Crcl mbrs
TM
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WH

Coles, Kendra

From: Hertz, Judi

2008001022

Sent: Thursday, January 24, 2008 1:28 PM

To: Coles, Kendra; Morlan, Terry

Subject: FW: Comment on Issues for the Sixth Pacific Northwest Power and Conservation Plan

Attachments: VRB-ESS Wind Application.pdf; Electricity Storage for Capital Deferral.pdf; PacifiCorp labels coal a no go.doc

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From: George Hughes [mailto:ghughes@yourcpas.com]
Sent: Thursday, January 24, 2008 1:14 PM
To: Hertz, Judi
Subject: Comment on Issues for the Sixth Pacific Northwest Power and Conservation Plan

JAN 24 2008

Mark,

I would like to offer the following comments regarding the **Sixth Pacific Northwest Power and Conservation Plan.** In essence, I would suggest that onsite power storage technology be considered and encouraged for renewable power generation.

Power Storage at Wind and Solar Generation Sites

As part of the Sixth Pacific Northwest Power and Conservation Plan, power storage technology at wind and solar generation sites should be planned for and encouraged by policy decisions and rate incentives. Power storage technology offers a number of advantages, and technology exists that could be implemented more widely.

The Plan's paper identifies the following key issues, and power storage offers solutions to each one:

- Climate change and related policies
  - Additional ability to integrate renewable power smoothly reduces the carbon footprint of generation. Gas turbine plants are currently planned as a tool to offset the variability of wind.
- Capacity to meet loads on an annual, daily, hourly, and sub-hourly basis
  - Power storage offers smoothing of production and the ability to shift power capacity to the time of day when demand peaks
- Expanding the menu of efficiency and generating resource choices
  - Power storage offers the ability to consider wind and solar as a form of baseload power generation
- Transmission constraints and their impact on electricity markets and resource development
  - Power storage reduces the otherwise increasing variability in generation resulting from increasing wind and solar generation. Variability stresses transmission capacity.
- Power plan interactions with the fish and wildlife program
  - We no longer have the ability to spill water to offset the variability of wind power. Fish and wildlife management have priority.
- Appropriate avoided cost measures for resource decisions
  - Power storage technology should avoid the need for much greater transmission capacity. A reduced need for gas turbine plants should be another result of power storage and related

power smoothing.

Wind and solar integration costs could be significantly lowered through the use of power storage technology located at generation sites.

In the Wind Integration Forum document 2007-1:

5) "There are steps we can take to increase integration capability and to lower integration costs. "

(4) "development and application of new flexibility technologies. Achieving these goals will require coordinated actions similar to those required to establish the Pacific Northwest Coordination Agreement of the Columbia River Treaty."

Power storage technology offers a solution for the new flexibility technologies.

Policies and rates should be structured to encourage on-site implementation of power storage technologies. Currently wind integration charges are proposed for future wind generation projects. The waiving of these charges for sites that implement power storage technology could be one form of incentive to encourage more rapid adoption. The system wide reduced requirement for transmission and gas generation should be reflected in incentives. Currently a premium is paid for renewable power generation. A slightly higher premium price could be paid for renewable power smoothed with power storage technology, and so help to make power storage technology economic for the wind power project developer.

While I don't want to favor any particular company's technology, I've attached information from VRB Power Systems, a presenter at the Pacific Coast Clean Energy conference that I attended. This type of technology could be a solution for a list of problems that arise from the variability of wind and solar power. For example, in the attached PacifiCorp article from the Oregonian, PacifiCorp mentions the need to build a gas turbine plant to offset the variability of wind power. It could be feasible that instead of building a gas turbine plant, that power storage systems like the ones made by VRB Power Systems could be installed at wind and large solar sites.

The power storage should offer "smoother" power than the combination of wind and gas turbines. Also, the smoother power should also minimize the extra transmission capacity that Bonneville Power and others would need to build. The storage systems also offer the ability to supply power "on demand", and so add additional flexibility to the base supply. The storage systems should actually be more flexible than the dams on the Columbia, given the need to regulate water flow for salmon.

Also, power storage reduces the "carbon footprint", as gas is not burned at a turbine plant.

The list of advantages, combined with the Oregon Business Energy Tax Credit incentive of a 50% tax credit and other possible rate and charge adjustments, should make this a financially feasible alternative, at least in Oregon. I haven't heard anyone discussing this, especially in combination with the financial support of the BETC.

From a public policy point of view, I would think that encouraging power storage would offer great advantages. At VRB's presentation, he mentioned that Europe is currently balking at the variability of Holland's wind systems. With the coming rapid growth of wind and solar generation, thoughtful public policy and good planning for power storage should make the overall economics work.

There should be an advantage to looking at the problems Holland has, and avoiding them with good planning and public policy.

Here's the VRB website for further info:

http://www.vrbpower.com/

Again, while I don't want to necessarily favor any one technology, the presentation I heard at the Pacific Coast Energy Conference started my thoughts regarding the ability of power storage to be a solution to the looming wind integration problem. At the conference it was mentioned that PacifiCorp has successfully used this technology for three years in Utah at a wind farm. This made me realize that technology solutions may be currently available.

I offer these comments as an individual involved in the industry as a CPA, and these are my personal comments, not the comments of our firm as a whole.

Thank you,

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The VRB Energy Storage System (VRB-ESS™)

The Multiple Benefits of Integrating the VRB-ESS with Wind Energy – Case Studies in MWH Applications

March 2, 2007

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Wind power generation is considered a non-firm resource for system planning purposes. The consequence of this is that the price paid for capacity from wind generation is severely discounted. The volatile nature of wind generation output limits the amount of wind generation that can be connected to the grid without causing voltage stability problems. A maximum figure of 20% penetration is often referred to. To address both the economic value and the technical limitations several studies have examined the benefits of firming up the wind generation by using energy storage. None of these studies has considered overall system benefits nor have they used the most recent pricing of energy storage systems, which have fallen considerably over the last year. This paper presents the multiple benefits of integrating the VRB-ESS with wind generation from both a theoretical perspective and practically through a case study of a hybrid wind, diesel and VRB-ESS installation.

