IRENA
International Renewable Energy Agency

# IMPLEMENTATION STRATEGY FOR A GLOBAL SOLAR AND WIND ATLAS

IN PARTNERSHIP WITH CLEAN ENERGY MINISTERIAL MULTILATERAL SOLAR AND WIND WORKING GROUP

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# 1 Collaboration in the context of the CEM Multilateral Working Group on Solar and Wind Energy Technologies

In July 2009, Major Economies Forum leaders met to prepare for the COP 15 Copenhagen Conference that took place later that year. At this occasion the Major Economies Forum Global Partnership for low carbon and climate-friendly technology was founded and Technology Action Plans (TAPs) for ten key low-carbon technologies were drafted. At that juncture Denmark, Germany and Spain took on the responsibility for drafting TAPs for Solar and Wind Energy Technologies. The TAPs were then consolidated and presented at COP 15 that would later take place in December in Copenhagen.

Since then, countries that led the development of the Action Plans have started their implementation. During a first Clean Energy Ministerial (CEM) in July 2010 in Washington on the invitation of Steven Chu, US Secretary of Energy, several initiatives were launched. Denmark, Germany and Spain took the lead in the implementation of the TAPs for Solar and Wind Technologies and initiated the Multilateral Working Group on Solar and Wind Energy Technologies (MWGSW). Several countries joined the working group in Washington and afterwards.

In two international workshops in Bonn (June 2010) and Madrid (November 2010) and in meetings during the first CEM in Washington (July 2010) and the second CEM in Abu Dhabi (April 2011) the Multilateral Working Group made substantial progress in the two initial fields of action: (I) the Development of a Global Solar and Wind Atlas; and (II) the Development of a Long-term Strategy on Joint Capacity Building.

Discussion papers on the respective topics were elaborated involving the Working Group’s member countries as well as various international institutions. This led to concrete proposals for several pilot activities in both fields of action. After further specifying key elements of the suggested projects in two expert workshops in spring 2011, the Multilateral Working Group convened for a third international workshop in Copenhagen, Denmark, to discuss the project proposals and explore options for joint implementation. Subsequently, the implementation phase for different pilot projects within both areas of activity started – work packages to create the Global Atlas for Solar and Wind Energy were set up and a steering committee overseeing the implementing organisations and partners was formed. The Multilateral Working Group moreover started some pilot projects in the area of capacity building.

The Working Group met in Berlin on 22 November 2011. In addition to progress reports of the different pilot projects, new areas of activity were discussed and elaborated.

The next meeting of the working group will take place in Madrid in spring 2012.

The following document represents the draft project proposal for implementing a Global Solar and Wind Atlas. This initiative integrates previous global multilateral initiatives.

# 2 Partnership

## 2.1 Lead countries

## 2.2 Participating countries

## 2.3 Partner organisations

## 2.4 Research institutes

## 2.5 NGOs

## 2.6 Private companies

# 3 Management structure

The programme involves four different categories of partners:

- The lead countries of the CEM Multilateral Working Group on Solar and Wind Energy (Denmark, Germany and Spain) in their role of financially contributing to the programme, or providing significant in-kind contributions through their ministries and the involvement of their national institutes;
- The international institutions, initially UNEP and IRENA, providing financial and in-kind resources to the process. Those partners interface with their member states to ensure the end-users needs are fulfilled, and the programme has a maximum impact supporting the deployment of renewable energy technologies;
- The data- and technology-solution providers, which are technical institutes and private or public organisations, owners of scientifically recognised datasets or processes, which will technically contribute to the process, providing finance is made available;
- The end-users, who initially comprise representatives of committed Member States; this group might be extended to NGOs and financing institutions and other stakeholders in a second step. The end-users group provides recommendations on the services they require, gives access to information layers they may have, and supports the definition of capacity-building programmes enabling the collection of higher resolution information and the creation of knowledge centres on renewable energy potentials assessment.

These four groups need to be strongly integrated in order to maintain a high level of leadership throughout the process. A light, compact and decentralised management structure is required to account for the various types of contributions involved. The proposed structure is summarized in Figure 1.

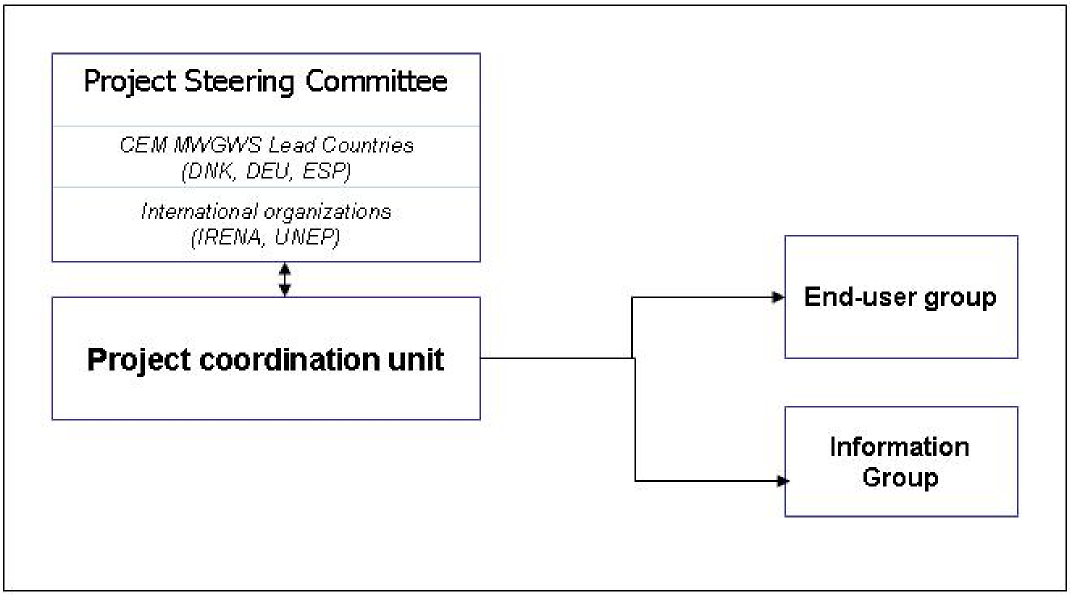



*Figure 1: Open and inclusive governance structure.*

The **Steering Committee** guides and follows the implementation of the programme, agrees on a strategy on an annual basis, assesses the available financing options, monitors the membership within the various groups, and establishes the mechanisms to ensure the highest quality output and outreach from the programme. This body should remain small and efficient. It includes the main contributors to the programme in terms of financial resources, or in-kind resources. It comprises the CEM MWGSW lead countries, the international organisations committing resources to the programme, and the institutes mandated by the leading Member States to deliver the programme. Additional membership to the Steering Committee should be agreed by the existing members, on the basis of committed resources.

