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Name, title and organisation of the scientific representative of the project's coordinator	Prof. Abdulnaser Sayma Professor of Energy Engineering City University London Tel: +44 (0)20 7040 8277 E-mail: a.sayma@city.ac.uk Project website address: www.omsop.eu

Abstract

The OMSoP project aims to demonstrate and optimise a micro power generator based able to produce electricity from the sun at a competitive price. The technologies of choice are parabolic dish for the solar energy collection and gas turbine for the heat to mechanical work energy conversion. Previous deliverable reports have shown the design, development and testing of certain components and, in due date, more information about system demonstration and testing will be provided.

This report presents the first phase of the techno-economic feasibility analysis of the OMSoP technology. The economic tasks of OMSoP aims to identify the areas which are likely to constitute true markets for the technology and, for them, optimise the system so that the cost and revenues are highest. This will enable the sustainability of the newly born industry in as far as the customer is favoured by costs and environmental impact and so is the technology provider which is able to develop a business in a non-subsidised scenario.

The structure of the report is as follows. First, some consideration about the history of dish Stirling technology is presented. This was the first technology to address the micro generation of renewable electricity with a concentrating solar thermal system. Numerous research centres have contributed to the technical development of these systems which, then, several companies have tried to deploy to the market. Unfortunately, none of these attempts have been successful to date. On the contrary, all the experiences so far have ended up in bankruptcy events.

A second section of the report presents a mehodology developed by the consortium to identify potential markets accurately. It is based on the so-called *index of interest (IoI)* which is an index measuring the lilkeliness of a given country to turn into a successful market for the OMSoP technology. This index can be interpreted as an absolute value for which a value of 1 indicates that there is no doubt that a market niche exists whereas 0 means that the country will show no interest in the technology. Nevertheless, it is also useful to use it in relative terms to see how dfferent countries compare when it comes to adopting different approaches to the analysis: willingness to take financial risks, comercialisation of individual stand-alone units or larger “farm-type” power plants made up of hundreds of units, etc.

A thirs section evaluates the certainty of the results. Three main sources of uncertainty are identified. First, the contribution of each one of the influential parameters used in the methodology (quality of grid, available solar energy…). Second, the input data used to feed the calculator. Third, the probability that the scenario or boundary conditions under which the analysis is performed change in the future. All these three sources of uncertainty are assessed and their potential impact on the results is dicussed in detail.

Finally, the numerical tool relies on a vast amount of information for each one of the candidate countries (i.e. countries considered in the analysis). This information is presented at the end of the report in a series of annexes that are structured similiarly. This similar organisation eases the comparison and enables the addition of new countries to the potential markets. With regard to these, it must be said that it has not been possible to consider all the countries in the world and hence just a reduced number of them have been considered. Nevertheless, in the process of selecting these countries, special emphasis has been put on trying to get a list where all the potential features were represented. In other words, countries with high and low insolation, stable and unstable socio-political conditions, large and small populations, even and uneven population and insolation distributions… The outcome of this approach is hopefully that the results obtained for the countries in the list can be extrapolated to countries with similar features.

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Context and structure

Context

The OMSoP project is co-funded by the European Union's 7th Framework Programme for Research and Development under grant agreement number 308952. It aims to provide and demonstrate technical solutions for the use of state-of-the-art concentrated solar power system (CSP) coupled to micro-gas turbines (MGT) to produce electricity. The project is structured in three complementary work packages, as indicated on the corresponding website (www.omsop.eu):

- WP1 System component development. This WP is aimed at developing and (separately) testing the components for a demonstration system in the range of up to 10kWe. It is expected that the acquired knowledge will enable the development of an optimised microturbine solar dish system for the power range up to 30kWe for future testing and deployment
- WP2 System design and integration. The system demonstration components developed in WP1 are integrated prior to performing the tests for the overall system. Data obtained will be used to feed back the design of optimised system components (WP1) and to inform the techno-economic assessment (WP3) to produce a final design for an optimum system for future testing and deployment.
- WP3 Techno-economic analysis. Thermodynamic and mechanical models of the system and its components will be developed and used for the analysis and design of both the demonstration system and optimised system in WP2. Further insight into future deployment will be gained by investigating concepts such as medium and long-term storage, hybridisation with other fuels and MGT power augmentation concepts. Market and cost analyses will also be performed in addition to uncertainty, sensitivity and risk studies. The above will provide crucial information to system and component development and will also provide insight into potential future deployment. Finally, a life cycle assessment will be performed to evaluate the environmental aspects and potential impact associated to the solar system.

Work package 3 is further subdivided into three tasks: market and cost analysis (T3.1), thermodynamic analysis and performance optimisation (T3.2) and life cycle assessment (T3.3). The first one, market and cost analysis, presents the following detailed structure:

- T3.1.1 Cost analysis.
- T3.1.2 Map of potential markets.
- T3.1.3 Uncertainty analysis.

With all this information in mind, this document presents the work developed in task T3.1.2 which, according to the Description of Work (DoW) constitutes milestone MS13 "*Potential markets for small scale solar-dish microturbines*" whose main findings are presented in deliverable D3.2 "*Report on potential markets for small scale solar-dish microturbines*". The information set forth in the market report will be later complemented with that coming from the cost and uncertainty analysis, giving place to deliverable D3.1 "*Report on system cost analysis*". Finally, both documents will be integrated into a final document delivered under title "*Final report on the economic appraisal of a 5-10 kWe dispatchable power generator*". This latter document will not limit to integrate the contents of D3.1 and D3.2 but it will also incorporate comparisons against other directly competing technologies (mainly PV) both technical and economic wise.

Structure

The document commences with a presentation of the very few mid-scale (>100 kWe) dish-Stirling power plants that have been constructed and operated to date. This is deemed necessary so as to understand how far the technology whose concept OMSoP has inherited has gone. The lessons learned from this experience are very valuable in order to identify the main technical hurdles and possibly to avoid making the similar mistakes. This first step will also allow to benchmark OMSoP with the sister technology.

The methodology employed to perform the market analysis is presented next. This is an approach specific to the project and thus aimed to incorporate those factors that are thought to influence the likeliness of a market success. Amongst these, the social, technological, economic and political features of each country and region are included.

The first step in the description of the methodology is the selection of the candidate countries. There are almost two hundred countries in the world so it is quite impossible to include them all in the analysis. Therefore, a selection of a little more than 10% has been done aiming to cover all the possible combinations of boundary conditions: countries that are sunny but under-developed, very wealthy states with little solar resources, countries with and without active renewable energy policies, countries with high and low degrees of electrification, etc. Overall, a total of twenty two countries from all over the world (all continents) have been selected.

Once the candidate countries are presented, the methodology is described. This novel approach is based on the weighted combination of a number of factors including social, political and financial-economic features of the country. These are assigned a scale based on different criteria and then each factor is weighted according to specific rules (which vary for stand-alone units and large facilities). The main figure of merit determining the interest of a certain country is termed *Index of Interest* ***IoI*** and it enables to set out a ranked list with which marketing activities can prioritised.

The analysis includes a first section where default values are assigned to both weights and influence factors. Nevertheless, in order to gain understanding about the most influential features of a country (for instance, business environment or legal stability) a sensitivity analysis is carried out, yielding very useful information about which socio-political occurrences might displace a country from the top of the aforecited list.

The analysis also takes into consideration that the markets are extremely dynamic. Unexpected socio-political changes take place continuously, regardless of their intensity, and more often than not they are not easily foreseen by the investors. This is easily observed in the volatility of oil prices[1] during the second half of 2014 (111.8 USD/bbl in June 2014) and first quarter of 2015 (58.10 US$/bbl in February 2015) or in the societal changes occurred in some countries like Egypt, Libya or Ukraine in the last years.

A last section of the report presents the annexes containing the technical documentation that is needed to valuate each country. This technical information is essential to provide the users of the report with the technical background to either discuss the assumptions and results of the methodology or to extend the analysis to new countries.

[1] Prices are given for Brent oil in the spot market.

Finally, a brief user's guide is provided for those interested in utilising the application developed for this task (Market Mapping Tool).

Introduction

The roots of the utility-scale dish-Stirling power plants: the Maricopa Solar Project

The Maricopa Solar Project, located in Peoria (Arizona, US), was inaugurated in January 2010, just one month after first start-up. The plant was developed by a consortium comprising sister companies Tessera Solar (owner and operator) and Stirling Energy Systems (technology developer) belonging to the Irish conglomerate NTR. Tessera Solar was an independent power company and developer, builder, operator and owner of large utility-scale solar power plants whose first large-scale dish-Stirling project was the 1.5 MWe Maricopa power plant. This facility was also the first demonstration project for CSP facilities using the parabolic dish as a concentrator.

Stirling Energy Systems, Inc. (SES) is a solar power equipment company with a Dish-Engine concentrating solar power generation (CSP) technology specifically designed for the utility scale solar power market. This SunCatcher® technology is based on a 38 ft diameter multi-faceted parabolic dish collector linked to a four double-acting cylinder power unit rated at 25 kWe. A picture of this system is shown in Figure 1.

Figure 1: SES' SunCatcher® unit.

A total of sixty SunCatcher units are arrayed in Maricopa over an area of 6 hectares, meaning a power production density of 24.7 W/m^2 of land. This arrangement is shown in Figure 2 where two phases are easily identified: twenty four plus thirty six.

As already discussed in deliverable D3.4, there are several features of dish-Stirling units that put them forward amongst the competing technologies, in particular photovoltaics but also other solar thermal technologies. For instance, with respect to PV, dish-Stirling's feature a higher solar to electric efficiency, peaking over 30% for the SunCatcher technology according to the company (31.25%) and with average values over 26%. In addition, this technology does not require AC-DC conversion units such as photovoltaic panels, which increases the net efficiency of the system further.

On the other hand, with respect to other solar thermal technologies, it is very easy to scale up and down dish-Stirling systems by virtue of its modularity of this concept. This is not the case for standard solar towers and parabolic trough collector power plants based on steam turbines which suffer a large efficiency drop when scaled-down. Also with respect to these, dish-Stirling systems are easy and fast to install and, thanks to the cited modularity, start producing electricity from the very beginning of the construction phase, thus reducing payback time substantially.

Figure 2: Maricopa power plant.

After construction and successful demonstration of the Maricopa project, the company developed an incredibly ambitious 1.4 GW construction plan in California with two flagship projects, Imperial Valley and Calico, with 709 MW and 850 MW installed capacity respectively. Their main characteristics and current status follow.

Calico Solar Project

The following information is an excerpt of the information available in the California Energy Commission website (accessed January 2015)[2].

"On December 2, 2008, Stirling Energy Systems Solar One, LLC (SES Solar Three LLC and SES Solar Six LLC) submitted an Application for Certification (AFC) to construct and operate the Stirling Energy Systems Solar One Project (SES Solar One), a solar dish Stirling systems project in San Bernardino County, California.

In January 2010, the project formally changed its name to the Calico Solar Project. The applicant, SES Solar Three LLC, was merged into SES Solar Six LLC, and that surviving entity was re-named Calico Solar, LLC. Calico Solar is a subsidiary of Tessera Solar™.

The proposed Callico Solar project would be a nominal 850-megawatt (MW) Stirling engine project, with construction planned to begin in late 2010 if the project is approved by the Energy Commission. Although construction would take approximately 40 months to complete, renewable power would be available to the grid as each 60-unit group is completed. The primary equipment for the generating facility would include the approximately 30,000, 25-kilowatt solar dish Stirling systems (referred to as SunCatchers), their associated equipment and systems, and their support infrastructure. Each SunCatcher consists of a solar receiver heat exchanger and a closed-cycle, high-efficiency Solar Stirling Engine specifically designed to convert solar power to rotary power then driving an electrical generator to produce grid-quality electricity.

[2] http://www.energy.ca.gov/sitingcases/calicosolar/

The proposed project will be constructed on an approximate 8,230-acre site located in San Bernardino County, California. The project site is approximately 37 miles east of Barstow, 17 miles east of Newberry Springs, 57 miles northeast of Victorville, and approximately 115 miles east of Los Angeles (straight line distances). Most of the power from the project will be generated at peak times, when the demand for electricity is greatest."

In spite of the very long permitting process undergone by Tessera, it seemed that all the factors needed to insure the project success were being met timely. Actually, Southern California Edison (SCE) expressed interest in buying electricity produced by the plant and this interest was very soon (2005) translated into a power purchase agreement for the energy coming from the first 750 MWe (Phase I).

Nevertheless, on December 23rd 2010 SCE cancelled without previous comments the PPA signed and soon after, December 29th 2010, the project was sold to K Road Sun, a subsidiary of K Road Power Holdings LLC dedicated to developing, owning, and operating utility scale solar power facilities in the western United States. In June 2012, K Road informed the California Energy Commission that, whilst the 100 MW of Phase II would intentionally rely on Stirling technology, the first 750 MWe were being converted to photovoltaic technology. However, following a series of down-sizing from the original 850 MWe to around 600 MW, the project was finally cancelled.

Imperial Valley Solar Project

The following information is an excerpt of the information available in the California Energy Commission website (accessed January 2015)[3].

On June 30, 2008, Stirling Energy Systems Solar Two, LLC (SES Solar Two, LLC) submitted an Application for Certification (AFC) to construct and operate the Stirling Energy Systems Solar Two project (SES Solar Two), a solar dish Stirling systems project in Imperial County, California. In February 2010, the company formally requested that the project change its name to Imperial Valley Solar. The company name was also changed to Imperial Valley Solar LLC.

The proposed Imperial Valley Solar/SES Solar Two project would be a nominal 750-megawatt (MW) Stirling engine project, with construction planned to begin either late 2009 or early 2010. Although construction would take approximately 40 months to complete, renewable power would be available to the grid as each 60-unit group is completed. The primary equipment for the generating facility would include the approximately 30,000, 25-kilowatt solar dish Stirling systems (referred to as SunCatchers), their associated equipment and systems, and their support infrastructure. Each SunCatcher consists of a solar receiver heat exchanger and a closed-cycle, high-efficiency Solar Stirling Engine specifically designed to convert solar power to rotary power then driving an electrical generator to produce grid-quality electricity. The 6,500 acre project site is located on approximately 6,140 acres of federal land managed by the Bureau of Land Management (BLM) and approximately 360 acres of privately owned land. The site is approximately 100 miles east of San Diego, 14 miles west of El Centro, and approximately 4 miles east of Ocotillo, California.

The project will be constructed in two phases. Phase I of the project will consist of up to 12,000 SunCatchers configured in 200 1.5-MW solar groups of 60 SunCatchers per group and have a net nominal generating capacity of 300 MW. Phase II will add approximately 18,000 SunCatchers, expanding the project to a total of approximately 30,000 SunCatchers configured in 500-1.5-MW solar groups with a total net generating capacity of 750 MW […].

[3] http://www.energy.ca.gov/sitingcases/solartwo/

The project would include the construction of a new 230-kV substation approximately in the centre of the project site, and would also be connected to the SDG&E Imperial Valley Substation via an approximate 10.3-mile, double-circuit, 230-kV transmission line. Other than this interconnection transmission line, no new transmission lines or off-site substations would be required for the 300-MW Phase I construction. The full Phase II expansion of the project will require the construction of the 500-kV Sunrise Powerlink transmission line project proposed by SDG&E. Within the Project boundary, Phase I requires approximately 2,600 acres and Phase II requires approximately 3,500 acres. The total area required for both phases, including the area for the operation and administration building, the maintenance building, and the substation building, is approximately 6,500 acres. The 230-kV transmission line required for Phase I would parallel the Southwest Powerlink transmission line within the designated right-of-way (ROW). A water supply pipeline for the project would be built on the approved Union Pacific Railroad ROW. Since the proposed project does not have a steam cycle, the primary water use would be for mirror washing."

In spite of the plans to construct the plant, the approval by the California Energy Commission (CEC) and the power purchase agreements already signed between Imperial Valley and San Diego Gas and Electric to acquire the electricity produced by the plant (Phase I), Tessera announced on February 11th 2011 that the project had been sold to AES solar. Soon after, on June 30 2011, AOS contacted CEC to communicate that the company had no intention to construct the project as licensed[4]. Actually, AES opted for photovoltaics as the technology of choice to power the reformed Imperial Valley Solar Project, which was also down-scaled to 100 MW.

The official reason given by Tessera Solar and SES to explain the sales was the lack of a secure financing position on the market to enable the development of the projects. In fact, SES filed for bankruptcy in September 2011 in spite of the 100 MUSD capital injection into the company by Irish finance firm NTR in 2008 (after which Tessera Solar was born in 2009).

There is hence no agreement on the underpinning reasons triggering the economic and technical collapse of the company. Actually, some experts state that this was caused by certain reliability issues of the technology itself, whereas other point out to license problems derived from environmental groups. It is thus a pity to say that, in the main, the lessons learned by the investors are that, in spite of the good performances that Stirling engines can achieve with no water cooling requirements, their higher capital and maintenance costs in comparison with photovoltaics make it a very questionable technology nowadays.

After SES, there have been others attempts to commercialise dish Stirling engines like Infinia in the US and Renovalia in Spain, but all of them have given up the developments owing to similar difficulties to secure financing brought about by the cited reliability problems.

Nevertheless, in spite of the discouraging track record of market failures experienced by the technology, there are still a few companies betting on it. Amongst these, the Swedish company Cleanergy is worth noting. Cleanergy acquired the industrial property of the V 161 engine from German manufacturer Solo Kleinmotoren GmbH. Along with the rights, the company acquired the team and the cumulated experience of the previous prototypes that were operated at the Plataforma Solar de Almería, Spain, since 1992 (totalling more than 35000 hours). As of today, the company has set out an ambitious commercialisation plan for solar (namely SunBox®) and CHP applications, the first step of which is the 100 kWe demonstration site constructed in Mongolia in 2012, Figure 3.

[4] Imperial Valley Solar (Formerly called SES Solar Two Project), Docket Number 08-AFC-5C, California Energy Commission, http://www.energy.ca.gov/sitingcases/solartwo/

Figure 3: Cleanergy demonstration plant in Mongolia.

In January 2014, the same company signed a Memorandum of Understanding (MOU) with the Dubai Electricity and Water Authority (DEWA) to install the first Stirling Engine CSP plant in the MENA region. The facility, currently under construction, will be identical to the Mongolian one, with a total production of 110 kW. These ten SunBox® units will be installed amidst other solar thermal technologies in a Solar Park with 1000 MWe capacity once completed.

This experience, definitely at a smaller scale than the impressive commercialisation plans set out by Tessera Solar originally, confirms that there is a market where the technology might become competitive provided that high thermal efficiency and low cost are achieved altogether. Hence, given the potential of OMSoP to outperform dish-Stirling units in both respects, the way is paved for an innovative to step in and become successful there where previous experiences have been so negative.

The OMSoP system as a competitive alternative to the Dish-Stirling

Many researchers and spokespersons from industry have claimed the advantages of Stirling engines over other heat engines since their early developments in the beginning of the 19th century by Rev. Robert Stirling. This was the case for R. Stirling himself:

> *These imperfections have been in a great measure removed by time and especially by the genius of the distinguished Bessemer. If Bessemer iron or steel had been known thirty-five or forty years ago there is scarce a doubt that the air engine would have been a great success… it remains for some skilled and ambitious mechanist un a future age to repeat it under more favourable circumstances and with complete success…" (R. Stirling, 1876)*

Some of the cited advantages are:

- High efficiency at modest temperatures (750 ºC)
- Capability to operate on a number of different fuels and waste heat sources,
- Good part-load performance,
- Low vibrations and noise.

Nevertheless, in spite of the revolutionary progress of materials science and manufacturing technologies in the last one hundred and fifty years, the market has not seen Stirling engines breaking through yet. This is because the aforecited advantages do not come alone. There are also substantial disadvantages that also come along and which have prevented the technology from entering the commercial phase. Some of these are:

- High manufacturing costs due to the high number of precision parts that have to be casted and machined owing to the reciprocating layout,
- High operation and maintenance costs, due to the need to utilise hydrogen or helium as working fluids if high efficiencies are sought,
- High mechanical losses that come about because of the bulky mechanical transmission chain and very high operating pressures.
- Low specific output (kW/kg) due to the engine being externally fired/heated.

These inherent limitations become more pronounced when integrated into a parabolic dish collector given the heavy weight and large volume of the power conversion unit even for low outputs. These turn into a need to reinforce the supporting frame and tracking system and also increases the auxiliary power consumption of the latter. For these reasons, this project explores the technical and economic feasibility of substituting a micro gas turbine for the typically employed Stirling engine in solar dish applications. By doing so, it is expected that the lower cost and higher reliability of micro gas turbines, many of which are derived from state-of-the-art turbochargers, will cut down on manufacturing and maintenance cost whilst hardly affecting the system performance.

Configurations considered

There is an open debate when it comes to distributed generation systems, in particular when renewable energy sources are considered. This debate is centred around the size of the reference plant to set up a business case. The following arguments are usually on the table:

- Any power generation technology is favoured by economies of scale; i.e. the cost of electricity is higher for smaller systems. According to a report by Kearney et al[5]., there is a potential 30 % reduction in capital costs (CapEx) coming from plant scale-up.
- These economies of scale last longer for solar thermal technologies whereas they vanish sooner for photovoltaics.
- Turbine-based technologies experience a dramatic drop in efficiency when scaled-down to the megawatt size (<10 MWe). Stirling engines are far more efficient in this power range.
- For the common pant size, the possibility to store heat sets dish-Stirling systems apart from photovoltaics.
- Large scale multi-megawatt facilities are likely to be the business case in western countries where there are hardly any people without access to electricity.
- On the contrary, stand-alone systems constitute the business case in less developed countries where remote rural areas with little or no access to electricity are profusely found.

[5] A.T. Kearny, *Solar Thermal Electricity 2025, Clean electricity on demand: attractive STE cost stabilize energy production*, June 2010

These arguments are set forth in many market analyses issued so far, for instance, the report on *small-scaled concentrated solar power* authored by James Rawlins and Michael Ashcroft of Carbontrust in 2010[6]. In this work, process heat produced by CSP in the range 200-300ºC is considered for industrial environments along with small heat, electricity and CHP generation systems in the range from 10 kW to 2 MW for remote rural areas with difficulties to access electricity. With regard to electric power generation, the following comments are given in the document:

- We are not aware of any estimates of the potential deployment of small-scale CSP in rural or off-grid applications.
- There is no doubt that the market for renewable energy technologies in rural / off-grid contexts is huge.
- Citing the International Energy Agency, in countries where electrification of households is not complete, small-scale or mid-scale CSP plants offer co-generation of electricity for remote or weakly interconnected grids, and process heat for some local manufacturing.
- Our interviews and research revealed very little activity in small-scale on-grid power generation.
- Very few of the CSP projects worldwide are less than 10MW in size and a significant number are in excess of 100MW. At these scales the economics of the plants are more attractive to project developers and the electricity output makes a more meaningful contribution to the grid.

Accordingly, the authors find negligible interest in multi-megawatt on-grid facilities between 2 and 10 MW and concentrate on stand-alone systems for off-grid applications. Furthermore, for these, "only the sub-Saharan countries would constitute a potential market, Chris Samson says"[6].

Nevertheless, there is no doubt that all power generation systems based on thermal processes (i.e. heat engines) benefit from economies of scale, and dish-based systems are not an exception to this rule. Therefore, the market of utility-scale OMSoP arrangements is deemed worth being studied in a range that has already been explored by other technology developers in the past. In this respect, the first attempt to demonstrate the technology by Tessera Solar was the 1.5 MW Maricopa solar plant, which confirmed the technology as both efficient and reliable even if the subsequent scale-up process failed due to financial problems. Further to this, Spanish firm Renovalia in partnership with Sunpower of USA (company that acquired the assets of Infinia Corporation), projected a 1 MW dish-Stirling power plant in Spain using free-piston engine technology. This plant, made up of 333 engines with a 3 kW peak capacity, was actually the vanguard of a very ambitious 300 M€ plan to install 71 MWe dish-Stirling capacity in Spain distributed amongst seven projects using the same technology. This yields an approximate size of 10 MWe per plant[7].

Further to this information, it looks like there is some sort of contradiction between the analysts (whether from private companies or public research centres) and the industry. Thus, whilst the former dismiss any industrial development above the megawatt range, the latter pinpoints an unquestionable market opportunity for this low to mid-scale power plants. This is confirmed by the cost analysis of renewable energy technologies for concentrating solar power issued by

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[6] James Rawlins and Michael Ashcroft, *Small-scale concentrated solar power, A review of current activity and potential to accelerate deployment*, Carbontrust, March 2010

[7] *Developed solar technology worldwide 3rd generation*, Renovalia, March 26th 2012, www.renovalia.com

IRENA (International Renewable Energy Agency) in 2012, where dish-Stirling technology is foreseen to be applicable to systems up to 15 MWe.

Based on these arguments, two very different system layouts are considered in this market analysis report.

- **Stand-alone** units. These are isolated units with a power output of up to 25 kWe serving the end-user (customer) needs. Stand-alone units are conceived to operate off-grid as they are thought to fit best in remote rural areas with little or no access to regular electricity supply from state grids. Nevertheless, there is always the chance to connect the system to the grid to ease out the start-up procedure and ensure permanent supply of electricity without the need of batteries or auxiliary power systems.
- Grouped units in a so-called **farm arrangement.** A large number of units are arranged in a squared-ish configuration (similar to a matrix where each element is an OMSoP unit) formed by arrays of engines connected to a common substation and sharing other equipment and infrastructures (for instance gas and electrical supplies). The locations of these power plants are constrained by the availability of connection points to the grid whereby the electricity produced is exported to the end users. Permitting is hence an important aspect of the project which adds to the standard engineering, construction and procurement tasks that are typical of larger power plants.

Objectives

As already discussed in the previous sections, there are two main deliverables of the project linked with the economic aspects of OMSoP: D3.1 on the cost analysis and D3.2 on the market analysis. The objective of D3.2 is twofold. The first objective is to develop a methodology, later implemented into an application, to analyse the likeliness of a country to constitute a true market for the technology, whether for stand-alone units or for larger power plants. This methodology must reunite a number of features in order to be effective: it must be as objective as possible to make it independent from the user's background; it must take into consideration most (if not all) the factors that influence the technology business-wise; it must enable modifications to account for changes that might take place in the future (political instabilities, changes in the characteristics of the power sector of a given country, etc.); it must be sensitive to two possible layouts; and it must allow for uncertainty analyses. These features have permanently been in back of the authors' minds to yield the most useful tool possible.

The second objective is to provide a list of countries where it is very likely that OMSoP becomes a popular technology to produce electricity from the sun. Such list is not aimed at being exhaustive though, given that it is not possible to account for the two hundred countries existing in the world today. Rather, a reduced list of twenty two countries is considered (ten percent of the total number of countries), which are representative of different regional, economic and social statuses. The extent to which the results for these countries can be extrapolated to others nearby is specifically assessed in the report.

It is also worth noting that this report ,must be necessarily accompanied by deliverable 3.1 for the cost analysis, and then read together in deliverable 3.3 (*Final report on the economic appraisal of a 5-10 kWe dispatchable power generator*). In other words, the market analysis is aimed at filtering out those countries where the minimum conditions needed to provide a minimum market volume for OMSoP are not met. This is done in this report based on generic information of the country. Then, once this is achieved, the specific information about the OMSoP costing given in D3.1 will be incorporated along with those of the direct competitors producing electricity from the sun in the same output range (in particular PV). Once this is done, it will be possible to ascertain the primary markets of the OMSoP system.

Methodology

As already explained, the market analysis of the OMSoP project aims to assess the interest of certain territories as potential sites where this solar power generator constitutes a true alternative to other renewable and non-renewable energy sources. These territories are typically identified as a country even if sometimes a region is used instead (for instance, we would typically refer to the Middle East and North Africa MENA region in the Southern coast of the Mediterranean).

Broadly speaking, the decision to install (i.e. commercialise) the OMSoP technology in a given market is uneasy. A myriad of different factors have to be taken into account: social, political, economic, environmental…, which are very difficult to evaluate either individually or integrated in a global decision factor. There are different reasons that make this evaluation difficult:

- Identification of the influential factors. Some key factors affecting the interest of a given country are obvious; for instance the available solar resource which is measured by the available direct normal irradiation (DNI) at ground level. Nevertheless, the influence of some others is difficult to ascertain. On the other hand, the social acceptance of cleaner and costlier electricity generation technologies is not easy to quantify. One would think that the share of renewable energy in the country would be an appropriate figure of merit but the case for Spain is a clear example of just the opposite. Figure 4 speaks for itself about the influence of a very fast and unstructured growth of the share of renewable energy sources on the price of household electricity. The cost per kilowatt hour has almost doubled in the last decade in Spain due to the very large amount of public money spent on subsidies in order to foster the development of these technologies.

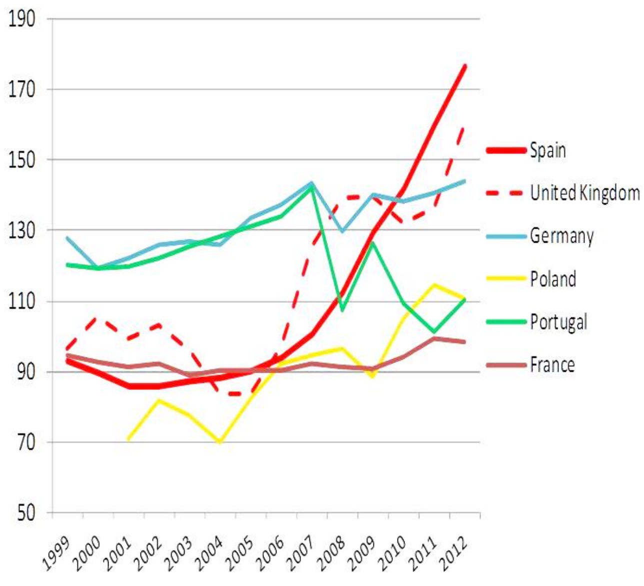

Figure 4: Change in electricity price for different countries in the European Union (Source: Eurostat).

The trend for Spain in Figure 4 shows an eloquent parallelism with those of the tariff deficit and cumulative subsidies to renewable (and other special) energy sources in the country shown in Figure 5, confirming the lack of a long term governmental development plan ensuring the sustainability of the system. Rather, the consumers (in particular households, and to a lesser extent the industry) have been left as the only pillars to support the consequences.

As a consequence of the unbearable rise of the electricity price in the country, Spain is now seeing an intense, public debate so as to whether it makes sense or not to run an expensive system whilst the complete fleet of combined cycle power plants are operating less than twenty five hundred hours on average (less than 20% utilisation factor).

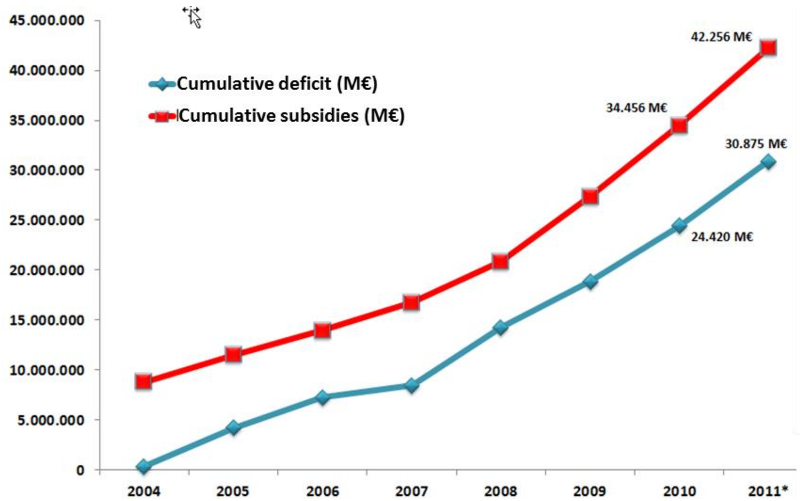

Figure 5: Change in tariff deficit and cumulative subsidies to special energy sources in Spain. Time series for 2004-2011 and forecast for 2011 (Source: www.madridmas.org).

This debate brings one's attention to two points which are key to this report. First, for large power plants in the multi-megawatt size, it is crucial to carry on a fair comparison, approached from a new angle where a future scenario with no subsidies is considered; i.e. not only must OMSoP beat photovoltaics, it must also ensure that the impact on the electricity market is either minimal or even beneficial. Second, for stand-alone units, a global market calls for global solutions, thus making it necessary that OMSoP outperforms other renewable energy (for instance photovoltaics) and fossil-fuel (for instance diesel) technologies.

- Averaging of country values. Some countries like Spain present rather homogeneous features, at least for more than 50% of the nation, in terms of solar resource, population density, grid, etc. On the contrary, other countries are fairly heterogeneous like Algeria with the best natural conditions in the South and virtually all the population in the North. This is even more evident in very large countries like China (Figure 6), India or even the United States of America. For these, providing mean values of the solar resource is difficult, and this gets worse in federal countries with dissimilar market conditions and renewable energy policies. In order to sort this out, two approaches are adopted. Either the average values are weighted by the population density or the most unfavourable regions of the country are excluded. Both simplifications are nevertheless coarse and will need to be refined in the next deliverable reports.