Introduction – The Value of Wind Generation

Wind generation systems have a fluctuating or intermittent power output due to the variability of the wind speed. Figure 1 lists causes and time scale of wind variations. In addition there is a finite ramp up and ramp down (decay) function from individual wind turbines when wind speeds change. Generally this is of the order of several minutes. Models of short-term (hour ahead) fluctuations are now very well advanced in many European countries to the extent that variations can be predicted with 95% levels of confidence. Combining this modeling with physical turbine inertias, the power outputs from wind farms can be deemed predictable and hence should be included in power system planning as a dispatchable resource certainly at a larger percentage of nameplate capacity than is currently recognized. However, there remains a limit to how much capacity credit can be given to a wind farm or individual turbine especially if the wind regimen is not coincidental with load demand. The capacity credit referred to here implies the amount of conventional generation that can be displaced by wind derived power generation. For example, in southern California the wind speeds are greatest when system demand is lowest. As far as utilities are concerned, prices for wind energy and capacity will always therefore be discounted at a short run avoided cost rate unless there is very high confidence of load demand and wind turbine output overlap.

In Germany, a capacity credit of 7.4% has been found, i.e.1,000MW of installed wind power capacity would lead to a replacement of only 74 MW of conventional capacity. The other extreme shows a capacity credit of 45 percent for the UK [1]. The capacity factor is determined by the diversity of loads and the period during the year over which it is considered. In Kansas and in the PJM (East coast) markets, capacity factor of 20% is paid – i.e. 80% discounted. It is often cited that the 20% figure depends upon the spinning reserve or reserve margins in the system which implies that unless wind power generation becomes firm, it will never achieve higher penetration levels than this. Considerable work in reviewing this needs to be done and several research projects are under way [5]

Utilities in general have tended to simply discount wind capacity and maintain additional alternative reserves. Part of this has been a result of the monopoly position whereby system expansion costs have been borne by the rate base through commission based tariff structures. A guaranteed return of say 12% can be achieved by simply building more infrastructure. This approach leads to poor system load factors and inefficient use of assets. Wind resources will always be penalized through this historic approach.

Causes of Variation	Time Scale of Variation	VRB-Energy Storage - resolves the problem? Y/N
Wind gusts (turbulence)	Short term seconds	Y
Diurnal Cycle	Daily	Y
Inversion Layers	Hourly	Y
Changing (long term) wind patterns	Days	Provides flexibility
Seasonal cycle	Monthly	Y
Annual Variation	Yearly	Y
Normal wind speed variations	Minutes	Y

Figure 1. Causes and Time scale of wind variation – [1]

Observations of several years ago that when wind penetration levels reached 15% or more of system capacity on a local basis, there would be severe resistance from utilities, has proven true. Several regions and countries have limited further wind farm installations until solutions to the power variability have been found. Differences in experience have shown that the Europeans have embarced storage as a requirement to allow for further wind penetration [9], whilst North America has yet to acknowledge this [8].

Where multiple generators are connected i.e. a wind farm, the fluctuation in total power output is reduced. Under ideal conditions the variations of power output will drop with 1/n, where n is the number of wind generators (Figure 2). Where wind penetration is high, this will reduce the overall power fluctuations on a system wide basis but may still lead to local power swing stability concerns [4]. System stability modeling considering dynamic power variations is complex. Certainly none of the current models are able to adequately represent both the uncertainty and the variability of wind output. Some models can represent the variability of wind by modeling a wind plant as an hourly transaction (power purchase) or modification to system load. However, both of these approaches typically assume no uncertainty of the wind generation in each hour of the year. Conversely, modeling wind as a thermal unit with multiple blocks and forced outage rates tends to smooth the statistically expected wind output, although it does account for uncertainty. This is because most models don't allow for hourly changes to the resource capacity and outage rates applied to the same unit [2]. Considerable work is needed in developing integrated software packages capable of providing load flows stability analyses with varying wind power inputs.

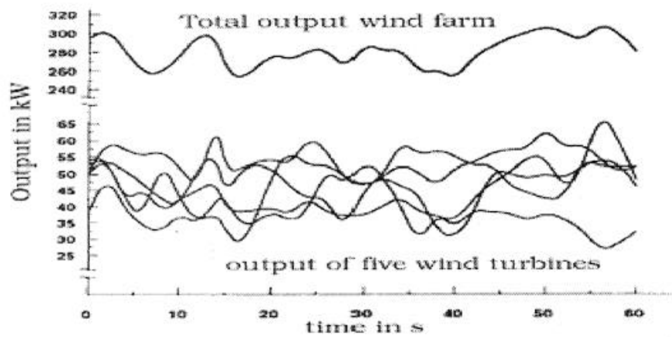
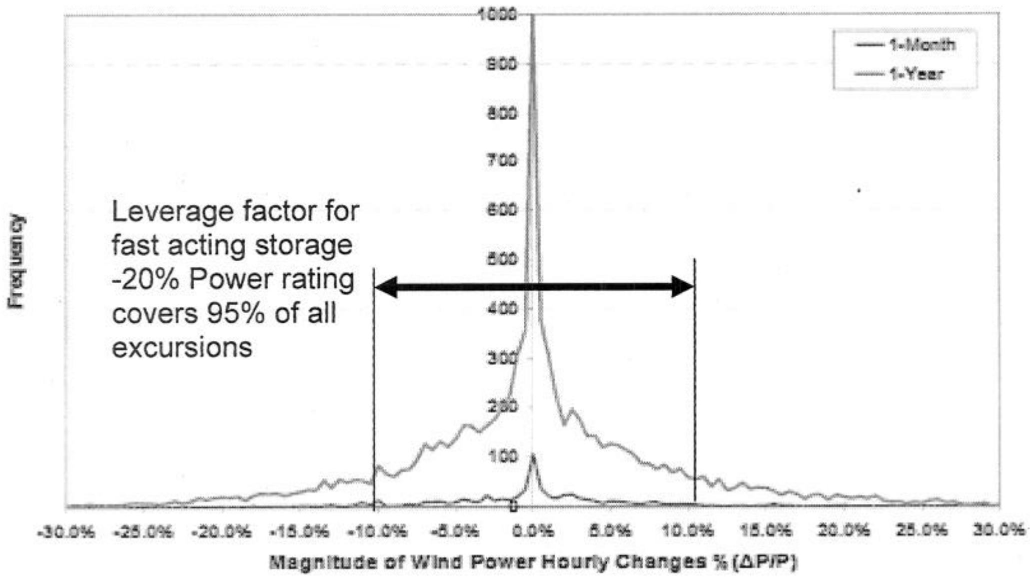


