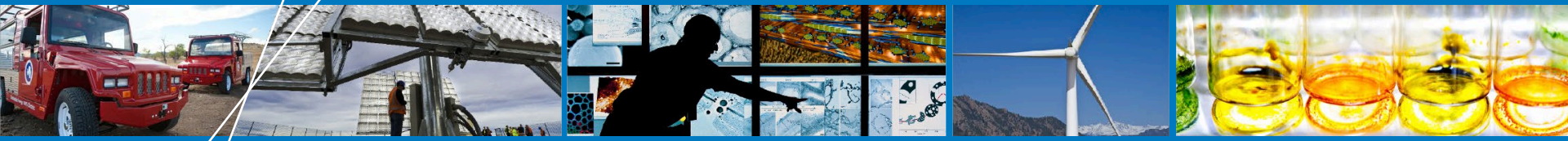
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Technologies Taking Us There



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National Renewable Energy Laboratory

Wind Energy Industry Symposium
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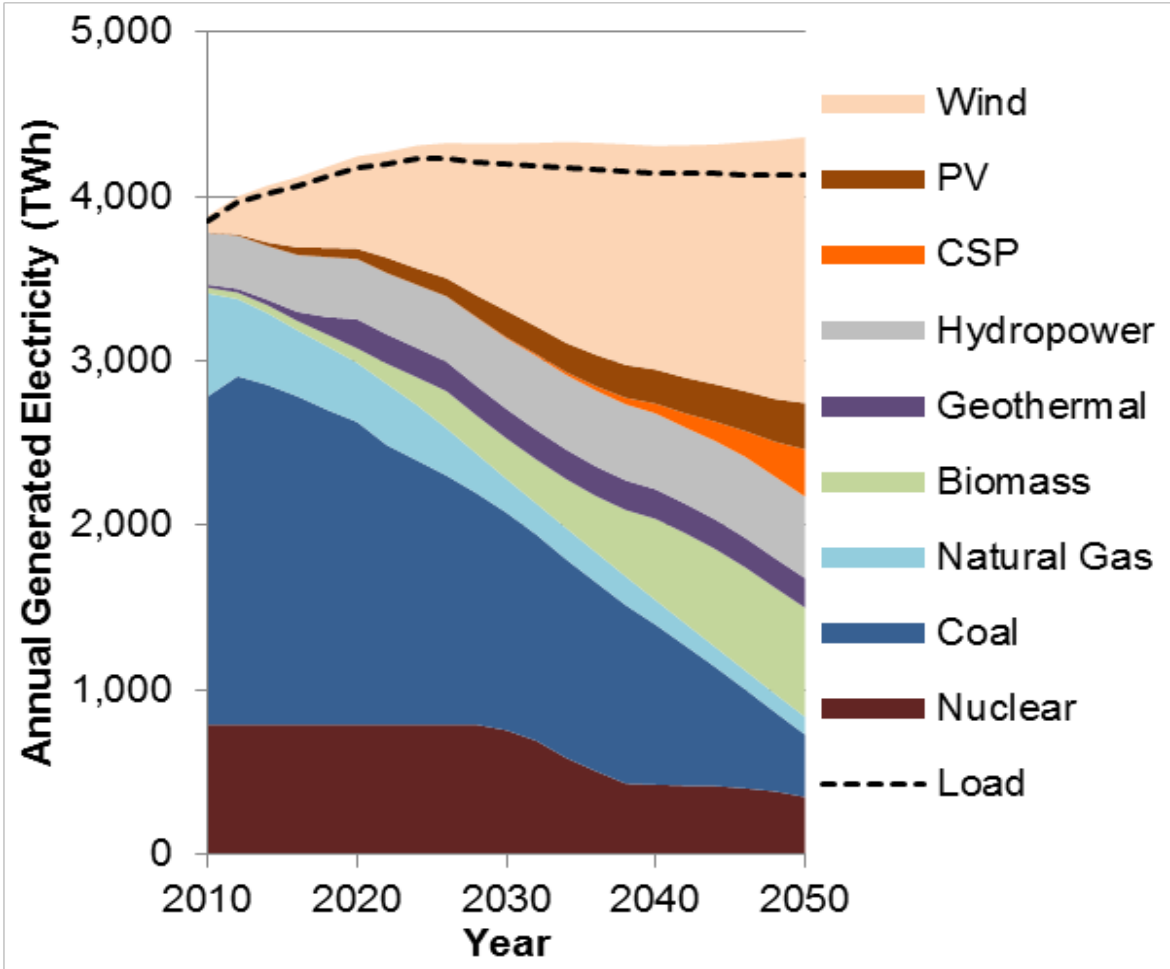
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

