EUROPEAN COMMISSION
DG RTD

SEVENTH FRAMEWORK PROGRAMME
THEME 6 - ENVIRONMENT
FP7-ENV-2008-1
GA No. 216364

EnerGEO

Earth Observation for monitoring and assessment of the environmental impact of energy use

Deliverable No.	EnerGEO D7.3-IV	
Deliverable Title	Final report	
Dissemination level	Restricted	
Written By	M. Schaap (TNO)	March 2014
	M. Weide (UNR)	
	N. Forsell (IIASA)	
	M. Schroedter-Homscheidt (DLR)	
	M. Mittlboeck (RSA)	
	D. Heslinga (TNO)	
	B. Gschwind (Armines)	
	P. Zeil (PLUS)	
Checked by	Dick Heslinga (TNO)	March 2014
Approved by	Martijn Schaap (TNO)	March 2014
Issue date	20-03-2014	

PROJECT FINAL REPORT

Grant Agreement number: 226364

Project acronym: ENERGEO

Project title: Earth observation for monitoring and assessment of the environmental impact of energy use

Funding Scheme: FP7

Period covered: from 01/11/2009 to 31/10/2013

Name of the scientific representative of the project's co-ordinator, Title and Organisation:

Dr. Martijn Schaap
TNO
Tel: +31 88 866 2074
Fax: +31 88 866 2044
E-mail: martijn.schaap@tno.nl

Project website address: www.energeo-project.eu

Contents

Final publishable summary

1.1 Executive Summary

A sustainable and reliable energy supply is a major challenge both globally and for Europe in the 21st century. The overarching aim of the EnerGEO project was to develop a strategy for a global assessment of current and future impacts of the exploitation and use of energy resources on the environment and ecosystems based on the use of the Global Earth Observation System of Systems (GEOSS) capacities and to demonstrate this strategy for a variety of energy resources worldwide.

A framework linking models and people was built
To assess environmental impacts of the large scale introduction of renewables in the power sector EnerGEO brought people together and linked leading energy system models with ecosystem, land-use and atmospheric models to perform a scenario analysis. For this purpose scenario definitions were harmonized among the different models including electricity production, final demand, as well as on electricity export and import balance up to 2050 for the Baseline and Low Carbon scenarios. We have improved the (health) impact assessment of fossil fuel use for ozone, particulate matter and mercury. The scenario analyses, available in the platform, demonstrated successfully how earth observations can enhance energy potential assessments for energy models and subsequent impact assessment on global and regional scales.

Optimal siting of renewable energy plants based on new renewable energy potential datasets
New renewable energy potential maps were generated for biomass, wind and solar energy. In addition, specific attention was paid to the predictability of the intermittent solar and wind energy production. The energy potential maps were used to generate a number of optimal siting applications. The applications combine the maps with geospatial Life Cycle Analysis and physical constraints that limit the exploitability of the theoretical resource. EnerGEO contributed to GEO Architectural Implementation Pilots with applications for solar energy in Europe (AIP4) and bioenergy in Pakistan (AIP5). EnerGEO developments have been fed into IRENA.

The innovative dissemination strategy
A web based GEO-portal was built and registered as part of the GEOSS registry. The portal provides the results and datasets produced in EnerGEO in a user friendly manner to share data and knowledge with a large community both in- and outside Europe. The portal is now extended to the 'EnerGEO Knowledge Portal' incorporating novel approaches for discovery and sharing of information. Web services provide access to impact assessment of selected energy scenarios as well as to optimal siting applications. Three summer schools were organized to train young researchers in the field of renewable energy and impact assessment. Besides building on capacity the aim was to promote the use of geo-information and to create global networks. With a particular focus on building relations between Africa and Europe, EnerGEO established and supports the Bioenergy Atlas for Africa Initiative, a GEO-task under EN01 and AfriGEOSS.

Achievements and Challenges:
The EnerGEO assessments show that renewable energy resources for low carbon economy in Europe are available. Moreover, the EnerGEO scenarios show that a larger share of renewables in the future energy mix than currently targeted for is possible. Moving from fossil fuels to renewables aimed at mitigation of climate change has large co-benefit for air pollution, whereas stringent air quality policies do not necessarily have effect on climate change.
EnerGEO has contributed to raising awareness of the importance of energy transitions in other regions of the world. To provide tailored information for decision making outside Europe, the assessment models need to be adapted or expanded to other parts of the world.

1.2 Summary description of project context and objectives

1.2.1 Back ground

Global energy consumption has grown considerably over the last decades and is anticipated to grow further in the future, at considerable cost to the environment. To date, a large share of the energy used originates from fossil fuels. To reduce the impact of energy use on climate, the European Commission has set goals to increase the share of renewable energies in Europe to 20% by 2020. According to the Roadmap towards a low carbon economy in 2050 in Europe, emissions from the power sector should be reduced by 54 – 68% in 2030 and 93 – 99% in 2050. To accomplish this energy transition is one of the major societal challenges in Europe of the 21st century.

Worldwide more than 1.5 billion people have no access to modern energy sources, of which most live in Africa. Providing access to these people through exploiting renewable energy resources may significantly improve living conditions and spark economic growth. Many developing countries may strengthen their economies further based on their renewable energy resources. These countries may reduce their dependency on fossil fuel imports. Hence, many less developed countries battle to provide a very basic energy supply to their citizens while eroding their natural resource base at a tremendous pace, and lack the observational means to monitor the impact and the tools to effectively plan. Hence, joint initiatives are needed to build capacity in these countries.

The energy transition will require a huge economic investment within the next decades. The exploration, transport and use of energy resources are associated with many environmental issues. It is therefore important to utilize co-benefits between climate policies and environmental policies where possible. Moreover, global competition issues are rising concerning energy and food security, energy and resource availability. Hence, robust information is sorely needed to help policy-makers assess the environmental impacts of energy production and consumption, gauge how best to diversify energy portfolios, and monitor geographical and temporal trends in (the effect of) the production, transportation and use of energy. Such information is essential to support decision making in the face of wide-ranging concerns about the sustainability of our global energy consumption and the pressure it places on the environment.

1.2.2 Overall objectives

The overarching aim of the EnerGEO project was to develop a strategy for a global assessment of current and future impacts of the exploitation and use of energy resources on the environment and ecosystems based on the use of the Global Earth Observation System of Systems (GEOSS) capacities and to demonstrate this strategy for a variety of energy resources worldwide.

The EnerGEO approach aims at:

- Linking Energy Use and Environmental Impact by making use of state of the art environmental, energy and scenario models;
- Collecting the necessary datasets and deriving relevant information from them by connecting to current GEOSS capabilities;
- Testing the EnerGEO-concept through dedicated pilots making our approach viable and supportive
- Enabling the collection of and access to EnerGEO-data by building a portal within the context of GEO and based on GEO-ADC-recommendations
- From Pilot-scale to Global Scale enabling to run global scenarios on energy use and environmental impact

The project logic aimed at connecting environmental impact assessment for the various energy resources with existing observation systems, developing an integrated, distributed observation capacity and demonstrating its applicability in a number of pilot-projects. These pilots focussed on 4 energy resources: fossil fuel, biomass, solar and wind energy. Based on the experience of the pilot-projects, first steps towards a global assessment of environmental impact for the extraction, transportation and use of energy resources have been made.

1.2.3 Contribution to GEO

EnerGEO provides the European contribution to the energy social benefit area of the group of earth observation (GEO). The activities of the social benefit area Energy in the 2009-2011 work plan has been divided over two tasks in the new 2012-2015 work plan:

- EN-01 Energy and Geo-Resources Management
- SB-05 Impact Assessment of Human Activities

Energy related strategic targets for these SBA's of GEO are:

EN01:

- Significant increase in use of Earth observations by all sectors (biomass, fossils, geothermal, hydropower, nuclear, ocean, solar and wind) for improved:
    - Prediction of potential hazards to the energy infrastructure;
    - Prediction of the production of intermittent sources of energy; and
    - Mapping of renewable energy potential.
- Improved energy management, including balance between energy demand and supply as well as development of alternative energy scenarios.
- Safe, efficient and affordable development and operation of existing and new energy resources, with emphasis on minimizing environmental and societal impact while moving towards a low-carbon footprint.
- Advancement of the application of data, systems and tools.

SB05:

- Significant increase in use of Earth observations by all sectors (biomass, fossils, geothermal, hydropower, nuclear, ocean, solar and wind) for improved environmental, economic and societal impact assessments of energy exploration, extraction, conversion, transportation and consumption.

Below we give an overview of the priority actions to which the EnerGEO project strongly contributes.

EN-01:

- Develop products and services required to assess countries' potential for energy production. Foster the use of Earth observation and information in energy-policy planning
- Develop a Bio-Energy Atlas for Africa to provide information on the quantity, distribution, usage, and quality of biomass.
- Encourage training of decision-makers at all relevant levels for interpreting relevant data and products.

SB-05:

- Develop a modelling platform that will enable planners and governments to forecast and monitor the environmental impact of changes in the energy mix
- Integrate Earth observation data with state-of-the-art modelling tools to calculate socio-economic impacts and environmental costs
- Develop new tools for impact monitoring of mining operations using Earth observations
- Integrate information from in-situ, airborne and satellite observation (through data assimilation) to provide impact diagnostics
- Integrate often sectoral monitoring approaches (and corresponding impact analysis) into a coherent approach, based on innovative Earth observation techniques (related to space-borne, airborne and ground-based sensor systems)

Furthermore, by developing a distributed system based on the recommendations of the GEO-Architecture and Data Committee (ADC), global collection and dissemination of data relating to the impact of energy use on the environment will be supported through EnerGEO.

1.2.4 Detailed objectives

In this section the detailed objectives of the EnerGEO project are given.

WP 1. Environmental Impact Model and Cost Assessment

1. To adapt and to link leading integrated assessment tools for comprehensive energy systems assessment in view of the emerging GEOSS
2. To develop a methodology, which is consistent with GEO, to assess the environmental impacts and costs of energy resource exploitation using a cluster of existing energy models
3. To set up the EnerGEO model cluster to assimilate products of GEOSS.
4. To develop consistent EnerGEO scenarios aimed at GEOSS impact assessment.

WP2. Global Observation Systems

- To assess current availability of datasets on soil, fresh water, ocean, land and biodiversity and use these results as input for a more focused analysis of data-availability in the framework of energy use.
- To assess availability of the key atmospheric information products for monitoring the exploitation of energy in terms of geographical coverage, resolution, temporal coverage, and spatial coverage.

WP 3. Systems Engineering

- Design the EnerGEO-system architecture to incorporate contributed components, services and data confirming interoperability using international standards and interoperability arrangements based on the GEOSS architecture.
- Design and implementation of the EnerGEO catalogue discovery system architecture based on international cataloguing standards.
- Design and implementation of the Energy – GEOSS Community Portal.
- Set up standards based EnerGEO Web- and Data-Services Infrastructure for utilization in WP4 and WP5.

WP 4. Development of Pilots

Biomass pilot:

- To provide biomass / bioenergy potential as input to REMIX, TASES and Bewhere models
- To integrate remote sensing data into existing model capabilities (EPIC/IIASA and BETHY/DLR) on different scales (Global, Reginal and Local)
- To validate biomass potential against in-situ data for selected areas
- To assess bioenergy potential using national biomass inventories
- To investigate scale effects
- To assess bioenergy potential using Lidar, ALOS, RapidEye

Solar energy pilot:

- To create a geospatial Site Ranking application that allows users to adjust certain criteria weightings according to individual preferences and include impact assessment (ARMINES) as criterion by the use of open service technologies.
- To validate the use of existing solar power prediction schemes
- To model time dependent averaging effects and cross-border energy flows over larger time periods and areas.

Wind energy pilot:

- To assess direct environmental impacts by wind energy as an energy source as well as the impacts due to substitution of fossil energy by wind power.

- To assess environmental impacts of substitution of fossil energy by wind power related to the complete energy balance of wind power over the total life cycle of a project (construction, operation, maintenance and decommissioning).
- To assess the potential (net) energy that can be produced from wind in a given area.

Fossil Fuel pilot:

- To implement a source apportionment for Particulate Matter (PM) to assess the contribution of various sources of fossil fuel to air quality over Europe.
- To evaluate energy transition scenarios in terms of air quality and the deposition of acidifying and eutrofying components over Europe.
- To model the concentration and deposition of mercury over Europe as an indicator of coal combustion
- To combine satellite derived AOD and NO2 column burdens in the regional air quality model LOTOS-EUROS to monitor NOx emission trends.
- To assess the contribution of fossil fuel to global CO2 concentration by using SCIAMACHY and MOPITT-data in conjunction with global air quality model TM5.
- To assess land degradation due to coal mining over eastern Europe using InSAR and Landsat-data.

WP 5. Platform for Integrated Assessment

- Implementation of the tools for performing integrated assessments
- Running the PIA for several known scenarios
- Definition of new scenarios for exploitation of energy resources
- Establishment of guidelines for an improved decision support tool

WP 6. Dissemination

- To maximize the dissemination of results outside the EnerGEO consortium to the global GEO-community, especially to the members of the Community of Practice (CoP) such as government organizations, energy analysts, environmental protection agencies and NGO's, in order to facilitate the application of the project results in GEOSS.
- To liaison with existing platforms and networks within GEOSS and GMES.
- To spread knowledge and to integrate the results in study programs, academic and professional training courses, summer schools within the EU but also with a particular focus on capacity building measures for developing countries
- To develop a exploitation plan and to integrate of the results in the GEOSS "system of systems"

1.3 Description of main S & T results/foregrounds

1.3.1 Renewable energy potentials

Development and validation of biomass potential distribution

The general objective of the biomass pilot is to implement the observational capacity for using biomass as an important current and future energy resource. The scope of this work was to generate biomass energy potentials for locations on the globe and to validate these data. Therefore, the biomass pilot was focused to use historical and actual remote sensing data as input data for biophysical carbon models as BETHY/DLR to derive biomass maps which were used as input layers for energy models or to derive Net Primary Productivity (NPP) maps as input and starting point for the forest vegetation model G4M. G4M was used for estimating future biomass potentials or future energy potentials of forests while EPIC was used for future agricultural biomass potentials or future energy potentials.

The biomass pilot tested the modeling capacity of models for potentials of biomass production. Different models have been investigated:

1. BETHY/DLR (NPP net production potential)
2. G4M (2nd generation bio-potentials)
3. EPIC (1st generation bio-potentials).

For validation purposes, forest biomass maps for 2000 for Germany (Bundeswaldinventur (BWI-2) and Austria (Austrian Forest Inventory (AFI) were prepared as reference.

For Europe maps of theoretical forest and the technical agricultural bioenergy potentials derived from BETHY/DLR were derived for the period 2000 to 2007. The calculations for forest bioenergy potentials are based on the assimilation of time series of the LAI derived from SPOT-VEGETATION into the model system. BETHY/DLR is further driven by meteorological data from the European Center for Medium-Range Weather Forecast (ECMWF), and additional static datasets, as a land cover information (GLC2000), a soil map (ISRIC-WISE) and an elevation model (ETOP05). The model output of BETHY/DLR is given as a time series of NPP in daily steps, at the resolution and projection of the land cover classification. For this study the Global Land cover Classification 2000 (GLC2000) with a 1km² resolutions is used. Integrating the yearly time series will result in yearly accumulated NPP which is first converted to straw potentials using simple allocation rules (root-to-shoot and yield-to-straw ratios) and then transferred to energy potentials using species-specific lower heating values.

Sustainable straw energy potential and sustainable forest energy potential were derived from BETHY/DLR. Compared to recently published straw potential values our method yields reasonable high coefficients of determination (R^2 up to 0.78) combined with a slight overestimation (up to 12%), allowing strong conclusions to be drawn about the usability of the presented method. In areas where the land cover classification (GLC2000) provided insufficient information (particularly in the Alps), modelled NPP was significantly underestimated (even to zero), producing high discrepancies between modelled NPP and empirical data in those regions. This indicates that a spatial resolution of $1km^2$ is insufficient to describe the heterogeneous small-scale structure of mid-European land use practices. BETHY/DLR underestimates the net increment of above-ground biomass for both deciduous and coniferous trees. The R2 values of 0.74 and 0.76 for deciduous trees indicate a high degree of correlation, however. The correlation for coniferous trees is even stronger, with R2 values of 0.95 and 0.93, but the underestimation is also higher here. In short, the BETHY/DLR model has been validated and data (2000 – 2007, 2010; 1x1 km2 scale; Europe) have been delivered to the energy models and to G4M (yields).

The EPIC (Environmental Policy Including Climate) model was used to assess agricultural side products (straw) on a European and global scale. EPIC operates on a daily time step and can simulate plant growth for hundreds of years. The global EPIC runs for bioenergy potentials derived from the following six crops (barley, grain maize, oats, rapeseed, rye and wheat) for the past (1961-1990), 2030, 2050 and 2090 at $10km^2$ resolution. CO_2 concentrations change over time in the forecasts. The forecasts show that straw production is expected to rise in the decades to come as driven by higher carbon sequestration induced by increased CO2 levels. We have compared the European EPIC 1km2 results to those derived from the BETHY/DLR model across Europe, with a reasonable level of agreement ($0.68 < R2 < 0.97$) showing a high general agreement between the models.

The Global Forest Model (G4M) was used to calculate theoretical energy potentials for forests on a European and global scale. G4M was developed at IIASA and predicts the annual above ground stem-wood increment

and stocking biomass. Currently the species beech, birch, fir, larch, oak, pine and spruce are parameterised. The model can estimate the current rotation time (time between afforestation to final harvest) assuming a normal forest out of a biomass map and a given yield. G4M needs a yield description as an input parameter as e.g. NPP, which was supplied by model results of the Biosphere Energy Transfer Hydrology (BETHY/DLR) model. G4M needs in addition the current forest and species cover, the stocking biomass or the stand density, the age structure if available and the management target. On a European scale G4M estimates energy potentials of 9.3 EJ for forests of Europe and on global scale energy potentials of 170 EJ for forests (Figure 1). Red coloured areas indicate tropical forests and savannahs, as reported in the World Wild Fund for Nature (WWF) terrestrial eco regions map. Because it is recommended that these areas should not be used for energy production, they were not included in the assessment. G4M was validated on Forests around Harz –Germany and on inventory points in Lower-Austria and Styria. Figure 6 shows estimates from G4M compared with measured increments from the German (BWI2) and Austrian forest statistics (AFI). It can be seen that the coefficient of determination is in the range around 40% – 70%. The model estimates in Europe seems to be acceptable as they are close to forest inventory observations. For the tropics currently the estimates are hard to validate because there is a huge range of uncertainties. As for EPIC, scenarios were produced up to 2050 with a 10 year interval.

The outcomes of biomass energy models are sensitive to input data by 40% or more. This is a consequence of biological sensitiveness to factors that determine growth such as weather, soil, species and cultivation. Collecting more and better input data is therefore essential. The three vegetation models, EPIC, G4M and BETHY/DLR, delivered input data for the energy scenario-models, REMIX and TASES as well as BeWhere, see below.

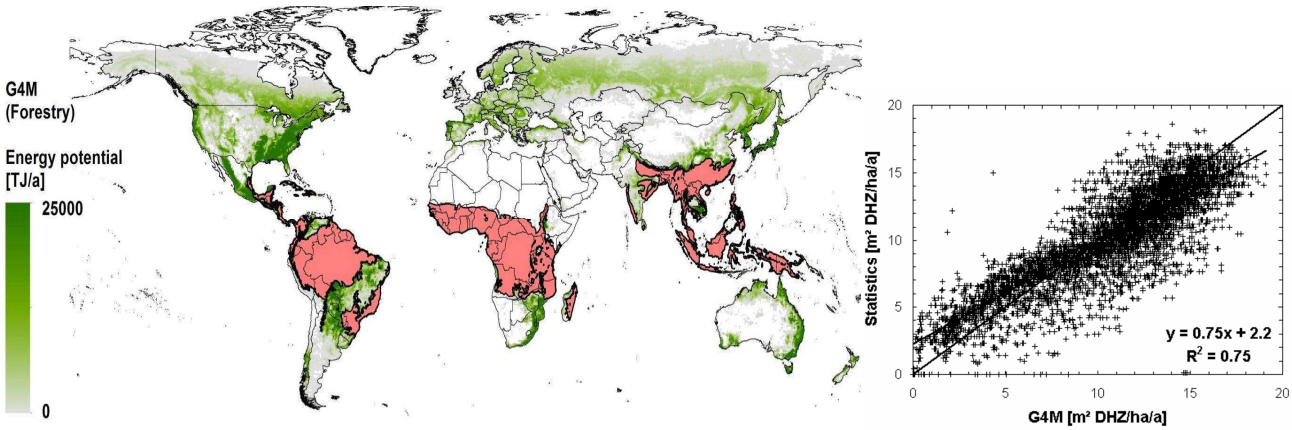


Figure 1. Left: Energy potentials from forests as computed with the G4M model. Values in TJ/y/grid cell of 0.5x0.5º. White: no forest. Red: tropical forests and savannahs. Right: Comparing G4M estimates with plot increments (Germany) and inventory observations (Austria)

Biofuel production in Europe based on modelled biomass potentials

Second generation biofuels are expected to replace 3-5% of the transport fossil fuel consumption by 2020. Different feed stocks can be used to meet this target such as forest residuals, crop residuals, construction and demolition wood, or paper and cardboard. Within EnerGEO the potential of second generation biofuel in Europe by 2020 for forest residuals and crop residuals was investigated, under varying biofuel support. A techno-economic, geographically explicit model, BeWhere, is used to determine the optimal locations of new bio-energy production plants by minimizing the costs and CO_2 emissions of the entire supply chain. Ethanol via hydrolysis and fermentation, and combined heat and power (CHP) are both considered to acknowledge feedstock competition.

