

Executive Summary

Specific Contract under the Framework Service Contract 89/PP/ENT/2011 – LOT 3

**Assessing the Economic Value of Copernicus:
“The potential of Earth Observation and Copernicus Downstream
Services for
the Renewable Energy Sources Electricity Sector”**

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1 CONTEXT

This document represents an annex to the report of the “**European Earth Observation (EO) and GMES Downstream Services Market Study**”, performed under the first Specific Contract of the Framework Service Contract 89/PP/ENT/2011 – LOT 3 (“Support to GMES related policy measures”).

It contains a high-level summary of key findings of the analysis of the potential market value for European Earth Observation and GMES¹ downstream services for the renewable energy sources (RES)² sector.

As highlighted in the main report, the study and sectoral analysis is subject to a set of key assumptions and enabling factors, reported in the following chapter.

2 KEY ASSUMPTIONS AND ENABLING FACTORS

The study is subject to the following **key assumptions**:

1. **Catalytic effect of free and open data provision**³: Copernicus services are expected to enable and stimulate the downstream sector by freely and openly providing access to basic pre-processed data and modelling outputs, more cheaply than would be the case if companies had to undertake such basic processing and modelling themselves. The business case for Copernicus is that the services improve the efficiency of the downstream sector, allowing the industry to offer better value for money in products and services to end users.
2. **Full and assured continuity of Copernicus**: In order for the potential of future markets for Earth Observation downstream services to be realised, the continued long-term availability of Copernicus data services is assumed. The investment incentives are crucially tied to both political and financial commitments at an institutional level. This continuity of services presupposes the continuity and evolution of Copernicus infrastructure providing the necessary data. Without continuity, the "raison d'être" of Copernicus is put into question, as users will only rely on Copernicus if a sustained flow of data is ensured. Without appropriate funding, existing services will cease their activities.

Furthermore, a set of **enabling factors** has been identified, on which action and associated investments are considered necessary for the realisation of downstream market potential. Certain institutional conditions are necessary to enable and accelerate the market dynamics foreseen in this study, linked, *inter alia*, to market development and capacity building. They are summarised below:

¹ GMES will hereafter be referred to as Copernicus, following the recent decision by the European Commission to change the name of the programme (as per http://europa.eu/rapid/press-release_IP-12-1345_en.htm).

² This will be referred to as RES Electricity for brevity from this point forwards.

³ This refers, in the first instance, to data derived from the Copernicus family of dedicated satellites, the Sentinels. The transitory phenomenon of Contributing Mission data will be dealt with in a follow-on study on the midstream, scheduled for 2013.

- a. **Regulation:** Free and open data policy; assurance of data continuity; quality assurance and standards-building.
- b. **Data Availability and Access:** Simplified access to Copernicus Sentinel datasets at ready-to-use processing levels (L1)⁴ for high-volume distribution, thereby responding to the needs of the value-adding industry, ideally avoiding the duplication of efforts at national level.
- c. **Demand/Market:** Continued dissemination efforts; regional/local demand incubation and communication schemes aimed at commercial users; federation / consolidation of user needs and industry requirements; further integration of EO information as a supplement to traditional systems.

Examples of relevant enabling activities, which already exist in Europe, include:

- Tools for Copernicus Sentinel data pre-processing, which are already being piloted in selected Member States.
- The provision of support to the promotion of Space applications-related ideas (e.g. Copernicus Masters) and business incubators.
- Easy access to credit for entrepreneurs willing to invest in the value-added service sector.
- Support to training programmes in geospatial sciences to ensure availability of necessary talents for these applications.
- The building of networks and the organisation of dedicated events to consolidate user needs and industry requirements.

These activities should be built upon, extended and promoted in order for the full potential of the market to be realised. Under the EU's Horizon 2020 strategy, "*it is expected that around 15% of the total combined budget for all societal challenges and the enabling and industrial technologies will go to SMEs*"⁵.

3 INTRODUCTION TO SECTORAL ANALYSIS

The RES electricity sector is an industry which stands to benefit from the provision of downstream services based on Copernicus Earth Observation data. Earth Observation can contribute to the optimisation of renewable energy systems for power production, and to the provision of information for optimal integration of traditional and renewable energy supply systems into electric power grids.

4 THE RES ELECTRICITY INDUSTRY: TRENDS AND CHALLENGES

The global demand for electricity is expected to rise fuelled by an increasing world population, coupled with rapid growth in renewable energy sources.