A Major Shift to Renewables in the United States Will Depend on an Even Higher Percentage of Wind

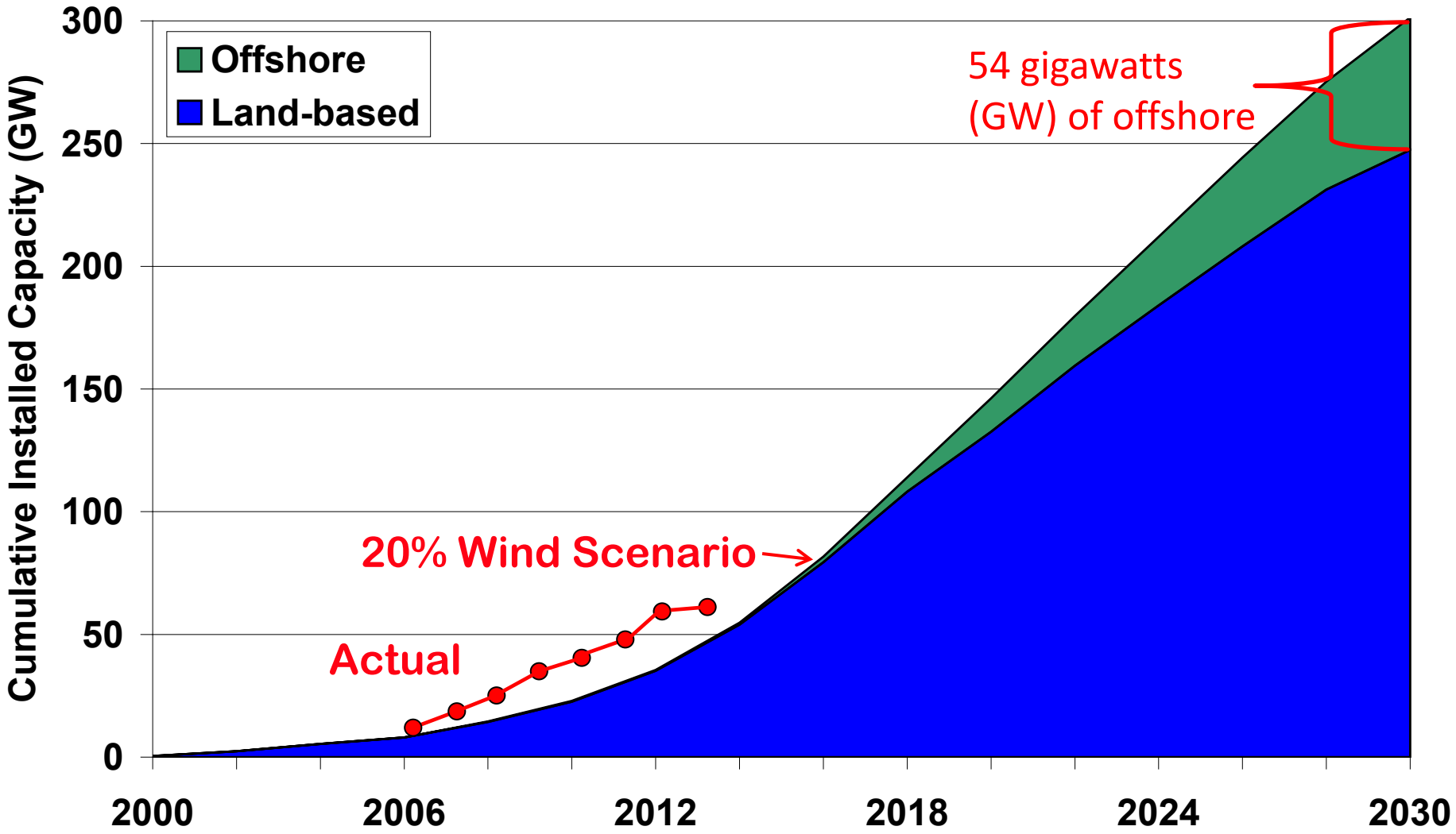
The Renewable Electricity Futures (REF) Study examined high renewable penetration (by 2050)

