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The project ENDORSE: exploiting EO data to develop pre-market services in renewable energy

Lucien Wald[1], Claire Thomas[2], Sophie Cousin[3], Philippe Blanc[1], Lionel Ménard[1], Marion Schroedter-Homscheidt[4], Elena Gaboardi[5], Emilio Simeone[6], Gerd Heilscher[7], Sophie Jacques[8], Sebastiano Serpico[9], Thomas Huld[10], Dominique Dumortier[11]

Abstract

The ENDORSE project is co-funded by the FP7 programme of the European Commission, from 2011 to 2013. It exploits the atmosphere service MACC of the European GMES programme (Global Monitoring for Environment and Security) together with other Earth Observation (EO) data and modelling. It aims at providing public authorities and private investors with accurate evaluation and forecasts of renewable resources. The focus is on the development of downstream services that create added-value information. We present here the achievements of the first period. A very accurate though fast algorithm describing the position of the sun in the sky has been developed. A series of recommendations for quality control of meteorological data have been issued. All algorithms are available as code sources and are being implemented as Web processing services (WPS). Support vector machine techniques prove successful to map the air temperature at 2-m height from satellite images and a few measurements at ground level. The next development of ENDORSE is a portfolio of pre-market downstream services, serving as precursors and examples of best practices for similar services. The resulting services will be described using the INSPIRE metadata and declared in an existing Catalog Service for the Web (CSW) dedicated to energy. Finally, we discuss the mutual benefits between GEOSS (Global Earth Observation System of Systems) and ENDORSE.

1. Introduction

Green energy is a growth sector, yet more reliable estimates of the potential of renewable resources as well as user-orientated tools are needed to optimise Europe's return on green investments. The potential of new solar, wind and biomass technologies for energy is dependent on local and regional climate factors. Their effective exploitation requires careful intelligence analysis in terms of power system planning and

[1] Center for Energy and Processes, MINES ParisTech, BP 207, 06904 Sophia Antipolis cedex, France
[2] Transvalor, Parc de Haute Technologie Sophia Antipolis, 694, av. du Dr. Maurice Donat, 06255 Mougins Cedex, France
[3] Armines, 60 boulevard Saint-Michel, 75272 Paris cedex 06, France
[4] German Aerospace Center DLR, Münchner Strasse 20, 82234 Wessling, Germany
[5] iCons, Via Moretto da Brescia 22, Milano, Italy
[6] Flyby, Via Carlo Puini 97, 57128 Livorno, Italie
[7] Fachhochschule Ulm, Prittwitzstrasse 10, 89075 Ulm, Germany
[8] 3E, Kalkkaai 6 quai à la Chaux, 1000 Brussels, Belgium
[9] Universita degli studi di Genova, Via Balbi 5, 16126 Genova, Italy
[10] JRC, Joint Research Centre of the European Commission, T.P. 450, 21023 Ispra, Italy
[11] ENTPE, 3 rue Maurice Audin - 69518 Vaulx en Velin Cedex, France

operations. Information from satellites and other Earth Observation (EO) instruments and models has the potential to further enhance the reliability of such data (Dunlop et al., 2006).

This communication aims at presenting the achievements already attained by the ENDORSE project, exploiting such EO data to deliver such valuable to European businesses and public authorities.

GMES (Global Monitoring for Environment and Security) is the European programme for the establishment of a European capacity for Earth Observation. It is managed by the European Commission (EC) and the European Space Agency. It consists in a complex set of systems which collects data from multiple sources, such as satellites, ground stations, airborne and sea-borne sensors, processes these data and provides users with reliable and up-to-date information through the services in the six following themes: land, atmosphere, emergency, security and climate change. Under particular interest here is the atmosphere service, called MACC (monitoring atmosphere composition and climate).

The Group on Earth Information (GEO) is coordinating international efforts to build a Global Earth Observation System of Systems (GEOSS). GMES contributes to the GEO. The emerging public infrastructure of GEOSS is interconnecting a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment.

2. ENDORSE project, its objectives, its audience targets

The ENDORSE (ENergy DOwnstream SErvices) project (www.endorse-fp7.eu) is co-funded by the EC FP7 programme from January 2011 to December 2013. It exploits EO data and GMES atmosphere service in order to deliver critical intelligence on renewable energies: solar, wind, and biomass energy, to promote them in buildings, electricity production and grid management. The focus is on the development of so-called downstream services that create added-value information, in particular from EO-derived data supplied by GMES services.

Accurate assessment and forecasts of renewable resources will be provided to public authorities, private investors, plant operators, and grid managers.

Reliable intelligence on resources determines where investments are profitable and how much the plants may produce. It helps in detecting failures in plant operation and issuing early warning to managers, such preventing large losses in production.