Figure 2. Single and total power output of a wind farm showing fluctuations over one minute – [1]

Wind power is intermittent. In order to be useful on a grid system, its fluctuations must be balanced by some other form of dispatchable generation in order to meet load. The process for performing this balancing differs somewhat by energy market, but generally involves the following processes:

1. Long term meteorological forecasts are used to assess seasonal trends, estimate gross energy production patterns and line up suppliers for the expected balancing power.
2. Day-ahead forecasts are prepared, translating expected wind patterns into hourly production estimates.
3. These hourly production estimates are compared with the forecasted hourly loads, and the difference is made up by scheduling dispatchable generation. In competitive markets, this is procured using a bid process, and a capacity payment is made to the generator whether or not the scheduled energy is actually delivered.
4. During the actual production day, wind output forecast errors are compensated for in one of two ways: If wind production exceeds forecast, the scheduled balancing power is not called. As stated previously, a capacity payment still must be made to the generator. The contracted energy can be sold into the spot market (if economic) or simply spilled. If wind production is less than forecast, additional balancing power must be procured in the real-time (spot) market.

The addition of storage to the wind farm serves to alleviate this problem of forecast error and in so doing, enhances the value of the produced wind power. The hourly, day-ahead forecast is entered into the storage plant control system, and in real-time, wind production above forecast is absorbed by the VRB-ESS and wind production below forecast is supplemented by the VRB-ESS. The day-ahead purchased balancing power is deployed exactly as scheduled, and no spot purchases are required. Thus, the "arbitrage" that the storage plant experiences is that its charging energy, the wind power produced above forecast, is of very low or no value, since the previously purchased balancing power capacity will have to be paid for anyway, while its discharged energy offsets potentially very high priced spot market purchases.



The above frequency distribution graph courtesy of NRE [10] shows that although there are certainly severe power fluctuations, the majority are confined to a reasonably narrow band of about 20% (plus 10% and -10%). Determining exactly what this spread is for given periods is very difficult but by adding in a fast acting energy storage sized at between 15 to 25% of nameplate wind turbine rating, can improve forecasting to the 95% confidence interval. In this way, the storage plant investment is leveraged, by conditioning a wind farm five times its size, and optimized, by arbitraging between very high value energy and low or zero cost energy.

Integration of Energy Storage Systems with Wind Generation

Perhaps the most logical solution to variability of output from wind turbines is to provide a means to store excess energy and to return that energy to the grid when the wind turbine output drops off. From the supply side perspective this is an availability enhancement tool. It provides spinning reserve. From the demand side it is a load shaping or levelling tool. Historically lead acid batteries have been used for large-scale energy storage but these have been very expensive, inefficient and incompatible with rapidly varying loads. New technologies have begun to emerge with the challenge being reliability, long life and low cost. The principle of integrating an energy storage system and a wind based generator in either a single wind turbine form or in a group of turbines, is to choose a capacity and storage duration which will allow the output to be "firmed up". If the cost of this energy storage system is such that the added benefits resulting from its installation including increased energy sales (less spillage), increased capacity payments in $/kW.month and any ancillary service benefits, amount to more than its operating and repayment costs, then it becomes a viable option. In addition it is one that will improve the penetration levels of wind power generation, will improve system parameters such as power quality, voltage control and overall load factor. By applying energy storage at distribution levels localized benefits as well as summated transmission system benefits occur.

The opportunity to take advantage of time-of-use tariffs and arbitrage becomes possible. A major benefit of electrochemical energy storage solutions is their ability to be placed locally where the need and benefit is greatest. They can be deployed rapidly with wind farms with little permitting concern. Systems of 100MWh are now technically feasible and economically viable. Alternative storage technologies such as Pumped Hydro Storage and Compressed Air Energy Storage (CAES) both require significant geological structures for their implementation either in the form of dams or deep mines. The VRB Energy Storage System (VRB-ESS) is an all vanadium flow battery energy storage system, which has been applied with several wind farm applications. It is described below.

The VRB Energy Storage System (VRB-ESS)

The VRB-ESS is an electrical energy storage system based on the patented vanadium-based redox regenerative fuel cell that converts chemical energy into electrical energy. Energy is stored chemically in different ionic forms of vanadium in a dilute sulphuric acid electrolyte. The electrolyte is pumped from separate plastic storage tanks into flow cells across a proton exchange membrane (PEM) where one form of electrolyte is electrochemically oxidized and the other is electrochemically reduced. This creates a current that is collected by electrodes and made available to an external circuit. The reaction is reversible allowing the battery to be charged, discharged and recharged.

The principle of the VRB is shown in more detail in Figure 3 - it consists of two electrolyte tanks, containing active vanadium species in different oxidation states (positive: V(IV)/V(V) redox couple, negative: V(II)/(III) redox couple). These energy-bearing liquids are circulated through the cell stack by pumps. The stack consists of many cells, each of which contains two half-cells that are separated by a membrane. In the half-cells the electrochemical reactions take place on inert carbon felt polymer composite electrodes from which current may be used to charge or discharge the battery.

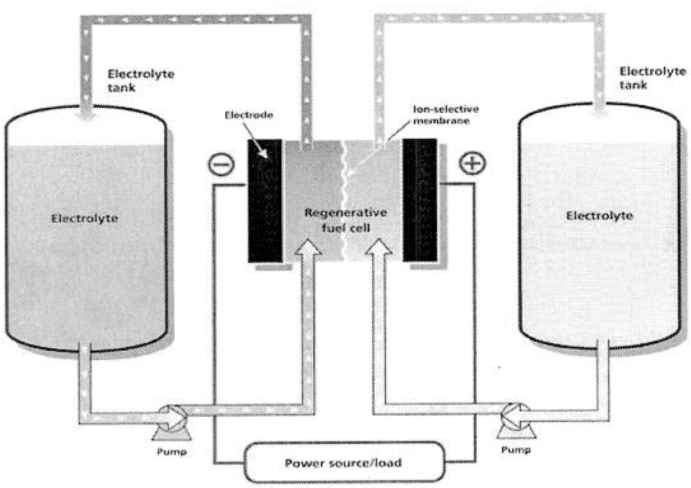


Figure 3 - Concept of the redox flow battery system

The open circuit cell voltage at a concentration of 2 mole per litre for each vanadium species is 1.6 V when fully charged. The relatively fast kinetics of the vanadium redox couples allows high Coulombic and voltage efficiencies to be achieved without costly catalysts.