- Market volume. A useful figure of merit assessing the commercial interest of a country must somehow incorporate the size of the potential market in a country, if any. This is difficult inasmuch as two aspects are involved: number of potential customers and intensity of the per capita demand. The combination of these two factors yield the market size in terms of installed capacity, which is then multiplied by the equivalent sun hours to yield the annual generation of electricity. How this combination is effectively implemented will be discussed later.

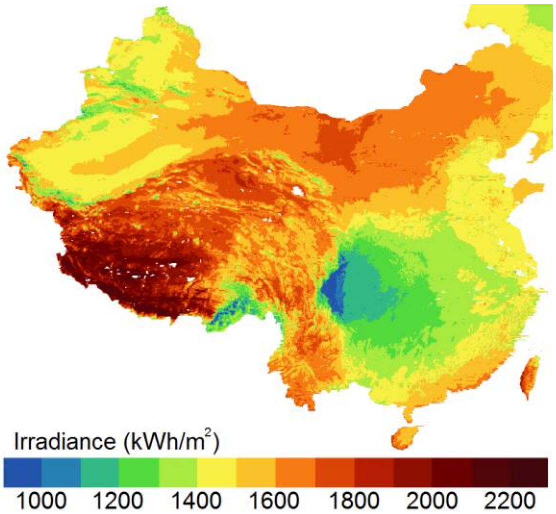

Figure 6: Direct normal irradiance in China.

- Business environment. The economic "climate" in a region is key to the health state of the corresponding market. This has been confirmed in the last years when different countries throughout the world have experienced financial difficulties leading to a dramatic drop in the liveliness of trade and industry.
  It is usually said that investors are fearful of uncertain socio-political situations and tend to seek refuge as soon as the first symptoms of such situations arise. Hence, as objective as possible measurements of the stability and mid-term certainty of the economic and socio-political features of a country must be incorporated into the equation used to rank potential markets.

In addition to this conceptual difficulties of developing the methodology to rank the potential markets, two issues must still be noted which add complexity and uncertainty to the whole process. Given the time needed to develop the technology, which is estimated in five years at the least, the input data to the model must be based on contemporary data but they must also be extrapolated to the near future. This is, in the current socio-political scenario, challenging. A few examples can illustrate this.

First example. Oil prices. Figure 7 shows the time series of Brent oil commodity prices in the last five years. The remarkable drop that took place in the second half of 2014 was utterly unpredictable in the previous months and years and even if it has not brought about changes in the fuel market yet, it will definitely do in the future[8].

A second question arises with respect to the mid-term impact of falling oil prices. How long will it last? Figure 8 shows that a similar fall took place back in the second half of 2008 but the market recovered from it soon after. The boundary conditions are much different today though, as suggested by the stable prices for a long period of time (2011-2015) in contrast to the price upsurge in 2007-2008. In effect, the current scenario does look like being affected by a true unbalance between production and demand rather than a bubble-bursting panorama brought about by market regulators.

So the next question is posed: will the oil price rebound or will it remain low? The answer to this question is crucial for the mid-term feasibility of renewable energies, in particular concentrated solar power. And even if it could be argued that oil is the reference fuel for the

[8] K.Silverstein, *How falling of oil prices will impact economy*, Forbes, January 9th 2015

transport sector but not for power generation, Figure 9 shows the case for natural gas price in Europe. A substantial reduction has been experienced in the last couple of years.

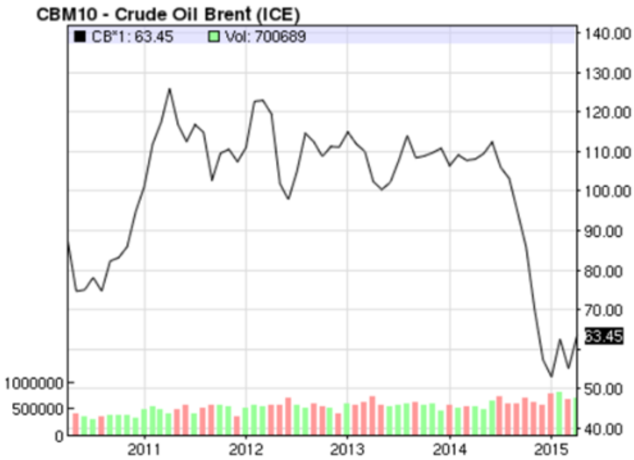

Figure 7: Crude oil Brent. Commodity price in the last five years (Source: Nasdaq).

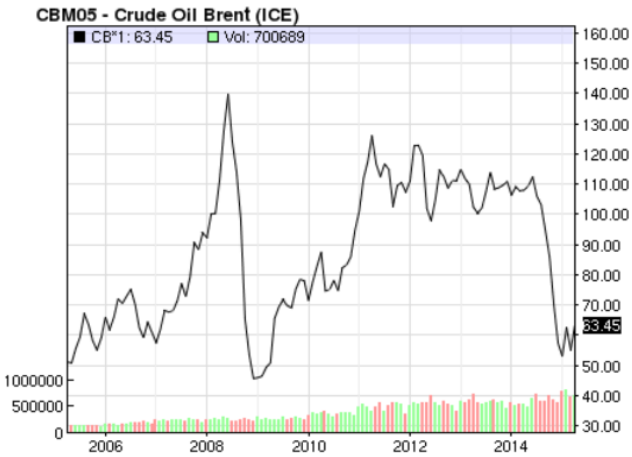

Figure 8: Crude oil Brent. Commodity price in the last ten years (Source: Nasdaq).

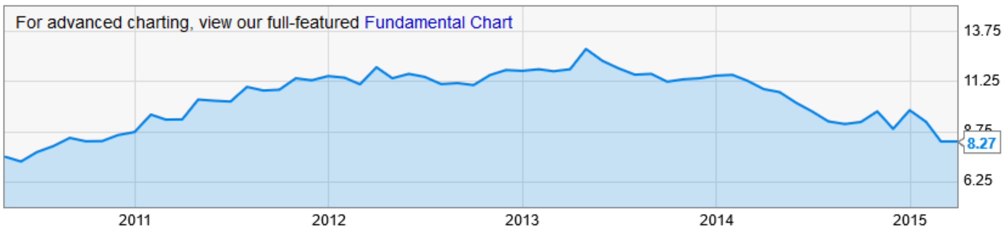

Figure 9: European Union natural gas import price (USD/MMBtu) (Source: Ychart).

Second example. New regulations for renewable energies in Spain. Changes in the regulatory framework influence the mind-set of decision-makers with respect to whether or not it is of interest to keep investing in a given technology in a given country. This has been the case of Spain, which has frequently been set forth as an example of how to integrate renewable energies into the grid, in particular solar thermal.

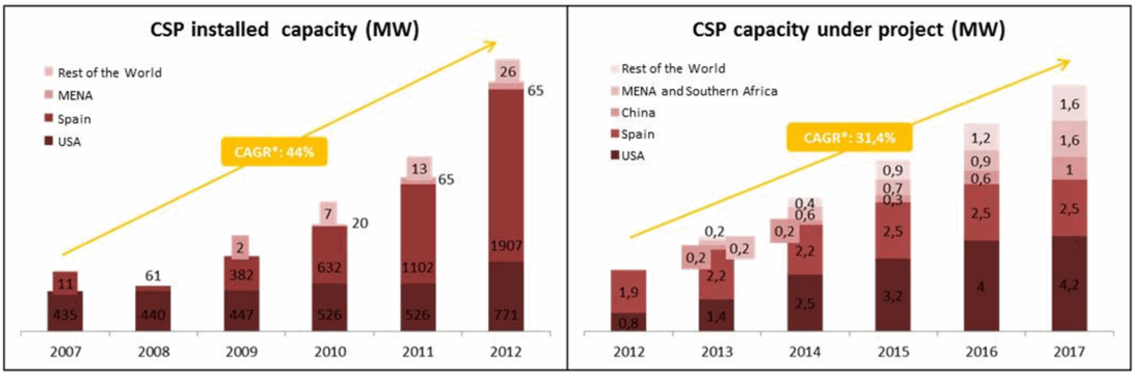

*Figure 10*Figure 10 shows the evolution of installed capacity in various countries in the period 2007-2012 along with a forecast for the next five years (2012-2017). It is interesting to see that hardly any additional capacity was scheduled to be installed in Spain later than 2012.

The reason for such abrupt descent in the number of CSP projects in the country is the new regulatory framework in place since 2012 (Royal Decree Law RDL 1/2012) whereby the very attractive feed-in tariff that had led the deployment of ca. 1500 MWe was cancelled. By virtue of this new law passed in January 2012, any CSP project which had not been pre-allocated by January 28th 2012 would not have access to incentives, hence deterring potential investors from developing new power plants. Such move by the government, which was even more aggressive for photovoltaic facilities, was arguably triggered by the unbearable tariff-deficit already commented in this report (see Figure 5).

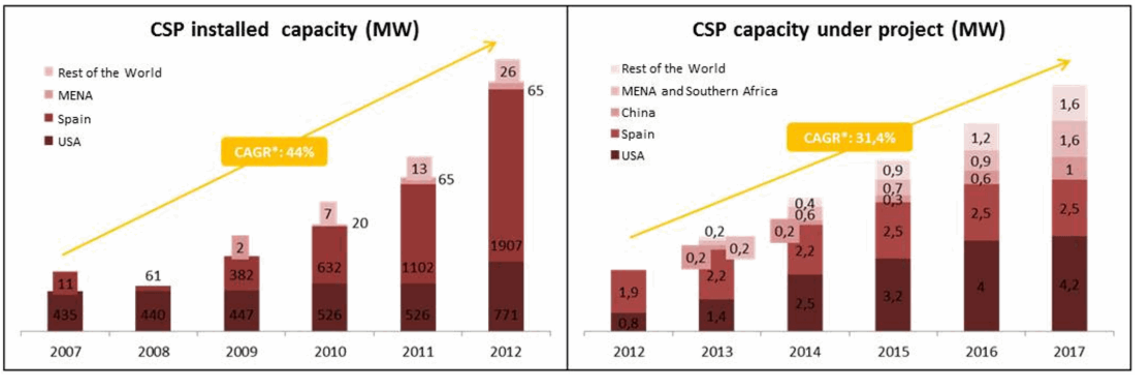

Figure 10: CSP capacity – Compound annual growth rate CAGR (Source: SIA Partners).

The conclusion drawn from this second example is twofold. On one hand, it has become evident that energy policies must be studied for all possible scenarios in order to anticipate systemic faults that could prevent its development in the future (e.g. tariff deficit). On the other, in the event that a systemic fault is identified, correcting it under the pressure of short-term objectives is very likely to bring about new systemic faults that were not foreseen due to the absence of a thorough analysis (again). This could be understood as a circular problem where legislation is mainly driven by correcting rather than constructive actions.

Third example. Changes in state economies. The world has seen several important changes in the last decade, including armed conflicts and economic crises. All these have influenced international politics and geo-strategy and, most importantly, international trade and markets. A common figure of merit to evaluate how an economy is perceived by the international markets is the *Sovereign Credit Default Swap* (SCDS). Credit Default Swaps are contracts whereby the seller of the swap (1st party) agrees to compensate the buyer (2nd party) in the event of a loan default by the debtor (3rd party). When applied to sovereign debts, CDSs are used to protect investors against losses on the cited debt arising from credit events such as default or debt restructuring.

There is an intense debate amongst analysts so as to whether SCDSs can confidently be used as market indicators of credit risk, given that they can be influenced by speculative trading yielding misleading, destabilising information. Nevertheless, in spite of this lack of agreement, it is also unquestionable that this index manages to capture trends that are very useful for risk analysis as shown in Figure 11.

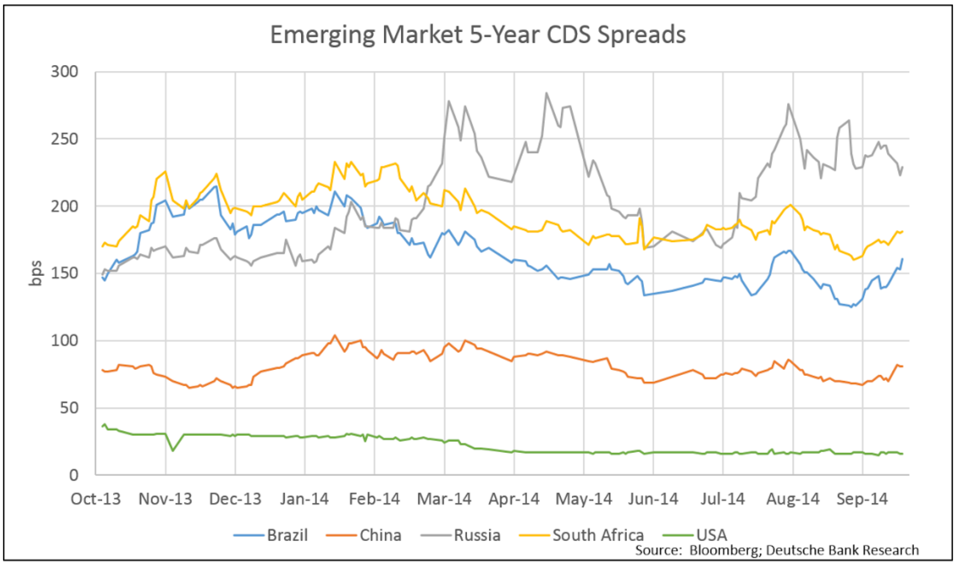

Figure 11: Changes in Sovereign Credit Default Swaps for various countries (Source: Global Risk Insights).

However, Iit could also be argued from the figure above that SCDSs are only meaningful in their absolute value but they do not quite capture changes in the geopolitical situation of a country. That is to say, it might seem that the markets are rather insensitive to changes in state economies. This is not the case though, as illustrated by Figure 12 where the political instabilities in Argentina are confirmed to have caused fast and abrupt SCDS's changes in the last five years.

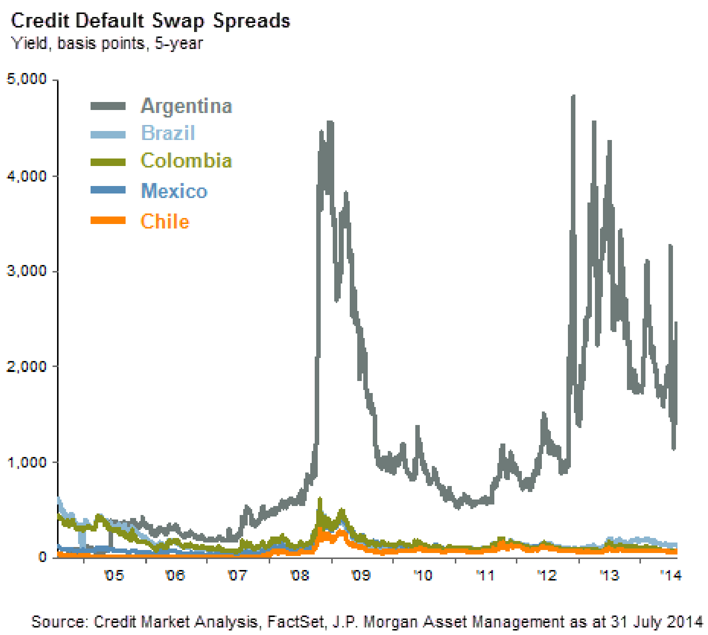

Figure 12: Changes in Sovereign Credit Default Swaps for various Latin American countries (Source: JP Morgan).

From the information in Figure 12 it can be concluded that it is very difficult to anticipate short-term events that can destabilise the market and, consequently, change the boundary conditions of a business plan completely. With this example, the difficulty to set up the business case when it comes to international investments is confirmed.

Baseline of the method

The methodology presented in this section constitutes the scientific basis for the identification of the most interesting markets for the OMSoP technology. In short, the objective is to develop a figure of merit which enables to rank a group of candidate countries according to how likely it is that the technology be successful marketwise. This global index is thus a compendium of the many different influential parameters that are characteristic of a region, among which the following have been selected:

- Available solar resource. This is the most obvious influence which, actually, is used to filter out those countries that are of no interest whatsoever. It will be shown later that there is a threshold DNI below which solar powered generators are not competitive or even feasible.
- Size of the (eventual) market. This depends on the expected demand for electricity produced from renewable energies, both in the distributed generation market and in the lowest range of the "power station" type of facilities (multi megawatt units). The size of the market is determined by two main features. First, the population of a given country or region since these people are the potential customers. Second, the per capita consumption of electricity of the country; i.e. how much electricity is expected to be consumed (on average) by each individual. All into account, large areas that very densely populated by people with very high demand of electricity step forward as the primary markets for this technology.
- The characteristics of the state grid. In spite of the statements made in the previous bullet point, one must acknowledge that the existence of many active consumers in a sunny country might not be enough to ensure the market success of a solar power generation technology. In this respect, the characteristics of the electricity grid are of

capital importance. Two possible situations emerge from this: (i) potential consumers in remote areas with no access to electricity supply and (ii) high voltage grids to which the electricity produced by multi megawatt, OMSoP-based power stations export their production. Each of these situations might pave the way for the deployment of OMSoP under a particular configuration (stand-alone vs. farm arrangement).

- Renewable energy policy. This is crucial for the take-off of the technology in a given region. Renewable energy policies are now in place in various countries to foster the market uptake of specific renewable energy technologies which are not necessarily economically competitive in their current state of development. As discussed later, the existence of a favourable legislative scenario might be decisive for a company considering investments in countries where the non-legal influence factors are similar. Actually, a less favourable natural environment (solar resource) might be compensated for by an appropriate legal framework.
- Financial risk of the country. This last aspect is again of paramount importance inasmuch as it integrates various financial and legal characteristics of a given country. Amongst other effects, the economic strength of the state's public sector is assessed to ascertain the likelihood of falling into late payments of state-owned facilities. Also the private sector is evaluated to account for its wellness and momentum in as far as growth and size are concerned. Finally, less measurable features like the level of corruption are valuated as well. All into account, risk factors as published by some large insurance firms are the basis for this analysis.

Each one of these features is quantified by a factor ranging from 0 to 1, namely:

- Irradiation factor: F_I.
- Demand factor: F_D.
- Grid factor: F_G.
- Policy factor: F_P.
- Financial risk factor: F_F.

These five factors are then combined to yield the **Index of Interest (IoI)**, which is the figure of merit enabling the identification of those markets with the highest potential based on the aforedescribed criteria. Nevertheless, these criteria do not have the same influence. Even if all of them are important, some are decisive in the sense that a low value discards the country under consideration directly (for instance, the available solar resource). To account for this, the factors are weighted differently as follows:

$$IoI_i = w_I \cdot F_{I,i} + w_D \cdot F_{D,i} + w_G \cdot F_{G,i} + w_P \cdot F_{P,i} + w_F \cdot F_{F,i}$$

It is worth noting that whereas the calculation of each influential factor (F_i) is based on measurements that are as objective as possible, the choice of weight factors is preconditioned by empirical knowledge, which is limited at this stage of the project. Hence, selecting the "*true*" weight factors will result in the "*true*" set of IoI's, based on which a truly reliable decision so as to where to invest can be made. Nevertheless, it is also acknowledged that weight factors must be chosen initially, in spite of the limited experience and inherent uncertainty. Ad later, in order to quantify and possibly attenuate this uncertainty as much as possible, a statistical study will be presented which complements the methodology. This study is very eloquent in the sense that it takes rid of many of the possible fears brought about by not knowing which input values are to be used. Actually, it will be shown that the ranked list of potential markets is hardly altered by small variations of the weight factor.

Another aspect that must be taken into account when quantifying factors and weights, is the configuration of interest for the case under analysis. Two different system layouts are considered in this project, stand-alone systems and the so-called farm arrangements. Each of them calls for different features of the end-user. For instance, stand-alone systems make more sense for remote off-grid sites in sunny areas whilst multi-megawatt facilities require a grid which can deliver the electricity produced to households and industries. These differences are mainly implemented in the influence factors though they also have an effect on the weight factors. A full description of the numerical analysis is given below.

Irradiation factor, F_I

As it was indicated before, this factor accounts for the solar resources in a given country. This feature is typically measured by the Direct Normal Irradiance (DNI), also called beam radiation and, wrongly though very usually, Direct Normal Irradiation. According to ISO standards, "*direct irradiance is the quotient of the radiant flux on a given plane receiver surface received from a small solid angle centred on the sun's disk to the area of that surface. If the plane is perpendicular to the axis of the solid angle, direct normal solar irradiance is received*"[9]. DNI is thus the amount of direct solar irradiance received normal to the ground surface and thus susceptible of being exploited by a concentrating solar power system.

Direct insolation over a year is another possible measurement even if is used less often. This is expressed in [kWh/m^2 y] and stands for the cumulative direct normal irradiance received by a square meter of land in one year at a given location.

The link between these two indexes of how much solar energy is received is time. This is why more recently the term *peak sun hours* is being used. This index reflects the solar energy (direct radiation only) received during total daylight hours as defined by the equivalent number of hours it would take to reach that total energy value had direct normal irradiance averaged XXX W/m^2.

The influence of the available solar energy is computed by F_I, taking into account the annually-averaged value of direct normal irradiance (DNI) in the country. The rationale behind it is that there is threshold DNI below which the technology is not only uneconomic but also hardly viable from a purely thermodynamic standpoint. This minimum value is determined by two main factors:

- Size of the collector: the lower the incoming solar energy, the larger the aperture area of the collector. Given that the cost of the collector accounts for a large fraction of the total cost of the system, enlarging this component proves uneconomic beyond a given limit.
- Efficiency of the power conversion unit: the peak temperature achievable at the receiver (focus of the collector) depends on:
    - Available DNI: high temperatures require a high energy flux.
    - Concentration factor of the collector: even if the solar energy flux at ground level is high, it still has to be augmented several times to achieve the required value. This is the collector's duty, to concentrate the energy collected at ground level, and it depends mainly on its geometry (whether it is a linear or point-focusing collector).
    - Design of the receiver (cavity vs. open): since the power conversion unit makes use of the net heat power absorbed by the collector, not only is it important to

[9] ISO 9488 (1999). Solar energy – Vocabulary. ISO, Geneva, Switzerland.

capture as much energy as possible, it is also crucial to reduce the heat losses from this component. The losses from the receiver are largely dependent on its design and its operating temperature.

Amongst these factors, there are two salient effects which do not actually depend on design practice: collector size and available DNI. They are in fact boundary conditions and thus it is out of the designers' command to modify them. In conclusion, if the available DNI is low, it will not be possible to raise the operating temperature and thus the efficiency of the power conversion unit will be low. If, still, a very large collector were used to collect a large amount of energy, this would not be converted efficiently and thus this higher cost would not pay off.
Based on this rationale and on a review of the few references covering this topic, the following upper and lower limits of the irradiance factors are set:

$$F_I = \begin{cases} 0 & If\ DNI \leq 1000\ kWh/m^2 \\ \dfrac{DNI - 1000}{1000} & If\ 1000\ kWh/m^2 \leq DNI \leq 2000\ kWh/m^2 \\ 1 & If\ DNI \geq 2000\ kWh/m^2 \end{cases}$$

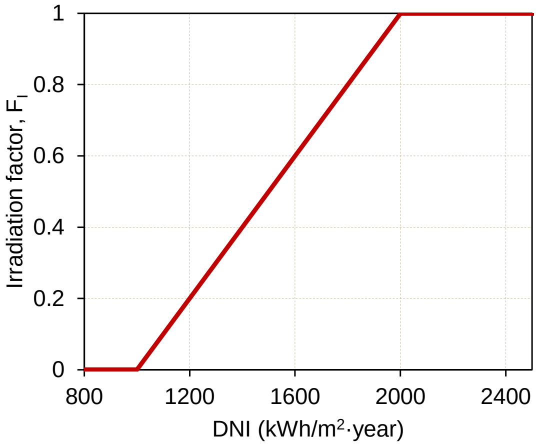

Figure 13: Irradiance factor.

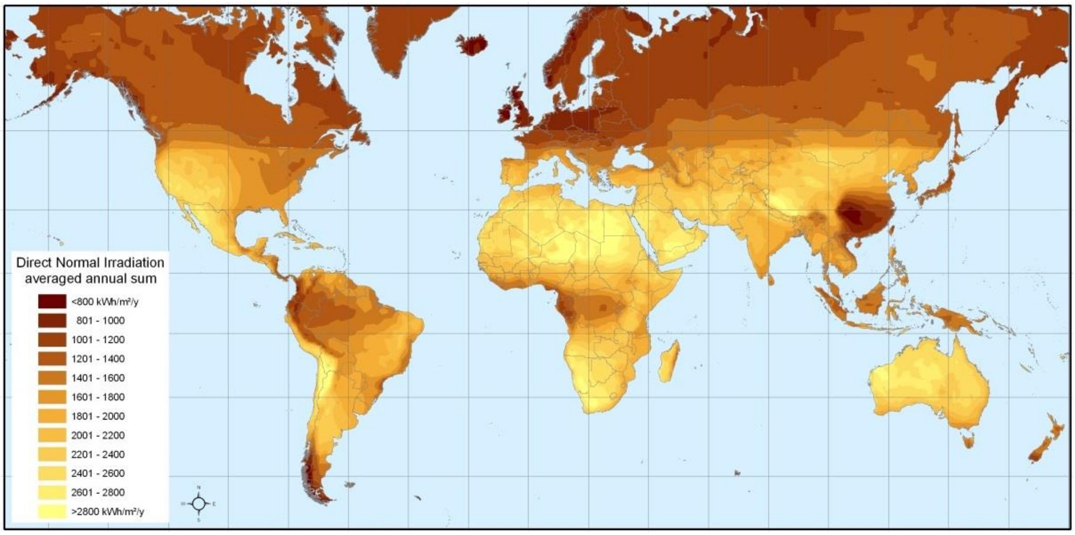

Figure 14: Direct Normal Irradiation (DNI) word map.

These limits suggest that regions with an annual direct insolation of 2000 kWh/m^2 or more are most interesting, being excellent sites to install the proposed technology in as far as the solar resources are concerned. On the contrary, if the annual insolation is 50% this value (i.e. only half the amount of energy in a year and at a much lower intensity), the site is not interesting at all. In between, the *interest factor* varies linearly with DNI.

Demand factor, F_D

Whenever a technology is being assessed from a commercial standpoint, it is necessary to quantify the potential customers or end-users that will eventually make use of it. In this respect, there are two factors affecting the expected demand of a power generation system in a particular country: population (P) and per capita consumption of electricity (c). These two could be dealt with in an aggregated manner by merely considering the global demand of electricity in the country. Nonetheless, they are presented independently here for the sake of clarity.

Following a similar approach to the previous one, it is considered that those countries with very low electricity consumption per capita or a very small population do not constitute a primary market for this new power generation technology. At the same time, it is also assumed that beyond a certain value of the national demand of electricity, the interest is highest and thus the value of this *demand factor* is one hundred percent.

The threshold values that are needed to equate the factor are calculated from the information about national consumption of electricity available in the World Bank database, which contains vast information of 138 countries. The top ten countries in the ranked list were considered as the most representatives in terms of national demand of electricity ($c \cdot P$) and thus the threshold value of $c \cdot P$ is set equal to the value of Brazil (tenth place): 4.8012·10^{11} kWh/year. Above this value, the factor takes the highest value regardless of the particular demand of electricity of the country. Below it, the factor falls as follows:

$$F_{D,ref} = \begin{cases} \dfrac{c \cdot P}{4.8012 \cdot 10^{11}} & If\ c \cdot P \leq 4.8012 \cdot 10^{10}\ \ kWh/year \\ 1 & If\ c \cdot P \geq 4.8012 \cdot 10^{10}\ \ kWh/year \end{cases}$$

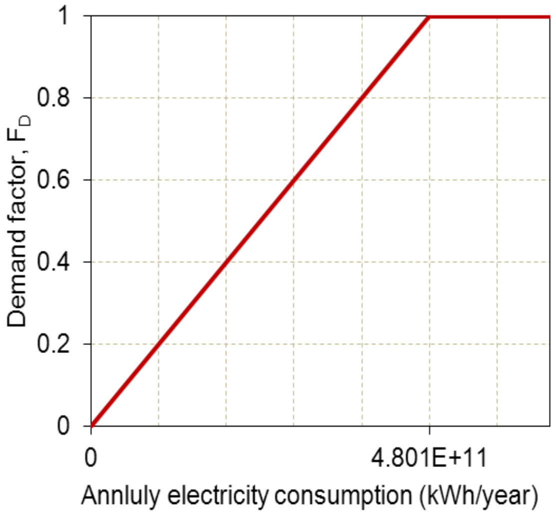

Figure 15: Demand factor.

It must be noted though that a different threshold value could have been selected. Nevertheless, the effectiveness of this factor is affected by taking too low a limit due to the reason that almost all of the wealthy countries exhibit a high consumption of electricity; i.e., if a very low threshold is taken, the factor is useless for it takes the highest value for virtually any country.

This demand factor has to be further modified to account for the different configurations of the OMSoP system:

- Stand-alone system: specifically aimed at consumers with limited access to the grid who are willing to own and operate the system to cover their electricity needs.
- Farm arrangement: aimed at companies willing to produce solar electricity which can be exported to the grid and mitigate the harmful environmental effects brought about by conventional fossil-fuel technologies.

Based on this classification, it is deduced that the potential users of stand-alone units will be found in areas with limited access to electricity whereas there are no restrictions for the potential customers of the farm arrangement: (i) in electrified regions, the production of the power plant will be exported to the grid; (ii) in non-electrified regions, this will be distributed amongst the users nearby the power station.

It must be noted though that this is an oversimplification of the problem aimed at enabling the numerical analysis presented in this report. In a practical case there would definitely be users with access to electricity willing to acquire an OMSoP generator just to mitigate global warming or a similar reason, in spite of the fact that this option is not considered initially and even if this would incur higher costs due to the lack of economies of scale without any clear advantage with respect to the farm arrangement.

In any case, this discrimination of the different cases is done by means of a modified factor accounting for the fraction of the population with access to electricity in a given country (A). In this respect, it is worth noting that the actual consumption of electricity per capita is higher than (c) if $A < 1$, given that all the inhabitants living in non-electrified regions are included in the calculation of c. Moreover, if the access to electricity were 100% ($A = 1$), stand-alone configurations would be of no interest, yielding the following values of F_D:

$$F_D = \begin{cases} F_{D,ref} & farm\ arrangement \\ F_{D,ref}\dfrac{(1-A)}{A} & stand-alone \end{cases}$$

This distribution assumes that the electricity consumption per capita remains the same regardless of whether the consumer makes use of the OMSoP technology or another technology.

Electricity grid factor, $\boldsymbol{F_G}$

The grid factor aims to represent the quality of the transmission lines which have different features for each one of the configurations considered. On one hand, for stand-alone systems, there is no need to have a connection to the grid inasmuch as the electricity generated is consumed by the owner him/herself. On the other, for farm arrangements, it is necessary to have medium or high voltage transmission lines through which the energy produced can be exported to the consumers. This depicts a scenario where the grid factor is very high for stand-alone applications and for larger scale facilities close to transmission lines, and very low for those multi-unit installations with no distribution lines available nearby.

At the national level, the accessibility to electricity presented before (A) is a good index of how good the transmission and distribution lines are in a country. Nevertheless, the transport of electricity through very long lines incurs considerable losses and thus, for the farm arrangements, it is also important to determine how close the highly populated areas are to those areas where the insolation is also very high (i.e. distance between production and consumption nodes). To assess this effect, which is termed *dislocation* here, the following numerical methodology is developed which combines DNI and population density maps for a given region. Let the case of Algeria be considered, Figure 16, for illustration.

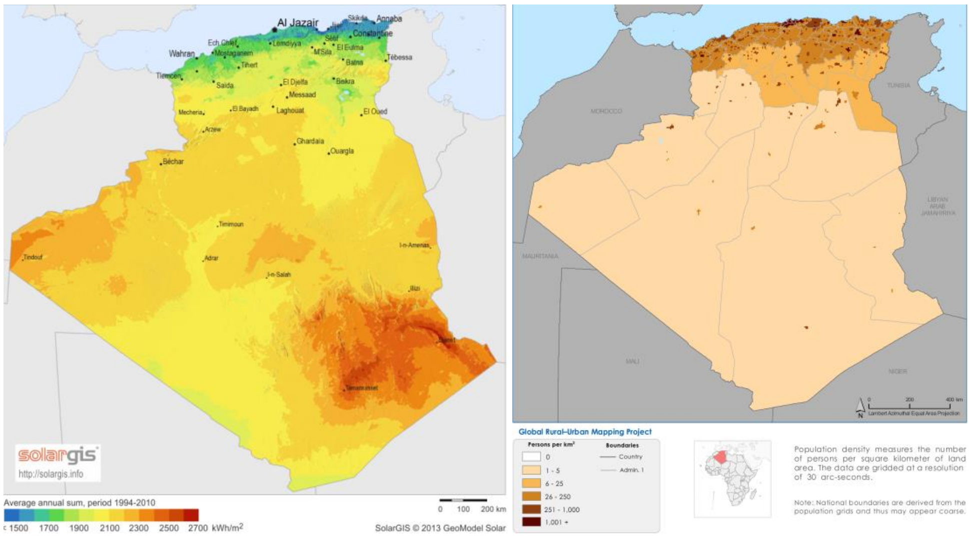

Figure 16: DNI (left) and population density (right) maps for Algeria.

