COST Action ES1002 “WIRE”

WEATHER INTELLIGENCE FOR RENEWABLE ENERGIES

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ABSTRACT

The first goal of WIRE is to contribute enhancing methodologies for forecasting wind and solar power production from minutes up to several days ahead combining numerical weather prediction (NWP) models with real-time surface and remote sensing measurements. The second goal is to establish an understanding between the scientific and end user communities, to optimize the technical and economic integration of renewable energies in the electrical grids and to transfer knowledge across Europe and worldwide.

A Current State report has been produced to evaluate the ongoing R&D activities in this field in Europe. This document also describes the penetration of Renewable Energies (RE) in the different member countries, together with the national forecasting activities.

To evaluate the potential of numerical production forecasting systems, a benchmarking exercise is presently ongoing to highlight the strengths and weaknesses of the present algorithms. A number of renewable energy power plants and high level meteorological stations has been selected for validation and the results will be analyzed based on a new protocol for wind and solar power forecasts evaluation.

The added value of new observation techniques in developing power forecasting models has to be quantified. In particular, the focus will be on space-borne and ground-based remote sensing technologies for determining i.e. cloud cover, vertical wind profiles and other sensitive parameters.

Integration of these highly intermittent and spatially distributed energy sources in the electrical grids is a major challenge, if only because of the economically sensitive potential partners. The COST Action ES1002 intends to focus on the standardization on the results of the numerical production forecasts together with the selection of adequate instruments traceable to the WMO/CIMO standards and the definition of Standard Operating Procedures to provide the RE power plant managers and the Transmission System Operators TSO with adequate tools for production forecasting and validation.

INTRODUCTION

The world population is constantly increasing and the world electricity consumption will presumably double by 2050 with potential dramatic effects on our climate.It is expected that worldwide primary energy demand will increase by 45%, and demand for electricity will increase by 80% between 2006 and 2030[1]. Consequently, without decisive action, energy-related greenhouse gas (GHG) emissions will more than double by 2050, and increased oil demand will intensify concerns over the security of supply. There are different paths toward stabilizing GHG concentrations, but a key issue in all of them is the replacement of fossil fuels by renewable energy sources.

The EU's dependence on imports of fossil fuels (natural gas, coal and crude oil) from non-EU countries, as a share of total primary energy consumption, rose from 50.8 % in 2000 to 58.2 % in 2009 [2]. In additions, baseline (reference) scenarios show a rising dependence on imports for most fossil fuels, although this is particularly relevant for gas, with forecasted imports (as a percentage of primary energy consumption) rising from around 58.2 % in 2009 to up to 84 % by 2030. In order to correct this situation, and considering that many countries have decided to lessen their dependence on nuclear energy, the European Union has adopted the goal of having 20% of its electricity supply from renewable energy sources by 2020, along with a commitment to achieve at least a 20% reduction of greenhouse gases by 2020, compared to 1990 (European Directives 2009/28/EC and 2009/29/EC).

WIND AND SOLAR ENERGIES

Wind and solar power are presently considered as the sources of renewable energy with the best chance to compete with fossil-fuel energy production in the near future and the configuration of the penetration of different sources of electricity is rapidly evolving: for example, in March 2011 the Spanish wind farms have produced 4’738 GWh of electricity, covering 21% of the demand or the consumption of 3 million homes: this monthly energy production would meet the needs of a smaller country such as Portugal. Such an impressive example shows that the penetration of renewable energies in Europe is on the right track.

However, the optimum integration of electricity produced by future wind turbines and solar power plants demands an accurate wind and solar energy potential availability evaluation and forecast. What happens when these conditions are not met? As an example, a 10% of uncertainties in the estimates of mean wind might lead to a 30% error in power production. Wind and solar energy potential evaluation and forecasting as well as electrical grid management studies aim to answer such questions and have the goal to help developers of renewable energy power plants to decide where to install and how to operate them most efficiently and to help the grid operators to manage this per definition intermittent production input more efficiently.

Long-term averages based mainly on historical measurement data are usually used for the resource assessments of the sites where wind farms or solar power plants will be installed. Once this is done, forecasting tools are applied for short-term information - i.e. 1- to 72 hours in advance depending on the usage - on the production. Indeed, for the operational management of electrical grids, integrating different power sources and dealing with the highly spatially distributed locations of the power plants together with the intermittency, weather dependent production becomes a very important aspect and determines if the production will remained balanced with the demand. For example, Denmark has already a high penetration of wind energy production: a small change in wind speed may result in a considerable change in the power production.

Different time scales for renewable energy production forecasting have to be considered. For very short-term prediction (from 30 minutes to 3 hours), persistence forecasting is presently used in the case of wind energy: it is based on the simple assumption that the wind speed will usually not change dramatically in the very short-term. The situation is different - and more difficult - for solar energy where extremely rapid changes in the local cloud cover may induce dramatic changes in the output of the individual power plant.

To improve the very short-term forecasts, the present trend is to use Numerical Weather Prediction NWP models, combined with post-processing techniques such as downscaling and the on-line assimilation of in-situ and regional ground-based or remote sensing measurements, as demonstrated by the CNMET project in Switzerland [3].The situation is more difficult for the prediction of solar energy where improvements of the cloud-tracking algorithms (a combination of satellite and ground-based measurements) are urgently needed. Furthermore, these very-short term predictions are much more difficult in complex terrain where the topography may dramatically decrease the accuracy of the prediction (turbulence effects, local wind conditions, etc.). Finally, harsh weather conditions (e.g. icing) is a further weather dependent source of potential failures for energy production and distribution.

