The policy problem wind energy presents to New York

Gary A. Abraham
garyabraham.com
October 29, 2007

To begin to understand this problem it is necessary to assess realistically the contribution industrial wind plants can make to New York's electricity needs, and to assess the land resources that will be needed. Utility terms "capacity factor," the "capacity credit" assigned to a power plant by a regional electric grid operator, and the plant's "baseload capacity" are helpful for understanding the ability of wind to generate electricity.[1]

Capacity Factor

Only some power plants operate at near full capacity, also called "nameplate," "rated" or "installed" capacity. The "capacity factor" for a power plant is calculated based on the amount of energy actually generated over the course of a year as a proportion of the energy the plant would have produced at full capacity, operating 24/7 every day of the year. Conventional power plants that burn coal typically operate at around 70% of their full capacity (70% capacity factor), nuclear power plants operate at 90% to 100%. Wind power plants typically operate at a capacity factor between 20% and 40%, depending on the local wind resource.[2]

The low capacity factor for wind reflects poor performance. Commercial wind turbines begin to generate electricity at about 9 mph and reach their rated capacity when winds reach about 27 mph.[3] Below 9 mph, no electricity will be generated, and between 9 and 27 mph less that full capacity will be generated. The energy actually generated (capacity factor X rated capacity) reflects the average wind resource over the year.

The diminished capacity factor of wind plants is obscured in official reports of wind's "capacity." For example, the New York State Energy Research and Development Authority (NYSERDA) states: "NYSERDA's, New York Energy $mart^{SM} program through 2001, has supported the construction and operation of 41.5 megawatts (MW) of wind energy generation in New York."[4] This statement refers to two wind energy projects rated at 30 MW and 11.5 MW, respectively.[5] Similarly, the U.S. Government Accountability Office (GAO) states: "U.S. wind power generating capacity quadrupled between 1990 and 2003—to 6,374 MW."[6] However, because they refer to installed capacity these statements provide no insight about how much actual energy would be generated by these investments.[7]

To date, on an annual basis no wind power plant in New York has achieved a 30% capacity factor.[8] The primary reason for this is that Class 4 winds (average winds ranging from 15.7 to 16.8 miles per hour) are the minimum necessary for large-scale wind power projects, and there are few areas in New York that possess such wind resources.[9] Accordingly, many wind power plants in New York are being proposed for locations with less optimal wind resource areas, with an exponential decrease in capacity factors.[10]

Capacity credit

The capacity factor is only part of the story of wind power's ability to contribute to New York's energy needs. The New York System Independent Operator (NYSIO), a non-profit company that manages the electricity grid for the state, needs to secure the amount of energy needed at times of peak load plus a reserve margin. NYSIO therefore assigns a "capacity credit" to each power plant in the state, representing the amount of electricity that the grid operator can rely on to meet peak demand.[11]

Based on NYSERDA-funded research, NYSIO assigns to wind power plants a 10% capacity credit in the summer and a 30% capacity credit the in winter.[12] This represents the grid operator's judgment about how much energy per unit of rated capacity can be relied on in each season. Thus, for the Maple Ridge Wind Farm on the Tug Hill Plateau in Lewis County, New York's largest wind power plant, located in the highest land-based wind resource area in the state, NYSIO calculates the plant can provide 32 megawatts in the summer, compared to its rated capacity of 322 MW.[13]

The poor capacity credit NYSIO assigns to wind probably overestimates wind's reliability since there will be many days in any summer when there will be little or no wind–less than 9 mph–and therefore wind plants will generate no energy at all. This means, to meet our peak demand needs we need to continue to build new more dependable capacity or continue to delay retiring old, polluting but dependable power plants.

Baseload capacity

An assigned capacity credit is based on an expected average over a season. Wind's contribution diminishes even further when we look at how daily fluctuations in electricity demand and electricity generation are managed. Most power plants can provide steady generation of electricity around-the-clock at a large fraction of their rated capacity. These plants provide what is called baseload capacity, that is, a minimum amount of electric power required over a given period of time at a steady rate.[14] "Fluctuations, peaks or spikes in customer power demand are handled by smaller and more responsive types of power plants."[15]

Daily demand for electricity is usually highest in the afternoon and early evening, "with about 16 hours of 'on-peak' time in the day and about 8 hours of 'off-peak' time during the night."[16] Due to the degree of its unreliability, wind power is unable to respond to fluctuations, peaks or spikes in customer power demand and therefore provides no baseload capacity.[17] Baseload plants must be kept on line even if substantial wind-generated electricity is added to the grid.

In fact, substantial amounts of wind-generated electricity increase the fluctuation in the grid as wind power comes on and off, and may increase the demand for responsive baseload plants. Fluctuations caused by integrating wind power into the regional electricity grid also

require additional "balancing" services from the grid operator, potentially increasing the cost of electricity.

