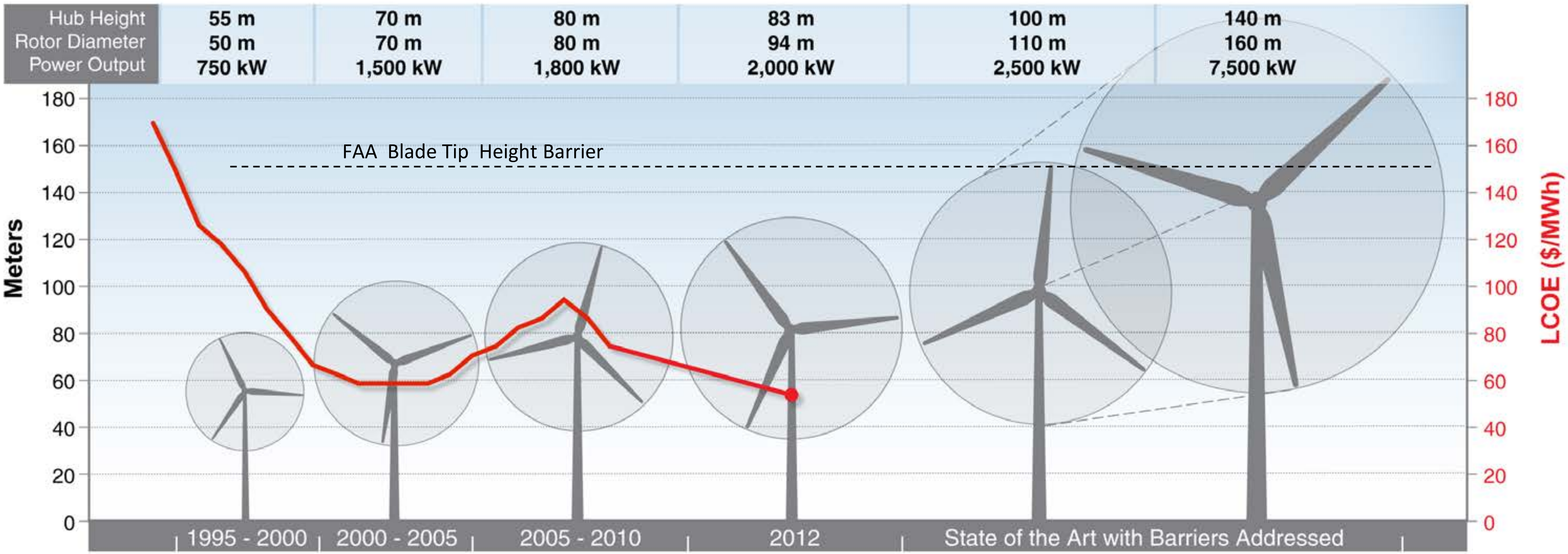
Reprinted with permission. Fischer, Martin. “World’s Largest Blade Begins Journey to Scotland.” SSP Technology A/S. July 17, 2013

Project Motivation and Objectives



Motivation: Transportation and logistics barriers limit

– Turbine size and height → – Levelized cost of energy (LCOE) reduction pathways → – Stakeholder support and market stability

– Development of new U.S. lands

– Manufacturing competitiveness

– Domestic content

Objectives:

– Identify U.S. logistical and transportation limits, barriers, and impacts

– Provide recommendations for strategies and specific actions.

Technical Approach

Identified mass, cost, and size breakpoints for blades, towers, and nacelles by:

- Performing interviews with wind industry project developers, original equipment manufacturers (OEMs), and transportation and logistics companies
- Reviewing published literature on trends and developments in increasing wind turbine size, logistics, and transportation issues.

Performed analyses to:

- Identify which transportation and logistics challenges affect wind plant installations today
- Determine the increase in turbine size that could be achieved if transportation and logistics challenges are solved.