The operators of electricity distribution grids face increasing shares of renewable sources in their grids. Accurate and locally-detailed forecasts of resources within the next few hours are a prerequisite to prevent grid instability and subsequent local blackouts.

Low-energy buildings rely on a large use of daylight to reduce the use of artificial light. Accurate evaluation of available daylight is essential to optimize the use of daylight with control systems in building design or retrofitting as well as energy regulation policies.

Benefits of using GMES services and EO data will be demonstrated to the targeted audience: public authorities, private investors, energy-related companies, by the means of products that users can exploit in their day-to-day operations.

In addition, a second community of users is targeted. As services are being developed within ENDORSE to produce products, ENDORSE will demonstrate these precursor services to the service-oriented companies, and will stimulate the market of services exploiting GMES services and EO data in renewable energies. Service-oriented companies will take these examples to create new or extended services and bring them into the market.

3. Achievements in environmental modelling

ENDORSE is contributing to advances in environmental modelling and meteorological data exploitation.

The position of the sun relative to an observer located at ground must be known precisely with an error less than 10” of arc angle to match the more and more stringent requirements induced by the fast development of sun-tracking systems producing electricity. An algorithm has been developed that offers this accuracy and is fast enough to be used in operation. In comparison with the widely used algorithm published in the European Solar Radiation Atlas (ESRA, 2000; Wald, 2007), the new one runs as fast and is 100 times more accurate. A report is publicly available on the ENDORSE web site. The code will be available at www.helioclim.org, and a web service is being developed at the energy community portal www.webservice-energy.org. Finally, an article is being submitted.

Meteorological measurements are prone to errors. Several reports from the World Meteorological Organization (WMO, 1982, 2007; Long/Dutton, 2002; NDBC, 2009) and other publications (e.g., ESRA, 2000) have been reviewed in the light of advances in sensors and processing techniques. A series of tests have been established and a report has been written which contains recommendations for quality control of meteorological data at surface. It is publicly available on the ENDORSE web site. A web service will be developed and deployed in the energy community portal. It will replace the service set up by Geiger et al. (2002).

Resampling in time is a very frequent operation when handling meteorological data. For example, changing from local legal time to universal time requests a resampling of data in time-series of hourly data: original data must be oversampled to say, 1 min, and then aggregated every 60 min with the appropriate offset to yield hourly values in the UT system. It happens that in many cases, the resampling operation does not support the consistency property. Given an original set of data, which has been oversampled in time or space, the consistency property states that the average of the oversampled set, back to the original sampling (resolution) of the original data set must be equal to the original data set (Thomas et al., 2008). We have assessed the importance of the deviation to this property onto quantities relating to energy production. ENDORSE proposes resampling techniques that include the consistency property as a constraint. A report is publicly available on the ENDORSE web site that describes these techniques.

Air temperature at 2-m height is usually known through ground measurements therefore at a limited number of places, or by re-analyses therefore at coarse spatial resolution. A regression-based approach is developed to model the relationship between satellite observations and air temperature at 2 m at fine scale (Moser/Serpico, 2009a). Support vector machine techniques prove successful to map air temperature in Provence or Tuscany, given a training set composed of in-situ measurements collected by a network of stations. Satellites images are either MODIS images or Meteosat images. Estimates of the point-wise statistics of the regression-error (e.g., in terms of standard deviation) will then be derived by the specific regression strategy (Moser/Serpico, 2009b); this endows each derived map of temperature estimates with a corresponding map expressing the pixel-by-pixel uncertainty associated to the retrieved temperature. The impact of spatial resolution on the estimation accuracy is being analyzed by experimenting with both Meteosat and MODIS images. The data acquired by the Meteo-France stations are used as test data to quantitatively assess the accuracy of the results. It is foreseen to study the possible benefit of using the daytime variation of the surface solar irradiance provided by the GMES atmosphere service as a strong correlation between changes in temperature and irradiance is often found. Once completed, the results will be subject to a report publicly available on the ENDORSE web site by January 2012.

4. Services in renewable energies

There are ten downstream services in five energy domains: sun, wind, electricity load, bioenergy, buildings.

4.1 Sun

The service S1 is entitled "generation of local atlases for decision-support in solar energy policy planning and private investment". The expectations of its possible users are a better spatial and temporal knowledge of the potential of solar energy in their area of interest. They also need to relate this information to other types of geographical information, e.g., physical and administrative, possibly within a computer-aided method for decision making, or a GIS, or for due diligences for banks. The information should be recent, of known quality and uncertainty, spanning over several years and easily accessible. In other words, users need a reference tool for studies for sitting, sizing and return-on-investment on solar plants, and local policies for energy planning and attraction of investors.