The **project coordination unit** takes over secretarial functions for the Steering Committee meetings and for the meetings of the project participants in close liaison with the project steering committee. It ensures continuous project coordination, e.g. via coordination with the lead institutions of the respective work packages. It can function as a focal point with regard to the end-user group and the information group.

IRENA organises the liaison between the **end-users group** and the Steering Committee for the implementation of the first work stream (see section 7). The organisations will jointly organise dialogue with the end-users through the creation of an end-user group initially involving committed Member States. Once the programme will be operational, the end-users group may be extended to include other major stakeholders, in accordance with the Steering Committee. The end-users group will be gathered through workshops and working group meetings, with three major tasks: defining the end-user requirements for the system, gathering existing datasets and including them within the system, collecting guidance for how to improve the measurement network, and developing capacity building activities with the **information group**. In accordance with the Steering Committee, IRENA **will** develop the concept of capacity-building activities to be developed between the end-users group and the information group.

The **information group** is in charge of collecting the information and providing the data and methods, for the implementation of the second and third work stream (see section 7). The group consists of the leading global institutes and private organisations within the area of renewable potential assessment that are willing to significantly and concretely contribute to the programme implementation. The information group’s activities can be supported by the contributions of the Steering Committee members. The membership is agreed by the Steering Committee, on the basis of the technical value of the partnership, the committed resources and significance of the proposed contribution.

## 3.1 Financing

Most of the technical work is implemented through in-kind contributions from the research institutes and international organisations, financed through their Member States. Direct financing is limited to organising the joint activities.

# 4 Added-value of a Global Atlas for Solar and Wind Energy

An energy system based on a high share of wind and solar energy resources needs to harvest solar radiation and wind when and where they are available. This requires factoring for different uses of the available space, be it on land or at sea. Spatial planning instruments help to identify the potential of different renewable technologies and their most suitable locations.

The investment timelines in the energy sector are of the order of decades, and the transition of a country's energy mix and energy system requires long-term planning over time (30 to 50 years). To be able to thusly plan investment and successfully transition requires an accurate knowledge of the renewable energy potential.

Combining planning strategies over space and over time in this way enables to define 'where' and 'when' a specific renewable energy source can be deployed. For governments, such approach enables to conciliate renewable energy deployment with other human activities and environmental protection, to plan the necessary infrastructures, to put in place market incentives, and the necessary policies to eventually develop and implement their national energy strategy.

In turn, transparent planning and policies at the governmental level can provide investors and the renewable energy industry with confidence in their own investments and undertakings. That then enhances market certainty, lowers the investment risks, and supports and eases access to capital. The private sector would also benefit from accurate data on a country or region's renewable energy potential, in order to prospect new markets or propose new solutions.

The value of the Solar and Wind Atlas as a global decision-making instrument is equally immense; it can direct and enhance cooperation on global scenarios and strategies. At a continental level, energy systems like electricity grids are interconnected or inter-related, and an accurate picture of resources is required for political coordination. The same is true at national, regional and local level. Each geographic scale requires a different data interpretation and a different approach.

## *4.1 Building on the existing works*

The concept of spatial planning to locate and map renewable energy resources is not new, and a vast amount of work has been conducted to evaluate the potential of the various renewable energy resources. Some areas of the globe are extensively covered, but a large part has scarcely been investigated, in particular developing countries. No system gives access to accurate, reliable and consistent information on renewable energy resources over the entire globe.

Existing data on solar and wind energy resources are often narrowly focused. Some provide information about physical information such as insolation or wind speed. Others focus on economic and policy frameworks, such as support mechanisms. Different systems, websites and maps use various data sources, services and various models with various resolutions and geographic coverage. Most maps are resource maps, and the definition of the potential varies from product to product. In short, existing data is inconsistent, incompatible and limited.

Computers today even allow for the simulation of large geographic areas with meteorological models initialized by reanalysis data. It is possible to simulate the entire world with high resolution using a mesoscale model and a medium-sized cluster of computers. However, there is a lack of detailed validation of these simulations. It is important for the Global Atlas for Solar and Wind Energy to build the method on open, transparent and validated methodologies.

Lastly, data consistency is crucial to compare and develop strategies, take joint decisions, and speak a common language. Those are the reasons for the development of a global system of this kind. Starting with wind and solar, the vision underlying the Global Atlas for Solar and Wind Energy is to develop a system capable of consistently addressing each geographic scale, for each renewable energy technology.

The Atlas should act as a host to the ongoing solar and wind energy networks and activities at a global level. Past and ongoing work has already generated a vast amount of knowledge. The wind and solar energy communities are well structured and involved in large and high quality initiatives. The Global Solar and Wind Energy programme intends to build on existing initiatives, adapt their outcome to suit global aims, and expand their international representativeness.

To that end the geographic representativeness of this work is a key success factor. Only a truly international project taking into account the various relevant networks and institutes will convince the governments of its usefulness and quality.

# 5 Strategic positioning of the Global Atlas

The potential spectrum of end-users for the Global Atlas for Solar and Wind Energy ranges from those who want to improve their general knowledge about renewable energy to investors and developers who perform siting studies and design systems. Each target audience has its own requirements in terms of data accuracy and services. Within the scope of the Global Atlas, IRENA and UNEP together intend to organise a series of end-user workshops in order to further refine the system specifications.

