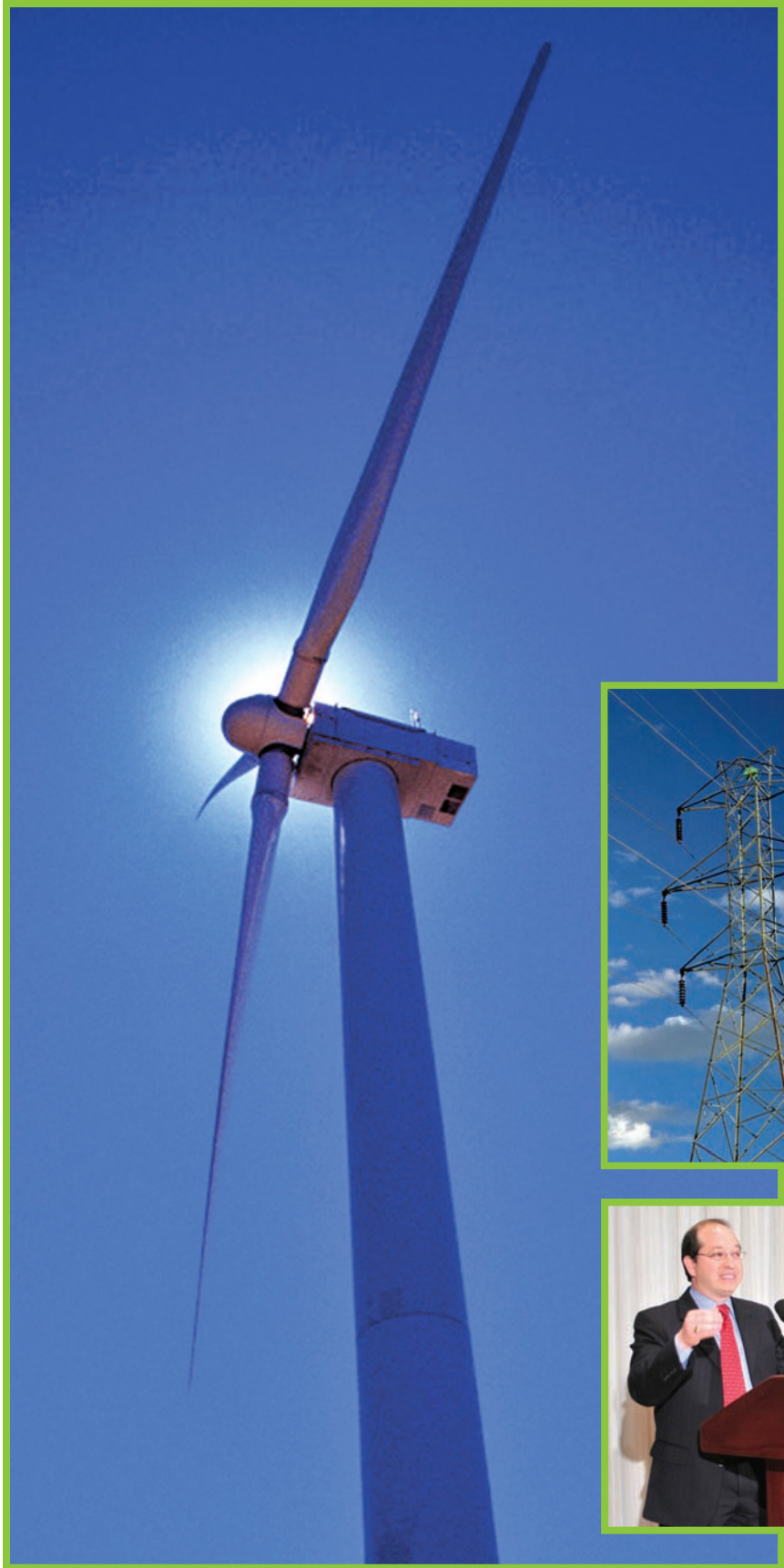
U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable



U.S. Department of Energy

20% Wind Energy—Diversifying Our Energy Portfolio and Addressing Climate Change

20% Wind Energy By 2030

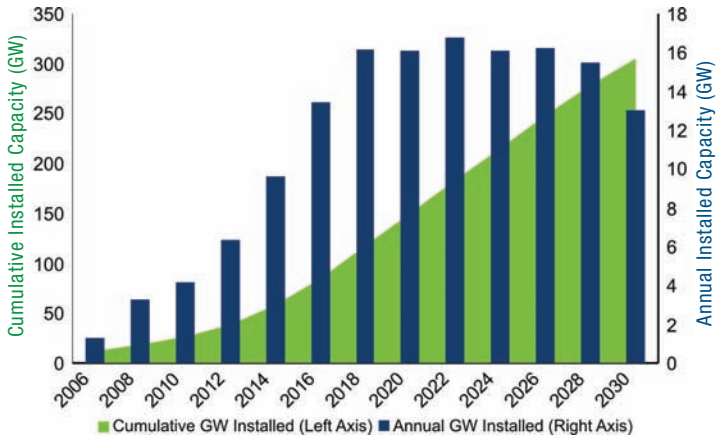
Energy prices, supply uncertainties, and environmental concerns are driving the United States to rethink its energy mix and develop diverse sources of clean, renewable energy. In 2006, President Bush emphasized the nation's need for greater energy efficiency and a more diversified energy portfolio. This led to a collaborative effort by the U.S. Department of Energy (DOE), industry, government, and several national laboratories to examine the feasibility of producing 20% of our nation's electricity needs with wind energy.