Liebherr's 1,350 t hydraulic crane lifting tower section of Alstom's 3-MW ECO 100 wind turbine at the National Wind Technology Center

Photo by Lee J. Fingersh, NREL

Summary of Transportation and Logistics Barriers

Exceeding Federal Aviation Administration (FAA) blade-tip height

Trucking large-diameter towers

Hoisting larger nacelles onto taller towers

Trucking larger blades with wider chords

Trucking longer blades

Trucking larger blades with bigger root diameters

Trucking heavier nacelles

- Impacts U.S. turbine installations today
- Potentially impacts U.S. turbine installations today
- Potentially impacts future U.S. turbine installations

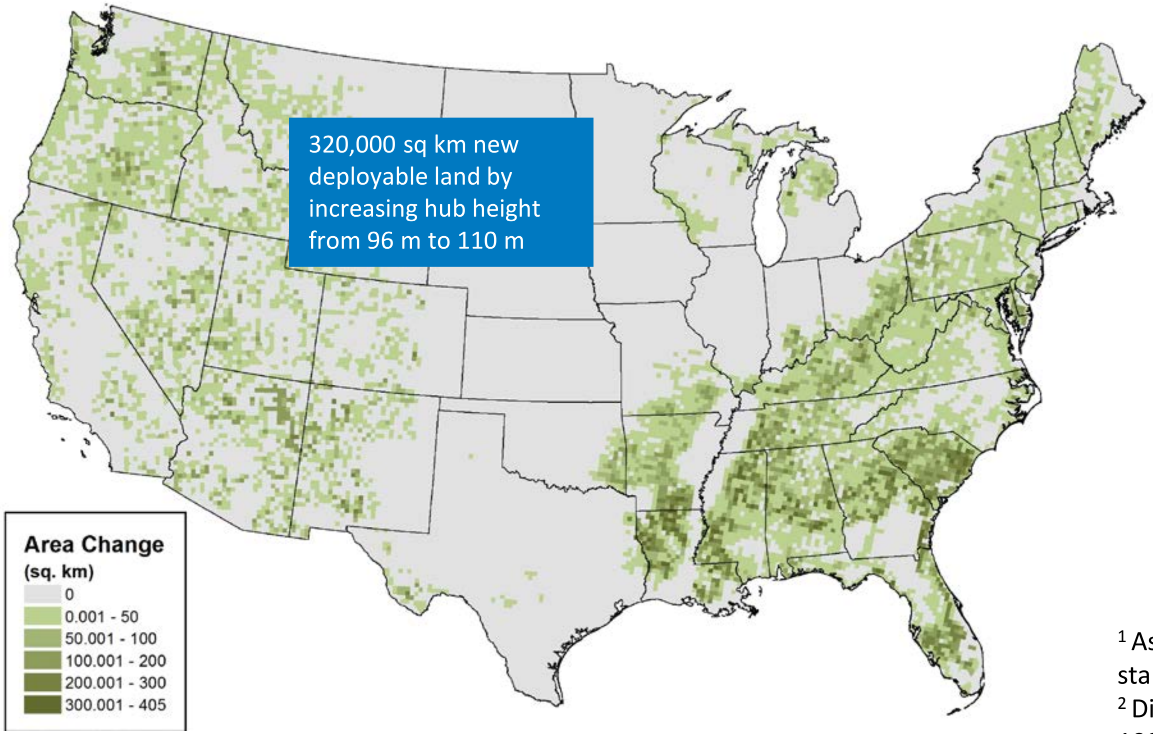
FAA Height Barrier

Barrier:

- Structures above 152 m trigger additional FAA lighting requirements and a review process that creates uncertainty and risk.

Barrier Impacts:

- Some U.S. OEMs and developers are unwilling to consider developments with blade tip heights above 152 m
- 320,000 sq km (~1,000 GW) new deployable land in low wind speed regions.[1,2]



Recommended Actions:

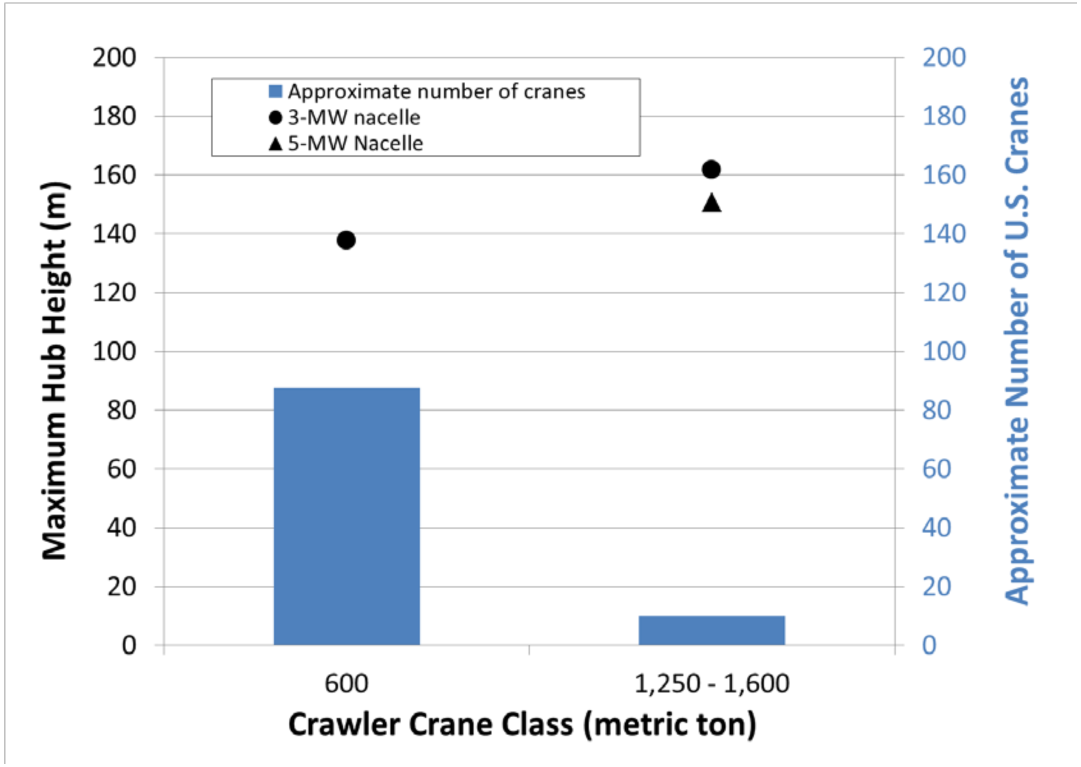
- Continue to work with FAA and stakeholders to improve the transparency of FAA lighting requirements above 152 m
- Further reduce uncertainty and risk by using demonstration projects.

[1] Assumes an enabling threshold of 30% gross capacity factor, standard land area exclusions, and 3 MW/sq km
[2] Difference between a 96-m and 110-m hub height for a GE 1.6-MW, 100-m rotor diameter

Nacelle Hoisting Barrier: Description

Current single-crane picks require rare, extremely large cranes to hoist nacelles of larger turbines, resulting in:

- Risk of crane shortages
- Wider wind plant access roads
- Limited access to complex terrain
- Smaller wind turbines and shorter towers.



Hub height that crawler cranes can hoist conventional turbine nacelles (with the gearbox and generator hoisted separately) and the number of cranes estimated to be available

