Subaru Project: Field test of Energy Storage Systems for Stabilization of 30.6MW Wind Farm

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1. The market of wind power in Japan

KYOTO protocol became effective from Feb 16, 2005. So, Japan, Eu, Canada and other Annex I countries must fulfill the greenhouse emission target during the first commitment period from 2008 to 2012. In Japan, the Government made power source mix a target in the electric power industry. The target is 3,000MW about total installed wind power by 2010. Electric Utilities in JAPAN have duty to buy or generate energy from renewable power source (wind power, solar power, etc) by the law. Its name is Renewable Portfolio Standard low, so called RPS LOW, varied from Apl, 2003. Because government has assisted to construct wind farm and the rating of wind power generator has increased by vender's development, the market for wind power generation has expanded rapidly in recent years in Japan, and many projects for constructing wind farms are underway. On 2000 total installed capacity of wind power is less than 100MW and it has increased to 935MW until March 31, 2005(Fig. 1).

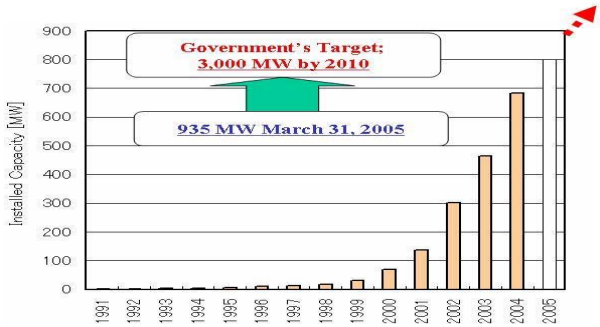

Figure 1 Wind Power Capacity in JAPAN

2. Limitation for installing wind power and to break through it

Japan's power systems are provided by 10 utilities, but are not interconnected with other countries. And there are two fundamental frequency areas (50Hz and 60Hz). In the 50Hz area, the installed capacity of generators is low in HOKKAIDO island. And the power flow between Hokkaido and Honsyu Island is limited, because it is interconnected by an HVDC system. However, many wind farms are located on the HOKKAIDO island, TOHOKU area on the HONSYU island, and the KYUSYU island, because wind conditions are better than in other regions (Fig. 2).

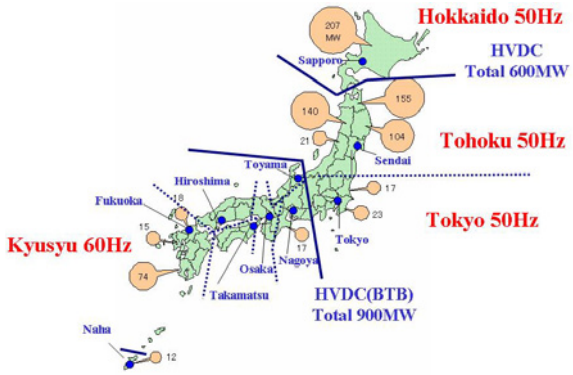

Figure 2 Japanese Power Systems and Wind Power Capacity

Typical power source mix, about 20-40% is nuclear, coal is 10-20%. So, especially in night time or off-peak time, spinning reserve or LFC margin are not enough for installation of huge wind-power to maintain frequency. Hokkaido Electric Power Corporation, and TOHOKU Electric Power Corporation have already announced the limitation of installation capacity of wind power cause of instability of frequency. In order to expand the capacity of wind power in Japan, some solutions should be developed in the near future to break through the limitation above. According to some newspapers, the Ministry of Economy, Trade and Industry (METI) of Japan will start to offer financial support for stabilizing the output of wind power electricity in 2006. Japan's government, Electric utilities, Wind farm companies, decided to install battery systems for new wind farms that will be constructed in future, in order to reach the target of installation capacity of wind power, 3000MW by 2010.