In May 2008, DOE published its report, *20% Wind Energy by 2030*, which presents an in-depth analysis of the potential for wind energy in the United States and outlines a potential scenario to boost wind electric generation from its current production of 16.8 gigawatts (GW) to 304 GW by 2030. According to the report, achieving 20% wind energy by 2030 could help address climate change by reducing electric sector carbon dioxide (CO_2) emissions by 825 million metric tons (20% of the electric utility sector CO_2 emissions if no new wind is installed by 2030), and it will enhance our nation's energy security by diversifying our electricity portfolio as wind energy is an indigenous energy source with stable prices not subject to fuel volatility.

According to the report, increasing our nation's wind generation could also boost local rural economies and contribute to significant growth in manufacturing and the industry supply chain. Rural economies will benefit from a substantial increase in land use payments, tax benefits and the number of well-paying jobs created by the wind energy manufacturing, construction, and maintenance industries.

Although the initial capital costs of implementing the 20% wind scenario would be higher than other generation sources, according to the report, wind energy offers lower ongoing energy costs than conventional generation power plants for operations, maintenance, and fuel. The 20% scenario could require an incremental investment of as little as $43 billion (net present value) more than a base-case no new wind scenario. This would represent less than 0.06 cent (6 one-hundredths of 1 cent) per kilowatt-hour of total generation by 2030, or roughly 50 cents per month per household.

Annual and cumulative wind installations by 2030

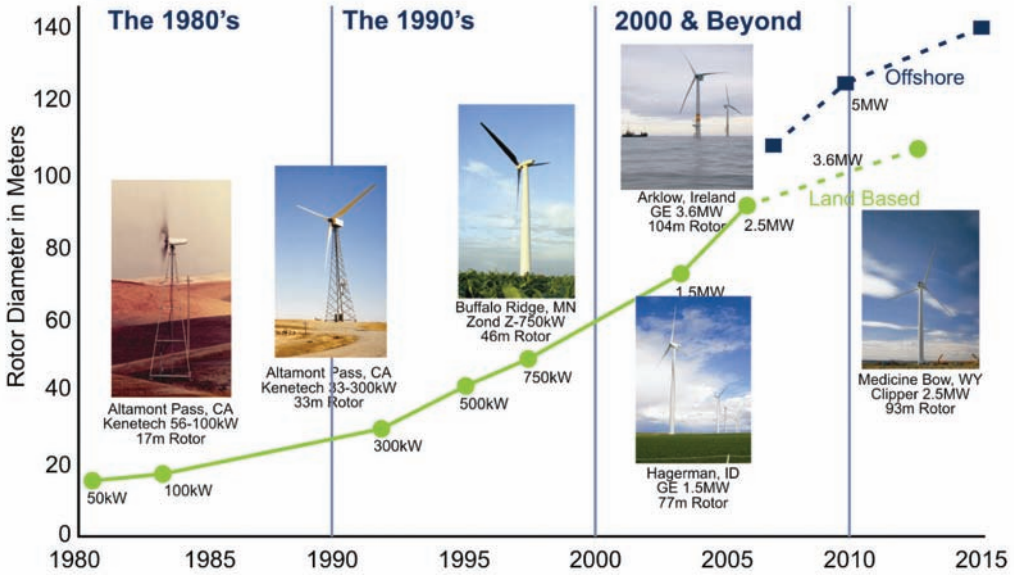


20% Wind Energy by 2030, May 2008, U.S. Department of Energy, www.eere.energy.gov/windandhydro

The report concludes that while achieving the 20% wind scenario is technically achievable, it will require enhanced transmission infrastructure, streamlined siting and permitting regimes, improved reliability and operability of wind systems, and increased U.S. wind manufacturing capacity. To meet these challenges, the DOE Wind Energy Program will continue to work with industry partners to increase wind energy system reliability and operability and improve manufacturing processes. The program also conducts research to address transmission and grid integration issues, to better understand wind resources, to mitigate siting and environmental issues, to provide information to industry stakeholders and policy makers, and to educate the future generations.