Features of a VRB Energy Storage System

- The system can be recharged at high rates in a fraction of the time needed for the lead-acid battery. It can be discharged and charged greater than 10,000 times (20% to 80% SOC).
- High-energy efficiencies – 65 - 75%.
- Indefinite life of electrolyte (no disposal issues).
- Remains fully charged with low self-discharge, almost indefinitely.
- Existing systems can be readily upgraded and additional storage capacity can be easily installed by changing the tanks and volumes of electrolyte.
- Cross mixing of electrolytes does not lead to the contamination of electrolyte.
- A theoretical charge/discharge window of 1:1 (practically 1.8:1), which is ideal for wind generation applications.
- Designed for unattended operation with very low maintenance costs ($0.008/kWh).
- Low operating temperature.
- 7x24 voltage regulation / VAR support and power quality benefits regardless of the VRB-ESS's charging/discharging state integrated multi-quadrant, fast acting Power Control System, which allows power factor compensation and dynamic filtering of system harmonics.
- Low environmental impact during life cycle. A study [7] of the environmental impact of both vanadium redox and lead-acid batteries, using a life-cycle assessment approach indicates that the vanadium redox battery contributes between 7-25% of emissions of key environmental impact (CO2, SO2, CO, CH4, NOx) during its life cycle when compared with lead-acid batteries.

Wind Power Generation & the VRB-ESS - Their Influence on Voltage Regulation & I^2R Losses

The combination of wind generation and the VRB-ESS can be analyzed as a distributed generator (DG) or embedded resource with defined response. Such a combination of systems addresses the issues of:

- Power system losses and power factor
- Voltage variations or regulation based upon load variations – especially light loading over weekends or nights
- Frequency control and system stability
- Reliability and power quality
- Capital expenditure and its deferment

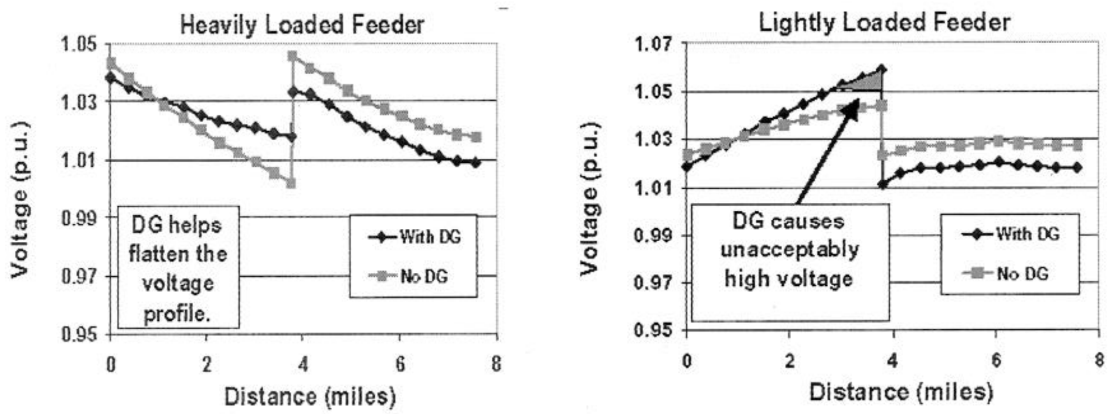


Figure 4. Plots of DG impacts on distribution feeders under different load conditions [6]

A distributed generation unit that supplies only active power, which is used locally, will reduce the voltage drop, because it reduces the active power flow from the feeder and thereby reduces the active and reactive voltage drop along the lines. If a wind farm feeds into the distribution network during low demand, but not during peak demand, the voltage variation will increase. This can be a serious problem requiring active management of the utility capacitors and voltage regulators. As the correlation between wind speed and local demand is usually low, distributed wind power generation will actually worsen the voltage variations unless energy storage is used which is capable of dynamic control and dispatch.

By controlling the excitation of wind power generators it is possible to control the voltage level within a local distribution network. However most of the current generators operate with a fixed power factor. The use of dynamic reactive power compensation in VRB-ESS offsets the needs for additional voltage regulation and capacitors at substation level. Problems associated with "light loading" over-voltages and system harmonic resonances, are actively addressed by the VRB-ESS.

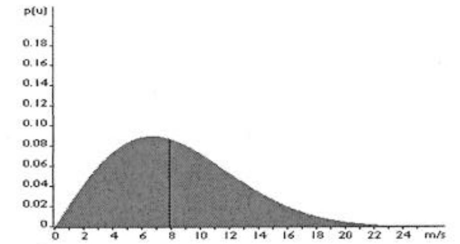
The normal **technical losses** in the power system due to transformer and line losses often ignore the issue of capacity constrained systems, which feed not only resistive loads, but also constant power loads such as compressors. Motors or machines consume 60% of all electrical power consumed in the USA, 35% of which are constant torque type. Low voltage therefore will result in increased current demand with a consequent increase in I^2R losses. There is also an increase in reactive energy demanded by induction machines operating at constant torque as the voltage declines. Power factor will decrease and transfer capacities reduce. The common practice of controlling transmission system stability by reducing voltage therefore only impacts 65% of the load. Installation of combined wind based power generation and the dynamic VRB-ESS provides a solution to this problem allowing for capacity extension deferrals and system efficiency enhancements.

The Leverage Affect – Sizing of the VRB-ESS for use with Wind Turbines

It is unnecessary to install a one to one rated VRB-ESS to that of the wind turbines. Furthermore the selection of energy storage duration is determined by the probability period of wind energy reducing to below the acceptable minimum. This set minimum is either the duration of the minimum load that has always to be met or is the "firm" capacity period contracted to in a PPA. Operating the VRB-ESS in a mode centered on a 50% state-of-charge (SOC) provides the ability to absorb energy and discharge energy at close to optimal cost.