⁴ Level 1 (L1) includes geometric and radiometric pre-processing.

⁵ COM (2011) 808, final, p. 10.

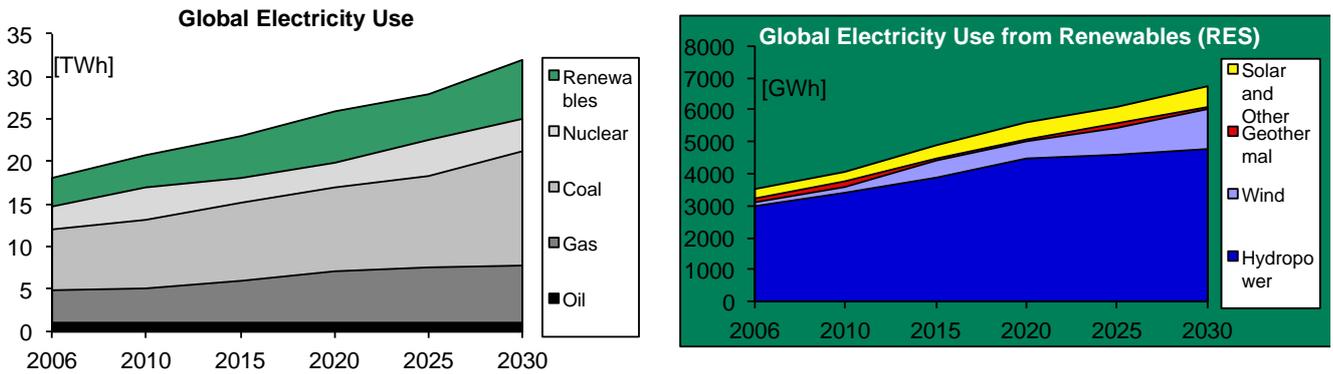


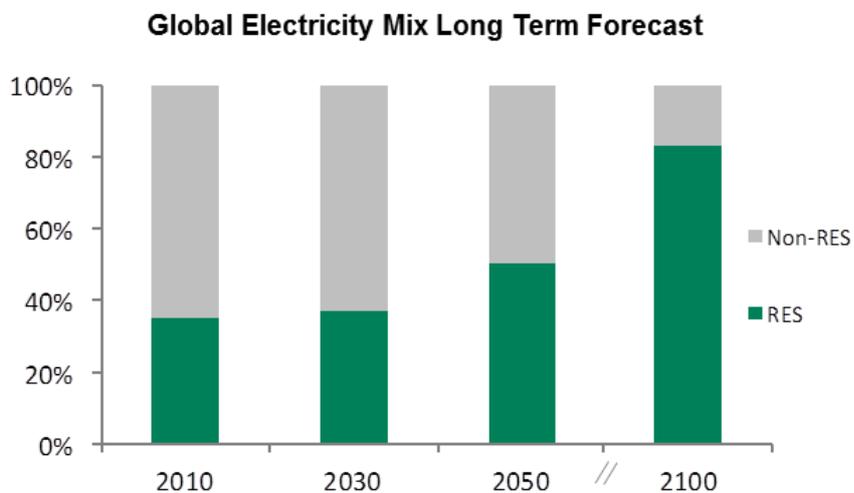
Figure 1: Global Electricity Use (2006-2030)

The per-capita demand for electricity is expected to rise, despite anticipated energy efficiency savings. Of all fuels, the renewables however will grow faster, albeit from a lower starting point. Significant growth is expected for solar and renewables, including bio-fuels.

4.1 Recent trends

RES electricity will be a key market opportunity in the near future, thanks to regulatory drivers (EU2020) and technological development, as investments in renewable technologies continue to drive down the costs of new plants and to smooth output variability. At present, the growing implementation of RES technologies continues in parallel to the use of traditional coal, gas and nuclear power generation methods.

As shown in the figure below, by the end of this century, most of the world’s electricity is expected to come from RES, with EU already taking actions in this direction. By 2100, solar will have become the dominant energy source, with over 50% share of the global energy mix, followed only by biomass, gas, hydro and coal.



Sources: Green Rhino Energy website, STP analysis.