For short-term forecast in the time horizon 3 to 72 hours, persistence should not be applied anymore. Extensive uses of Numerical Weather Predictions with appropriate post-processing algorithms are usually implemented. Here again, the wind energy production forecasting systems are more advanced than for solar energy, because of the improvements of the capability of NWP models to predict the wind conditions days ahead with a reasonable accuracy in contrast to cloud cover prediction and aerosol loads which are particularly important for the solar energy production.

ELECTRICAL NETWORKS

From the electrical grid point of view, the situation is different: the penetration of renewable energies implies more “intelligence” in order to manage their integration and to guarantee continuously the equilibrium between production and demand. Electrical grids were built in Europe more than 50 years ago from a strictly national point of view. Existing electrical grids are very centralized, transferring the power between big power plants towards the end users; however, the number of relatively small decentralized production units will increase dramatically.

What is today needed is an “exportable” approach which would allow increasing electricity transfers amongst grids at different levels from local to national to European. Meteorological conditions in Europe are such that the wind is likely to blow or the sun is likely to shine at some place in Europe: in order to increase the penetration of renewable energies, it is mandatory to consider the electricity exchanges on a more extensive scale: these will be efficiently managed only by introducing "intelligent" technologies such as smart grids.

The challenge for the electrical grid operators is to synchronize at every moment the energy production with the demand. This equilibrium is constantly changing with the fluctuation of the demand and it is further jeopardized by the increasing penetration of renewable energies, which are (for solar and wind energy) highly intermittent inducing significant energy fluctuations on the grid. Indeed, the intermittent, difficult to predict character of renewable energy production is an increasing challenge for the Transmission System Operators TSOs which have to cope with the dangerous risks of grid instabilities: already nowadays wind or solar power plants have to be disconnected from the grid in case of low demand. Accurate power forecasting, efficient and intelligent grid management and increased flexible storage capacity are mandatory for the efficient development of the future energy policies in Europe and elsewhere, not to mention the benefits in terms of climate change when considering the greenhouse emissions of the respective energy productions: for example, energy produced with coal emits about 85 times more CO_2 than wind energy, petrol 70 times and natural gas 40 times.

The potential of power line to transport energy as function of the environmental conditions, in particular the temperature (Dynamic Line Rating DLR), has to be considered in terms of efficiency. The fact that renewable energies will be often produced in remote and decentralized sites implies that the electrical grid will be extended with power lines often running through areas with different(often harsh) weather conditions. DLR has to be taken into account in order to design these new installations in an optimal way and to operate them efficiently by taking into account their environmental conditions (e.g. icing). Standard transmission and distribution lines have however an inherent reserve capacity. The question of DLR may nevertheless be raised for “bottlenecks” in the system, or when the reserve capacity is limited during peak load hours. Such peak loads may occur during cold winter days in northern Europe when there is a high power demand for house heating or during hot summer days in southern Europe when there is likewise a high demand for air conditioning.

These systems must be associated with intelligent management systems ("smart grids") which will aim at adapting in real time and efficiently the energy production to the fluctuating demand. Storage will then be able to combine centralized and decentralized (renewable energies) production systems. For this purpose, short-term weather - and production - forecasts will play a major role when considering the whole of Europe.

Finally, financial aspects have also to be considered. For independent wind-farm or solar power plant operators selling their electricity directly on the market, inaccurate production forecasts make the difference between large profits and large fines for non-compliance. For grid operators, accurate forecasting will result in less fossil-fuel based energy production kept "burning" and a better efficiency in the use of storage capacity.

COST ACTION ES1002 “WIRE”

The COST Action ES1002 “Weather Intelligence for Renewable Energies WIRE” was launched in November 2010 to promote the short time forecasts of energy production for wind and solar energy. Its goals are 3-fold: evaluate the accuracy of existing forecast systems (including post processing algorithms) by validating their results with in-situ measurements performed mainly at power plant sites (Working Group 1), promote the use of ground-based standard and remote sensing measurements together with satellite-borne information and analyze the potential to increase the quality of the short-term forecast with such systems (Working Group 2) and finally strengthen the collaboration between end-users (power plant operators and TSOs) and modelers in order to best characterize their needs and requirements (Working Group 3) based on the modeling results.

Two major strategies are applied: first, solar and wind energies are considered in a single approach reflecting the challenges set by a high penetration of renewable energies in Europe and elsewhere from the electrical grid point of view. Second, a European-wide approach is promoted reflecting the fact that the most efficient way to manage the growing share of wind and solar energies will be to consider Europe as a whole.

CONCLUSION

The COST Action ES1002 will continue its activities following the goals defined in the Memorandum of Understanding (www.wire1002.ch) :

- Promote the development of forecasting systems for the production of renewable energies.
- Support the development of standard and remote sensing measurement to increase the quality of the forecast systems (in-situ fast measurements and data assimilation for very short term forecasting) and to validate the performances of the forecasting systems
- Evaluate the performances of measurement systems
- Increase the collaboration with the power grid managers to promote the use of accurate forecasting systems for the production of renewable energies

Halfway through the present Action, the following recommendation for future activities can be already expressed:

The increased integration of renewable energies at the European level will be best sponsored by the establishment of a European institution dedicated to renewable energy production forecasts through a specific joint initiative within the forthcoming European programs including:

- The support of R&D activities in this field.
- The promotion of the development of operational forecast (NWP) of related variables specific for renewable energies.
- The promotion of the development of energy meteorology for specific harsh environmental areas such as mountainous areas and coastal zones.
- The promotion of the use and integration in numerical models of modern measurement technologies such as ground based sky imagers, radars, lidars, ceilometers, satellite estimates, etc...
- The contribution to the optimal design and control of European electrical grids.

- The support of the penetration of renewable energies in technically less developed countries.

References:

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