The method of sizing the VRB-ESS is as follows. The power, probability density distribution function for the wind farm is determined using the Weibull distribution for the turbines power output at various wind speeds, multiplied by the projected wind speeds over the year. The graph in Figure 5 shows a Weibull distribution for a single turbine with k=2 (Raleigh distribution), mean wind speed = 8.4m/s. Figure 6 shows the projected (15minute average) power output for a 24hour period for 5 turbines. The mean output is shown. This is the selected operating point of the VRB-ESS. The VRB-ESS capacity rating in kW is chosen as the greater of the maximum power deviation below or above the mean. This ensures that all the excess energy generated by the turbines (above the mean) and absorbed by the VRB-ESS, equals all that exported from the VRB-ESS (below the mean) and supplied to the grid during any 24hour period – i.e. a net energy balance of zero. Furthermore it sets the contracted "firm" capacity for the wind farm. The utility can plan on this as a minimum firm rating – and pay for it.

Figure 5. Single turbine power density distribution function



The leverage factor is evident in that the VRB-ESS is rated at only the maximum deviation from the mean in kW whilst the total turbine nameplate capacity rating is 2450kW. In this example the leverage factor is 927/(1410-927) = 1.9. You are able to deliver a 38% firm capacity of 927kW using a VRB-ESS of 483kW on nameplate rated turbines of 2450kW.

The storage duration is determined from the power density probability function for the wind farm as a whole by determining the maximum summated energy (power x time) per day that the output of the collective wind farm turbines drops below the mean.

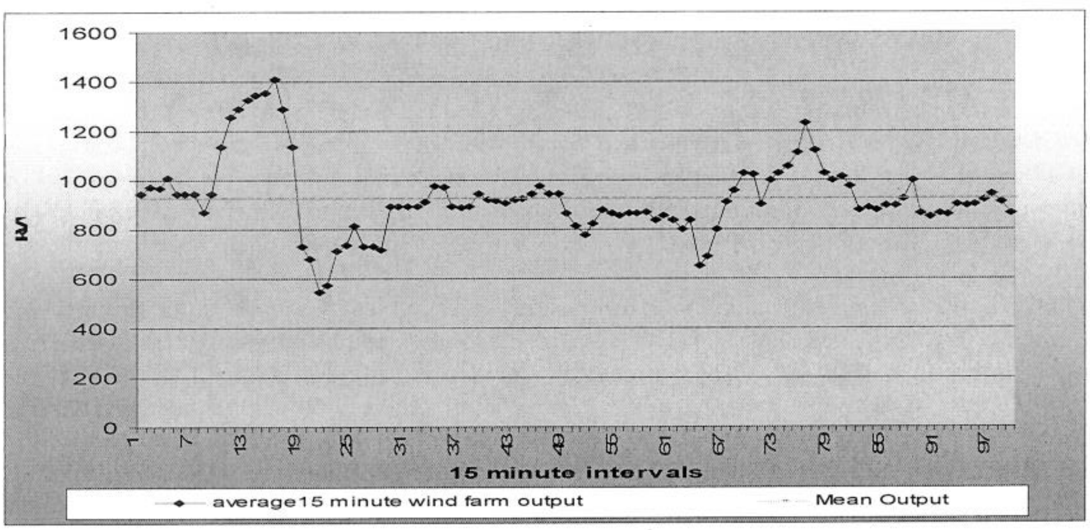


Figure 6. Average wind power output for a 2450kW nameplate wind farm

In Figure 7 all those periods to the left of the mean (930kW) equate to 0.15 x 24 = 3.6hours. Thus the VRB-ESS is sized at 483kW x 3.6hours = 1.74MWh. Since the incremental cost of additional storage in kWh is only 10 to 15% of initial capital cost, adding more hours of storage is a very cost effective option if load and wind regimens are not coincidental.

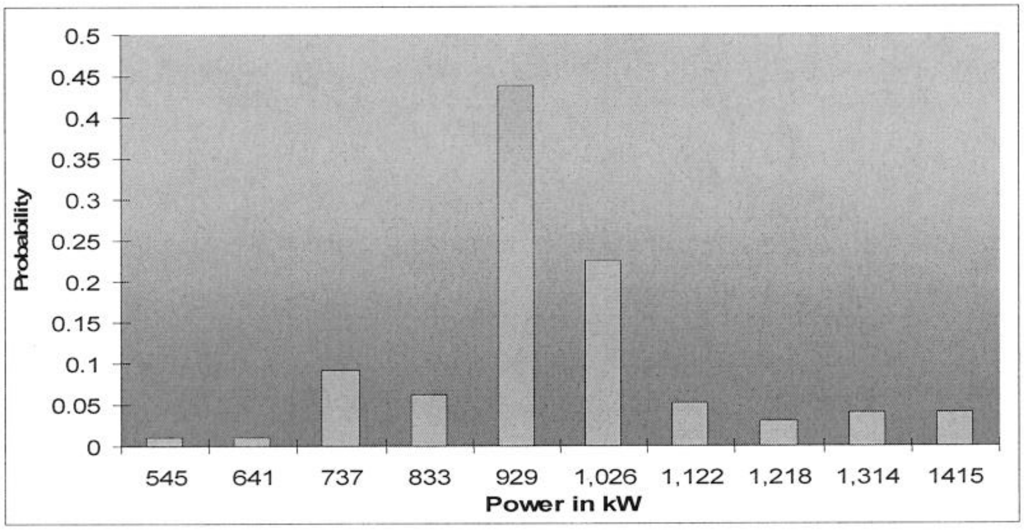


Figure 7. The daily wind farm power probability density distribution derived from figure 6.