The potential supply of forest biomass is assumed to be dependent on the total annual increment of forest biomass and is obtained from G4M. For straw energy potentials BeWhere absorbed results of BETHY/DLR modelled for Europe. The results show that if no biofuel support is applied, 5% of the European transport fuel can be produced from crop residues, and for a biofuel support of up to 30 EUR/GJ, Europe can produce up to 950 PJ annually (20% of the European transport fuel). Of this more than half would be provided from crop residues. Biofuel would be mainly produced from woody biomass in Scandinavia and France, and crop

residuals in Central Europe, while South Europe would be more dependent on import of both feedstock and biofuel.

Land cover map of Pakistan

A land cover /land use classification map in Pakistan was developed from Landsat ETM data images with 30 m resolution of the years 2004-2006. For developing the required land cover map, following methodology were applied: first cloud free images of Landsat were obtained of the period 2004 - 2006. Then the data images were processed to cover the whole area of Pakistan. From the mosaic image, Pakistan's area was extracted by applying vector file of country's boundary line. Then the extracted imagine file of Pakistan was run by pixel based supervised classification. Supervised classification method was maximum likelihood. For this, first the pixels on the basis of their spectral reflectance were chosen to assign signatures by drawing ROI (region of interest). Then this signature file was saved to classify the image accordingly. Ten classes were identified in the classification. Final classified image was opened and validated with ground data and accordingly adjusted.

The output classified land use / land cover map of Pakistan (figure 2 clearly depicts the interprovincial topology variations and impact of these factors. However, for the Pakistan test site no model run could yet be performed due to too coarse the land cover / land use data for modelling bioenergy potentials at 1km spatial resolution.

Identification of energy crops

DLR has started an analysis for testing a new approach to identify energy crops based on satellite data. The new approach uses time series of the LAI derived from SPOT-VEGETATION. These data are also used for modeling the biomass and energy potential with BETHY/DLR. Before the classification starts the LAI time series are systematically processed to find outliers and to fill gaps by applying the tool "Harmonic Analysis" which was developed at DLR also. For each pixel the result of the "Harmonic Analysis" is a set of up to five harmonics including the amplitude, frequency and phase for each harmonics. Thus a set of up to 15 parameters (bands) is obtained describing the temporal development of the LAI of each pixel. In second step an unsupervised classification (algorithm: KMeans) is applied. In several tests we have varied the number of classes which is an input for the unsupervised classification.

Based on the results it is concluded that it is not yet possible to differentiate between food crop and energy crop using LAI time series. At best one can identify phenologies which cannot yet be linked to specific crops. On the other hand we assume that a differentiation between food and energy crops is never possible because the use of crops for food or energy supply after harvest depends on the best price achievable on the market. In addition the phenology of e.g. maize is not different when planted as food crop or planted as energy crop.

LIDAR data analysis

First preliminary results on the LIDAR analysis regarding forestry biomass for the Austrian test site Sauwald have been achieved. First results on tree species classification based on LIDAR data are promising but not yet in a status to be used for estimate biomass potential. The most relevant parameter derived from LIDAR data is the tree height. It allows for a first estimation of current forest biomass status by identifying and accounting single trees and assigning them to a certain growth height range.

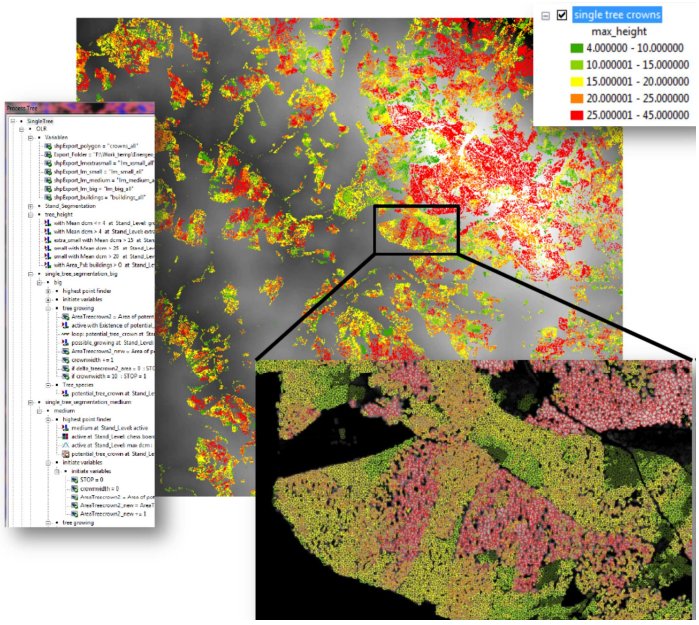


Figure 2. Tree height estimates for the test site Sauwald, derived from LIDAR data

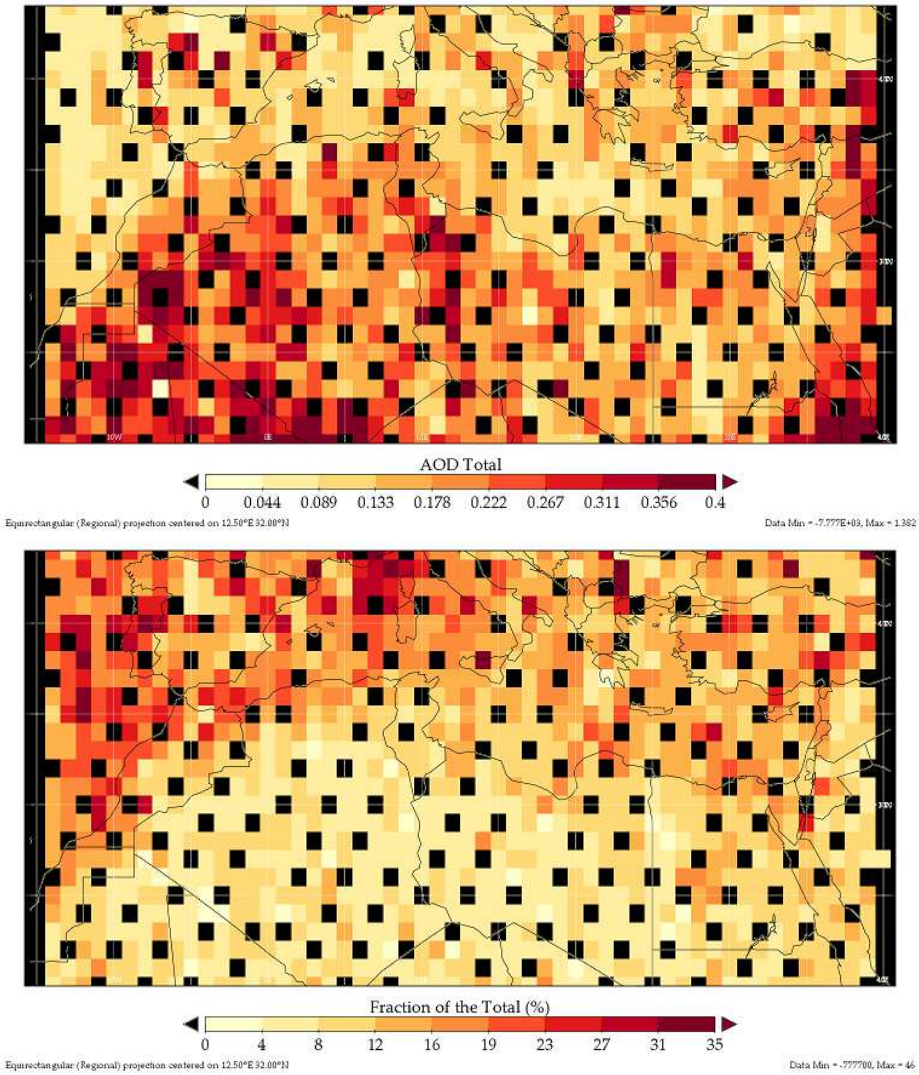


Figure 3. Results for 2008. AOD in the total column of air (upper) and ratio between the AOD in the first 150m and the total column of air (lower panel)

Impact of dust on energy potentials of concentrated solar plants (CSP)
Total AOD has been traditionally used to depict the extinction phenomena along the whole column of air but it is inadequate to describe the local effects occurring in a concentrating solar power plant if implemented in a tower design. Due to the optical path from the sun to the heliostat and then to the receiver at the tower, the optical path is extended and the AOD in this lowest layer of 100 to 200 m has to be taken into account twice. Annual maps of the presence of aerosols in the lower boundary layer for 2007 and 2008, based on CALIPSO satellite data are presented. The geographical domain spans horizontally the North African and Mediterranean regions and vertically from surface and an altitude that varies between 120m and 180m above ground depending on the topography. Total AOD at 532nm was selected as indicator of aerosol presence. The ratio between the 120m-180m-AOD and the Total- AOD reflects the share of lowest layer aerosols. All kind of aerosols are included. New maps on the aerosol impact on CSP revenue have thus been developed.

Improved detection of cirrus clouds for improved solar potential assessment
The IASI dataset of dust AOD for Northern Africa, the Arabian Peninsula and the Mediterranean region has been expanded from the year 2009 only to the periods of the FENNEC field campaign (June 2011, June 2012) as well as the year 2008 (currently being reprocessed). The algorithm has been further developed towards a better suited representation of dust extinction, retrieval of dust particle size, lower sensitivity to surface emissivity and using Bayesian inference for distinguishing between dust and ice clouds. From the same source (IASI) also a dataset of thin ice cloud (cirrus) coverage and optical depth has been created using the same methodology as the dust retrieval and the ice cloud optical properties parameterization of Yang et al. (2005). Both datasets are intended to help in the characterisation of the solar irradiation for solar siting purposes.
Bayesian inference of a posteriori probability estimates for dust and ice clouds is used for differentiation (an observation is assigned dust or ice cloud by selection of the higher Bayesian probability). Consequently the dust and ice cloud frequency and optical depth datasets are fully consistent. Besides Bayesian probability and intrinsic uncertainty each observation (dust as well as ice cloud) is delivered together with a 5-step quality flag, which allows for selecting observations by the desired degree of reliability of the retrieval results.

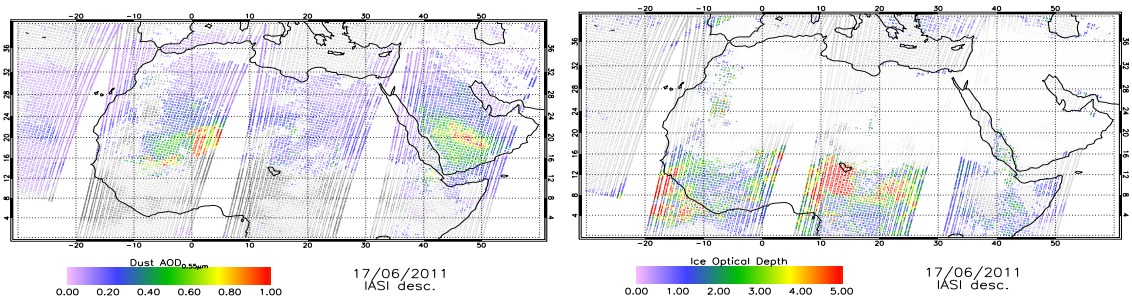


Figure 4. Dust (left) and ice cloud (right) optical depth at 0.55µm over Northern Africa, the Mediterranean Sea and the Arabian Peninsula for June 17, 2011 retrieved from IASI observations. Only dust and cloud observations with sufficient high quality flag (reliable retrievals) are shown.

Reliability of short-term solar energy forecasts
As solar energy as an intermittent energy resource, accurate solar energy production forecasts may reduce the need for backup power kept in the electricity grid management. This would result in reduced costs of the renewable energy supply and – in case of using conventional reserve power – in reduced environmental impacts of conventional power production.
Solar energy specific weather forecasts need to provide mainly global and direct irradiances, together with temperature, wind speed, rain and snow. The latter meteorological parameters are of less importance and therefore neglected in this study. Our hypothesis was that the accuracy and reliability of solar energy production forecasts on the intra-day and day-ahead forecast horizon differs from region to region depending on the variability of the meteorology and the skill of the meteorological model. The available ground measurement network for direct irradiances is extremely sparse, in Europe and Northern Africa there are up to 10 stations working at maximum. For global irradiances the situation is much better, but also there the representativeness error of ground measurements gets larger than a typical satellite observation's error once

there is a distance above 50 km from the next ground measurement station. Therefore, satellite based observations have been used as reference for the verification of global and direct irradiance forecasts from ECMWF. They allow the spatially distributed analysis of forecast accuracies and even the assessment of spatial correlations of forecast errors.

The original hypothesis of the existence of a spatial dependency of error characteristics in day-ahead global and direct normal irradiance forecasts has been confirmed. Figure 5 shows that for global radiation the reduction of relative RMSE is large due to the use of the ECMWF model. Relative RMSE values show a nearly latitudinal distribution. Less accuracy for the ECMWF is observed only over the Alps – an area with a strong orography not fully described in the coarse ECMWF model. In general, ECMWF 2 day forecasts outperform the 2-day persistence rule for hourly DNI values. It was illustrated that spatial and temporal autocorrelations of weather parameters can be calculated and thus be used for energy systems planning exploiting statistical independencies. Forecast skills are likely to improve in the future as more EO information will help improve weather forecasting models.

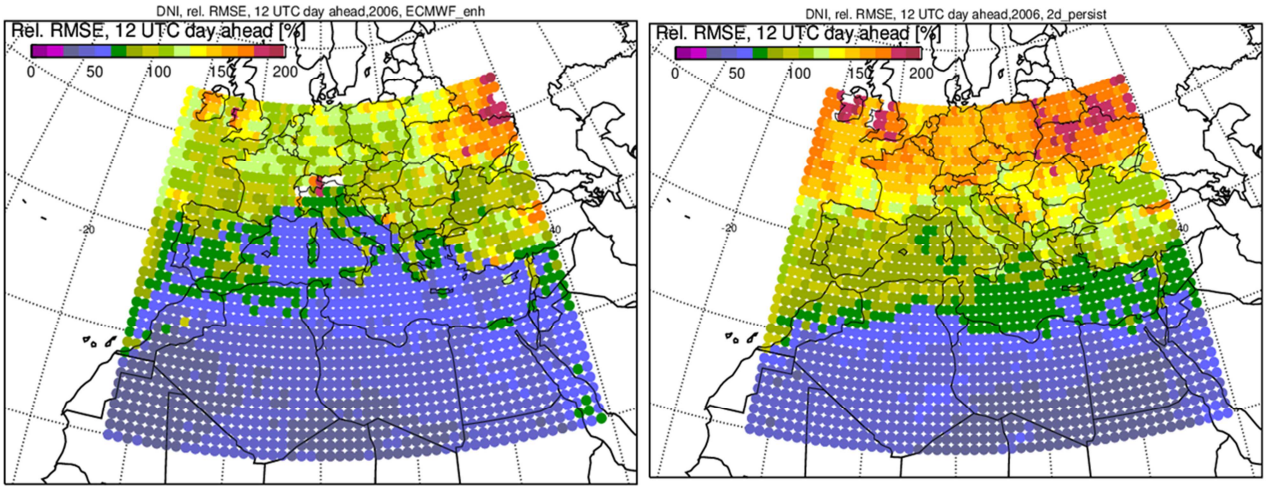


Figure 5. Error estimate of direct normal irradiation, forecast 12 hours ahead: Root mean square error divided by mean DNI. Left: based on ECMWF forecast; Right: based on 2day persistence method, which assumes yesterday's weather conditions and electricity generation also for the following day

Development and validation of wind potential distribution

To assess the potential (net) energy that can be produced from wind in a given area wind speeds statistics at hub height and the theoretical turbine power curve are required. Wind fields for the period 2000 - 2011 were produced with the help of a high-resolution Weather Research and Forecasting (WRF) model, covering a large part of Europe. From these results yearly and monthly wind speed statistics and potential energy production maps were derived. These maps show mean expectation values and variability intervals. Also, average down-time statistics due to too low or too high wind speeds have been determined. Special attention was given to the computation of effective turbine failure rates based on location, environmental parameters and maintenance parameters. The reachability of a wind park at sea is a limiting factor and depends on wave conditions and distance to the nearest harbour.

Besides the evaluation of historical data, which are important for optimal siting applications, a power output forecasting system to forecast energy production on short terms was developed. This application uses the same approach but combines the short term weather forecasts with the energy yield modules. EnerGEO developments have contributed to commercial forecasts to a Dutch energy company during the project. This development has led to a better understanding of the important factors in offshore wind farm construction and operation.

Wind energy is intermittent: the energy is only produced when the wind blows and this cannot be planned or controlled. The wind hind cast data sets have been used to investigate the statistical characteristics of this intermittency and determine the distribution of the energy production. One way to mitigate intermittency effects is to combine the contribution from wind parks at different locations, wide apart, in the European energy grid. A correlation analysis was used estimate how far apart wind parks should be placed: at distances

of about 600 km the correlation in energy production dropped to 0.5 (which is half way between 'exactly the same' and 'totally independent'). As an example, the statistical power production of the combination of three turbines (one in the North Sea, one in the Baltic sea, and one north west of Spain) was determined and found to be much more homogeneous than each of the contributing turbines. Maps were generated that show the correlation in the energy production by wind farms at different (distant) locations.

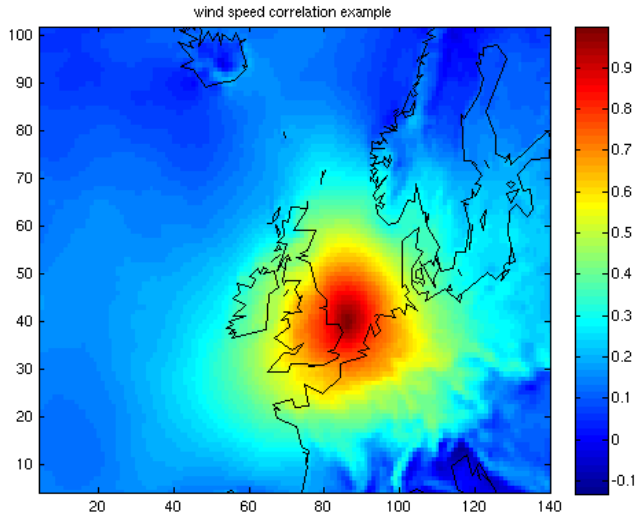


Figure 6. Correlation between wind speeds at a location off the coast near Norwich and the rest of the domain. This figure is an example and can be produced for each location in the domain.

1.3.2 Geo-localized optimal siting applications for wind, solar and biomass

Optimal siting of off-shore wind turbines

A geo-dependent life cycle assessment has been then developed to assess the geo-localized environmental performances of potential offshore wind farms. A user driven service is deployed to deliver Environmental performances of electricity generation, expressed as environmental impacts per kWh of electricity produced.

After a prospective technical analysis of near future offshore wind technologies and the identification of the different key components of a typical offshore wind farm, the materials and energy flows consumed during the components lifetime have been collected to build a modular life cycle assessments (LCA) model. Two types of 5 MW windmill have been selected: a fixed one (tripod style) and a floating one, settable in deep water. The geographical and technical key parameters which could have potential influence on the environmental performances of an offshore wind farm have been identified:

- Distance to coast has an impact on sub-marine cabling
- Distance to the relevant nearest harbour has impact on marine transport
- Water depth has an influence on the foundation choice (floating vs. fixed)
- Wind speed distribution has consequences on the amount of electricity generated by the wind turbine

Other technical parameters such as the turbine power, the cables and transformers' capacity have been taken into account to size the different components and to perform realistic analyses.

A web client incorporating Web Processing Service (WPS) and Web Map Services (WMS) was developed and deployed. The Web Client allows the user to analyse the wind farm environmental performance for different environmental criterions. The user is asked to specify a number of parameters including impact type, system lifetime, farm size, maintenance level, failure rate, and foundation type. The user is able to make several requests and gets as results corresponding maps and legends. He can compare different geographical options getting several environmental performance numerical results by clicking on selected points on the map. Figure 7 shows the result the user can expect for a specific configuration. It shows the global result map as well as the exact values (gCO2eq/kWh) for a given location (latitude, longitude).

The tool should support decision makers in assessing the global environmental impacts caused by an offshore wind farm in Northern Europe. The results of this EnerGEO wind pilot are related to North West Europe and the North Sea basin, but the modular geo-localised LCA algorithm implemented in this methodology could be applied to different regions in the world accounting for different climates.