The population density and DNI distribution maps are numerically discretised and the area-averaged values for each one calculated. Then, the maps are normalised with respect to their average values and the surface integral of their product distributions calculated. The end result of this is a factor (F_ρ) whose value is high there where there are both high population density and available DNI and low where either of these figures of merit is low:

$$F_\rho = \frac{\int \frac{DNI}{\overline{DNI}} \cdot \frac{\rho_{Pop}}{\bar{\rho}_{Pop}} \cdot dS}{\int dS}$$

Where $\overline{DNI}$ and $\bar{\rho}_{Pop}$ are the area-averaged values of DNI and population density across the country of interest, calculated as follows:

$$\begin{cases} \overline{DNI} = \dfrac{\int DNI \cdot dS}{\int dS} \\ \bar{\rho}_{Pop} = \dfrac{\int \rho_{Pop} \cdot dS}{\int dS} \end{cases}$$

Figure 17 shows a sample distribution of F_ρ in Spain. Darker colours are used for lowly populated areas whereas those regions in yellow indicate high population density and electricity consumption along with intermediate to high irradiance. It is easily deduced that population density is dominant over the solar resource. Otherwise the very sunny Southside of the country would yield higher values of F_ρ.

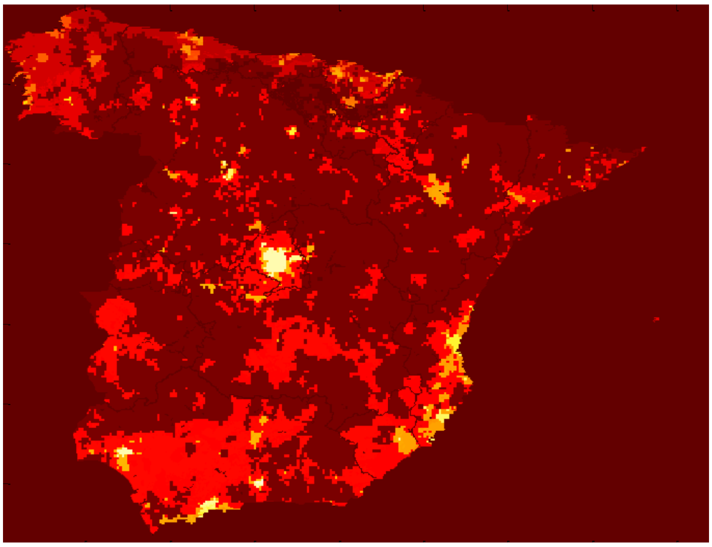

Figure 17: Representation of factor F_ρ for Spain.

When all these factors discussed in the paragraphs above are arranged together, the final grid factor shows the following aspect:

- Stand-alone system.

$$F_G = 1$$

- Farm arrangement:

$$F_G = F_\rho \cdot A$$

It must be noted that, as opposed to the other factors employed in the methodology, it is possible that $F_\rho > 1$ in those countries where highly populated areas are exposed to irradiation levels above the average DNI for the given country. Such is the case of Brazil, for instance, a country exhibiting large extensions of land with hardly any population and a very low irradiance (Amazon). On the contrary, countries like Nigeria would exhibit a very low $F_\rho \ll 1$ due to highly insolated areas not being populated densely.

Energy policy and social factor, F_P

This is probably the most complex factor due to the large number of aspects that influence the dependence of the market interest from the socio-political characteristics of a country. Thus, it has been deemed reasonable to account for all these contributions in an independent manner, making use of secondary factors or, more simply, sub-factors. These sub-factors are associated to:

- **Fraction of the annual consumption of electricity that is imported from nearby markets** (f_{import}). The fact that a large fraction of the electricity consumed in a country is imported from a nearby state poses a need to augment the capacity of the national power system. Therefore, it is assumed that those countries where electricity imports are high are more favourable for the deployment of the OMSoP system. On the contrary, countries with no electricity imports are considered self-sufficient and thus the potential demand for OMSoP units will not come from a lack of capacity but from other factors (probably environmental or purely economic or market-related).

Based on this rationale, the sub-factor is given the lowest value when the fraction of electricity imported is null ($f_{import} = 0$) whereas its value is highest if all the electricity is imported ($f_{import} = 1$).

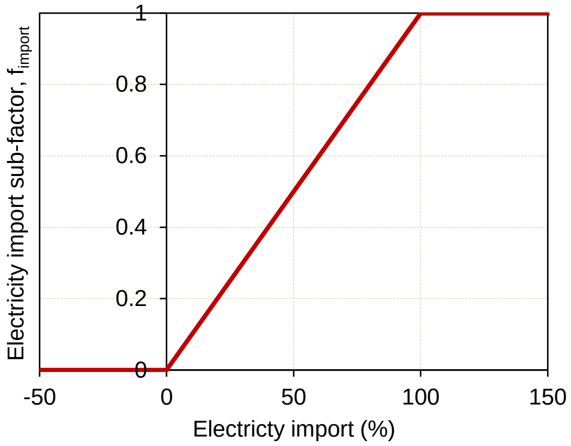

Figure 18: Electricity import sub-factor.

- **Fraction of renewable energies in the electricity mix ($f_{renewable}$).** The term "electricity mix" refers to the fraction of electricity consumed in a country that is produced by each technology or energy source. The fraction of renewable energy is thus the amount (percentage) of electricity consumed in a country from renewable energy sources (hydroelectric excluded) with respect to the overall production of electricity. This index is considered to be an indicator of the willingness of a country (both the population and the administration) to set up a low-carbon and environmentally friendly electric system.

  Quantitatively, the values of this sub-factor are based on the 2020 climate and energy package enacted in 2009 whereby the member states set out the following objectives for 2020:

  - Reducing the greenhouse gas emissions in the European Union (EU) by 20% from 1990 levels.
  - Raising the share of EU energy consumption produced from renewable resources to 20%.
  - Achieving a 20% improvement in the EU's energy efficiency.

  Based on this 20-20-20 objectives, the interest is assumed highest ($f_{renewable} = 1$) if the participation of renewables in the electricity mix is below 20%, on the basis that it is expected that the country struggles to achieve this value. This assumption applies even if the country is not a member state of the European Union, given that the objectives set forth by the EU are still considered a representative framework for the analysis. Beyond this value of 20%, the sub-factor decreases down to a residual value of $f_{renewable} = 0.25$ when the contribution of renewables to the electricity mix is 40% or higher. This threshold value is taken as twice the EU objective and the fact that there is a residual interest sub-factor lies on the fact that it is quite likely that a country with such a high contribution from renewables keeps on increasing its green profile.

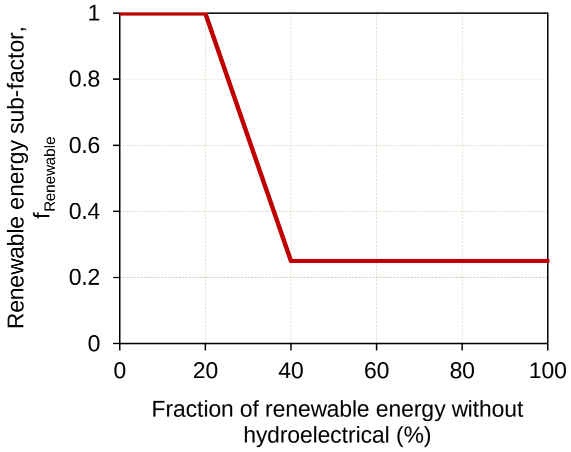

Figure 19: Renewable energy sub-factor.

- **Microeconomic wealth - per capita GDP** (f_{wealth}). The economic status of a country's inhabitants is a primary factor affecting the likeliness of the technology being successful in the market. For less developed economies, it is quite likely that the basic services are heavily subsidised and that the consumers have access to them at a lower than the actual cost. One of these services is, naturally, electricity. It is deduced from this assumption that there will hardly be any individual consumers or even small companies willing to invest in technologies that are more expensive than the conventional competing generators.

  For similar reasons, wealthy economies are very likely to emerge as markets where, should the necessary boundary conditions be met (mainly irradiance), the technology would be deployed more easily. This interest is assumed to vary linearly between "weak" and "strong" economies.

  Following a similar approach to the one used for the electricity consumption per capita, the highest value for this sub-factor is given to the GDP per capita in the transition from the first to the second quartiles in the database of the World Bank. This turns out to be Algeria with a GDP per capita of 5360.70 $US/year in 2013. The resulting f_{wealth} distribution is shown in Figure 20.

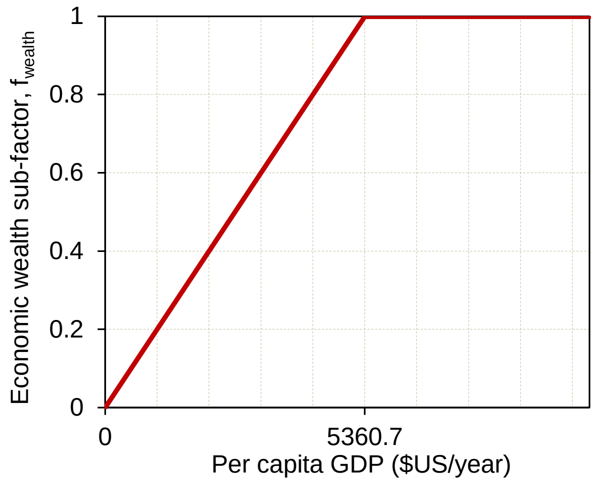

Figure 20: Per capita income sub-factor.

It is worth noting that, given that this factor applies to the economic wealth of individuals in a country, it makes sense for the stand-alone configuration only. For a multi-unit arrangement, the next sub-factor is used instead.

- **Macroeconomic wealth - GDP growth rate** (f_{growth}). This sub-factor is equivalent to the previous one when farm-arrangements are considered. The growth rate of the gross domestic product is understood as a representative figure of merit of the current and expected industrial activity in a country. High growth rates are thought to indicate the existence of investors (whether local or foreign) searching for new market opportunities in various sectors, in particular the power generation industry. The threshold values (lower and upper limits) are set to 0% for the least interesting country and 3% for the highest interest ($f_{wealth} = 1$). This latter figure is commonly assumed as a reasonable value indicating a healthy economy in a western country, as illustrated in Figure 21 and Figure 22.

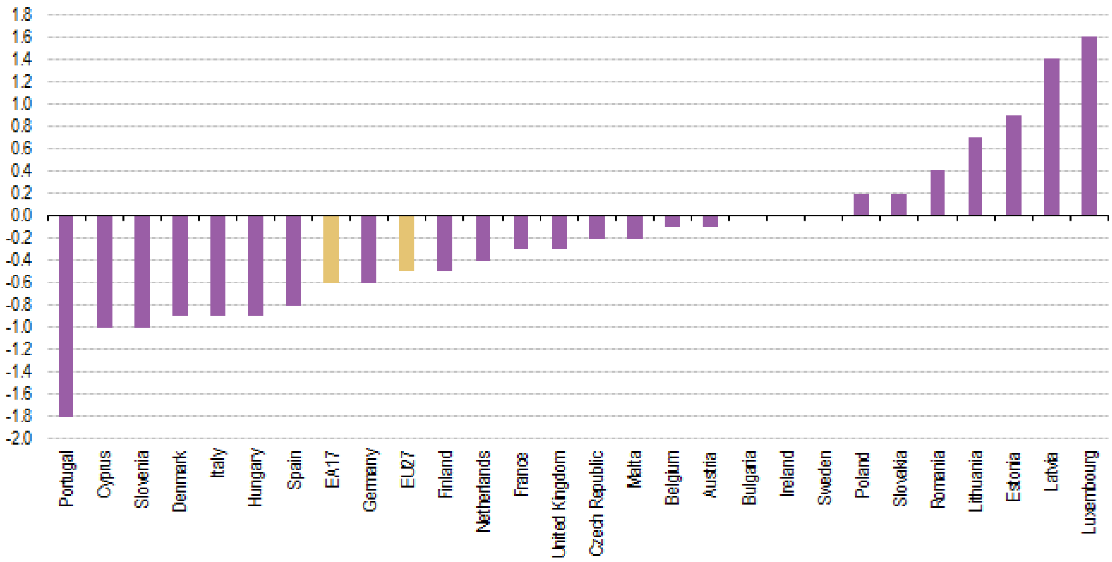

Figure 21: GDP growth rate for the EU27 and member states in Q4-2012 (Source: Eurostat).

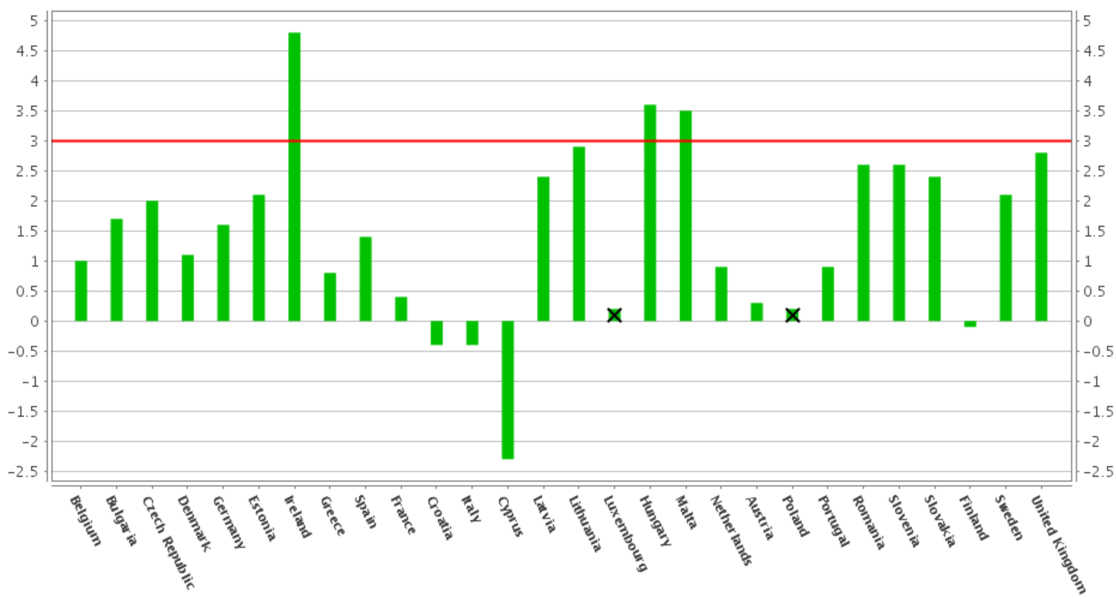

Figure 22: GDP growth rate for the EU27 and member states in 2014 (Source: Eurostat).

These figures show the GDP growth rate in the European Union EU27 in 2012, second half of the economic crisis, and 2014, beginning of the economic recovery. The latter figure confirms that none of the central countries in the continent is currently growing at a rate higher than 3%. The same applies to other regions of the world as quoted in Figure 23.

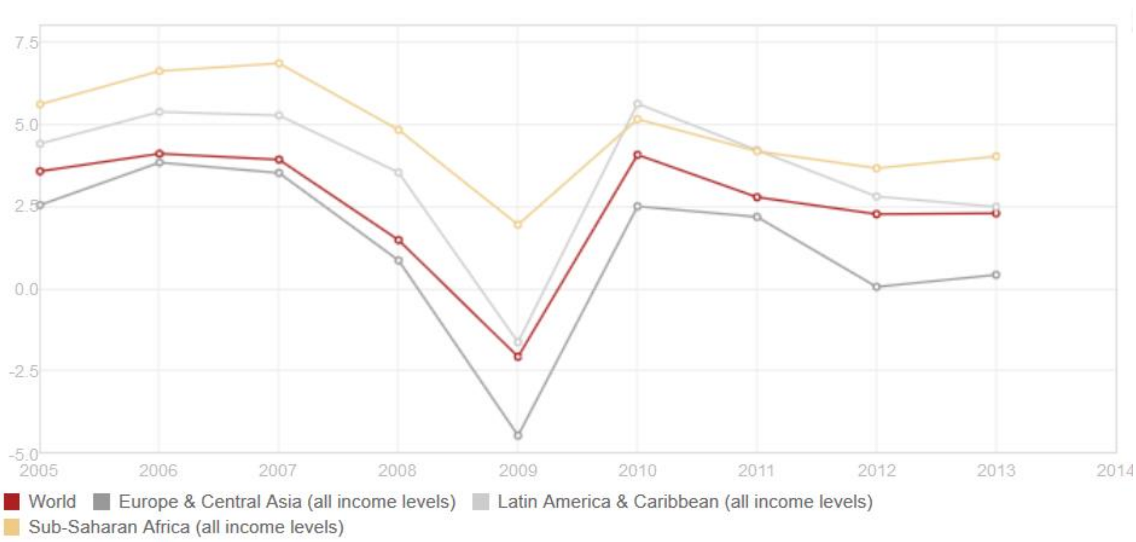

Figure 23: GDP growth rate for various regions in the world (Source: World Bank).

With all this information into account, the final growth sub-factor for farm arrangements is depicted in Figure 24 below.

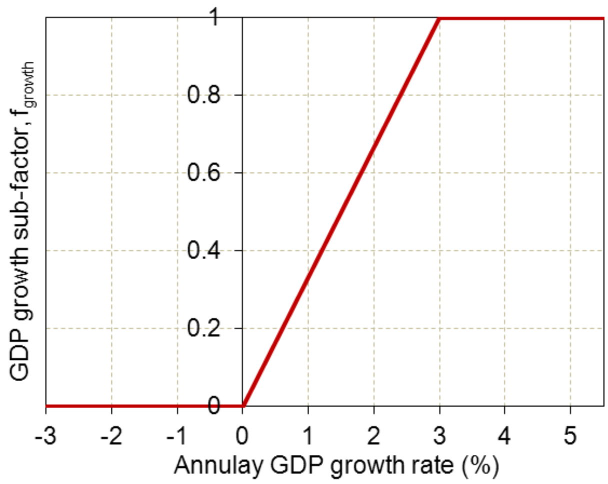

Figure 24: GDP growth sub-factor.

- **Regulatory framework – renewable energy policy** (f_{policy}). A last sub-factor is introduced to account for the existence of a favourable regulatory framework where the installation of renewable energy facilities is promoted. Ranking the various legislations and taxation schemes is not easy when it comes to quantifying whether it is more interesting to have tax credits or feed in tariffs. Thus a binary scheme is adopted whereby $f_{policy} = 0$ if an active renewable energy policy is not in place and $f_{policy} = 1$ if there are incentives, regardless of their type. This is in line with other market analyses which basically discriminate those countries where these renewable energy policies are monetised from those where these policies, if any, do not translate into tangible economic benefits for the investors.

When all these sub-factors are integrated, the energy policy and social factor has the following normalised expression:

$$F_P = \begin{cases} (f_{import} + f_{renewable} + f_{growth} + f_{policy})/4 & farm\ arrangement \\ (f_{import} + f_{renewable} + f_{wealth} + f_{policy})/4 & stand-alone \end{cases}$$

Financial risk factor, F_F

There are many non-quantifiable factors that have to valuated by decision makers when performing project appraisal. In the main, these are grouped together under the broad term *risk.* Risk is associated with a number of occurrences which would change the boundary conditions and main assumptions of the business case after which the decision to invest was made. Amongst them, the following are identified:

- **Default risk**. Also termed non-payment risk, it is the risk that companies or individuals will be unable to make the required payments on their debt obligations. Original equipment manufacturers, lenders and frequently investors are exposed to default risk in virtually all forms of credit extensions. In the context of this work, this risk represents the possibility that the equipment is deployed but against future payment milestones which are eventually not achieved.
- **Change in the regulatory and financial frameworks**. Investors in renewable energy technologies have seen the regulatory and financial scenario around their investments changing unexpectedly and without previous warning halfway through the project lifetime. Actually, various experiences in Europe can be mentioned in which feed-in-tariffs or favourable permitting were drastically reduced and even cancelled virtually overnight (recall the case of Spain mentioned earlier in the report). Such experiences raise the level of uncertainty (i.e. risk) and in turn increase the financial cost which can, eventually, make the investors turn down the investment opportunity.
- **Transparency**. The development of investment projects, whichever their nature is, involves multiple interactions between investors and local and national Administration offices. Identifying the different steps to be followed, taxes and fees to be paid, regulations to comply with, etc. is laborious and slows down the project initially (permitting phase). This situation, which is fairly common worldwide, worsens when the aforecited Administration is affected by corruption problems. In these cases both the cost and uncertainty rise exponentially.

Quantifying these features is difficult as they are based on foreseeing problems that may or may not arise in the future. Thus, it is decided to develop an approach based on the various indexes provided by Euler Hermes®, leading provider of trade-related credit insurance solution based in France. These indexes are the *country grade* (CG) and the *country risk level* (CRL) which are explained below[10]:

[10] Information taken from www.eulerhermes.com

- The *country grade* (CG) measures economic imbalances, the quality of the business climate, and the likelihood of political hazards. It is on a six-level scale running from AA to D, in which AA is the highest level of country grade and D is the lowest. The country grade is the combination of three scores:
  - The *Macroeconomic Rating* (ME) based on the analysis of the structure of the economy, budgetary and monetary policy indebtedness, the external balance, along with the stability of the banking system and other factors.
  - The *Structural Business Environment Rating* (SBE) measures the perceptions of the regulatory and legal framework, control of corruption and relative ease of doing business.
  - The *Political Risk Rating* (P), which is based on the analysis of mechanisms for transferring and concentration of power, the effectiveness of policy-making, the independence of institutions, social cohesion and international relations.
- The country grade is then combined with two short term alert indicators to produce the *country risk level* (CRL). The country risk level is measured on a four-levels scale running from 1 to 4, in which 1 is the highest level and 4 is the lowest. Those levels are also labelled as low, medium, sensitive and high in the country risk map. The two short-term indicators are:
  - The *Financial Flows Indicator* (FFI), a measure of short-term financing risks for an economy that can impact payments of trade receivables between companies.
  - The *Cyclical Risk Indicator* (CRI) which measures the short-term disruptions in demand. It includes macroeconomic and insolvency forecasts.

The approach to risk assessment is complemented by the assumption that CG is a good indicator of the risk deriving from the features of the public sector (budgetary and monetary policies, regulatory and legal framework, control of corruption, independence of institutions) whereas CRL is representative of the risk coming from private trading (financing risks, disruptions in demand). Based on this rationale, the calculation of the global risk factor weights these two indexes according to the fraction of GDP coming from public expenditures (S). For this purpose, the alphabetical scale employed to assign the *country grade* (GC) [AA A BB B C D] is converted into a numerical scale for convenience [1.0 0.8 0.6 0.4 0.2 0.0], yielding $f_{risk,1}$. Then the *country risk level* (CRL) is also normalised from [1 2 3 4] to [1 2/3 1/3 0] in increasing risk order, $f_{risk,2}$.

$$F_F = S \cdot f_{risk,1} + (1 - S) \cdot f_{risk,2}$$

Figure 25 shows a sample of a country risk map as provided by Euler Hermes for the first quarter of 2015. Short and medium term risks are combined to yield a single indicator that is plotted in a coloured scale. Attention must be paid to the independence of country risk from economy size. For instance, it is worth noting that Morocco receives the same risk level as the United States and Canada, countries with much larger economies. And the fact that Greece does not receive the highest risk level is worthy of note given that countries in a somewhat comparable situation like Argentina or Russia are actually coloured in dark red.

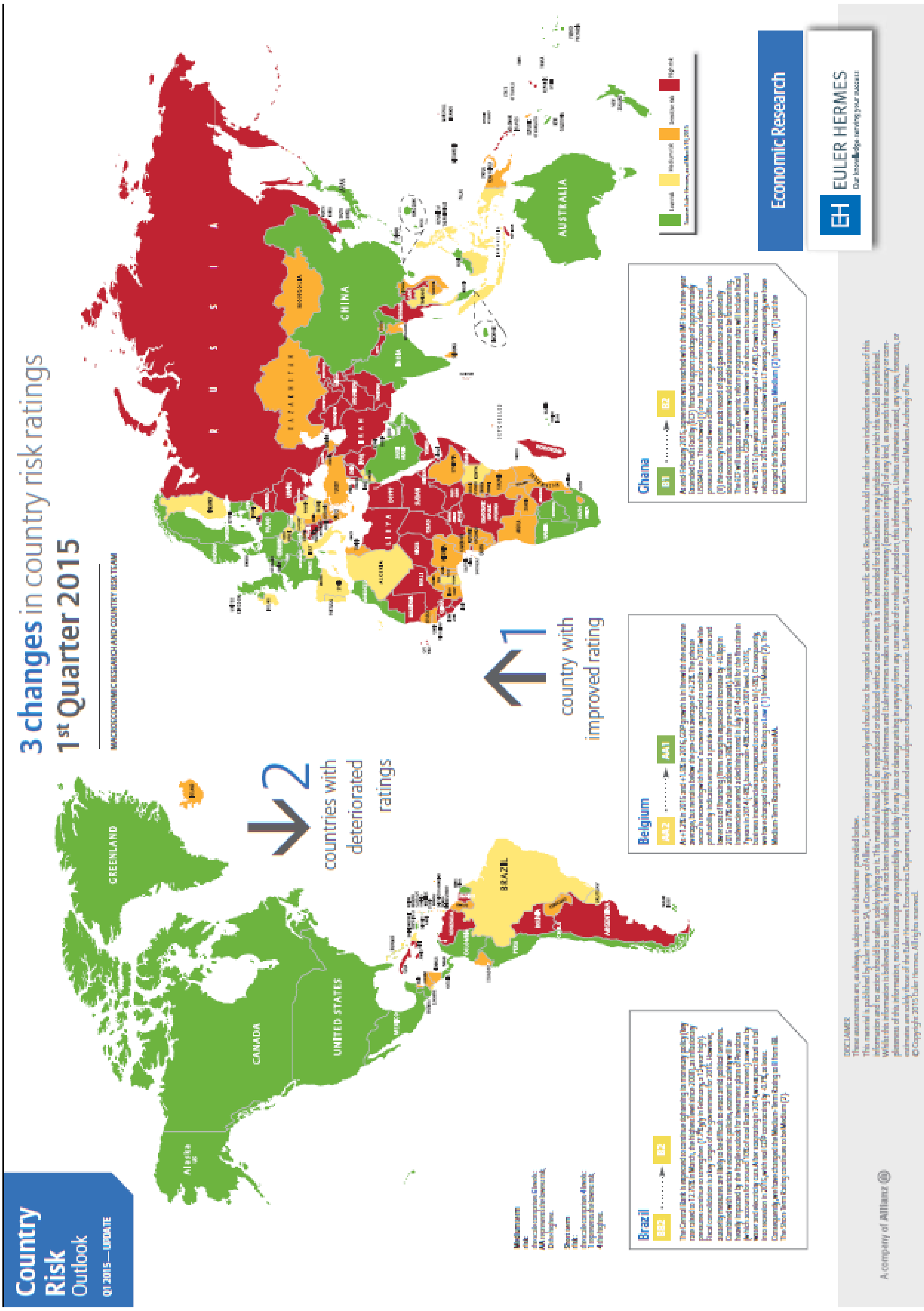

Figure 25: Country risk outlook for first quarter of 2015 (Source: Euler Hermes).

Statistical study

The five factors previously obtained for each country are now combined by the corresponding weight factors to yield the Index of Interest (IoI) for each country. Nevertheless, given the inherent uncertainty found in the process of assigning weights to the factors, the results are accompanied by statistical information aimed at providing an estimate of the confidence level of the results. The process is as follows:

- The five factors comprising the index of interest are calculated according to the methodology explained above. This calculation provides the results shown in Table 1 below for the default values.

	Farm Arrangement					Stand-alone				
	F_I	F_D	F_G	F_P	F_F	F_I	F_D	F_G	F_P	F_F
Algeria	1.0000	0.0891	0.6824	0.7500	0.5729	1.0000	0.0005	1.0000	0.7500	0.5729
Australia	1.0000	0.5161	0.8646	0.7500	1.0000	1.0000	0.0000	1.0000	0.7500	1.0000
Brazil	0.4783	1.0000	1.0360	0.7700	0.6520	0.4783	0.0070	1.0000	0.7700	0.6520
Canada	0.3121	1.0000	0.9112	0.5000	1.000	0.3121	0.0000	1.0000	0.5000	1.000
Chile	0.9549	0.1309	0.8624	0.9213	0.9752	0.9549	0.0000	1.0000	0.9213	0.9752
China	0.5009	1.0000	0.8865	0.5368	0.9156	0.5009	0.0020	1.0000	0.5368	0.9156
Egypt	1.0000	0.2979	0.8925	0.4167	0.0000	1.0000	0.0012	1.0000	0.4157	0.0000
India	0.3951	1.0000	0.7044	0.5803	0.9291	0.3951	0.3280	1.0000	0.4053	0.9291
Italy	0.3469	0.6872	0.8763	0.4350	0.6932	0.3469	0.0000	1.0000	0.6850	0.6932
Kenya	0.6063	0.0143	0.1943	0.5087	0.5854	0.6063	0.0603	1.0000	0.3084	0.5854
Libya	1.0000	0.0507	0.7782	0.2500	0.0000	1.0000	0.0001	1.0000	0.5000	0.0000
Mexico	1.0000	0.5330	0.8536	0.2500	0.9525	1.0000	0.0059	1.0000	0.5000	0.9525
Morocco	1.0000	0.0568	0.9488	0.9883	0.8847	1.0000	0.0000	1.0000	0.8937	0.8847
Namibia	1.0000	0.0074	0.5298	0.6932	0.8352	1.0000	0.0050	1.0000	0.6932	0.8352
Nigeria	0.3989	0.0539	0.4625	0.5000	0.3064	0.3989	0.0583	1.0000	0.4003	0.3064
Saudi Arabia	0.9535	0.4900	0.7795	0.5000	0.9111	0.9535	0.0049	1.0000	0.5000	0.9111
South Africa	1.0000	0.5080	0.7129	0.6250	0.9111	1.0000	0.0918	1.0000	0.7500	0.9111
Spain	0.7667	0.5373	0.7947	0.6471	0.6935	0.7667	0.0000	1.0000	0.8971	0.6935
Sudan	0.9932	0.0113	0.2804	0.2500	0.0000	0.9932	0.0278	1.0000	0.3376	0.0000
Tunisia	0.8963	0.0294	0.7423	0.7127	0.3453	0.8963	0.0001	1.0000	0.7625	0.3453
Turkey	0.6552	0.4228	0.9923	0.9280	0.3132	0.6552	0.0000	1.0000	0.9280	0.3132
USA	0.7830	1.0000	0.8900	0.6925	1.0000	0.7830	0.0000	1.0000	0.7758	1.0000

Table 1. Country factors for the stand-alone and farm arrangements.

- The weights are assumed to be represented by a normal (Gaussian) probability function taking the mean value and standard deviation provided by the analyst. This standard deviation is based on the confidence level of the analyst.
- The Monte Carlo method is then applied, assuming that the factors remain constant whilst 1000 values of the weight are taken randomly. In this analysis, the factors are changed individually in order to avoid meaningless results. Hence, a total of ten different sets of results are obtained: one for each factor (IoI_I, IoI_D, IoI_G, IoI_P and IoI_F.) and one for each configuration.