## 5.1 Global Atlas for policy-making

**Policy-makers and public authorities** in charge of planning their energy future are looking for synthetic maps of technical and economic potentials. Besides the potential, the corresponding economic, legal, regulatory and policy information would also be highly valuable. Suitable areas, expectable energy production and energy and investment costs are amongst the main parameters of high interest for this group of stakeholders.

The information can be used for spatial planning, policy making or defining support schemes, based on selectable land use assumptions. Those processes provide confidence and stability to the private sector for investing in the country. Uncertainties in the data and methodology should be documented, and their impact on decisions should be looked into. Depending on the decision-making level, different information scales might be needed, from the regional to the global level.

### 5.1.1 Use of the Global Atlas

Figure 2 shows the theoretical cascade of steps for the successful development of renewable energy technologies. Renewable energy markets need appropriate and stable political and economic framework conditions. The cascade starts with analysis of the available resources. These can include maps of wind speeds, annual solar irradiance (a measure of the amount of solar energy that arrives at a specific area) or available biomass. This information can be combined with data on available area necessary for the deployment of different technologies (e.g. roof or land area for photovoltaic cells, land area with suitable irradiance levels or wind speed for concentrating solar power and wind power) to determine the technically feasible resource potential of different technologies.

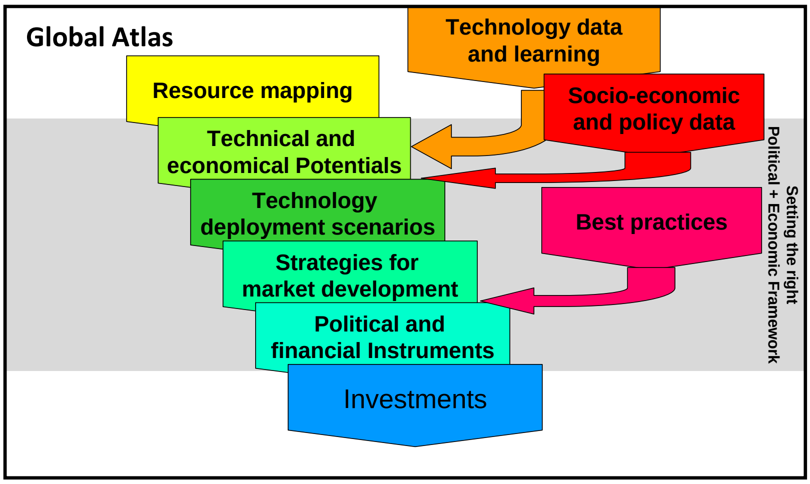



*Figure 2: Positioning of the Global Atlas in the theoretical cascade of steps for policy making towards market uptake.*

To what extent this technical potential can be exploited in practice will depend on the structure of the existing energy system (available flexibility in generation and demand, state of the transmission grid etc.) as well as the anticipated development of energy demand. By combining the information on renewable resources and system flexibility, the possible contributions of different renewable energy technologies to an area can be assessed. In addition, more general energy policy targets (climate change mitigation, energy security, energy affordability, green growth etc.) will determine the adequateness of the different technologies for a given area.

This selection of suitable technologies is the first important step in strategy development. The next step is the development of scenarios that provide possible pathways for future deployment of different technologies, price impacts, and data on the share of energy supply different technologies can provide under certain boundary conditions. The scenarios are the basis for strategic decisions, such as which technologies to support first, and how and where to develop them. Based on these strategic decisions, instruments for market introduction can be designed, such as institutional reform, streamlining of administrative procedures, feed-in tariffs, soft loans, clean development mechanisms, etc. These instruments will set the framework conditions for investors to invest in renewable energy technologies. Once the framework conditions are set, investors can begin providing the necessary investments to support such projects.

## *5.2 Global Atlas for market screening*

**Investors and developers** will benefit from the Global Atlas through the clear positioning from national governments on their investment plans derived from the Atlas as well as direct access to the synthetic overview of the market potentials provided by the Atlas, before engaging in their own detailed studies. The data provided by the Atlas can be used for market prospection, by cross-checking the renewable energy potential and the available socio-economic conditions, laws and regulations, and policy data, including the updated financial supports and tax incentives.

The Global Atlas will also generate a trusted data source developed by the leading scientific institutes. The level of confidence in the Atlas' output can help investors raise money for more detailed assessments by commercial service providers. The Atlas does not intend to take over the business of private companies involved in the field of high-resolution resource assessment, as it does not intend to provide bankable information at the spatial and temporal resolution required for project development. Rather, the Global Atlas will be kept open to participation of the private sector of resource assessment. Indeed several private companies may have generated information with a high level of quality and scientific transparency that can be included in the Global Atlas. It is planned that the Atlas should be open to the participation of the private sector, which can participate in using and enhancing this infrastructure by providing data and building tools which exploit the data.

### 5.2.1 Use of the Global Atlas

Since resource data is the basis of both a country's general energy strategy as well as an investor's investment decisions, access to the data is crucial. Easy access to trusted ('bankable') data is thus likely to significantly help the development of renewable energy technologies. Different levels of resource data are needed at different steps of project development.

In the initial phase (pre-feasibility and feasibility) more coarse data is sufficient. Annual averages are often enough for a first assessment of a project. As the development of a project continues, more detailed data will be needed, but at that stage more financing may also become available for more advanced projects. An easily accessible Global Atlas for Wind and Solar Energy can help in the very early stages of development to get projects started.

## *5.3 Global Atlas for general awareness*

**Educators and the interested public** may require basic information on wind and solar resources, particularly valuable in countries with little practical experience with renewables. The information in the Atlas would allow for the cross referencing of best practice examples, capacity-building initiatives or (micro-) finance options, with online tools developed for demonstration purposes.