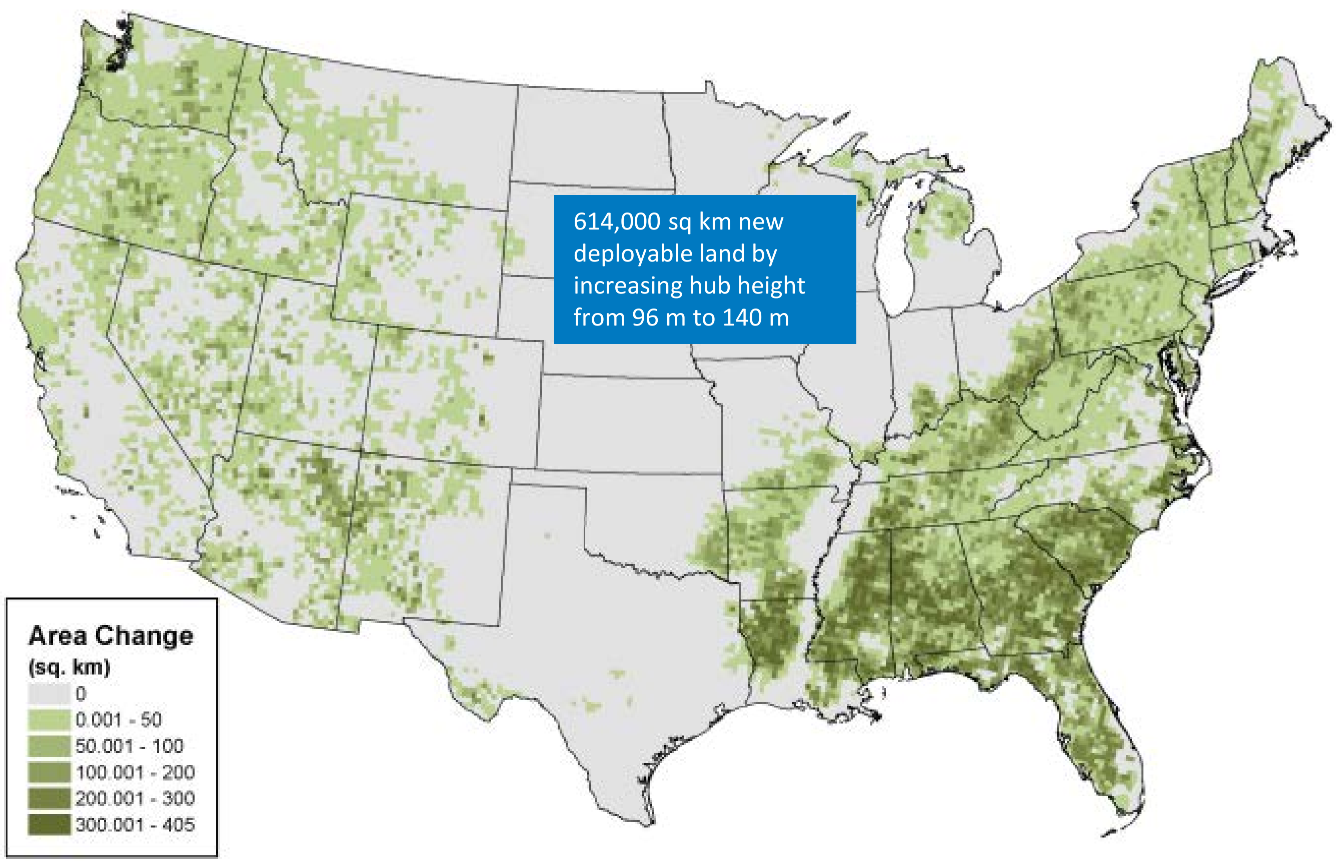
Nacelle Hoisting Barrier: Impact

Benefit of Addressing the Barrier:

– Nearly doubles the new deployable land to 614,000 sq km (~2,000 GW)

Recommended Action:

– Reduce uncertainty of multicrane lifts via stakeholder engagement and demonstration projects.



Blade and Tower Transportation Barriers

Blade designs are limited to lengths of ~62 m to accommodate turns and overhead traffic features


Photo by Sandia National Laboratories, NREL 17325


Photo by Jim Green, NREL 16178

Barrier:

– Dimensional and weight-transportation constraints increase blade and tower costs and limit deployment opportunities

Barrier Impacts:

– Smaller, structurally suboptimal (expensive) tower and blade designs

– Economic upper limit on turbine size

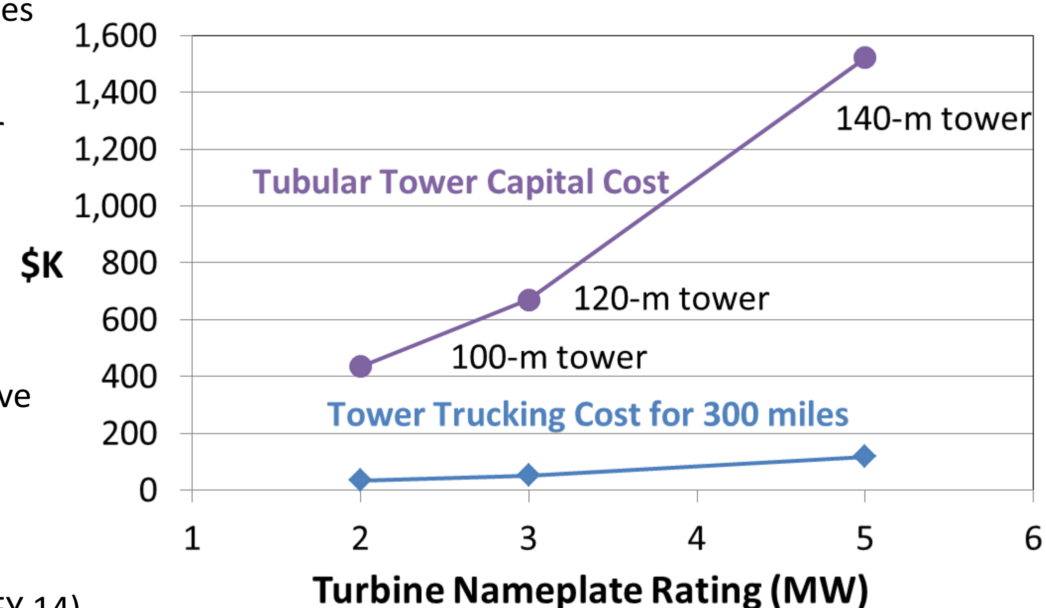
Recommended Action:

– Continued technology development and demonstration of segmented blades and alternative tower manufacturing and assembly methods

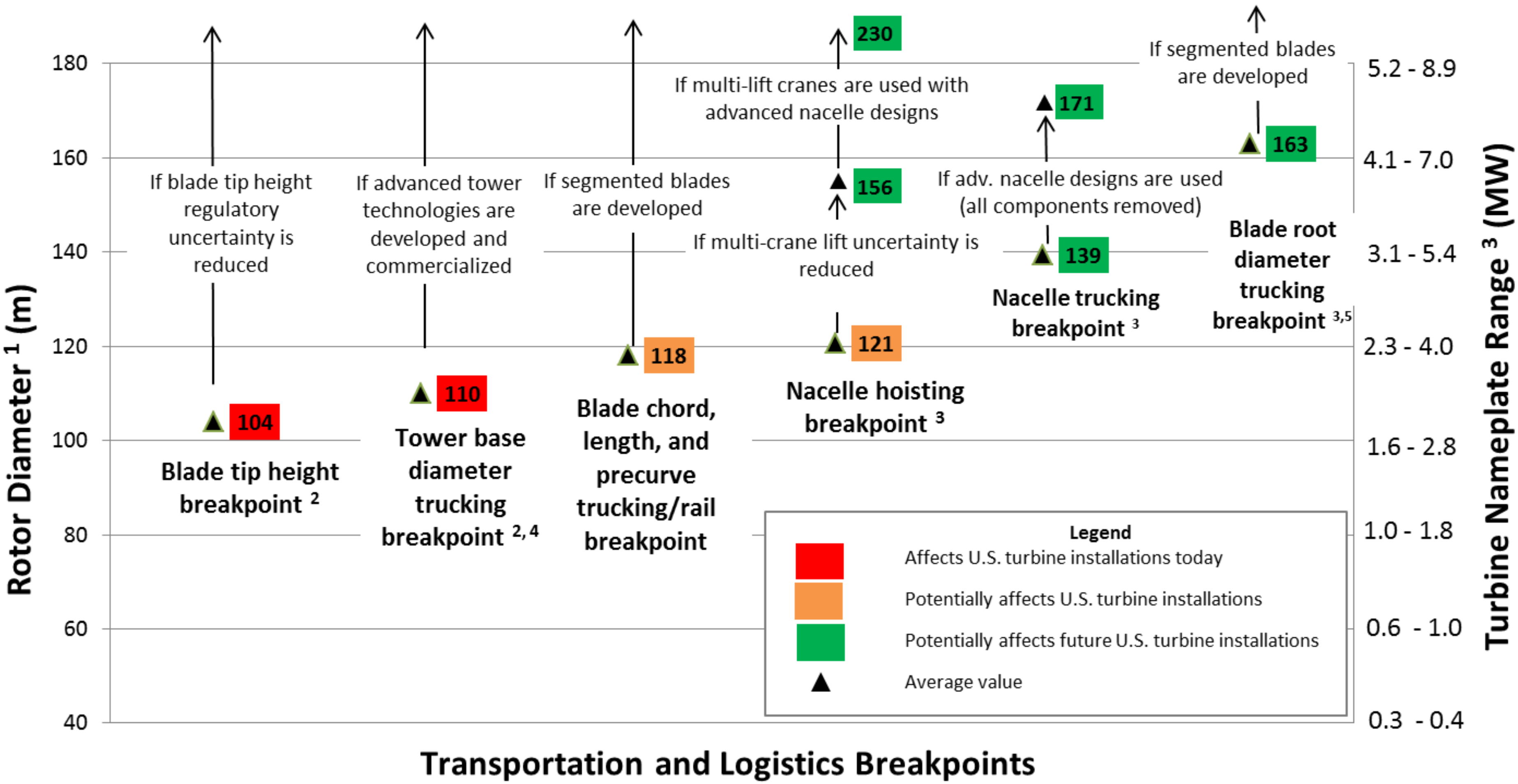
Benefits:

– New LCOE reduction pathways

– New deployable land area (will be estimated in FY 14).



Potential Impacts of Mitigating Barriers

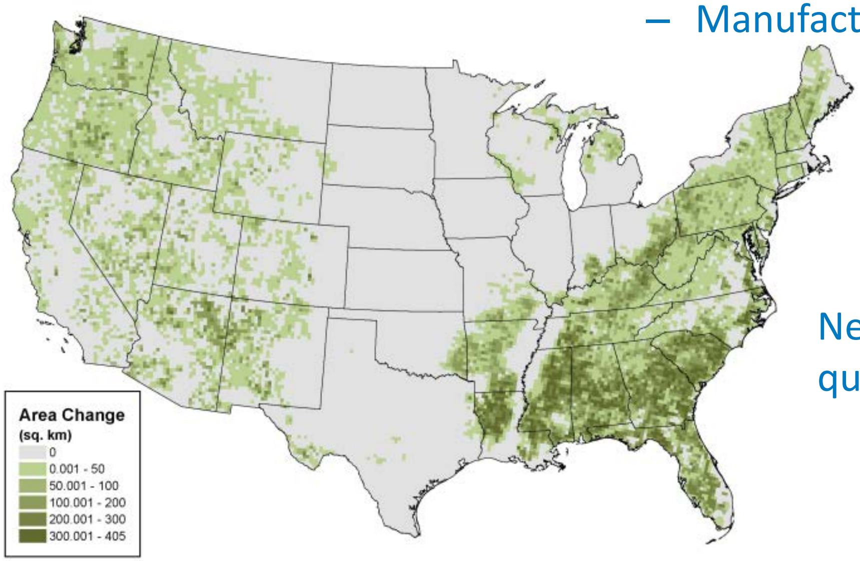


Footnotes
1. The variability in rotor diameter reflects the variability in U.S. wind turbine design parameters (specific power rating, tower heights, blade precurve, etc...); the variability does not reflect the uncertainty or error in the data
2. Assumes hub height range of 80 m to 120 m
3. Assumes specific power rating range of 204 to 350 W/m2
4. Assumes rotor diameter to tower height ratio of 1.1
5. The very strong correlation between blade root diameter and blade length results in a negligible range of rotor diameters.

Summary and Next Steps

Addressing transportation and logistics barriers provides long-term economic benefits by:

- Enabling larger, taller turbines
  - Providing LCOE reduction pathways
  - Unlocking new U.S. land for deployment (~ 3,000 GW)
    - Improving stakeholder support and market stability
    - Manufacturing competitiveness and domestic content.



Next, to estimate the deployment rate, we need to quantify:

- System cost of energy
  - Costs for big advanced turbines
  - Installation costs
- Permitting and regulatory requirements.

For more information, see the associated NREL technical report: *Analysis of Transportation and Logistics Challenges Affecting the Deployment of Larger Wind Turbines: Summary of Results* http://www.nrel.gov/docs/fy14osti/61063.pdf