- Finally, statistical information indicating the mean value of the index of interest and its standar deviation is provided. The list of countries is ranked according to the IoI for each configuration but, rather than providing a univoque result, the list is ordered according to the number of times that a country gets the n^{th} position when the Monte Carlo method is applied. This is shown in Figure 26 for Algeria with a population of 10^3 samples and standard deviation equal to 20% for all the weight factors:

  - Farm-arrangement $w_I = 0.35$; $w_D = 0.25$; $w_G = 0.20$; $w_P = 0.10$; $w_F = 0.10$
  - Stand-alone $w_I = 0.35$; $w_D = 0.20$; $w_G = 0.00$; $w_P = 0.20$; $w_F = 0.25$

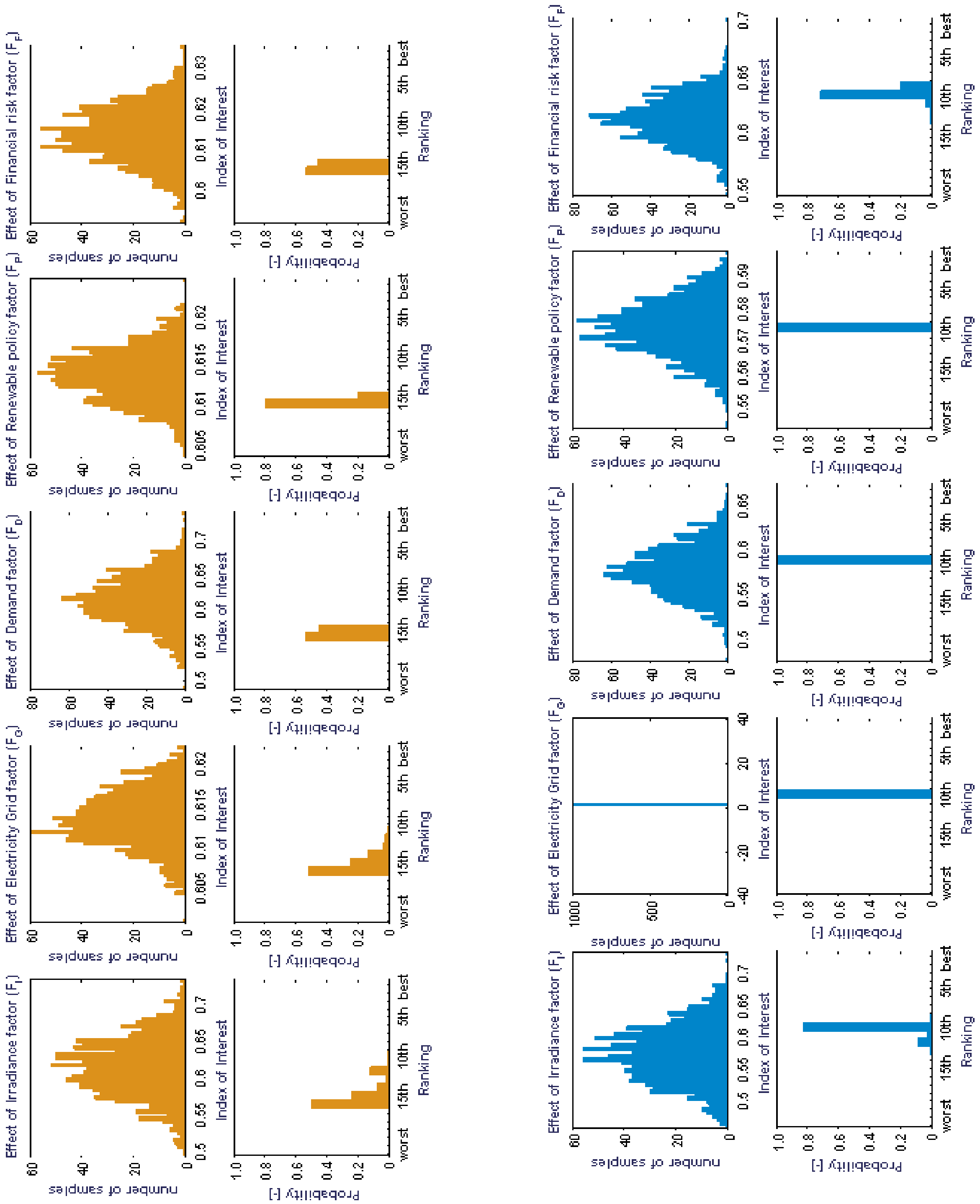

Figure 26: Example of statistical results obtained for Algeria.

The first and third lines in Figure 26 show a histogram of the results for both configurations, farm arrangement in yellowish colour and stand-alone units in blue. This information is given for variations of the five weights. The second and fourth lines integrate this information to show the probability that a country occupies a certain position in the ranked list, considering the mean value and standard deviations of the corresponding weight. The numerical values of the information in the figure are given in Table 2 below.

	Farm Arrangement					Stand-alone			
	IOI_I	IOI_D	IOI_G	IOI_P	IOI_F	IOI_I	IOI_D	IOI_P	IOI_F
1st	0	0	0	0	0	0	0	0	0
2nd	0	0	0	0	0	0	0	0	0
3rd	0	0	0	0	0	0	0	0	0
4th	0	0	0	0	0	0	0	0	0
5th	0	0	0	0	0	0	0	0	0
6th	0	0	0	0	0	0	0	0	0
7th	0	0	0	0	0	0	0	0	0
8th	0	0	0	0	0	0	0	0	0.3
9th	0.4	0	0	0	0	1.5	0	1	20
10th	1.7	0	0	0	0	82.5	100	99	70.9
11th	1.8	0.8	0	0	0	2.9	0	0	4.2
12th	13.5	2.4	0	0	0	10	0	0	3.8
13th	2.1	3.1	0	0	0	1.1	0	0	0.6
14th	5.6	14.6	0.4	0	0	0.5	0	0	0.2
15th	24.7	29.7	43.5	21.1	44.1	1.3	0	0	0
16th	50.2	49.4	56.1	78.9	55.9	0.2	0	0	0
17th	0	0	0	0	0	0	0	0	0
18th	0	0	0	0	0	0	0	0	0
19th	0	0	0	0	0	0	0	0	0
20th	0	0	0	0	0	0	0	0	0
21st	0	0	0	0	0	0	0	0	0
22nd	0	0	0	0	0	0	0	0	0

Table 2. Probability of Algeria taking the n^{th} position in the ranked list when the Monte Carlo method is applied to account for weight uncertainty.

Interestingly, the factors are not affected equally. For instance, when the influence of demand factor (F_F) is studied for the stand-alone configuration, a rather high dispersion of IoIs is obtained (fourth plot in the top line) but it hardly affects the position of Algeria in the ranked list. On the contrary, the very low dispersion of the values of IoI when the energy policy factor is considered brings about potential changes in the place occupied by the country. Moreover, when the information in Table 2 is considered, the irradiance factor (F_I) is revealed as very influential and likely to alter the ranked list of both configurations.

Analysis

Intrinsic to any market analysis, and even after the statistical treatment of the problem, the results obtained with the methodology presented herein are affected by a certain level of uncertainty. This comes from three main sources: the weight factors, the actual data employed in the model (i.e. uncertainty in the input models defining the factors numerically) and their future trends, and finally the methodology itself. By carrying out studies of the influences of factors and weights, the potential changes in the business case scenario, and comparing the validity of the results for different countries, the cited doubts can be reduced to a lower value (though not eliminated completely). In this context, this section provides an assessment in order to check the reliability of the methodology developed.

Factor weights

As said, beside the factors' influence on the index of interest, the methodology considers the weight of each factor. These weights take different values for the farm-arrangement and stand-alone configuration, the reason being that each application have distinguished properties (e.g., in stand-alone the connection to the grid is not relevant):

- Farm-arrangement $w_I = 0.35$ $w_D = 0.25$ $w_G = 0.20$ $w_P = 0.10$ $w_F = 0.10$
- Stand-alone $w_I = 0.35$ $w_D = 0.20$ $w_G = 0.00$ $w_P = 0.20$ $w_F = 0.25$

Whichever the configuration, it is clear that the solar irradiation is of high importance for the OMSoP technology and thus one would be tempted to increase the corresponding weight. Care must be taken though, inasmuch as assigning a very high weight would probably lessen the significance of the remaining coefficients. Moreover, some of the countries with excellent insolation level only could gain too much interest which would eventually turn out to be unreal. On the contrary, by setting the weight to too low values, mildly insolated countries with good business environments would step into the top of the list of potential markets. Due to these reasons, the established weight is 0.35.

The weight assigned to the demand factor is different for both configurations. For the farm-arrangement this factor is more important because the system is envisaged to be incorporated into a large system characterised by a high demand. The larger the system, the more opportunities to take part in it. For the stand-alone configuration this factor is not so significant, though it cannot be omitted. On one hand, this factor is connected to the electrification rate of a country. If it is 100%, the need for an isolated power producer which produces electricity from the sun at a higher cost than it would have if acquired directly from the grid (potentially coming from other renewable sources) is disputable. However, it is also true that the idea of self-consumption of emission-free electricity is attractive and hence might find a market even in those countries with a high degree of electrification. For these reasons, the weight is set to 0.2 for stand-alone and 0.25 for farm-arrangement.

For the electricity grid factor the weight is set to 0.2 for farm-arrangement and 0.00 for stand-alone. For the former, the existence of a high voltage grid through which the electricity can be exported is deemed crucial for the feasibility of the project. This is even more important in regions that are highly populated and with a very high insolation. For the stand-alone configuration, the system does supply electricity to a specific consumption node nearby and therefore it is not affected by the quality of the grid.

The influences of renewable energy policies on IoI are different for each configuration also. For the farm arrangement, the corresponding weight is set to 0.10. The underpinning reason for this is that, even though the current map of CSP markets confirms that the existence of governmental support is the primary factor of influence, this has proved to be a wrong approach (let the case of Spain be recalled again). In other words, a different approach is adopted in this report whereby the OMSoP technology is expected to compete against other technologies in the same market conditions. If this were not possible, the business plan would be utterly vulnerable to political decisions and thus it would not be recommended. For the stand-alone layout, on the contrary, the weight is increased to 0.20 as the individual users are thought to be financially weaker and thus in need of an initial momentum to keep decentralising the power generation system.

The financial risk factor is a reflection of the country's business environment health. That is why for stand-alone configuration it is relevant. This weight takes a higher value for stand-alone systems, based on the assumption that wealthier countries are likely to be more receptive to more expensive technologies which exhibit other less tangible features like environmental friendliness, self-sustainability of power supply and other. As it comes to farm-arrangement, the influence of this factor is diminished on the assumption that it is probably multinational corporations and/or investors who face the investment. As known, these entities can capitalise (i.e. finance) their projects in the international markets, thus being less dependent upon local conditions.

Results

For the foregoing values of factors and weights, the methodology yields the following results:

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.704
2	Australia	0.827	1.526
3	Mexico	0.768	1.771
4	Brazil	0.763	2.181
5	South Africa	0.751	1.877
6	Saudi Arabia	0.731	1.798
7	China	0.73	1.958
8	Chile	0.714	2.980
9	Morocco	0.704	3.525
10	Spain	0.704	0.884
11	Canada	0.692	3.080
12	Egypt	0.669	3.143
13	India	0.66	2.499
14	Turkey	0.648	1.759
15	Italy	0.615	2.345
16	Algeria	0.613	4.011
17	Namibia	0.583	4.532
18	Tunisia	0.579	3.934
19	Libya	0.543	5.086
20	Sudan	0.431	7.036
21	Kenya	0.358	4.645
22	Nigeria	0.323	3.296

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462
2	Chile	0.733	3.717
3	South Africa	0.697	3.580
4	United States	0.687	3.479
5	Mexico	0.67	3.956
6	Morocco	0.666	4.395
7	Spain	0.65	3.775
8	Namibia	0.637	4.167
9	Saudi Arabia	0.611	3.867
10	Algeria	0.58	5.170
11	Tunisia	0.57	4.636
12	Italy	0.511	5.036
13	Egypt	0.489	6.906
14	Brazil	0.484	4.119
15	Turkey	0.479	5.556
16	Canada	0.464	4.757
17	China	0.462	4.371
18	India	0.459	3.125
19	Libya	0.454	7.230
20	Sudan	0.423	7.578
21	Kenya	0.411	4.253
22	Nigeria	0.294	6.446

Table 3. Country rankings for farm arrangement (left) and stand-alone (right) configurations.

Table 3 shows the values of IoI and its dispersion due to uncertainties of the assigned weights. The introduction of this feature is interesting as some countries sharing similar values of the index of interest exhibit different deviations. For instance, even if Morocco and Spain are ranked similarly, the position of Spain is much more certain than that of Morocco which, in practice, could be higher but also lower in the list. The same applies to other countries, in particular for the stand-alone configuration whose market is inherently more difficult to appraise.

For the farm arrangement, the top-five list is composed by United States, Australia, Mexico, Brazil and South Africa. The appearance of USA and Australia is not surprising. They are economically stable countries with good solar conditions. As it comes to Brazil, Mexico and South Africa, they are big economies (for instance, South Africa's GDP contributes 25% of the continent's economy) even if influenced by domestic instabilities of different type. Still, their very good boundary conditions allow them to position themselves amongst the most interesting countries.

In this latter respect, it is interesting to see that the irradiance factor for these five countries is not the same. For Australia, South Africa and Mexico F_I is equal to one, while it decreases down to 0.8 in USA and to 0.5 in Brazil due to large regions in these countries having poor insolation. Other countries with very high average DNI are Algeria, Chile, Morocco, Libya, Namibia, Sudan, Saudi Arabia and Tunisia. This takes Saudi Arabia, Chile and Morocco just below the top-five list whilst the other countries are burdened by unstable economic conditions and/or very low consumption of electricity.

Another important contribution comes from the demand factor. Those countries with high electricity consumption together with large population require more capacity and energy infrastructures. This is the case of China, USA, India, Canada and Brazil which are most representative even if China, Canada and India have scarce solar resources, even lower than Brazil. Of course, this applies to average values that will have to be revisited by considering particular regions within these very large countries.

The next factor conditioning the top five list is the electricity grid factor. For this factor the most distinctive countries, in addition to USA and Brazil, are Canada, Egypt, Italy, Morocco and Turkey. These additional countries reunite better conditions in as far as the integrated value of insolation and population (F_ρ) is concerned, though they are affected by other factors negatively. Australia, Mexico and South Africa are just behind in terms of this factor, hence sustaining their strong position thanks to this aspect as well.

Going further, the policy factor is a complex combination of other four variables: fraction of electricity imported, share of renewable energy, existence of renewable energy policy and (for farm-arrangement) fraction of GDP growth. Considering the contribution coming from this factor only, the top-five countries for the farm arrangement would be Morocco, Turkey, Chile, India and China. However, none of these are found in the top-five list for the overall IoI. Two reasons are identified. First, even if the other candidate countries have lower values of this factor, they are not far behind. Second, these five countries are burdened by a poor performance in other aspects that take part in the IoI.

Finally, the list closes with the financial risk factor. In general, the values of the twenty two countries considered are very different to one another. The strongest ones are those of Australia, USA and Canada, which peak at $F_F = 1$, followed by other countries like Chile, Italy and Spain. The remaining values drop below 0.7.

This information is expanded in Figure 27 below where the contribution of each sub-factor is depicted for the first half of the list in the farm arrangement. The fact that, for some countries, a very high performance in one of the sub-factors may not be able to compensate a very low value of one of the other F_is is clearly observed. Different situations are identified:

- Cases like China, which have very high demand, grid and energy policies but, at the same time, lack a higher solar resource. This is an indicator that, most likely, there is a potential market in certain regions of the country where the insolation is higher. Local analyses are thus mandatory.
- Cases like Australia, with very high performance in all sense but a very low population density with most of the population nodes concentrated on the coast (or another specific location in other countries). Even if both layouts are of interest, it is clear that stand-alone units have a market niche in this country.
- Countries like Spain with average performance in all the sub-factors and thus very well raked in both layouts.
- Countries which would accommodate a large number of OMSoP units if it were not for the low population density. This is the case of Chile which has very good characteristics but, at the same time, low demand as a consequence of which the country gets a very high position for stand-alone units but not so high for farm arrangements. Had it had a higher demand, the results would have been similiar to those of United States.

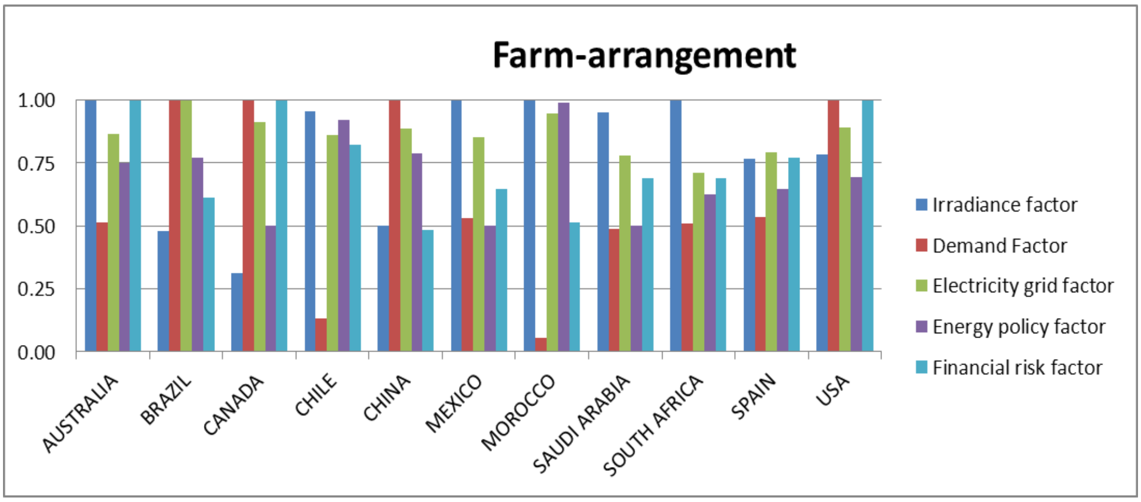

Figure 27: Sub-factors for the first half of the IoI list. Farm arrangement.

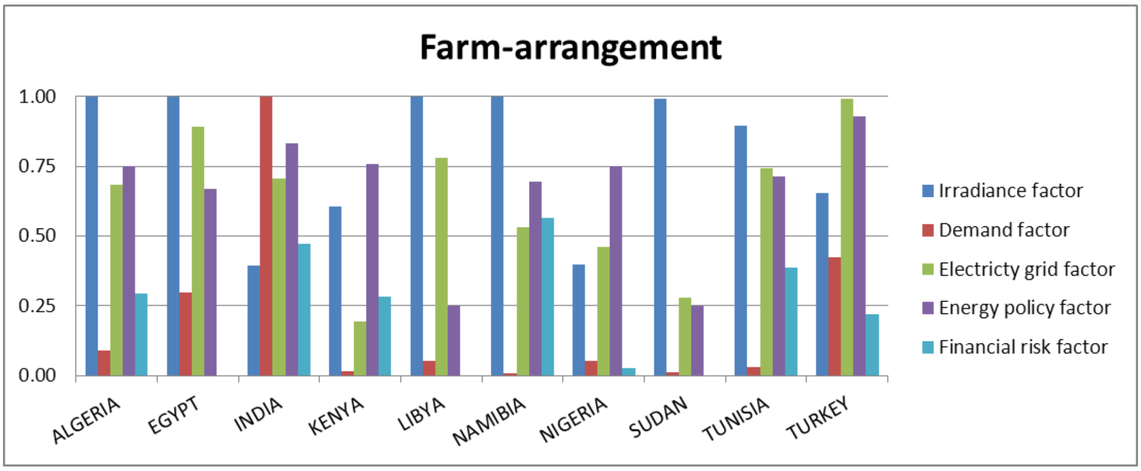

Figure 28: Sub-factors for the second half of the IoI list. Farm arrangement.

Taking a look into the bottom of the list, Figure 28*Figure 28*, the least interesting countries are Tunisia, Libya, Sudan, Kenya and Nigeria. A common pattern is observed which is characterised by the two following aspects:

- High irradiance and energy policy factor. These countries have growing economies and population and thus most of them have implemented strategy plans to increase the capacity of the national power systems. This is why F_I and F_P are high.
- Low demand and financial risk factors. The low demand is brought about by a sparse population (low density) that adds to the low electricity consumption per capita (that is typical of emerging markets or less developed economies). The financial risk factor is low because most of this countries are either facing internal conflicts, unstable politics or concentration of political power.

It is interesting to note the case of India. It exhibits reasonable performance in all factors except irradiance and financial risk. This means that it is very likely that a market niche could be found in certain regions of the country.

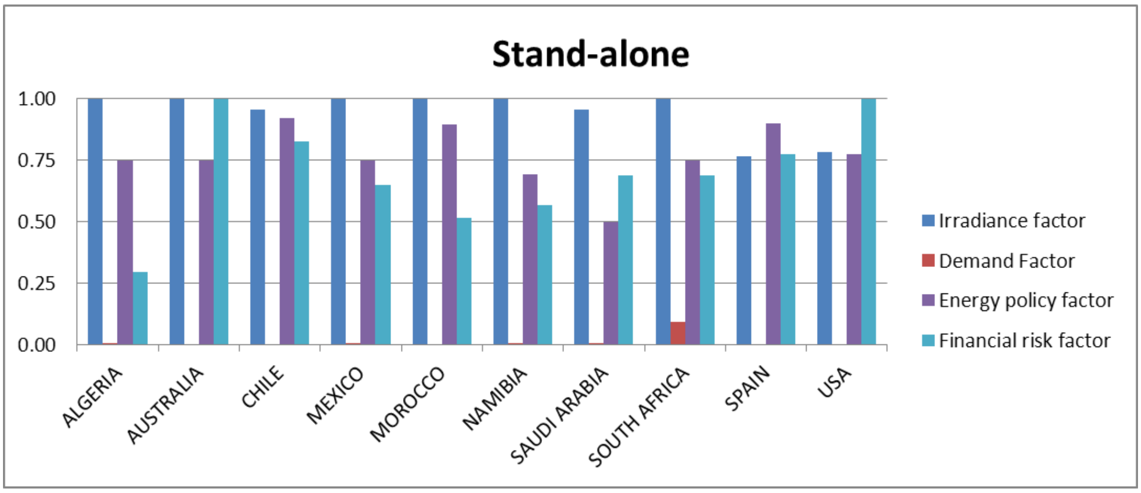

Figure 29: Sub-factors for the first half of the IoI list. Stand-alone.

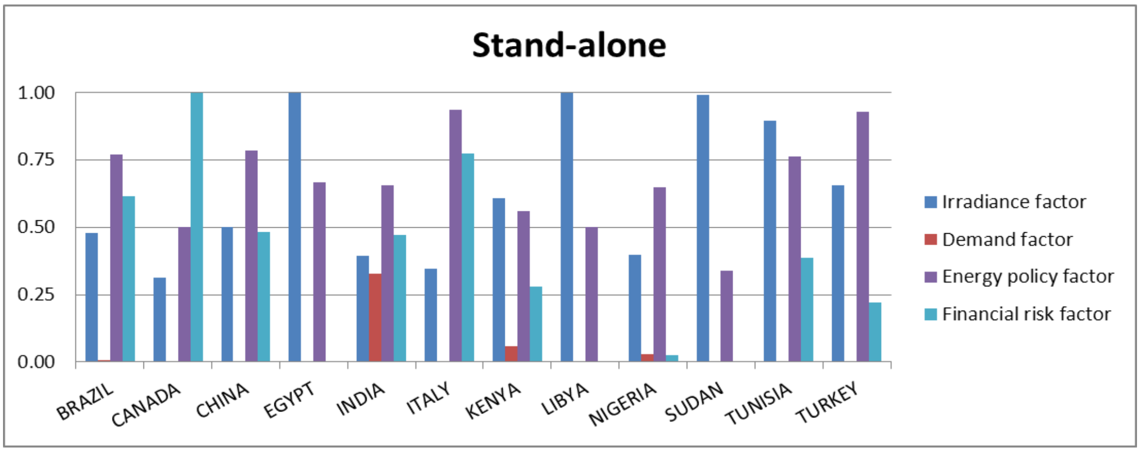

Figure 30: Sub-factors for the second half of the IoI list. Stand-alone.

The behaviour of the index of interest for the stand-alone configuration is shown in Figure 29 and Figure 30 for the first and second halves of the list respectively. A common feature is observed for most of the countries which is a very low demand factor deriving from the very high degree of electrification that is found in virtually all countries in the world. Exceptions to this statement are India and South Africa. Another common feature in Table 3 is the uniform deviation, which for most of the countries take values between 3.5% and 5%. Again, Sudan is having the maximum level of deviation.

In this mode, the countries found at the top of the list are the same as in the farm arrangement, though with different relative positions. The case of Brazil is relevant though, as it drops ten positions down to the fourteenth place. And so is the case of Chile which climbs up to the second position by leveraging on a very balanced performance in all the factors. The top-five countries are Australia, Chile, South Africa, United States and Mexico. This reallocation with respect to the farm arrangement is mainly due to changes in the policy factor and in the weights.

Further comments must be added with respect to the demand factor. This is not as important in this configuration as the introduction of stand-alone units seems to not be driven by a massive demand from people without access to the grid. Rather, it looks that in none of the countries with lowest degree of electrification are not able to climb up to the first positions of the list owing to the heavy burden of the low DNI, less developed economies (thus fewer potential buyers of the technology) and possibly financial instability. In fact, United States is dropping to the fourth position due to lower solar irradiation compared to the first three countries. Moreover, South Africa is in greater need for stand-alone units because of a lower electrification rate.

Conclusion

The first set of conclusions drawn from this analysis is qualitative. The methodology is able to filter out those countries with imbalances. This is to say, amongst the candidate countries, only those with good performance in all aspects considered relevant to ensure market success exhibit a high index of interest IoI. This issue is clearly shown in Figure 27 to Figure 30 for the farm and stand-alone arrangements.

For large power plants of the farm type, the most interesting countries are those reuniting reasonably high insolation, large demand of electricity and not bad business environments. This is the case of United States, Australia, Mexico Brazil and South Africa. Interestingly, each one of these exhibit a different best feature (i.e., peak F_i shown in bold) meaning that it is not only the solar resource which drives the market analysis.

COUNTRY	F_I	F_D	F_G	F_P	F_F
United States	0.783	1.**000**	0.890	0.693	**1.000**
Australia	**1.000**	0.517	0.865	0.750	**1.000**
Mexico	**1.000**	0.533	0.854	0.500	0.647
Brazil	0.478	**1.000**	1.036	0.770	0.615
South Africa	**1.000**	0.508	0.713	0.625	0.689
Tunisia	0.896	**0.029**	0.742	0.713	0.388
Sudan	0.993	**0.011**	0.280	0.250	**0.000**
Libya	1.000	**0.051**	0.778	0.250	**0.000**
Kenya	0.606	**0.014**	**0.194**	0.759	0.281
Nigeria	0.399	**0.054**	0.462	0.750	**0.027**

Table 4. Break down of IoI for the five most and least interesting countries. Farm arrangement.

The same argument holds true for the least interesting countries, somw of which like Libya, Tunisia and Sudan exhibit a very high insolation. However, they either have a very small market potential (low demand) or experience political instabilities which make it very difficult to attract capital to be invested.

The most leveraged performance is hence obtained for the top ten countries in Table 3. Any of these is likely to constitute a true market opportunity for the OMSoP technology. Furthermore, there are some cases which have a higher potential than reflected in the table.

Such is the case of China whose very large extension burdens F_I. This, in addition to the reported difficulties to comply with the very many local/regional legislations, brings about a low IoI. Globally, it can be stated that certain regions of the country meet the requirements that would enable the successful deployment of OMSoP. The validity of this statement will be confirmed at a later stage of the report.

From a different angle, those countries for which one or more of the figures of merit (sub-factors) have very low values are located at the bottom of the list; i.e. it is not possible to support a strong position based on just one or two factors. This is the case of the bottom five countries in Table 4 which are burdened by a low demand (low consumption of electricity, both per capita and overall) and, for some of them, also high country risk due to political instability.

For stand-alone systems, the situation is somewhat different. In this case, the detailed information of the five most and least interesting countries is summarised in Table 5.

COUNTRY	F_I	F_D	F_P	F_F
Australia	**1.000**	0.000	0.750	**1.000**
Chile	**0.955**	0.000	0.921	**0.825**
South Africa	**1.000**	0.092	0.750	0.689
United States	0.783	0.000	0.776	1.000
Mexico	**1.000**	0.006	0.750	0.647
India	0.395	**0.328**	0.655	0.471
Libya	1.000	**0.000**	0.500	0.000
Sudan	0.993	**0.028**	0.338	**0.000**
Kenya	0.606	**0.060**	0.558	0.281
Nigeria	0.399	**0.058**	0.650	**0.027**

Table 5. Break down of IoI for the five most and least interesting countries. Farm arrangement.

As expected, the most interesting regions are those for which the factors are higher. Nevertheless, a somewhat contradictory situation occurs, whereby the demand and financial subfactors turn out to be in opposition. In effect, the countries with a more favourable business environment usually correspond to developed economies where virtually all the population has access to electricity. On the contrary, those other countries where a significant fraction of the population does not have electricity supply are usually less or even under developed and thus the opportunity to business is not so high. This is due to both a lower consumption of electricity per capita and a higher financial risk. In consequence, subfactors F_D and F_F follow opposing trends as easily observed when scrolling down in Table 5.

Hence, in the light of the paragraph above, the argument that stand-alone units are very interesting for remote rural areas with little access to electricity is not valid any more at a country level. There are not many countries which, as a whole, feature this characteristic that large regions are not connected to the grid. This makes it very difficult, if not impossible, to screen and identify where a large volume of units could be deployed. Rather, the analysis of potential markets for stand-alone units must be done at the application level. This means that indutrial or residential installations which could become market niches for OMSoP must be identified and, then, quantified in order to assess (i) whether or not this market exists and (ii) whether or not is large enough to be worth the investment.

This second approach will not be considered in this document though given that is requires a cost analysis to assess whether or not it makes sense to substitute OMSoP for the power generation system currently used by this application. Therefore, it is decided to keep the current approach which, if not in absolute values, proves to be useful in relative terms.

From a quantitative stand-point, the conclusion obtained from the application of the methodology to the candidate countries is that, for large power plants with multiple units, United States and Australia are the most interesting countries. This is deduced from their higher *index* *of interest* and lower percentage deviation. On the other hand, there is a group of countries where it is more than likely that the introduction of the OMSoP technology would be successful. These are Mexico, Brazil, South Africa, Saudi Arabia, China, Chile, Morocco and Spain, all of which exhibit a fairly similar value of the *index of interest*.

These results are in line with the current status of other concentrated solar power technologies like parabolic trough or solar towers. United States is one of the most active markets today with 1750 MW in operation, 115 MW under construction and over 2000 MW under development as made public by the Solar Energy Industries Association SEIA, Figure 31.

Major Solar Project Capacity by Technology and Completion Status (MW)

Technology	Operating	Under Construction	Under Development	Grand Total
CSP	1,747	115	2,080	3,942
PV	8,306	3,407	23,661	35,374
Grand Total	**10053**	**3522**	**25741**	**39316**

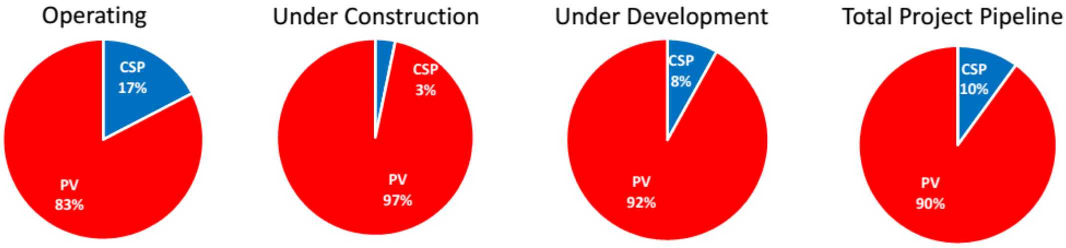

Figure 31. Status of solar projects in United States.

The case of Australia is similar. A recent report on the potential of concentrating solar power in Australia developed by IT Power for the Australian Solar Institute discusses the potential of CSP facilities of different types. Amongst the different considerations made, the following are worth noting:

- The cost of electricity generated in CSP facilities varies largely with technology, location and other features like financial conditions of the plant. The revenues obtained from the electricity also vary substantially depending on whether or not the power plant incorporates thermal energy storage or not. Regardless of this uncertainty, the truth is that CSP electricity is not competitive in Australia for the time being. This is shown in Figure 32 where a large gap of some 100 S/MWh (10 ¢$/kWh) still exists.

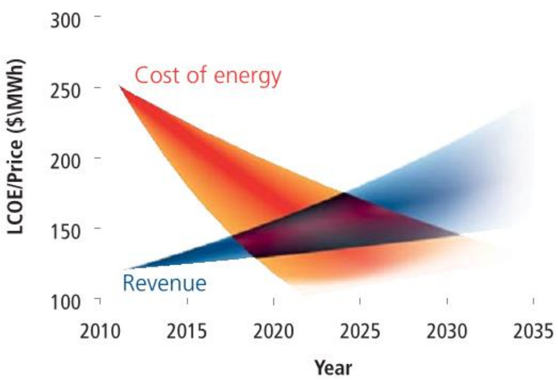

Figure 32. Cost-revenue gap for CSP electricity in australia[11].

- Is is acknowledged that Australia is a potential market for both configurations, off-grid and grid-connected facilities: "*Australia's growing electricity demand and mandatory*

[11] K. Lovegrove et al., *Realising the potential of concentrating solar power in Australia*. 2012. Australian Solar Institute report.

renewable energy targets mean that there is a use for any electricity produced as long as the output profile is suitable to the customer".

- Further to the previous point, and with regard to off-grid applications, the report states that the accesibility to the grid in those regions with highest insolation is limited, as shown in Figure 33 below. This is a very interesting feature of Australia's even if it is not in agreement with the information provided by World Bank that populates the databased used in this analysis. In particular, the world bank reports that 100% of the population in Australia have access to electricity whereas the cited analysis by the Australian Solar Institute points out that a fraction of this corresponds to consumers who have electricity supply from stand-alone generators, mainly diesel gensets. This aspect is important and its influence on the calculation of the index of interest might become relevant.