- **Wind must supply 40%** of electricity in the long term for an 80% renewables scenario

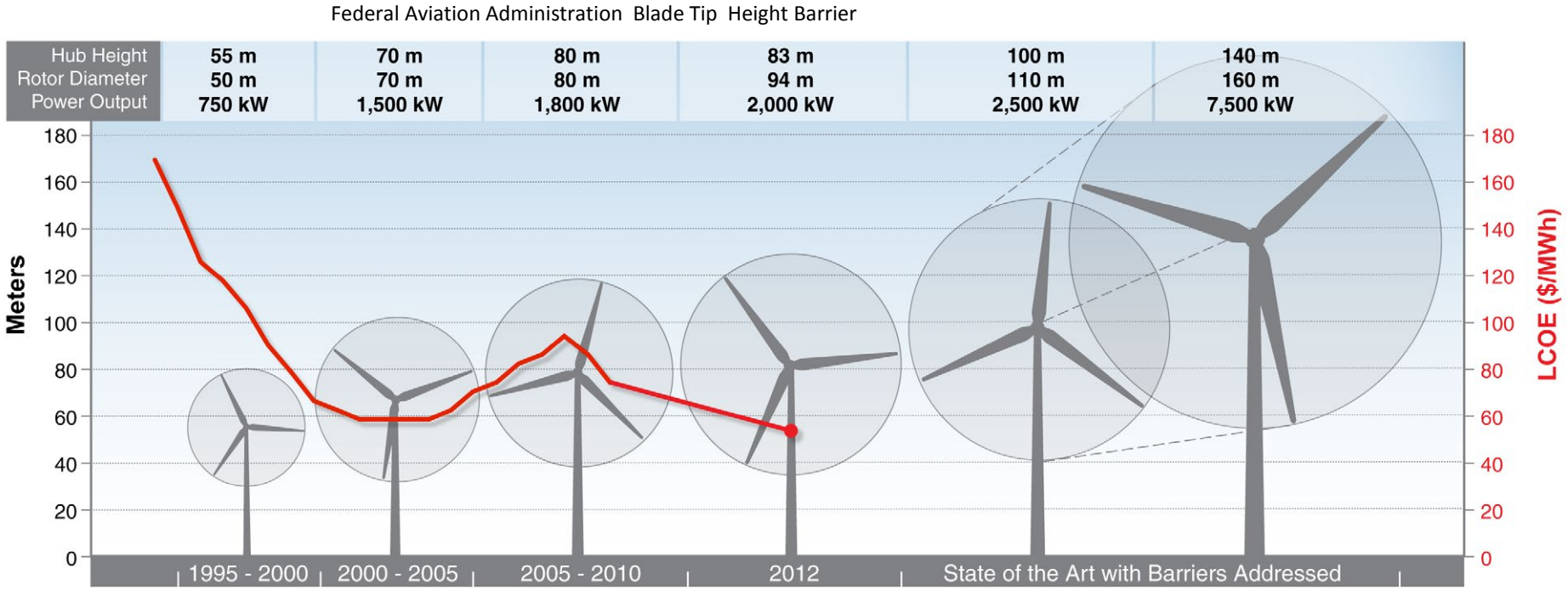
80% REF scenario



20% Scenario for U.S. Electricity – Update



Historical Levelized Cost of Energy (LCOE) and Wind Turbine Size



kW: kilowatt

MWh: megawatt-hour

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

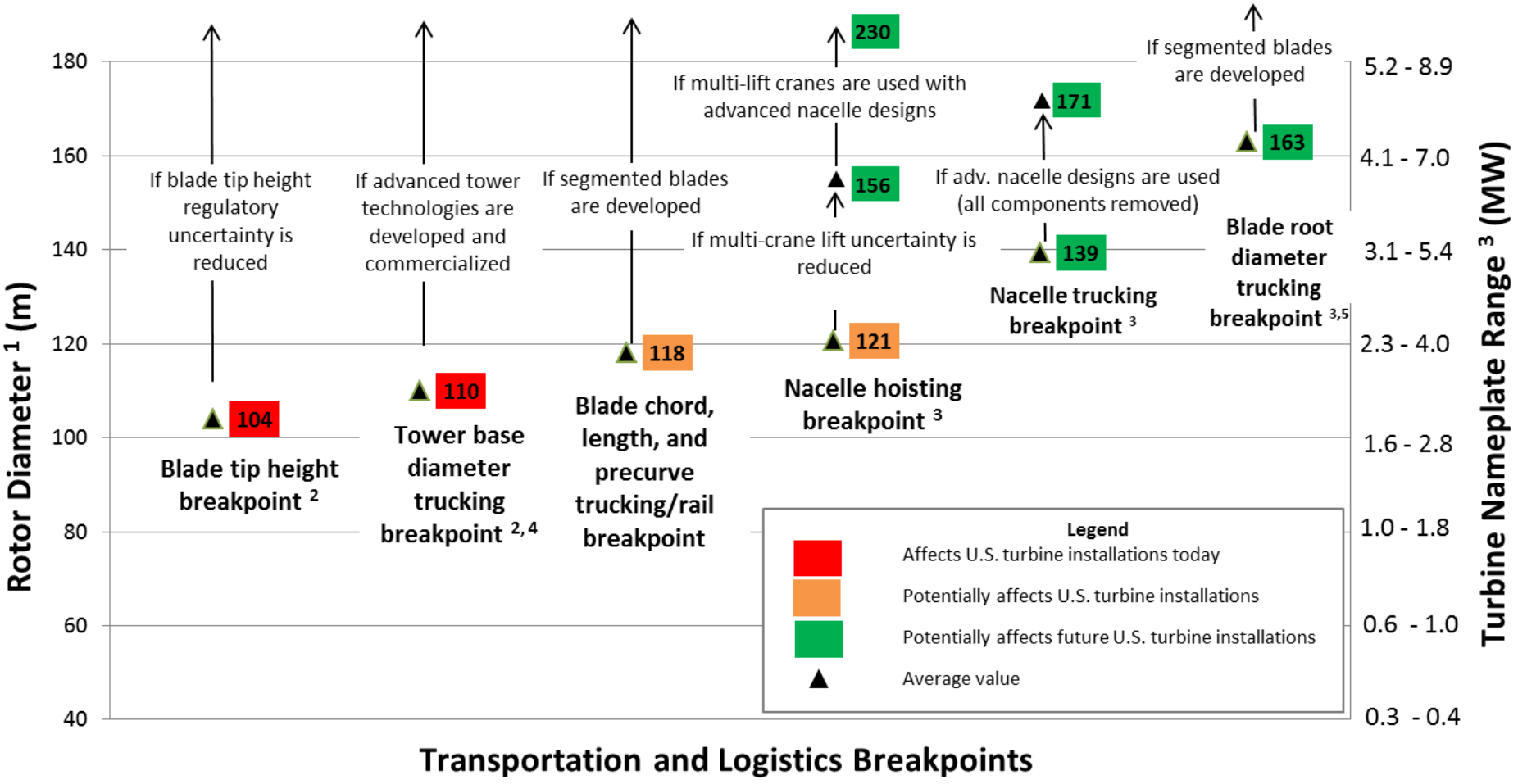
Trucking longer blades

Trucking larger blades with bigger root diameters

Trucking heavier nacelles

