the ENERGY lab

ANALYSIS FACTS

Life Cycle Analysis

Role of Alternative Energy Sources

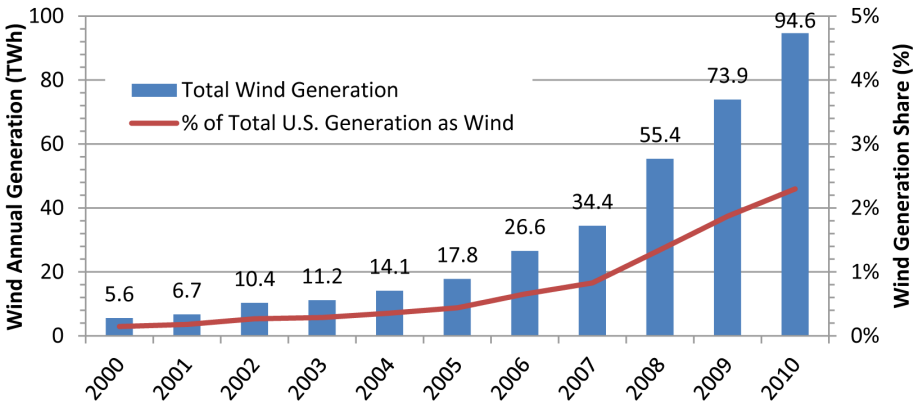
Wind Technology Assessment

Project Description

This analysis evaluates the role of wind power in the future energy portfolio of the United States. Wind power is evaluated with respect to resource base, growth, environmental profile, costs, barriers, risks, and what others are saying.

Resource Base and Growth

The resource base of onshore wind power is estimated to be sufficient to supply approximately 10,400,000 MW of wind power capacity, although much of this capacity is located in remote areas (DOE, 2012). U.S. offshore wind resources are estimated to be sufficient to support approximately 4,150,000 MW of power production (Schwartz et al 2010). The fraction of total U.S. power generation from wind power has grown from approximately 0.2 percent in 2000, to approximately 2.3 percent in 2010.



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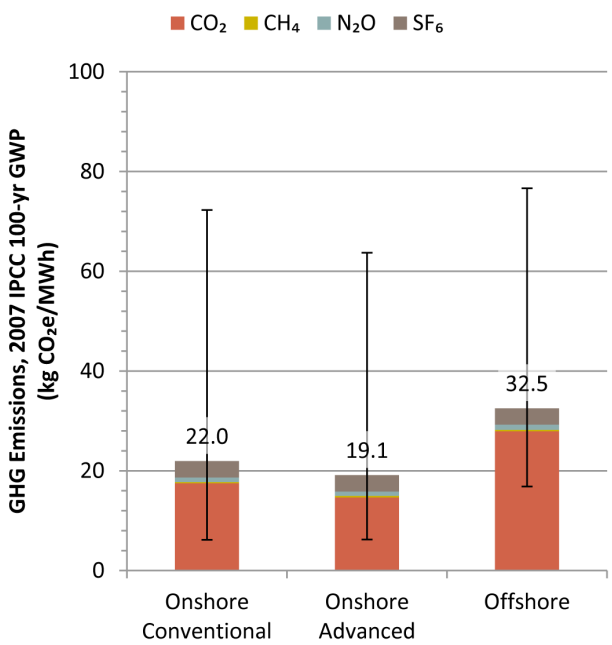
Environmental Profile

NETL conducted a life cycle analysis (LCA) of onshore and offshore wind power. The boundaries of the LCA begin with the acquisition of raw materials used for fabricating wind turbines, include the construction and operation of the wind farm, and end with decommissioning of the wind farm. The life cycle GHG emissions of conventional and advanced onshore wind power are 22.0 and 19.1 kg CO_2e per MWh, respectively (advanced wind turbines have a larger rotor diameter than conventional wind turbines). The life cycle GHG emissions for offshore wind power are 32.5 kg CO_2e per MWh. The advanced onshore system has lower greenhouse gas emissions than the conventional system, which is due to the higher economy of scale between turbine materials and turbine rating (MW) for the advanced systems. Offshore wind power has higher life cycle GHG emissions than onshore wind power due to the complexity of installing, maintaining, and connecting wind turbines located 20 km from the shore.