Figure 2: Long Term Forecast of the Global Electricity Mix

The EU aims to obtain over 20% of its energy generation from renewable resources in 2020, according to the Europe 2020 strategy. This implies, as indicated by JRC estimates, that 35 to 40% of the total electricity (3,200 – 3,500 TWh⁶) would have to come from RES in 2020 (with 15-20% coming from wind, solar and marine sources, in particular). The share of RES in electricity generation will increase even more pronouncedly after 2020; by 2050, virtually all electricity generated should come from carbon-neutral sources. The European Commission's Directive 2009/28/EC on the promotion of the use of energy from renewable energy sources set the mandatory targets for the European Union's Member States, defined a trajectory on how the targets should be reached, and required Member States (MS) to adopt a National Renewable Energy Action Plan (NREAP), setting out targets within each sector and measures for achieving them.

4.2 Challenges

Energy sources such as solar, wind, and wave power facilities, which offer environmentally-friendly alternatives to fossil fuels, are particularly sensitive to environmental conditions. These energy sources are intermittent, and their availability depends largely on local climate and weather. Data on cloud cover, solar irradiance, and on wind/wave speed and direction (combined with other environmental parameters such as land elevation and land cover models) are vital elements in developing a strategy for the location and operation of solar, wind, and wave power facilities.

5 THE POTENTIAL USE AND BENEFITS OF EO DOWNSTREAM SERVICES

Real opportunities exist for information from Earth Observation to contribute to the optimisation of renewable energy systems for power production, and to the optimal integration of traditional and renewable energy supply systems into electric power grids. For the purposes of this case study, solar power will be examined in detail in the following sections.

European institutions and national agencies are already launching initiatives related to the exploitation of Earth Observation data in respect of supporting the renewable energy sector, for example:

- ESA is funding projects to develop downstream services under its Earth Observation Market Development (EOMD) programme, including **ENVISOLAR** ("Environmental Information Services for Solar Energy Industries") for near-real-time data and solar resource forecasts
- The EC-funded project **MESoR** ("Management and Exploitation of Solar Resource Knowledge, 2007-2009") aimed at providing the solar energy industry, the electricity sector, governments, and renewable energy organisations and institutions with the most suitable and accurate information of the solar radiation resources at the Earth's surface in easily-accessible formats and understandable quality metrics
- The FP7-funded **ENDORSE** ("ENergy DOWnstream Services") project (www.endorse-fp7.eu, January 2011-December 2013) is developing a portfolio of pre-market services has been identified, including irradiance forecasts, local solar energy atlases, load balancing within electricity distribution grids and mapping biomass potential
- The German Space Agency (DLR) has set up a solar resource assessment service, **SOLEMI** ("Solar Energy Mining") which will provide historical long-term data for Europe and Africa (>20 years) and Arabia and Asia (>10 years).

⁶ Terawatt hours, a unit of energy equivalent to 10¹² watt hours.

5.1 Use of Earth Observation information along the value chain

The contribution of Earth Observation application to the value chain of RES and solar electricity production is illustrated in the figure below.