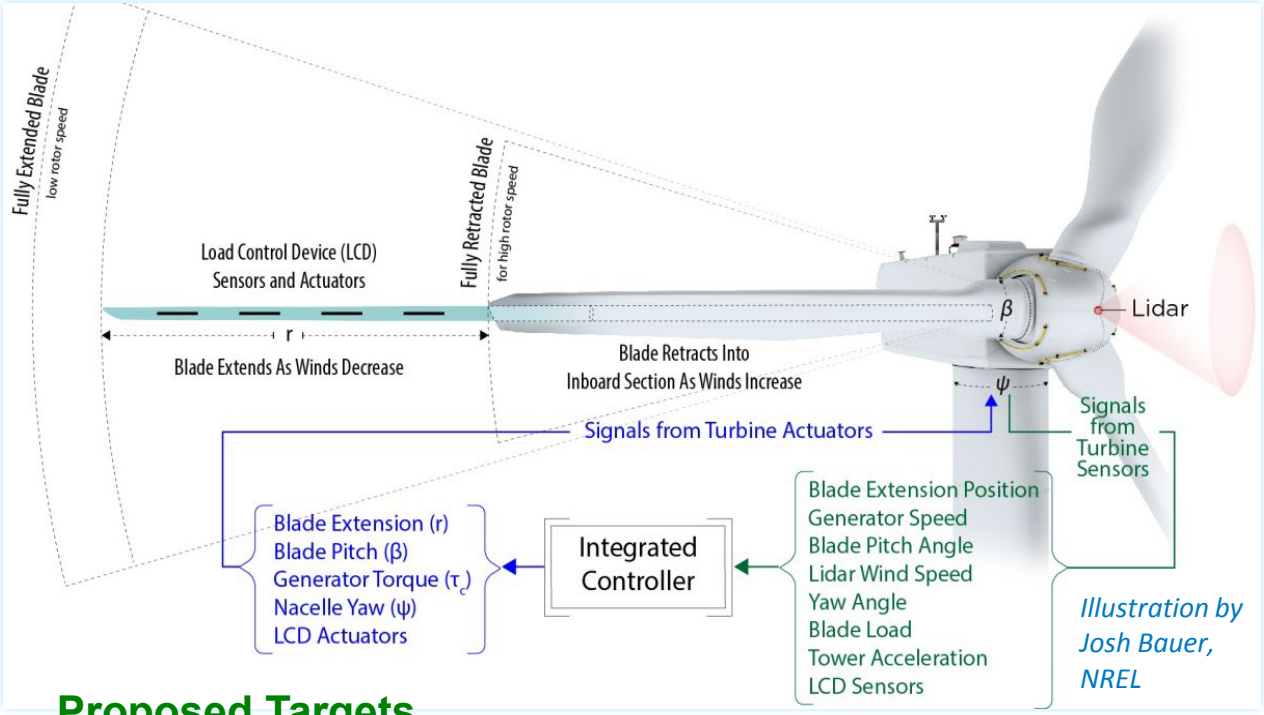
- **Impacts U.S. turbine installations today**
- **Potentially impacts U.S. turbine installations today**
- **Potentially impacts future U.S. turbine installations**

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.

An Extendible Wind Turbine Blade and Integrated Control System that Reduces the Cost of Electricity by 31%



Captures up to 71% more energy than a conventional turbine at a low wind speed site

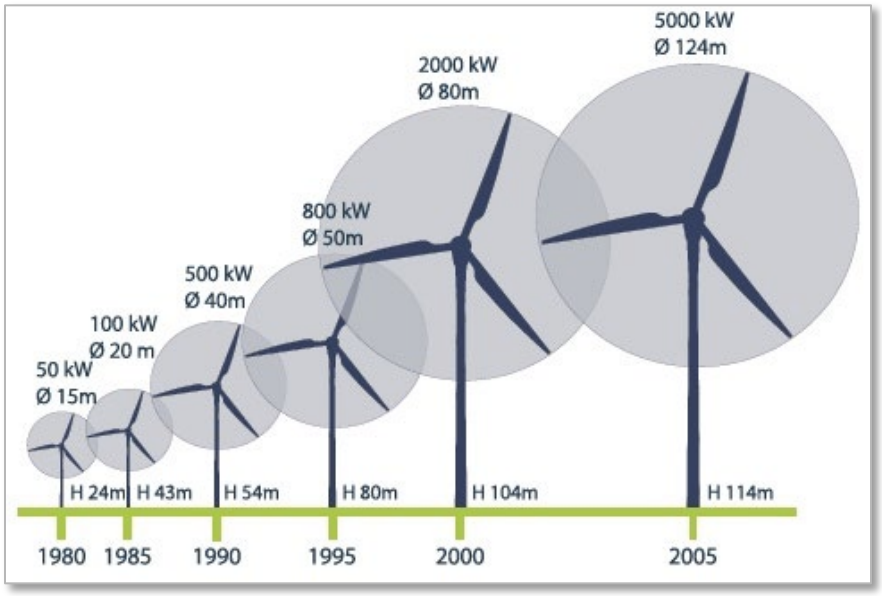
Proposed Targets

Metric	State of the Art	Proposed
Levelized cost of energy at a low wind speed site	$112/MWh	$77/MWh
Blade length	62 meters (m) (fixed length)	62–100 m (variable length)
Economically viable land area (United States)	2.9 million km^2	4.6 million km^2

5,000 GW of additional wind energy technical potential

Shifting the Research and Development (R&D) Focus to Plant Optimization

Yesterday
(Individual Turbines)



2015–2021 (and beyond)
(Smart Wind Plants)

