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CASE STUDY

REAL PROJECT
08

WIND ENERGY PROJECT

WIND FARM INTEGRATED INTO HYDROELECTRIC POWER SYSTEM / WASHINGTON STATE, USA

RESULTS

This project's results and analysis are based on the experience of the Okanogan Public Utility District (PUD) in Washington State USA for integrating wind and hydro power systems. Okanogan PUD did decide to purchase a 25% share in the 64 MW Nine Canyon Wind Farm starting in 2002. The PUD's hydro resources with their flexible ramp rates and access to storage are particularly effective at firming the energy output of wind production.

The developer, Energy Northwest is a joint operating agency created to develop generation resources for its member Public Utility Districts in the State of Washington, USA. Energy Northwest, financed the wind farm project in two phases: Phase I involved a $70 million tax-exempt bond issue in 2001 to cover the first 37 wind turbines with commercial operation in September 2001; the second phase 12 turbines were financed with a $21.7 million bond issue in 2003 and was completed by December 2003.

The Wind Farm's purchase agreement assumed a 3% per year annual increase in the power purchase price over the life of the 22-year contract. If the rate of increase in market power prices were to be 3% per year also, then the purchase from the Energy Northwest would be expected to cost the same as purchasing from the market.

SYSTEM DESCRIPTION

The project uses forty-nine 1.3 MW turbines from Bonus Energy of Denmark; it has a capacity of 63.7 MW and a predicted 31.4% average capacity factor. Thus, the project should produce about 175,000 MWh/year at the turbines with average capacity of 20 MW.

The project's underground 34.5 kV power lines and 115 kV substation were constructed by one of the purchasers, Benton County PUD and interconnects with the Bonneville Power Administration's (BPA) 115 kV system. Okanogan PUD's share of the Project's output is transmitted over BPA lines to Douglas PUD's Load Control Area (LCA)[1]. The LCA operator uses Okanogan's 65 MW's of hydropower capacity at Wells Dam on the Columbia River to smooth and make available for future use Okanogan share of the project, essentially eliminating the need to purchase additional ancillary services.

As a proxy for balancing cost we assumed an internal cost of $0.9/MWh[2] for Okanogan PUD. By comparison, if this balancing service were purchased from BPA the price would be $4.50/MWh[3] in part because BPA treats wind integration differently than Okanogan PUD.

[1] Load Control Areas (LCA) are important "islands" within the larger power system to schedule in and out power to serve the LCA's total load with the resources within the LCA.

[2] Based on "Integrating Wind Energy with the BPA Power System: Preliminary Study" by Eric Hirst, Sept-2002

[3] See link: www.bpa.gov/Power/PGC/wind/BPA_Wind_Integration_Services.pdf

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LESSONS LEARNED

1) FIRST THREE YEARS WIND PRODUCTION

Total delivered wind power to the Okanogan PUD over a three year period was a little over 106,500 MWh, or 90% of expected "normal" production. This still provided roughly 7% of the utility's energy requirements. For example:

- In 2003 actual power production was 5% less than forecast with a negative net value (market value of purchases minus purchase cost) of $174,000.
- In 2004, 10% less was produced with negative net value for 2004 of $120,000.
- For 2005 production was 13% less than forecast with a positive net value of $273,000.

2) FIRST THREE YEARS FINANCIAL RESULTS

Okanogan PUD's average net delivered cost for wind energy was about $44.1/MWh, including an average cost of $3.2/MWh for transmission. If this electricity had been purchased at market rates, the cost would have been $43.9/MWh.

The net actual value (without any assumed balancing costs) of the Okanogan PUD's wind power for the 2003 through 2005 period was negative $21,000. However, in the second half of 2005, the utility sold Renewable Energy Credits[4] (REC's) for over $58,000 at a market price of $3/MWh, ($5.36/tonne of CO_2 base on GHG analysis in RETScreen with 0.559 tonne of CO_2/MWh). This REC sale led to a net positive value for wind power of $37,000 over the three-year period.

3) GREEN POWER BENEFITS

Over the life of the project, the Okanogan PUD will reduce greenhouse gas emissions, on average, by 22,000 tonnes of CO_2 per year, through the displacement of fossil fuel-powered generation. The project profitability has been improved by providing monetary benefits from these emissions reductions. The utility will certainly continue selling RECs in future years.

