Geophysical Research Abstracts
Vol. 12, EGU2010-3553, 2010
EGU General Assembly 2010

Effects of large scale integration of wind and solar energy in Japan

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A number of different energy scenarios exist for the development of renewable energy technologies in a variety of countries. Each of these scenarios produces different composition mixes depending on the assumptions on which they are based and the motivation of the authors. These studies are often based on annual data, which make general assumptions about the maximum and minimum output of a range of renewable technologies that are not considered to produce electricity at a predictable rate. These include solar power (which generally varies with the intensity of sunlight) and wind power (depending on the strength of the wind). To take into account the variability in the production of these technologies, many authors assume that the energy production sector cannot whole rely on these technologies, and that enough conventional production capacity (thermo, nuclear or hydro) must exist to cover the essential part of the electricity production.

In the present work, the authors used the historical records of wind and solar radiation to estimate the minimum amount of electricity that could be produced by a given composition of renewable energies in the year 2100. The methodology used starts by inputting the geographical location and power rating of each of the power plants in the system. It assumes that PV installations will be located in roof-tops in cities (hence each of the major cities would act as a solar power plant) and that the location of wind farms closely resembles those of today. Wind farms, however, are assumed to use much greater units than those presently used, with each one having a rated power of 20MW. The method then used the historical meteorological data obtained from the Japan Meteorological Agency to compute the power production at each location sequentially for each of the 8760 hours in the year. The results show how although on adverse climate days in certain parts of the country the electricity generation from renewables is greatly reduced, when the results for the country as a whole are considered it is still substantial. The results are greatly dependant on the mix between the proposed renewables (solar and wind), and by comparing different distributions and mixes, the optimum composition for the target country can be established.

The methodology proposed is able to obtain the optimum mix of solar and wind power for a given system, provided that adequate storage capacity exists to allow for excess capacity to be used at times of low electricity production (at the comparatively rare times when there is neither enough sun nor wind throughout the country). This highlights the challenges of large-scale integration of renewable technologies into the electricity grid, and the necessity to combine such a system with other renewables such as hydro or ocean energy to further even out the peaks and lows in the demand.