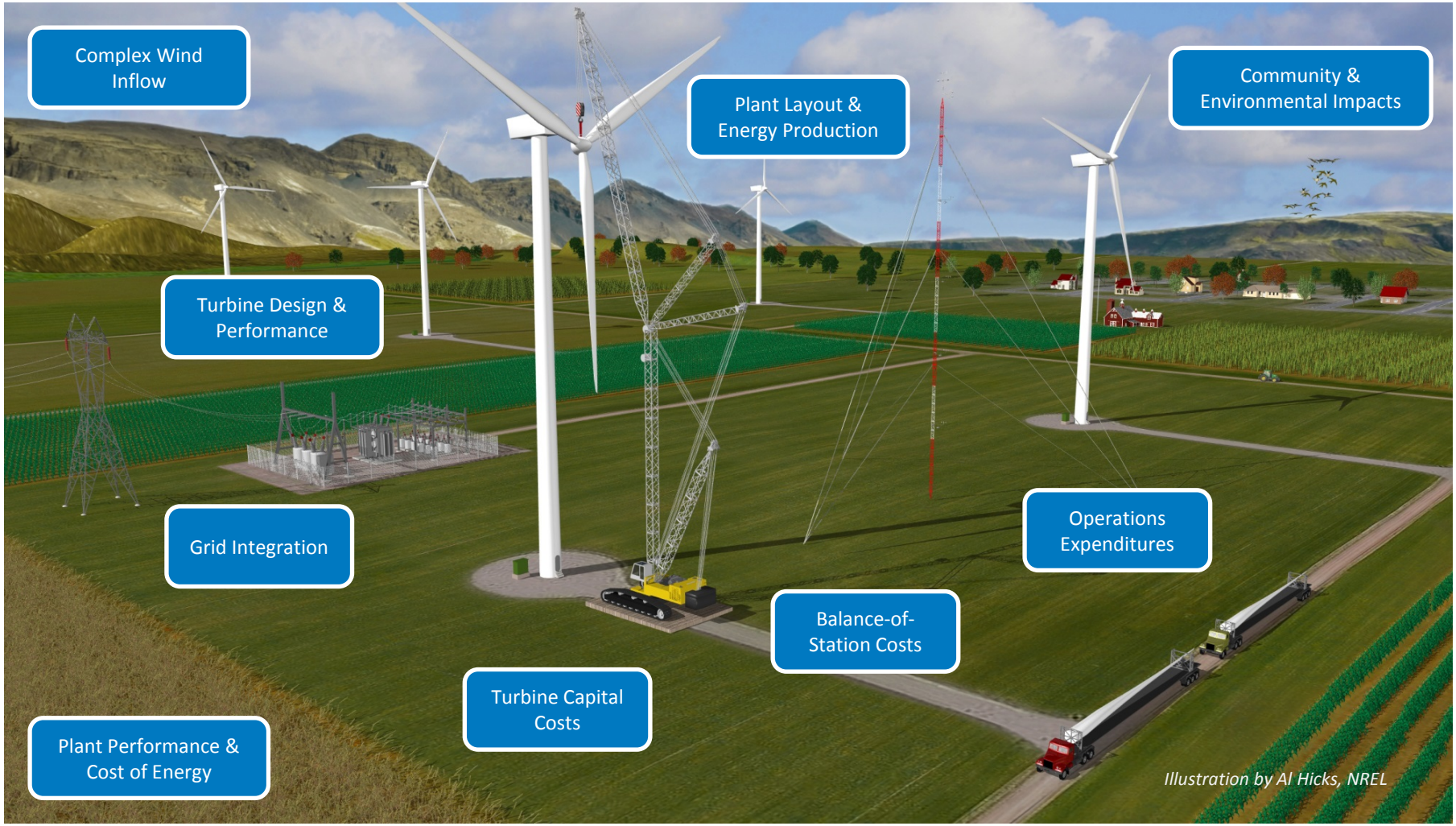
Individual wind turbine R&D

- Significant investment in developing core competencies
- Turbine and rotor scaling driving LCOE reductions
- Well-defined design process and value engineering
- What role is industry asking the U.S. Department of Energy (DOE) to play?

Wind plant optimization R&D

- Resolving the underlying physics affecting wind plant performance
- Design for operation at optimal project profitability and internal rate of return (IRR)
- Develop new technologies that exploit interactions among turbines, resource, and operating environment.