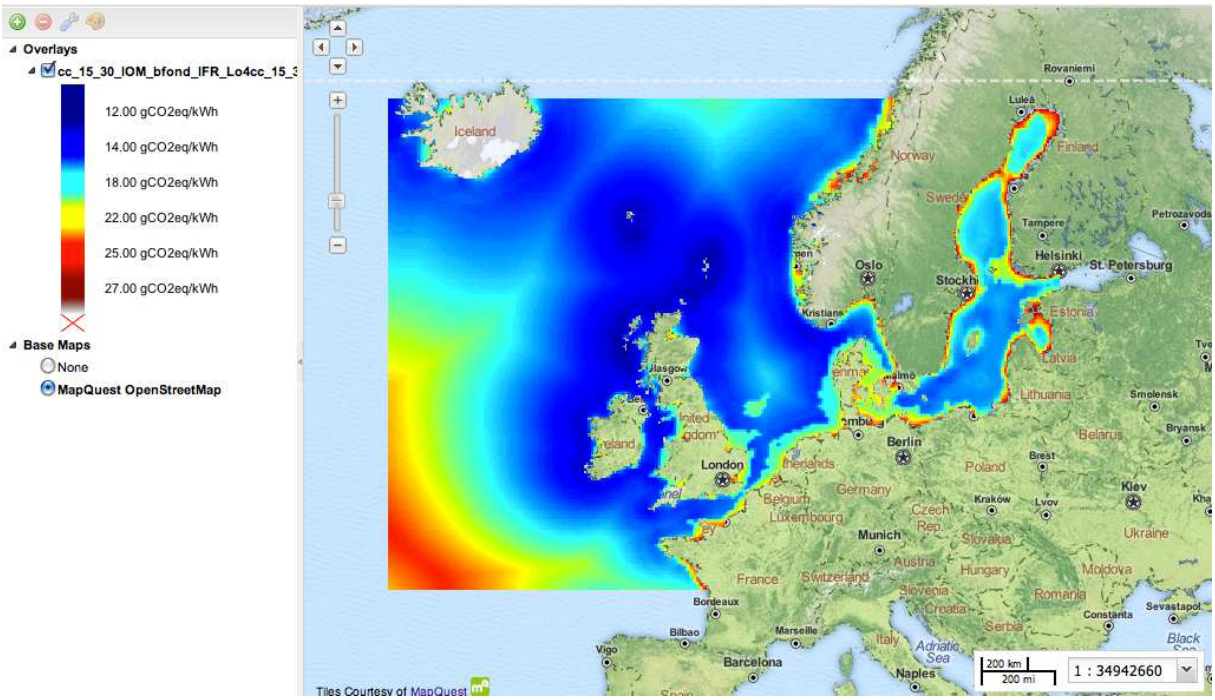


Figure 7. Environmental impacts of a Wind Turbine expressed in GHG emission per unit electricity produced (gCO2eq/kWh)

Optimal siting of solar panels

Investors and electricity producers willing to invest in solar plants need precise information to support decision-making. On their behalf, consulting companies perform feasibility studies in order to decide where to place power plants and which technology to use ensuring a profitable return on investment. To reach that goal, consultants need an easy and unified access to data sets. Such data sets include meteorological, geographical and environmental parameters that will be provided by GEOSS e.g. from atmospheric and land observations.

The developed siting support service is a Spatial Decision Support System (SDSS) which calculates location suitability expressed by a site ranking. It intends to help the decision-making process at the phase of pre-feasibility studies to identify interesting locations for solar power plants (not individual installations). The ranking itself is dynamic and is based on spatial relations to human infrastructure and physical constraints, and user driven criteria weighting.

Due to data availability, the area of Europe was chosen for this pilot. The pilot is accessible as online tool based on GEO/GEOSS compliant web service architectures, consisting of a web-based GIS user interface and an OGC Web Processing Service (WPS). Many efforts were spent on enhanced features like result and task management, options for adding other GEO/GEOSS related data and user-friendly guidance through the site supporting process. This makes the pilot less of a demonstrator but rather a useful tool that can be easily enhanced with existing data and services. The pilot provides an online service for site prospecting and a user interface which enables users to integrate the site ranking service in a subsequent workflow by adding further GEOSS related data or services. Furthermore, an online service providing environmental impacts of 3 kWc PV systems is available. Such services are ready and available to be connected to a future site ranking service.

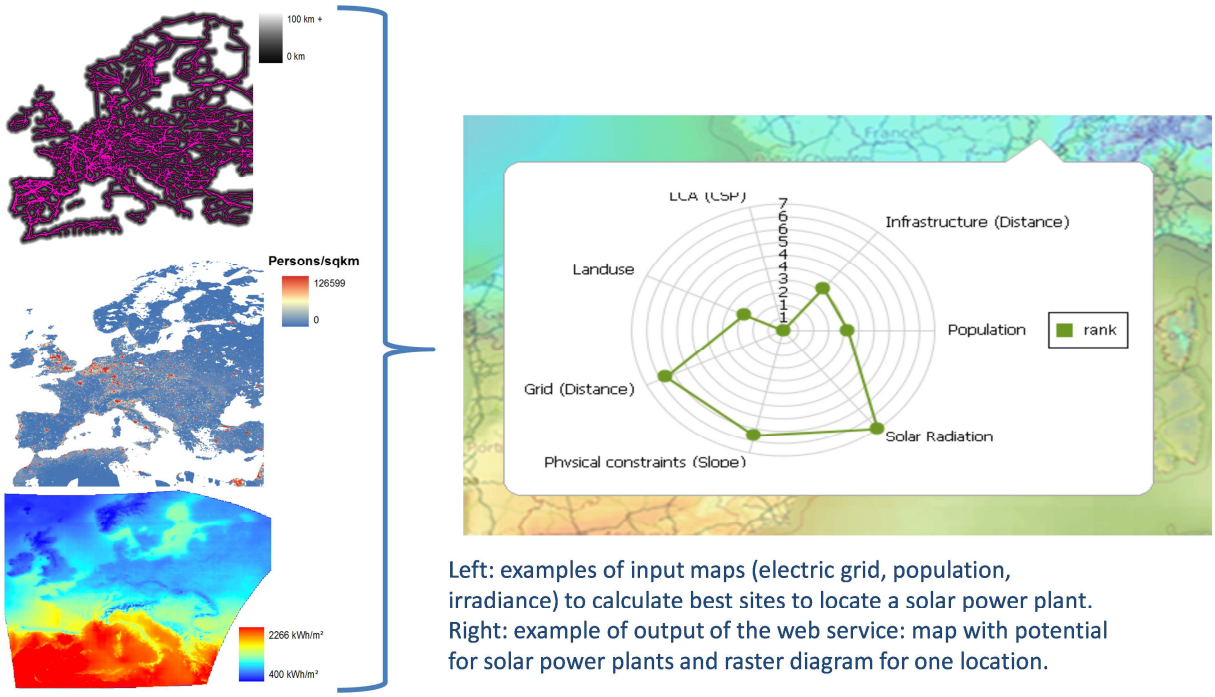


Figure 8. Overview of optimal siting application for solar plants

Optimal siting of biomass combustion plants

Within EnerGEO a novel method to determine ideal biomass power plant locations and their supply areas was developed and applied to Pakistan. First, we assessed time-series of bioenergy potentials (2001-2010) from agricultural side products for Pakistan on a spatial resolution of 1km². For this we used the Biosphere Energy Transfer Hydrology (BETHY/DLR) model to calculate time series of Net Primary Productivity (NPP). NPP was then validated using empirical data on acreage and yields. NPP was then transferred to energy potentials, using country specific conversion factors on e.g. the above-to-below ground biomass, yield-to-straw ratios and lower heating values. Second, to identify ideal biomass supply areas for potential biomass power plant locations we developed and applied the Autarkic Spatial Energy Cluster Optimization (ASECO) approach. ASECOs main aim is to identify self-sufficient supply areas for renewables within a sub-region. The model has a special scope on the identification of optimized transport flows among a region to meet its energy demand. In a first step the optimization determines which locations – out of a set of preselected locations – would be the most favourable for biomass power plant installations. For these locations the optimized power plant size and its required biomass supply area is calculated. Both optimization steps are based on maximal biomass availability and minimal biomass collection cost in terms of harvesting and transport.

Figure 9 illustrates the assessment of optimal biomass power plant locations (Yellow dots) with assigned biomass supply areas (red shading) over all districts of Pakistan with relevant biomass potentials. For 57 out of 115 districts an optimized power plant location was been identified. Supply areas in the northern and southern districts are larger than in the central districts due to lower biomass potentials around plant sites. In this study we used a medium resolution of 1km², but this method could also be used for an assessment on significant higher resolution, if all required datasets are available. Therefore, the methodology developed here can be applied for any region around the world. Note that high quality information on transportation costs is an important factor for the accuracy of the optimization.

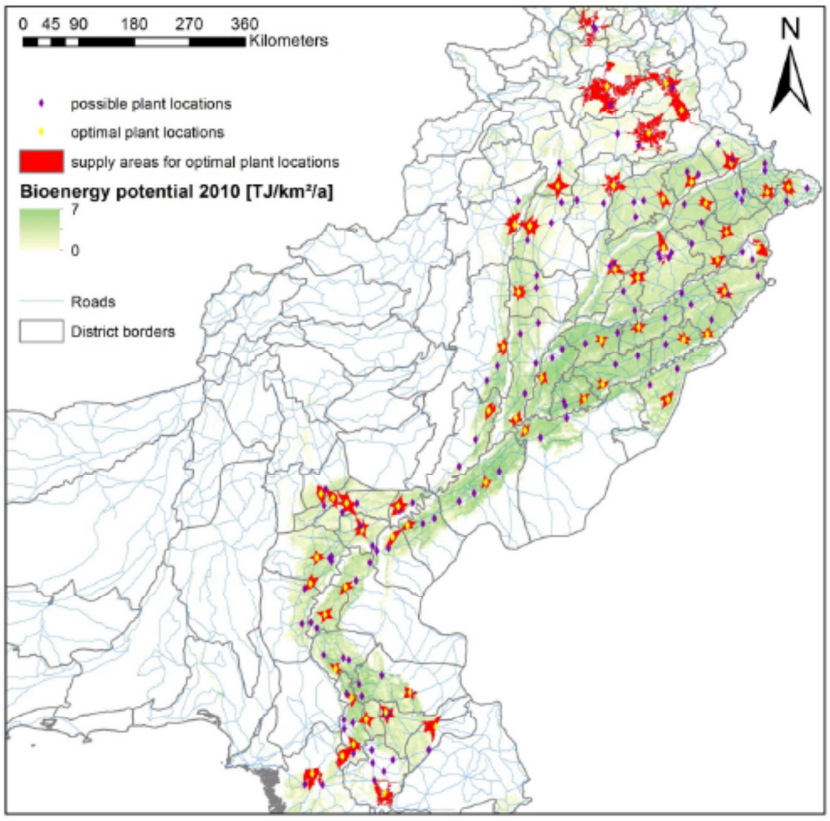


Figure 9. Assessment of optimal biomass power plant locations (Yellow dots) with assigned biomass supply areas (red shading) over all districts of Pakistan with relevant biomass potentials.

1.3.3 Improved energy modelling

European scale

The energy modeling tool REMix is a model capable of simulating large scale energy systems comprised of a large number of countries, high temporal resolution and a variety of both renewable and fossil generation as well as several storage technologies. The model is composed of two modules: EnDAT and OpTiMo. EnDAT is a globally applicable tool preparing hourly electricity generation data on country level using an exhaustive database on renewable resources, land use data along with a vast database on economic and technical parameters. EnDAT is capable of providing stand-alone results such as the assessment of theoretical, full load hour and cost potentials for the technologies photovoltaic, concentrating solar power, on and offshore wind and hydro power. The REMix module OptiMo builds upon the data provided by EnDAT in terms of using the country based hourly electricity generation time series as input to the optimization runs for the volatile renewable generation technologies. Moreover, the renewable technologies biomass, geothermal and concentrating solar power altogether providing firm power are implemented. Fossil generation is feasible using gas, coal and nuclear power.

Within EnerGEO, a new transmission model which enables to model imports and exports of each country to the neighboring countries has been implemented. The state-of-the-art transmission model uses what is known as the DC-approximation of the AC flow. It is based on fundamental assumptions made for the existing AC grid. The distances between the geographic centers are used to approximate the respective energy loss due to transmission. Furthermore, the implementation of CSP plants located in North Africa and the Middle East is carried out. These plants are directly linked to the European grid via high voltage direct current transmission lines. The locations of the CSP plants and the corridors for the transmission lines are outcomes of an assessment carried out within the REACCESS project. The explicit modeling of installed capacities in MENA countries allows to dynamically model solar electricity imports from this region.

Global scale

Our current energy system is mainly based on fossil fuels and nuclear power. The spatial context in such a system is secondary since transport efforts are marginal and supply and demand locations can be easily matched. That is also reflected in most system modeling approaches in terms of not paying further attention to spatial correlations. The current transition of the energy system towards a higher share of temporally and spatially highly disperse renewable energy resources make it necessary to consider spatial correlations between different resources and also demand structures. The outlined TASES model approach aims to enrich economically driven global forecast energy system models – usually distinguishing only several regions as aggregated clusters – with spatially relevant impacts derived from remote sensing data as part of the objective function. The energy system model TASES (Time And Space resolved Energy Simulation) has been developed in order to tackle best all relevant geographical correlations in energy systems. Especially renewable energy sources are often location dependent and highly intermittent. The model is a snap shot model focusing on one year, including seasonal and day/night variations among the region of interest. It outlines the optimal energy system setup in terms of locations for PV, wind turbines or biomass power plants also with respect on an optimal transmission grid as part of the entire system.

Remote sensing data are used to derive spatial indicators which are utilized as geographic discrete parameters in the TASES model. to reach a new and improved input dataset for the TASES model, new data sources based on earth observation data have been used. To identify relevant bioenergy potentials global results from the G4M and EPIC model provided by IIASA have been taken. These models outline the annual growth potential in forest (G4M) and agriculture (EPIC) on a global scale with a spatial resolution below 0.5°. Aggregated to the 2.5° spatial resolution of the TASES model these results have been taken as constraint for the bioenergy processes considered in the power sector in the TASES model. Temporal and spatial pattern on solar and wind potentials on a global scale have been derived from the NASA CERES database. This database provides 3 hourly irradiation and daily averaged wind speed data for the complete globe in a 1° spatial resolution. These data have been taken directly as input for the TASES model and replaced the old roughly modelled datasets on solar and wind potentials which have been used before.

The spatially relevant impacts are applied in the model approach to identify optimal locations for solar PV, wind power and biomass plant installations as part of the entire energy system in order to match best the electricity demand. The approach has been applied in a scenario comprising the entire globe in order to figure out possible correlations among different supply and demand locations connected via a grid infrastructure. The scenario in Figure 10 can be interpreted as snap shot for an optimal system setup in 2020 if it would be build up from scratch. It shows where PV, wind power and biomass plant installations would be optimally located in order to keep energy harvests high and transmission losses low. The related transmission line capacity needed to transfer electricity from identified optimal renewable energy plant locations to demand hot spots would sum up to 1175 TW*km.

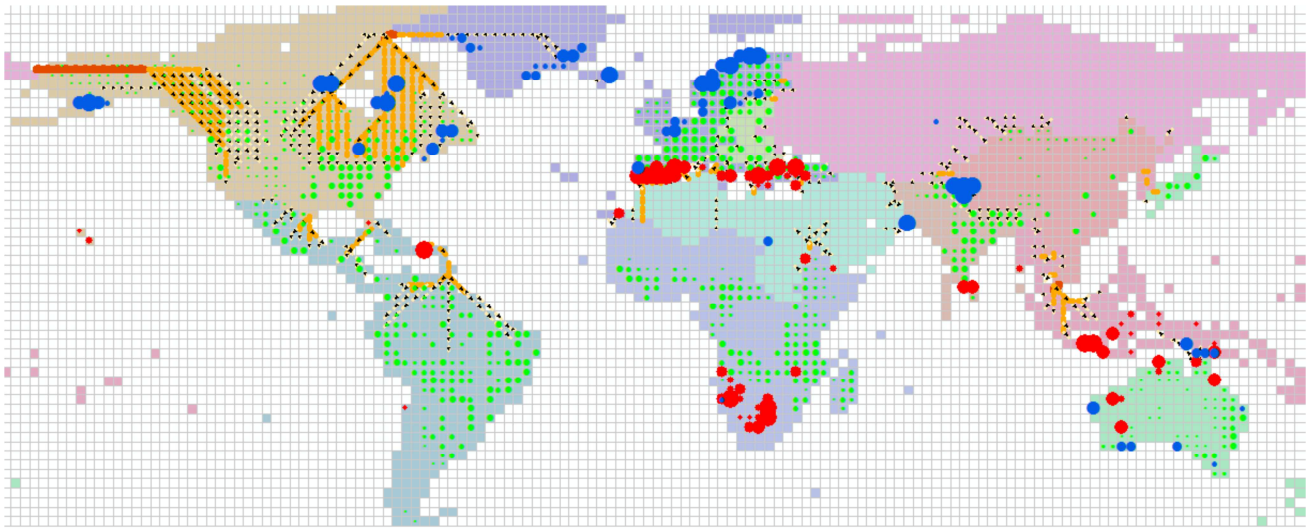


Figure 10. Global TASES scenario with visualized optimal locations for wind turbine, PV and biomass plant installations in 2020.

1.3.4 Air quality modelling for improved assessment of energy scenarios

Fossil fuels are the most important source for energy currently used in society. The impact of the exploitation of fossil fuels on the environment and ecosystems are many. The use of fossil fuels, mainly through combustion, causes a vast amount of air pollutants emitted into the atmosphere. These pollutants include CO_2, CO, carbonaceous particles, NO_x, SO_x, dioxins and mercury. These emissions alter the composition of the natural atmosphere and have an impact on different scales. For example, poor air quality through particulate matter and ozone is associated with negative health effects, greenhouse gases and particles impact the climate system and nitrogen and sulfur oxides are associated with acidification and eutrophication of ecosystems. The significant health and economic rewards of abating air pollution are becoming increasingly evident. A shift away from fossil fuels to renewable energy sources may have substantial benefits for air quality.

Chemistry transport models (CTM's) provide a deterministic method to relate emissions to atmospheric levels of air pollutants. CTMs are now widely being used for designing and evaluation of mitigation strategies. In fact, the relation between emission and impact as calculated with a CTM is the core of the GAINS integrated assessment model used in EnerGEO. To provide high quality assessments of the environmental impact of renewable energy it is very important that fossil fuel combustion emissions and the relation between emissions and their effects is correct, and that all pathways for impacts of renewable energy use are incorporated. In the fossil fuel pilot these points were addressed for particulate matter, ozone and mercury.

Assessment of the impact of fossil fuel use on particulate matter

Chemistry Transport Models (CTMs) are a useful tool to assess air pollution. For LOTOS-EUROS, a regional CTM, a dedicated module was developed to be able to track air pollutants from the source to the receptor region by 'labelling' each nitrogen, sulfur and carbon atom with its origin. This enables chemically consistent source apportionment studies that before were not feasible because of high computational demand. The source apportionment module provides many opportunities, e.g. for the assessment of impacts from the current situation as well as the consequences of a large change in the energy system.

LOTOS-EUROS with its source apportionment module was used to establish the contribution of fuels on particulate matter (PM) concentrations in Europe for the period 2007-2009. Fuel use explains about 40% and 55% of the modeled PM_{10} and $PM_{2.5}$ concentrations, illustrating the importance of combustion emissions for PM concentrations. Diesel and coal are the most important fuel sources of PM. Coal and heavy fuel oil (mainly used in sea ships) are important sources of sulphate, whereas diesel contributes about 40% of nitrate and 65% of EC in western Europe. Although LOTOS-EUROS misses up to half of the measured PM mass across Europe, the model with its source apportionment tool is useful to study the relative contribution of a wide range of emission sources.

Another approach to gain information on the sources of air pollution is positive matrix factorisation (PMF), which is based on measured PM concentrations. A multi-site, multi period source apportionment of PM_{10} mass concentrations has been carried out using the Positive Matrix Factorisation receptor model using data from the Netherlands, Belgium and Germany. Analysis of the data with a PMF model yielded seven distinguishable factors contributing to the PM concentration. One of these factors, contributing about 5% of the total PM concentration in north-western Europe, was identified as originating from heavy fuel oil combustion (shipping and refineries). This factor is characterized by high shares of vanadium and nickel, although the factor mass is determined by nitrate, sulphate and unaccounted rest. A substantial negative west-east concentration gradient of the concentrations from this factor points to sources close to the sea.

The heavy fuel oil factor contributions and its chemical compounds were compared with concentrations of heavy fuel oil combustion modelled by LOTOS-Euros. The comparison of the modelled labelled concentrations and concentrations assigned to the V-Ni factor in the PMF showed a correlation for some PM substances that can be tracked to emissions during heavy fuel oil combustion (sulphate and especially total carbon). For the other components present in the PMF profile weaker (nitrate) or no (ammonium) correlation was found.

Although quantitative agreement between the LOTOS-EUROS and PMF results was not found for most components and comparison between CTM and PMF results is challenging, qualitatively the results agreed quite well both for total PM and for the heavy fuel oil combustion factor. This increases the confidence in the quality of source apportionment results produced with LE using the labelling module.

