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Original Research Article

The need for SCADA communication in a Wind R&D Park

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ABSTRACT

This paper describes the changes made to a wind park to incorporate a Battery Energy Storage System (BESS). It can be quite costly if the BESS charges when the wind is not producing electricity therefore logic was added which ensured that charging only took place when sufficient wind power was available. The addition of logic to the SCADA system greatly improved the performance of the BESS and eased the financial and operational burden. The process is outlined in this paper.

Introduction

Wind energy is one of the cleanest and cheapest sources of new electricity production, the price has decreased as the installed capacity has grown during the past decade. Wind power has grown from 39 GW of installed capacity in 2003 to 318 GW in 2013 [1] and in 2014 provided 4% of the world's electricity [2].

Among the challenges that face the wind industry is the issue of wind's intermittency, which does not allow its production to meet the electricity demand [3]. One method to integrate wind into the electric grid is through the use of energy storage to mitigate both short and long term power fluctuations [4].

A supervisory control and data acquisition (SCADA) system is typically implemented to allow the storage system to correctly interact with the other components of the wind park and to collect high quality data. Unless specified during the design and purchase, SCADA systems usually do not have any control functions incorporated, but only gather data from the different components and store it for later use.

It can be quite costly if the BESS charges when the wind is not producing electricity. In some jurisdictions, the rate structure for commercial customers includes an energy charge as well as a demand charge for the highest 15–30 min average during the billing period. It is desirable to minimize both these charges by only charging the BESS when there is sufficient electricity production from the wind farm.

If the Battery Energy Storage System (BESS) and turbines do not communicate, the operator must base the charging of the BESS on the wind forecast, which is a sub-optimal control methodology because wind forecasts are not always accurate. Not only can costs be incurred for charging at the wrong time, but the BESS is likely to be cycled less due to doubt that the wind power would be available for the entire cycle. The BESS power and BESS demand for a typical month with no logic implemented is shown in Fig. 1. In this month, eight discharges at 500 kW were accomplished as well as a lower power discharge during the BESS maintenance cycle. Once during the month, the battery was charged when there was no wind, which resulted in a large demand charge for that month. In an efficiently-run wind park, installation of a BESS necessitates interaction between the components so that the BESS would charge based on wind generation.

The interaction between a wind farm and a storage system in order to help mitigate short and long term fluctuations has been modeled in [5] where capacitors are used for very short term fluctuations and a battery storage system for longer term fluctuations. Models for showing control strategies in a theoretical wind park with storage have also been proposed for a vanadium flow battery [6] and for a sodium–nickel chloride battery [7]. In [8] a 25 MW h/100 MW NaS battery is proposed to act as primary regulation to back stop wind power in the event of the entire 100 MW wind park goes offline. Finally in [9] a strategy to mitigate wind power fluctuations and maximize battery life time is presented. Unfortunately the power reference is calculated based on the 1 h average of the wind power, which is then used to operate the battery so that the net power remains at that average. This is

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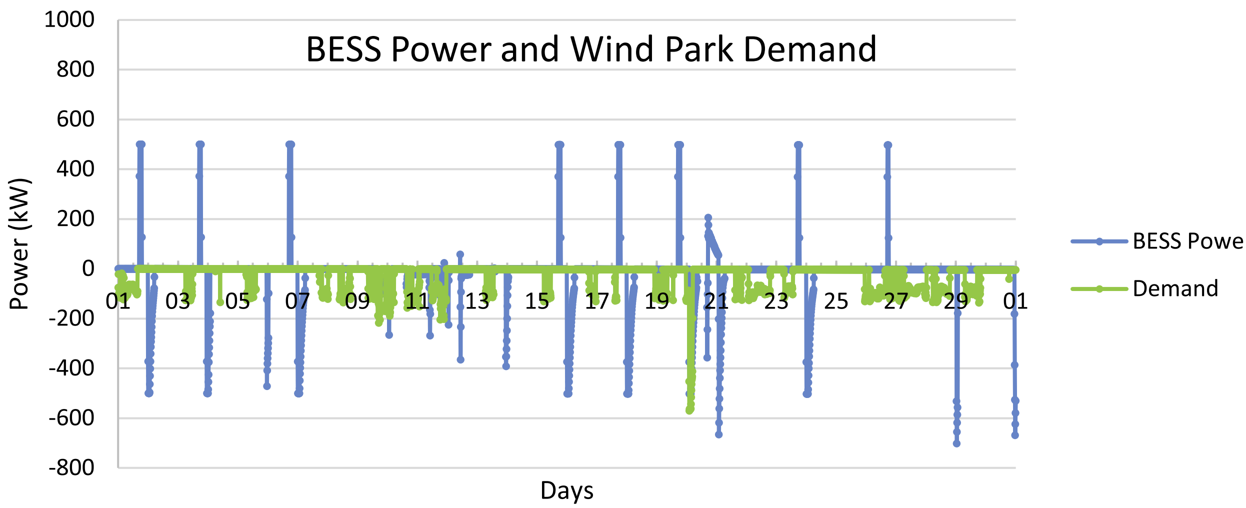