The development path and growth of wind turbines

Evolution of U.S. Commercial Wind Technology



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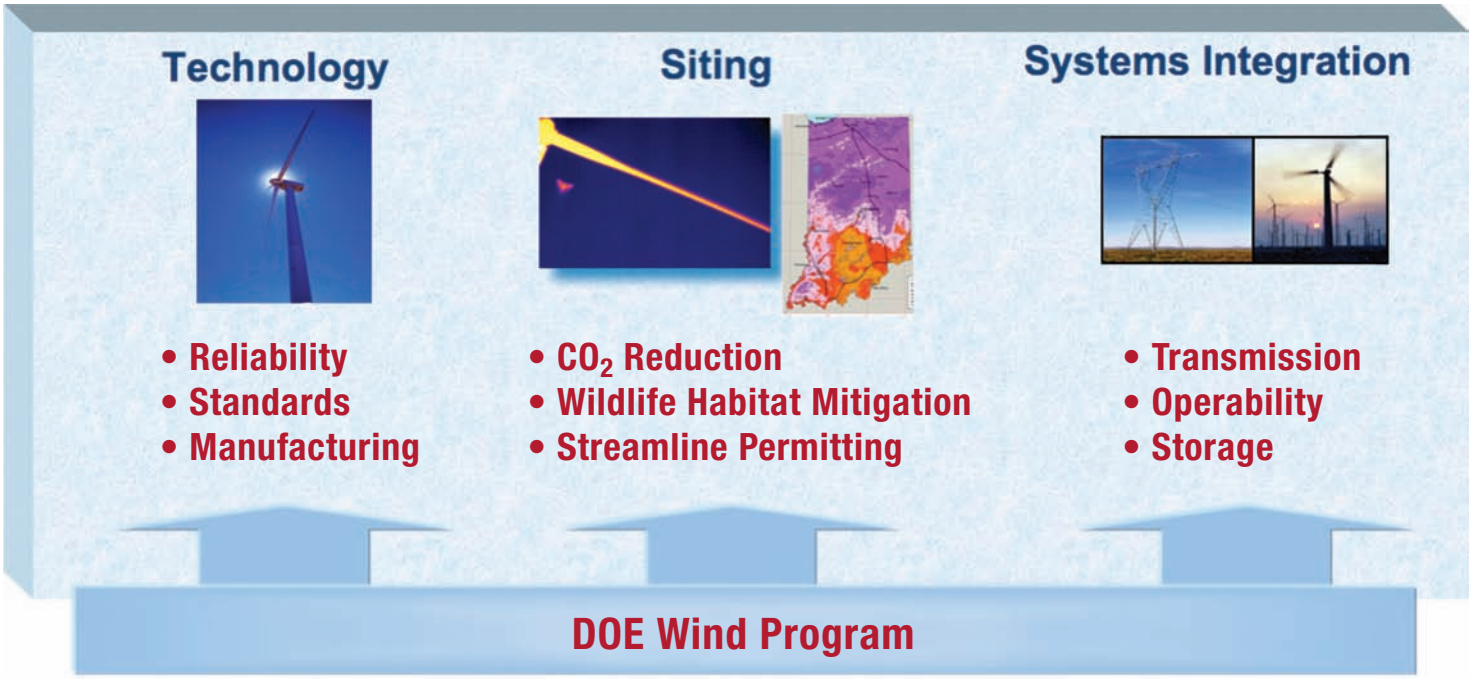
Wind Energy Research & Development to Meet the 20% Challenge



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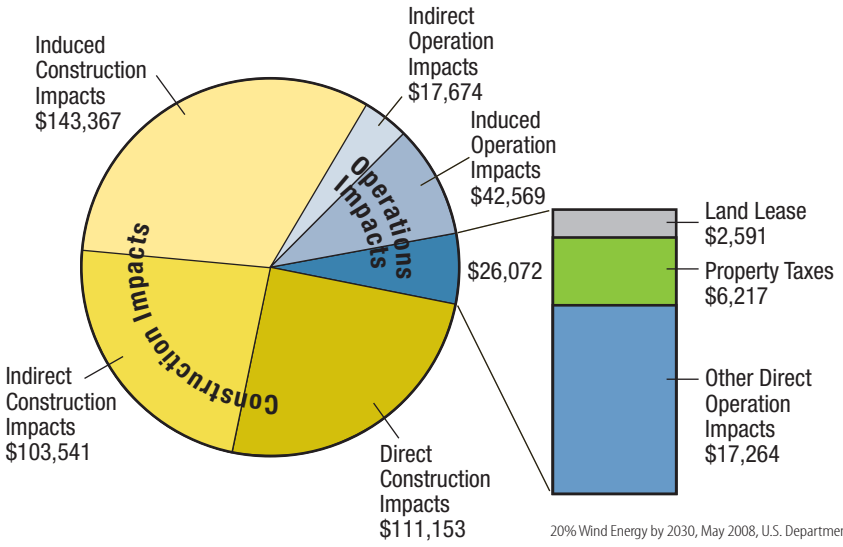
Total economic impacts of 20% wind energy by 2030 on a relative basis