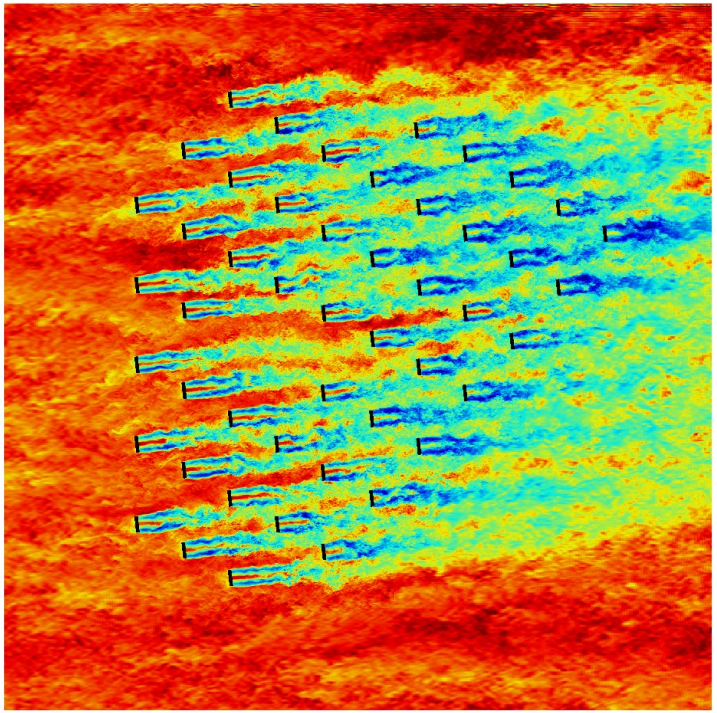
Systems Engineering Perspective – End-to-End Optimization



Wind Plant Aerodynamics are a New Focus of Research

- Subject of DOE focus area for the Wind Power Program
- Building high-performance computing resources to facilitate progress.

Lillgrund Offshore Wind Farm, Sweden.
Siemens Press Picture, NREL 27851



Simulation of array effects

U.S. Multimegawatt Research Facilities for Grid Integration of Renewable Energy Technologies

Energy Systems Integration Facility (ESIF)

The Energy Systems Integration Facility at NREL. *Photo by Dennis Schroeder, NREL 26217*

1+MW

National Wind Technology Center (NWTC)

The National Wind Technology Center in Boulder, Colorado. *Photo by Dennis Schroeder, NREL 30771*