Case Study - VRB at J-Power installation in Japan

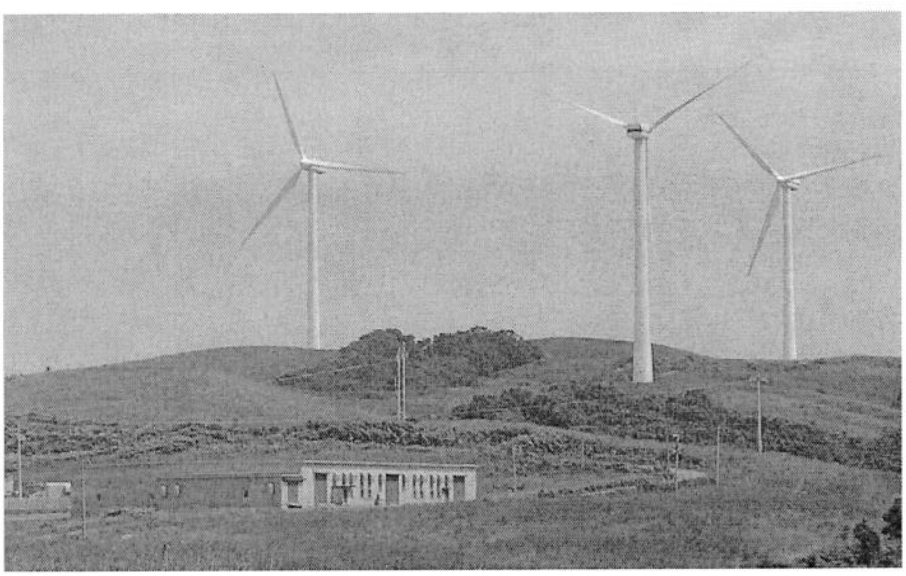
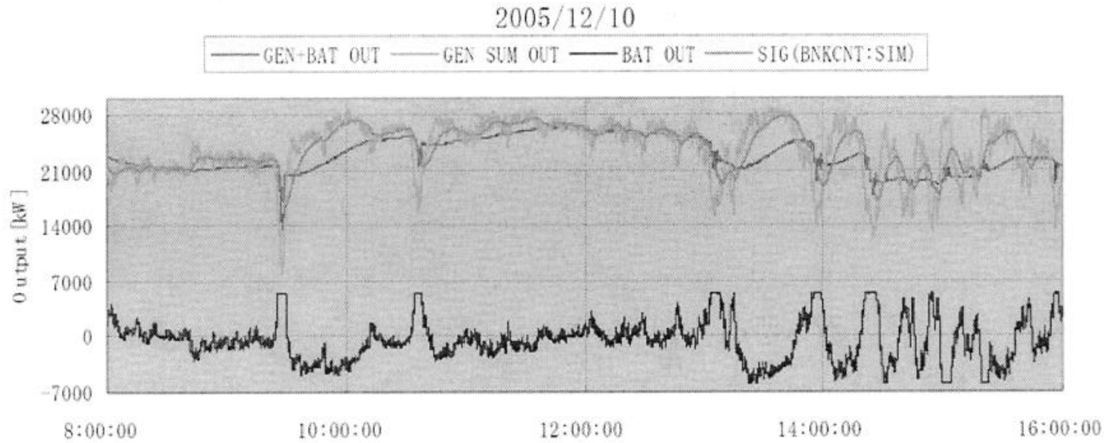


Figure 8. 32MW wind farm using a 4MW 1.5hour with 6MW peak VRB installed in Sapporo Japan to smooth voltage fluctuations caused by wind variations.



- The VRB-ESS (blue line) runs continuously to smooth wind farm production (green line).
- At only 20% of the wind farm's nameplate capacity, the VRB ESS has a significant smoothing effect to total wind farm + battery output (red line)
- The VRB-ESS intelligently recharges throughout the day so that it maintains 50% SOC – integrated control strategy

Figure 9. Output smoothing and stability provided for the J-Power wind farm in Japan using a VRB storage system (courtesy J-Power). When the wind power drops off the VRB discharges and smooths the output. The key to this is the VRB unique rapid response and ability to cucle thousands of times and hundreds of times daily.

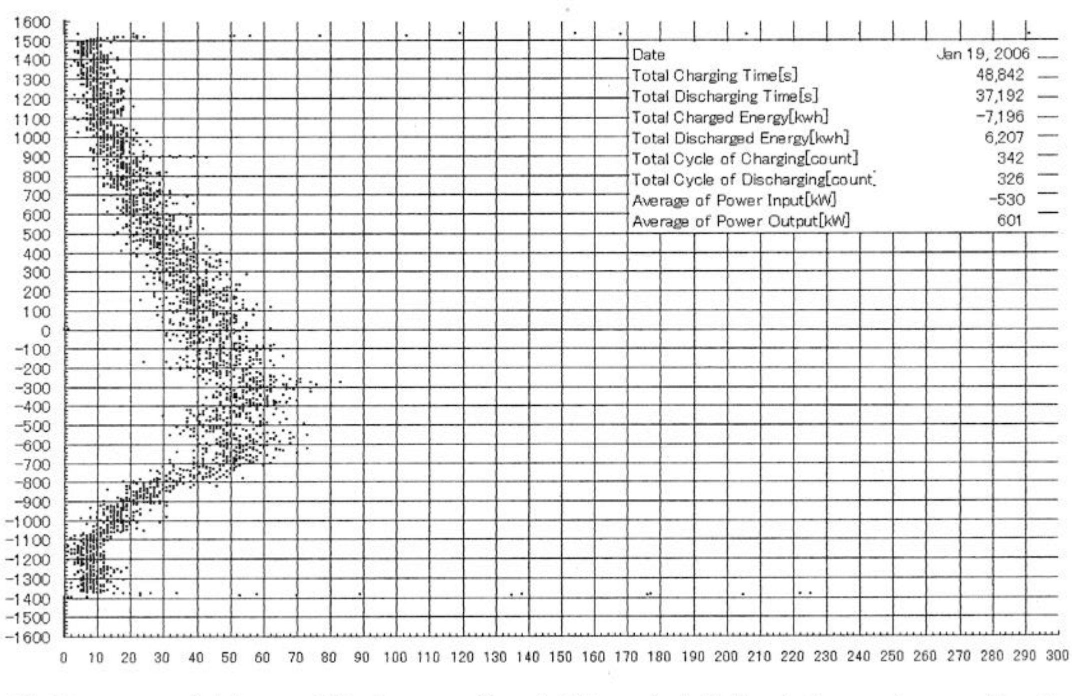


Figure10: Frequency of chárge and discharge cycling at J-Power installation in Japan. A conventional battery system would last less than a month with this frequency of operation. The VRB operates 600times a day ramping up and down as required. The leverage factor 6MW/32MW= 18% of nameplate is shown.