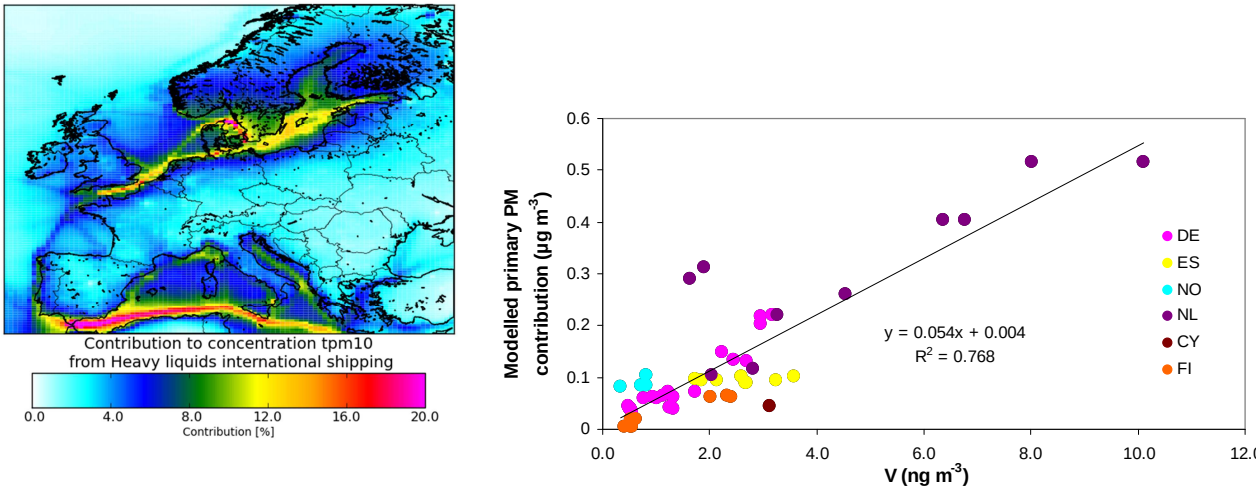


Figure 11. Left: Modelled contribution of heavy fuel oil combustion to PM10 concentrations in Europe. Right: Comparison of modeled primary contribution of heavy fuel oil combustion and measurements of Vanadium in PM10. The slope of the regression closely represents the 2% Vanadium content in primary PM emissions.

Assessment of the impact of fossil fuel use on mercury concentrations and deposition

Next to particulate matter, the focus in this part of the fossil fuel pilot was on mercury because of its negative impacts on wildlife, ecosystems and particularly human health. Anthropogenic emissions of (reactive) mercury in Europe come mainly from coal burning. As measurement data of mercury concentration and deposition are limited, dispersion modeling has an important role in mercury monitoring. A mercury model was developed in the Polyphemus system and used to model mercury concentration and deposition across Europe. Because of the properties and behaviour of reactive mercury in the atmosphere it is present in high concentrations/depositions near emission sources. Because elemental mercury shows less spatial variation, reactive Hg is a more relevant indicator of coal combustion. Mercury modelling is complex due to the many reactions in the solid, gaseous and liquid state the different forms of mercury can participate in. On top of that, emission data are still quite uncertain. Several simulations of atmospheric dispersion of mercury were done over Europe and Poland using different emission databases. In one of the model runs new bottom up emission factors for mercury emissions from the power sector were used. The databases used in this study provide more spatial and sectorial detailed mercury emissions than the commonly used EMEP database. The emission sets show differences in spatial distribution as well as in absolute emission values. The bottom up study yielded much higher emission factors for (brown) coal than the top-down inventories. Splitting the total mercury emissions into sectors is important as the fractions of elemental, particulate and reactive mercury depend on the source sector. Over some parts of Europe (particularly in regions where coal is burnt) up to 90% of the Hg^{II} and Hg_P concentration and deposition originates from the power sector. This should be taken into account when developing mercury reduction strategies or when considering the location of new power plants.

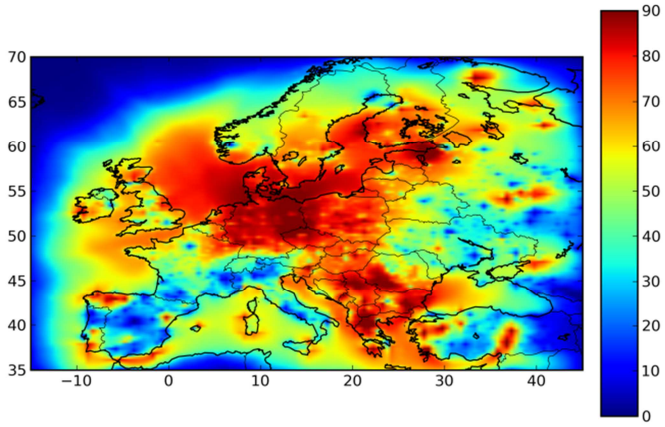


Figure 12. Relative contribution (%) of emissions from the power sector to the total concentration of particulate mercury across Europe.

Assessing the importance of changes in land use and emission timing for air quality

Large-scale transitions towards renewable energies are at first sight expected to be purely beneficial for the environment because they lead to a reduction of emissions of greenhouse gases and air pollutants. However, some effects might also be detrimental and are so far not regularly taken into account when an assessment of an energy scenario is made. Two examples that were investigated in this pilot are the distribution of emissions over time and emissions due to land use change.

The CTM LOTOS-EUROS, equipped with a source apportionment tool, was used to model the effects of a change in the electricity production system on air quality and source receptor matrices. For this purpose, two emission scenarios were developed in which solar and wind energy fulfil 25% of total electricity demand. In these scenarios, the annual total emissions from the power sector are reduced and the way the emissions are divided over the year is changed. Part of the reduction of air pollution because of lower emissions is cancelled out by the timing effects. The variability in the emissions will change as function of season, synoptic time scale, as well as time of day. Therefore, a correct representation of emission timing is important and deserves more attention than it has been given so far. The changes in source-receptor relations observed in this relatively simple experiment are a clear indicator that linear source-receptor relations do not hold if the emission quantity or conditions are changed to a large extent. Therefore the EnerGEO scenarios presented below were calculated using both constant and variable REMIX-based emission time profiles.

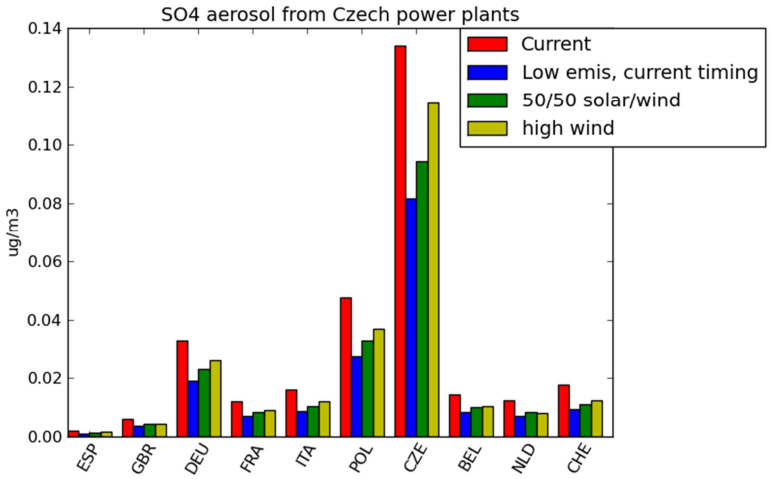


Figure 13. Modelled contribution of Czech power plants to sulfate levels in several countries for the current situation (red), for a situation with 25 % renewable energies without accounting for a change in emission timing (blue) and for a situation with 25 % renewable energies including the effect of changing time profiles under high shares of wind energy (light green) or comparable wind and solar energy (dark

green). Accounting for changing use of the backup power yields higher concentrations per unit emission than the current situation.

The sensitivity of source receptor matrices to LOTOS-EUROS model resolution was tested as well. Grid resolution can have a large influence on modelled distribution close to source areas. On a high resolution the model predicts larger contributions (up to a factor 1.8) of a country's emission to the concentrations in its own territory compared to a low resolution. For small countries this difference between 56 and 14 km cells can be up to a factor 1.8, for large countries this effect is much smaller. The impact of both small and large countries on other (neighbouring) countries becomes smaller with increasing model resolution. The impact of resolution on SRMs depends on the life time of the component and the primary or secondary nature of the components. The effects that were observed can be explained by the fact that a model run on a higher resolution has a much sharper representation of country borders.

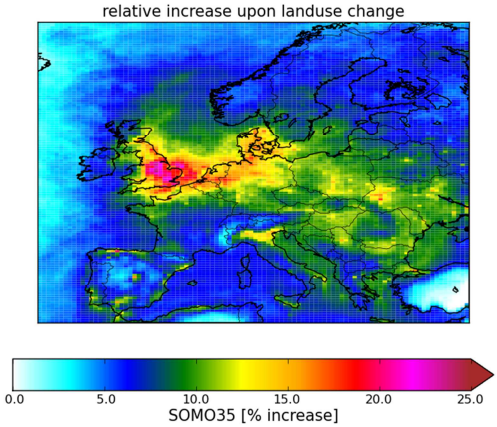


Figure 14. Relative increase of SOMO35 as a consequence of a change of 5% of agricultural area to poplar plantation across Europe.

Biomass is often regarded as a suitable fuel source to replace fossil-based energy. However, to produce biomass on a large scale, land use changes will occur. This may have consequences for air quality as tree types that are in general considered for biomass plantations, fast growing species such as poplar and willow, often have a high isoprene emission rate. Isoprene is an ozone precursor. A scenario in which 5% of the agricultural area in Europe was transformed to poplar plantations was investigated. In this scenario, isoprene emissions increase with 45% compared to the current situation. This causes an increase in ozone values, especially during peak episodes, which has a detrimental effect on ecosystems, crop production and human health. To counteract the increase of the health relevant ozone indicator SOMO35, a NOx emission reduction of 50% is needed in some areas in Europe. Hence, although the introduction of renewables and avoided fossil fuel combustion is expected to have a large positive impact on air quality in Europe, also a few counteracting impacts are expected. Based on these results we recommend to include land use changes and subsequent emission changes explicitly into the integrated assessment tools such as GAINS.
These examples show before large-scale transitions towards renewables are effectuated, expected air quality changes should be carefully studied in all their aspects. Global as well as regional CTMs are indispensable in the study of scenarios representing transitions towards renewable energies.

1.3.5 Integrated impact assessment

Building a modelling framework that incorporates the potential maps into energy models and subsequently integrated impact assessment models
Ener*GEO* uses scenario analysis to assess the impact of energy use on the environment by bringing together and linking leading energy system models with ecosystem, land-use and atmospheric models. For this purpose scenario definitions were harmonized among the different models including electricity production, final demand, as well as on electricity export and import balance up to 2050 for the Baseline and Low Carbon scenarios.

Figure 15 shows a schematic representation of the modelling framework that is developed within EnerGEO. Models calculating energy potentials for solar, wind and biomass provide information to energy and integrated assessment models assessing the environmental impacts. Via damage functions and life cycle assessments, the total impacts (on the environment, climate and health) can be assessed. This modelling framework is established for the global (using energy model TASES and integrated assessment model MESSAGE) and the European case, in which REMIX and GAINS are applied. Note that not all novel potential maps have been included in the energy system models within the project as work was performed in parallel and in some occasions the pilots on potentials did not have the same spatial scope as the energy models.
Building the framework also means that some individual models are improved or extended. For example, the GAINS model was extended to include impacts from mercury emissions. For this purpose, mercury emission sources (other than fuel combustion), emission factors per mercury compound, efficiency of control measures, etc. were implemented within the GAINS model framework.

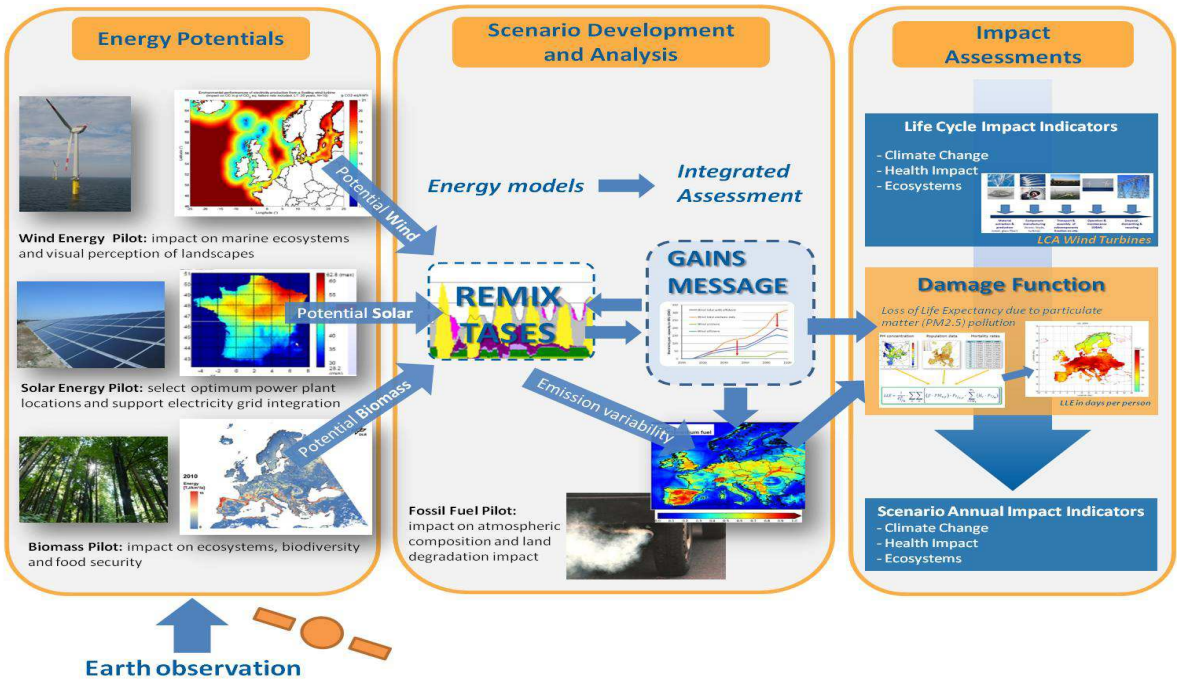


Figure 15. Schematic of modelling framework developed within EnerGEO. The model names refer to the European domain.

Assessment of European energy scenarios
Three low carbon scenarios were developed to illustrate the assessment capacity developed within EnerGEO. In a first stage, the effects of different structures of power generation for three low carbon energy pathways, referred as CLE scenarios (Current Legislation), has been elaborated:

1. "Open Europe", which assumes import of solar power from North Africa, high renewable energy share in electricity generation, and phase-out of nuclear energy.
2. "Island Europe", which allows a high share of power generation from renewable sources but no imports from outside Europe; missing electricity can be generated by nuclear plants.
3. "Maximum Renewable Power", which assumes the highest possible electricity generation from renewable sources.

At a second stage, EnerGEO project established a new set of scenarios which differ not only with the assumptions about the level and structure of energy demand, but also take into account the effects of different sets of measures to control air emissions (emission and fuel quality standards). Three packages of control measures have been analysed resulting in a new set of scenarios:

- The "Current Legislation" (CLE) case assumes for each country a successful enforcement of current air pollution control legislation (international and national emission limit values as well as fuel quality and product standards).

- The “Fixed Emission Factors” (FEF) scenario simulates effects of freezing the emission factors for each source at the level of the reference year (2005).
- The “Maximum Technically Feasible Reductions” (MTFR) scenario corresponds to scenarios where emissions are reduced through implementation of the best available technologies (BAT) for each emission source included in GAINS.

Scenarios were developed through linking the IIASA GAINS model with the DLR scenario generation tool as used in the TRANS-CSP study (Trieb et al., 2006). IIASA compiled national energy scenarios using available long-term projections and studies. In the next step, electricity demand, as in IIASA scenarios, was used by DLR to determine the structure of power generation by country and integrating renewable energy potentials, following assumptions of each scenario (compare Trieb et al., 2012). Finally, demand for primary energy consistent with the DLR scenarios was implemented in GAINS.
Analysis was done with the IIASA “Greenhouse Gas and Air Pollution Interactions and Synergies” GAINS model. GAINS provides a consistent framework for identification of co-benefits of strategies aimed at reduction of greenhouse gases for air pollution. GAINS methodology is described in Amann et al., 2011a. The model considers emissions of the following air pollutants: nitrogen oxides (NOx), sulfur dioxide (SO2), particulate matter (TSP, PM10, PM2.5, PM1, BC and OC), non-methane volatile organic compounds (NMVOC), ammonia (NH3), carbon monoxide (CO) and mercury (Hg). Greenhouse gases included are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and F-gases. GAINS addresses health and ecosystem impacts of particulate pollution, acidification, eutrophication and tropospheric ozone. Simultaneously, the model considers greenhouse gases (GHG) emission rates and their CO2 equivalents. Historic emissions of air pollutants and GHG are estimated for each country based on information collected by available international emission inventories and on national information supplied by individual countries. GAINS assesses emissions on a time horizon up to the year 2050.
The total amount of emissions of greenhouse gases and air pollutants is assessed for the baseline scenario and the three low carbon pathways. The power capacity and the way it is met as well as the electricity generation and emissions of carbon dioxide for the three low carbon scenarios are displayed in Figure 16.

Scenarios clearly demonstrate significant co-benefits of low carbon policies in Europe for air pollution. With the Current Legislation controls, emissions of SO2 in 2050 for the low carbon scenarios are 80% lower than in 2005, which is nearly twice as much as for the Baseline case. Also reductions of NOx and Hg are higher (NOx: 70% for low carbon scenarios compared with 50% for the Baseline; Hg: 30% vs. only 6%). Power production from renewable sources can importantly contribute to the decrease of air pollution and mitigation of negative impacts of energy use on the environment. Within the next 40 years the European energy system will become much cleaner. Renewable electricity will be an important step towards achieving sustainability goals in the area of air pollution in Europe.
Scenarios also demonstrate the role of pollution control legislation on emissions of air pollutants and greenhouse gases. Implementation of the MTFR measures can importantly reduce the pollution loads, even for the Baseline energy pathway. If combined with the low carbon (Maximum Renewable Power) pathway, the 2050 emissions can be reduced by up to 90% for SO2 and NOx, 80% for PM2.5, and about 70% for Hg compared with 2005. This decrease in pollution loads causes decreasing of the YOLL (Years of Life Lost) indicator to only 15% of 2005 value. This is equivalent to saving of about 260 million years of life regarding the current European population. Ozone related deaths can be more than halved, which means about 19000 deaths per year avoided.

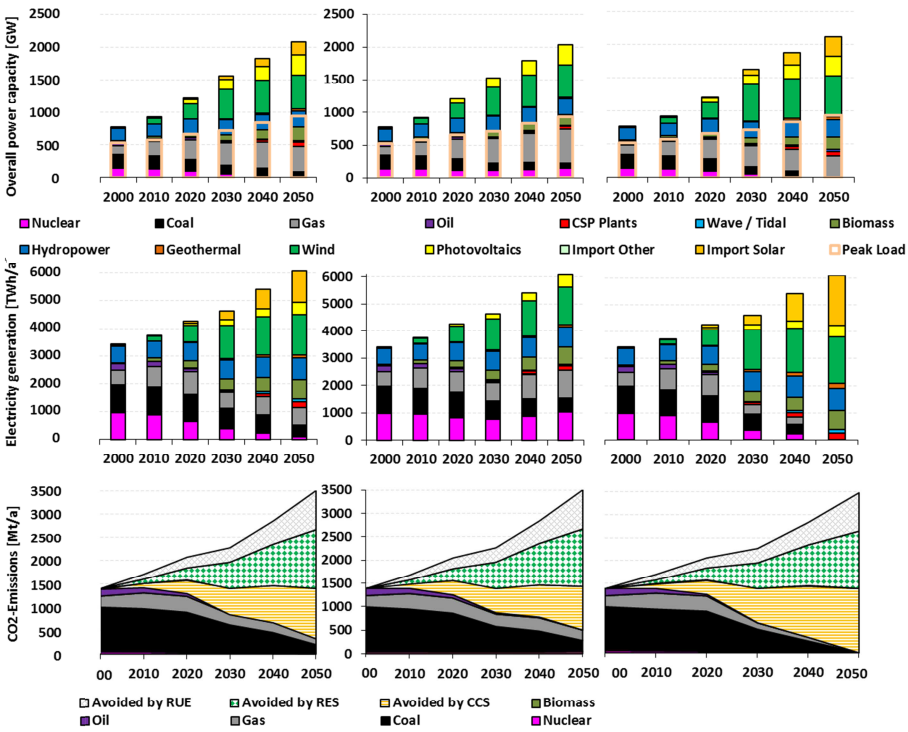


Figure 16. Power generation and CO_2 emissions for the three low carbon scenarios developed in EnerGEO. Left: Open Europe, middle: Island Europe, right: maximum renewables.

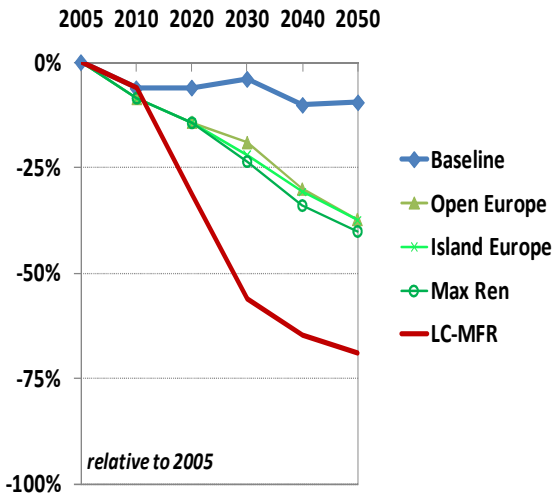


Figure 17 Evolution of total mercury emissions from electricity production for the baseline scenario and three low carbon scenarios

In turn, leaving emission factors at 2005 level, as in the Fixed Emission Factors cases, results in much higher emissions, which for the Baseline activity pathway are higher than the base year (2005) emissions.
Low carbon scenarios, if combined with controlling the emissions of air pollutants and non-CO2 greenhouse gases, importantly reduce the total emissions of climate relevant gases. European emissions of those gases for the most stringent scenario included in our study (Maximum Renewable Power energy pathway, MTFR controls), decrease from about 7.6 billion tons to only 2.2 billion tons of CO_2-eq in 2050.