# 6 Outcome

The final outcome of this programme is a collaborative internet-based Geographic Information System (GIS). The information will not be physically stored on a single server. The system will use the capabilities of the internet to operate in a transparent manner for the end user. Depending on the user's request, the system collects the needed information on various places over the internet to provide its service. The information flux can be encrypted to ensure security. In such case, the intellectual property of the information is not transferred. The table below lists most of the existing international initiatives addressing the various end-user groups.

| **Users** | **Needs** | **Existing services and tools (samples)** |
|---|---|---|
| Policy makers | • Resource maps and the numbers behind them<br>• Tools for potential and policy related analysis<br>• Socioeconomic data<br>• Global homogeneous resource data sets for global policy analysis | • SWERA<br>• PVGIS<br>• Solar-Med-Atlas<br>• REN21<br>• RES Legal, PV Legal |
| Investors | • Site specific data (for small investments and feasibility studies)<br>• Maps for site selection<br>• Aggregated resource data and socio-economic/policy data for the development of new markets | • MESoR<br>• Various commercial service providers |
| Educators, general public | • Convincing data maps<br>• Aggregated information, e.g. on country potentials<br>• Tools related to renewable energy systems, e.g. yield assessments, replaced conventional energy | • SWERA<br>• PVGIS<br>• REN21<br>• Reegle |

*Table 1: Outline of user needs for different target groups.*

## 6.1 Open architecture

The aim of the Global Atlas is to build on existing partnerships and develop an inclusive, open system that connects the major databases and information sources. The Global Atlas aims at creating as little new information as possible. Instead, the information will be gathered through partnerships and the system will be based on open system architecture. This calls for use of state-of-the-art collaborative architecture that provides an easy and unified way to access the different existing data sets from various sources and portals.

Collaborative information systems link multiple sources of data and provide it to users through a single, comprehensive interface, which acts as a broker of the data. The data can be accessed in different ways through a web interface or web services, and then used directly in various software applications.

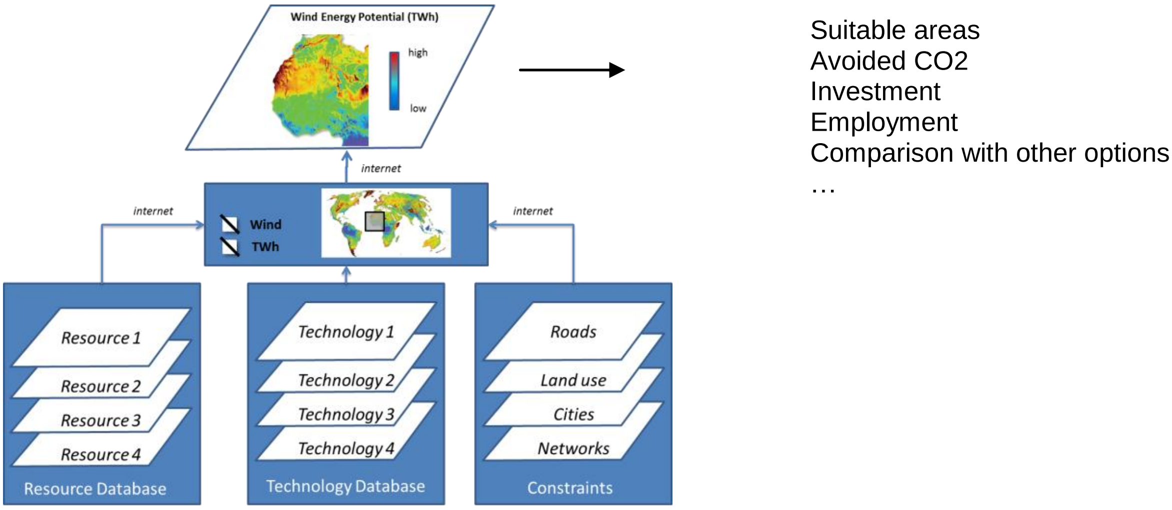



*Figure 3: Schematic overview of the final system. The system exploits several databases to compute the end-users requests. In this example, the resource and constraints databases are located on different internet servers. The information is collected through the internet-based GIS, computed and formatted by the system. The illustrations are not representative of the final product. The map used as illustration concept is downloadable on the 3Tier website.*

Different services can be provided, targeted to the various user-groups. The end-user needs will be assessed by UNEP and IRENA through dedicated workshops at the Member State level. The services could include:

- Technical potential analysis at any geographic scales (e.g. global, continent, region, country);
- Maps showing several renewable energy options using common physical units, showing potential synergies between technology options, and allowing to “zoom” into the maps;
- Real-time calculation of specific indicators, e.g. $CO_2$ reductions, total investment, market volumes, employment volumes. Such indicators will be calculated from existing methodologies (RetScreen, HOMER). All assumptions will be transparent and documented;
- Potentially, the ability to download maps in the electronic format that is compatible with standard GIS systems;
- Documented levels or ranges of uncertainty.

The process requires collecting different categories of information:

- Resource maps, with documented methodology and uncertainty levels;
- Technology information, i.e. technical specificities of the technology, enabling to evaluate the amount of available energy;
- Technical information, such as the connection points to the electricity grid;
- Policy information enabling the user to select areas with the most promise, and avoiding the areas excluded by the legislation;
- Socio-economic models, providing information to the decision-making process by evaluating the impacts of the renewable energy production in terms of reduced $CO_2$, employment, and market volumes.

## 6.2 Restrictions of use

The datasets comprising the Global Atlas will be created to suit the needs of the policy makers and energy planners. Through dialogue with the Integrated Assessment Model (IAM) community the required specifications of the Global Atlas datasets will be determined.

The datasets will give both spatial and temporal variation of resources, which account for resource variance across a geographic location and time. Temporal variation of resource can be of particular importance when considering the energy mix in a region. For example daily or yearly variation of a wind resource may be complimentary to other renewable energy sources.

It is expected that geospatial information system (GIS) applications will be one of the significant destinations of the Global Atlas datasets. Location of resources and their relationship to population centres, electrical transmission grids, terrain types, and protected land areas are likely to be important parts of the resource assessment beyond general statistics.