Wind, Diesel and Storage

Excessive amounts of wind penetration above a figure of 15% or so, generally leads to instability in the grid especially on weak networks. This is particularly concerning in RAPS applications. The example below shows a remote community with 3MW of diesel engines and a peak load of about 2MW. It is possible to add 2 x 1.5MW wind turbines or a 100% wind penetration by using fast acting VRB-ESS™ sized at 1.5MW with 9.5hours of storage. This will result in a reduction in diesel usage by 86%, overall cost of energy reduction of 55%, and reduced CO_2 emissions of 85%. The payback for this project is 5years on an unleveraged basis.

Component	Production (kWh/yr)	Fraction
Wind turbines	12,444,722	94%
Cat 3512	434,767	3%
Cat D398/379	0	0%
CAT 3516	315,715	2%
Total	13,195,204	100%

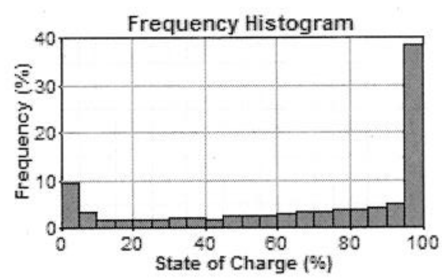
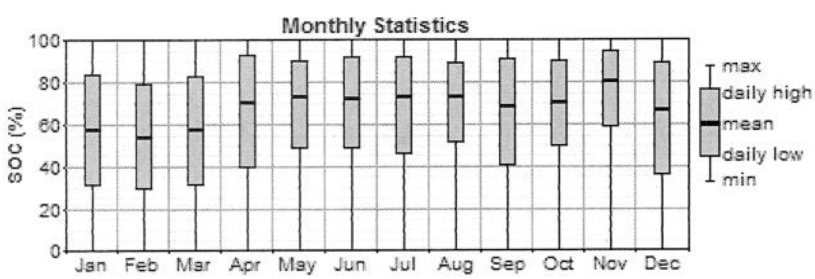


Figure 11: The generation mix after installation of wind and the VRB-ESS. 100% of generation was originally diesel based



Figures 12 and 13: The usage of the VRB-ESS in terms of State of charge (SOC) annually and by month.

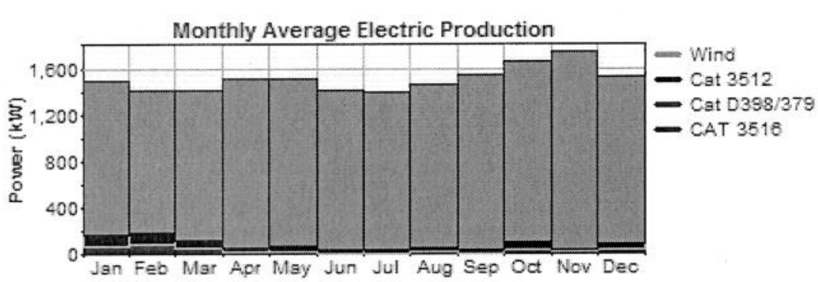


Figure 14: The impact of wind on total generation mix.

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CASE STUDY

ELECTRICITY STORAGE FOR CAPITAL DEFERRAL

End-User: Utah Power, a subsidiary of Scottish Power affiliate PacifiCorp

Application: Defer capital expenditure by shifting peak load on a 25 kV distribution feeder

Benefits: Improved distribution throughput, lower line losses, better power quality

Basic Specifications of the VRB Energy Storage System (VRB-ESS™):

Continuous Power Rating: 250 kW, 250 kVAR, 353 kVA using intelligent, programmable four-quadrant power converter

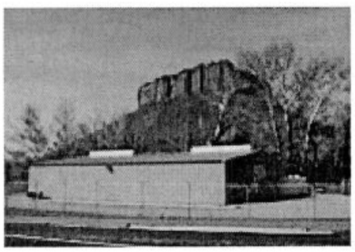
Energy Storage: 2,000 kWh – 8 hours discharge at full rated power output

Footprint: 3,800 square feet (350 square meters) – allows for expansion to 500 kW within existing building

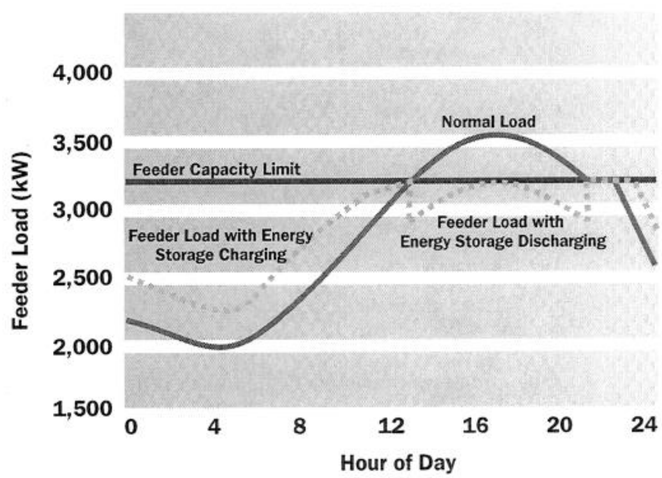
Operation Start: March 2004

Project Background and Objectives:

Utah Power operates a 209 mile, 25 kV distribution feeder in environmentally pristine Southeast Utah, near Moab. Bordering the eastern side of Arches National Park and following the Colorado River valley, the line traverses great distances to serve small, isolated rural communities. Reliability and power quality problems had resulted in Public Service Commission complaints, and new service connects were being denied because the feeder could not supply any significant amount of new load without causing low voltage to existing customers. PacifiCorp investigated several possible solutions, including line reinforcement, substation upgrades and increased reactive compensation. Ultimately, it decided on an energy storage solution from VRB Power as an economically attractive way to avoid both the high cost of adding a large increment of new capacity using conventional means, and the lengthy permitting process that would have been required in this sensitive geography.