7 MVA

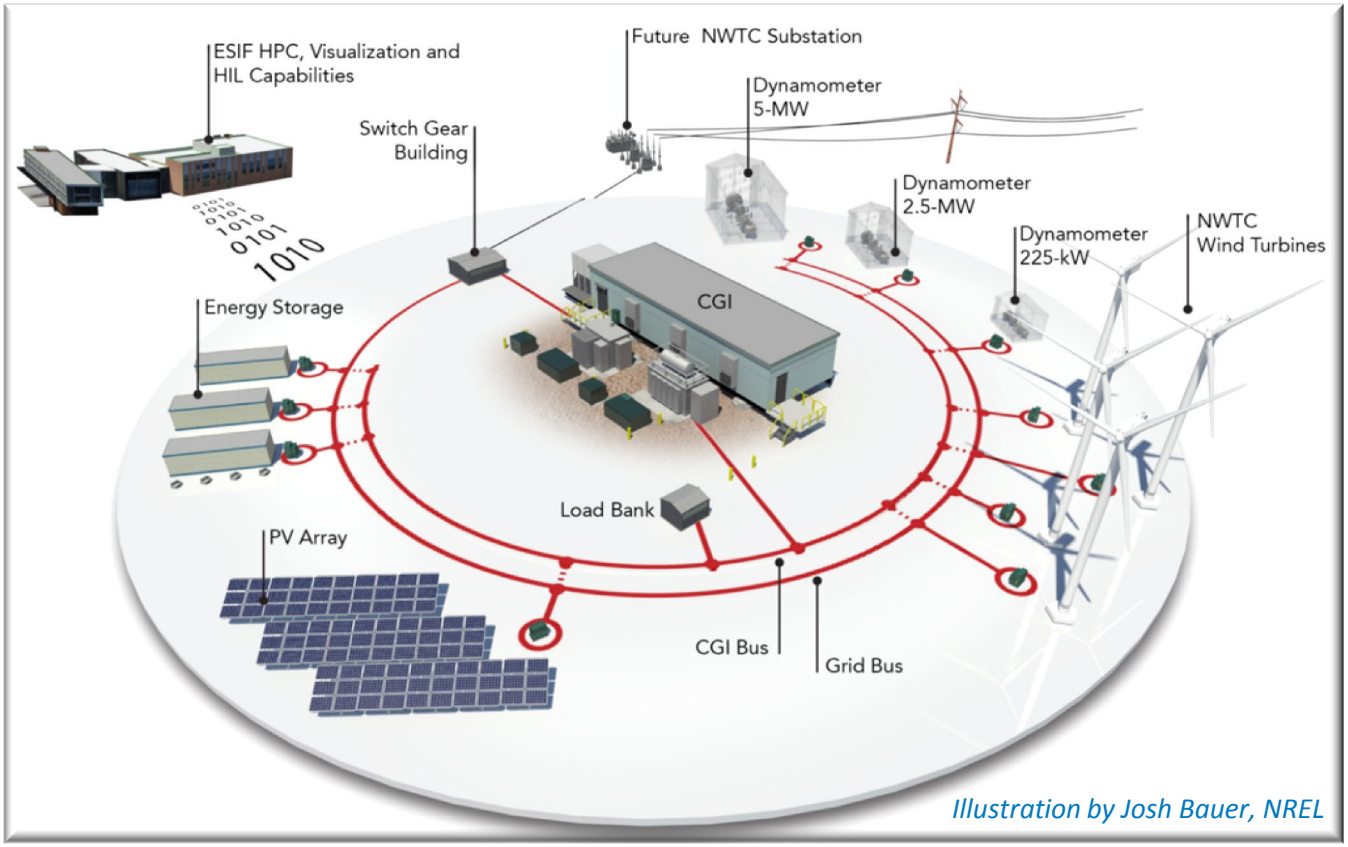
- DOE Wind Program investment in world-class testing facilities
- Component, wind turbine, plant levels
- Key enabler for wind technology validation and commercialization
- Specific focus on testing ancillary service controls

Clemson SCE&G Energy Innovation Center, eGRID Facility

15 MW

Clemson University's 15-MW test rig. *Photo courtesy of Clemson*

Transforming National Wind Technology Center (NWTC) for Renewable Energy System Integration Testing



Transmission-Level Grid Integration Research Facility

NWTC location leverages staff expertise and research facilities, enabling an integrated research environment for system to full-scale testing of renewable energy systems at transmission and distribution grid integration levels.

Two New Ways to Get More Involved

Institute for Advanced Composites Manufacturing Innovation (IACMI)

- **Fifth institute in the National Network of Manufacturing Innovation**
- **Committed to increasing domestic production capacity, growing manufacturing, and creating jobs across the U.S. composite industry**
- **Development efforts will focus on low-cost, energy-efficient manufacturing and recycling fiber-reinforced polymer composites**
  - Composite materials and processes
  - Compressed gas storage
  - Design, modeling, and simulation
  - Vehicles
  - Wind turbines
- **Projects up to $600k**
  - First round deadline September 30, 2015
  - 50% cost share

http://iacmi.org/

DOE Small Business Voucher Program

- **Increase small business accessibility to lab capabilities**
- **First round of awards due October 23, 2015**
  - $1 M available for wind
  - $1.5 M available for marine and hydrokinetic
  - $0.8 M available for hydro
  - 20% cost share requirement.

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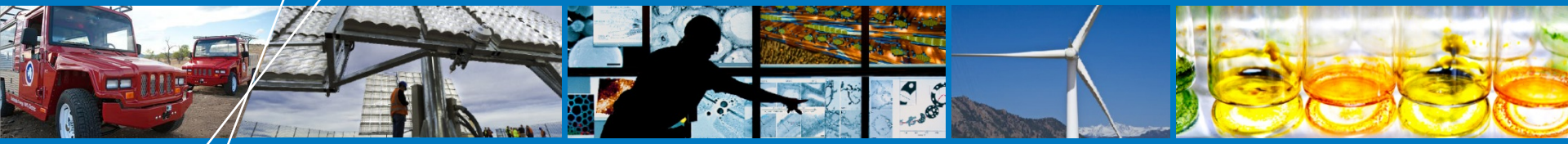

Thank You for Your Attention!

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