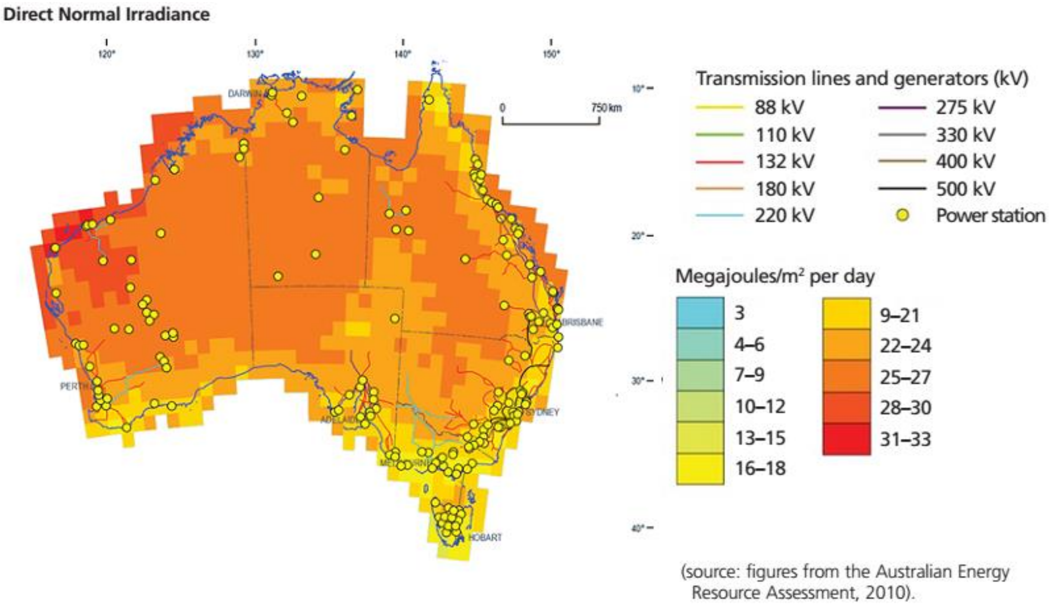

Figure 33. Solar resource and grid distribution in Australia[11].

- In a moderately optimistic business case, Australia is expected to account for 20 GW new installed capacity in CSP systems. The breakdown of technologies is as follows:
    - Some 100 MW in off-grid or mini-grid systems. This would be the market niche for stand-alone OMSoP units.
    - 500 MW in solar add-ons to fossil fuel systems. This is not a market niche for OMSoP.
    - About 300 MWe in 10.50 MWe systems connected to energy distributions networks (mid-voltage grids). This is again a market niche for OMSoP units arranged in farms.
    - 1000 MW in large units connected to high voltage transmission networks.
- Whether or not CSP will actually be deployed as expected depends on the costs of the technology which, today, are too high. This is a transversal statement which applies to either very large facilities or small parabolic dish units. There is no question that concentrating solar power systems exhibit a strong economy of scale, meaning that the cost of electricity decreases when the facility grows bigger. But not only does the cost change, also the certainty on the real value of the kilowatt hour. This is illustrated in Figure 34 below where LCOE is plotted as a function of plant size (values are relative to a 100 MW power plant with five hours storage capacity). Two opposed effects must be assesed then:

- On one hand, the cost-revenue gap is smaller for small off-grid (mini) applications given that the alternative electricity supply does not beefit from economies of scale (for insance, diesel gensets or sysmtes comprising photovoltaic pannels and backup batteries), Table 6. This can be interpreted in Figure 32 as a shift in the rightwards direction.
- On the other, as indicated in Figure 34, the uncertainty is much higher in the low scale range meaning that the real cost of commercially ready solar thermal power generators in the range of about a hundred kilowatts is not known accurately. This can be interpreted Figure 32 as a displacement of the organge region in the upwards direction, which brings about an increse of the cost-revenue gap.

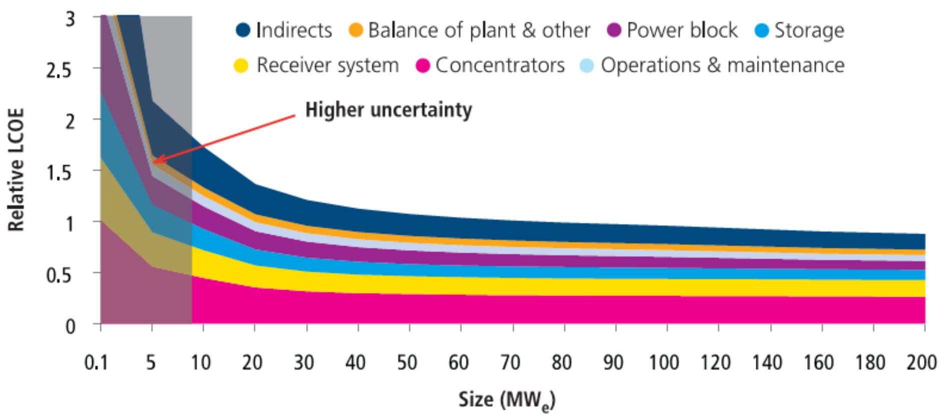

Figure 34. Estimated LCOE dependence on system size (normalised to a 100 MWesystem with 5 hours storage)[11].

	CSP with no storage			CSP with significant (5+ hours) storage		
	LCOE ($ / MWh)	Value ($ / MWh)	Gap ($ / MWh)	LCOE ($ / MWh)	Value ($ / MWh)	Gap ($ / MWh)
Large Systems on NEM	220 to 300	100 to 106	115+	250 to 360	125 to 138	110+
Small Systems on NEM	350 to 550	102 to 110	240+	370 to 500	132 to 148	220+
Large Systems on SWIS	250 to 300	98 to 102	150+	260 to 360	154 to 162	100+
Off-grid / mini grid	400 to 550	290 to 390	10+	500 to 650	340 to 450	50+

Table 6. Estimated 2012 Australian LCOE and market value of CSP systems

The statements picked-up from the cited report by the Australian Solar Institute (ASI) confirm that Australia is a potential market for the OMSoP technology, both in stand-alone configuration and also in larger arrays of units. Nevertheless, there is agreement between the present study and the one by ASI that whether or not this contry will effectively become a primary market for this and other CSP technologies remains unknown as this is highly cost-dependent. In other words, once a region with the socio-economic boundary conditions required to favour the deployment of the technology is identified, the next step is to evaluate specific applications costwise and then compare the results against those coming from other competing technologies. The same path is followed by the OMSoP consortium.

It is this concluded that the methodology proves to be effective and can thus be used reliable to explore potential markets (or conversely filter out those regions with no interest). The following sections will confirm the robustness of the methodology, which means the likeliness that the results vary completely when the input data are changed.

Sensitivity to weights

Even though it will be presented in full length in an independent uncertainty analysis, a first assessment of the influence of the assigned weights on the ranked list of potential markets is provided here. This is done to obtain a first estimate of how likely it is that the countries change positions when different sets of weights are used.

Default weights were presented before along with the rationale behind their selection. Nevertheless, there is a considerable subjectivity in this selection and thus the assigned values might result disputable. For this reason, let us assume that one did know nothing about which weights he or she should use, and hence this analyst would opt for assigning the same weight to each subfactor:

- Farm-arrangement $w_I = 0.20 \quad w_D = 0.20 \quad w_G = 0.20 \quad w_P = 0.20 \quad w_F = 0.20$
- Stand-alone $w_I = 0.25 \quad w_D = 0.25 \quad w_G = 0.00 \quad w_P = 0.25 \quad w_F = 0.25$

Farm arrangement

Results for these data sets applied to the first configuration are given in Table 7 below. Results are shown for the original weights and the new ones. There are some interesting observations, the first of which is that the top of the list remains unaltered: United States and Australia are still the most interesting countries for large scale facilities. Similarly, the bottom of the list is still occupied by the same countries even if in a slightly different order (in fact, the second half of the list hardly suffers any changes).

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.873	0.695
2	Australia	0.826	1.108
3	Brazil	0.780	1.411
4	Canada	0.745	1.956
5	Chile	0.739	2.097
6	China	0.732	1.430
7	South Africa	0.707	1.191
8	Mexico	0.707	1.389
9	Spain	0.704	0.700
10	Morocco	0.702	2.655
11	Saudi Arabia	0.682	1.314
12	India	0.680	1.674
13	Italy	0.674	1.366
14	Turkey	0.644	2.273
15	Egypt	0.572	3.306
16	Algeria	0.563	2.967
17	Namibia	0.559	2.941
18	Tunisia	0.554	2.841
19	Lybia	0.416	4.933
20	Kenya	0.371	3.701
21	Nigeria	0.338	3.988
22	Sudan	0.307	6.118

Table 7. Country rankings for farm arrangement: default weights (left) and evenly distributed weights (right).

In order to ease out the comparison, Table 8 plots arrows to indicate the change in relative position. The main features are:

- As said, the two most interesting countries remain the same.
- The first ten countries of the list change position but virtually remain the same with the only exception of Canada. This is the newcomer to the top ten countries due to the lower weight of the irradiance factor which is very low for this country ($F_I = 0.312$).
- For similar reasons, Mexico drops five positions pulled by the low demand and policy factors and so does Saudi Arabia whose most attractive feature is the excellent irradiance.
- The countries in the second half of the country do not exhinit very good features in any of the items considered relevant for a large scale layout and hence they do not see significant changes.

In summary, it is stated that most of the changes are brought about by the lower weight of the irradiance factor. So the question remains whether the corresponding weight (w_I) should be reduced or not. In the context of a utility scale application, the answer is *no* given that the ultimate objective is that the technology becomes competitive against the technologies that are currently supporting the system. In other words, a high irradiance is regarded as a cheaper fuel and so it is a fundamental feature which must dominate the index of interest. If its influence were lowered, one could end up with some “outsiders” (for instance Canada) for which high demands and/or secure market conditions may outweigh the main factor behind the cost of electricity.

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.873	0.695
2	Australia	0.826	1.108
3	Brazil	0.780	1.411
4	Canada	0.745	1.956
5	Chile	0.739	2.097
6	China	0.732	1.430
7	South Africa	0.707	1.191
8	Mexico	0.707	1.389
9	Spain	0.704	0.700
10	Morocco	0.702	2.655
11	Saudi Arabia	0.682	1.314
12	India	0.680	1.674
13	Italy	0.674	1.366
14	Turkey	0.644	2.273
15	Egypt	0.572	3.306
16	Algeria	0.563	2.967
17	Namibia	0.559	2.941
18	Tunisia	0.554	2.841
19	Lybia	0.416	4.933
20	Kenya	0.371	3.701
21	Nigeria	0.338	3.988
22	Sudan	0.307	6.118

Table 8. Variations of the ranked list for farm arrangement: default weights (left) and evenly distributed weights (right).

In a more ample context where the index of interest is considered as the figure of merit determining whether or not a market constitutes a priority, Table 8 can be seen from a different angle. In effect, the potential candidates are those with an $IoI > 0.7$ which are the same in both subtables. In other words, the panorama does not change even in this scenario of very high uncertainty which can be ascertained by a comparison of the maps given in Figure 35 and Figure 32; as seen, both maps show similar information. Nevertheless, it is true that there are more variations in the top of the list than at the bottom of it. Moreover, lowering down the influence of irradiation and demand factors provoked an artificial increase for IoI for Canada, Chile and India. Moreover, countries like Mexico or Saudi Arabia loosed their strong position, falling to eighth and eleventh position respectively. This shows how important it is to establish accurate values of the weights in order to filter out false or artificial results.

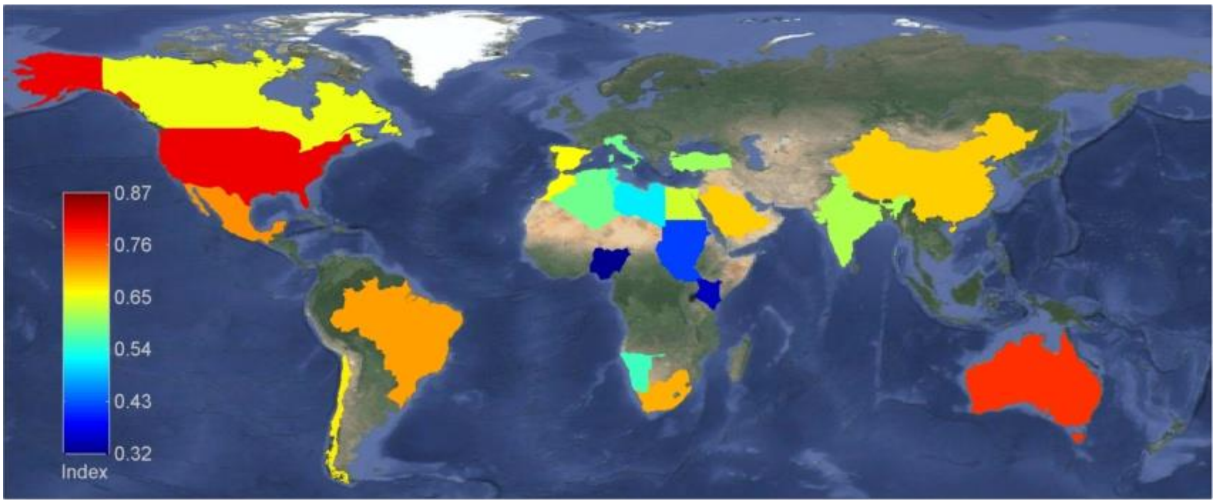

Figure 35: Map of IoI for the default weights. Farm arrangement.

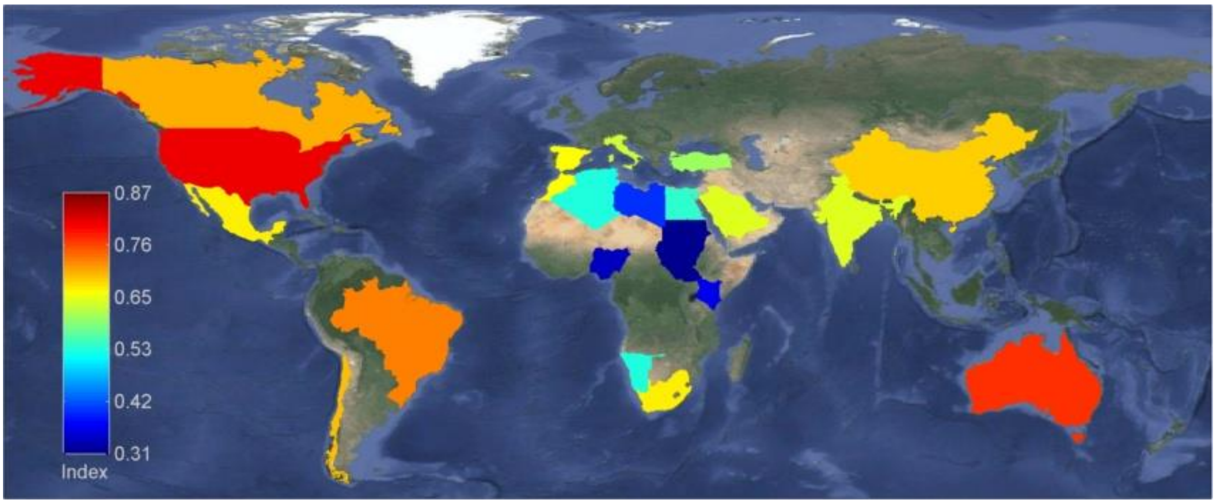

Figure 36: Map of IoI for the evenly distributed weights. Farm arrangement.

A new set of weights is therefore studied in order to further assess this observation and based on the evidence that the most relevant factor is that corresponding to the solar resource. For this reason, the weights are set to:

- Case 1: $w_I = 0.50 \quad w_D = 0.15 \quad w_G = 0.15 \quad w_P = 0.10 \quad w_F = 0.10$
- Case 2: $w_I = 0.60 \quad w_D = 0.10 \quad w_G = 0.10 \quad w_P = 0.10 \quad w_F = 0.10$

The results are summarised in Table 9 for Case 1 and the default set of weights (for comparison) and in Table 10 with arrows indicating the reallocation of countries. It is very easily observed that there is a drastic reallocation of countries. Actually, it could be said that the table is turned upside down so the information displayed on the right column is the list of countries ranked according to their direct normal irradiance. This is not utterly true though as there is still fifty percent of the index of interest that comes from other features, even if it is certain that the ranking is dominated by DNI. The confirmation to this is the results obtained for Case 2, Table 11 where even though the weight of the irradiance factor is increased further, the changes incurred are much lower.

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.896	2.146
2	United States	0.857	1.817
3	South Africa	0.819	2.685
4	Mexico	0.817	2.554
5	Chile	0.808	3.175
6	Morocco	0.789	3.924
7	Saudi Arabia	0.786	2.488
8	Spain	0.731	1.905
9	Namibia	0.715	4.521
10	Algeria	0.708	4.729
11	Egypt	0.707	4.704
12	Brazil	0.670	3.542
13	Tunisia	0.664	4.290
14	China	0.648	3.295
15	Turkey	0.625	3.316
16	Libya	0.612	6.314
17	Canada	0.602	4.909
18	India	0.580	4.197
19	Italy	0.556	4.252
20	Sudan	0.553	7.752
21	Kenya	0.450	5.087
22	Nigeria	0.340	5.293

Table 9. Country ranking for default weights (left) and weights in Case 1 (right). Farm arrangement.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
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No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.896	2.146
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9	Namibia	0.715	4.521
10	Algeria	0.708	4.729
11	Egypt	0.707	4.704
12	Brazil	0.670	3.542
13	Tunisia	0.664	4.290
14	China	0.648	3.295
15	Turkey	0.625	3.316
16	Libya	0.612	6.314
17	Canada	0.602	4.909
18	India	0.580	4.197
19	Italy	0.556	4.252
20	Sudan	0.553	7.752
21	Kenya	0.450	5.087
22	Nigeria	0.340	5.293

Table 10. Variations of the ranked list for different weights: default (left) and Case 1 (right). Farm arrangement.

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.896	2.146
2	United States	0.857	1.817
3	South Africa	0.819	2.685
4	Mexico	0.817	2.554
5	Chile	0.808	3.175
6	Morocco	0.789	3.924
7	Saudi Arabia	0.786	2.488
8	Spain	0.731	1.905
9	Namibia	0.715	4.521
10	Algeria	0.708	4.729
11	Egypt	0.707	4.704
12	Brazil	0.670	3.542
13	Tunisia	0.664	4.290
14	China	0.648	3.295
15	Turkey	0.625	3.316
16	Libya	0.612	6.314
17	Canada	0.602	4.909
18	India	0.580	4.197
19	Italy	0.556	4.252
20	Sudan	0.553	7.752
21	Kenya	0.450	5.087
22	Nigeria	0.340	5.293

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.913	1.411
2	South Africa	0.853	2.458
3	Mexico	0.853	2.474
4	Morocco	0.851	2.650
5	Chile	0.847	1.966
6	United States	0.828	0.834
7	Saudi Arabia	0.818	2.348
8	Egypt	0.785	4.000
9	Algeria	0.781	4.053
10	Namibia	0.779	4.091
11	Spain	0.735	0.671
12	Tunisia	0.725	3.464
13	Libya	0.708	5.961
14	Sudan	0.650	7.554
15	Turkey	0.649	1.035
16	Brazil	0.629	3.464
17	China	0.616	2.744
18	India	0.538	3.848
19	Canada	0.529	5.897
20	Italy	0.511	4.584
21	Kenya	0.488	3.616
22	Nigeria	0.369	2.014

Table 11. Variations of the ranked list for different weights: Case 1 (left) and Case 2 (right). Farm arrangement.

Beyond these evident trends of the analysis, it is worth noting that the list of potential markets does not change as dramatically as it could have been expected or as it seems at the beginning. Actually, there are only three countries amongst the original top ten list (default values) that sink in the table and lose their place in these privileged positions. These are China and Brazil, which are found down in the sixteenth and seventeenth positions of the list for Case 2. The reason for this is a heterogeneous distribution of the solar resource in the country. As shown in Figure 37, there are regions of the country with very high insolation whereas some other areas hardly receive direct solar radiation. On the contrary, other countries like Sudan or Libya, for which the risk ($F_{F,Libya} = 0.037$ and $F_{F,Sudan} = 0.042$) and demand ($F_{D,Libya} = 0.069$ and $F_{D,Sudan} = 0.026$) indicators are low indeed are not burdened any more by this feature and hence climb to the top of the list. This cannot be regarded as real as it is less likely that these countries offer better market conditions.

The case of Namibia is also interesting as it goes up from seventeenth position up to number ten thanks to a very high irradiance factor ($F_F = 0.979$) and fairly good performance in terms of financial risk ($F_F = 0.708$), policy ($F_P = 0.555$) and grid ($F_G = 0.633$). The fact that in only lacks a higher demand to truly become a priority market will explain the high position of this country when stand-alone applications are considered.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.896	2.146
2	United States	0.857	1.817
3	South Africa	0.819	2.685
4	Mexico	0.817	2.554
5	Chile	0.808	3.175
6	Morocco	0.789	3.924
7	Saudi Arabia	0.786	2.488
8	Spain	0.731	1.905
9	Namibia	0.715	4.521
10	Algeria	0.708	4.729
11	Egypt	0.707	4.704
12	Brazil	0.670	3.542
13	Tunisia	0.664	4.290
14	China	0.648	3.295
15	Turkey	0.625	3.316
16	Libya	0.612	6.314
17	Canada	0.602	4.909
18	India	0.580	4.197
19	Italy	0.556	4.252
20	Sudan	0.553	7.752
21	Kenya	0.450	5.087
22	Nigeria	0.340	5.293

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.913	1.411
2	South Africa	0.853	2.458
3	Mexico	0.853	2.474
4	Morocco	0.851	2.650
5	Chile	0.847	1.966
6	United States	0.828	0.834
7	Saudi Arabia	0.818	2.348
8	Egypt	0.785	4.000
9	Algeria	0.781	4.053
10	Namibia	0.779	4.091
11	Spain	0.735	0.671
12	Tunisia	0.725	3.464
13	Libya	0.708	5.961
14	Sudan	0.650	7.554
15	Turkey	0.649	1.035
16	Brazil	0.629	3.464
17	China	0.616	2.744
18	India	0.538	3.848
19	Canada	0.529	5.897
20	Italy	0.511	4.584
21	Kenya	0.488	3.616
22	Nigeria	0.369	2.014

Table 12. Summary of variations of the ranked list for different weights: default (left), Case 1 (centre) and Case 2 (right). Farm arrangement.

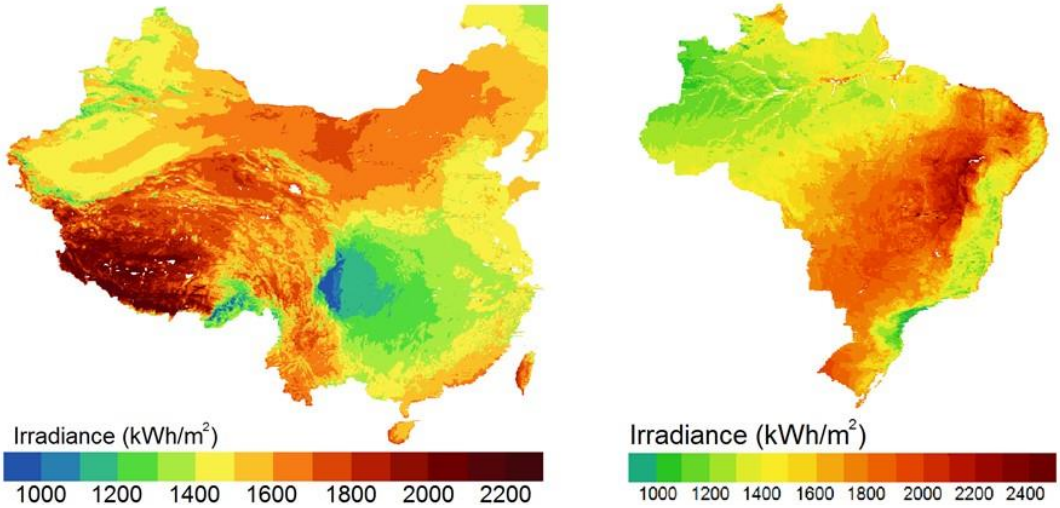

Figure 37: Map of direct normal irradiance in China (left) and Brazil (right).

The foregoing analysis has evidenced the relevance of the irradiance factor as a discriminating feature of the candidate countries. Nevertheless, this cannot be overweighed as it might happen that countries with not very good market conditions from a financial and legal standpoint or with potentially few consumers are (erroneously) labelled as interesting.

Hence, to further assess this fact, the policy and financial risk factors are now looked into in detail. This is done by considering the following sets of weights, for which results are presented in Table 13 and Table 14:

- Case 3: $w_I = 0.30 \quad w_D = 0.20 \quad w_G = 0.15 \quad w_P = 0.10 \quad w_F = 0.25$
- Case 4: $w_I = 0.30 \quad w_D = 0.20 \quad w_G = 0.10 \quad w_P = 0.15 \quad w_F = 0.25$

The results of this analysis show that there is a minor reallocation of the countries in the top ten list with the only noteworthy improvement of Chile and a less important drop of China. The latter is nonetheless brought about by an improvement of the neighbouring countries in the list rather than a deterioration of China's performance (i.e. IoI_{China} remains constant). In the main, the list does not change in as far as the ten most interesting countries are concerned. Canada and Spain swap places but the comments already made about Canada suggest that this is mainly brought due to the higher influence of non-solar features like political stability and business environment.

It is interesting to note that the particular value of the index of interest increases for most of the countries that lead the list. This is a confirmation that not only is it important to be gifted with natural resources, it is equally important to reunite the conditions under which a commercial project must be developed. A similar reading can be made for those countries that are positioned at the bottom: their positions hardly change and the corresponding IoIs tend to decrease.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.884	1.661
2	Australia	0.852	2.105
3	Brazil	0.780	2.734
4	Mexico	0.772	1.953
5	Chile	0.753	3.290
6	South Africa	0.752	2.245
7	Saudi Arabia	0.737	1.969
8	Morocco	0.734	3.855
9	China	0.731	2.723
10	Canada	0.727	2.839
11	Spain	0.723	1.930
12	Turkey	0.664	3.514
13	India	0.657	3.199
14	Egypt	0.656	3.715
15	Italy	0.652	2.919
16	Algeria	0.614	4.070
17	Tunisia	0.596	3.886
18	Namibia	0.594	4.169
19	Libya	0.532	4.587
20	Sudan	0.397	6.500
21	Kenya	0.359	5.757
22	Nigeria	0.354	5.142

Table 13. Variations of the ranked list for different weights: default (left) and Case 3 (right). Farm arrangement.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.854	1.752
2	Australia	0.824	2.191
3	Brazil	0.772	2.772
4	Mexico	0.755	2.039
5	Chile	0.740	3.352
6	Morocco	0.738	3.760
7	South Africa	0.736	2.305
8	China	0.731	2.704
9	Saudi Arabia	0.718	2.077
10	Spain	0.704	1.986
11	Canada	0.691	3.024
12	Turkey	0.681	3.224
13	Egypt	0.676	3.218
14	India	0.658	3.241
15	Italy	0.634	3.058
16	Algeria	0.623	3.895
17	Tunisia	0.599	3.789
18	Namibia	0.587	4.241
19	Libya	0.540	4.384
20	Sudan	0.405	6.356
21	Kenya	0.368	5.714
22	Nigeria	0.354	5.095

Table 14. Variations of the ranked list for different weights: default (left) and Case 4 (right). Farm arrangement.

Stand alone

Two analyses will be presented for the stand-alone configuration, given that the ranked list of potential markets seems to be less sensitive to changes in the factors' weights. These two cases correspond to the following sets of weights:

- Case 1: $w_I = 0.45 \quad w_D = 0.15 \quad w_P = 0.20 \quad w_F = 0.20$
- Case 2: $w_I = 0.35 \quad w_D = 0.30 \quad w_P = 0.15 \quad w_F = 0.20$

Results for the first case are shown in Table 15. These represent the situation in which the influence favourable solar conditions is enhanced at the cost of a lower influence of demand and renewable energy policies . It would be the case of a target market with fewer but very well defined potential customers who are based either in remote areas or in areas with access to the grid but with the potential to become cost competitive/effective. It is observed that there are few changes in the first half of the list and even these are just reallocation of countries; i.e. there are not changes in the components of the top ten list.

On the contrary, a stronger reallocation is observed in the second half of the list. This is due to the stronger influence of the irradiance factor and weaker effect of demand. Thus, countries with reasonably abundant solar resources are favoured, in particular if they lack a good financial environments. This is the case of Sudan and Lybia which have high DNI in most of the country but rather poor characteristics for business. This is confirmed in Figure 38 for the solar resources of both countries.

No.	COUNTRY	IoI	DEVIATION (%)	No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462	1	Australia	0.800	2.458
2	Chile	0.733	3.717	2	Chile	0.779	2.302
3	South Africa	0.697	3.580	3	South Africa	0.751	2.767
4	United States	0.687	3.479	4	Morocco	0.732	3.188
5	Mexico	0.670	3.956	5	Mexico	0.730	3.102
6	Morocco	0.666	4.396	6	United States	0.708	1.977
7	Spain	0.650	3.775	7	Namibia	0.702	3.468
8	Namibia	0.637	4.167	8	Spain	0.679	1.978
9	Saudi Arabia	0.611	3.867	9	Saudi Arabia	0.667	3.515
10	Algeria	0.580	5.170	10	Algeria	0.659	4.255
11	Tunisia	0.570	4.636	11	Tunisia	0.633	3.524
12	Italy	0.511	5.036	12	Egypt	0.583	5.848
13	Egypt	0.489	6.906	13	Libya	0.550	6.521
14	Brazil	0.484	4.119	14	Turkey	0.524	3.202
15	Turkey	0.479	5.556	15	Sudan	0.518	7.188
16	Canada	0.464	4.757	16	Italy	0.498	3.541
17	China	0.462	4.371	17	Brazil	0.493	2.064
18	India	0.459	3.125	18	China	0.480	2.129
19	Libya	0.454	7.230	19	India	0.452	1.423
20	Sudan	0.423	7.578	20	Kenya	0.450	3.026
21	Kenya	0.411	4.253	21	Canada	0.441	3.844
22	Nigeria	0.294	6.446	22	Nigeria	0.324	3.682

Table 15. Variations of the ranked list for different weights: default (left) and Case 1 (right). Stand-alone configuration.

A different approach to the same trend is the variation of IoI. In effect, the index rises by about 0.5 points for the most attractive countries owing to the favourable contribution of DNI and the balanced performance or the remaining subfactors. On the contrary, the variations of this factor are more erratic (in the sense that they either rise or drop) and the absolute variation is in any case lower, with the exception of Libya and Sudan already mentioned.

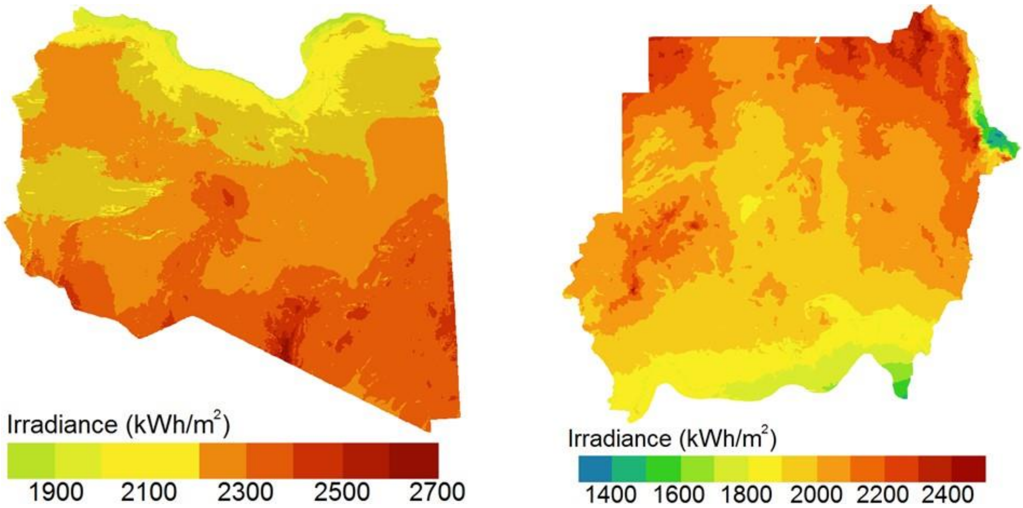

Figure 38: Map of direct normal irradiance in Libya (left) and Sudan (right).

The main argument against the hypotheses setting the case for Case 1 is the fact that a minimum market size is needed. For this reason, Case 2 doubles the influence of demand (weight goes from 0.15 to 0.30) and reduces that of irradiance and policy. The results are shown in Table 16 with respect to those of Case 1.

No.	COUNTRY	IoI	DEVIATION (%)	No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.800	2.458	1	Australia	0.642	5.323
2	Chile	0.779	2.302	2	Chile	0.633	5.526
3	South Africa	0.751	2.767	3	South Africa	0.623	5.000
4	Morocco	0.732	3.188	4	Morocco	0.597	5.932
5	Mexico	0.730	3.102	5	Mexico	0.591	5.663
6	United States	0.708	1.977	6	United States	0.572	5.261
7	Namibia	0.702	3.468	7	Namibia	0.568	5.806
8	Spain	0.679	1.978	8	Spain	0.555	5.579
9	Saudi Arabia	0.667	3.515	9	Algeria	0.537	6.350
10	Algeria	0.659	4.255	10	Saudi Arabia	0.533	5.678
11	Tunisia	0.633	3.524	11	Tunisia	0.517	6.061
12	Egypt	0.583	5.848	12	Egypt	0.477	7.222
13	Libya	0.550	6.521	13	Libya	0.445	7.533
14	Turkey	0.524	3.202	14	Turkey	0.439	6.687
15	Sudan	0.518	7.188	15	India	0.432	3.426
16	Italy	0.498	3.541	16	Sudan	0.420	7.713
17	Brazil	0.493	2.064	17	Italy	0.415	6.810
18	China	0.480	2.129	18	Brazil	0.408	5.855
19	India	0.452	1.423	19	China	0.398	6.081
20	Kenya	0.450	3.026	20	Kenya	0.379	5.332
21	Canada	0.441	3.844	21	Canada	0.354	5.749
22	Nigeria	0.324	3.682	22	Nigeria	0.285	6.590

Table 16. Variations of the ranked list for different weights: Case 1 (left) and Case 2 (right). Stand-alone configuration.