With this purpose, a Platform of Integrated Assessment (PIA) has been elaborated to provide impact results for the EnerGEO scenarios. The PIA gives to the users an access to impact indicators represented as maps and tables to support the scenario analysis.
EnerGEO PIA gives an on-line access to two human health indicators: LLE from PM25 and number of deaths from ozone concentration. A new algorithm for PM2.5 related impacts on human health is also provided. This new dynamic approach takes into account the variations of the pollutants concentrations during the population lifetime which make this indicator better suited for scenario analyses. This indicator is 20% lower than GAINS indicators by 2050 for low carbon scenario.

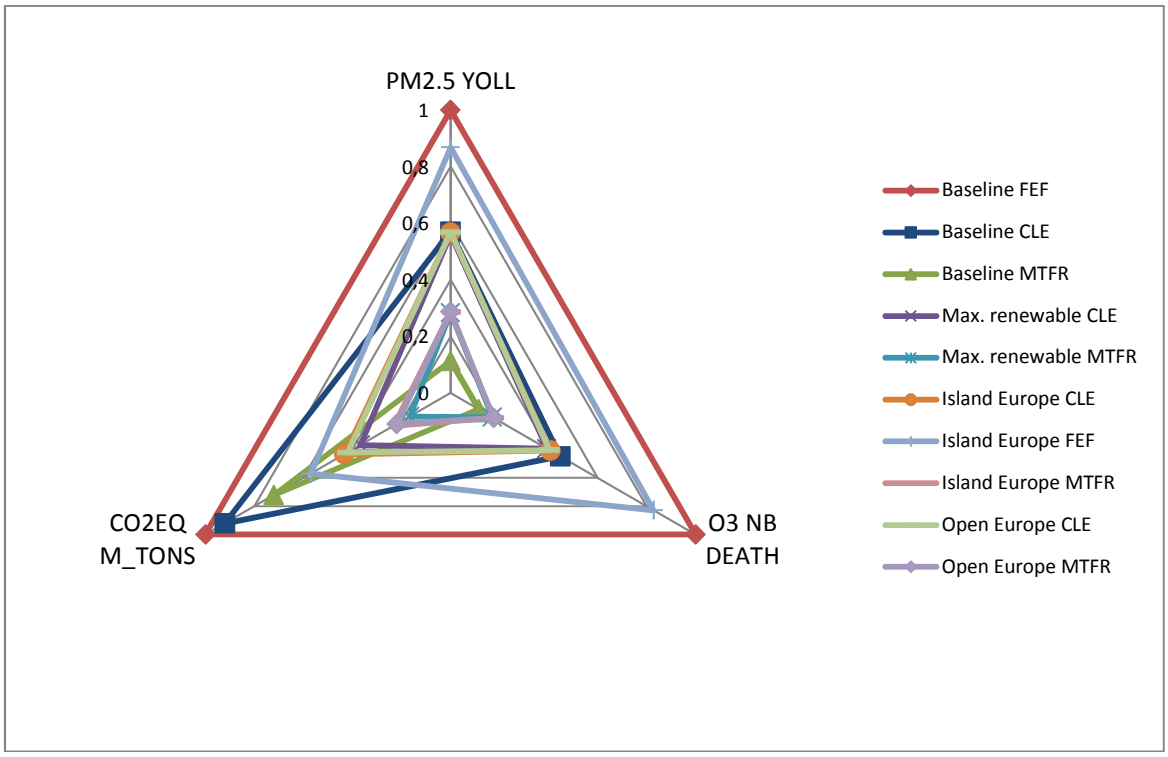


Figure 18: Comparison of the 10 EnerGEO scenarios for 3 impact indicators integrating emissions from 2005 to 2050 horizon cumulated for all European countries. All scenarios indicators are related to the Baseline FEF scenario indicators taken as the maximum reference and the minimum of each indicators less 10% taken as minimum reference.

The EnerGEO scenarios have been assessed in terms of annual electricity supply and of installed power capacity using the REMIX model. An example is given for the installed power capacity representative for Maximum Renewable scenario in Figure 19. In this case the firm capacity installed is always 125% with respect to peak load. To achieve this, a significant capacity of gas power plants is maintained even in the long-term, although electricity generation by fossil fuel is reduced to zero. This means that fossil fuel plants are strictly restricted to provide capacity for reserve and emergency. The import of solar electricity from North Africa and also the use of variable renewable sources in Europe require a significant expansion of the European electricity grid in order to cope with the electricity flows between countries. However, the well-balanced mix of volatile and flexible sources allows for a minimum expansion of grid capacity and pump storage. These results demonstrate the capability to provide a translation to required back-up power capacity and grid requirements.

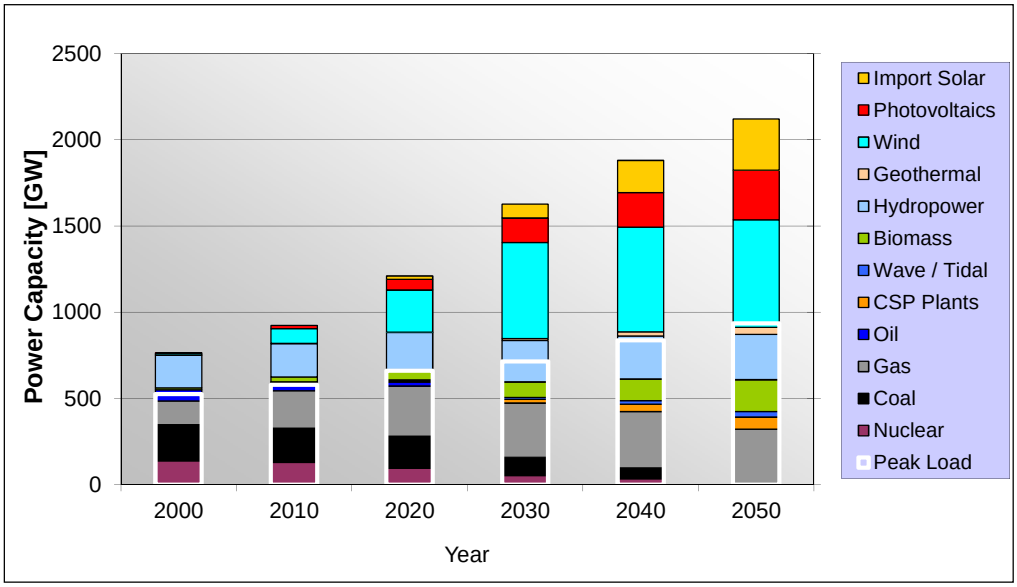


Figure 19. Installed capacity versus peak load in the Maximum Renewable scenario pathway: close to 100% renewable share, nuclear phase out, gas power capacity is maintained for backup and emergency, due to CSP imports 125% firm capacity is always available with respect to peak load.

Assessment of global energy scenarios

In parallel, comparable Baseline and Low Carbon scenarios were run by IIASA for the entire world. Details on electricity and fuel demands and production were sent to the TASES modelling team to develop a detailed implementation of the energy mix, particularly with regard to integration of intermittent renewables into electricity generation and distribution systems. Furthermore, GAINS has been extended to cope with mercury emissions from energy production. This extension is fully operational and has been applied to assess emissions for two global energy scenarios.

1.3.6 Architecture

EnerGEO portal

The GEOSS Common Infrastructure (GCI) includes four main elements: 1) the GEO Portal allowing the user to search for information and services available in GEOSS; 2) the GEOSS Clearinghouse is the element that collects search and presents the various existing GEOSS components to the users via the GEO Portal; 3) the GEOSS Component and Service Registry allowing GEOSS organizations to contribute components and services to the community; 4) the Standards Registry which enables contributors to GEOSS to configure their own systems to be compatible and interoperable with others systems.

To provide the results and datasets produced in EnerGEO in a user friendly manner, a web portal was built that is part of the GEOSS platform. A schematic of this is displayed in Figure 20. Collaborating with the GEO-ADC, a portal for metadata registration and discovery purposes, the EnerGEO Geoportal, has been successfully registered as a Community Catalogue in the GEOSS registry. The EnerGEO portal has been successfully tested regarding cataloguing process towards various Web Services standards. The Geoportal has been enhanced by developing a new web design for enhancing the user experience (Figure 21). In addition, the discovery component was improved and a recommender engine has been integrated. As a further approach for distributing the pilot inputs and results for presentation a user-centric map-viewing component, the EnerGEO Map-Viewer template has been developed and upgraded. The EnerGEO GEO-portal is now extended to the 'EnerGEO Knowledge Portal' supporting discovery, evaluation, and access to EnerGEO results. This global approach enables EnerGEO data providers to leverage their own resources visibility not only in the EnerGEO catalog but also to a larger extent toward the GEOSS user community.

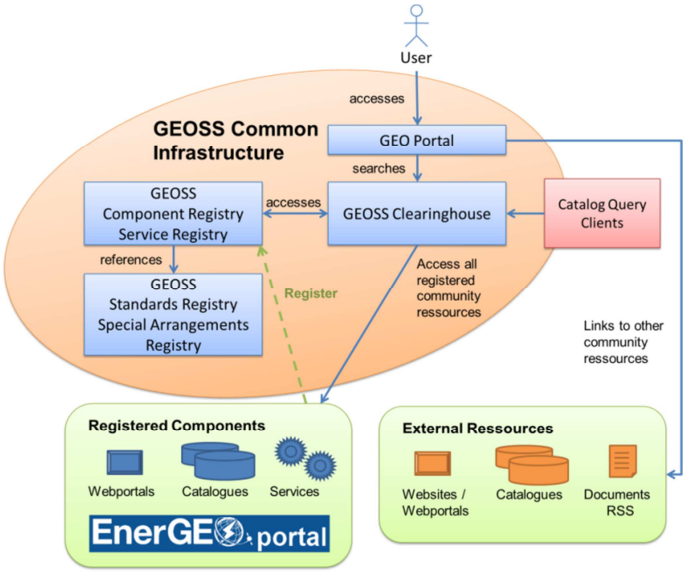


Figure 20. EnerGEO Portal Architecture linked to GEOSS Common Infrastructure (GCI)

Two main functionalities from the EnerGEO platform are:
1. Ensuring a complete and coherence discovery of any resources that has been recorded by data provider in the metadata.
2. Providing a seamless propagation of metadata from the original records in the EnerGEO catalog up to the GEO Portal response to a query.

The EnerGEO platform allows the EnerGEO data provider and the EnerGEO platform user to perform the following actions:

EnerGEO data provider:

- Management of a pool of metadata in a dedicated section based on authentication
- Edition of metadata describing a geo-localized resources

EnerGEO platform user:

- Provide the “search and discovery” of resources through simple or advance search function as well as from content type and/or category browsing
- Provide portrayal option from compatible resources such as OGC WMS, WFS
- Provide download capacity if relevant from the metadata resource description

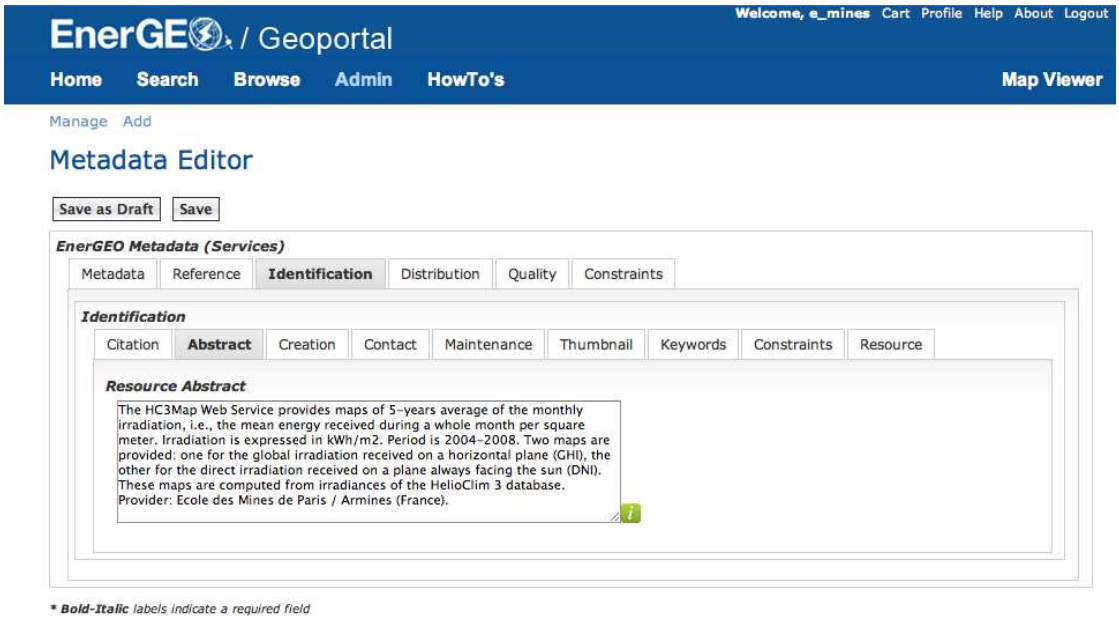


Figure 21: EnerGEO Portal restricted admin metadata on-line edition

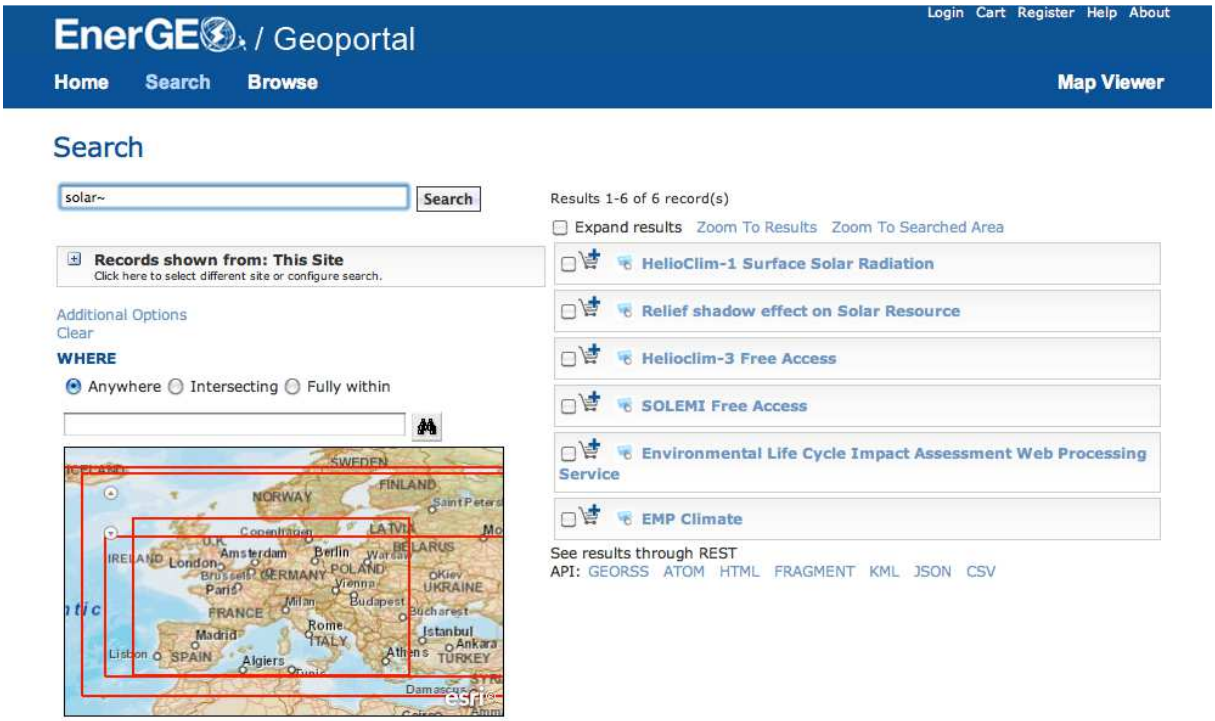


Figure 22. EnerGEO Portal simple search for "solar" results

Architecture implementation pilots (AIPs)

MINES ParisTech is lead of the GEOSS AIP-4 (Architecture Implementation Pilot Phase 4) energy scenario that include components developed in the EnerGEO project. This scenario aimed at giving an easy access to the HeliocClim 1 database from MINES ParisTech containing 21 years of solar radiation available at ground level. Those data derived from the Meteosat satellite cover Europe, Africa and Middle East. This scenario has demonstrated the usefulness of the EnerGEO OGC (Open Geospatial Consortium) CSW (Catalogue Service for the Web) catalogue (http://energeo.researchstudio.at) for disseminating the content of the HelioClim 1

solar radiation database made available as OGC Web Processing Service (WPS). The AIP-4 engineering reports as well as a 5 minutes video about the energy scenario are available at:
http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP4/index.html
EnerGEO contributed to the AIP-5 activity by the establishment of a land use / land cover database for Pakistan (see above).

1.3.7 Monitoring of energy use and transition on atmospheric composition and land degradation

Earth observations provide a host of data for monitoring the impact of energy use. In the fossil fuel pilot research was concentrated on detecting trends in three impact parameters: emissions and concentrations of CO, emissions and concentrations of NOx, and land subsidence by mining activities.
Consistent time series of remotely sensed trace gas levels may provide a useful tool to estimate surface emissions. We used the OMI-NO2 product in conjunction with the LOTOS-EUROS CTM to estimate European emission trends through correction of the OMI-time series for meteorological variability as well as through assimilation using an EnKF-system. The chemistry transport model captures a large fraction of the variability in NO_2 columns at a synoptic timescale, although a seasonal signal in the bias between the modelled and retrieved column data remains. Significant negative trends of 5-6 $\%a^{-1}$ were found in highly industrialized areas across Western Europe. It was established that the trends based on the V2 product are systematically lower obtained using V1. To facilitate the interpretation a source apportionment simulation was performed to evaluate the sensitivity of the Ozone Monitoring Instrument (OMI) to NOx emission sources across Europe. The most important contribution (~35 %) in western Europe is made by road transport. Off-road transport and industrial combustion each contribute 10-15 % across continental Europe. In eastern Europe power plants contributions are of comparable magnitude as road those of transport. Comparison between the trends derived for all methods show lower changes per year than officially reported emissions for European countries. Trends derived from in–situ concentration data also indicate lower trends than those in emissions.

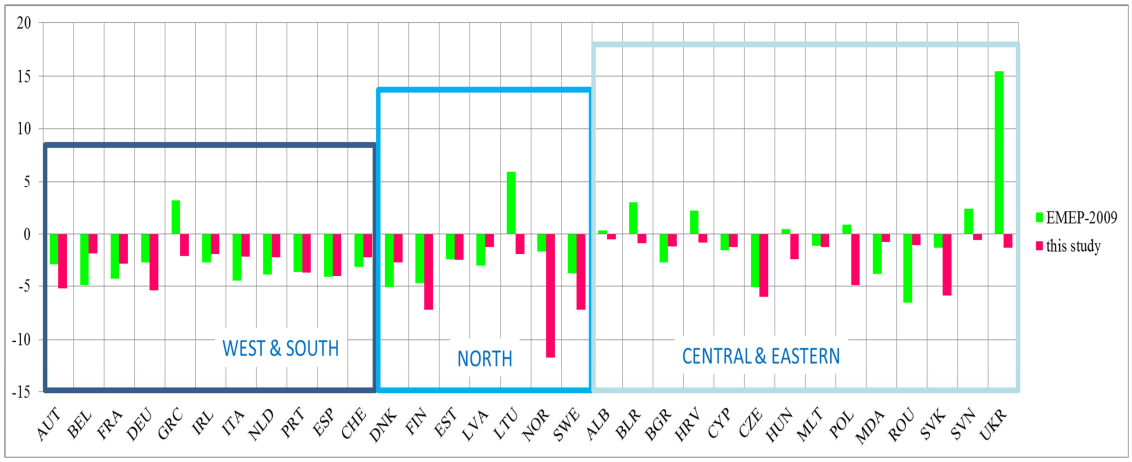


Figure 23. Comparison of satellite derived NO2 trends compared to reported emission trends (EMEP-2009) for the period 2005-2009.

Carbon monoxide (CO) is a long lived global pollutant that derives from fossil fuel combustion. We aimed to investigate the use of data from recent satellite sensors for measuring atmospheric carbon monoxide (CO). In the future, such sensors may contribute to the monitoring of carbon dioxide (CO2) emission. It is possible to measure CO2 directly from space, however, because of the large natural variability of CO2 it is difficult to relate those measurements directly to fossil fuel use. A promising option is to combine measurements from CO and CO2.
We have applied Empirical Orthogonal Function (EOF) analysis to 10 years of monthly averaged MOPITT CO measurements from 2002 to 2011. Decompositions were carried out for total column CO as well as separate contributions to the column from the lower and upper troposphere. The spatial patterns and the corresponding time variations related to the influence of the Seasonal Cycle and the El Nino Southern

Oscillation (ENSO) on the CO field could be extracted from the data without using any a priori assumptions about these effects or about their evolution in time. This is an important advantage of the EOF method in comparison, for example, with the more commonly used Linear Regression. MOPITT data representative of the lower troposphere show a slightly downward trend (about 1.5 ppb/yr on average), in agreement with NOAA flask data, whereas no significant trend is found for the total column. The difference is explained by the tropical upper troposphere (roughly between 40°S and 25°N), which shows an upward trend in concentrations. After correcting for a drift in the data an upward trend of about 1 to 1.5 ppb/yr remains, which is in agreement with a trend analysis of MOZAIC data at 200 hPa. The cause of this positive trend remains unclear. It is not found in the equivalent output of the CTM TM5, although the modeled output does show a positive CO trend of about 0.5 ppb/yr at 50 hPa, which coincides with a positive trend in modeled OH concentrations.