The service S1 will generate local atlases. An atlas comprises the detailed databases on hourly basis as well as synthetic maps, e.g., monthly and annual mean values. Depending on users requirements to be developed in the project, the atlas may comprise meteorological data (surface solar irradiance, air surface temperature) as well as other information of other nature, such as physical, (orography, hydrography), administrative (cities, districts, protected areas, hazards…), or policies (regulation, incentives rules, plans). This service should be implemented as a Web map service.

The service S2 is entitled “design and performances analyses of concentrating solar power (CSP) systems”. The expectations of its possible users are a support for optimal system configuration. A service providing technical advice at planning stage, including site evaluation and advice on components selection and purchase, will be perceived by users as extremely beneficial. Once solar power systems are active, their owners want the guarantee that the systems return the expected yields, thus a service supplying a reliable management of CSP systems, based on remote monitoring and yield analysis, is of crucial importance. Users will consider as particularly advantageous a service which cuts the running operation costs, by early failure detection and quick troubleshooting.

At the planning stage, the service S2 will provide support to evaluate the site, to configure optimally the CSP system and to estimate the profitability of the investment. At the operational stage, it will provide an internet-based, cost-effective and secure local system monitoring solution.

The service S3 is entitled “Irradiance forecasts for electricity production” and is an improvement of an existing service. The company Solar Millenium AG is currently developing a solar energy production forecast for concentrating solar power plants in close collaboration with DLR within the European Space Agency project CSP-FoSyS (Kraas et al., 2011). ENDORSE aims at improving this service, and particularly the forecast of direct irradiance with a horizon of up to 48 h, by using GMES core capabilities and by performing the R&D needed for that.

The service S4 is entitled “generation of highly spatially-resolved Typical Meteorological Year (TMY) data sets for the design and the performance assessment of complex solar energy based systems for electricity production”. An accurate assessment of the value of the utility electricity generation in the early stages of a large investment project is very important since this figure is the basis of many other calculations that define the profitability of this project and therefore the “go-no-go” decision made by banks and investors. This assessment is made by using numerical simulators of the power plant, whose inputs are, among others, meteorological data. In order to save time and efforts, energy companies and banks have agreed to use TMY data sets rather than complete data sets spanning over 10-15 years as inputs to the simulators. A TMY is a series of meteorological values, typically one per hour, covering one full year. It is a synthesis of the meteorological situation of a past period spanning over several years, typically 10. It is made of observed values, and not averages for instance, which are selected according to specifications by user. For instance, a TMY may represent the median situation or the worst situation with respect to energy production. The service will generate TMYs by exploiting the GMES atmosphere service which delivers solar irradiation. It will add the air humidity parameter and air temperature, and possibly wind speed. This service should be implemented as a Web service.

The service S5 is entitled “A Web-based GIS for concentrating solar systems”. The expectations of the possible users are a decrease in the risk in the search for appropriate sites for CSP power plant develop-

ment. At this very initial state usually availability of financing is very low. Project development companies therefore need a tool which helps them in the search of possible sites for a CSP project. Data needs are long term available direct normal solar radiation, access to infrastructure (e.g. streets, overhead lines), land cover and properties. A valuable tool for such searches is e.g. Google Earth or maps.google.com. Infrastructure data is available on such tools and the satellite images give a good first impression of the suitability of the land cover. Missing information is exclusion maps which remove protected, too steep or otherwise unsuitable areas and available solar radiation. This service will be a Web map service which uses the Google API and adds those layers.

4.2 Wind

The service W1 is entitled “generation of annual energy output (AEO) for decision-support in on-shore wind energy policy planning and private investment”. In the process of building an on-shore wind farm, an accurate assessment of its annual energy output is very important at an early stage. This assessment will lead the decision making of users. Users need an easy-to-access and fast tool for studies for sitting, sizing and return-on-investment on wind farms, and local policies for energy planning and attraction of investors. The service aims at answering these needs by generating AEO estimation/wind resource estimation for a wind farm project.

4.3 Electricity load

The service E1 is entitled "load balancing within electricity distribution grids enabling high penetration of photovoltaic power systems". The operators of electricity grids face increasing shares of photovoltaic power systems in their grids. The fluctuation of the power due to variation in the sunlight will cause problems for the grid stability in the future. Therefore the grid operators want to learn in advance how a larger fraction of solar power will influence the grid. For the safe grid operation load forecasts are needed for the scheduled operation of conventional power plants. The grid management needs to know in which way solar power could be integrated in the load forecast and the scheduling of conventional power plant operation. An accurate knowledge on the behaviour of solar power at the utility level is a prerequisite for the development of energy services and load balancing. The service to be developed will provide solar radiation data at 15 min time resolution and high spatial resolution during analysis phase. Solar power forecast on a local level with high spatial and time resolution will be delivered for the operation of distribution grids with high penetration of PV and the load balancing service.