The above results do not account for the GHG emissions from land use change. The GHG emissions from direct and indirect land use change are 2.70 kg CO_2e/MWh for standalone onshore conventional wind power, 2.72 kg CO_2e/MWh for onshore advanced, and 0.729 kg CO_2e/MWh for offshore wind power. Thus, the land use GHG emissions from onshore conventional wind power increase the total life cycle GHG emissions from 22.0 to 24.7 kg CO_2e/MWh, from 19.1 to 21.8 kg CO_2e/MWh for onshore advanced wind power, from 32.5 to 33.2 kg CO_2e/MWh for offshore.

Wind power is intermittent and thus the need for backup power increases the life cycle GHG emissions of wind power. When a GTSC (gas turbine simple cycle) power plant provides backup power, the life cycle GHG emissions are 502 and 429 kg CO_2e per MWh for conventional onshore and offshore wind, respectively. When average U.S. power mix is used in lieu of GTSC, the life cycle GHG emissions are 487 kg and 416 kg CO_2e/MWh for onshore conventional and offshore wind power, respectively. For comparison, an advanced fossil combustion technology such as an Integrated Gasification Combined Cycle (IGCC) plant with a carbon capture and sequestration (CCS) system has net life cycle GHG emissions of 218 kg of CO_2e/MWh (NETL, 2010).

Costs

Compared to offshore wind power, onshore wind power has lower capital and O&M costs per kilowatt of power. The nominal capital costs for onshore and offshore wind power are $1,970 and $5,470 per kW, respectively. Offshore wind power has a higher average capacity factor than onshore wind power (39% vs. 30%), which helps reduce its per kWh costs in comparison to onshore wind power. When the same financial assumptions are applied to onshore and offshore wind power, the COE (cost of electricity) is $116/MWh for onshore wind power and $259/MWh for offshore wind power. The nominal cost results show that onshore wind power has a lower COE than offshore wind power, but overlapping uncertainties for these results indicate that if offshore wind power has better-than expected performance or a financing structure with lower expected returns, it could be cost competitive with onshore wind power.

Barriers

The barriers to implementation include uncertainties in construction schedules, especially for offshore wind projects. Onshore wind farms have shorter planning and construction horizons than fossil fueled power plants, with a typical planning cycle of approximately 3-4 years (EIA, 2011). The planning schedules for offshore wind power, in contrast, lag behind the onshore wind industry. For instance, the first major offshore wind project in the U.S. was approved after a decade of planning and compliance procedures in April, 2010 (Cape Wind, 2010). Availability of power transmission capacity, combined with the difficulty of constructing long distance power transmission lines, is another barrier to the implementation of wind power.

Risks

The risks of implementation include various impacts that are unique to wind power, including increases in bird and bat strikes from wind turbines. For offshore wind power, the interference with marine navigation, loss of benthic biota, and interference with cultural and visual resources (USACE, 2006) are further risks of implementation.

Expert Opinions

The opinions of wind power experts include the outlooks of wind developers and industry associations. Fearful of entering into a boom-bust scenario, many wind developers are calling for additional federal policies to support continued wind development. Onshore wind development has, in some cases, reached cost competitiveness with natural gas based power production, on a per kWh basis. However, according to Denise Bode, CEO of the American Wind Energy Association (AWEA), wind power lacks predictable federal policies needed to drive consistent wind power growth. Some analysts are predicting that wind growth may shift toward offshore installations in the near to midterm. Based largely on the recent release of the Obama Administration's offshore wind strategy (EERE, 2011), economists are anticipating a surge in offshore wind installations (Reuters, 2010).

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