Land degradation
The analysis of negative impact of coal exploitation on the environment was performed for three selected mining sites. One of the selected coal mine, “Prosper-Haniel”, is located in the West Germany in the Ruhra region and two coal mines, “Kazimierz-Juliusz” and “Sobieski”, are located in the South Poland within the Upper Silesian Coal Basin. Land cover change and land subsidence due to coal mining activities were assessed at two locations using Landsat satellite data. Based on the obtained results of qualitative and quantitative analysis it can be stated, that the mining activities in the area of *Prosper-Haniel* coal mine does not influence the land coverage types. The performed analysis of ground deformations within “Kazimierz-Juliusz” and “Sobieski” coal mines revealed the subsidence phenomenon for these regions. The location of subsidence areas are strongly correlated with the location of exploitation fields. Using satellite images acquired from ENVISAT and ERS-2 satellites the values of deformations can be only determined for small temporal baseline. In case of large temporal baselines only global tendencies of subsidence can be revealed. In order to improve obtained results more accurate radar data can be used.

1.3.8 Future directions

Although major steps forward were made, important open research areas remain which were identified through a partner consultation. Below, we summarize the main topics.

1. Resource assessment and optimal siting
To develop a strategy for renewable energy it is important to assess the theoretic, technical and economic potential for the available resources in the region of investigation. Further improvement of potential assessments differentiated to different technologies for solar, wind and biomass are highly needed as these are considered the most important sources for renewable energy. Besides, additional resources, e.g. marine (tide, salt water) and geothermal, should be investigated so that they can be included in the energy system modeling. As these potentials are highly dependent on local variables, these potential maps should be made spatially explicit. For this purpose, GEOSS capabilities are crucial. Coupled to life cycle assessment optimal siting applications should be developed to assist evidence-based decisions both for planning at a specific area and promotion of a specific technology.
Specific topics to be addressed are the impact of air pollution and desert dust on solar power energy production, forecast ability, impact of environmental conditions on maintenance and down time, integration of LCA techniques into optimal siting applications for biomass and biofuel production.

2. Integrated assessment systems for policy support
As large investments in energy infrastructure will be made in coming decades, efficiency evaluation of the investments is important. EnerGEO focused on electricity production in the power sector. As electricity or fuel use concerns all sectors, expansion of the assessment to all sectors is advised. Such a step requires expertise on energy scenario building as to incorporate further electrification and the introduction of biofuels in the transport sector. Further attention is needed to energy system modelling to determine optimal energy mix, depending on potentials, technologies, infrastructure and political choices. These models also quantify fossil fuel back-up capacity and usage. EnerGEO has shown that increased detail in back up fossil fuel use is needed to assess impacts during the energy transition and monitor the progress of international policies.

There is a need for tools that focus on regional to national impacts but that also consider the global context and indirect impacts outside the focus region and that supply relevant information to policy makers at national and international level.

3. Impact indicators

Impact indicators or impact routes currently assessed in life cycle analysis or integrated assessment models, e.g. GAINS, are aimed at assessing fossil fuel related impacts. Hence, specific impacts related to renewables are not incorporated yet. These include noise pollution and biodiversity impacts from on-shore wind, (indirect) land use change impacts, resource availability, food security (crop competition). New impact indicators and methodologies should be developed to incorporate these impacts into the integrated assessment. As transport, transformation and exposure are regionally different impact factors could be made continent or region specific. Integrated assessment tools need to be expanded by the impact indicators and associated source receptor relations need to be developed. Existing impact indicators that should be given more attention are particulate matter health effects and climate change impacts of short lived climate forcers.

4. The impact of GEOSS data core

A host of new earth observations products are becoming available through GEOSS. EnerGEO has already demonstrated the increased and beneficial use of GEO data sets. Further integration of earth observation into the assessment framework is necessary to improve evidence based geo localized decisions. Improved interpretation of earth observation data enables to monitoring the impact of the global/regional related policies. There are two challenges: the larger one is data integration. A lot of data is available or will soon be available. The problem is that people don't know about the data and that tools are not ready to incorporate it. The second notion is that there are still crucial variables needed for a better assessment that have not been measured/recorded but should be included in sensors and campaigns in the future.

5. Capacity building and information accessibility

EnerGEO has built a knowledge portal that functions as the portal for energy and human impacts assessment SBA. Continuation of the portal and bringing additional related activities under its umbrella will strengthen the use of the GEOSS data. Specific attention needs to be remain compliant with the GEO ADC recommendations. An important additional question is whether the right stakeholders have been addressed so far. Is there a need to include other groups of people that have not been involved in current projects? Is it fully understood what kind of people are crucial for the implementation of the energy transition. What are effective tools for those stakeholders? Another issue I find relevant: data accessibility: where are really the constraints when it comes to assessment of impacts but also the implementation of measures and what are practical solutions to it? Is it knowledge, physical constraints?

EnerGEO has held summer schools designed to facilitate dialogue between policy-makers and researchers, to stimulate new thinking on energy planning, and taking different development pathways into account. These broader developmental goals, and the encouragement of new approaches to energy planning, are a key feature of the EnerGEO project. With its focus on shared data, and a common infrastructure of observational systems, the EnerGEO project facilitated new approaches to energy planning that will help provide answers to these challenges. The summer schools envisaged to build new networks. A follow up should broaden these capacity building activities to other stakeholders. However, the newly formed network should be maintained and a dedicated Africa – EU collaboration activity contributing to AfriGEOSS and The Bioenergy Atlas for Africa may have a large societal impact.

1.4 Potential impact and main dissemination activities and exploitation results

1.4.1 GEO

The EnerGEO distributed system for the interactive, semi-real time, monitoring and forecasting of the impact of the use of energy resources on the environment and ecosystems supports the objectives of the GEO work plan. EnerGEO provides the European contribution to the Energy Social Benefit Area (SBA). The activities of the social benefit area Energy in the 2009-2011 work plan have been divided among two tasks in the new 2012-2015 work plan:

- EN-01 Energy and Geo-Resources Management
- SB-05 Impact Assessment of Human Activities

Energy related strategic targets for these SBA's of GEO are:

EN01:

- Significant increase in use of Earth observations by all sectors (biomass, fossils, geothermal, hydropower, nuclear, ocean, solar and wind) for improved:
    - Prediction of potential hazards to the energy infrastructure;
    - Prediction of the production of intermittent sources of energy; and
    - Mapping of renewable energy potential.
- Improved energy management, including balance between energy demand and supply as well as development of alternative energy scenarios.
- Safe, efficient and affordable development and operation of existing and new energy resources, with emphasis on minimizing environmental and societal impact while moving towards a low-carbon footprint.
- Advancement of the application of data, systems and tools.

SB05:

- Significant increase in use of Earth observations by all sectors (biomass, fossils, geothermal, hydropower, nuclear, ocean, solar and wind) for improved environmental, economic and societal impact assessments of energy exploration, extraction, conversion, transportation and consumption.

The priority actions to which the EnerGEO project strongly contributed, are:

EN-01:

- Develop products and services required to assess countries' potential for energy production. Foster the use of Earth observation and information in energy-policy planning
- Develop a Bio-Energy Atlas for Africa to provide information on the quantity, distribution, usage, and quality of biomass.
- Encourage training of decision-makers at all relevant levels for interpreting relevant data and products.

SB-05:

- Develop a modelling platform that will enable planners and governments to forecast and monitor the environmental impact of changes in the energy mix
- Integrate Earth observation data with state-of-the-art modeling tools to calculate socio-economic impacts and environmental costs
- Develop new tools for impact monitoring of mining operations using Earth observations
- Integrate information from in-situ, airborne and satellite observation (through data assimilation) to provide impact diagnostics
- Integrate often sectoral monitoring approaches (and corresponding impact analysis) into a coherent approach, based on innovative Earth observation techniques (related to space-borne, airborne and ground-based sensor systems)

The development of the EnerGEO assessment and analysis system needs to be of open access. The full integration into the global GEO Portal required the compatibility with the standards of the GEO-Architecture and Data Committee (ADC) to facilitate global collection and dissemination of data related to the impact of energy use on the environment. The EnerGEO Portal containing data and model outputs is now available through the GEO-Portal.

The dissemination and outreach activities of WP6 (see above under 1.1) were specifically designed to achieve awareness and societal impact. The networking activities, especially concerning the outcomes of the stakeholder meetings, addressed the future community of practice (CoP). Through the CoP engineers and practitioners are informed about the EnerGEO portal and are invited to fill it with own data, services and best practice examples. For the concept and implementation of GEOSS, several key issues were addressed: data quality reporting, redundancy and gap filling, standardization, and characterizing flows of data and information. Key representatives from industry, academia, and government were invited for demonstrations of recent and future possibilities within and beyond GEOSS.
The demonstration activities aimed to (i) improve our understanding of basic Earth processes that are at work in each societal benefit area, (ii) optimize the use of GEOSS observations, (iii) ensure the transition from research to operational systems, and (iv) generate new applications in existing and emerging fields. EnerGEO provides linkages to major scientific research institutions in each societal benefit area, and ensures that relevant scientific and technical experts are involved and contributing to GEOSS in a participatory way (e.g. summer schools, workshops, and the EnerGEO Knowledge Portal)

1.4.2 Awareness

Global energy consumption has grown considerably over the last decades and is anticipated to grow further in the future, at considerable cost to the environment. To date, a large share of the energy used originates from fossil fuels. To reduce the impact of energy use on climate, the European Commission has set goals to increase the share of renewable energies in Europe to 20% by 2020. According to the Roadmap towards a low carbon economy in 2050 in Europe, emissions from the power sector should be reduced by 54 – 68% in 2030 and 93 – 99% in 2050. To accomplish this energy transition is one of the major societal challenges in Europe of the 21st century.

Worldwide more than 1.5 billion people have no access to modern energy sources, of which most live in Africa. Providing access to these people through exploiting renewable energy resources may significantly improve living conditions and spark economic growth. Many developing countries may strengthen their economies further based on their renewable energy resources. These countries may reduce their dependency on fossil fuel imports. Hence, many less developed countries battle to provide a very basic energy supply to their citizens while eroding their natural resource base at a tremendous pace, and lack the observational means to monitor the impact and the tools to effectively plan. Hence, joint initiatives are needed to build capacity in these countries.

Awareness about the use of alternative energy resources, the options for a transition from traditional to innovative means for energy supply and possible development agendas taking climate change issues into account, has to be addressed at a broad scale. EnerGEO used standard measures (e.g. website, newsletter, factsheets) as well as specific means (e.g. videos, non-scientific publication) to address the broad audience to be targeted. The target audience ranged from the energy researcher, engineers, to policy makers and the interested lay-person.

The different means to address awareness and the target audience were:

Website
www.energeo-project.eu

Means: Information on all related issues of the project.

Target audience: full range

Newsletter
Vol. 1 to 6
Access via website or mailing list

Means: information on specific work packages, introduction of partners, announcement of events, reports about past events

Target audience: full range via website (pull), targeted recipients (mailing list)

Conferences
Title and number of conferences attended are recorded in the networking records of the project

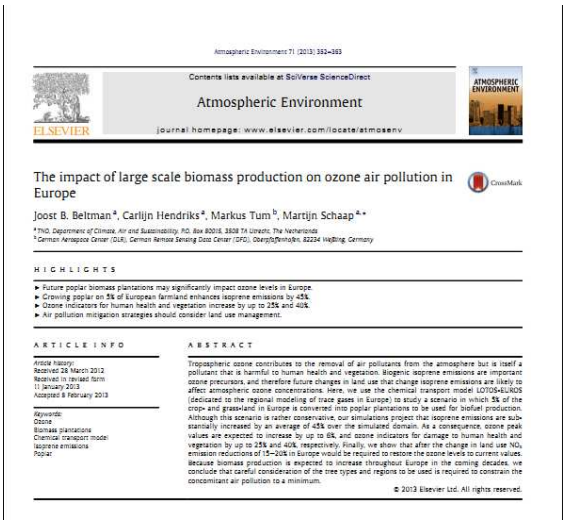
Means: paper presentations, special sessions, booth

Target audience: scientific community, engineers, thematic networks – in Europe, Asia, Africa.

Publications
Scientific dissemination and exploitation through writing and submission of journal publications has resulted in 31 peer reviewed publications. This number is expected to grow as the process is still on-going as evidenced by the number of submitted and planned manuscripts
For a full list of publications refer to the publication record of the project.

Means: peer reviewed scientific publications, popular science reports (at research media)

Target audience: scientific community, general public, policy makers



Videos
4 videos accessible via website

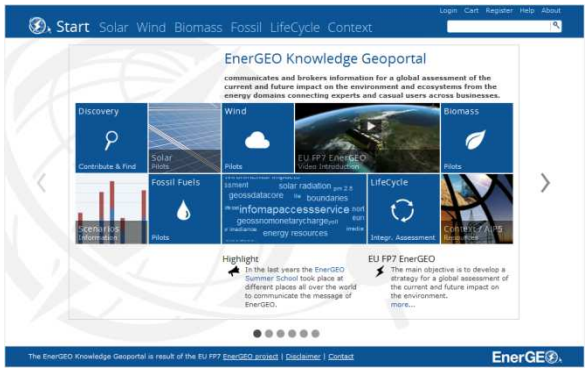
Means: introduction to EnerGEO, Biomass, Wind, Solar pilots

Target audience: full range, with focus on interested public

Knowledge Portal
accessible via project website, special website (energeo.researchstudio.at/energeo/catalog/main/home.page), and offline version on memory stick

Means: a full compilation of all results, dissemination material, publications, and visuals; knowledge sharing platform

Target audience: full range with interested public



1.4.3 Societal impact

Impact assessment considers more than the immediate, predicted outputs of an intervention (project or programme) and is much more concerned with the implications in the medium and long term. In order to measure lasting change meaningfully after the termination of a project, it is vital that change processes are tracked throughout the project cycle. Understanding and measuring change should therefore be a focus of ongoing monitoring and other key stages of the programme cycle.

So what did EnerGEO change? In general it is most probably too early to attempt to assess the lasting impact of the project that just closed. However, in the sense of the notion above emphasizing the change process, we can at least identify specific elements contributing to a noticeable change of thought.

Workshop Uganda 2009
In October 2009 PLUS took the opportunity of the AfricaGIS Conference to organize a 2 day Workshop on 'Biomass Energy Modelling with GIS and Remote Sensing' at Makerere University, Kampala, Uganda. The workshop was attended by 25 experts from 10 countries receiving support from the GEO Secretariat. In the early days of EnerGEO, the event created a momentum for a collaborative environment involving experts/researchers from EU, Brazil, and Africa in the field of renewable energies.

Change initiated: stimulated by the EnerGEO concept and with the outlook to benefit from the results of the project in the coming years, the workshop participants fully supported the proposal by the expert from the GEO Secretariat (F. Ramos, Brazil) to develop an initiative to compile a Bioenergy Atlas for Africa.

Bioenergy Atlas for Africa Process

The process to establish the expert network required to develop a continental atlas was facilitated by EnerGEO during dedicated workshops associated to Conferences of the African Association of Remote Sensing of the Environment AARSE in 2010 (Addis Ababa, Ethiopia) and 2012 (El Jadida, Morocco). An implementation plan was compiled and communicated. In 2011 the Bioenergy Atlas was included as a sub-task in the GEO Workplan 2011-2015.

Change initiated: The Atlas initiative created a widening community of researchers and experts who analyse critically national energy policy and explore options for energy transition in their respective countries. The South African Government decided to pledge 2 Mio ZAR to start with a national assessment. A research network on Biomass energy assessment and modelling is evolving and engages in collaborative grant applications.

Summer Schools

The three Summer Schools conducted demonstrate the implementation of GEO strategic objectives, build networks of young researchers and energy experts across borders, and represent a crucial and effective component of outreach. All participants – students and lecturers alike – profited by sharing knowledge and skills. Framed by a science-policy dialogue, the main elements of the Summer School concept facilitate the sharing of knowledge and skills – lectures and hands-on sessions. The encounter with the 'real world' and the possibility to exchange with local communities rounds off the concept.

- *Energy Resources, demand & supply and the impact on biodiversity and ecosystems*, Salzburg, Austria, 2011, to coincide with the annual co-located meeting of the GEO Committees with the objective to explore synergies with committees and experts attending the Meeting
- *Unlocking the renewable energy potentials for Africa. Biomass & Solar Energy and the impact on the Environment*, Kampala, Uganda, 2013
- *Environmental impact assessment of a transition to renewable energies*, Utrecht, The Netherlands, 2013

Change initiated: Methodologies for assessment, modelling supply & demand for energy and integrated impact analysis are now shared knowledge with a large number of participants from outside the consortium and from a wide variety of disciplines. In the spirit of GEO, the EnerGEO summer schools demonstrated the need to take several SBAs into account when addressing the energy transition. Integration of individual research agendas within the consortium was stimulated. All participants – students and experts – value the challenges of a constructive science-policy dialogue.

GEO Workplan

The EnerGEO distributed system for the interactive, semi-real time, monitoring and forecasting of the impact of the use of energy resources on the environment and ecosystems supports the objectives of the GEO work plan. EnerGEO provides the European contribution to the Energy Social Benefit Area (SBA). The activities of the social benefit area Energy in the 2009-2011 work plan have been divided among two tasks in the new 2012-2015 work plan: EN-01 Energy and Geo-Resources Management and SB-05 Impact Assessment of Human Activities. GEO provides a broad platform to enhance the awareness and the integration of the Energy issue (towards a transition to renewable energy resources).

Change initiated: EnerGEO substantially boosted the activities under the Energy Task. The GEO Energy Portal and the EnerGEO Knowledge Portal are registered resources under GEOSS.

AfriGEOSS

The Group on Earth Observations (GEO) has launched the AfriGEOSS initiative, which aims to coordinate the implementation of the Global Earth Observation System of Systems (GEOSS) and related Earth observation activities in Africa. Supported by the GEO Secretariat and recognized by the Executive Committee, this initiative seeks to identify the challenges and then put in place measures to enhance Africa's participation in, and contribution to, GEOSS. This participation will contribute to the continent's efforts to bridge the digital divide and to build a knowledge-based economy using GEO networks and the GEOSS infrastructure.

Change initiated: The Africa Chapter of GEO endorsed the Bioenergy Atlas for Africa (BAfA) initiative as a priority task under the AfriGEOSS action list (see also the recent showcase no 5 video produced for the GEO Geneva Ministerial Summit 2014). Negotiations are now under way to establish BAfA as a working group under AfriGEOSS.

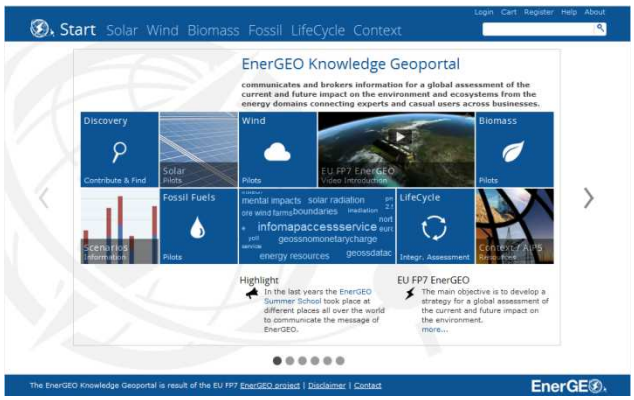
Energy GEO Portal

An energy dedicated data and information portal fully linked with the GEO-Portal is operational at the completion of the EnerGEO Project. The portal is directly contributing to the Energy Task of the GEO Workplan. Additionally, the EnerGEO Knowledge Portal provides information for policy makers and scientists/technical experts on the use and environmental/health impact of renewable energy resources. This is a prime entry point for information to those who explore renewables for implementation or undertake research on energy transition.

Change initiated: The EnerGEO GeoPortal is fully integrated into GEOSS and supports access to and analysis of energy related data resources.

EnerGEO Knowledge Portal

The EnerGEO Knowledge Geoportal has been selected to disseminate the results of EnerGEO online. It shows new methods to communicate outcomes in a user-friendly, modern and up-to-date way. Thus, it extends traditional ways of result presentation to a step that especially enables non-expert users to extract answers out of task-driven and result-oriented applications. This means that the platform is easy to use, providing meaningful information and knowledge and not just plain data to the users.

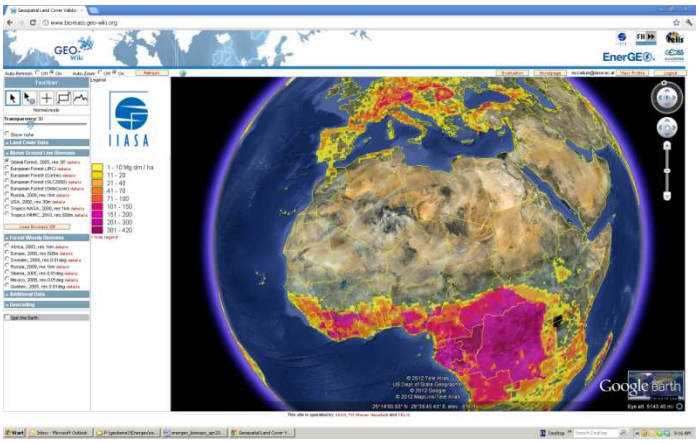


Change initiated: One-stop-shop for policy makers

The knowledge portal includes a number of web services. Condensed user information, derived from the produced data sets, will be made available on web servers linked to the GEO portals to support decision makers who are charged with planning future offshore wind parks. The data also served as input for the LCA and samples were made available to the operators of the TASES and REMIX energy models in EnerGeo. The implemented LCA algorithms have been applied to the offshore area of NW Europe. The results in this pilot might enable a comparison of wind energy with the three other energy sources considered in the EnerGeo project, The developed WebGIS client, WMS and WPS services are concrete illustrations of how a Web based tool greatly eases LCA results dissemination to non LCA experts. This WebGIS client is easily accessible from the Internet and can be used by a wide range of users: energy operators, energy policy decision-makers as well as offshore wind parks developers. It has been presented at the Enviroinfo conference (Blanc et. al., 2012). Running our WebGIS client highlights the importance to consider geo-dependent life cycle approach when assessing the global environmental performances caused by electricity production from offshore wind turbines. Based on specific technical characteristics, the tool enables to generate different potential scenarios based on variable failure rates, O&M schemes, turbine lifetime, potential losses, and technical choices. Other parameters such as local environmental impacts, soil characteristics, protected zones and maritime routes localizations may be also considered to enlarge multi-criteria analyses.

