Calculating Wind Power's Environmental Benefits

Erroneous assumptions can cast doubt on wind power's ability to cut greenhouse gas emissions.

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It's commonly believed that new wind power generation will displace coal and natural gas-fueled power plants and thereby avoid all their associated greenhouse gas (GHG) emissions such as carbon dioxide (CO_2), nitrous oxide (NO_X) and sulfur dioxide (SO_2). The benefits of these avoided emissions have become a major factor in wind developers gaining public support for their plans to site wind farms. These purported benefits also are the reason for the large subsidies governments have provided to offset wind's higher power production costs.

Unfortunately, some of these environmental claims are built upon incorrect assumptions about how U.S. environmental regulations actually work and the type of generation a new wind project will displace.

On any given power project, the benefits of avoided air emissions can be calculated as the simple difference between whether a designated project is built versus if the project is not built. This simple calculation has been incorrectly done by several renewable project developers and their consultants. Their mistakes have led them to incorrectly claim large air emission benefits from building new wind facilities.

Effects of Environmental Regulation

Any analysis of the benefits of avoided air emissions must first correctly account for existing environmental regulations and their impact on utility emissions. Much of the power industry's emissions are currently regulated under strict emission cap and trade programs. Under this framework, the government establishes an emissions tonnage cap. This cap is enforced by issuing a specified number of allowances that can be allocated and/or purchased by affected emission sources. All affected emitters must hold sufficient allowances to cover their emissions of the regulated pollutant. Since the number of distributed allowances is constant, the industry's total regulated emissions will not change based upon the generation mix or renewable generation level. Any displaced generator can sell its unused allowance credits to another power provider, enabling this entity to emit even more. Therefore, any air pollutant subject to a cap and trade program may be displaced but not avoided.

Currently, all power plants in the Lower 48 states are subject to an existing SO_2 cap and trade program. In addition, power plant NO_X and CO_2 emissions are also subject to existing and/or future regional cap and trade programs as shown in Figures 1 and 2. Therefore, no new Northeastern or Midwestern wind project can offer any incremental avoided emission benefit of CO_2, NO_X or SO_2. If Congress adopts a national CO_2 cap and trade program as part of climate change legislation, wind projects may no longer claim any additional future incremental avoided CO_2 emission benefit in the United States.

Second, many studies advocating avoided emissions benefits from wind power incorrectly model the two cases (with and without the identified project). Two common mistakes are made:

Figure 1 STATES WITH ANNUAL NO_X CAP-AND-TRADE PROGRAMS

Figure 2 REGIONAL CO_2 CAP-AND-TRADE PROGRAMS

Project operating period: Most analyses compare a wind project's output distribution over a prior historical year. The proper comparison is to look at it over the time the project will operate. Given that the generation mix constantly changes with time, displaced units on the margin continue to get cleaner as stricter environmental requirements are adopted. This trend is illustrated by an annual analysis of marginal emission rates by ISO New England (*2006 New England Marginal Emission Analysis*, September 2008,

ISO New England) to calculate benefits of energy efficiency measures (Figure 3). Therefore, by selecting any historic year, one will tend to overestimate any displaced emissions.

Closed and protected renewable power markets: Developer analyses sometimes incorrectly calculate the baseline emissions (no project case). By selecting a historical year, the baseline has no new facilities, so the wind project generation would be replaced with conventional fossil fuel generation sources. This assumption is incorrect for closed power markets where projects are built to meet a renewable portfolio standard (RPS), such has been adopted in 28 states (Figure 4) or if a new national renewable portfolio standard is adopted by Congress.

Any analysis of wind power's potential for emissions displacement must begin with a distinction between the 28 states with an RPS in place and those without one. Renewable standards set aside a protected portion of the market that can only be met by qualifying renewable sources. Since renewables are not yet competitive in the open market with fossil fuels, all wind projects currently being built are to meet this special set-aside market demand.

