WIND ENERGY PENETRATION IN ISLANDS: LIMITATIONS AND PROSPECTS

Nikos Hatziargyriou (National Technical University of Athens, , Greece)
Panayotis Chaviaropoulos, Greece (1) S. Papathanasiou, Greece (2)
(1) Center for Renewable Energy Sources (2) National Technical University of Athens

The utilization of renewable energy sources for electricity production in islands is of primary importance, since electricity is usually produced by oil burning units at high economical and environmental costs. The increased penetration of wind power however raises a number of operational concerns due to the intermittent nature of wind and the inability of traditional fixed-speed wind turbines to control their power. In this paper the main technical problems limiting large wind power penetration in islands and some technical solutions proposed in order to overcome these problems are reviewed. The paper focuses on modern EMS tools to aid power system operators to deal with wind power problems.

The population of the EU who live in islands is about 2 million in French islands, 5 million in Italy (Sardinia and Sicily), 1 million in Greece, about 3 million in the Spanish islands (Baleares and Canary islands) and more than 1 million in the Portuguese islands (Azores and Madeira). This makes in total about 12 million, not taking into account the British islands and Ireland. Electricity production in island power systems is mainly based on imported oil resulting in high costs of the energy produced, pollution of their fragile environment and increased dependency on primary energy sources. Under these conditions, the exploitation of local renewable resources, especially wind, is very beneficial, not only from the environmental, but also from the financial point of view. The increased penetration of wind power however raises a number of operational concerns due to the intermittent nature of wind and the inability of traditional fixed-speed wind turbines to control their power. The installation of modern, variable speed wind turbines based on power electronic interfaces ameliorates the above problems, however the efficient operation of isolated systems requires enhanced scheduling and control tools, like wind power forecasting and effective spinning reserve management. Dynamic security assessment (DSA) is a further key function in island system operation and management.

In this paper the current status of the operating conditions and of the wind power penetration in the Greek islands is presented. Based on this experience, the main technical problems limiting large wind power penetration in islands are reviewed and some technical solutions proposed in order to overcome these problems are presented.

One of the key considerations concerns power quality issues. A quantification of these issues has been attempted in the EU project WIRING. In this project, a power quality measurement campaign has taken place in the autonomous power system of the Greek island Samos, where a considerable number of (earlier generation) constant speed wind turbines were connected. Even in this case, the power quality assessment results showed that the flicker emitted from the wind turbines was not important comparing with the background flicker produced by the firing harmonics of the power station diesel engines. The connection of wind turbines leaved more or less unaffected the overall flicker levels, and, in certain cases even reduced them. On the other hand, the most important effect of the connection of wind turbines was the high demand for reactive power, which led to considerable voltage reductions at certain times.

Due to the relatively small size of island power systems, high wind power penetration levels are easily achieved, as is already the case in several Greek islands. For this reason, technical requirements for the response of the installed WTs in case of system disturbances, usually referred to under the generic term of Low Voltage Ride-Through (LVRT), are directly applicable in order to minimize potential risks for the dynamic security of the isolated island systems. Such requirements encompass the immunity levels of the WTs in case of voltage sags, the variation of their active and reactive output powers in similar events, as well as additional requirements on their controllability and regulation capabilities. Most manufacturers provide today LVRT capabilities for their latest WT designs, which are typically larger than 1.5 MW. Smaller machines, on the other hand, which are more suitable for small and medium size islands, often lack such capabilities, since they are mostly older designs.

Electric energy storage is regarded as the ultimate solution to exploit the available wind power potential in islands. Currently, among the available storage technologies, only pumped storage appears to be technically and economically feasible for multi-MW sized island power systems. It consists in pumping water to a high altitude reservoir, when excess wind power is available, and recovering the stored potential energy via hydro turbines at low wind or high demand intervals. However, the implementation of pumped storage stations, besides the high initial capital cost, is also subject to the availability of suitably sized water reservoirs with sufficient altitude separation. Further, regulatory issues remain to be resolved regarding the mode of their operation and control and the tariffs applicable for the generated and absorbed energy and power.

Finally, the application of Advanced EMS functions that are capable to provide aid to the power system operators is proposed. Indicative results from the application of these tools developed within the EU projects CARE and MORE CARE are presented.