4) CORRELATION BETWEEN DROUGHT PERIODS AND LACK OF WIND AND HIGH PRICES

Data from this project indicate that in the Pacific Northwest region (where this project is located), drought periods tend to coincide with low wind periods. The Columbia River normally has about 132 billion cubic metres of snow pack water runoff during this period. This runoff is the "fuel" from winter storms and spring rains that make up the majority of the area's hydropower supply.

Since September 2002, in general there has been less precipitation and less wind than normal. This apparent correlation does not help the financial feasibility of wind power in the area because drought periods are normally also high cost power periods. However, as this project demonstrated in the 2005 drought year, the net value of wind power can still be positive when reduced wind power production corresponds with higher market prices.

5) EQUIPMENT DESIGN FLAWS OR MALFUNCTIONS

The Nine Canyon Wind Farm has had a number of problems with its turbines. Broken gearbox teeth and bearing problems have plagued the project. There have been more than a dozen such events since commercial operation began in September 2002. There is concern that if these problems are not resolved, then project profitability will be affected once the warranty has concluded.

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[4] Renewable energy credits (REC's) are also known as "Green Tags". An REC is a tradable unit representing the environmental benefits associated with 1 MWh of renewable energy.

6) REPI CREDIT REVENUES

Revenues from the Renewable Energy Production Incentive (REPI) credit, nominally $18/MWh, have been only a bit more than 80% of what had been expected (pre-feasibility study was based on $15/MWh). The federal REPI program has provided $15/MWh amounting to ~$2,428,000 annual savings for Energy Northwest and the nine participating PUDs. The project would not be profitable if REPI credit program was not available.

7) INTEGRATING WIND POWER INTO A HYDROPOWER-BASED UTILITY

The Nine Canyon Project experience has demonstrated that wind power can be integrated into a hydropower Load Control Area (LCA) with little, if any, energy imbalance capacity devoted to following wind power swings beyond that required by a utility simply following its natural load swings. This suggests that there is minimal need for additional ancillary services. For the case study, Okanogan PUD's internal balancing costs are assumed to be $0.9/MWh (~$145,000 per year); however, this price would increase to $4.5/MWh (~$728,000 per year) if this service had to be purchased from Bonneville Power Administration. (Note that this balancing cost of $0.9/MWh is added to the annual transmission costs of $3.2/MWh for the "annual O&M cost" analysis.)

8) LIMITS ON WIND POWER PENETRATION

There is significant debate on the penetration limit of wind energy that a small utility with hydropower resources can absorb. No serious problems arise at a 11.4% power penetration level (i.e. 16 MW of wind power on a base of 140 MW of total hydropower capacity[5]), but at some point there could be shortcomings in the ability of hydropower to back up, shape, and accommodate the wind power without unencumbering hydropower capacity to serve load.

THE BIG PICTURE

The State of Washington has a proposed initiative in 2006 to require large utilities to obtain 15% of their electricity from "new" renewable energy resources by 2020. Okanogan PUD is currently at about 7% of this target with its share of the Nine Canyon Wind Farm Project.

As energy prices continue to increase in the future, Okanogan PUD's wind power is expected to supplement its hydropower resources at below market prices. Although drought periods tend to be associated with lower average wind speeds, there is some wind power during these times with relatively high value which tends to compensate for the lack of wind.

Okanogan PUD is pleased with the purchase of wind plant resources to date and wind power's ability to be competitive with the market. Okanogan PUD also sees benefits in the project's ability to complement its hydropower base. The PUD will certainly consider adding more wind power to meet future power load growth, especially since the PUD's ratepayer surveys indicate they prefer cost-effective renewable energy resources over other generation resources.

[5] Okanogan's total peak load is served by approximately 65 MW's of Wells Dam capacity, 75 MW's of BPA's "Slice Product" which is primarily hydropower, and a BPA "Block Product" with up to 25 MW's.

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49 x 1.3 MW, WIND FARM INTEGRATED INTO HYDROELECTRIC POWER SYSTEM / WASHINGTON STATE, USA
PHOTO CREDIT: LARRY FELTON, FELTON AND ASSOCIATES.

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