The data from the Global Atlas will need to be complemented by site specific resource analysis for project developers at the stage of the final investment decision, as the accuracy of the resource data and the level of verification will not be able to meet the same standards obtained via dedicated resource assessment. Its purpose regarding the target group of investors is to enable them to make an informed decision on the site where such detailed resource assessment is to be conducted and to raise capital for this purpose.

Validation and uncertainty calculation is crucial to the production of valuable information, therefore extensive and detailed validation work should be done. The validation should cover as much geographical area and different types of terrain as possible to be representative. This work requires a significant effort. The scope and extension of the validation task will be limited by the available resources and the existence of good quality data in different regions.

## 6.3 From resource to potential

As yet, no global, scientifically agreed methodology aiming at evaluating the renewable energy potentials form the resource has been designed. Within the framework of the Global Atlas for Solar and Wind Energy, consultation with the scientific community will take place to help develop an agreed methodology.

A large amount of information is required to convert data on renewable energy generation potential into concrete socio-economic indicators, such as the employment volumes, market volumes, investments, and reduced $CO_2$, to be used as a preliminary impact assessment supporting the deployment of renewables.

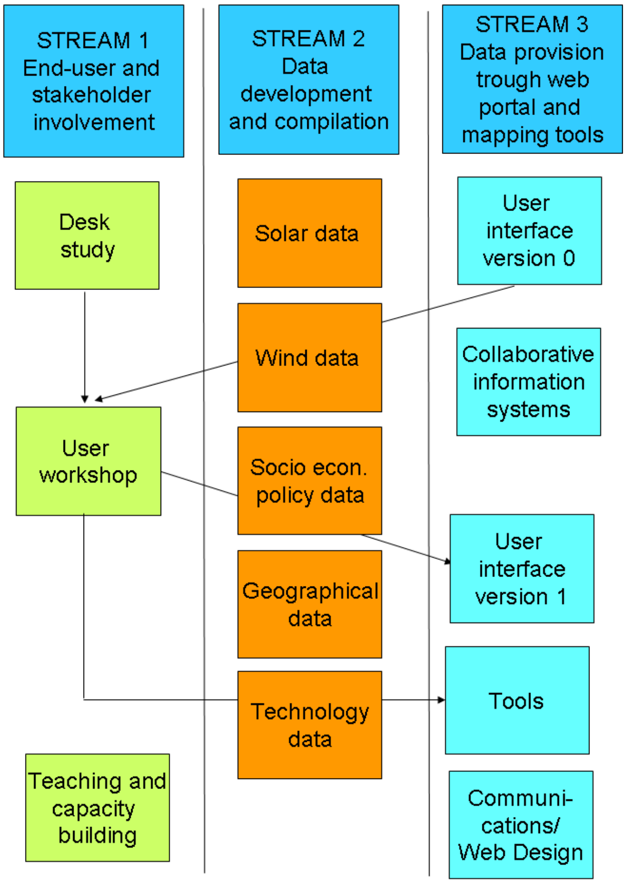
As a start, a first set of simple assumptions can be made, based on the literature. In the future more complex cost models could be linked to the system, providing more precise information. Some areas are still open fields of research, leaving open the possibility of increased collaboration and further research. During the first year, the approach and strategy towards the integration of socio-economic information should be formulated.

NREL is compiling available reports on the economic, environmental, social, and energy system impacts of wind and solar (and other renewable energy) systems for the Clean Energy Ministerial countries and can share these reports and related information to help build these socio-economic databases.

# 7 Outline of working streams and approach

## 7.1 Work structure

The work will be organised in three main streams.




The first work stream focuses on the definition of the end-users' requirements through the organisation of regional workshops, and the creation of an end-user group. As a result, the stream is bidirectional, getting information from the users (e.g. assessing their needs or getting feedback on implemented parts of the Atlas) and gathering information in the form of training and capacity building elements.

The second work stream focuses on the data that will be available within the Global Atlas. Each of the work packages will analyse which data is available and how it can be made accessible with the Atlas. If the information does not yet exist, a gap will be left in the system. When needed, high resolution quality data will be calculated, complementing the dataset with accurate data. This approach enables the delivery of results, even partial, on a short notice. The quality should be assessed and improved by through the repetitive calculation and checks of an iterative process.

The third stream focuses on the creation of a backbone of collaborative information systems and the set-up of user interfaces to gain access to the information provided by the Atlas. The interface and tools are defined in partnership with the end-users involved in the first work stream.

A fourth work stream will consist of managing activities. This is first of course the management of the work streams as well as activities linking these activities to other activities within and outside the Clean Energy Ministerial process.

## 7.2 Partnerships

| | |
|---|---|
| **STREAM 1: end-user and stakeholder involvement** | |
| **1.1** | End-user needs assessment: identify the members of the end-users group, and a first set of end-user needs, for future discussion input to the technical definition of end-user requirements. |
| | *UNEP, IRENA, REN21, Prognos, WindGuard, DLR* |
| **1.2** | User Workshops (2): further refine user needs by involving representatives of end-user groups in end-user workshops and the creation of an end-user group with committed countries. |
| | *IRENA, UNEP, REN21, Prognos, WindGuard* |
| **1.3** | End-users' requirement translation into system and data requirements. |
| | *IRENA, DLR, Information Group* |
| **1.4** | Dissemination and Capacity Building |
| | *UNEP, IRENA, REN21* |
| **STREAM 2: data development and compilation** | |
| **2.1** | Provision of global solar radiation data. |
| | *DLR, JRC, CENER, NREL, NASA, IRENA, UNEP* |
| **2.2** | Wind resource data |
| | *RISØ/DTU, NREL, CENER, IRENA* |
| **2.3** | Socio economic and policy data |
| | *UNEP, REEEP, REN21, IDAE, IRENA, Res Legal* |
| **2.4** | Collect geo-referenced data and make the data available for the Global Atlas |
| | *DLR, UNEP, Mines ParisTech (GEOSS), Risoe DTU, NREL* |
| **2.5** | Renewable energy technology data |
| | *IRENA, NREL, Risoe/DTU, Mines ParisTech, (IEA), CENER* |
| **STREAM 3: data provision through web-portal and mapping tools** | |
| **3.1** | Develop an easy to use user interface which can also be used as a collaborative platform. |
| | *DLR, NREL,IRENA, CENER, GeoModel Solar, UNEP, MASDAR* |
| **3.2** | Define backbone collaborative information systems and infrastructure for the Global Atlas |
| | *Mines ParisTech* |
| **3.3** | Tools for data handling |
| | *DLR, NREL, JRC, GeoModel Solar* |
| **3.4** | Dedicated web design and communications of the web tool/user interface |
| | *IRENA* |
| **4.0** | Management of the implementation process |
| | *DLR, IRENA* |