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20% Wind Scenario: Projected Impacts*

- **Environment:** Avoids air pollution, reduces GHG emissions, and reduces water use in electricity generation. Reduces electric sector CO_2 emissions by 825 million metric tons.
- **U.S. energy security:** Diversifies our electricity portfolio and represents an indigenous energy source with stable prices not subject to fuel volatility
- **Energy consumers:** Wind potentially reduces demand for fossil fuels, in turn reducing fuel prices and stabilizing electricity rates
- **Local economics:** Creates new income source for rural landowners and tax revenues for local communities in wind development areas.
- **American workers:** Generates well-paying jobs in sectors that support wind development, such as manufacturing, engineering, construction, transportation, and financial services. The new manufacturing will cause significant growth in the wind industry supply chain.
- **Water savings:** Reduce cumulative water use in the electric sector by 8% (4 trillion gallons)

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Wind Turbine Technology

For wind energy to contribute a larger percentage of our nation's energy generating needs, the technology must continue to evolve, building on earlier successes to further improve reliability and operability, increase capacity factors, and reduce costs.

Future technology R&D activities essential to achieving the 20% wind scenario include:

- Improve the reliability of gearboxes, towers, blades and power electronics to lower operation and maintenance costs.
- Establish remote research affiliate partnerships (RemRAPs) to evaluate turbine performance and reliability in diverse operating environments.
- Develop a national database to track the reliability and performance of components, turbines, and wind plants.
- Form international coalitions to improve wind plant power performance by understanding the windflow conditions produced in complex terrains and multiple array configurations.
- Explore innovations to enhance capacity factor and efficiency including taller towers and enhanced rotor technologies.
- Lower turbine component costs through the development of new materials, designs, and manufacturing processes.
- Maintain accredited national test facilities and actively participate in international certification and standards programs to mitigate risk and facilitate investment in wind technology.

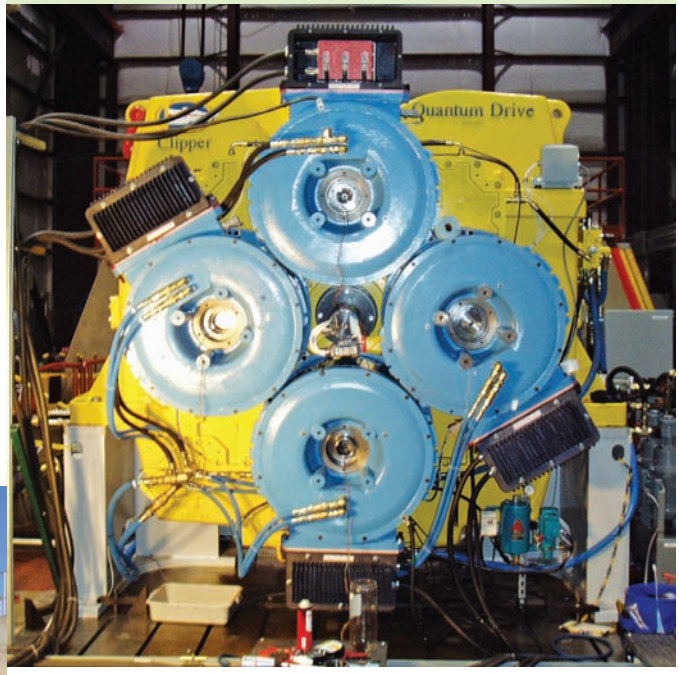
Technology Metrics

DOE Led R&D Efforts

- Increase gearbox meantime-to-failure to 15 years by 2015.
- Populate national reliability database with 10% of U.S. wind generation by 2012.