It is very interesting to see the very few changes incurred by the new assumptions. The explanation for this is twofold:

- For many countries, the access to electricity is very high (almost 100%) and hence the potential market is almost independent from the demand factor. This can be further observed in Figure 39.
- For those countries with lower access to electricity in Figure 35, India, Kenya, Sudan, Namibia and Nigeria, the population is not usually large with the cited exception of India and also Nigeria. This can be confirmed by combining the information in Figure 35 and the population data, yielding the plot in Figure 40. This shows tha number of people in each country who do not have access to electricity, which can be regarded as the size of the potential market if this focused on remote off-grid applications only.

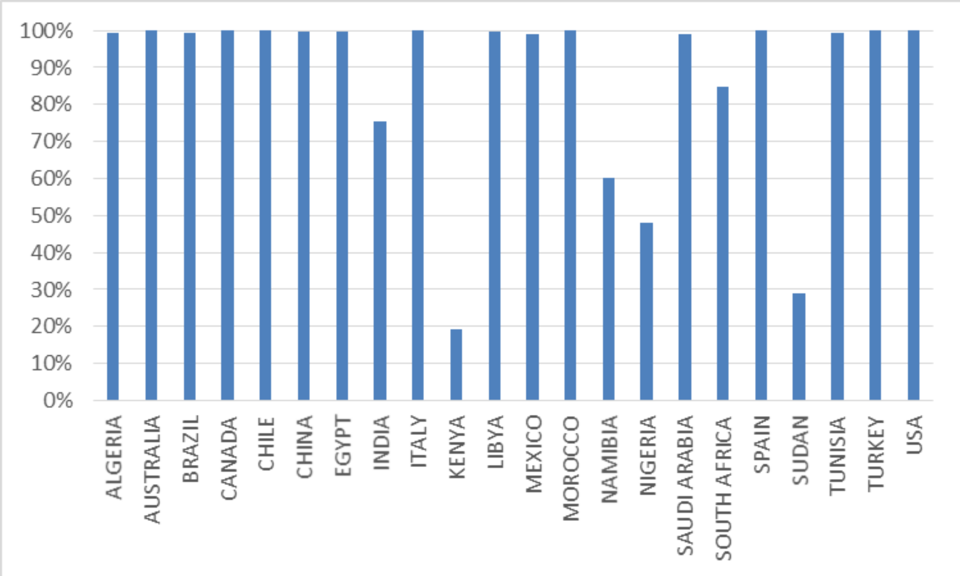

Figure 39: Access to electricity (percentage of population) in the candidate countries.

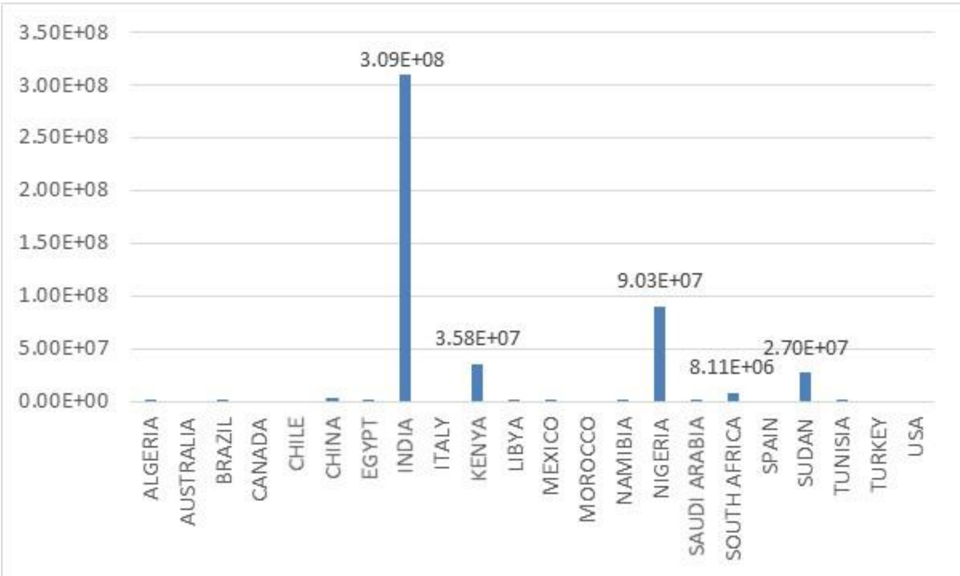

Figure 40: People without access to electricity in the candidate countries.

There are various interesting conclusions that can be drawn from this analysis:

- The first one is that the identification of potential markets seems to be easier for stand-alone configurations. This is based on the fact that changing the weights from the default values to the values in Case 1 and Case 2 does not change the list of most interesting countries; it only affects their relative position.
- The demand factor seems to be less influential than expected. This is because those countries with lower access to electricity (higher fraction of the population without access to electricity) either lack solar resources (case of Nigeria and Kenya) or have small population (case of Namibia). The exception to this rule is India.
- The top half of the list of potential markets is less sensitive than the bottom half. This means that a primary market is expected to be found in countries where there is a good environment for business and socio-political stability.

Therefore, as said from the very beginning of this report, remote rural areas with no access to electricity seem to be a natural market niche for this application. Nevertheless, the market is not that large and hence well developed economies should also be targeted. Nevertheless, for these, it is not enough to provide a reliable power generator running on renewable energy. This system must also be cost competitive. This conclusion sets a strong requirement on the OMSoP consortium inasmuch as the design must be cost driven at the same level as performance driven.

Threshold values defining the factors

The definition of the factors contributing to the index of interest is based on a number of threshold values, both upper and lower, beyond which these factors do not change anymore. This has already been discussed in an earlier section.

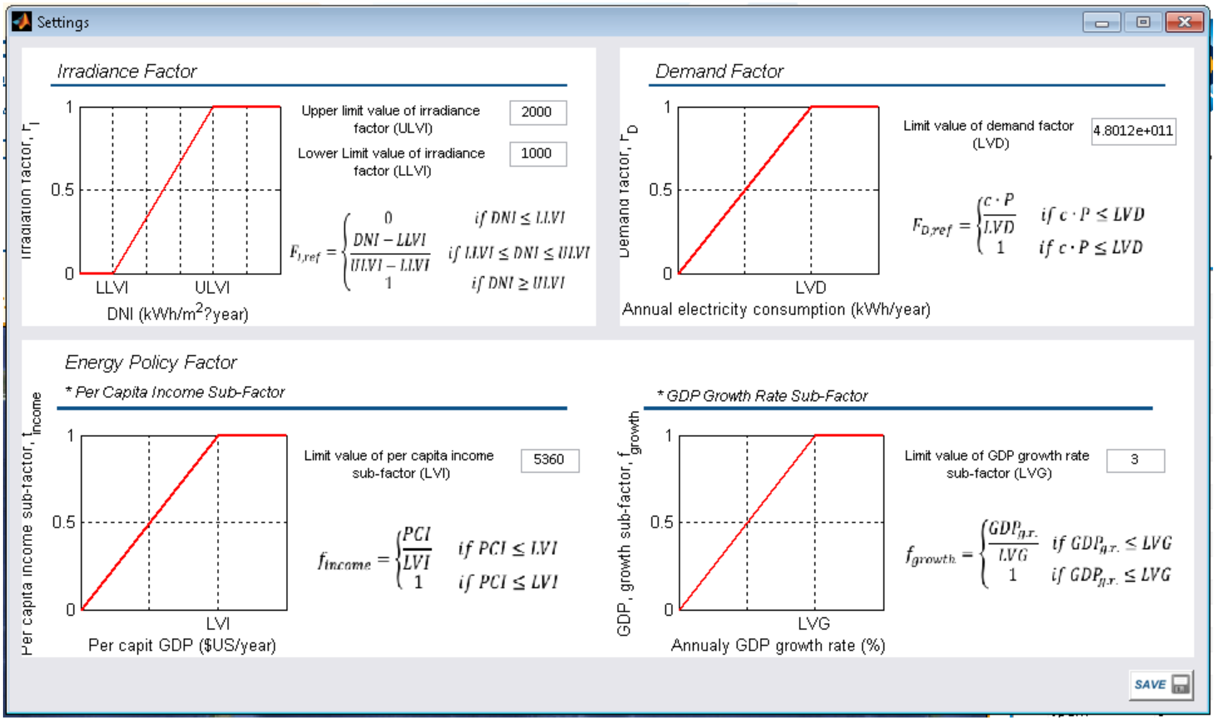

Figure 41: Settings menu in the OMSoP application.

The threshold values can be changed though in order to account for new boundary conditions or, for instance, to refine the market analysis to a group of similar countries for which a zoom into the results can be useful. The menu from which this is done in the application is shown in Figure 41. It is observed that there are five threshold values available.

Let Nigeria be considered. Its mean annual DNI reaches 1398.86 kWh/m^2, which is not a very favourable condition for a solar application like OMSoP (for instance, Spain has a mean value of ca. 1800 kWh/m^2). However, a closer look at Nigeria's DNI map shows that the DNI is not homogeneous in the country. There are regions where the values are much higher than average (close to 1800 kWh/m^2) which are in contrast with the southernmost regions near the coast and the border with Cameroon which have poor insolation.

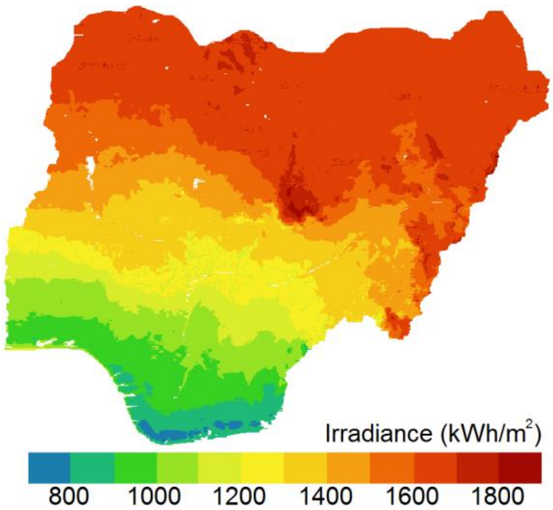

Figure 42: Average DNI in Nigeria.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.947	0.437
2	Brazil	0.946	0.555
3	China	0.904	0.769
4	Australia	0.827	1.513
5	Spain	0.785	1.623
6	Turkey	0.769	2.195
7	Mexico	0.769	1.770
8	South Africa	0.751	1.877
9	Saudi Arabia	0.747	1.954
10	Chile	0.730	3.028
11	Morocco	0.705	3.483
12	Egypt	0.670	3.147
13	Canada	0.660	3.691
14	India	0.620	3.229
15	Tunisia	0.616	4.147
16	Algeria	0.613	3.992
17	Namibia	0.584	4.506
18	Italy	0.580	3.079
19	Libya	0.543	5.081
20	Nigeria	0.534	5.096
21	Kenya	0.496	5.878
22	Sudan	0.434	7.066

Table 17. Variations of the ranked list for different (upper) threshold DNI value: Default (2000 kWh/m^2) and value for Nigeria (1398.86 kWh/m^2). Farm arrangement.

If the threshold value of the application were set to the mean Nigerian DNI, the list of candidate countries would change dramatically as seen in Table 17, in particular for the first half of the list. As expected, those countries whose interest relies on favourable market conditions or energy policies though not as good insolation are favoured by the new approach and thus climb to the top of the table. More in detail, those countries formerly at the top of the list are now in a lower position even though their IoIs remain with the same value owing to the fact that they were not reliant on the solar resources. On the contrary, those countries that were burdened by a low irradiance factor, for instance Brazil or China, are in a much better position now for their updated F_I.is much higher now.

In the bottom half of the list, the relative positions remain more or less the same inasmuch as their lower IoI was not due to a low DNI only but also because of low values of the remaining factors.

The same information is now shown for the stand-alone configuration, Table 18. There are several differences with respect to the previous case. First of all, the changes are generalised in the sense that they affect to virtually all the countries in the list, most of which lose positions. There are only seven countries in the list that improve their performance: United States, Spain, Brazil, Turkey, China, Kenya and Nigeria. And for all of them the performance improvement is substantial (the lowest improvement is two positions for Turkey).

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462
2	Chile	0.733	3.717
3	South Africa	0.697	3.580
4	United States	0.687	3.479
5	Mexico	0.670	3.956
6	Morocco	0.666	4.396
7	Spain	0.650	3.775
8	Namibia	0.637	4.167
9	Saudi Arabia	0.611	3.867
10	Algeria	0.580	5.170
11	Tunisia	0.570	4.636
12	Italy	0.511	5.036
13	Egypt	0.489	6.906
14	Brazil	0.484	4.119
15	Turkey	0.479	5.556
16	Canada	0.464	4.757
17	China	0.462	4.371
18	India	0.459	3.125
19	Libya	0.454	7.230
20	Sudan	0.423	7.578
21	Kenya	0.411	4.253
22	Nigeria	0.294	6.446

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.763	3.471
2	Australia	0.758	3.468
3	Chile	0.750	3.737
4	Spain	0.732	3.805
5	South Africa	0.698	3.604
6	Mexico	0.671	3.986
7	Brazil	0.667	4.066
8	Morocco	0.666	4.417
9	Namibia	0.638	4.213
10	China	0.637	4.471
11	Saudi Arabia	0.628	4.027
12	Tunisia	0.607	4.827
13	Turkey	0.600	5.575
14	Algeria	0.581	5.230
15	Kenya	0.549	5.194
16	Nigeria	0.505	6.571
17	Egypt	0.490	7.014
18	Italy	0.477	5.748
19	Libya	0.455	7.386
20	Canada	0.434	5.464
21	Sudan	0.426	7.796
22	India	0.420	3.743

Table 18. Variations of the ranked list for different (upper) threshold DNI value: Default (2000 kWh/m^2) and value for Nigeria (1398.86 kWh/m^2). Stand-alone systems.

Second, a closer look into the particular values of the index of interest discloses the main reason for this reallocation of places. Those countries that had the highest value of the irradiance factor lose positions because they hold the same IoI in the new scenario: $IoI_{Australia} = 0.757 - 0.758$, $IoI_{Chile} = 0.733 - 0.750$, $IoI_{Morocco} = 0.666 - 0.666$, $IoI_{Mexico} = 0.670 - 0.670$. For all these, their average irradiance is equal or higher the original threshold value of 2000 kWh/m^2 ($I_{Australia} = 2387.66$, $I_{Chile} = 1954.88$, $I_{Morocco} = 2049.11$, $I_{Morocco} = 2103.90$) On the contrary, those countries with favourable conditions but lower than highest irradiance factor (United States -$I_{USA} = 1783.04$-, Spain -$I_{Spain} = 1766.74$-, Brazil -$I_{Brazil} =$

1478.32-) experience the largest improvements. Actually, the lower the average irradiance is, the higher the improvement in position (which was on the other hand expected).

The results obtained in Table 18 pose a new requirement to the consortium. In effect, the threshold value for DNI turns out to be fundamental to determine the markets of interest. Hence, the designers of the system must specify the minimum DNI that would make their system both (i) technical viable and (ii) economically competitive. Upon receipt of this information, the application must be updated accordingly prior to performing a final market analysis. So far, based on the information available in literature, the threshold value for the upper limit of DNI is kept at 2000 kWh/m^2 year.

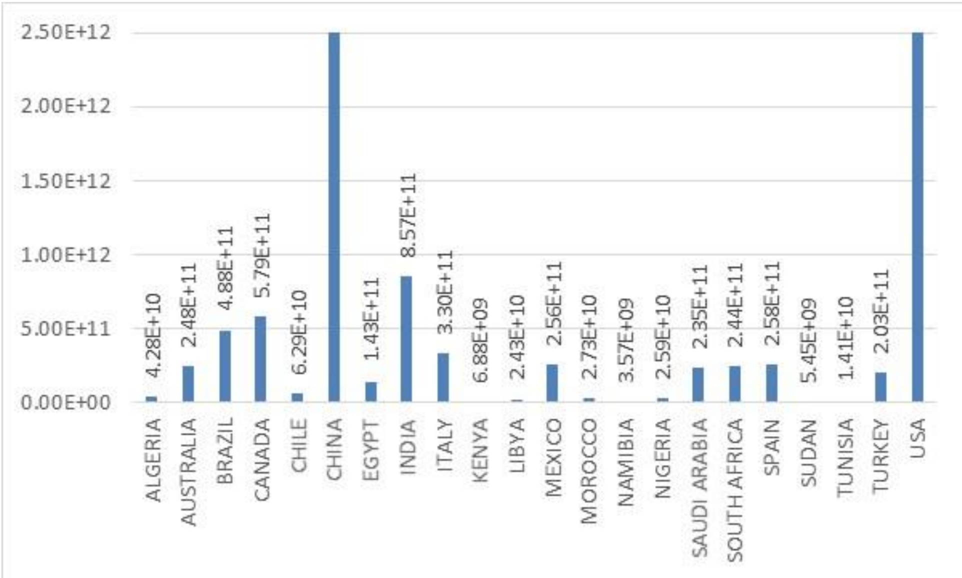

Figure 43: Annual consumption of electricity (kWh/year) of the candidate countries (note China and USA have annual consumptions higher than $4{\cdot}10^6$ GWh).

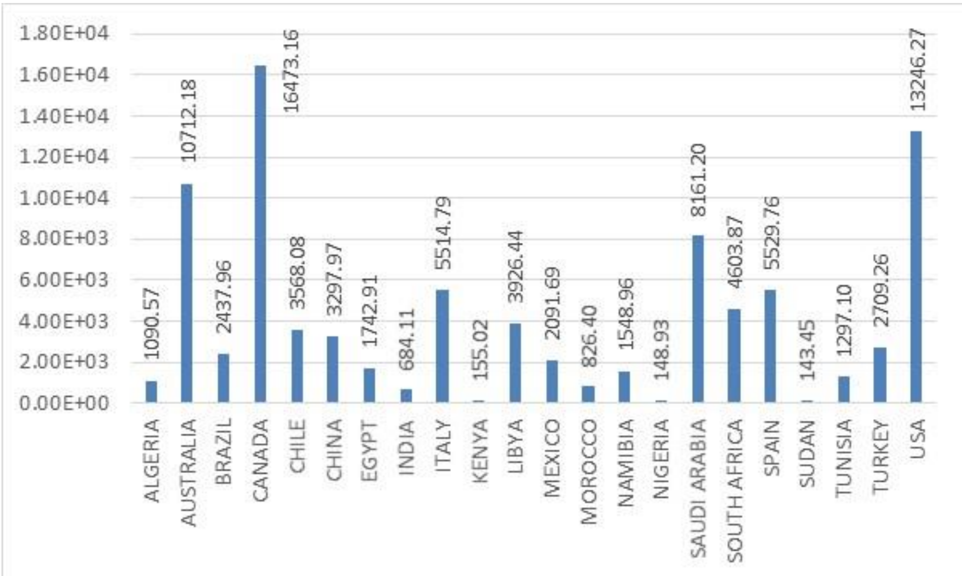

Figure 44: Electricity consumption per capita (kWh/year) of the candidate countries.

A similar analysis could be performed for the demand factor which has a similar threshold value for the annual consumption of electricity. This is used to evaluate the expected size of the market. The default value for this index is that of Brazil (〖5·10〗^5 GWh) though here the changes when the value for Turkey (〖2·10〗^5 GWh) is used instead are studied. As shown in Figure 39, Brazil is ranked tenth in terms of annual electricity consumption whereas Turkey occupies the twentieth position. The results of the analysis for the farm arrangement are shown in Table 19 and look similar to those obtained in the previous analysis. Nevertheless, a closer look into the numerical values shows that a pattern does not exist. For instance, at first glance the table suggests that those countries with highest electricity consumption are penalised by the new threshold value, giving their places to other countries with lowest consumption of electricity. This would be the case of United States, China and India. Nevertheless, this argument fails to explain why Chile, whose electricity consumption is certainly small, dips towards the bottom of the table. Or, conversely, the case of Algeria which exhibits the opposite behaviour to Chile in spite of a very similar electricity demand.

No.	COUNTRY		
1	United States	0.871	0.697
2	Australia	0.827	1.521
3	Mexico	0.769	1.739
4	Brazil	0.763	2.132
5	South Africa	0.751	1.842
6	Saudi Arabia	0.731	1.769
7	China	0.730	1.929
8	Chile	0.714	2.990
9	Morocco	0.704	3.525
10	Spain	0.704	0.886
11	Canada	0.691	3.014
12	Egypt	0.670	3.083
13	India	0.659	2.410
14	Turkey	0.648	1.735
15	Italy	0.614	2.272
16	Algeria	0.613	3.964
17	Namibia	0.584	4.484
18	Tunisia	0.580	3./14
19	Lybia	0.544	4.991
20	Sudan	0.432	6.586
21	Kenya	0.359	4.590
22	Nigeria	0.323	3.229

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.948	0.424
2	Mexico	0.886	0.892
3	South Africa	0.874	0.973
4	Egypt	0.776	1.717
5	United States	0.734	2.535
6	Morocco	0.725	3.196
7	Saudi Arabia	0.692	2.053
8	Spain	0.685	2.545
9	Brazil	0.679	3.575
10	Turkey	0.678	3.112
11	Algeria	0.645	3.361
12	China	0.642	3.469
13	Canada	0.637	4.122
14	Italy	0.632	3.962
15	Chile	0.594	2.088
16	India	0.590	3.852
17	Namibia	0.586	4.495
18	Libya	0.562	4.621
19	Tunisia	0.433	3.105
20	Nigeria	0.273	3.219
21	Sudan	0.262	5.150
22	Kenya	0.258	3.468

Table 19. Variations of the ranked list for different (upper) threshold electricity consumption value: Default ($5 \cdot 10^5$ GWh) and value for Turkey ($2 \cdot 10^5$ GWh). Farm arrangement.

These observations suggest that, when the threshold value of the electricity demand is set to a very low value, it ends up being meaningless. In other words, the position of each country in the ranked list becomes independent of this factor except for those which are burdened by a low value of it.

The conclusion is that the threshold value of the demand factor cannot be set to an arbitrary value. Rather, it must be selected carefully in order to ensure that the corresponding analysis is based on a meaningful influence of the size of the market (farm arrangement) and intensity of the consumers (stand-alone).

Results for the stand-alone configuration are shown in Table 20. Even if in this case the results are more logical, there is no doubt that the main conclusions in the paragraph above are applicable to them as well.

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462
2	Chile	0.733	3.717
3	South Africa	0.697	3.580
4	United States	0.687	3.479
5	Mexico	0.670	3.956
6	Morocco	0.666	4.396
7	Spain	0.650	3.775
8	Namibia	0.637	4.167
9	Saudi Arabia	0.611	3.867
10	Algeria	0.580	5.170
11	Tunisia	0.570	4.636
12	Italy	0.511	5.036
13	Egypt	0.489	6.906
14	Brazil	0.484	4.119
15	Turkey	0.479	5.556
16	Canada	0.464	4.757
17	China	0.462	4.371
18	India	0.459	3.125
19	Libya	0.454	7.230
20	Sudan	0.423	7.578
21	Kenya	0.411	4.253
22	Nigeria	0.294	6.446

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.758	3.393
2	South Africa	0.716	3.234
3	Mexico	0.672	3.842
4	Morocco	0.667	4.306
5	Namibia	0.639	4.037
6	Algeria	0.581	5.062
7	Chile	0.567	4.342
8	United States	0.550	4.514
9	Spain	0.516	4.713
10	Egypt	0.491	6.786
11	Libya	0.455	7.087
12	Italy	0.450	6.209
13	Saudi Arabia	0.446	3.454
14	Tunisia	0.414	4.672
15	Canada	0.410	6.058
16	Brazil	0.401	5.323
17	India	0.390	4.319
18	China	0.374	5.513
19	Turkey	0.365	6.647
20	Kenya	0.323	4.029
21	Sudan	0.258	6.199
22	Nigeria	0.241	7.288

Table 20. Variations of the ranked list for different (upper) threshold electricity consumption value: Default ($5\cdot10^5$ GWh) and value for Turkey ($2\cdot10^5$ GWh). Stand-alone.

Potential changes

The analyses presented in the previous section give answer to the inherent difficulties of evaluating the real value of the index of interest. Two are the most visible sources of interest. First, the inevitable uncertainty when the contribution of each parameter of influence is considered; i.e. the value of each weight and threshold value. A second source of uncertainty is the impossibility to guarantee the boundary conditions that will actually exist in the future. In other words, there are circumstances that cannot be foreseen and which change the scenario of the analysis completely. This second source of uncertainty is addressed in this section.

One of the most noteworthy changes in the energy industry is the unexpected drop of oil prices that took place in 2014-2015. The combination of a lower demand, reluctance of oil exporters to reduce the production rate and introduction of new energy sources brought about a new scenario wherein oil prices dropped down dramatically. Figure 45 presents a world map of basins with assessed shale oil and shale gas formations. According to a report issued by the International Energy Agency in 2013, there are seven areas that have large and attractive shale gas and shale oil sources: USA, Canada, Argentina, China, Algeria, Australia and Mexico. However, amongst these, only USA and Canada have officially started to exploit these resources, replenishing the primary reserves to 39% and 15%[12] of total respectively. This has, for instance, turned USA into an energy exporter rather than an importer.

[12] EIA article from October 23rd 2013, North America leads the world in production of shale gas

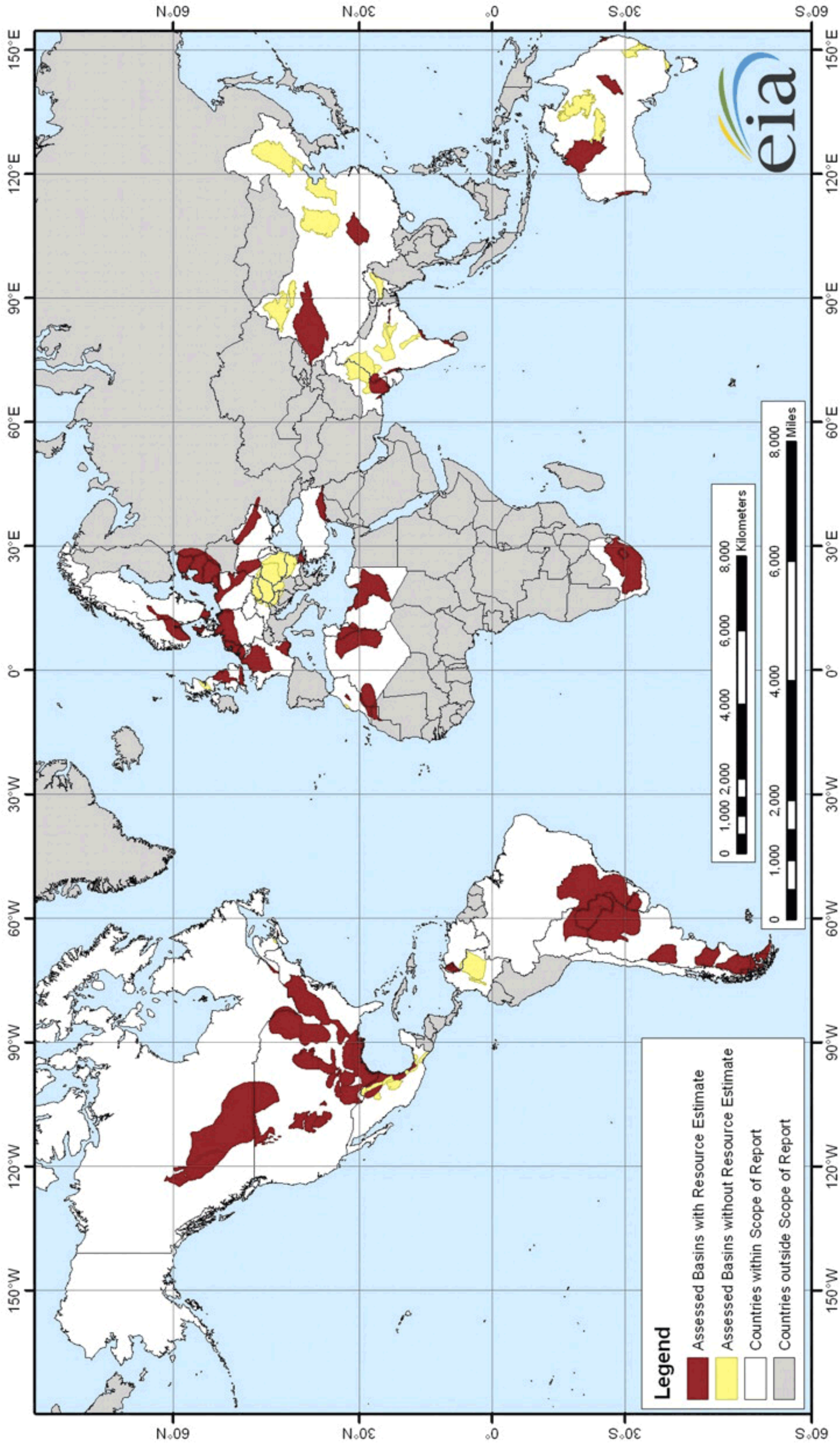

Figure 45. Map of basins with assessed shale oil and shale gas formations, as of May 2013. Source: EIA (Energy Information Agency).

The situation presented in the previous paragraph is expected to continue and, for instance, the IEA estimates that 40% of the global energy demand will be covered by unconventional gas by 2035. This can be regarded as a sort of energy revolution whereby the lower oil prices will expectedly influence the economies of some countries like Iran and Russia negatively, which rely on the oil market heavily. It does also make sense to expect strong influences in other related sectors of the economy like chemical industry and others even if it is still too early to ascertain those. The following items have to be evaluated before anticipating how the irruption of shale gas might affect different market segments:

- Reaction of oil and gas producers in terms of production rates and price policies.
- Creation of infrastructures to enable international trading of this new energy source.
- Evolution of shale gas price when the expected growth in demand exceeds the extraction capacity.

Socio-political changes are another very important source of uncertainty. A very good example of this is the Arab Spring initiated in 2011 which effected the oil market and energy policies (affected by the security of supply). It must be acknowledged that the world is currently struggling with poverty, corruption, social inequities and political instability that are bringing about the escalation of domestic and international conflicts. Figure 46 presents a map developed by the Heidelberg Institute for International Conflict Research where the countries affected by domestic conflicts are identified. A colour code indicates the severity of the conflict. Surprisingly, some countries which one would think are free from conflicts are, actually, subjected to violent crisis. Such is the case of United States where racial problems have recently triggered episodes of violence.

For the worst conflicts, the map shows that there are a few countries suffering from war in their homeland: Ukraine, Yemen, Somalia, Sudan, Congo, Iraq, Syria, Tibet, Afghanistan and Nigeria. Sometimes, the conflict is due to national affairs and domestic socio-political discrepancies. However, sometimes, there are international implications. For instance, Yemen is currently affected by the growing tension between Iran and Arabia Saudi which is based on religious, political and economic discrepancies that are not easy to interpret.

As a matter of fact, Arabia Saudi is home to the largest oil and gas producer, Saudi Aramco[13]. And talking about gas distributors, Gazprom[13] is the second largest supplying gas to most of Europe. The latest Russian conflict with Ukraine brought about the involvement of the European Union and United States which established proper sanctions on Russia whose economy experienced certain instabilities in turn.

It becomes evident that there is always a risk that the socio-political circumstances in a country or region change unexpectedly and, with it, the so called business environment. As a result, the private investors would rather reposition themselves waiting for a more calm and stable period whilst governments would have hard times in trying to secure the supply of energy to the country in question. This latter issue would most likely have a negative influence on the entire economy of the country/region.

