Average Annual Daily Potential Wind Energy

This EnviroAtlas national map estimates the average annual daily potential kilowatt hours of wind energy that could be harvested per square meter each day (kWh/m2/day) within each 12-digit hydrologic unit (HUC) across the conterminous U.S. It is a conservative estimate based on wind power density at a height of 10 meters. This calculation is based on environmental factors; it does not consider land cover, ownership, land use, or viability of wind power systems.

Photo: Wind turbines, Winchell Joshua, USFWS

Why is wind energy important?

Wind energy represents a freely available, seemingly inexhaustible, ecosystem service. Wind energy potential for the conterminous U.S. is expressed in the EnviroAtlas map, Average Annual Daily Potential Wind Energy, as kilowatt hours per square meter per day (kWh/m^2/day). Though the map overestimates actual electricity generation capacity, the annual daily potential wind energy map is a good indicator of regional wind resources. The wind energy map shows that the best opportunities for commercial wind power generation are located in the plains states of the U.S. and on the windward side of various mountain ranges. In 2015, Iowa generated 31% of its electricity from wind power.[1] The southeastern U.S., by comparison, does not have the potential for commercial wind power generation with today's technology.

Commercial wind energy production began in the mid-1980s with the development of a wind farm near Altamont, California. Today, wind energy production is the fastest growing renewable energy industry in the U.S., supporting more than 100,000 wind-related jobs and creating more than 82 gigawatts (82 billion watts) of electricity in 2016.[2] The U.S. was second to China in wind energy production for both newly installed capacity and cumulative installed capacity in 2016.[2] Wind power supplies about 5% of the electricity produced in the U.S. With continuing improvements in technology, wind is projected to supply 20% of national electricity demand by 2030.[3] Fossil-fuel-generated electricity presently contributes about 40% of carbon dioxide emissions in the U.S. Increasing the contribution of renewable energy sources is expected to reduce future carbon dioxide emissions. The model for increased wind energy production in 2030 projects an 8% reduction in greenhouse gases (GHGs) from the contribution of wind energy.[3]

The main obstacle to capturing consistent wind energy for power generation over the maximum land area is the height of the rotor blade assembly. The standard height of wind turbines in the U.S. is 80 meters (262 feet). Germany is presently extracting commercial wind energy from relatively low wind capacity areas using rotor heights of 110–140 meters (361–459 feet). If, as is planned, the U.S. transitions to >100 meter wind turbines, additional regions of the U.S. presently lacking commercial wind power generation, such as the Southeast, Ohio Valley, and Northeast, will become commercially viable wind energy producers.[3] Personal homeowner wind energy installation, though available, is a another resource remaining largely untapped. Federal tax credits for home wind power are presently available (though they will be phased out by 2019).

Though commercial wind projects create clean energy, they do have an environmental cost. Wind farms can be very land-intensive; for example, sample project areas for larger wind farms vary from 94,000 acres (Washington), to 400,000 acres (Texas) to 40 square miles (Utah). Wind turbines' low frequency noise can cause headache, sleep loss, and inner ear balance issues for nearby residents. The huge area covered by hundreds of wind farm turbines can be aesthetically disturbing and affect scenic and tourism values. Large wind developments may block wildlife travel routes and disrupt breeding populations through loss of habitat.[4] Birds and bats are often killed by collisions with rotors. Strategies to reduce wildlife impacts include deterrents (sound or visual devices to discourage wildlife from approaching), curtailment (shutting down turbines seasonally or when sensitive wildlife are sighted), and design modifications to the shape or speed of turbine blades.[5]

CONTINUED ON BACK ▶

How can I use this information?

This EnviroAtlas national map, Average Annual Daily Potential Wind Energy, estimates the average daily potential kilowatt hours of wind energy that could be captured per square meter within each 12-digit HUC. The map illustrates the wind energy potential recorded across a given area without taking into account land use, ownership, land cover, or aspect. The map provides planners and the public with a national and regional view of gross wind energy potential. The map can help inform discussions about the benefits and environmental tradeoffs of wind energy applications.

The wind energy potential map may be overlaid and compared with other EnviroAtlas maps depicting land cover and habitat, such as protected areas, ecoregions, GAP ecological systems, and connectivity. These data layers along with information on species distributions and habitat needs can help to assess the adequacy of reserves, remaining habitat core areas, and movement corridors for wildlife near large existing or proposed wind energy developments.

How were these data created?

The average daily potential kilowatt hours of wind energy were estimated from data produced by the National Renewable Energy Laboratory (NREL) and AWS TrueWind in cooperation with the U.S. Department of Energy's WINDExchange program. The data used includes shapefiles showing an estimate of annual wind resources for states and regions at 50-meter resolution. Because this data was not available for all states, another NREL dataset, showing wind resources at a 25-km resolution for the conterminous U.S., was obtained to use where 50-meter resolution data was not available. The mapped wind power class attributes were converted to energy in kWh/m2/day. Zonal statistics were estimated for a final value of average kWh/m2/day for each 12-digit HUC using a rasterized version of the NHDPlusV2 WBD Snapshot - EnviroAtlas Version. For more information about the wind energy dataset, refer to the NREL website.

What are the limitations of these data?

The source data was not produced using the same methods for all states, resulting in values that sometimes vary along state lines. These data represent potential wind energy; the actual energy produced in a location may be lower. These estimates only apply to areas of low surface roughness, such as grassy plains. In areas with greater surface roughness, wind power will be reduced. **The 50m-resolution datasets that were produced by AWS TrueWind account for surface roughness; however, the 50m datasets produced by NREL (Illinois, North Dakota, and South Dakota) do not. For several states (Louisiana, Mississippi, Alabama, and Florida), NREL only offered data at 25-kilometer resolution.** NREL's datasets may have been developed using different methodologies than those used by AWS TrueWind. These estimates are an average of potential wind power across a 12-digit HUC; they should not be used to extrapolate down to a smaller area or for micro-siting wind turbines.

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. The wind energy data used to create this map may be downloaded at the NREL website. NREL has also developed dynamic maps and analysis tools to help apply renewable energy data.

Where can I get more information?

A selection of resources related to the environmental benefits and possible effects of wind energy development is listed below. For additional information on how the data were created, access the metadata for the data layer from the drop down menu on the interactive map table of contents and click again on metadata at the bottom of the metadata summary page for more details. To ask specific questions about this data layer, please contact the EnviroAtlas Team.

Acknowledgments

EnviroAtlas is a collaborative effort led by EPA. This EnviroAtlas map was developed by Megan Mehaffey, EPA, and Megan Culler, EPA Student Services Contractor. The fact sheet was created by Sandra Bryce, Innovate!, Inc.

Selected Publications

1. American Wind Energy Association. 2016. U.S. number one in the world in wind energy production. Accessed April 2017.

2. Global Wind Energy Council. 2017. Global statistics. Accessed April 2017.

3. Zayas, J., M. Derby, P. Gilman, S. Ananthan, E. Lantz, J. Cotrell, F. Beck, and R. Tusing. 2015. Enabling wind power nationwide. U.S. Department of Energy, Oak Ridge, Tennessee.

4. Leung, D.Y.C., and Y. Yang. 2012. Wind energy development and it environmental impact: A review. *Renewable and Sustainable Energy Reviews* 16 (2012): 1031–1039.

5. Sinclair, K., and E. DeGeorge. 2016. Framework for testing the effectiveness of bat and eagle impact-reduction strategies at wind energy projects. National Renewable Energy Laboratory Technical Report NREL/TP-5000-65624, National Renewable Energy Laboratory, Golden, Colorado. 47 p.