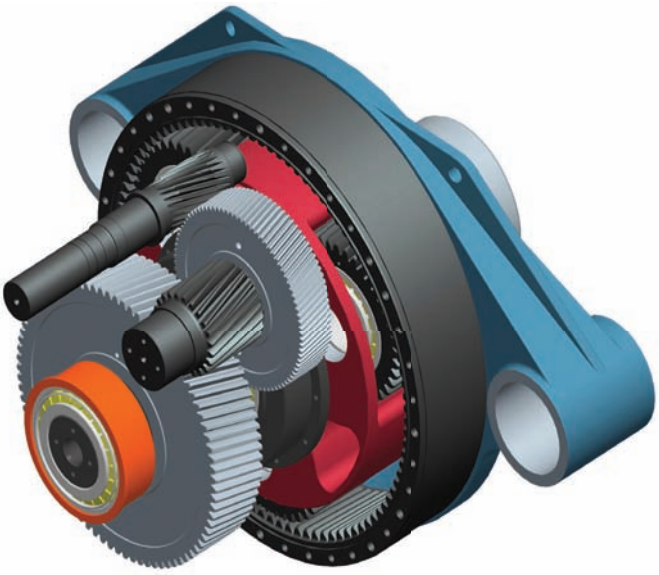
Industry Led R&D Efforts

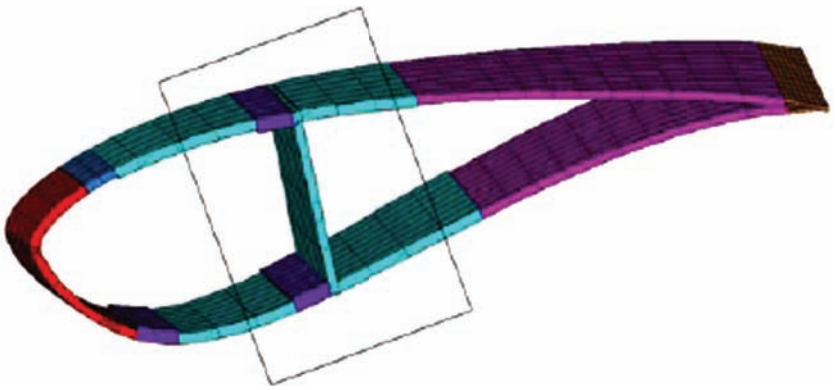
- Increase average turbine capacity factor from 35% to 40% and reduce turbine capital costs by 10% from today's cost of $1,900/kW by 2015.
- Reduce lifecycle O&M costs from 1.5 – 2 cents to 0.7 cents per kWh by 2015.



Designing innovative drive trains to reduce size, weight, and costs and increase reliability.

Conducting tests to ensure endurance and reliability





Developing new aerodynamic designs and materials to reduce blade costs.

Systems Integration

The lack of transmission is one of the largest impediments to producing 20% of our nation's electricity demand with wind energy. According to industry representatives, approximately $60B will need to be invested in our nation's energy infrastructure to meet our future electricity needs regardless of the energy type. In addition, the natural variability of the wind resource can present challenges to grid system operators and planners with regard to managing regulation, load following, scheduling, line voltage, and reserves. Systems integration R&D activities essential to achieving 20% wind energy include:

- Support new transmission planning and business processes.
- Perform high-penetration renewable energy integration studies, including detailed mesoscale and wind plant modeling to facilitate regional deployment.
- Develop broader market cooperation, asset management and dispatch strategies, to enable lower cost system balancing at higher wind penetration levels.
- Support grid code development and improve wind plant models to reflect system stability requirements and new wind turbine technology capabilities.