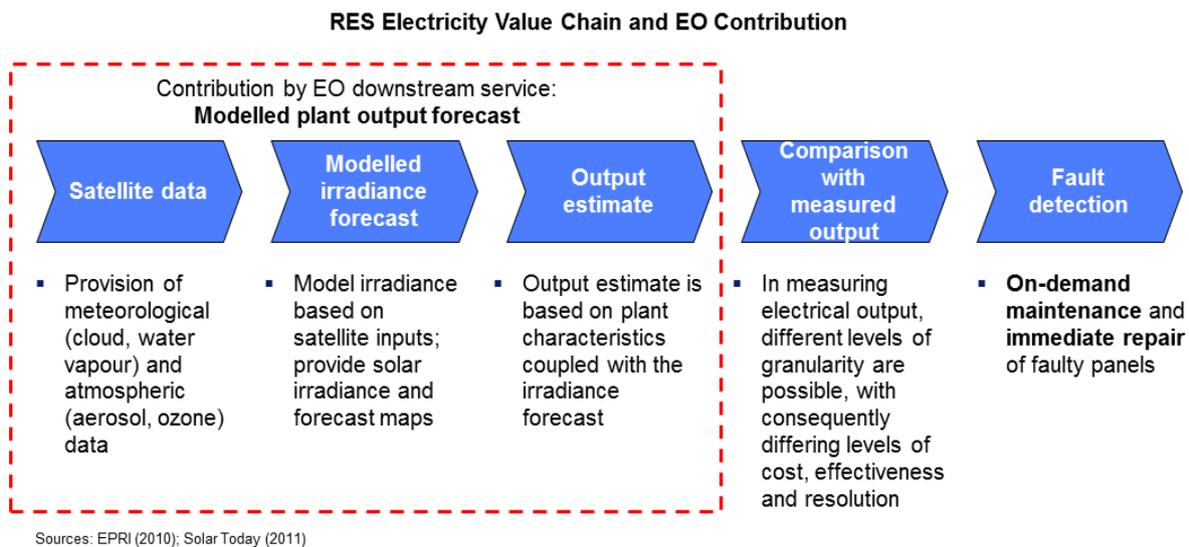


Figure 3: The Role of EO Data and Services in the Renewable Energy Sources - Electricity Value Chain

5.2 Benefits of EO information

The benefits of using EO downstream services in the RES electricity sector arise as a result of decreased costs, increased productivity (translating into improved profitability) and from competitive advantage through optimised investment decisions (based on better forecasts of cost and income). They are summarised in the table below.

Cost reduction	Reduced costs of monitoring and on-going and on-demand maintenance through the early detection of panel faults
Improved profitability	Increased plant productivity as a result of reduced downtime through the avoidance of “silent failures”
Competitive advantage	Better site selection and investment decisions for new solar installations based on projected cost assessment, plant output forecasts and income prediction

Table 1: Benefits of EO for the RES Electricity Industry

The output of solar plants are linked to the speed and efficiency with which faults in solar panels can be detected and corrected. Performance monitoring of photovoltaic (PV) systems is an increasingly important aspect of solar plant operations, as the number of grid-connected PV plants is growing, and expected to continue do to so at an accelerating rate over the next few years. The following factors underscore the importance of performance monitoring for PV plants:

- The majority of PV plants are remote and unsupervised;

- Preventative repair and maintenance missions can be expensive (regularly scheduled whether breakages are detected or not);
- Panels are subject to failure and output can be affected by dirt, shading or other external damage e.g. vandalism;
- The vast majority—in some cases up to 90%—of budgeted operations and maintenance (O&M) expense is preventative maintenance, while a small fraction (roughly 10%) tends to be reactive;
- Monitoring equipment represents 1-2% of overall plant installation costs.

In order to monitor the performance of the PV system and detect faults, the expected (potential) output is measured and then compared with the actual output. Any discrepancies indicate that there is a problem, either with the output monitoring sensors (which can suffer from the effects of dirt and damage) or with the panels. In either case, maintenance teams can be dispatched quickly to resolve faults. Over time, this reduction in downtime translates into higher average productivity.

The actual output of the PV system is measured by data logging devices. A number of different levels of granularity are possible, with consequently differing levels of cost, effectiveness and resolution.

Monitoring level	Cost	Effectiveness	Resolution
Inverter monitoring	1	3	1
Array monitoring	3	3	2
String monitoring	3	3	3
Micro inverter monitoring	4	4	4
Legend: 0Low 4High			

Table 2: Cost, Effectiveness and Resolution of PV Output Monitoring Systems

The expected output is a function of the efficiency of the panels and their inclination, whether they are static or mobile (tracking the sun), the solar irradiance over the area and the factors, which affect it, such as cloud cover.

One of the most influential factors is the amount of ground-level solar radiation available to the site. This can be measured using arrays of ground-based irradiance sensors, but these are costly and susceptible to failure, dirt, and irregularities. Satellite data - specifically, meteorological (cloud, water vapour) and atmospheric (aerosol, ozone) - are used as key inputs into modelling systems which forecast the available ground-based solar irradiance over a given area. Satellite data provides a cost-effective alternative and/or complementary option to ground-based measurements, and in certain cases (such as large, remote and/or unsupervised plants), satellite monitoring is the only option for predicting solar irradiance. EO downstream services can support performance monitoring and early fault detection, reducing downtime and thus improving plant output.

During project planning, information on the availability of solar resources is required for site selection, cost assessment and income prediction. Near-real-time information on solar irradiance is necessary for the surveillance of sites, as output will vary in line with irradiance. The transmission of solar radiation through the atmosphere is influenced primarily by clouds, aerosols and water vapour - data on these variables can be derived from satellites. This allows investment decisions to be better

targeted towards high-potential projects, and the improved information could also play a role in securing funding from outside investors. Energy consumption benchmarking is another area in which EO data can play a role.