Baseload plants may also be operated at reduced capacity when electricity from wind plants is added to the grid. If operated at reduced capacity (for example in the winter, when substantial wind-generated electricity might be added to the grid), power plants that burn fossil fuels operate less efficiently, emitting more pollution per unit of energy produced than if they were allowed to run continuously at maximum capacity. "Combined with the pollutants emitted and CO_2 released in the manufacture and maintenance of wind towers and their associated infrastructure, substituting wind power for fossil fuels does not improve air quality very much."[18]

Land resources

Wind power is being promoted in New York not because it is cheaper or effective in achieving the state's energy needs, but because it might provide a some of the last few percent mandated by the state's policy to obtain 25% of its energy from renewable sources, the "renewable portfolio standards" mandate.[19] A central consideration in any policy to increase the role of commercial wind power in achieving renewable portfolio standards in New York should be the amount of land required to reach such a goal.

In 2005 New York consumed 154 million MWh of electricity.[20] NYSERDA has said that New York has enough "land based wind potential . . . to generate . . . 10 percent of the State's electricity consumption."[21] A typical 60-turbine wind plant in New York requires about 10,000 acres (a conservative assumption).[22] Thus, to generate 15.4 million MWh with wind plants that on average achieve a 20% capacity factor will require about 146 wind plants and 1,460,000 acres, or 2,281 square miles.[23]

The small potential contribution commercial wind power can make to New York's electricity generation needs coupled with the large land resources wind power requires raises the following policy questions:

(1) Whose landscape will bear the burden of the effort to achieve maximum wind-powered electricity in New York? Put differently, do downstate electricity consumers want to sacrifice upstate land values to feel good about unreliable renewables?

(2) Do New York taxpayers want their renewable energy capital investments to be directed at the lowest energy output of any current alternative[24] while avoiding little if any building of new fossil fuel capacity?

(3) Should wind power require greater scrutiny into the potential adverse impacts of wind plants on rural communities (such as changes to nighttime noise and viewscapes, habitat fragmentation, avian mortality)? Put differently, should New York consider state-wide siting restrictions on commercial wind plants?

REFERENCES

1. *Cf.* U.S. Department of Energy (DOE), Energy Information Agency (EIA), "Glossary" ("capacity factor," "capacity credit," "base load," "base load capacity, and "base load plant"), available at <http://www.eia.doe.gov/glossary/>.

2. University of Massachusetts, Renewable Energy Research Laboratory, "Wind Power: Capacity Factor, Intermittency, and what happens when the wind doesn't blow?", n.d., p. 1, available at <http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_2a_Capacity_Factor.pdf> (visited August 20, 2007) ("Typical wind power capacity factors are 20-40%"); American Wind Energy Association, "How Does A Wind Turbine's Energy Production Differ from Its Power Production?", available at <http://www.awea.org/faq/basicen.html>; Wikipedia, "Wind Power," <http://en.wikipedia.org/ wiki/Wind_power>.

3. GE Energy, "1.5 MW Wind Turbine Technical Specifications, available at <http://www.gepower.com/prod_serv/products/wind_turbines/en/15mw/specs.htm>. *See also* Iowa Energy Center at Iowa State University, "Wind Energy Systems," available at <http://www.energy.iastate.edu/renewable/wind/wem/wem-07_systems.html>; American Wind Energy Association, "How Does A Wind Turbine's Energy Production Differ from Its Power Production?", available at <http://www.awea.org/faq/basicen.html>.

4. NYSERDA, "Utility Scale / Large Wind" (n.d.), available at <http://www.powernaturally.org/Programs/Wind/UtilityScale_LargeWind.asp>. This statement describes two wind power facilities, the Fenner Wind Project, rated at 30 MW, and the Madison wind Project, rated at 11.5 MW.

5. These are the Fenner Wind Project and the Madison Wind Project. *See* id. (map).

6. GAO, Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities, September 2004, at <http://www.gao.gov/new.items/d04756.pdf>. The GAO study uses installed capacity as the basis for this statement. *See* id., p. 15 (Table 3). *See also e.g.*, American Wind Energy Association, "Wind Energy Projects in California," note (**), available at <http://www.awea.org/projects/california.html>.

7. The GAO study acknowledges this but only in footnotes. See id., pp. 1.n.3, 14.n.16. However, the study goes on to compare electricity generation from wind with facilities using fossil fuel, nuclear, natural gas and oil, all of which have at least twice the capacity of factor of wind. Id., p. 9.n.6.

8. U.S. Department of Energy, Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006 (May 2007), p. 17, Fig. 23, available at <http://www.nrel.gov/docs/fy07osti/ 41435.pdf>. *See also* id., p. 4 ("New wind plants contributed roughly 19% of new nameplate capacity added to the U.S. electrical grid in 2006, compared to 13% in 2005"). *See also* Prefiled Testimony of Thomas A. Hewson, BSE, in the matter of the East Haven Windfarm,

January 1, 2005, available at <http://www.windaction.org/documents/720> (average capacity factors for new wind projects in 2003 was 26.9%); NYSERDA, "Madison Windpower Project Final Report, December 2003, p. iii, available at <http://www.powernaturally.org/About/documents/ madisonCountyWindpower.pdf> (capacity factor for the Madison Windpower Project in Madison County is 21%). *Compare* NYSERDA, Frequently Asked Questions for Large-Scale Wind Energy Projects, p. 4 (n.d.), available at <http://www.powernaturally.org/Programs/Wind/toolkit/ 23_frequentlyaskedquestions.pdf> ("When averaged over a year, wind projects typically operate at levels equivalent to 30 to 40% of their full capacity (aka capacity factor.").