Fig. 1. BESS Power and Power Demand for the Wind R&D Park.

obviously not helpful for real time battery operation as the hourly average is unknown until the end of the hour.

From all these simulations little insight into the control and operation of a real battery in a wind park is obtained, neither are the communication protocols, discussion of influence of availability on the control strategies nor incentive to mitigate wind power fluctuations.

A lithium battery (400 kW/744 kW h) coupled with a wind turbine (800 kW) is installed at Cowessess First Nation in Saskatchewan. They have shown that the battery is able to help smooth output fluctuations (by 65%) and provide dispatch power during periods of high load [10]. The control system limits the charge of the battery from the grid during periods of low wind, but the ability to change the logic within the system is unknown.

Other storage installations at wind farms are reported in [11] which argues that energy storage is a good source for frequency regulation. In [12] the control strategy for a wind farm operating in China with large spillage requirements is examined for justification for their 5 MW × 2 h BESS. In this paper the control strategy is developed but the results from their storage system are not reported.

In this work, logic was added to the SCADA systems of a wind park that contained a BESS to ease the financial and operational burden of the BESS in the wind park and to demonstrate how energy storage can be used to integrate wind energy into the electric grid.

Equipment and methodology

Equipment

The wind park used in this study has five DeWind 9.2 turbines, which each have a 2 MW rated output and a rotor diameter of 93 m. These wind turbines have a synchronous generator that is connected to the variable speed shaft through a hydraulic Voith WinDrive.

The BESS that is part of the wind park used in this study is 1 MW/2 MW h and is comprised of S&C's Purewave inverter system, which interfaces GE's Durathon batteries to the substation.

The turbines and BESS are connected through several SCADA systems, as shown in Fig. 2. The simplified one-line diagram for the wind park and storage system is shown in Fig. 3.

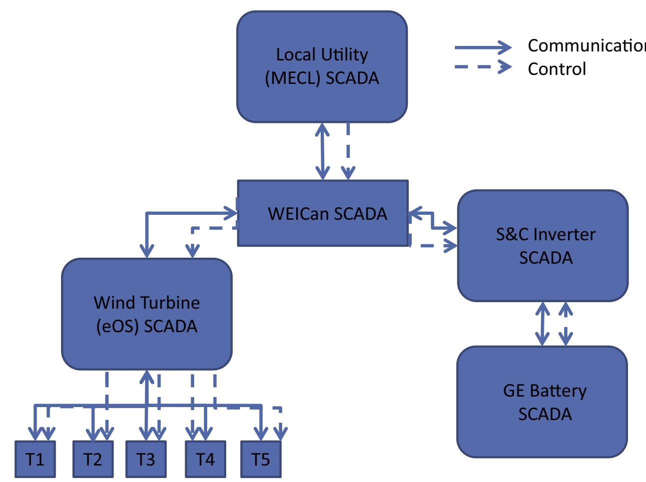

Fig. 2. WEICan SCADA's and the interaction between them.

Methodology

Electric utility rate structure

In the jurisdiction where this study took place, Prince Edward Island (PEI), Canada, the rate structure for small industrial customers is the following:

- Demand Charge: $7.46/kW, for the highest 15 min monthly average.
- Energy Charge: $0.1591/kW h for first block (100 times monthly demand), $0.0784/kW h for remaining energy.

BESS operation

Before the logic was finalized, the BESS was operated with two scenarios. Both scenarios used peak shaving mode as an example of a promising potential usage of the BESS. In the first scenario, the BESS was charged at 500 kW from midnight to 6:00, depending on wind power availability. The discharge was also 500 kW and was carried out from 17:00 to 20:00. In the second scenario, the charge rate was reduced to 220 kW to avoid the large demand charges that occurred during operation in the first scenario due to poorly predicting the amount of wind available from the wind park. The charge duration was increased to take place from 23:00