In these states, the proper comparison is not to look at wind versus coal or gas, but wind generation versus other qualified renewable technologies competing for this special set-aside market (in other words, solar, biomass, geothermal, landfill gas). If wind were not used, utilities would replace it with another qualifying renewable resource in an effort to meet RPS goals. For these markets, displaced emissions for a given wind project will be the net difference between the project emissions (zero) and other competing renewable project emissions such as solar, geothermal or biomass that would also be zero.

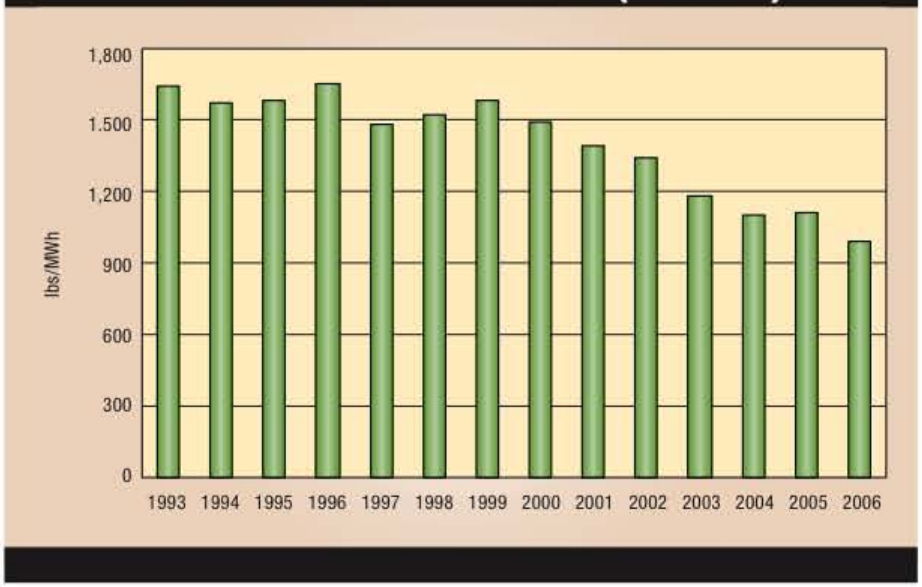
Therefore, no avoided air emission benefit exists if wind generation displaces another renewable project generation to meet a state (or future national) renewable portfolio standard.

Open Power Markets

Until a U.S. carbon cap and trade program and/or national RPS is adopted by Congress, only a few select areas remain in which wind could even compete in an open power market and create potential avoided CO_2 emission benefits. In these few areas, new wind generation will displace highest incremental cost generation on the regional power pool margin. This regional marginal generator constantly changes throughout the day due to continuing load fluctuations. This constantly changing power market makes it extremely difficult to predict what resources would be displaced throughout a given year.

Without use of a regional dispatch model in combination with the project generation profile, wind developer consultants may make simplified and often flawed assumptions. These assumptions often center on displaced generation being either coal-fired generation or a weighted average regional blend of fossil fuel generation. Given that higher cost gas and oil can be on the margin, a weighted average fossil fuel mix that better reflects the dominant baseload generation resources (more heavily coal based) produces an overestimated picture of displaced emissions for their selected historical period. This is also an error as previously outlined.

Figure 3 CALCULATED NEW ENGLAND GENERATION CO_2 MARGINAL EMISSIONS RATES (LBS/MWh)



For example, a report for the DOE's Clean Energy/Air Quality Integration Initiative uses EPA emissions data to analyze the aggregate avoided emissions of three proposed wind projects with 160 MW of capacity in a mid-Atlantic state. Since no site-specific data exist for the three plants, the report used "typical performance data on comparable wind generation facilities" and determined marginal differences existed. Additionally, since hourly generation records from comparable fossil fuel plants are not available, the study constructs it using hourly CO_2 emissions and generation average CO_2 emission rates per megawatthour as reported to the EPA. The report's methodology compares typical hour-by-hour generation output of wind plants and fossil-fueled units in the regional power market. Hour-by-hour analysis proves difficult and inaccurate because the marginal generating unit changes frequently due to load fluctuations over the course of the day.