A site was selected in Castle Valley, Utah, where a simple metal building was erected to house the initial 250 kW, 8-hour (2MWh) system, with space allowed for future expansion. Construction of the storage system was straightforward, consisting of two off-the-shelf double wall fiberglass electrolyte tanks, six cell stacks (two in series, three pairs in parallel), pumps, heat rejection equipment, a packaged power conversion system, and Allen Bradley controls and monitoring.



continued (over)

VRB Power Systems INCORPORATED

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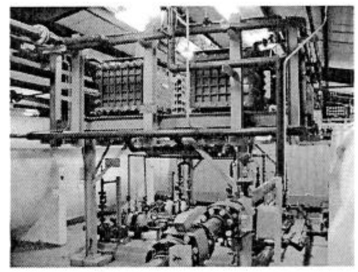
The system was initially started in November, 2003 and formally commissioned in March, 2004. Designed for unmanned operation, the system was initially set up for time-of-day cycling, charging overnight and discharging during the peak afternoon period. Voltage response is less than 5 milliseconds, and the operating temperature range is 41° to 104° (5° to 40°C). The charge/recharge cycle (adjustable remotely by PacifiCorp Dispatcher or on site via technician) is based on a time-of-day, local time algorithm, with control override based on battery state-of-charge. The VRB-ESS controller program allows easy changes to all parameters, including dates and times. The scheduled kW output changes have a defined ramp and fall rate to allow step-type voltage regulators time to keep up with any system voltage changes.

The system also provides a temporary voltage support mode. If the measured voltage at 480 V drops between 2 and 10% of the previously measured voltage for three consecutive controller scan cycles, the VRB-ESS increases discharge to full 250 kW within 5ms even if it was in charging state, and maintains this output for 30 minutes (provided the fault current settings allow this). After 30 minutes, the VRB-ESS returns to the normal schedule following the kW rate of change ramp. Ongoing testing will make use of the system's ability to provide automated VAR support.



Results:

The system has provided full power daily cycling operations since March, 2004 and has effectively served its intended purpose through a full summer peak season. Feeder power factor improvement has reduced line losses by 40 kW, more than offsetting the parasitic losses of the storage system. Continuous performance monitoring is ongoing, with a study to be conducted by EPRI beginning in the first quarter of 2005.

VRB Power has made further enhancements to system efficiency and reliability through the upgrade of the power conversion system and cell stacks in late 2004. Current results will be made available as data is collected and analyzed. PacifiCorp has begun preliminary analysis on a possible expansion of the system at Castle Valley to provide additional capacity and reliability enhancements to the community.

The application has demonstrated the viability of using a VRB-ESS as a planning solution for utilities, and the results of this project will enable a number of other utility applications for electricity storage in the future.

CASE STUDY

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PacifiCorp labels coal a no-go for new plants

Going green - The utility says its long-range plans will look elsewhere for resources to generate electric power
Friday, December 07, 2007
TED SICKINGER
The Oregonian

PacifiCorp has backed away from plans to build any new coal plants within the next 10 years, conceding that coal no longer can overcome tightening regulations and environmental opposition.

In recent filings and communications with regulators in Utah and Oregon, the Portland-based company said three coal plants included earlier this year in long-range resource plans and subsequent requests for proposals were "no longer viable options."

PacifiCorp cited as reasons for its decision: The likelihood of national carbon emissions legislation, which it said makes accurate cost projections and risk assessment for coal plants "futile," and the fact that most of the coal plants proposed around the United States recently have been canceled, denied permits or been involved in protracted litigation.

In a filing with the Utah Public Service Commission, the company said it wasn't excluding coal from its 20-year planning options. But "absent some change in conditions, it cannot be determined at this time whether new coal generation ownership will satisfy the least-cost, least-risk standards that would enable us to consider it as a viable option in our 10 year plans."

Ratepayer advocates and environmentalists called the utility's decision a victory.

"We're encouraged that they seem to be moving away from coal," said Bob Jenks, executive director of the Citizen's Utility Board. "It's a good sign. I also think it's a sign of the reality that they're not going to get approval for it."

The move away from coal is an about-face for a company that generates nearly 65 percent of its electricity from coal.

Until recently, there was a distinct difference in receptivity to new coal plants on the two sides of the company's service territory. In Utah, where customers make up more than 40 percent of the company's total electricity consumption, regulators and state authorities have been far more willing to consider coal plants.

By contrast, regulators and lawmakers in Oregon, Washington and California have sent a clear signal that they don't want any more.

Earlier this year, Oregon passed a law requiring utilities to serve 25 percent of customer demand with renewable resources such as wind and geothermal by 2025, with interim targets. California and Washington have their own standards in place.

PacifiCorp's decision to drop coal from its near-term resource plans came after that legislation passed. It also came after Utah's decision to join the Western Climate Initiative, a group of Western states working on a regional plan to curb carbon emissions, said Marc Krasnowsky, a NW Energy Coalition spokesman.

David Eskelsen, a PacifiCorp spokesman, said there was no connection between Utah's action and its decision, though the company is certainly aware of increasing state pressures to go green. The question now, he said, is "if not coal, then what?"

The cost factor

Coal-fueled electricity, he said, has been less expensive, and the company's decision to invest in it allowed it to become one of the nation's lowest cost providers of electricity. Uncertainty around coal will push the company toward more gas-fired generators and as much wind power as it can round up, he said.

"If policies change, we'll comply," Eskelsen said, "but we want policymakers to be informed about the consequences on reliability and price. The price impact is unescapable."

Consumers advocates disagree. They contend that climate legislation will dramatically increase the cost of coal power. Moreover, they say, the capital costs for adding a gas plant are low compared with coal, so if a utility is forced to back off using a gas plant or shut it down, it doesn't cost ratepayers as much. By contrast, once utilities sink capital into a coal plant with a 60-year useful life, they want to use it.

Steve Weiss, an analyst with the NW Energy Coalition, also points out that gas-fired power plants, which can be cycled up and down rapidly, are more compatible with the intermittent renewable resources such as wind and solar, which are becoming a larger part of utilities' generation mix.

Natural gas emissions

Burning gas to make electricity still creates carbon dioxide, but at about half the level of an equivalent amount of electricity from a coal-powered plant, Weiss said.

PacifiCorp forecast in May that its overall customer demand would grow by 2.4 percent per year between 2007 and 2016. Most of that growth was skewed toward the east side of its six-state territory, particularly Utah and Wyoming.

By 2012, the company is projecting the need for an additional 1,700 megawatts of generation capacity. Consequently, it is hoping state regulators will expedite their review of a new request for a proposal it hopes to issue to suppliers in January. That call for bids will exclude coal.