[13] Forbes ranking: The World's 25 Biggest Oil Companies 2013

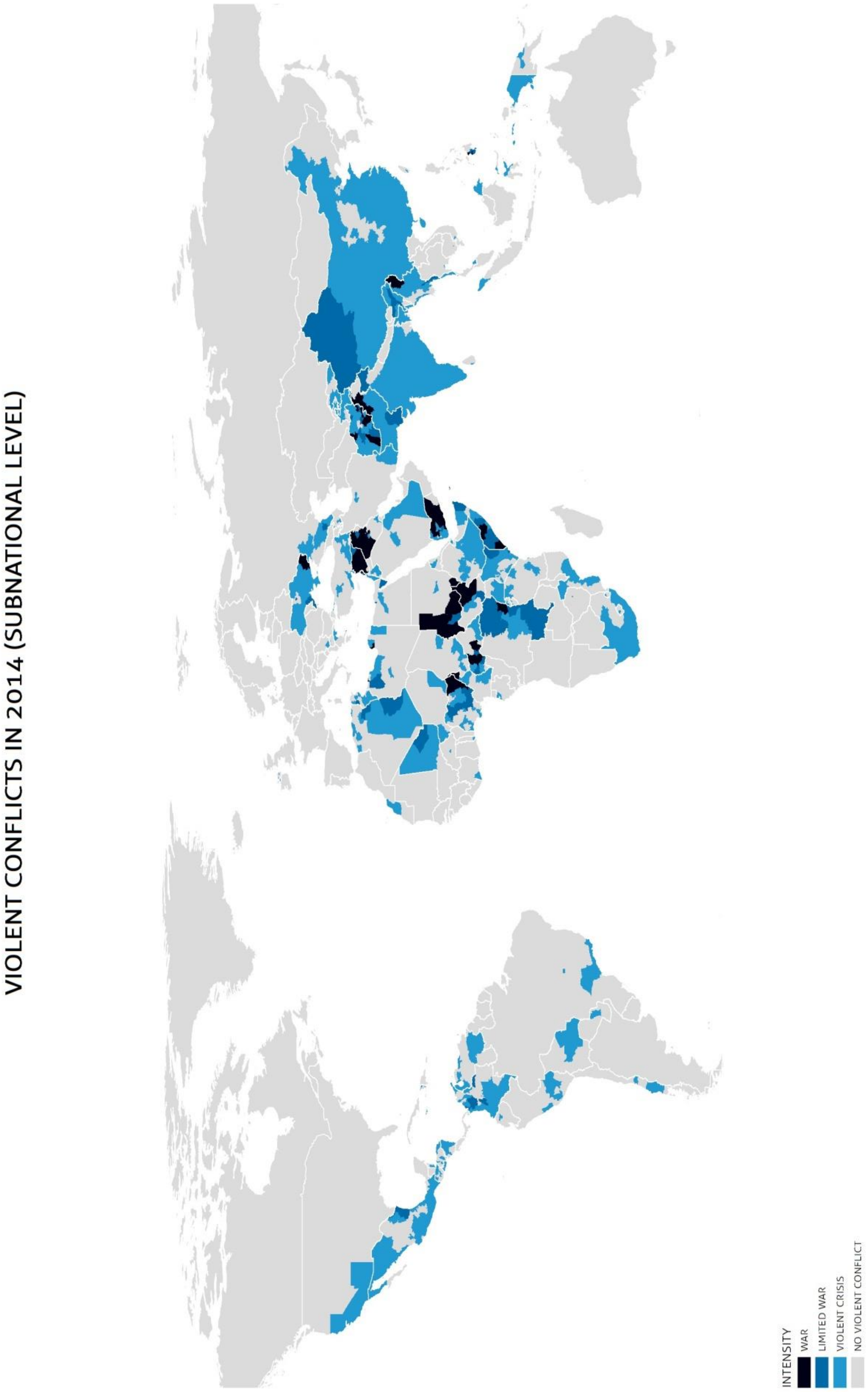

Figure 46: Violent conflicts in 2014 at subnational level according to HIIK research.

Some other examples of past experiences are found in Spain and Japan. The former case was already mentioned in the introduction to the methodology. Spain had a feed-in-tariff scheme which was very favourable for renewable energy producers which, at a time, were earning some 300 €/MWh. This policy proved not to be sustainable though, as it rapidly incurred a huge tariff deficit of up to 25 billion Euro (20000 M€) before actions were taken by the government. The decision was to drastically cut down the incentives and it effectively managed to reduce the deficit. Nevertheless, the unforeseen consequence was an abrupt deceleration of the country's solar industry which ended up finding new international market niches. Virtually no new projects were developed in the country after the new legislation was passed.

The experience of Japan with nuclear energy is somewhat similar. After the accident in Fukushima in 2011, the decision of the government was to immediately shut down all of the nuclear power plants mainly to calm down the rising public concern about nuclear security. This is illustrated in **¡Error! No se encuentra el origen de la referencia.** below. However, other problems came about when new primary energy sources had to be procured in the expensive international market. The strong dependence on foreign fuels along with the impact that this had on the cost of the economy resulted in a gradual nuclear comeback.

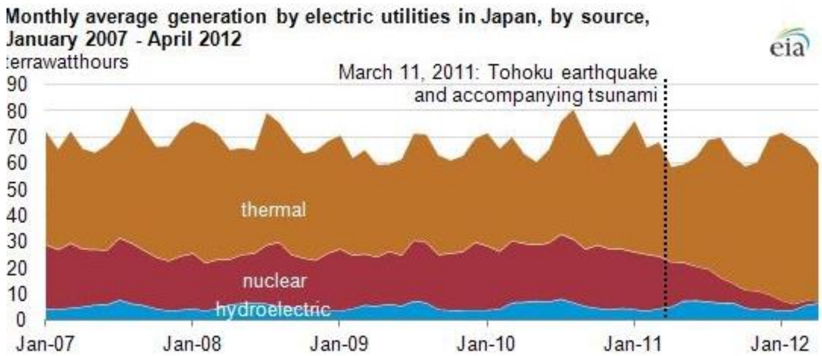

Figure 47: Monthly average generation by electric utilities in Japan (by source). 01/2007 – 04/2012.

Further to these considerations, some simulations are presented below in order to reflect the IoI performance in new scenarios. The aspects discussed in the previous paragraphs are mostly reflected in two factors, financial risk and energy policy. Thus a first scenario considers the economic stability in Mexico, Egypt and Tunisia due to the mitigation of domestic and international problems. As a result Mexico is capable of a much better country ranking (AA1) whilst Egypt and Tunisia are thought to be able to reach C1 and B1 once they recover from the internal conflicts. Also, as a consequence of the economic stability, the gross domestic product (GDP) is expected to grow and, with it, a higher demand of electricity will most likely be experienced.

All this into account, the sub-factor measuring the gross domestic product (GDP) increases for all these countries taking them to values between 0.8 (Egypt) and 1 (Mexico). The impact on the country ranking is shown in Table 21 and Table 22 for the farm arrangement and stand-alone configurations respectively.

For the farm arrangement, Mexico is observed to step forth one position, jumping to the second place. Even though this seems to be a minor change in terms of the relative position, it actually stands for a substantial improvement. In effect, the index of interest increases from 0.77 to 0.83, a value that is on pair with Australia and just a little behind USA. Moreover, the original difference with the latter country, which is at the top of the list, is halved as a consequence of the cited change in boundary conditions (scenario). A second effect is found on the uncertainty of the index of interest which is reduced from about 1.8% to less than 1.5%. The reason why

Mexico does not get closer to USA is mainly because of a lower demand of electricity (hence lower size of the potential market) and limited import of electricity (Mexico has started to import electricity from USA just very recently in 2015). Egypt moves up from 12th position to 9th, placing itself in the top ten list whilst Tunisia experiences a small improvement due to the burden of a very low demand factor (Table 4).

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.704
2	Australia	0.827	1.526
3	Mexico	0.768	1.771
4	Brazil	0.763	2.181
5	South Africa	0.751	1.877
6	Saudi Arabia	0.731	1.798
7	China	0.730	1.958
8	Chile	0.714	2.980
9	Morocco	0.704	3.525
10	Spain	0.704	0.884
11	Canada	0.692	3.080
12	Egypt	0.669	3.143
13	India	0.660	2.499
14	Turkey	0.648	1.759
15	Italy	0.615	2.345
16	Algeria	0.613	4.011
17	Namibia	0.583	4.532
18	Tunisia	0.579	3.934
19	Libya	0.543	5.086
20	Sudan	0.431	7.036
21	Kenya	0.358	4.645
22	Nigeria	0.323	3.296

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.703
2	Mexico	0.829	1.464
3	Australia	0.827	1.516
4	Brazil	0.763	2.182
5	South Africa	0.751	1.871
6	Saudi Arabia	0.731	1.793
7	China	0.730	1.954
8	Chile	0.714	2.958
9	Egypt	0.707	2.749
10	Morocco	0.704	3.504
11	Spain	0.704	0.880
12	Canada	0.692	3.078
13	India	0.660	2.488
14	Turkey	0.648	1.775
15	Italy	0.615	2.353
16	Algeria	0.613	3.991
17	Tunisia	0.600	3.730
18	Namibia	0.583	4.507
19	Libya	0.543	5.073
20	Sudan	0.431	7.019
21	Kenya	0.358	4.637
22	Nigeria	0.323	3.305

Table 21. First case. Country rankings for default input data (left) and with potential changes implemented (right). Farm-arrangement configuration.

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462
2	Chile	0.733	3.717
3	South Africa	0.697	3.580
4	United States	0.687	3.479
5	Mexico	0.670	3.956
6	Morocco	0.666	4.395
7	Spain	0.650	3.775
8	Namibia	0.637	4.167
9	Saudi Arabia	0.611	3.867
10	Algeria	0.580	5.170
11	Tunisia	0.570	4.636
12	Italy	0.511	5.036
13	Egypt	0.489	6.906
14	Brazil	0.484	4.119
15	Turkey	0.479	5.556
16	Canada	0.464	4.757
17	China	0.462	4.371
18	India	0.459	3.125
19	Libya	0.454	7.230
20	Sudan	0.423	7.578
21	Kenya	0.411	4.253
22	Nigeria	0.294	6.446

No.	COUNTRY	IoI	DEVIATION (%)
1	Mexico	0.759	3.484
2	Australia	0.757	3.503
3	Chile	0.734	3.762
4	South Africa	0.698	3.669
5	United States	0.687	3.474
6	Morocco	0.667	4.511
7	Spain	0.650	3.795
8	Namibia	0.638	4.302
9	Saudi Arabia	0.612	3.997
10	Tunisia	0.608	4.350
11	Algeria	0.581	5.359
12	Egypt	0.574	5.372
13	Italy	0.511	5.074
14	Brazil	0.484	4.127
15	Turkey	0.479	5.665
16	Canada	0.464	4.766
17	China	0.462	4.402
18	India	0.459	3.156
19	Libya	0.455	7.563
20	Sudan	0.424	7.958
21	Kenya	0.412	4.365
22	Nigeria	0.295	6.581

Table 22. First case. Country rankings for default input data (left) and with potential changes implemented (right). Stand-alone configuration.

As far as the stand-alone configuration is concerned, the impact of the new set of boundary conditions on Mexico's index of interest is largest. In effect, this country moves from the fifth position, slightly above Morocco, to the first one thanks to a rise in IoI of some 0.9 (for the farm arrangement layout, this rise was 0.06).

The case of Tunisia and Egypt is different though as their improvement with respect to the default scenario is only 0.04 and 0.09. The corresponding change in position is hence just one place up. Again, the reason for this minor improvement is found in the lower risk rating and a very low demand (Table 5).

The second case study is based on energy market changes in USA due to the aforesaid shale gas revolution. According to the Annual Energy Outlook 2015 by the US Energy Information Administration[14], the United States is currently an exporter of petroleum products and coal, but an importer of natural gas and crude oil. When the energy content of these fuels is combined, the United States in 2014 imported 23.3 quadrillion British thermal units (Btu) of energy and exported 12.2 quadrillion Btu. Projections in the EIA's recently released report show that, on an energy content basis, U.S. energy imports and exports could come into balance in coming years. The time at which this will occur depends on the assumptions made in the forecast. For a reference case by the IEA, the balance will be achieved between 2015 and 2030 whereas it can take place earlier if the high oil price and high oil and gas resources scenario persists. This is illustrated in Figure 48.

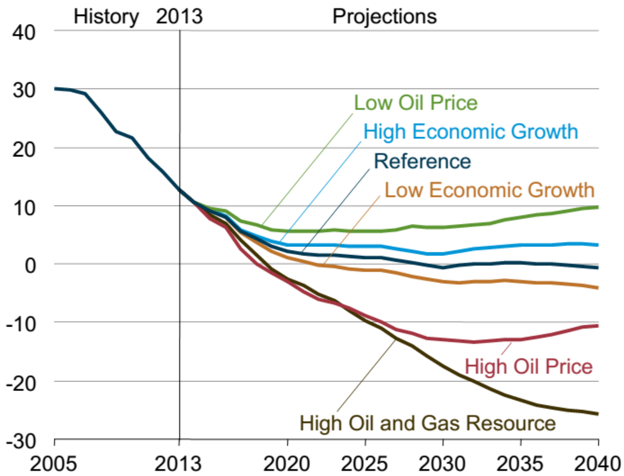

Figure 48: US net energy imports in six different scenarios, 2005-40 (quadrillion Btu)[14].

Let it then be assumed that (i) the new fuel source turns the country into a net exporter of energy as suggested in Figure 48 and (ii) there is no renewable energy policy in place in any of the countries considered. The list of potential markets results as shown in Table 23. The following observations are made:

- As far as the farm arrangement is concerned, United States remains at the top of the list in spite of the lower index of interest that comes about because of a lower demand factor (the country is not in need of domestic supply as there is actually a surplus production of energy).
- For stand-alone applications, the reduction in the index of interest is higher (0.06 vs 0.03) but within the same order of magnitued. Nevertheless, given to the very tight values of the nearby countries in the list, United States sinks to the 8th position (losing four positions).

[14] John J Conti et al., 2015, *Annual Energy Outlook 2015 with projections to 2014*, US Energy Information Administration.

The conclusion is that the occurrence of events that were not expected or anticipated and which cause changes in the socio-economic boundary conditions of the market analysis, have a stronger influence on the potential market list for stand-alone applications. This is due to the more similar indexes of interest that the countries have at the top of the list, as opposed to the more widespread values when the farm arrangement is considered.

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.871	0.704
2	Australia	0.827	1.526
3	Mexico	0.768	1.771
4	Brazil	0.763	2.181
5	South Africa	0.751	1.877
6	Saudi Arabia	0.731	1.798
7	China	0.730	1.958
8	Chile	0.714	2.980
9	Morocco	0.704	3.525
10	Spain	0.704	0.884

No.	COUNTRY	IoI	DEVIATION (%)
1	United States	0.844	0.861
2	Australia	0.827	1.569
3	Mexico	0.768	1.833
4	Brazil	0.763	2.257
5	South Africa	0.751	1.948
6	Saudi Arabia	0.731	1.861
7	China	0.730	2.024
8	Chile	0.714	3.049
9	Morocco	0.704	3.609
10	Spain	0.704	0.902

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.757	3.462
2	Chile	0.733	3.717
3	South Africa	0.697	3.580
4	United States	0.687	3.479
5	Mexico	0.670	3.956
6	Morocco	0.666	4.395
7	Spain	0.650	3.775
8	Namibia	0.637	4.167
9	Saudi Arabia	0.611	3.867
10	Algeria	0.580	5.170

No.	COUNTRY	IoI	DEVIATION (%)
1	Australia	0.758	3.470
2	Chile	0.734	3.724
3	South Africa	0.698	3.594
4	Mexico	0.671	3.976
5	Morocco	0.667	4.416
6	Spain	0.650	3.779
7	Namibia	0.638	4.195
8	United States	0.629	3.440
9	Saudi Arabia	0.612	3.898
10	Algeria	0.581	5.207

Table 23. Second case. Top and bottom ten list of countries for the default input data (left) and with potential changes implemented (right), for farm-arrangement (top) and stand-alone (bottom) configurations.

Disclaimer of annexes

The analyses presented so far are based on detailed information about each one of the twenty two candidate countries. This information provides the theoretical basis that ensures that, in spite of the inevitable subjectivity that comes in when the factors' thresholds and weights are selected, the process is as objective a systematic as possible

The information collected is structured in four blocks: (i) the analysis of the energy system, (ii) the analysis of the economic system, (iii) a third part with maps of interest of the country, and finally, (iv) an example of the application of the method. The three first parts are composed by information gathered from publicly available sources so as to allow the readers to check and even update them (World Bank, official government websites, etc.; see reference section at the end of the document), whereas the last one has been created specifically for this project.

The analysis of the energy system goes through the same sections for each country (whenever possible), with minor modifications depending on the available information found. In this sense, the topics covered are:

- Reliance
- Extend network
- Capacity concerns
- Renewable energy
- Solar Energy
- Ownership of electricity
- Competition
- Energy framework
- Energy debates
- Energy studies
- Role of government
- Government agencies
- Energy procedure
- Energy regulator
- Degree of independence
- Regulatory framework
- Regulatory roles
- Energy regulation role
- Regulatory barriers

With regard to the economic analyses, which are less extensive, they are based on the reports by Euler Hermes cited in the reference. The sections considered for each country are:

- Strength and weaknesses
- Economic structure
- Economic forecast

The third section of each annex contains graphical information about population density, DNI and grid. An overlapped map is also presented. The population and DNI maps are taken from the Solargis® website whilst the information about the national grids are taken from different sources related to each country's government.

ANNEX 1. Algeria

Analysis of the national energy system

In 2008, Algeria was the world's fourth-largest supplier of LNG, delivering 10% of the gas consumed by Europe. One-sixth of the total oil output is consumed at home, while the rest is exported as crude, LPG or refined oil products. However, the domestic energy consumption is on the rise, e.g. petrol and diesel demands exhibited increments of 10 and 13% respectively in 2008. Natural gas comprises 60% of Algeria's hydrocarbon consumption, including the public distribution systems of gas to households.

On the other hand, the share of renewable energy in this country is 0.3%, mainly hydropower, in spite of the noticeably high sunshine levels. This sets forth an important renewable potential to Algeria.

The annual production of electricity in Algeria is in the order of 35 TWh, almost exclusively based on natural gas.

Reliance

Algeria has imported diesel fuel for several years to help cope with the rising domestic demand. In particular, the country has purchased about 100,000 tonnes of diesel oil per year since 2007, spending US$ 52 million annually to meet local growing demand. Overall, the total oil and petroleum product imports in 2007 were 914 ktoe and, for coal, the entire supply is also imported. Algeria has the capacity to export electricity to neighbouring Morocco and Tunisia.

Extend network

The vast majority of the Algerian territory is desert land with very few inhabitants who live in harsh conditions though with abundant solar energy resources. It is estimated that an area of 1 million km^2 has not been electrified yet and the numerous technical difficulties make it very unlikely that this situation can be reverted in the future, in particular if traditional means are used to extend transmission networks. It is also worth noting that the grid in Algeria is not interconnected in the sense that it is formed by autonomous power systems (islands) within the country.

In spite of the large areas with no electric power supply, the fact that the population in Algeria is not distributed homogeneously ensures that 98% of the Algerians have access to electricity. In addition, there are plans to expand the existing 140,000 miles of power transmission lines by 5% in order to reach isolated rural communities and hydrocarbon-related projects in the Sahara Desert.

Capacity concerns

There is an urgent need in Algeria to reinforce and update the energy infrastructures so that they can provide higher levels of economic development. This would enable high quality energy supply, irrespective of the site of residence.

In this regard, some analysts foresee that Algeria will lose its status as a natural gas exporter by the mid-2030s, if domestic consumption keeps increasing and no alternative energy solutions are implemented on a large scale. This scenario brings about serious problems for Algeria, whose economy is highly dependent on fossil fuel exports, and poses a need to develop new technologies for domestic energy supply. Nevertheless, even if renewable and nuclear energies are in the Government's portfolio of candidate energy sources, they still play a marginal role in the national electricity mix.

Renewable energy

Algeria's privileged geographical location sets it forth as a very important player in the implementation of renewable energy technologies in northern Africa. Actually, the numerous renewable energy resources in the country are enough to provide sufficient energy for its own needs and even export a large amount of electricity to neighbouring countries and even Europe. It is consolidated with Dii organisation (previous Desertec), which support utility-scale for solar and wind powers in North Africa, the Middle East (MENA), Turkey and other countries with ambitious renewable energy projects. The organisation aims to integrate RE into regional power markets and also to open an exchange market of RE between other countries and continents. In fact, in the report [REF] by the International Energy Agency (IEA) it is suggested that countries like Algeria are potential exporters of solar energy exporters to the Europe, as it gradually becomes connected to European energy networks. Further estimations on this report confirm that within 20 years, the installed capacity to produce solar electricity will be equivalent to 72 coal-fired power stations. This is enough to supply 100 million people, which is the aggregated population of Algeria, Morocco, Tunisia and Libya.

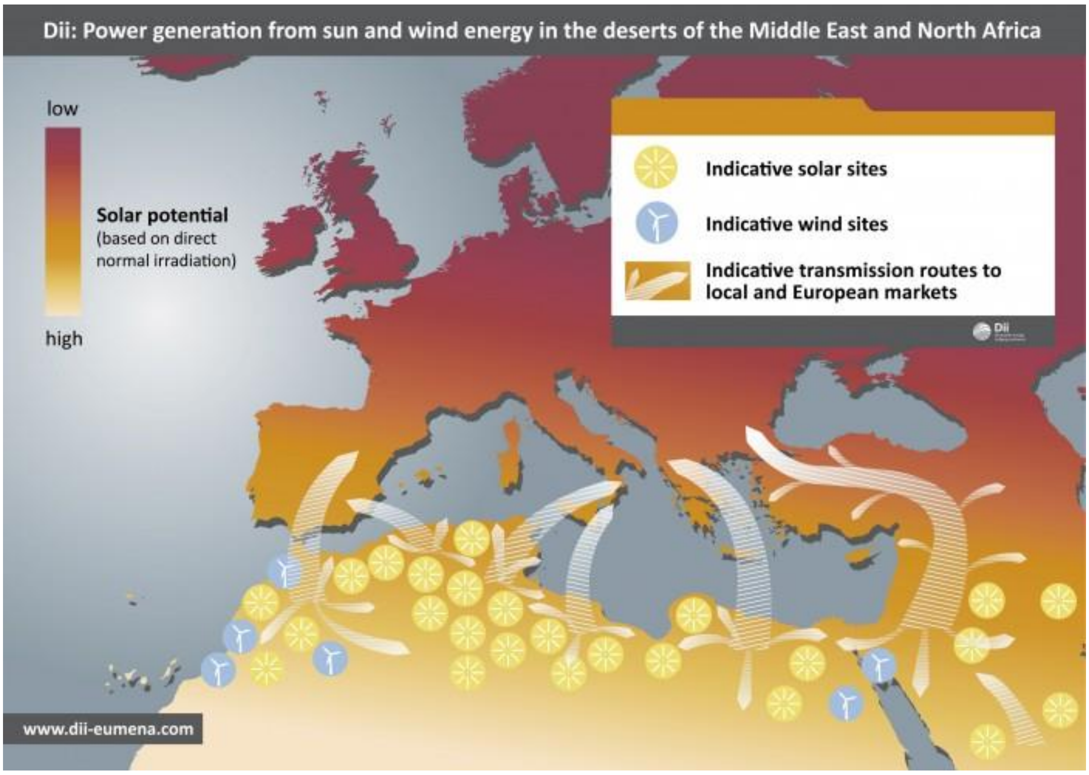

Figure A. 1. Dii alliance concept.

Solar Energy

The Algerian Ministry of Energy and Mines (MEM) states that "*the biggest potential in Algeria is for solar*" based on data from the World Energy Council, pointing out that the Sahara region has the highest potential. The annual average insolation is 2,000 hours with the sites at high altitude receiving about 3,900 hours. This results in an average solar energy of 6.57 $kWh/m^2 \cdot day$.

The development of solar energy plants is supported by the MEM and realised mainly by SONELGAZ (*Société Nationale de l'Electricité et du Gaz*) and other private installer companies. Moreover, solar energy is currently regarded as a key research line within the structure of the department of renewable energies of SONELGAZ.

Ownership of electricity

SONELGAZ is the state-owned electricity and downstream gas utility. Over 90% of the electricity production is based on natural gas, with the remaining coming from fuel oil/diesel and hydropower. To keep up with demand growth, 8-10 GW of power generating capacity are expected to be added by 2015, about 70 % by independent power producers. Electricity tariffs are low in Algeria: around 6 US¢$/kWh for residential customers, and 3 US¢$/kWh for industrial users. This is due to the low internal prices for natural gas (it is estimated that industrial corporations and power producers pay below 1 US$/MBTU, while current export prices are over 8 US$/MBTU). The government's objective is to adjust domestic energy prices to international levels, even if this process is likely to be slow.

Competition

Algeria's re-structuring electricity law was enacted in 2002. The state electricity and gas monopoly SONELGAZ was required to unbundle its activities and an independent regulatory body was established. Several projects of independent power producers (IPP), some with international equity participation, have emerged since then.

SONELGAZ has been restructured as a holding company along with:

- Société Algérienne de Production de l'Electricité - (SPE)
- Opérateur Système Electrique - (OS)
- Société Algérienne du Gestion du Réseau de Transport de L'Electricité - (GRTE)
- Société Algérienne du Gestion du Réseau de Transport du Gaz - (GRTG)
- Société de Distribution de l'Electricité et du Gaz d'Alger - (SDA)
- Société de Distribution de l'Electricité et du Gaz du Centre - (SDC)
- Société de Distribution de l'Electricité et du Gaz de l'Est - (SDE)
- Société de Distribution de l'Electricité et du Gaz de l'Ouest - (SDO)

Energy framework

The major text of the legislative purview concerning electricity production from renewable sources is the law 02-01 dated 5th February 2002, also related to the distribution of electricity and gas through pipelines. This law established a new legal framework for electricity production aiming at reforming the Algerian electric system, affecting the entire productive sector and including electricity from renewables. The amount of energy to be sold as well as the encouragement of renewable sources, cogeneration, etc. should be subject to a call for tenders defined through statutory channels. This system favours renewable electricity production, as clarified in the draft executive decree relative to the costs of diversification of the electricity production that was adopted by the Council of government in January 2004.

The market of renewable energy is very small. Currently, the electricity market, which is extensively defined by the Law on Electricity and Distribution of Gas No. 02-01, has ambitious quantitative targets. Derived from that, the Algerian's environmental friendly energy strategy has set up solar and wind projects for a total power production of 575, 1400 and 7500 MWe for the respective horizons of 2015, 2020 and 2030.

One of the particular aims for such renewable energy development established by the MEM is to give energy supply to isolated zones, located far from gas distribution networks (electricity and oil products). Another objective is to contribute to the preservation of hydrocarbon reserves by exploiting renewable energy resources instead, particularly solar power. The growth in solar capacity will contribute to satisfying national energy needs and also will eventually give place to exporting a fraction of this electricity to the European market. This prospect fits with a sustainable development process which contributes to the preservation of the environment.

Various programmes have included different solar applications (rural electrification, photovoltaic pumping, water heating and other industrial applications) as sets forth by the National Rural Electrification Programme, which shows Algeria's commitment to provide solar power to villages in southern Algeria. Following a successful first phase; the second phase is now underway.

Energy debates

In December 2011, SONELGAZ signed a Memorandum of Understanding (MoU) to cooperate with the European Desertec (now Dii) consortium planning to harness solar energy and other renewables in the deserts of North Africa and the Middle East (MENA). The MoU was signed by SONELGAZ chief executive Noureddine Boutarfa, Dii, Industrial Initiative CEO Paul Van Son, EU energy commissioner Gunther Oettinger, and Algerian energy and mining minister Youcef Youfsi.

Boutarfa said "*The development of renewable energy is a key strategy for Algeria. If the right conditions are met we are convinced that we can export 10 GW of solar power to Europe a year*". Youfsi added that while solar was the most obvious renewable source for Algeria, the country was also developing other technologies, "*With wind energy we have projects ready to start in the south and we have potential for geothermal where we are looking to get started in a very promising region in the east of the country*". "*I am convinced that with these joint efforts with European partners we can overcome the technological, economic and regulatory challenges that need to be addressed to develop these new sources of energy*" Youfsi said.

Energy studies

Algeria is a member of the Comité Maghrébin de l'Electricité (COMELEC), which also includes Mauritania, Morocco, Tunisia, Libya and Egypt. Since its creation, COMELEC has played an important role in operating and strengthening the integrated electricity networks of Maghreb countries, maintaining strong ties with sister institutions such as EUROELECTRIC and the Union of Arab Electric Utilities. It participates in the activities of the Energy Laboratory of the Mediterranean (OME) and is also an active member of MEDELEC (the association of electric utilities of the Mediterranean countries).

COMELEC's role is significant in establishing a future electricity market between the countries of the Maghreb region and Europe, as well as with the countries of the Mashrek region. COMELEC also promotes the opening of the electricity market for private investment and competition in the sector.

Role of government

Ministry of Energy and Mines of Algeria (MEM)

The MEM develops the legislative, regulatory and institutional mechanisms to attract investment, both direct and through partnerships, in the hydrocarbon, energy and mining sectors. This includes activities such as those downstream of hydrocarbons and the production of renewable energies.

Ministry of Environment

The Ministry of Environment is connected to all the aspects of sustainable development and environmental protection policies, e.g. legislation of industrial emissions control and standards.

Government agencies

The Renewable Energy Development Centre (CDER, Algiers)

The *Station d' Expérimentation des Equipements Solaires* (SEES) was transformed in 1988 to become the *Centre de Développement des Energies Renouvelables* (CDER) with a wider remit covering all renewable energy sources. The main goal of CDER is the evaluation of renewable energy potential, including the development and application of solar thermal energy, solar photovoltaic energy, geothermal energy, wind energy and solar desalination in the remote area of Sahara.

New Energy Algeria (NEAL)

NEAL was established in 2002 by SONATRACH (45%), SONELGAZ (45%) and the private Algerian company SIM (10%). NEAL's mission is the development of solar and other renewable energy production. NEAL has joined the International Energy Agency's SolarPACES programme and incorporated renewable energy targets into national laws to help create a stable environment for long-term investors.

The National Agency for Promotion and Rationalisation of Energy Use (APRUE)

The APRUE is central to the implementation of the National Energy Efficiency Programme (PNME). It is responsible for the information, communication and management training of all public players involved in energy efficiency. As well as the establishment of partnerships in order to draw up together transversal or sector action programmes, falling within the framework of the PNME, and which may potentially benefit from the financial incentives of the FNME.

The National Energy Efficiency Fund of Algeria (FNME)

The FNME was created in 2000 (Decree no. 2000-116), to give financial support to those energy-efficient investments promoted by APRUE and PNME, for which it has an annual budget of € 57 million. The resources of the funds include taxes on natural gas (AD 0.00015/btu) and electricity (AD 0.02/kWh) and an initial government contribution of AD 100 million (€ 1.15 million). Additional resources may include taxes on energy intensive equipment, penalties, loan repayments, government and other contributions.

Energy procedure

With regard to energy, the main efforts of government are put on a project for the rural electrification (by means of photovoltaic solar energy) of a total of 18 villages which are far from the existing electricity networks and primarily located in the provinces of the great South (Adrar, Illizi, Tindouf and Tamanrasset). This program is financed entirely by the Special Funds for Development of the South areas from the MEM. SONELGAZ has gone down the solar route for these 18 villages in the rural electrification programme with the aim of kick-starting the use of renewables, in particular photovoltaic energy.

The Gas and Electricity Regulatory Commission (CREG) published a press release in 2011, which revealed that 22 GWe coming from renewable energies would be generated by Algeria by 2030. About 12 GW would be destined for the national market and 10 GW could be exported.

It was announced that the national electricity generating programme would comprise the completion of 67 projects; 27 photovoltaic power stations, 27 hybrid diesel and/or gas turbine, 6 solar thermal power stations and 7 wind farms. It was specified that Algeria would be investing some US$ 20 billion in domestic renewable energy projects, on its way to a goal of 40% of the nation's electricity coming from renewable sources by 2030.

Energy regulator

The Algerian Electricity and Gas Regulation Commission (CREG) was stablished under the law 02-01 of 5th February 2002 relating to electricity and gas distribution and it started its activities in 2005.

Degree of independence

CREG is the financially autonomous and independent regulatory authority. It is managed by a steering committee, comprised of a chairman and three directors appointed by presidential decree on proposition of the Minister in charge of Energy. An Advisory Council is instituted within the regulation commission. It is composed by two representatives of the relevant ministerial departments, and all interested parties (operators, consumers, employees).

Regulatory framework

The Energy Efficiency Law (*Loi relative a la Maitrise de l'Energie*) of July 1999 encompasses the following components:

- Establishment of a national energy agency for energy efficiency (EE).
- Introduction of EE standards.
- Introduction of a national programme for EE.
- Establishment of a national energy management fund.
- Mandatory labelling of every new or used electric appliance to be sold on the national territory.
- Monitoring EE.
- Mandatory energy audits.
- Support of research and development activities.
- Incentives for EE improvements.
- Measures to improve public awareness of the necessity to reduce energy consumption.

The Law on Renewable Energy (*Loi relative a la promotion des energies renouvelables dans le dare du developpement durable*) of August 2004 establishes a National Programme for the promotion of Renewable Energy (RE) until 2020. The programme includes a multi-annual evaluation of the use of RE compared to fossil fuels, and several measures to inform about RE publicly. It is integrated into a framework for sustainable development and land-use planning and comprises mechanisms for the economic assessment of energy technologies.

In 2004, incentives for RE were specified through a Decree on the Diversification of Power Generating Costs, which introduced feed-in tariffs for power coming from renewable sources. The renewable energy technologies covered include hydropower, wind power, geothermal and solar power and electricity from waste utilisation. As the government considers the combined utilisation of solar energy and natural gas the most efficient way to make use of RE, the decree creates specific feed-in tariffs for Integrated Solar Combined Cycle (ISCC) power plants. The feed-in tariffs are based on the regular rates for electricity, which are set by CREG. Feed-in tariffs for ISCC plants discriminate the share of solar energy used by the plant.

Algeria's renewable electricity goals are set out as percentage values of overall power generation. For 2017, the Algerian electricity regulatory commission (CREG, 2008) published a 5% renewable electricity target. By 2030, Algeria expects to reach 20% renewables; 70% generated by concentrating solar power plants, 20% by wind and 10% by photovoltaics. The first 25 MW solar power project at Hassi R'mel is under implementation and three new projects are under consideration. Through a March 2004 decree, the government also introduced incentives for electricity production from renewable energy plants, including a feed-in tariff.