The following table indicates several examples of the applications of remotely-sensed Earth Observation information in the renewable energy industry.

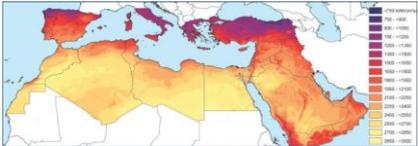
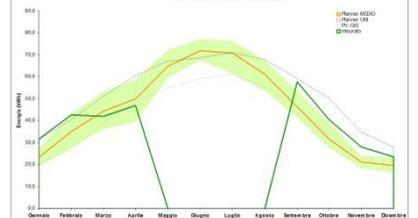
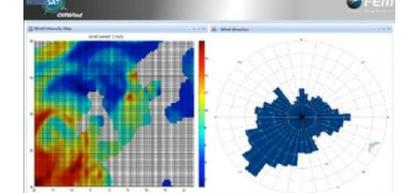
Application	Service Description	Example
<p>Solar plant site selection</p>	<p>Degree of solar irradiance serves as an input into feasibility studies for potential solar power generation sites. Example of energy resource map: Annual solar radiance in the Mediterranean region (kWh/m2) DLR (2005)</p>	
<p>Solar plant efficiency monitoring</p>	<p>Solar irradiance data is compared against power output to identify panel failures and reduce downtime. The example shows a power loss identified by Flyby's PVController application.</p>	
<p>Offshore wind farm site selection</p>	<p>Selection of offshore wind farms based on satellite-derived maps of potential sites. The example is a screenshot of I-EM's WindSAT application showing offshore wind speed data.</p>	

Table 3: Examples of Applications of Remote Sensing Data

6 DOWNSTREAM MARKET FORECAST

6.1 Relevant statistics and parameters

The present study used Eurostat's NACE⁷ taxonomy as a basis for the identification of potential industrial application areas for Copernicus downstream services. The relevant statistical data for the RES electricity sector was drawn from Eurostat's Structural Business Statistics, using the database "Annual detailed enterprise statistics for industry (NACE Rev.2 B-E) (sbs_na_ind_r2)". The most recent information on this sector was available for the year 2009, for a subset of Member States. This was extrapolated to EU-27 by means of Member States' percentage contribution to total EU GDP.

The basic information collected for the sector includes the number of enterprises, the number of employees, the industry turnover, and the purchases of goods and services. These are summarised in the table below.

Number of enterprises	38.064 ⁸
Number of employees	419.733 ⁹
Turnover	€ 228 Bn ¹⁰
Purchase of goods and services	€ 158 Bn ¹¹

Table 4: Relevant Statistics of the Total Electricity Generation Sector in Europe (Eurostat, 2009)

RES electricity generation currently represents 21% over total electricity generated in Europe and is expected to grow to 34% after 2020, also thanks to the existing European Commission Directive 2009/28/EC on the promotion of the use of energy from renewable energy sources.

6.2 Market forecasts

The European market for commercial applications of EO downstream services in the renewable energy sector is estimated to be approximately € 10 million in 2011 and € 12.1 million in 2015. This estimation is based on the current penetration of EO downstream services market in the sector

⁷ NACE is a standardised classification system for describing economic sectors and their activities in the European Union. The second revision of the NACE taxonomy has been used in this study.