# Annex 1: Note on solar resource assessment

Solar radiation, which is the radiant energy emitted by the sun, is highly variable in time and space. The annual sum of incoming solar radiation can change significantly from year to year due to varying weather conditions. Figure 5 shows that if a project is based on short term measurements of only a year or two, the estimation of the resource may be very distant from what can be expected at this site in the long term.

In addition, resource assessments have to be site specific. In figure 6, the variability patterns are quite different each year and the deviation changes over short distance. This means if one knows the deviation of data for the current year to a long term average on one site, one cannot transfer this result to the next site.

These two examples show two important features of good solar energy resource assessment: it needs to be based on long term data (at least 10 years) and must have a high spatial resolution of a few kilometres. Satellite based resource assessments can provide both: satellite raw data is archived for many years and data from meteorological satellites in geostationary orbits has a very high spatial resolution.

The basic principle of satellite based assessments is that if the atmospheric conditions are known then the transfer of the solar radiation from the top of the atmosphere to the surface can be modelled. Information about atmospheric composition is taken by remote sensing or global weather models. The most variable factor are clouds, this information is derived from geostationary meteorological satellites in high spatial (1-5 km) and temporal (15-30 minutes) resolution. With these information maps a high resolution can be calculated.

Providing solar radiation information on internet portals has shown to be very beneficial as experiences from the SoDa portal, PVGIS and various commercial providers show. The integration with geoinformation as in the Geospatial Toolkits from SWERA has been very useful in the SWERA countries. Solar data that will be integrated into the portal should be based on open and transparent methodologies and been benchmarked according to accepted practices in the solar resource community, as e.g. in the IEA SHC Task 36 and 46 or the MESoR project within the EU.

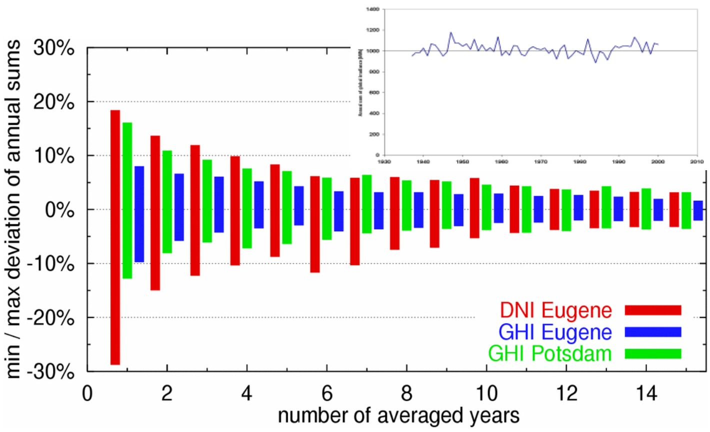



*Figure 4: Annual variability of solar radiation. The top right figure shows the annual sum of global horizontal radiation in Potsdam for 63 years from 1937 to 2000. The big figure shows how moving averages from one year to 15 years compare to the long term average of two data sets in Potsdam (Germany) and Eugene (USA). The graph shows the maximum and minimum deviation. The graph shows that in order to stay within a margin of ±5% at least a ten year average is needed.*

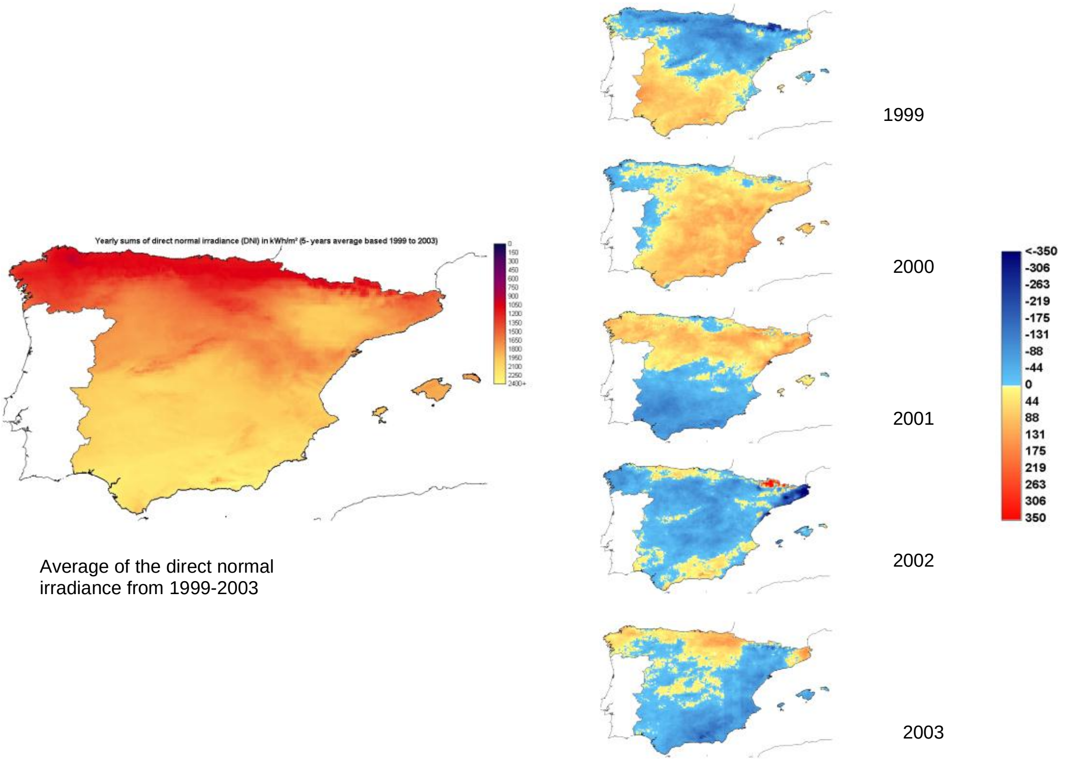



*Figure 5: Spatial variability of the solar radiation. The left figure shows a five year average of direct normal radiation in Spain. The figures on the right show the annual differences to this five year average. The patterns are quite different for each year and the values change at short distances.*