3. Outline of Subaru Project

Subaru Project provides wind power stabilization by using an energy storage system connected to a large scale wind farm. This is one of the solution break-throughs for expanding the capacity of wind power in Japan. The target is to stabilize the fluctuation of power output of wind farm in short term range of several seconds to several tens of minutes. Because Vanadium Redox - Flow Storage Battery (VRB) system has the independence of power and energy capacity, and is easy to measure its state of charge (SOC) by cell monitoring, it has been adopted in this project. Field test started at "Tomamae Wind Villa Wind Farm" on the HOKKAIDO island in January 5th, 2005 and is going to operate until early 2008(Fig. 3).

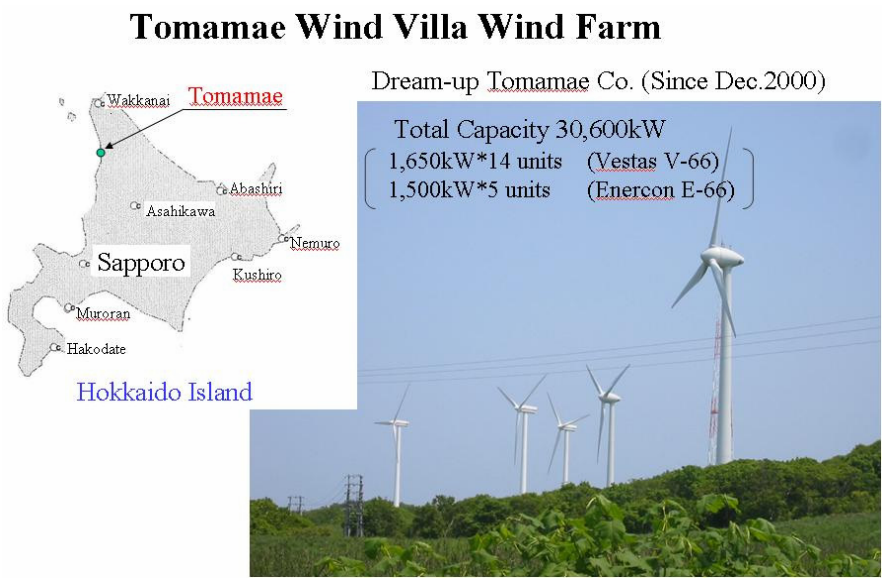

Figure 3 Tomamae Wind Villa Wind Farm

VRB was supplied by Sumitomo Electric Industries, Ltd.(SEI). Wind Villa site consists of 19 wind-turbine generators, and the total electrical power output is 30,600 kW_{ac}. By the pre-simulation of the design, the selected battery rating is 4,000kW_{ac} for 90minitues (6,000 kWh) , otherwise 6,000kW_{ac} for 20minutes. To pursue the most effective operation of the system, control methods (i.e. State of charge feed back control system, Variable time constant control system, and Battery bank control system) have been developed for reducing the rating of battery and inverter output, and power loss(e.g. pump power for the battery). Effectiveness of those control systems will be verified by the field test. And After the development of the simulation model program on the basis of the field test data, the numerical simulation is going to be applied to the other wind farm data. We are now demonstrating the effectiveness and applicability of the storage battery technology for smoothing output fluctuation of a wind farm.

4. Result of the field test about the state of charge feed back control system

One of the results of the field test about the state of charge feed back control system is shown in Figure 4. Wind power stabilization requires the battery to be frequently charging or discharging. Unless controlled, this operation plus losses from the battery and inverter can completely discharge the battery (Without SOC FB

Control). So, the method of control to keep the battery SOC within normal range is required for continuous operation. Battery output and SOC are controlled by feedback from the SOC measured directly at the VRB monitor cell. Battery's SOC kept in normal range even though the wind power output fluctuated more than in the case without SOC FB Control (With SOC FB Control).