Systems Integration Metrics

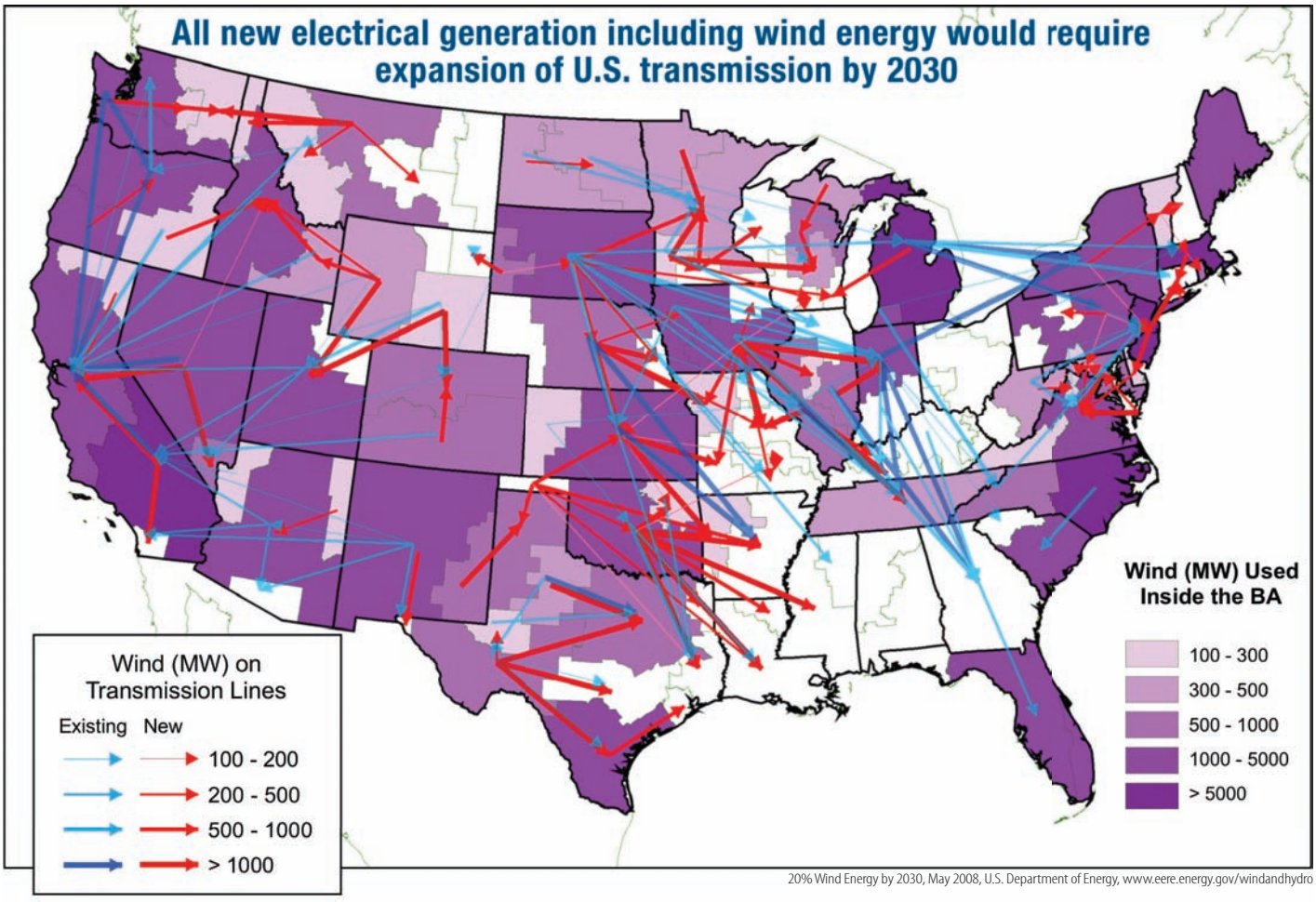
DOE Led R&D Efforts

- Establish Renewable Energy Zones (REZ) in western states by 2010.
- Complete transmission and integration studies for 80% of the U.S. electricity generation and loads by 2011.
- Conduct 1-3 regional assessments of large-scale storage technologies by 2010.

Industry Led R&D Efforts

- Reduce hour-ahead forecasting of plant output error to 5% and day-ahead forecasting error to 10% by 2015.
- Integrate forecasting into management of three major control areas by 2010.

- Develop improved wind forecasting tools and control room strategies for effective wind plant management and grid operations.
- Evaluate the feasibility and cost of installing large-scale storage options into the grid to facilitate grid management.
- Establish national and international forums to exchange technical information on system operation with wind plant interconnection.



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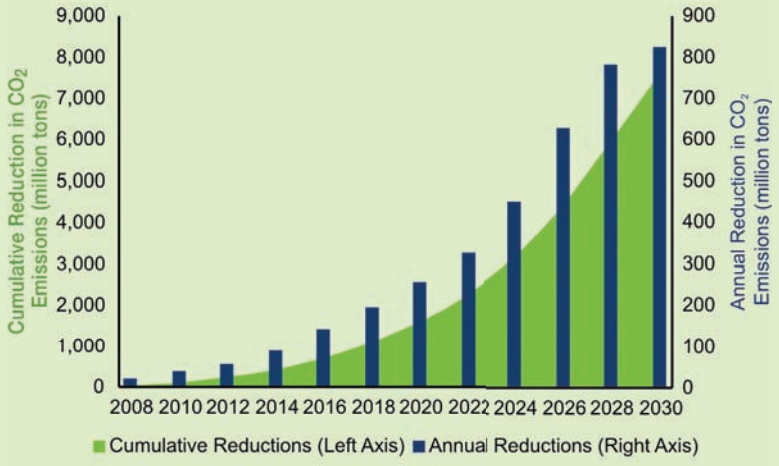
Total Between Balancing Areas Transfer >= 100 MW (all power classes, land-based and offshore) in 2030.
Wind power can be used locally within a Balancing Area (BA), represented by purple shading, or transferred out of the area on new or existing transmission lines, represented by red or blue arrows. Arrows originate and terminate at the centroid of the BA for visualization purposes; they do not represent physical locations of transmission lines.

Siting and Environment

Although wind energy is one of the cleanest, most environmentally neutral energy sources in the world today, siting wind plants can raise concerns in local communities and can have negative impacts on wildlife habitats and individual species. In addition, there are some concerns about the impact of wind plants sited in close proximity to radar installations. Research efforts can help establish wind plant siting and approval processes to accommodate increased rates of installation while addressing environmental risks and community concerns.

Annual CO_2 emissions avoided (vertical bars) would reach 825 million tons by 2030.



The cumulative avoided emissions by 2030 would total 7,600 million tons.

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Siting Metrics

DOE Led R&D Efforts

- Disseminate siting best practices for adoption by states and counties by 2009.
- Demonstrate widely accepted radar mitigation techniques by 2010.
- Provide validated wind resource maps at modern wind turbine hub-heights in the Midwest and the Great Lakes states by 2015.

