Forecasting and nowcasting: Improving management of renewable resources

by Mike Rycroft, features editor, EE Publishers

Prediction and forecasting of the power and energy production from renewable energy (RE) systems on a day ahead or short-term basis is essential for the management of networks that incorporate RE. Many existing systems, based on wide area look ahead weather forecasts, and numerical weather programs, have proven to be difficult to use and inaccurate in the short term. With more distributed RE coming online, and the development of networks, the need has developed for real-time high resolution estimating and forecasting systems.

Prediction models for widely spaced concentrated resources can make use of wide area forecasts, but when the network contains a large number of small distributed resources, such as rooftop solar, real-time estimates of the power and energy production need information with higher resolution and on a smaller scale, where individual patches of cloud cover can influence both demand and supply, and individual location wind patterns can differ from the gross pattern over an area.

The impact of rooftop solar on a distribution network can be significant, and real-time estimates of the energy generation capabilities based on spatial information and real-time cloud cover can be useful in managing the stability of a network. Prediction of not only instantaneous power but of rapid changes in generation can be of great help. In addition to voluntary rooftop solar, the emergence of planned microgrids with distributed generation is driving the need for higher resolution localised short-term energy forecasts.

The stochastic nature of small scale phenomena and the complexity of cloudy situations poses a difficult challenge to forecasting. In particular for solar energy, the radiation transfer within a cloud could be described theoretically but its modelling is usually precluded by the complexity of accurately describing the cloudy situation [1].

Numerical weather prediction (NWP) methods can give a long-term picture of estimated average conditions, but cannot predict sudden or rapid changes in weather such as wind or solar radiation, and do not give the spatial resolution required for RE management.

More recent developments using digital mapping and geomatic techniques, as well as increased resolution of weather recording and high resolution satellite observations, have allowed more accurate spatial and temporal estimates to be made. The system, known as “nowcasting” is finding application in the management of electricity distribution networks.

Forecasting systems
Three different approaches can be taken in the use of forecasting of RE performance:
- Long-term forecasting
- Short-term forecasting
- Nowcasting

Long-term forecasting
Long-term forecasting usually refers to forecasting of the annual or monthly available resource or output for a particular project, although long-term forecasts of the performance of complete networks may also be used. This is essential for energy producers who have to negotiate contracts with utilities that purchase and control the generated energy. Usually these studies based on historical statistical data, but may also include relatively long-term collection of data on the proposed site.

Long-term (>1 year) forecasting of known sites using known and projected historical data for established systems can give an insight into how a national fleet of renewable energy sites could perform and gives a useful comparison against actual performance. Such a forecast was carried out by A Brent et al [2] based on solar PV installations installed or planned to be installed in South Africa in 2015 as part of the REI4P. The study took into account all site details, including temperature and humidity.

One of the noteworthy conclusions was that the calculated total maximum power output of the 25 aggregated stations was 14% lower than the registered capacity, due to the effect of temperature on PV cell output, which is site dependant and is not taken into account when stating the capacity of a farm [2]. The study also showed that forecast capacity factors for the fixed tilt sites ranged from 18 – 22%, while a single axis tracker site achieved 25%.

Short-term forecasting
Short-term forecasting provides data on average conditions over a relatively large area for short periods up to seven days ahead. The meteorological resources are estimated at a different temporal and spatial resolution, often on a global scale and over a long period (typically the estimated duration of a weather event). This implies that meteorological variables and phenomena are looked at from a more general perspective, not as local.

To improve the relevance of forecasts to specific areas, global and wide area patterns are refined to produce mesoscale forecasts. Mesoscale forecasting uses atmospheric phenomena with typical spatial scales between 10 and 1000 km. Examples of mesoscale phenomena include thunderstorms, gap winds, downslope windstorms, land-sea breezes, and squall lines. Many of the weather phenomena that most directly impact human activity occur on the mesoscale. Research in mesoscale meteorology has been spurred by recent advances in observational and numerical modelling capabilities that have greatly improved the tools used by atmospheric scientists to study mesoscale weather systems [3].

Most of the approaches make use of different numerical weather prediction models (NWP) that provide an initial estimation of weather variables. Several models are used by the SAWS and other institutes such as the CSIR. NWP are configured to cover different variables, such as precipitation and the development of storms, as well as wind speed and solar radiation. In order to improve the resolution of these models, other models have been developed which are generally called mesoscale models. To run these models a wide expertise is needed in order to obtain accurate results, due to the wide variety of parameters that can be configured.

Mesoscale modelling has been used to produce a long-term model of the wind potential in South Africa (the SA Wind Atlas project). The model is based on observations of wind speeds as well as geographic and topographic information (Fig. 1)
Nowcasting

Nowcasting is used for specific weather data that affects renewable energy production, such as wind speed, solar radiation, cloud patterns and movement and well as air temperature.

The time scale varies from a few minutes to hours, and the spatial resolution can be from forecasting “fuel availability” for solar, or predicting the motion of air masses and the evolution of clouds for wind energy.

Because of the stochastic nature of processes leading to cloud formation, it is difficult for Numerical Weather Prediction (NWP) models to precisely forecast the occurrence of clouds in time and space. This is linked with many topics in meteorological and climate research. A frequent finding is that different methods apply at different temporal or spatial scales.

While NWP modelling based on large weather systems is used for longer time scales (up to a few days), short time scales are best treated by using observation-based techniques, such as surface in-situ and remote sensing observations for time scales typically shorter than an hour, and satellite observations for time scales up to a few hours. There is a need for such an optimal solar radiation forecasting method tuned for RE generation. Such specially designed forecasting methods should encompass times scales from a few minutes to a few days, and address spatial grids as low as hundreds of metres.

Nowcasting can be used both by customers as well as utilities, where smart inverters and hybrid BTM systems are used not only to forecast power generation but to control the operation of storage systems as well.

Sharp, a PV system maker in Japan, has been marketing residential storage systems combined with a cloud-based energy management system. By accessing information such as weather forecasts, utilities’ rate plans, and the national government’s warning of voluntary power-saving, the system can determine the best times to release and store electricity for its consumers [4].

For example, if rain is forecast for the next day, the system will store electricity from the grid during the night when the electricity rate is the cheapest and release power during the daytime when the PV system cannot produce electricity. Even shorter term forecasts at higher resolution could be used to control small PV systems, e.g. if a rainstorm or cloudy weather is headed towards an area, the controller could initiate storage and terminate feed-in at short notice.

Sharp’s new Cloud Battery Storage system is an especially noteworthy addition to the company’s portfolio, designed to be coupled with a Sharp hybrid inverter and lithium-ion battery sized at either 4.8 kWh or 9.6 kWh. Remotely managed, the cloud system can draw on weather data to optimise charging, and uses predictive analytics to anticipate extreme weather events, bringing greater control, monitoring and data feedback to system owner.

References

Contact Mike Rycroft, EE Publishers, mike.rycroft@ee.co.za

Fig. 1: Simulated climatological 30-year forecast of annual mean wind speed (m/s) 100 m above ground level [5].