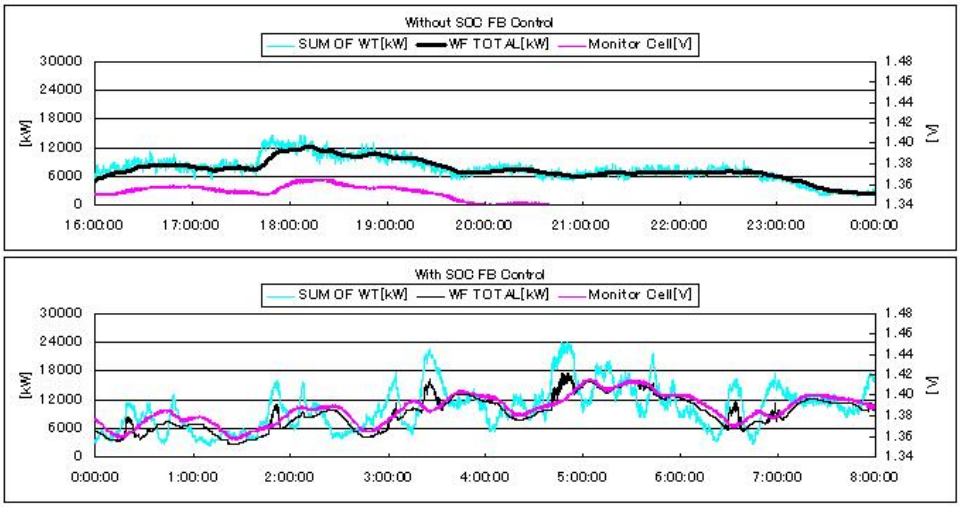

Figure 4 Result of the field test about the state of charge feed back control system

In the Case of With SOC FB Control, Battery sometimes tried to operate without its rating power due to large wind fluctuations, and is unable to continue expected stabilizing. To fix this problem, we have developed Variable time constant control. Variable time constant control changes the time constant value in accordance with battery output to continue stabilizing wind power (Fig. 5). Until Mar. 2006, We will temporally finish the field test about State of charge feed back control system, Battery bank control system and Variable time constant control system. After Apr. 2006, the field test will go into the second stage.

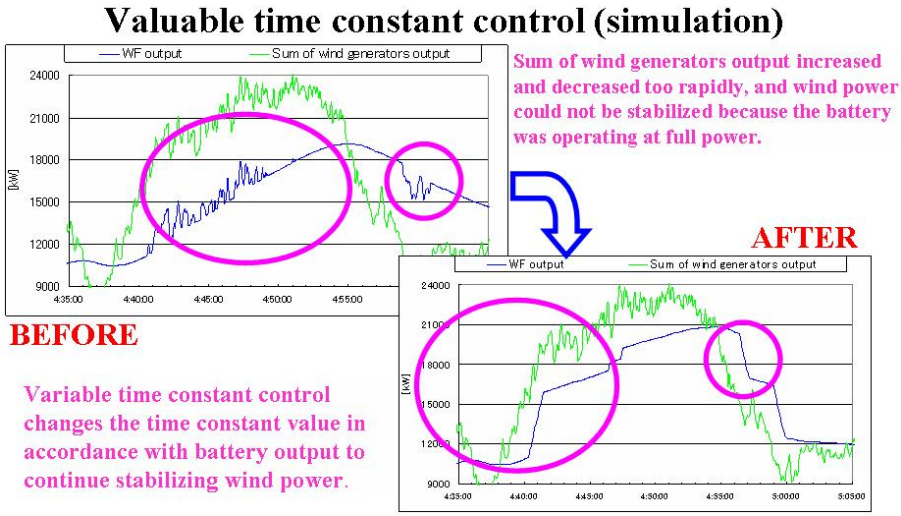

Figure 5 Effectiveness of Valuable Time Constant Control(simulation)

5. Conclusion

Subaru project is to provide the technology of power stabilization by using an energy storage system connected to a large scale wind farm. Field test will verify the effectiveness of energy storage to smoothing wind power and the effectiveness of control systems to operate the system. This project is funded by New Energy and Industrial Technology Development Organization (NEDO), a Japanese government agency, through the Electric Power Development Co., Ltd.