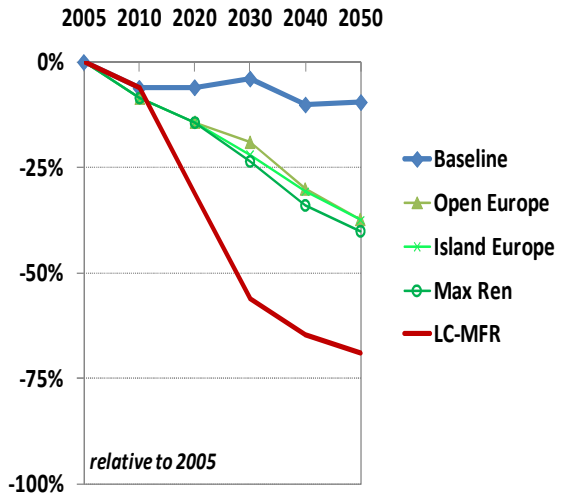
Biomass Geo-Wiki

A Biomass Geo-Wiki (http://biomass.geo-wiki.org) has been created: a platform to visualize, analyse and improve Biomass datasets, which also relates to the dissemination objectives of the project. The Geo-Wiki Project is a global network of volunteers who wish to help improve the quality of global environmental data. Since large differences occur within existing global environmental datasets (e.g. land cover, biomass, cropland), the Geo-Wiki Project provides a platform to visualize, analyse and improve upon these differences. The Biomass Geo-Wiki has collected a comprehensive set of recent biomass data from around the globe, and makes it freely available for visualization. Users are provided with an instant global overview of available datasets, overlaid on the Google Earth platform with comparable units. This provides an instant gap analysis of global data. Additional data to be uploaded could include geo-tagged pictures, in-situ measurements and more. Finally, it would be possible with a critical mass of data to produce a global mosaic of terrestrial biomass. As part of EnerGEO IIASA has launched the biomass Geo-Wiki, a sub domain of the Geo-Wiki Project.



Improved integrated assessment
Within Europe the GAINS integrated assessment is used for the CLRTAP convention as well as European Commission to design cost effective mitigation strategies. These assessments inform the policy process including negotiations and stakeholder consultations within Europe. Within EnerGEO the GAINS system and its input has been improved to be able to better incorporate the impacts of renewable energy resources. Moreover, a new impact pathway through mercury emissions was incorporated. The system has been demonstrated for low carbon scenarios.

Change initiated: Improved knowledge base to better inform policy makers



1.4.4 Achievement and challenges

Overall achievement
The EnerGEO assessments show that renewable energy resources for low carbon economy in Europe are available. Moreover, the EnerGEO scenarios demonstrate that a larger share of renewables in the future energy mix than currently targeted for is possible. Moving from fossil fuels to renewables aimed at mitigation of climate change has large co-benefit for air pollution, whereas stringent air quality policies do not necessarily have effect on climate change.

Specific achievements concerning awareness & societal impact
A web based GEO-portal was built and registered as part of the GEOSS registry. The portal provides the results and datasets produced in EnerGEO in a user friendly manner to share data and knowledge with a large community both in- and outside Europe. The portal is now extended to the 'EnerGEO Knowledge Portal' incorporating novel approaches for discovery and sharing of information. Web services provide access to impact assessment of selected energy scenarios as well as to optimal siting applications.

Three summer schools were organized to train young researchers in the field of renewable energy and impact assessment. Besides building on capacity the aim was to promote the use of geo-information and to create global networks. With a particular focus on building relations between Africa and Europe, EnerGEO established and supports the Bioenergy Atlas for Africa Initiative, a GEO-task under EN01 and AfriGEOSS, contributing to the Africa-EU Energy Partnership.

Specific challenges concerning awareness & societal impact
Recognizing that the assessment of 'awareness' is difficult shortly after the closure of the project, EnerGEO has contributed to raising awareness of the importance of energy transitions in other regions of the world. However, to provide tailored information for decision making outside Europe, the assessment models need to be adapted or expanded to other parts of the world.

A project can only have an impact on societal processes when the 'news' about relevant results is spread. Journal publications alone will not effectively create a wider impact beyond the scientific community. As in many other research projects, it has been not easy to ascertain input for dissemination & outreach from partners of the consortium. The summer schools and the development of the knowledge portal were instrumental for raising the awareness of involved scientists that sharing of knowledge is of mutual benefit.

The maintenance/evolution of the Knowledge Portal under the coordination of the GEO Secretariat is planned. At the moment the EnerGEO knowledge portal is being integrated into the GEO website at the secretariat.

1.5 Address of project public website and relevant contact details

The address of project public website containing the knowledge portal is **www.energeo-project.eu.**

Table 1. Project partners, their main representatives and contact details

Project partner	Contact persons	Email address
TNO	Martijn Schaap Dick Heslinga	martijn.schaap@tno.nl dick.heslinga@tno.nl
ARMINES	Thierry Ranchin	thierry.ranchin@mines-paristech.fr
DLR	Marion Schroedter-Homscheidt Carsten Hoyer-Klick	marion.schroedter-homscheidt@dlr.de carsten.hoyer-klick@dlr.de
ARGOSS	Hein Zelle	hein.zelle@bmtargoss.com
RSA	Manfred Mittleboeck	manfred.mittlboeck@researchstudio.at
IIASA	Michael Obersteiner	oberstei@iiasa.ac.at
UNR	Maarten Weide	m.weide@uniresearch.nl
PLUS	Peter Zeil	peter.zeil@sbg.ac.at
AGH-UST	Artur Wyrwa	awyrwa@agh.edu.pl
SUPARCO	Rahmatullah Jilani	diradrpc@suparco.gov.pk
IUTA	Thomas Kuhlbusch	tky@iuta.de
SRON	Sander Houweling	s.houweling@sron.nl

2 Use and dissemination of foreground

A plan for use and dissemination of the knowledge developed (foreground) was established at the beginning of the project and updated at the end (EnerGEO deliverable D6.1). Here an overview is presented of the dissemination of results which are in in public (for a larger part scientific) It gives an overview the use and dissemination of foreground consistent with the report on societal implications on the use and dissemination of foreground.

This part of the report consists of:

- Section A

  This section describes the dissemination measures, including any scientific publications relating to foreground. Its content is available in the public domain thus demonstrating the added-value and positive impact of the project on the European Union.

- Section B

  This section specifies the exploitable foreground and provide the plans for exploitation. All these data can be public or confidential; the report must clearly mark non-publishable (confidential) parts that will be treated as such by the Commission. Information under Section B that is not marked as confidential **will be made available in the public domain** thus demonstrating the added-value and positive impact of the project on the European Union.

Section A (public)

This section includes two templates

- Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[1] (if available)	Is/Will open access[2] provided to this publication?
1	Emissions of mercury from the power sector in Poland	J. Zyśk	Atmospheric Environment	43/3	Elsevier	Netherlands	2010	605-610	10.1016/j.atmosenv.2010.10.041	**no**
2	Validation of modelled forest biomass in Germany using BETHY/DLR	M. Tum	Geoscientific Model Development	4	Copernicus	Germany	2011	1019-1034	doi:10.5194/gmd-4-1019-2011	**yes**
3	Optimal Locations for Methanol and CHP production in Eastern Finland	K. Natarajan	Bioenergy Research	5	Springer	Germany	2011	1 - 12	10.1007/s12155-011-9152-4	**no**
4	Validating modelled NPP using statistical yield data	M. Tum	Biomass & Bioenergy	35	Elsevier	Netherlands	2011	4665-4674	doi:10.1016/j.biombioe.2011.09.01	**no**

[1] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[2] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

									5	
5	Cost-effective policy instruments for greenhouse gas emission reduction and fossil fuel substitution through bioenergy production in Austria	J. Schmidt	Energy Policy	39	Elsevier	netherlands	2011	3261-3280	39(6):3261-3280;2011	**no**
6	Environmental impact assessment of electricity production by photovoltaic system using GEOSS recommendations on interoperability	Ménard L.	Proceedings of the 25th International Conference on Informatics for Environmental Protection		Shaker	Aachen	2011	765-774		**no**
7	Energy planning in a changing world	M. Schaap	International Innovation	2	Research Media		2012	69-71		**yes**
8	Benefit of GEOSS Interoperability in Assessment of Environmental Impacts Illustrated by the Case of Photovoltaic Systems	L. Ménard	*IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*	5			2012	1722 - 1728	10.1109/JSTARS.2012.2196024	**no**
9	CHP or biofuel production in Europe	S. Leduc	Energy Procedia	20	Elsevier Science	Netherlands	2012	40-49	10.1016/j.egypro.2012.03.006	**no**
10	Optimal use of forest residues in Europe under different policies-second generation biofuels versus combined heat and power	Wetterlund, E.	Biomass Conversion Biorefinery	3 (1)	Springer	Berlin	2012	3 -16	DOI 10.1007/s13399-012-0054-2	**yes**
11	Optimal localisation of biofuel production on a European scale	Wetterlund, E.	Energy Procedia	41(1)	Elsevier	Netherlands	2012	462-472		**no**
12	How sensitive are estimates of carbon fixation in agricultural models to input data?	M. Tum	Carbon Balance and Management	7 (3)	Springer	Berlin	2012	1 - 13	10.1186/1750-0680-7-3	**yes**
13	Estimating the loss of life expectancy attributable to PM2.5 emissions in Europe with the use of high special resolution modelling	Debrszok, K.M.	Proceeding of 6th SETAC World Congress / SETAC Europe 22nd Annual Meeting		Shaker	Berlin	2012	383		**yes**
14	Observing Forest Biomass Globally	S. Fritz	Earthzine				2012			**no**

15	‘Renewable energy based electricity supply at low costs - Development of the REMix model and application for Europe	Scholz, Y.	PhD thesis				2012			**yes**
16	Modelling of atmospheric dispersion of mercury for energy scenarios of the EnerGEO project	J. Zyśk	Rtec w srodowisku Identyfikacja zagrozen dla zdrowia człowieka	3	Wydawnictwo Uniwersytetu Gdanskiego,	Gdańsk, Poland	2013	47-56	978-83-7865-090-4	**no**
17	Quantifying the carbon uptake by vegetation for Europe on a 1km2 resolution using a remote sensing driven vegetation model	K. Wißkirchen	Geoscientific Model Development	6	Copernicus Publications	Germany	2013	1623-1640	10.5194/gmd-6-1623-2013	**yes**
18	Source apportionment using LOTOS-EUROS: module description and evaluation	R. Kranenburg	Geoscientific Model Development	6	Copernicus Publications	Germany	2013	721-733	10.5194/gmd-6-721-2013	**yes**
19	Improved light and temperature responses for light use efficiency based GPP models	I. McCallum	Biogeosciences	10	Copernicus	Germany	2013	8919-8947	doi:10.5194/bgd-10-8919-2013	**yes**
20	Sensitivity of air pollution simulations with LOTOS-EUROS to temporal distribution of anthropogenic emissions	A. Mues	Atmos. Chem. Phys. Disc.	13	Copernicus	Germany	2013	19311-19350	10.5194/acpd-13-19311-2013	**yes**
21	Assessing the Sensitivity of the OMI-NO2 Product to Emission Changes across Europe	M. Schaap	Remote sensing	26	MDPI	Basel	2013	4187-4208	10.3390/rs5094187	**yes**
22	Road Traffic: A Major Source of Particulate Matter in Europe	F. Amato	Urban Air Quality in Europe	26	Springer-Verlag	Berlin-Heidelberg	2013	165-193	10.1007/698_2012_207	**no**
23	Anthropogenic and Natural Constituents in PM10 at Urban and Rural Sites in North- Western Europe: Concentrations, Chemical Composition and Sources	Weijers E.	Urban Air Quality in Europe	26	Springer-Verlag	Berlin-Heidelberg	2013	239-258	10.1007/698_2012_207	**no**

24	Establishing the origin of Particulate Matter concentrations in the Netherlands	Hendriks, C.	Atmospheric Environment	69	Elsevier		2013	289-303		**no**
25	The impact of large scale biomass production on ozone air pollution in Europe	Beltman, J.B.	Atmospheric Environment	71	Elsevier		2013	352-363	10.1016/j.atmosenv.2013.02.019	**no**
26	Scenarios of global mercury emissions from anthropogenic sources	P Rafaj	Atmospheric Environment	79	Elsevier	Netherlands	2013	472 - 479	http://dx.doi.org/10.1016/j.atmosenv.2013.06.042	**no**
27	Ancillary Benefits of Climate Policies for the Mitigation of Atmospheric Mercury Emissions	P Rafaj	Proceedings of the 16th International Conference on Heavy Metals in the Environment	1(30002)	EDP Sciences		2013		http://dx.doi.org/10.1051/e3sconf/20130130002	**no**
28	Sustainable Bioenergy Potentials for Europe and the Globe	Tum M.	Geoinfor Geostat: An Overview	S1	SciTechnol		2013	pp.1-7	10.4172/2327-4581.S1-010	**yes**
29	Modelling of atmospheric dispersion of mercury for energy scenarios of the EnerGEO project	Zysk J	Mercury in the Environment. Identification of Hazards to Human Health, L. Falkowska (ed)		University of Gdansk	Gdansk	2013	47-56	ISBN:978-83-7865-090-4	**no**
30	A Process based Vegetation Model for Estimating Agricultural Bioenergy Potentials	M Tum			Springer	Germany	2013	97-110	10.1007/978-94-007-6642-6	**no**
31	Synergistic use of OMI NO2 tropospheric columns and LOTOS-EUROS to evaluate the NOx emission trends across Europe	R.L. Curier	Remote sensing of the environment	in press	Elsevier	Netherlands	2014			**no**
32	The impact of accounting for the timing of fossil fuel use in combination with renewable energy sources on source receptor matrices in Europe	C. Hendriks	Climatic change	submitted	Elsevier	Netherlands	2014			**no**
33	Multi-site/multi period PM10 source apportionment by Positive Matrix Factorisation	U. Quass	Atmospheric Environment	submitted	Elsevier	Netherlands	2014			

	for north-west Europe									
34	An EOF analysis of 10 years of MOPITT CO measurements: variability and trends	F. Alkemade,	Atmos. Chem. Phys.	Submitted	Copernicus	Germany		-		
35	Boundary layer aerosol concentration for solar tower power plant design	D. Mancera	Atmos. Chem. Phys.	to be submitted	Copernicus	Germany	2014			**no**
36	Spatial error structures in solar irradiance forecasts with respect to electricity market design	M. Schroedter	Atmos. Chem. Phys.	to be submitted	Copernicus	Germany	2014			**yes**
37	Estimation of NOx emission trends across Europe through assimilation of OMI-NO2 data into a chemistry transport model	M. Schaap	Atmos. Chem. Phys. Disc.	to be submitted	Copernicus	Germany	2014			**no**
38	Evaluation of modelled source apportionment using arsenic and vanadium measurements	F. Amato	Atmospheric Environment	to be submitted	Elsevier	Netherlands	2014			**no**
39	Future air quality in Europe under the EnerGEO scenarios	J. Kuenen	Atmospheric Environment	to be submitted	Elsevier	Netherlands	2014			**no**
40	Comparing source apportionment results by a chemistry transport model against PMF analyses for north western Europe	M. Schaap	Atmospheric Environment	to be submitted	Elsevier	Netherlands	2014			**no**
41	Modelling the the temporal change in PM2.5 in the assessment of human health impact: illustration with renewable energy scenarios at 2050 horizon	B. Gschwind	Environmental Impact Assessment Review" (EIAR)	to be submitted			2014			**no**
42	Web tool for energy policy decision-making through geo-localized LCA models: A focus in offshore wind farms in Northern Europe	Blanc, I., Guermont, C., Gschwindt, B., Menard, L., Calkoen, C., Zelle, H.	Proceedings of the 26th International Conference on Informatics for Environmental Protection		Shaker	Aachen	2012	499-506	978-3-8440-1248-4	**no**

43	Feedstock choices for second generation biofuel production in Europe	Leduc, S.	Proceedings of SEEP2012				2012			
44	Fully integrated workflow for combining object-based image analysis and LiDAR point cloud metrics for feature extraction and classification improvement	D. Tiede	Proceedings of the International LiDAR Mapping Forum 2012			Denver	2012	6		**no**
45	Uncertainty mapping for state-of-the-art DNI day ahead forecasts	M. Schroedter-Homscheidt	Proceedings Solar Paces 2012 Conference				2012			**no**
46	Using a web-based SDSS for siting solar power plants	T. Wanderer	Proceedings EnviroInfo 2013 Conference				2013			**no**
47	The EnerGEO Platform of Integrated Assessment (PIA): environmental assessment of scenarios as a web service	I. Blanc	Proceeding of the 27th Conference on Environmental Informatics - Informatics for Envionmental Protection, Sustainable Development and Risk Management - Part I	Shaker Verlag	Germany	2013		978-3-8440-1676-5/1616-0886	no	
48	Human health impacts for Renewable Energy scenarios from the EnerGEO Platform of Integrated Assessment (PIA)	M. Lefevre	Proceeding of the 27th Conference on Environmental Informatics - Informatics for Envionmental Protection, Sustainable Development and Risk Management - Part I	Shaker Verlag	Germany	2013		978-3-8440-1676-5/1616-0886	no	
49	Modeling impacts of European renewable energy policies on the emissions of mercury	P. Rafaj	Proceeding of the 27th Conference on Environmental Informatics -		Shaker Verlag	Germany	2013		978-3-8440-1676-5/1616-0886	**no**

			Informatics for Envionmental Protection, Sustainable Development and Risk Management - Part I							
50	Estimating particulate matter health impact related to the combustion of different fossil fuels	M. Schaap	Proceeding of the 27th Conference on Environmental Informatics - Informatics for Envionmental Protection, Sustainable Development and Risk Management - Part I		Shaker Verlag	Germany	2013		978-3-8440-1676-5/1616-0886	**no**
51	Challenges of electricity production scenarios modelling for life cycle assessment of environmental impacts	Blanc I.	Proceedings of the 27th Conference on Environmental Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management		Shaker	Hamburg	2013	p. 443		**no**
52	Environmental data for the planning of off-shore wind parks from the EnerGEO Platform of Integrated Assessment (PIA)	H. Zelle	Proceedings of the 27th Conference on Environmental Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management		Shaker	Hamburg	2013	p.109		**no**
53	The EnerGEO Platform of Integrated Assessment (PIA): environmental assessment of	I. Blanc	Proceedings of the 27th Conference on Environmental		Shaker	Hamburg	2013	p.85		**no**

	scenarios as a web service,		Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management							
54	Human health impacts for Renewable Energy scenarios from the EnerGEO Platform of Integrated Assessment (PIA)	M. Lefevre	Proceedings of the 27th Conference on Environmental Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management		Shaker	Hamburg	2013	p.120		**no**
55	Environmental impact for offshore wind farms: Geolocalized Life Cycle Assessment (LCA) approach	T. Ranchin	Proceedings of the 3rd Conference on Ocean & Coastal Observation: Sensors and observing systems, numerical models & information Systems (OCOSS),			Nice	2013			**no**
56	Modelling impacts of European renewable energy policies on the emissions of mercury	P. Rafaj	Proceedings of the Enviroinfo 2013 Conference		Shaker Verlag	Aachen	2013	503-513	ISBN: 978-3-8440-1676-5	**no**
57	Loss of Life Expectancy related to temporal evolution of PM2.5 considered within energy scenarios in Europe	M. Lefèvre	Proceedings of the SETAC Europe 23rd Annual Meeting,			Glasgow	2013			
58	Environmental assessment of electricity scenarios with Life Cycle Assessment,	I. Blanc	Proceedings of the SETAC Europe 23rd Annual Meeting,			Glasgow	2013			**no**

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[3]	Main leader	Title	Date	Place	Type of audience[4]	Size of audience	Countries addressed
1	Conference	TNO	EMEP steering body meeting	17-19 September 2012	Geneva, Switzerland	Policy makers	60	EU
2	Conference	TNO	Final Conference	24-25 Oct 2013	Utrecht, The Netherlands	Scientfic Community		Europe
3	Conference	TNO	GEO Workplan Symposium 2013	June 3 -7	Geneva	Scientfic Community	150	world
4	Conference	TNO	GEOSS Plenary	Nov 3-4 2010	Beijing, China	Policy makers	400	EU, USA, China
5	Conference	TNO	MACC Conference	23.-27.5.2011	Utrecht, Netherlands	Scientfic Community	100	EU29, USA
6	Conference	TNO	GEO VIII Plenary	16.-17..11.2011	Istanbul, Turkey	Policy makers		EU, USA, China
7	Conference	TNO	ISRSE conference	10-15 April 2012	Sydney, Australia	Scientfic Community	50	AU, china, EU
8	Conference	TNO	European Aerosol Conference	2-7 September 2012	Granada, Spain	Scientfic Community	50	EU27, US, asia
9	Conference	TNO	EGU 2012	23-27 April 2012	Vienna, Austria	Scientfic Community	100	many
10	Conference	TNO	32nd NATO/SPS International Technical Meeting on Air Pollution Modelling and its Application	7-11 May 2012	Utrecht, Netherlands	Scientfic Community	150	EU27, US, Canada, Asia
11	Conference	TNO	32nd NATO/SPS International	7-11 May 2012	Utrecht, Netherlands	Scientfic Community	150	EU27, US, Canada, Asia