# Annex 2: Note on wind resource assessment

The current practice of global energy modellers is to use coarse resolution reanalysis datasets. This has the serious shortcoming that the wind energy resource is underestimated, as small scale variability of wind is missing. This missing variability is responsible for a large part of the wind resource not being captured in the analysis.

The Global Wind Atlas will provide data at high resolution for the whole world, using a unified methodology, and will provide an uncertainty estimate to factor for potential errors or gaps in the data based on use of a number of input reanalysis datasets and methodologies, including selective mesoscale modelling areas and satellite retrieved winds offshore. Crucially, the method will employ microscale flow modelling to calculate the small scale variability of winds, and thus capturing the sizable wind resource missed by the current methods.

- The global wind atlas will account for the effects of high resolution but not produce a high resolution map for site specific application.
- The value of global wind atlas is at the county /region aggregation level, for upscaling and use in energy integration analysis.
- The uncertainty for a specific site is higher than a dedicated wind resource assessment for a specific site. Uncertainty assessment, uncertainty maps and analysis result will be given.
- The project applies trusted data, transparent of methodologies and verification from leading research institutions.
- Capacity building is a central value in the project, in both calculation and application of the data. Therefore document guides will be available for download.

The term wind resource assessment covers a very broad range of methods and many kinds of data. For example, the assessment can be based on *in situ* measurements taken at the location and as such pertain to the measurement location and height only, unless some kind of treatment of the measured winds is carried out. At the other end of the range, the assessment may be based on modelling, giving wind resource in three dimensions. However, the value of such model-derived assessment is limited without some kind of verification against measurements.

Wind resource in a broad sense is highly dependent on the measurement site and the period of time invested in measuring it. Within a certain world region we can pinpoint notable changes of the average wind speed not only from one point to another but also from different years of measurement, not taking into account the seasonal variability of this factor. Figure 4 shows the differences between average wind speeds measured in one month of February against others, for the whole Spain.

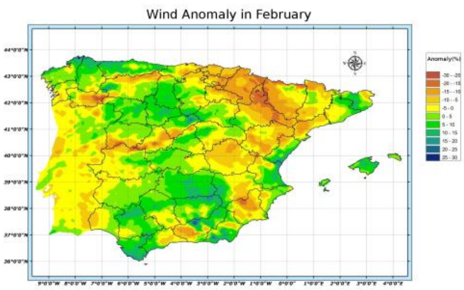



*Figure 6. February wind anomalies in Spain. Source: CENER*

Therefore the most valued wind resource assessment will feature a combination of measurement and modelling, using a generalisation step[1]. Wind resource assessments require a dense network of high quality and long term measurements. Where measurement data is missing, numerical methodologies are used.

The conventional numerical atlases use long term and coarse resolution atmospheric datasets to force mesoscale models, capable of modelling the atmospheric flow at scales ranging approximately from 100 km to 5 km. The method uses a generalization step, and microscale modelling. For the purpose of downscaling high-resolution datasets, surface elevation and roughness, data needs to be derived from global topography and land cover datasets.

### 7.2.1 Verification and uncertainty estimation

The schematic graph illustrates the expected uncertainty at different aggregation scales for different wind resource methodologies. The Global Wind Atlas methodology shows a low uncertainty for a wide range of scales, down to the county level (approximately 50x50 km region). Below this scale, approaching site scale wind resource estimation, the uncertainty rises significantly. Only dedicated site specific study methodologies can provide low uncertainty at site and small aggregation scales. However, the cost of such studies is not only prohibitive for a global mapping effort like the Atlas, but also exceeds its intended function. In contrast, coarse climate data provides aggregated wind resource data that has a high uncertainty even on very large aggregation scales, because of the missing spatial variance in wind speeds. Data of this type is currently in use in the policy makers, energy planners, and IAM communities.

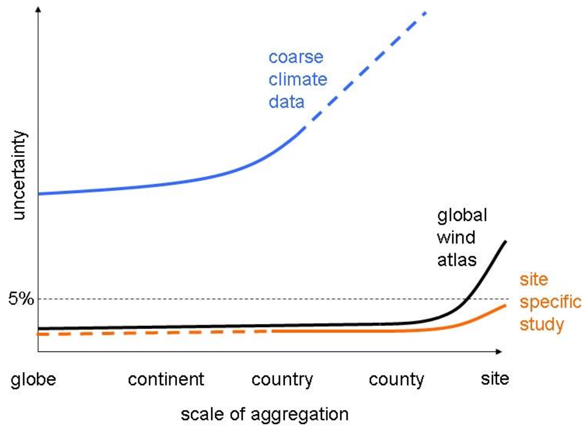



*Figure 7: Uncertainty of wind resource data as a function of different scales of aggregation. Schematic graph illustrating the uncertainty of wind resource data as a function of different scales of aggregation. The horizontal axis gives scale of aggregation, decreasing from left to right, from global to turbine site scales. The vertical axis gives uncertainty and a value of 5% is given as reference level of uncertainty. The expected uncertainty is given for three methodologies. The 'coarse climate data' represents the current source of global resource estimation used by global energy planners. The 'site specific study' represents state of the art resource studies conducted by, among others, commercial companies. The 'global wind atlas' represents the methodology designed to optimize usefulness for global energy planners whilst being economical to produce*

The verification processes involving mesoscale modelling will be conducted to assess the uncertainty that is introduced by the main method which skips the mesoscale modelling process. It can be expected that the level of uncertainty will depend on terrain type and climate. An optimized sampling of the diversity of the terrain and climate types around the world, via careful selection process, can be used to estimate the uncertainty globally.