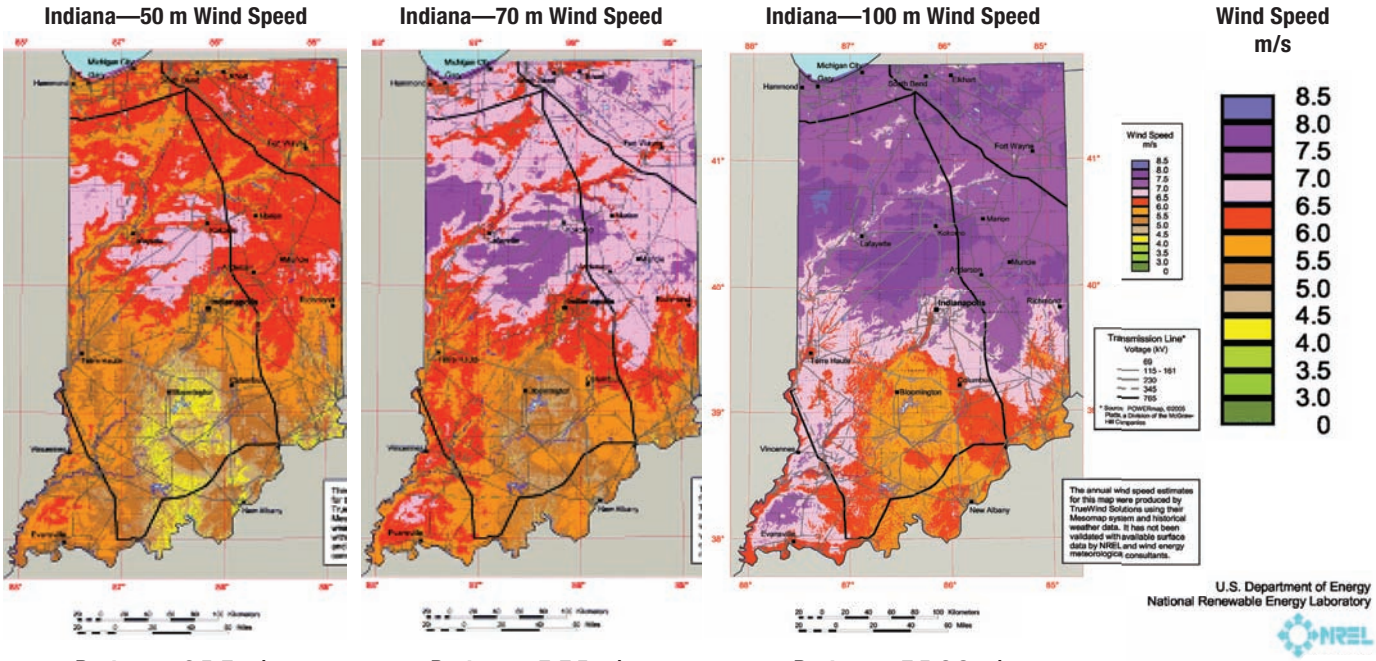
Industry Led R&D Efforts

- Develop GIS database of favorable site locations with existing resources, transmission, policies, and environmental assessment information by 2015.
- Establish an American Wind Wildlife Institute to address wildlife issues and develop mitigation measures.

Siting and environment R&D activities essential to achieving the 20% wind scenario include:

- Understand wind conditions and new resource potential in diverse environments.
- Lead consortia to research wildlife habitats and identify effective mitigation strategies.
- Conduct systematic risk research that examines the full range of human, ecological, and socioeconomic effects of wind project siting.
- Develop strategies to identify sites highly favored for wind energy development with ecological risks and community conflict and the mitigation strategies to address the risks and conflicts.
- Develop uniform and streamlined permitting processes and address public concerns.

Providing Validated Wind Resource Maps at Modern Wind Turbine Heights



Best areas 6.5-7 m/s
Capacity factors 30-35%

Best areas 7-7.5 m/s
Capacity factors 35-40%

Best areas 7.5-8.2 m/s
Capacity factors 40-45%

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These Indiana high-resolution wind resource maps show how wind resources increase with height. The wind resource data acquired at the 100-m tower height revealed a significant increase in wind resources that helped jump start the state's wind industry development.

Education and Analysis

The recent growth experienced by the wind industry has been driven by a number of factors; including the cost competitiveness of wind energy, increasing public interest spurred by environmental concerns, and the growth of renewable energy or "green power" markets. For 20% of our nation's electricity to be provided by wind energy, demand and supply markets would need to expand to deliver wind energy to end-use customers, and the myths that have impeded industry growth in the past need to be dispelled through the provision of information to the public and industry stakeholders. Stakeholders include the public, utilities, utility commissions, transmission organizations, state and federal legislators, and financiers.

In addition to providing the analyses needed to support policy development and market growth, the Wind Energy Program is working with schools and universities to ensure that the industry will have the skilled technical, business and service workers it will need in the near future. Since the 1980s, the number of engineering students graduating from power engineering programs has dropped from 2,000 per year to about 500 per year. To ensure that we have the professional workforce required to support rapid industry growth, the Wind Program is working with communities, K-12 schools, and colleges to ensure that today's students are aware of the exciting employment opportunities offered by the wind industry, and that they acquire the skills and knowledge they need to become the next wind energy professionals.