4.4 Bioenergy

The service B1 is entitled “mapping biomass potential for forested areas”. Biomass of forested areas is currently used for energetic and material purposes; an increase use is expected for substituting fossil fuels. In addition, the cultivation of short rotation forests as biofuel resource will get more attention in the next years. Therefore, a reliable and automatic method for estimating the growth of forested areas becomes more and more attractive especially when large areas are investigated. New method for estimating biomass potential based on modelling, remote sensing data and meteorological data is expected to help regular assessment of forest biomass in Brandenburg. The development of this new method is expected to support a sustainable, economic and ecological development of a region in respect to timber and energy production. The service will provide maps of the net primary productivity and total stem of forested areas at European NUTS-3 level.

The service B2 is entitled “Definition and development of a service for certifying the sustainable production of bioenergy products”. The Deutsche BiomasseForschungsZentrum (DBFZ) was founded on February 28, 2008, by the Federal Republic of Germany, represented by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The DBFZ supports the BMELV in strategic questions concerning the use of biomass, is involved in policy development for a sustainable bioenergy use and closely

accompanies the definition of certification and controlling authorities on the national level. Members of the DBFZ work in committees for standardization and directives. Therefore, the proposed service for certifying the sustainable production of bioenergy products will be defined in close co-operation and will be analyzed with regard to its practicability. The objective of the service is to provide a certification of sustainable biomass production to a given crop.

4.5 Buildings

The service D1 is entitled "Computation of the annual lighting energy savings resulting from the control of blinds and artificial lights by daylight, for building design and retrofit, energy regulation policy planning, and private investment". Low-consumption energy buildings have to rely on a larger use of daylight to reduce the use of artificial light as much as possible. Artificial light should be seen as a complement to daylight, so its power should be controlled according to the amount of daylight available indoor. Bringing more daylight into the building should not lead to occupants' discomfort. Blinds should be available and controlled according to daylight. There is a strong link between daylight availability, blinds use and artificial light use. The energy savings resulting from a larger use of daylight cannot be evaluated ignoring this link. Users need a reference tool to know how much energy, can be saved every year, from increasing and optimizing the use of daylight with control systems. This information is essential to compute the return on investment and make decisions on building design or retrofitting, energy regulation policies, product development…

The service will compute the annual energy consumption used for lighting a room in which blinds and lights will be controlled by daylight. The users of the service will be able to define the size and the shape of the room, the reflection factors of the surfaces, the number, size and orientation of the windows, the transmission of the glass and of the blinds, the lighting system. The blinds and the lights in the room will be controlled by daylight to satisfy visual comfort and performance. The users of the service will be able to select different control systems available on the market; they will be able to define their own control strategies. The service will allow users to compare different scenarios: number and size of windows, control strategies... Users will be able to produce results for any site in Europe.

5. Mutual benefits between GEOSS and ENDORSE

The execution of the research in ENDORSE partly relies on the GEOSS. Of practical interest, are the interoperability capabilities offered by the many tools set up by the various stakeholders. The metadata are a standard means to describe data and services. We use the editor set up by the INSPIRE team to create the metadata describing all services in ENDORSE, whether they are Web services or not. These metadata are hosted in a catalogue, namely a catalogue service for the Web (CSW). This CSW is a component registered in the GEOSS common infrastructure (GCI) and can be harvested and searched from the GEO Web portal and alike (Resch et al., 2009). Thus, the ENDORSE services can be discovered easily. ENDORSE is benefiting from the CSW specific to energy established by the EnerGEO project co-funded by the EC FP-7. Several services developed in ENDORSE are either Web map services (WMS) or Web processing services (WPS). Once they are discovered, such services can be executed though a simple browser, thus making the Web a computational platform (Percivall et al., 2011; Robinson et al., 2009). Reciprocally, ENDORSE provides feedbacks to GEOSS on the use of these tools via indirect participation to the architecture implementation pilots. ENDORSE provides also valuable information on users needs in energy, thus contributing to the users interface committee of the GEOSS.

6. Conclusion

The ENDORSE project is the only one dealing with energy within the projects funded by the GMES part of the EC FP7 programme. It is presently consolidating tools and methods for modelling environment that are necessary for an efficient exploitation of data from GMES services and other EO capabilities. Built on top of these, services will be developed to answer needs expressed by public authorities and companies. ENDORSE will therefore support the economic sustainability of this sector. It will realise tools aiming at an increasing use of renewable energies, with a decreasing dependency of Europe on fossil fuels and non-European suppliers. It supports the efforts towards a sustainable Europe and contributes to the European excellence in the space sector.

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