[1] See: I. Troen, E. L. Petersen (1989). European Wind Atlas.

Within this framework CENER has been working since 2005 with the SKYRON mesoscale model developed by the University of Athens. It provides excellent validation results in very different parts of the world both in onshore and offshore domains. Right now this validation process has been carried out in three different continents. A verification method involving remote sensing of surface winds over the ocean can be used to assess the uncertainty in selected offshore (near coast) areas. Again the selection of the verification areas should reflect the diversity of coast type and climate.

Uncertainty estimated can also be established via the use of several reanalysis datasets. The idea is that where there is disagreement in reanalysis datasets, there may be a high uncertainty in the large scale climate. Having a system designed to allow the use of several reanalysis datasets will keep open the possibility of introducing new datasets as they become available. However, the capability of updating the Global Wind Atlas with these new datasets may have implications for the dissemination platform and create a burden of recalculation.

The final outcome could have the following characteristics:

- Simulation period in the range 10 years – 20 years (to avoid non-homogeneity of reanalysis).
- Only annual and monthly average values (no time series) of:
  - Wind speed
  - Weibull parameters
  - Energy density
- Fixed heights above ground level: 3 heights for small, medium and big wind turbines.
- Map or information about uncertainty related to type of terrain/latitude/etc.

### 7.2.2 Data sources

The data sources will include data about the atmospheric state and flow (reanalysis datasets), and data about Earth's surface topography. An atmospheric reanalysis blends the continuity and breadth of output data of a numerical model with the constraint of vast quantities of observational data. The result is a long-term continuous data record. Four new products are proposed for use in the Global Wind Atlas:

- ECMWF reanalysis (ERA) Interim
- NASA Global Modelling and Data Assimilation Office (GMAO) Modern Era Retrospective-Analysis For Research And Applications (MERRA)
- NCAR Climate Four-Dimensional Data Assimilation (CFFDA)
- Global Forecasting System (GFS) stored data.

# Annex 3: Note on collaborative information systems

Numerous platforms are disseminating renewable energy products. They are based on the effort of various actors such as companies, governmental agencies or research institutes, and rely on different strategy targets, goals, timelines and various funding mechanisms.

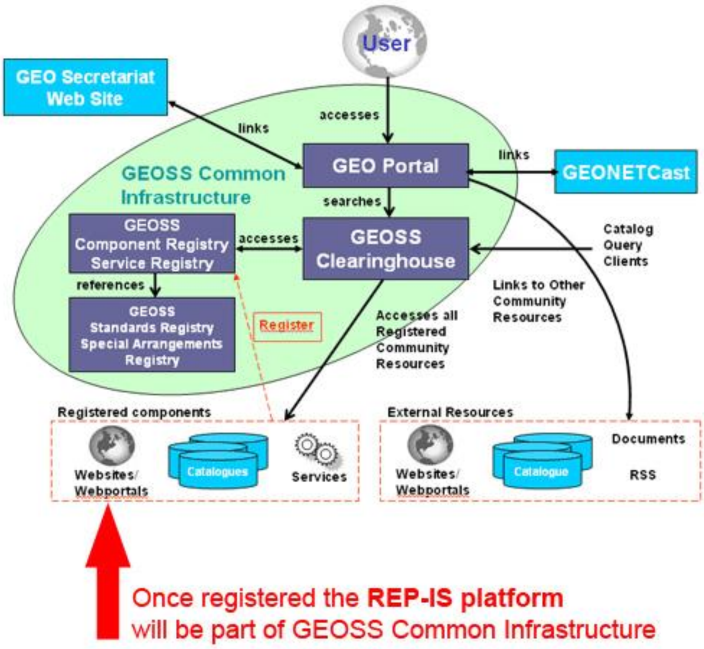
In the framework of a Clean Energy Ministerial project, a unique chance is given through the Global Atlas for Solar and Wind Energy to gather a high level consortium of potential renewable energy data providers.

To help Renewable Energy data providers to choose the best possible dissemination strategy there is an existing international initiative called GEO (Group on Earth Observation) that is constructing GEOSS (Global Earth Observation Systems of Systems) on the basis of a 10-Year Implementation Plan for the period 2005 to 2015. The Plan defines a vision statement for GEOSS for the benefit of nine “Societal Benefit Areas” including: disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.

Following the strategic and technical recommendations of GEOSS will ensure the Global Atlas for Solar and Wind Energy is a key player and contributor for the Energy SBA of GEOSS.

Beside recommendations, guidance and expertise, GEOSS has set-up an infrastructure called the GEOSS Common Infrastructure (GCI) that allows the user of Earth observations to access, search and use the data, information, tools and services available through the Global Earth Observation System of Systems. The infrastructure consists of five main elements:

- The GEO Portal
- The GEOSS Clearinghouse
- The GEOSS Components and Services Registry
- The GEOSS Standards and Interoperability Registry
- The Best Practices Wiki




GEOSS interoperability emphasizes the use of non-proprietary standards, with preference for formal international standards. Among the existing standards recommended by GEOSS that should cover the Global Atlas’s dissemination’s needs, the ones provide by the Open Geospatial Consortium (OGC) are of particular interests. The partial list includes:

- Web Map Service (WMS) enables requests for geo-registered map images from one or more distributed geospatial databases over the Web;

- Web Feature Service (WFS) allows feature-level geospatial data to be published on the web;
- Web Processing Service (WPS) allows geospatial computational service to easily be deployed on the web;
- Catalogue Service for the Web (CSW) enables the cataloguing process of metadata for search and discovery purpose.

One of the main advantages of a distributed collaborative information system is that the databases in the systems can stay with the data providers. There they can maintain the database to keep it up to date and ensure their own intellectual property rights on their data as the data is not given away to a central facility but only accessed through a networked system.

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