9. Wind resource maps for New York are available from NYSERDA, "Wind Speed of New York at 100 Meters [328 Feet]," <http://www.awstruewind.com/inner/windmaps/maps/NorthAmerica/UnitedStates/NewYork/NY_SPD100m_25May04.pdf>. *See also* EIA, "Classes of Wind Power Density at Heights of 10m and 50m" (table), July 2007, available at <http://www.eia.doe.gov/cneaf/solar.renewables/ page/wind/wind.html>; EIA, "Wind Resource Potential" (map), available at <http://www.eia.doe.gov/cneaf/solar.renewables/ ilands/fig13.html> (both visited August 20, 2007).

10. Energy output from the wind is proportional to the cube of the wind speed. That is, as mean wind speeds decrease, the capacity factor for wind turbines decreases exponentially. *Cf.* Brad G. Stevens, P.E., "Wind Energy Resource and wind Farm Siting" (powerpoint for Northwest Wind energy workshop, August 3, 2006), slide 9, available at <http://www.cleanenergyresourceteams.org/northwest/Stevens%20NW%20CERT%2008_03_06.pdf>.

11. NYSIO, 2007 Load & Capacity Data (2007 Goldbook), available at <http://www.nyiso.com/public/webdocs/services/planning/planning_data_reference_documents/2007_GoldBook_PUBLIC.pdf> (visited October 5, 2007).

12. Id., p. 58.

13. Id., Table III-2, p. 28.

14. EIA, "Glossary," note 1, above ("load capacity, and "base load plant").

15. Wikipedia, "Base load power plant," at <http://en.wikipedia.org/wiki/Base_load_power_plant> (visited October 5, 2007).

16. EIA, THE CHANGING STRUCTURE OF THE ELECTRIC POWER INDUSTRY 2000: AN UPDATE, p. 9n.16 (October 2000), available at <http://www.eia.doe.gov/cneaf/electricity/chg_stru_update/update2000.html> (visited October 5, 2007).

17. New Jersey Blue Ribbon Panel on Development of Wind Facilities in Coastal Waters, Final Report, p. 21 (April 2006), available at <http://www.njwindpanel.org/docs/finalwindpanelreport.pdf>:

> wind power alone cannot reduce the state's dependence on fossil fuels. Nor can wind power provide "base load" power needed to meet every day energy demands. Due to these limitations, wind power cannot remedy the current energy related environmental issues facing New Jersey.

Compare the industry advocate Alliance for Clean Energy New York, "New York State Wind Facts," available at <http://www.aceny.org/cleantechnologies/new_york_state_wind_facts.cfm> ("20 percent of the total wind energy can be considered base load, like traditional fossil-fuel plants, and that . . . helps to improve overall utility system reliability.").

18. H. Sterling Burnett, Ph.D., "Wind Power: Not Green but Red," testimony presented to the American Legislative Exchange Council Task Force on Energy, the Environment, Natural Resources and Agriculture Austin, TX (May 1, 2004), available at <http://www.ncpa.org/prs/tst/20040501hsburnett.htm> (visited October 5, 2007).

19. *See* NYSERDA, "About New York's Renewable Portfolio Standard," Available at <http://www.nyserda.org/rps/about.asp>.

20. EIA, "New York Electricity Profile" (2005), available at <http://www.eia.doe.gov/cneaf/electricity/st_profiles/new_york.html> (retail sales and direct use).

21. NYSERDA, "Utility Scale/Large Wind," at <http://www.powernaturally.org/Programs/Wind/UtilityScale_LargeWind.asp>.

22. Phase 1 of the Maple Ridge Wind Farm in Lewis County, with 120 1.65 MW turbines, "spans approximately 21,000 acres." PPM Energy, Press Release, "PPM and Zilkha Announce Maple Ridge Wind Farm Landmark Project Will Quadruple New York Wind Energy Capacity," April 5, 2005, available at <http://www.ppmenergy.com/rel_05.04.05.html>. However, a recently approved 65-turbine wind power plant in Washington requires 6,000 acres. *See* Energy Facility Site Evaluation Council, Order No. 826, *In the Matter of . . . Kittitas Valley Wind Power Project* (March 27, 2007), available at <http://www.efsec.wa.gov/kittitaswind/adj/Order%20826.pdf>.

23. That is, (15.4 million MWh ÷ 8,766 hrs. in a year = 1,757 MW) X 20% capacity factor = 8,785 MW rated capacity needed ÷ 60 turbines per wind plant X 10,000 acres = 1.46 million acres or 2,281 square miles.

24. One promising alternative is enhanced geothermal energy, recently assessed by MIT in a study that concludes known deep geothermal resources can provide 57,000 times the current energy needs of the U.S. Links to the MIT study and current information on enhanced geothermal energy are posted on the website of Concerned Citizens of Cattaraugus County, at <http://www.homestead.com/concernedcitizens/windfarms.html#anchor_13>.