[3] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[4] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

			Technical Meeting on Air Pollution Modelling and its Application					
12	Conference	TNO	IGARSS	22-27 July 2012	Munich, Germany	Scientfic Community	100	EU27, US, Canada, Asia
13	Conference	TNO	EMS	10-14 September 2012	Lodz, Poland	Scientfic Community	30	EU27
14	Conference	TNO	EMEP Task Force Measurement and modelling	6-8 May 2013	Zagreb, Croatia	Policy makers	60	EU
15	Conference	TNO	32nd NATO/SPS International Technical Meeting on Air Pollution Modelling and its Application	26-30 August, 2013	Miami, USA	Scientfic Community	150	EU, USA, China
16	Conference	TNO	GEO VIII Plenary	16.-17..11.2011	Istanbul, Turkey	Policy makers		
17	Conference	TNO	EnviroInfo	9-13 September 2013	Hamburg, Germany	Scientfic Community	50	EU
18	Conference	TNO	64th International Astronautical Congress	9-13 September 2013	Beijing, China	Industry	50	China, USA, EU
19	Project meeting	TNO	GEO project meeting GEWP6	7-9 May 2012	Rome, Italy	Scientfic Community	100	EU
20	Seminar	TNO	ForschungsZenrtrum		Jülich, Germany	Scientfic Community	25	Germany
21	Seminar	TNO	The Dutch Ministry for Infrastructure and Environment	23/08/2012	the Hague, the Netherlands	Policy makers	25	NL
22	Seminar	TNO	Seminar Antwerp University	27 September 2013,	Antwerp, Belgium	Scientfic Community	15	Belgium
23	Seminar	TNO	IIASA seminar	24/04/2012	Laxenburg, Austria	Scientfic Community	20	EU
24	Symposium	TNO	ESA Living Planet	9-13 September 2013	Edinburgh, UK	Scientfic Community	100	EU, USA
25	Symposium	TNO	Geo Work Plan	4-6 June 2013	Geneva, Switzerland	Scientfic Community	100	EU, USA
26	Workshops	TNO	EC GEO Project Workshop GEOPW7	April 15-16	Barcelona	Scientfic Community	250	world

27	Workshops	TNO	NSO Workshop	14.10.2011	The Hague, Holland	Policy makers	50	NL
28	Workshops	TNO	NL-GEO workshop geeft meer bekendheid aan Group on Earth Observations (GEO)	14.10.2011	Den Haag, The Netherlands	Policy makers	50	NL
29	Workshops	TNO	EC4MACS workshop	8-9 March 2012	Paris, France	Scientfic Community	60	EU27 countries
30	Workshops	TNO	Task Force on Measurements and Modelling; 13rd Annual Meeting:	17-19 April 2012	Gozo, Malta	Scientfic Community	50	EU27 countries
31	Workshops	TNO	EMPA seminar	1 Februar 2012	Zurich, Switzerland	Scientfic Community	35	Switserland, Germany
32	Workshops	TNO	GEO project (GEWP7)	15-17 April, 2013	Barcelona, Spain.	Scientfic Community	40	EU
33	Workshops	TNO	JRC workshop on source apportionment	27-28 February 2013	Ispra, Italy	Scientfic Community	80	EU
34	Workshops	TNO	UBA Tagung zum Jahr der Luft	16-17 September 2013	Dessau-Roβlau, Germany	Policy makers	130	Germany
35	Workshops	TNO	EMEP Taskforce Integrated Assessment modelling	7-9 May 2012	Bilthoven, the Netherlands	Policy makers	60	EU
36	Workshops	TNO	National modelling and data centre (NMDC) workshop	27-Sep-11	Utrecht, the Netherlands	Scientfic Community	40	NL
37	Oral presentation	SRON	Fall conference AGU	12/06/2012	San Francisco, USA	scientists	~100	EU
38	Conference	RSA	GeoForum Mecklenburg-Vorpommern 2012	16./17.4.	Rostock, Germany	Industry	200	Germany, mainly
39	Conference	RSA	GeoForum Mecklenburg-Vorpommern 2012	16./17.4.	Rostock, Germany	Industry	200	Germany, mainly
40	Poster + Presentation	RSA	GEO Workshop Vienna	12/10/2012	Vienna, Austria	Scientfic Community	100	Austria
41	Presentation	RSA	SynerGIS 2012	22-24 Oct. 2012	Alpbach, Austria	Scientfic Community	300	Austria
42	Presentation	RSA	SOMAP 2012 Vienna	23/12/2012	Vienna, Austria	Scientfic Community	100	Europe

43	Presentation	RSA	Agit 2013	04/07/2013	Salzburg, Austria	Scientfic Community	200	Europe
44	Presentation	RSA	ESRI European User Confernece	25/10/2013	Munich, Germany	Industry	600	Europe, Middle East
45	Presentations	RSA	GIScience Lunchtime Colloquium	5/15/2012	Salzburg, Austria	Scientfic Community	25	world
46	Videos	RSA	videos (project, Biomass, Solar, Wind)					
47	Videos	RSA	videos (project, Biomass, Solar, Wind)					
48	Web sites/Applications	RSA	Knowledge Portal			Scientfic Community		world
49	Workshops	RSA	3rd Energeo Summerschool	22/10/2013	Utrecht, Netherlands	Scientfic Community	15	world
50	Conference	PLUS	AARSE 2010	Oct 25 - 29 2010	Addis Ababa, Ethiopia	Scientfic Community		
51	Conference	PLUS	13th GEO CBC Meeting	Febr. 28-Mar2 2011	Sao Paulo			
52	Conference	PLUS	GEO co-located committee meeting	13-15.09.2011	Salzburg, Austria	Scientfic Community	70	
53	Conference	PLUS	20th European Biomass Conference and Exhibition	18-21 June 2012	Milan, Italy	Scientfic Community	1500	Europe
54	Flyers	PLUS	6 factsheets					
55	Flyers	PLUS	Flyer for 2nd EnerGEO Summer School					
56	Flyers	PLUS	Flyer for 3rd EnerGEO Summer School					
57	Flyers	PLUS	Update of project flyers					
58	Flyers	PLUS	project flyers, project roll-up					
59	Flyers	PLUS	Update of project flyers					
60	Posters	PLUS	Poster for 2nd EnerGEO Summer School					
61	Posters	PLUS	Poster for 3rd					

			EnerGEO Summer School					
62	Posters	PLUS	3 posters for 20th European Biomass Conference and Exhibition	18-21 June 2012	Milan, Italy	Scientfic Community	1500	Europe
63	Posters	PLUS	3 posters for GEO Beijing Ministerial Summit (Biomass, Fossil Fuels, Wind)					
64	Posters	PLUS	9 posters for GEO VIII Plenary Istanbul (pilot posters, project poster, PIA poster, Bionenergy Atlas Africa, Summer Schools)					
65	Posters	PLUS	3 posters for 20th European Biomass Conference and Exhibition	18-21 June 2012	Milan, Italy			
66	Presentations	Plus	Summer school 2013	October 2013	Utrecht, The Netherlands	Scientfic Community	10	
67	Videos	PLUS	DVD EnerGEO material for training and capacity building					
68	Workshops	PLUS	Biomass Atlas for Africa	Oct 22 -23	Addis Ababa, Ethiopia			
69	Workshops	PLUS	1st EnerGEO Summer School	7.-15.09.2011	Salzburg, Austria	Scientfic Community	10	Austria, Germany, The Netherlands, South Africa, Pakistan, Thailand, Iran
70	Workshops	PLUS	GEO workplan symposium	30 April - 02 May 2012	Geneva, Switzerland	Scientfic Community		world
71	Workshops	PLUS	AARSE 2012 - workshop: Bioenergy Atlas for Africa	03-Nov-12	El Jadida, Morocco	Scientfic Community	10	Africa
72	Workshops	PLUS	2nd EnerGEO Summer School	04-13 March 2013	Kampala, Uganda	Scientfic Community		Uganda, Ethiopia, Kenya, South Africa,

								Italy
73	Workshops	PLUS	3rd EnerGEO Summer School	15 – 25 Oct 2013	Utrecht, The Netherlands	Scientfic Community		Germany, Ethiopia, Morocco, Zambia, Switzerland,Zimbabwe, Malaysia
74	Workshops	PLUS	GEO Institutions & Development Implementation Board Meeting	03.-04 Sep.2012	Bonn	Scientfic Community	20	world
75	Workshops	PLUS	Biomass Atlas for Africa	Oct 22 -23	Addis Ababa, Ethiopia			
76	Workshops	PLUS	1st EnerGEO Summer School	7.-15.09.2011	Salzburg, Austria	Scientfic Community	10	Austria, Germany, The Netherlands, South Africa, Pakistan, Thailand, Iran
77	Workshops	PLUS	AARSE 2012 - workshop: Bioenergy Atlas for Africa	03/11/2012	El Jadida, Morocco	Scientfic Community	10	Africa
78	Conference	IIASA	Enviroinfo 2013	2-3 September 2013	Hamburg, Germany	Scientfic Community	40	
79	conference	IIASA	International Conference on Sustainable Energy and Environmental Protection	5-8 May 2012	Dublin, Ireland	Scientific Community	50	World
80	conference	IIASA	ICHMET 2012 Conference	1-Sep-2012	Rome	Scientific Community	50	World
81	conference	IIASA	Enviroinfo 2013 Conference	1-Sep-2013	Hamburg	Scientific Community	50	Europe
82	conference	IIASA	11th ICMGP International Conference on Mercury as a Global Pollutant	1-Aug-2013	Edinburgh	Scientific Community	50	World
83	workshop	IIASA	First International BeWhere Workshop	8-9 Oct 2013	Laxenburg, Austria	Scientfic Community	20	World
84	Conference	DLR	Fachtagung Energiemeteorologie	6.-8.4.2011	Bremerhaven, Germany	Scientfic Community		
85	Conference	DLR	COST WIRE State of the Art Workshop	22.-24.3.2011	Nice, France			

86	Conference	DLR	EMS 2011	12.-16.9.2011	Berlin, Germany			
87	Conference	DLR	SolarPaces 2011	19.-23.9.2011	Granada, Spain			
88	Conference	DLR	ISES 2011	28.8.-2.9.2011	Kassel, Germany			
89	Conference	DLR	ICEM 2011	08.-11.11.2011	Gold Coast, Australia			
90	Conference	DLR	Fachtagung Energiemeteorologie	6.-8.4.2011	Bremerhaven, Germany			
91	Conference	DLR	3rd iLEAPS Conference	16.-17.09.2011	Garmisch-Partenkirchen, Germany			
92	Conference	DLR	EOC Symposium 2011	11.-12.10.2011	Oberpfaffenhofen, Germany			
93	Conference	DLR	SolarPaces 2012	11-14 Sept 2012	Marocco	Industry	500	World
94	Exhibitions	DLR	20th European Biomass Conference and Exhibition	18-21 June 2012	Milan, Italy	Scientfic Community	1500	world
95	Exhibitions	DLR	20th European Biomass Conference and Exhibition	18-21 June 2012	Milan, Italy	Scientfic Community	1500	world
96	Lecture	DLR	SFERA Summerschool 2012	15./16. May 2012	Almeria, Spain	Scientfic Community	50	Europe
97	Posters	DLR	9th ICDC	3.-7. June 2013	Beijing, China	Scientfic Community	500	World
98	Presentation	DLR	SPIE - Remote Sensing	24-27 September 2012	Edinburgh, UK	Scientfic Community	100	World
99	Presentations	DLR	9th AARSE Conference	29.10.-02.11.2012	El Jadida, Morocco	Scientfic Community	350	Africa
100	Presentations	DLR	1st EGGPAL Conference	15.-17. May 2013	Warsaw, Poland	Policy makers	200	Eastern Europe
101	Presentations	DLR	EnviroInfo 2013	2.-4. September 2013	Hamburg, Germany	Scientfic Community	50	Europe
102	Presentations	DLR	Fachtagung Energiemeteorologie	4.-6. Juni 2013	Grainau, Germany	Scientfic Community	90	D/CH/A
103	Presentations	DLR	ICEM 2013	25.-28. June 2013	Toulouse, France	Scientfic Community	400	World
104	Presentations	DLR	EMS 2013	9.-13.Sept 2013	Reading, UK	Scientfic Community	150	Europe
105	Presentations	DLR	IEA Task 46 expert meeting	7./8. Oct 2013	Oldenburg, Germany	Scientfic Community	40	World

106	Presentations	DLR	EnviroInfo 2013	2.-4. September 2013	Hamburg, Germany	Scientfic Community	50	Europe
107	Web sites/Applications	DLR	BETHY/DLR results published online					
108	Web sites/Applications	DLR	launch of Biomass Geo-wiki					
109	Web sites/Applications	DLR	Launch of Irena Global Atlas with Solar Site Ranking Tool					World
110	Conference	ARMINES	23rd SETAC Europe Annual Meeting	12-16 May 2013	Glasgow, UK	Scientfic Community	40	
111	Conference	ARMINES	Enviroinfo 2013	2-3 September 2013	Hamburg, Germany	Scientfic Community	40	
112	Conference	ARMINES	Enviroinfo 2013	2-3 September 2013	Hamburg, Germany	Scientfic Community	40	
113	Conference	ARMINES	Enviroinfo Conference 2013 / Special EU-Session organized by EnerGEO	September 2013	Hamburg, Germany	Scientfic Community	30	
114	Conference	ARMINES	SETAC 2013	May 2013	Glasgow, UK	Scientfic Community	50	
115	Conference	ARMINES	OGC network : GEOSS AIP-3 kick-off meeting	2010	Rome		30	
116	Conference	ARMINES	Enviroinfo 2012	september 2012	Dessau, Germany	Scientfic Community	50	
117	Conference	ARMINES	enviroinfo 2011	september 2013	Ispra, Italy	Scientfic Community	50	
118	Conference	Armines	EnviroInfo	2-4 Sept2013	Hamburg, Germany	Scientfic Community	80	Europe
119	participation with presentation	ARMINES		Oct-11	Masdar Institute of Science and Technology, Abu Dhabi, UAE	scientific community	10	United Arab Emirates
120	participation with presentation	ARMINES		Jan-13	ADEME, Paris, France	policy makers	5	France
121	Participation with presentation	ARMINES	GEO Work Plan Symposium	may-11, may-12, jun-13	Geneva, Switzerland	Science Community,policy makers, medias	100-200	All GEO countries

122	Participation with presentation and posters	ARMINES	"L'energie demain" colloque de l'institut Mines Telecom	may-13	Paris, France	scientific community	150-200	France
123	Participation with presentation, posters and videos	ARMINES	GEOSS Plenary and Ministerial	Nov-10	Beijing, China	all	500	All GEO countries
124	Participation with presentation, posters and videos	ARMINES	GEOSS Plenary	Nov-11	Istanbul, Turkey	all	500	All GEO countries
125	Participation with presentation, posters and videos	ARMINES	GEOSS Plenary	Nov-12	Foz Di Iguazu, Brazil	all	300	All GEO countries
126	Participation with presentation, posters and videos	ARMINES	GEOSS Plenary and Ministerial	Jan-14	Geneva, Switzerland	all	?	All GEO countries
127	Posters	ARMINES	EnviroInfo 2013	sep 2-4 2013	Hamburg	Scientfic Community		International
128	Scientific Release in the annual report of MINES ParisTech	ARMINES		2011 and 2012	France	all	more than 1000	all
129	Conference	AGH-UST	23rd SETAC Europe Annual Meeting	12-16 May 2013	Glasgow, UK	Scientfic Community	40	
130	Conference	AGH-UST	Mercury in the environment – identification of risks for human health " [in Polish]	8-10 May 2013	Gdynia, Poland	Scientfic Community	100	Poland
131	conference	AGH-UST	Mercury in the Environment. Identification of Hazards to Human Health	1-May-2013	Gdynia	Scientific Community	50	
132	Posters	AGH-UST	6th SETAC World Congress / SETAC Europe 22nd Annual Meeting 2012	20-24 May 2012	Berlin, Germany	Scientfic Community	40	
133	Presentations	AGH-UST	Information Day of 7 Framework Programme - Theme : Environment (PL)	21 June 2013	Warsaw, Poland	Scientfic Community	40	Poland
134								

Section B (Confidential[5] or public: confidential information to be marked clearly)
Part B1

The project EnerGEO did not result in patents, trademarks or registered designs.

The list should, specify at least one unique identifier e.g. European Patent application reference. For patent applications, only if applicable, contributions to standards should be specified. This table is cumulative, which means that it should always show all applications from the beginning until after the end of the project.

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[6]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)
none					

[5] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[6] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2
Please complete the table hereafter:

Type of Exploitable Foreground[7]	**Description of exploitable foreground**	**Confidential Click on YES/NO**	**Foreseen embargo date dd/mm/yyyy**	**Exploitable product(s) or measure(s)**	**Sector(s) of application**[8]	**Timetable, commercial or any other use**	**Patents or other IPR exploitation (licences)**	**Owner & Other Beneficiary(s) involved**
none								

In addition to the table, please provide a text to explain the exploitable foreground, in particular:

- Its purpose
- How the foreground might be exploited, when and by whom
- IPR exploitable measures taken or intended
- Further research necessary, if any
- Potential/expected impact (quantify where possible)

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[8] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

3.1 Societal impacts specified

A General Information	
Grant Agreement Number:	226364
Title of Project:	EnerGEO
Name and Title of Coordinator:	Dr. M. Schaap

B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***NO***
2. Please indicate whether your project involved any of the following issues (tick box) :	***NO***
RESEARCH ON HUMANS	
• Did the project involve children?	NO
• Did the project involve patients?	NO
• Did the project involve persons not able to give consent?	NO
• Did the project involve adult healthy volunteers?	NO
• Did the project involve Human genetic material?	NO
• Did the project involve Human biological samples?	NO
• Did the project involve Human data collection?	NO
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	NO
• Did the project involve Human Foetal Tissue / Cells?	NO
• Did the project involve Human Embryonic Stem Cells (hESCs)?	NO
• Did the project on human Embryonic Stem Cells involve cells in culture?	NO
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	NO
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	NO
• Did the project involve tracking the location or observation of people?	NO
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	NO
• Were those animals transgenic small laboratory animals?	NO

• Were those animals transgenic farm animals?	NO
• Were those animals cloned farm animals?	NO
• Were those animals non-human primates?	NO
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	NO
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	NO
DUAL USE	
• Research having direct military use	NO
• Research having the potential for terrorist abuse	NO

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	3
Work package leaders	3	5
Experienced researchers (i.e. PhD holders)	5	10
PhD Students	4	3
Other	6	9

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**8**
Of which, indicate the number of men:	3

D Gender Aspects

5.	**Did you carry out specific Gender Equality Actions under the project**?	X ○	Yes No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
X	Set targets to achieve a gender balance in the workforce	○	○	○	X	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

X Yes- please specify: summer schools

○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

X Yes- please specify: DVD, knowledge portal

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

X Main discipline[9]: Earth and related environmental sciences

X Associated discipline[9]: Mathematics and computer sciences

X Associated discipline[9]:Physical, chemical and biological sciences

G Engaging with Civil society and policy makers

11a	**Did your project engage with societal actors beyond the research community?** *(if 'No', go to Question 14)*	X ○	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

[9] Insert number from list below (Frascati Manual).

X Yes- in determining what research should be performed X Yes - in implementing the research X Yes, in communicating /disseminating / using the results of the project		
11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ X	Yes No
12. Did you engage with government / public bodies or policy makers (including international organisations)		
○ No X Yes- in framing the research agenda X Yes - in implementing the research agenda X Yes, in communicating /disseminating / using the results of the project		
13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers? X Yes – as a **primary** objective (please indicate areas below- multiple answers possible) ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible) ○ No		
13b If Yes, in which fields?		

Agriculture Energy Environment Information Society Public Health Regional Policy Research and Innovation Space					

13c If Yes, at which level? X Local / regional levels X National level X European level X International level	
H Use and dissemination	
14. How many Articles were published/accepted for publication in peer-reviewed journals?	**31**
To how many of these is open access[10] provided?	**12**
How many of these are published in open access journals?	**12**
How many of these are published in open repositories?	**0**
To how many of these is open access not provided?	**19**
Please check all applicable reasons for not providing open access:	
X publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available X no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access X other[11]: strategy to spread publications across journals and communities	
15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box). — Trademark	**0**
Registered design	**0**
Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?	**0**
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑ Increase in employment, or	❑	In small & medium-sized enterprises
❑ Safeguard employment, or	❑	In large companies
❑ Decrease in employment,	X	None of the above / not relevant to the project
❑ Difficult to estimate / not possible to quantify		

[10] Open Access is defined as free of charge access for anyone via Internet.

[11] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	X

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

X Yes ○ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

❑	Press Release	X	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	X	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	❑	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

X	Language of the coordinator	X	English
❑	Other language(s)		