Education and analysis R&D objectives include:

- Increase educational and outreach efforts to inform national, regional, and state decision makers and stakeholders.
- Develop wind curricula for K-12 schools, community colleges, and .universities.
- Engage K-12, community college, and university students through interactive competitions, scholarships, internships, and hands on experience with operating wind projects.
- Compare lifecycle risks and benefits assessment of current and prospective electricity supply options.
- Analyze the economic, market, and environmental benefits and impacts of wind technology for utility-scale, community, and distributed wind applications.
- Examine public policy options to support continued wind industry growth.

Education and Analysis Metrics

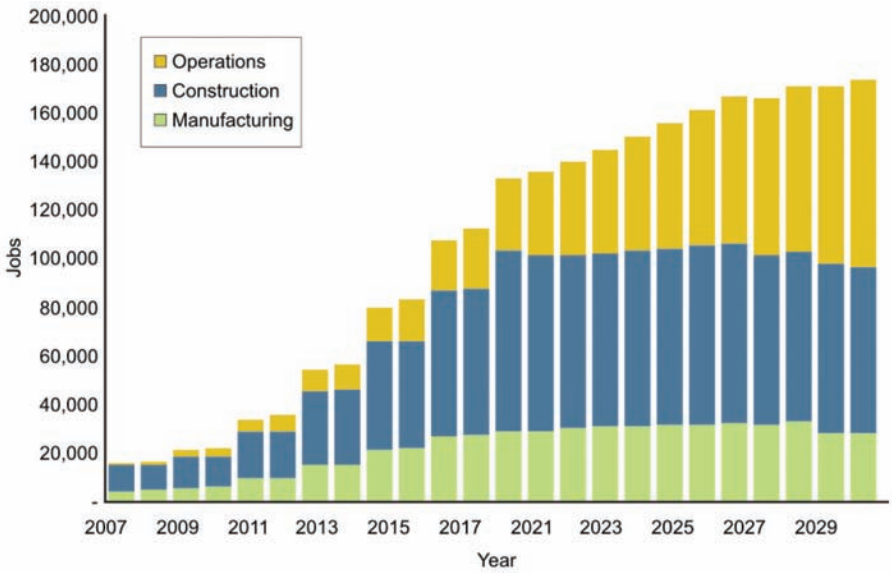
DOE Led R&D Efforts

- Develop an American Academy of Wind Energy that co-operates with leading research institutes and universities on wind energy R&D and education by 2010.
- Develop best practices and tools for modeling wind technology in generation capacity expansion models by 2010.
- Perform detailed lifecycle technical studies that examine all energy sector impacts, including water, air, climate/greenhouse gas by 2012.

Industry Led R&D Efforts

- Establish grants and scholarships to support wind energy technology training and education programs by 2010.
- Build a research and training facility that houses training capabilities to support workforce development and a public outreach and education center by 2012.

Direct manufacturing, construction, and operations jobs supported by the 20% Wind Scenario



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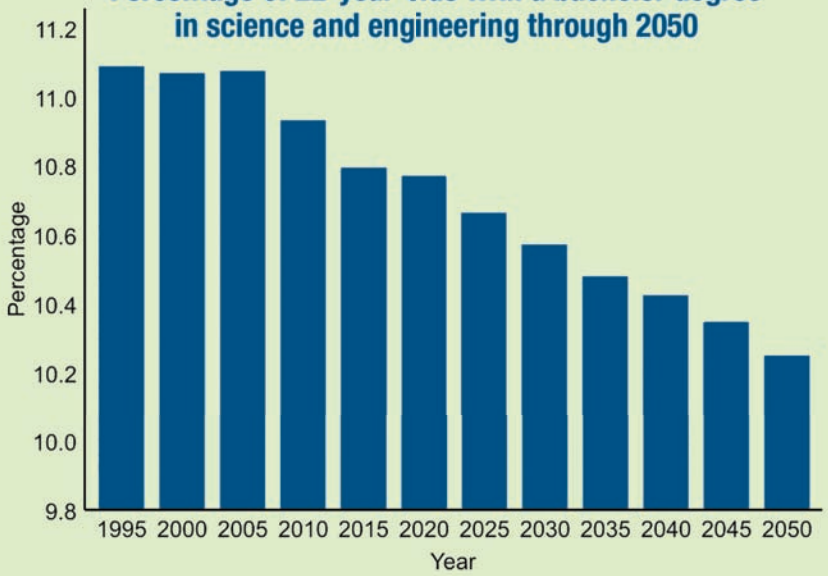
Percentage of 22-year-olds with a bachelor degree in science and engineering through 2050



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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

For more information contact:

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