Despite the report's tendency to overlook the incompleteness and general inadequacy of its data, the authors leave little room for doubt in concluding that when wind energy is available, it will displace generation at high operating cost fossil-fueled units. Unfortunately, the methodology used to calculate the fossil fuel-weighted average emission rate and its inherent displaced emissions does not reflect this observation. The paper simply states the emissions from those fossil fuel generating units are then avoided.

Impact of Wind Variability

While wind energy may be able to displace some fossil fuel emissions in an open power market, integrating it into a generation mix poses additional problems that offset a portion of any projected benefits. Electric grids require reliable power delivery to meet their grid reserve margins. Wind's nature means it contributes little towards meeting a grid's reserve margin capacity requirements. To compensate for wind's limited capacity credit, regional power providers must still build additional capacity—usually gas-powered units—to make up for gradual yet nonetheless significant swings in wind energy output to achieve regional reserve margin requirements.

In *Cost and Quantity of Greenhouse Gas Emissions Avoided by Wind Generation*, Peter Lang analyzes the challenges associated with using gas turbines as back-up units to meet power shortages caused by wind's unpredictability. He details two classes of gas-powered turbines, open cycle gas turbine (OCGT) and combined cycle gas turbine (CCGT) as best able to follow the load changes created by wind power. While OCGT may be well-suited to back up wind, doing so becomes more expensive and actually produces a negligible reduction in GHG emissions when compared to using a cleaner burning CCGT plant alone.

"Because wind cannot be called up on demand, especially peak demand, installed wind generation does not reduce the amount of installed conventional capacity required," Lang states. "Wind is simply an additional capital investment."

To estimate wind's potential to displace emissions and its inherent costs, Lang compares CCGT plants versus wind generation plus OCGT back-up. For wind and OCGT to generate the same amount of power, it would only be 11 percent less carbon intensive and more than double the cost (Table 1).

Finally, proponents who suggest that wind is able to entirely displace CO_2 overlook a fact fundamental to energy generation: wind's unpredictability means it truly has no generating capacity value and its construction will not displace building any new coal or natural gas generating capacity. Grid reserve margins require wind back up and the inefficiency of quickly firing up a natural gas unit to meet erratic wind generation output means any emissions displacement is minimal. Wind is simply an additional capital cost which proves to be more than twice as expensive for the ratepayer.

TABLE 1 OPERATING EXPERIENCE AT THREE POWER PLANTS

Technology	CF	Factor t CO_2/MWh	Emissions t CO_2/MWh	Rate$/MWh	Cost/MWh$/MWh
CCGT	45%	0.577	0.577		$54
OCGT	15%	0.250	0.250	$105	$35
Wind	30%	0.018	0.018	$90	$60
Backup for Wind	30%	0.250	0.250	$39	$26
Total Wind and OCGT	45%	0.519	0.519		$121

Conclusions

Any analysis of wind power's potential to displace fossil fuel generation must

first correctly reflect current environmental regulations. Any air pollutant subject to a cap and trade program covering SO_2, NO_x and regional CO_2 may be displaced but not avoided. Emission levels will remain at the same capped levels with or without wind project development. With the eventual implementation of a federal cap and trade law regulating CO_2 emissions appearing likely, wind power will likely offer no future incremental greenhouse gas emission reduction benefit.

Figure 4 28 STATES AND THE DISTRICT OF COLUMBIA HAVE ADOPTED RENEWABLE PORTFOLIO STANDARDS

One must also distinguish between closed market states with renewable portfolio standards and those open market states without them. Those competing in these closed set-aside protected markets are competing against other renewable projects and not in the open market against lower cost conventional power sources. In these closed markets, no incremental carbon reduction benefits exist between competing renewable power projects. However, these closed power markets were established though regulation and/or legislation and their creation carved out a portion of the open market that reduced the demand for conventional power generation and non-capped fossil fuel emissions. In any case, any avoided emissions benefit is not attributable to a single wind developer, but to regulatory action that has created the closed market for wind and other renewables.

Creating a federal renewable portfolio standard would create a nationwide closed market for renewables, meaning wind projects would again offer no incremental emissions benefits given their direct competition with other renewables and not coal or natural gas. Unfortunately, many of the claims made regarding wind's supposed avoided air benefits are overstated. pe

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