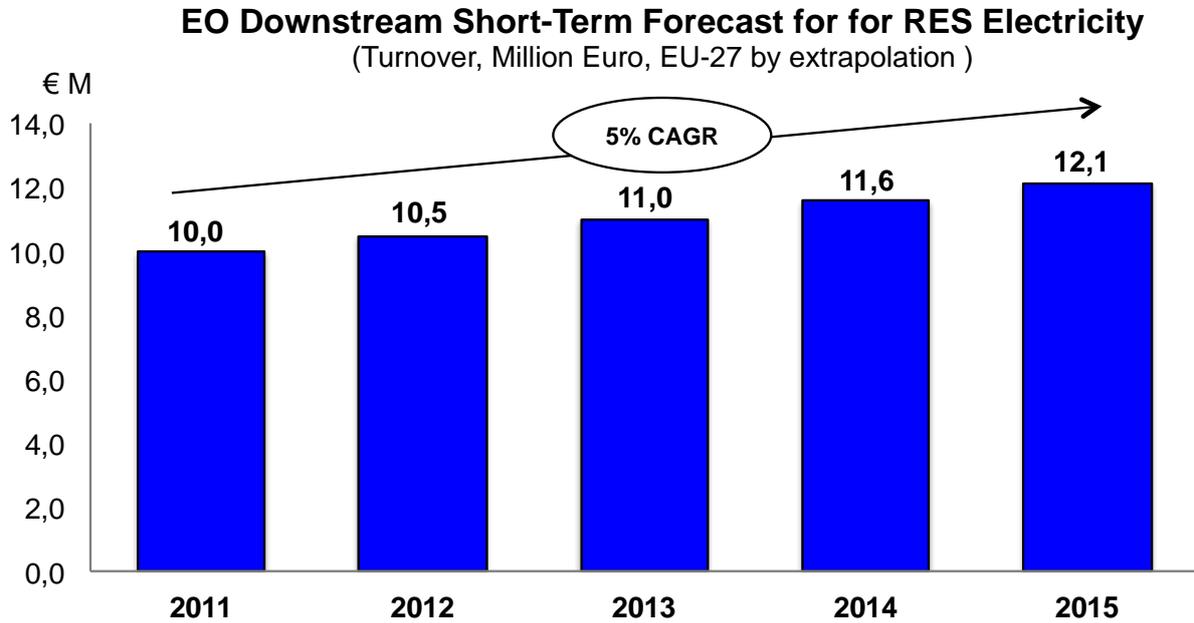
⁸ Originally 21.544 applicable to 20 Member States, representing 57% of total GDP: BG, DK, EE, ES, IT, CY, LV, LT, LU, HU, NL, AT, PL, PT, RO, SI, SK, FI, SE, and UK.

⁹ Originally 177.967 applicable to 18 Member States, representing 42% of total GDP: BG, DK, EE, ES, IT, CY, LV, LT, HU, NL, AT, PL, PT, RO, SI, SK, FI and SE.

¹⁰ Originally 116.856 applicable to 16 Member States, representing 51% of total GDP: BG, DK, EE, ES, IT, CY, LT, HU, AT, PL, PT, RO, SK, FI, SE and UK.

¹¹ Originally 81.131 applicable to 16 Member States, representing 51% of total GDP: BG, DK, EE, ES, IT, CY, LT, HU, AT, PL, PT, RO, SK, FI, SE, UK.

applied to the Eurostat inputs described above and Euroconsult EO downstream market forecasted CAGR.



Sources: Eurostat, EC, JRC, WBGU, STP Analysis
Extrapolated from a sub-set of Member States (MS) to EU-27 on the basis of % contribution to GDP.

Figure 4: EO Downstream Services Short-term Forecast for RES Electricity

The long-term market potential for the sector has been assessed through the concept of the Total Addressable Market (TAM). This concept expresses hypothesised market penetration, under specific assumptions and within certain limitations. It serves as a metric of the underlying revenue potential of a given opportunity, and should be treated as a “bounded theoretical maximum”.

The TAM has been estimated using the following parameters:

- The percentage of renewable energies against total energy production in 2025, based on forecasts from the German Advisory Council on Global Change;
- The relationship between purchases of goods and services and turnover in the sector
- The percentage of spending on value-added services, derived by analysis of other industries.

The estimated EO downstream services Total Addressable Market for the RES Electricity sector amounts to approximately € 70 million.

7 IMPACT OF COPERNICUS DATA AND SERVICES

Copernicus can contribute to the development of RES-related downstream applications through the Marine and the Atmosphere service, which provide wind and wave models and global surface solar irradiance monitoring. The following table shows how Copernicus data and services could enable assessment and monitoring processes for a number of renewable energy sources.

RES	Process/Application	Copernicus enabling capacity	
Solar	Energy resource assessment for site selection	3	<ul style="list-style-type: none"> • Sentinel-4 on the Meteosat Third Generation satellites will contribute to Copernicus solar resource monitoring by providing: <ul style="list-style-type: none"> – A continuous operational European capacity for atmospheric monitoring – High temporal and spatial resolution monitoring of solar radiation – Coherent information on atmospheric variables in support of European policies • The Copernicus Atmosphere Monitoring Service will provide: <ul style="list-style-type: none"> ○ Global surface solar irradiance monitoring ○ Aerosol analysis and forecasts
	Plant monitoring	3	<i>(as above)</i>
Wind (off-shore)	Energy resource assessment for site selection	1	The Copernicus Marine Environment Service will provide: Global wind observations
Wave (off-shore)	Energy resource assessment for site selection	1	The Copernicus Marine Environment Service will provide global wind observations

Table 5: Obstacles and the Enabling Capacity of Copernicus

8 CASE STUDY

An example of EO based solar plant monitoring service is provided by the company Flyby. Founded in 2001, Flyby is an Italian SME operating as a private limited liability company. The company focuses on transforming applied research into commercial product offerings in the space, environment and biomedical sectors. In the field of renewable energy, Flyby has developed an integrated system for remotely monitoring the efficiency of photovoltaic and solar thermal plants (known as SolarSAT).

Archive satellite data are used to predict ground-level solar energy at a specific location. Real-time satellite data are then used to assess the potential energy output, taking into account plant characteristics. Services are deployed on the web through user-friendly and customisable interfaces.

In a collaborative project with Enel (a major Italian energy provider), Flyby deployed its solar plant monitoring system at three Italian photovoltaic plants:

- 59 kW plant in Rome
- 49 kW plant in Milan
- 26 kW plant near Messina.

At all sites, production increased as malfunctions were detected and repaired.

“In January 2009 the Milan plant experienced a failure due to snow cover. Using satellite data, this was detected very fast and corrected. Optimal operation all the time is very important. Just 10% reduction in the yearly production of a typical photovoltaic plant producing 35 000–40 000 kWh per year could extend the return on investment of the complete plant by one more year.”

- *Ciro Lanzetta, Flyby.*

However, satellite and sensor-based approaches to solar radiation monitoring have comparative benefits and disadvantages. These are summarised in the table below.

	Pros	Cons
Satellite-based	<ul style="list-style-type: none"> • Lower system cost (0.5% of 50kW plant cost) • No maintenance required • No HW waste to dispose of 	<ul style="list-style-type: none"> • Lower accuracy (relative error, 8% with clear sky, up to 18% with cloudy sky) • Lower sampling rate • Accuracy degraded by cloud presence
Sensor-based	<ul style="list-style-type: none"> • Higher accuracy (5% relative error) • Higher sampling rate • Accuracy not affected by cloud presence 	<ul style="list-style-type: none"> • Higher system cost (0.7% of 50kW plant cost) • Sensor maintenance required • Light sensor affected by same problems as solar cells • HW waste disposal required

Table 6: Comparative Benefits and Disadvantages of Satellite and Sensor-based Approaches

9 CONCLUSIONS

The RES electricity sector is an industry, which stands to benefit from the provision of downstream services based on Copernicus Earth Observation data. Earth Observation can contribute to the optimisation of renewable energy systems for power production, and to the provision of information for optimal integration of traditional and renewable energy supply systems into electric power grids.

Energy sources such as solar, wind, and wave power facilities, which offer environmentally-friendly alternatives to fossil fuels, are particularly sensitive to environmental conditions. These energy sources are intermittent, and their availability depends largely on local climate and weather. Data on cloud cover, solar irradiance, and on wind/wave speed and direction (combined with other environmental parameters such as land elevation and land cover models) are vital elements in developing a strategy for the location and operation of solar, wind, and wave power facilities.

The benefits of using EO downstream services in the RES electricity sector arise as a result of decreased costs, increased productivity (translating into improved profitability) and from competitive advantage through optimised investment decisions (based on better forecasts of cost and income). Monitoring and maintenance costs are reduced through the rapid identification of solar panel failure. The avoidance of “silent failures” leads to higher overall productivity and therefore, profitability. During project planning, investment decisions can be better targeted towards high-potential projects, and the improved information on the availability of solar resources could also play a role in securing funding from outside investors.

The European market for commercial applications of EO downstream services in the renewable energy sector is estimated to be approximately € 10 million in 2011 and € 12 million in 2015. The estimated EO downstream services Total Addressable Market for the RES Electricity sector amounts to approximately € 73 million. The fulfilment of market potential and the time required for this potential to be fulfilled are subject to a set of important enabling factors:

- Regulatory factors, including a free and open data policy and assurances of data continuity;
- Supply side factors such as data processing, access and availability;
- Market development activities, such as out-reach and user engagement and federation and consolidation of user needs and industry requirements.

Copernicus can contribute to the development of RES-related downstream applications through the Marine and the Atmosphere service, which provide wind and wave models and global surface solar irradiance monitoring.

10 RELEVANT LITERATURE

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