Regulatory roles

The CREG is commissioned (art. 113) to watch over the competitive and transparent functioning of the electricity market both for the users and operators' interests. Its role is fundamental in the organisation and functioning of the electricity market, in general, and the renewable electricity, in particular. By means of article 128 of the law on electricity, operators have to lodge with the CREG sale and purchase contracts of electricity. This provision allows them to know the exact quantity and nature of the electricity sold in the market; i.e., it is thus possible to know the origin of renewable electricity: thermal, solar, wind, biomass or geothermal.

Energy regulation role

The MEM is responsible for the regulatory mechanisms designed to develop and administrate investment plans in the hydrocarbons industry, whilst contractual affairs are the responsibility of ALNAFT. The Hydrocarbons Regulatory Agency is responsible for the technical regulation in the hydrocarbons sector including; transportation tariffs, third-party access to pipelines, and construction standards for health, safety and environmental protection.

Regulatory barriers

The legislative framework suggests that Algeria's renewable energy policy is very advanced compared to other developing countries. The government has translated international examples of best practice into the Algerian policy framework in order to promote renewable power generation, such as the German feed-in law for renewable energy. However, so far, the implementation of the adopted regulations is limited, which is why it remains to be seen if they can significantly increase the share of renewable energy in Algeria's energy supply (electricity mix).

Analysis of the national economic system and politics

Strength and weaknesses

The natural gas and oil resources provide the country with certain solidity and a strong liquidity because of the sustained high oil price[15]. However, the downside of the economy's strong dependence on hydrocarbons is a practical lack of industrial diversification which has brought about high rates of unemployment and underemployment. Another negative effect of this reliance on oil and gas is that the development of the private sector is limited because of the political influence of the military elite as well. This statement can be extended to the banking sector.

Another negative contribution to the situation is the occasional terrorist acts which raise the vulnerability of oil and gas facilities and infrastructures. Globally speaking, the sectors with higher risks are business and politics, since economic, financing and commercial are favoured by the elevated liquidity of the country's Administration. This is shown in Figure A. 2.

[15] Note that the content of this report dates from the first half of 2014. It will have to be reviewed if the recent drop in oil prices is sustained in 2015.

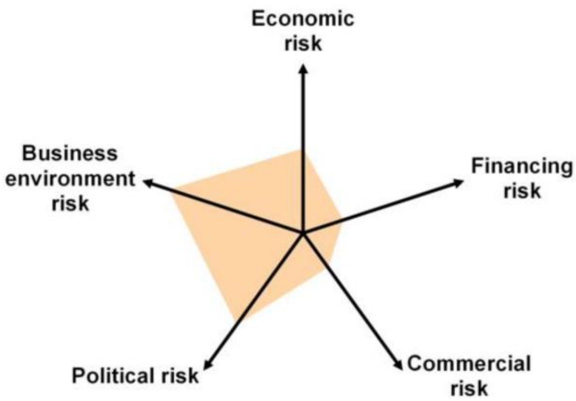

Figure A. 2. Risk dimensions estimated by Euler Hermes. Algeria.

Economic structure

The main economic sector of the country is mining given the importance of the oil and gas commerce, which represents more than 90% of the exported goods. In contrast, imports are more uniformly shared amongst the agro-alimentary and energy industries.

Micro-economy is also reliant on agriculture and thus it varies with weather, bringing about strong fluctuations of the prices of elementary consumer's goods. For instance, the high liquidity in the market together with an unfavourable climate conditions during 2012 yielded a poor harvest in the country, after which the inflationary pressure rose up to 9%. On the contrary, the better harvest of 2013 and the improvements in the markets reduced the inflation down to 3.25 % the year after.

Economic forecast

In spite of the impact that the Arab Spring has had in Northern-African countries, the GDP growth of the country has remained positive since the beginning of the century, with annual rates between 2 and 6%. Forecasts for the following years are also positive owing to the foreseeable improvement of the European economy/markets. The external debt is kept low (around 2.3% of the GDP) which is in line with ca. 8% national debt-GDP ratio.

With respect to the expected behaviour of inflation, there are opposing influences. On one hand, the inflationary pressure will increase in the next years as a consequence of the depreciation of the monetary unit (DZD) after the inflation peak achieved at the end of 2013. On the other, the interest of governors in limiting the social discontent that it may produce will contribute to absorb part of the inflation growth. These opposing effects are expected to yield inflation rates of around 6% in 2015.

The high incomes of the national Administration in the economic annuities of 2010 and 2011 allowed for a reduction of the fiscal deficit, which in 2012 represented a -4.7% of the GDP. This deficit is expected to be reduced to about -2.7% in 2015, also thanks to the efforts of the country in avoiding social protests. It is noted that social stability is crucial to attract foreign capital.

The abundant reserves of oil and gas, estimated for the next fifty five years, attribute a noteworthy trading solidity to Algeria, which together with the solar source availability in a large portion of the country; set this country forth as a principal candidate market for the OMSoP technology. In contrast with these attractive economic and natural/environmental features, the political instability of the country is identified as the main hurdle for market success.

Maps

Population

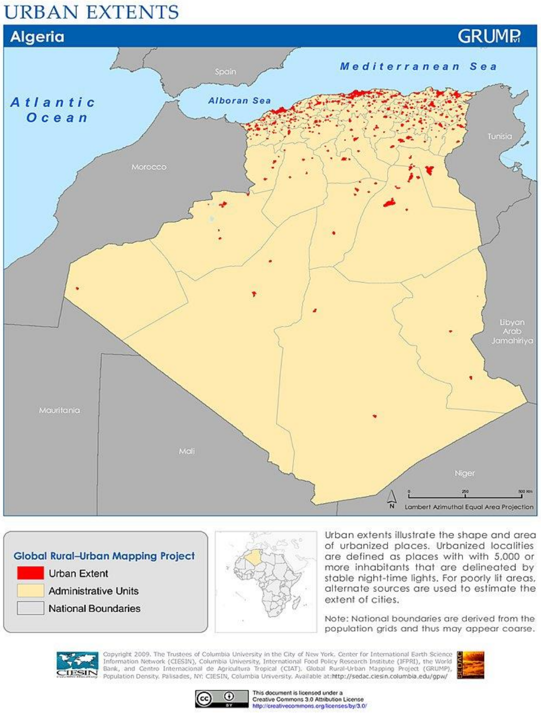

Figure A. 3. Algeria population map.

DNI

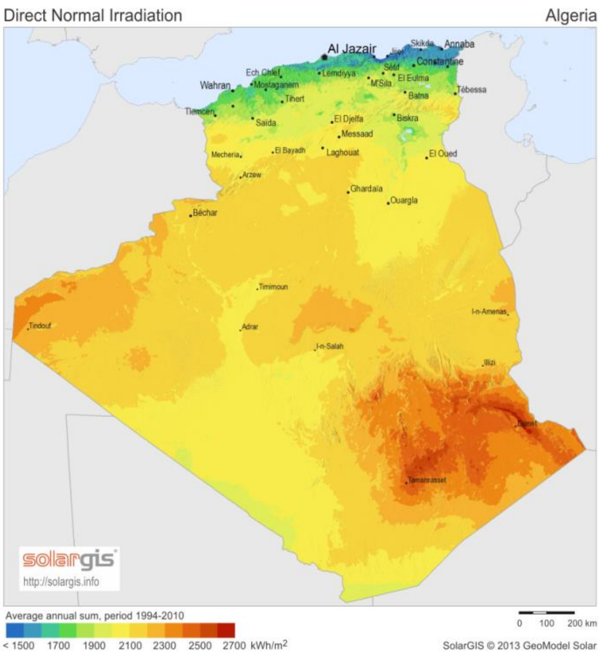

Figure A. 4. Algeria Direct Normal irradiation.

Electricity grid

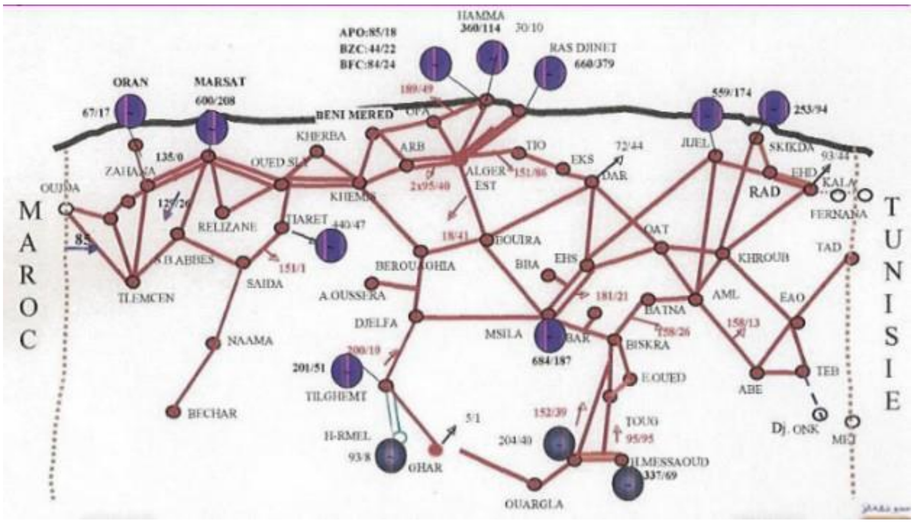

Figure A. 5. Algeria electricity grid.

Maps overlapped

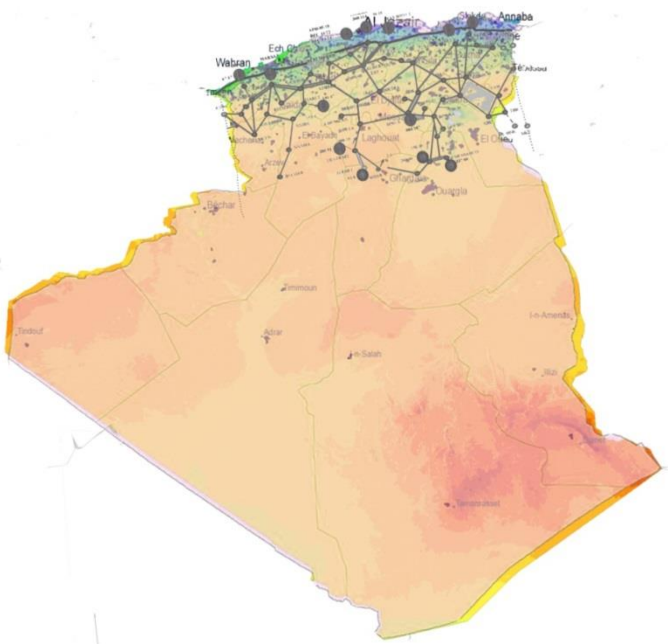

Figure A. 6. Algeria overlapped maps.

Application of the method

- **GDP:** US$ 210.18 Billion (in 2013)
- **Annual GDP Growth rate:** 2.70 % (in 2013)
- **Population:** 39.208 Million people (in 2013)
- **Annual population Growth rate:** 1.87 % (in 2013)
- **Annual electric consumption (per capita):** 1091 kWh (in 2011)
- **Government debt:** N/A
- **Accumulated external debt:** US$ 5.643 Billion, 2.68 % GDP (in 2012)
- **Inflation rate (consumer prices):** 3.25 % (in 2013)
- **Country rating (Euler Hermes):** C2
- **Annually averaged DNI:** 2398.05 kWh/m^2
- **Population with access to electricity:** 99.4 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.6824	0.1365
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	0.2938	0.0294
		TOTAL	0.8409

Table A. 1. Farm arrangement. Algeria.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0060	0.0015
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	0.2938	0.0294
		TOTAL	0.6559

Table A. 2. Stand-alone configuration. Algeria.

ANNEX 2. Australia

Analysis of the national energy system

In 2008, the total primary energy supply was 5427.8 PJ (peta joule), 5.6% of which corresponding to renewable sources, and the energy self-sufficiency reached 232.6 %.

Australia holds abundant and diverse energy resources, in fact being the ninth largest energy producer worldwide with around 2.4% of the world energy production. In 2008-2009, Australia's energy production was 17769 PJ and the net energy exports accounted for 68% of the domestic energy production. It is one of the three net energy exporting nations in the OECD.

The main fuels produced in Australia are coal, uranium and natural gas. In particular, the Australian uranium accounts for 47% of the total world resources, while coal accounts for 10% of the world total.

In 2008-2009, Australia's energy production was dominated by coal, which accounted for 54% of the total energy production in energy content terms, followed by uranium with a share of 27% and natural gas with a share of 11%. Crude oil and liquefied petroleum gas (LPG) represented 6% of total energy production and renewable contributed with another 2%.

Australia was the world's largest coal exporter and, according to Cedigaz, the fourth largest exporter of liquefied natural gas (LNG) in 2010, after Qatar, Indonesia, and Malaysia; this makes the country a net importer of crude oil and refined petroleum products but a net exporter of liquefied petroleum gas (LPG). Hydrocarbon exports accounted for 34 % of total commodity export revenues in fiscal year 2009-2010. Natural gas production in Australia reached 1.6 Tcf in 2010 and could triple by 2020. About half of this natural gas production is converted into LNG for export purposes and the other half is consumed domestically.

Australia accounts for around 6% of world black coal production and it is the fourth largest producer after China, the United States and India. Australian coking and steaming coals are high in energy content, and low in sulphur, ash and other contaminants. Around 87% of Australia's black coal production is exported, which makes this fuel Australia's largest commodity export, providing earnings in the order of AU$ 44 billion in 2010–11. It is also an important component of domestic energy supplies, representing around 75% of the fuel used for electricity generation. Over time, Australian coal production has been increasing in the last decade, underpinned by a strong growth in demand and the addition of new capacity.

In 2008-2009, around 261 TWh of electricity (including off-grid electricity) was generated, mostly from thermal sources. Coal accounted for 77% of the total electricity generation, followed by natural gas (15%), hydro (4.7%), wind (1.5%), biomass, biogas and solar (1.2%) and oil (1.0%). Coal is thus the major source and is expected to remain so, reflecting its wide availability and relatively low cost. However, given the number of gas-fired, Coal-Seam Methane-(CSM)-fired and wind projects under development, those sources are expected to show an increasing proportion in the electricity mix.

Reliance

Australia is a net importer of crude oil and petroleum products, but a net exporter of LPG; in particular, more than 60 % of crude oil production is exported, while around 70% of Australia's refinery feedstock is imported. This is because a large proportion of Australia's oil production is based off the north-west coast, which is closer to refineries in Asia than to domestic refineries on the east coast. In 2009-2010, Australia had net total oil imports of about $4.4 \cdot 10^5$ bbl/d.

Australia's crude oil and condensate imports come from the South East of Asia (Malaysia, Indonesia, and Vietnam) mainly, while Australia's refined product imports come largely from

Singapore. During the same period (2009-2010), Australia exported $3.11 \cdot 10^5$ bbl/d of crude oil and condensates and $4.78 \cdot 10^4$ bbl/d of LPG, about 70 % of its total oil production ($5.11 \cdot 10^5$ bbl/d). These volumes were exported to Asian markets, mainly Singapore, South Korea, China, and Japan. Australia's 2009-2010 gross exports of refined petroleum products were $1.48 \cdot 10^4$ bbl/d (3 % of its production), New Zealand and Singapore being their main clients.

Australian coal production increased at an average annual rate of 4.1 % between 2000 and 2007. Thus, the total coal production in 2007 was $2.18 \cdot 10^5$ ktoe, ca. 73% of which was exported, and the same 70% percentage remained in 2009-2010 (about 300 MMt). Japan was the destination for 43% of Australia's coal exports during the same period, followed by South Korea (15%), China (14%), and India (11%). About 8% of Australia's coal exports went to Europe.

Extend network

The vast majority of the population of Australia has access to electricity, despite the very low population density of the country. The national transmission grid comprises 27640 km of transmission lines, with 10300 km of them operating above 330 kV. There are two separate grids in the country, the eastern grid operating under the National Electricity Market (NEM), and the South-West Interconnected Supply Area, serving Western Australia. The vast majority of the transmission infrastructure is located around the major load centres, with no connection between Western and Southern Australia. In addition, Tasmania is connected to the Victorian grid through an unregulated interconnection under the NEM.

The NEM is connected by seven major transmission interconnectors. These interconnectors link the electricity networks in Queensland, New South Wales, Victoria, South Australia and Tasmania. The NEM transmission and distribution (T&D) networks consist of around 790700 km of overhead (T&D) lines and around 113700 km of underground cables.

Capacity concerns

In 2009, the Australian government released the National Energy Security Assessment (NESA), aimed at assessing the challenges that could affect current and future energy security. The energy security scenario was defined by an adequate, reliable and affordable energy supply in order to support economy and social developments. “Adequate” means enough amount of energy, “reliable” implies minimal supply disruptions and “affordable” is related to energy prices not affecting the competitiveness of the economy and encouraging investment in the sector.

NESA determined that Australia's energy security has declined according to the 2004 Energy White Paper because of the need to address new challenges like carbon emissions reduction. The challenges faced by the Australian government in order to maintain or improve Australia's energy security are: (i) further market reforms and greater infrastructure resilience, (ii) the rising cost of investment capital globally, and (iii) the transition to a lower-carbon economy. NESA is a key input into the development of the new Energy White Paper.

As aforesaid, between 2000 and 2007, the gas supply grew fastest, at an average annual rate of 4.1%, followed by coal (1.9%), oil (1.3%) and others (1.5%). The rate of electricity T&D losses stood at 7% in 2009, below the world average.

Renewable energy

In 2007, Australia generated $5.6 \cdot 10^3$ GWh of electricity from renewable sources. Under the previous Mandatory Renewable Energy Target (MRET), which targeted $9.5 \cdot 10^3$ GWh of the total electricity generation from renewable sources, solar hot water, wind energy and solar electricity experienced the largest growth. Currently, the target is set to $4.5 \cdot 10^4$ GWh of new renewable electricity generation by 2020 under the Renewable Energy Target (RET), which began on January 1st 2010.

Australia's renewable energy currently comprises less than 5% of total energy consumption (around 244 PJ), and is recently finding a decline due to low biomass production, which was affected by the low energy content and high handling and processing costs.

Solar energy

The majority of the Australian territory receives a high level of direct solar radiation, sufficient to make it one of the countries with better prospects for concentrating solar power (CSP) plants. The average irradiance across the Australian land is 5.0-7.5 kWh/m^2/day, rising up to 8.5 kWh/m^2/day in some northern areas. Currently, the utilisation of CSP technologies is not widespread, as deduced from the juts 40 MW plant based on linear solar reflectors installed in New South Wales. However, many new CSP projects are planned to be constructed in the near term.

Ownership of electricity

The current structure of Australia's eastern electricity market was shaped by industry reforms initiated in the early 90s. A key element of these reforms was the National Electricity Market (NEM), which started operation in 1998. NEM allows for the market to determine the power flows across the Australian Capital Territory, New South Wales, Queensland, South Australia, Victoria and Tasmania. Western Australia and the Northern Territory are not connected to NEM, mainly because of geographical reasons. NEM operates as a wholesale spot market in which generators and retailers trade electricity through a gross pool managed by the Australian Energy Market Operator (AEMO http://www.aemo.com.au/), which aggregates and dispatches supply to meet demand. In addition to the physical wholesale market, retailers may also contract generators through financial markets to better manage any price risk associated with trade on the spot market.

AEMO was established on July 1st 2009 by the Council of Australian Governments (COAG) and developed under the guidance of the Ministerial Council on Energy (MCE) as a key component of the ongoing energy market reforms. It is incorporated as a company limited by guarantee under the Corporations Act and its ownership of AEMO is 60% government members and 40% industry members. AEMO is the aggregation of 6 electricity and gas market bodies: the National Electricity Market Management Company (NEMMCO), Victorian Energy Networks Corporation (VENCorp), the Electricity Supply Industry Planning Council, the Retail Energy Market Company (REMCO), the Gas Market Company and the Gas Retail Market Operator. AEMO's functions include:

- Managing NEM and the retail and wholesale gas markets in eastern and southern Australia.
- Overseeing the system security of NEM electricity grid and the Victorian gas transmission network.
- Economy-wide transmission planning.
- And establishing a short-term trading market for gas from 2010.

AEMO is also responsible for improving the operation of Australian energy markets. As of December 2014, AEMO has published the 2014 20-year National Transmission Network Development Plan to provide more information about market participants and potential investors. This report complements the Electricity Statement of Opportunities and the new Gas Market Statement of Opportunities enabling to forecast long-term supply and demand. AEMO also maintains the Gas Market Bulletin Board and currently oversees Australian energy market governance in cooperation with the Australian Energy Market Commission, as the rule-making body, and the Australian Energy Regulator, as the regulating body.

Competition

On one hand, NEM comprises both a wholesale sector and a competitive retail sector, and, on the other, AEMO is an independent, member-based organization. NEM is hence separated into generation, transmission, distribution and retail supply components. Some assets comprised in NEM's infrastructure are owned and operated by state governments, and some are owned and operated under private business arrangements. AEMO operates within a broader market governance structure alongside the Australian Energy Market Commission (AEMC) and the Australian Energy Regulator (AER). With AEMO's establishment in 2009, Australia became one of the first countries in the world to establish highly competitive and transparent gas and electricity markets underpinned by strong governance structures. While individual energy markets remain separate with their own participants and jurisdictions, evolution in market operations can now build on the consistent framework of operational rules and underlying systems to ensure maximum efficiency, combined with maximum integrity or energy resource development.

Energy framework

Australia's energy policy framework was significantly modified in 2009, through amendments to the existing policy and legislation. The three pillars where this new policy is built on are:

- Reducing Australia's emissions of greenhouse gases.
- Adapting to unavoidable climate change.
- Helping to shape a global solution.

The Australian government is committed to a long-term goal of reducing Australia's greenhouse gas emissions to 60% below the 2000 levels by 2050, and the developments are focused on the next directions:

- A Review of the Australian taxation system.
- Updating the Energy White Paper 2004.
- Releasing the National Energy Security Assessment.
- Establishing the Australian Energy Market Operator.
- Releasing the National Strategy for Energy Efficiency
- Passing of the Renewable Energy Electricity Amendment Bill 2009 and the Renewable Energy Electricity Charge Amendment Bill 2009 to expand the renewable energy target
- A proposal for an emissions trading scheme.

The Renewable Energy Target (RET) established on January 1st 2010 aims at a higher than 20% (around 60000 GWh) of electricity supply provided by renewable sources by 2020. This includes the new target of 45000 GWh of new renewable electricity generation, on top of 15000 GWh of existing renewable electricity generation, compared with 95000 GWh by 2010 under the previous Mandatory Renewable Energy Target (MRET). RET also brings existing state-based targets, such as the Victorian Renewable Energy Target and the proposed New South Wales Renewable Energy Target, into a single Australia-wide scheme. RET is scheduled to end in 2030, when the proposed Carbon Pollution Reduction Scheme (CPRS) is expected to be the primary driver of investment in renewable energy, replacing RET. In June 2010, legislation was passed to separate the RET scheme into two parts from 1st January 2011: the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET).

In 2000, Australia introduced a voluntary measure for fossil fuel electricity generators to reduce the greenhouse intensity of energy supply. The Generator Efficiency Standards apply to new projects and existing electricity generators above a minimum threshold (30 MW), whether grid-connected, off-grid or self-generators. In 2004, the best-practice efficiency guidelines were defined for new plants, and the measurements are implemented through legally binding, five-year Deeds of Agreement between the Australian government and participating businesses.

The Energy Efficiency Opportunities program (EEO) came into force in 2006, under which all large energy-using businesses (more than 139 GWh/year or 12 Mtoe/year) are required to undertake an energy audit every five years and to report publicly on cost-effective energy savings opportunities. EEO covers approximately 240 businesses across all sectors accounting for more than 60% of total business energy use.

The Australian Ministerial Council on Energy (MCE) endorsed the National Framework for Energy Efficiency (NFEE) in 2004, following the 2002 Energy South Australia study, and approved the implementation of a number of energy efficiency packages. The stage 1, put in practice in June 2008, included 9 policy packages, and stage 2 started in July 2008 with 5 new energy efficiency measures: (i) Expanding and enhancing the Minimum Energy Performance Standards program for electrical appliances and gas appliances; (ii) developing a heating, ventilation and air conditioning (HVAC) high efficiency systems strategy; (iii) phasing-out of incandescent lighting in the households sector; (iv) providing government leadership to stimulate energy efficiency in buildings through green leases; and (v) developing measures to improve the energy efficiency of water heaters.

The National Strategy for Energy Efficiency (NSEE), released in 2009, is a 10-years strategy for energy efficiency improvements for households and businesses that is added to the NFEE. Through this approach, NSEE delivers a range of policy measures with a focus on increasing the global system efficiency.

The National Energy efficiency Initiative (Smart Grid, Smart City) was implemented by the Department of Resources, Energy and Tourism in 2009. It aims to demonstrate that Australia is the first fully integrated, commercial scale smart grid. Smart grids combine advanced communication, sensing and metering infrastructure with existing energy networks. This enables a combination of applications that can deliver a more efficient, robust and consumer-friendly electricity network.

In July 2009, the New South Wales government implemented an energy saving obligation for electricity retailers and other parties who buy or sell electricity (Energy Savings Scheme, ESS). Total energy savings requirements are fixed for each year of the scheme, as a given percentage of the electricity sales. The target for the first year was set to 0.4% of total electricity sales, and has gradually increased to 4% until 2014.

In 2009, Australia launched a Solar Flagships program aimed at supporting large-scale solar power generation of up to 1 GW.

In 2010, the Energy Efficiency Program was established within the framework of the Australian Carbon Trust to promote take-up of energy efficient technologies and practices in the business sector. It provides innovative finance solutions and expert advice to help businesses achieve energy efficiency improvements and cost-effective carbon emission reductions. Five initial projects were announced in November 2010, an investment totalling 23.7 million Australian dollars over three years.

The Minimum Energy Performance Standards program (MEPS) aims at increasing the energy efficiency of products used in manufacturing sectors (three-phase electric motors, etc.).

The Department of Innovation, Industry, Science and Research provides Clean Business Australia and the Green Car Innovation Fund to support businesses.

In November 2011, the Australian parliament passed the Clean Energy Act 2011, which establishes the structure of a process for introducing an economy-wide carbon price on July 1st 2012, and the transition to an emissions trading mechanism on July 1st 2015.

The Act covers the following:

- Liable entities' obligations to surrender emissions units corresponding to their emissions.
- Limits on the number of emissions units that will be issued.
- The nature of carbon units.
- The allocation of carbon units, including by auction and the issue of free units.

- Mechanisms to contain costs, including the fixed charge period and price floors and ceilings.
- Links to other emissions trading schemes.
- Assistance for emissions-intensive trade-exposed activities and coal-fired electricity generators.
- Monitoring and enforcement.

The Clean Energy Future package incorporates the carbon pricing mechanism, along with a commitment to renewable energy, energy efficiency and action in the land sector.

Energy debates

The Minister for Resources, Energy and Tourism launched a Draft Energy White Paper 2011 (*Strengthening the Foundation for Australia's Energy Future*) on December 13th 2011. The Draft Energy White Paper provides an overview of Australia's future energy needs to 2030 (and in some cases beyond) and defines a comprehensive strategy policy framework to guide further development of Australia's energy sector. The draft Energy White Paper proposes four priority action areas to enhance Australia's energy potential in response to the challenges facing Australia's energy sector. These priority action areas are:

- Strengthening the resilience of Australia's energy policy framework.
- Reinvigorating the energy market reform agenda.
- Developing Australia's critical energy resources, particularly Australia's gas resources.
- Accelerating clean energy outcomes.

The Energy White Paper also incorporates elements of other reviews and initiatives, including the design of the Carbon Pollution Reduction Scheme (CPRS, a proposed emissions trading scheme), the Australia's Future Tax System Review, the Garnaut Climate Change Review, the Review of Export Policies and Programs (the Mortimer Review) and the Strategic Review of Australian Government Climate Change Programs (the Wilkins Review).

Australia is considering a scheme to curb carbon emissions, in line with its ratification of the Kyoto Protocol. The CPRS will use a cap and trade mechanism to impose a price on carbon, which is expected to make gas and renewable energy resources more competitive against coal. It is expected to directly affect around 1000 entities.

The Government will establish an AU$10 billion commercially oriented for the Clean Energy Finance Corporation (CEFC) to invest in businesses seeking funds to get innovating clean energy proposals and technologies off the ground. CEFC will invest in energy efficiency and low emissions technologies as well as the manufacturing businesses that provide inputs for these sectors.

Energy studies

The Garnaut Climate Change Review was commissioned by Australia's Commonwealth, state and territory governments to examine the impacts, challenges and opportunities of climate change for Australia. The Final Report was published in September 2008.

The Wilkins review, completed in July 2008, developed a set of principles to assess whether existing programs are complementary to an emissions trading scheme. These principles are expected to include whether programs address market failures that are likely to continue after the introduction of emissions trading, or which may be necessary to prepare for emissions trading.

Role of government

The Council of Australian Governments (COAG) comprises the Prime Minister of Australia, the State Premiers and the Territory Chief Ministers. It meets at least once a year to consider issues that affect all jurisdictions, including those related to energy.

The Ministerial Council on Energy (MCE) was established by COAG in 2001 to deliver the economic and environmental benefits for Australia from implementation of the COAG national energy policy framework. MCE was the national energy policy and governance body for the Australian energy market. The remits of MCE have been withdrawn following the formal commencement of the COAG's Standing Council on Energy and Resources (SCER). SCER will carry on key reform elements of the Ministerial Council on Mineral and Petroleum Resources and the MCE. The standing council will:

- Progress consistent upstream petroleum administration and regulation standards.
- Address issues affecting investment in resources exploration and development.
- Develop a nationally consistent approach to clean-energy technology.
- Promote efficiency and investment in generation and networks.
- Build on Australia's resilience to energy-supply shocks.

The Department of Resources, Energy and Tourism (RET) helps promoting internationally competitive and sustainable businesses. It is the principal Commonwealth energy policy-making body. The department administers the Energy Efficiency Opportunities (EEO) program, and works with the Department of Climate Change and Energy Efficiency (DCCEE) to further investigate the merits of a national Energy Saving Initiative (ESI) amongst others. The divisions and agencies with a role in energy are:

- The Energy and Environment Division is responsible for domestic and international energy policy, including climate change, renewable energy, energy efficiency and energy security policies. It gives advice on sustainable development policies for industry and the economy, and it also works on energy market reform.
- The Resources Division provides legislative advice and administrative support to the government on the resources sector, including the upstream and downstream petroleum sectors, and the minerals and coal industries. Its jurisdiction includes the release of offshore petroleum exploration areas, refining and fuels, resources taxation, offshore petroleum safety regulation, and liquefied natural gas (LNG).

The Department of the Environment, Water, Heritage and the Arts (DEWHA) develops and implements national policy, programmes and legislation to protect and preserve Australia's natural environment and cultural heritage. It administers the Environment Protection and Biodiversity Conservation Act 1999.

The Department of Climate Change and Energy Efficiency (DCCEE) is responsible for energy efficiency as it applies to other sectors of the economy, such as residential and transport, small and medium businesses and commercial buildings. This department is also responsible for the analysis of the projected effects of the Equipment Energy Efficiency Program over the period 2000–2020. Results have been published in: "*Prevention is Cheaper than Cure - Avoiding Carbon Emissions through Energy Efficiency, Projected Impacts of the Equipment Energy Efficiency Program to 2020*". Finally, DCCEE administers the National Greenhouse and Energy Reporting Scheme (NGERS), which commenced in 2009. It will be mandatory for all companies that use more than 0.1 PJ of energy per year to report on their energy consumption and greenhouse gas emissions.

Government agencies

The Australian Centre for Renewable Energy (ACRE) is part of the AU$ 5.1 billion Clean Energy Initiative. The Centre is a new body to promote the development, commercialisation, and deployment of renewable energy technologies and enabling technologies. ACRE is overseen by a specialist board with expertise in research, venture capital, intellectual property and commercialisation. It takes over management of grants awarded under the Renewable Energy Demonstration Program, the Geothermal Drilling Program, the Second Generation Biofuels R&D Program, the Wind Energy Forecasting Capability Program, the Advanced Electricity Storage Technologies programme and the Renewable Energy Equity Fund.

A new independent agency, the Australian Renewable Energy Agency (ARENA), will be established incorporating measures currently managed by the Australian Solar Institute (ASI), ACRE, and RET. ARENA will consolidate a range of existing renewable energy measures and funding including:

- Solar Flagships Programme.
- ACRE Solar Projects.
- Renewable Energy Venture Capital Fund.
- Australian Biofuels Research Institute.
- Low Emissions Technology Demonstration Fund (Solar).
- Connecting Renewables Initiative.
- Renewable Energy Demonstration Programme.
- Emerging Renewables Programme.
- Geothermal Drilling Programme.
- Australian Solar Institute.
- Second Generation Biofuels Research and Development Programme.

ARENA will manage various funding to be invested in renewable energy and enabling technology projects until 2020. For instance, in 2012, ARENA consolidated administration of AU$ 3.2 billion in Government support for renewable energy technology innovation, assuming management of funding previously administered by ACRE, the Australian Solar Institute and the Department of Resources, Energy and Tourism.

Energy procedure

The Draft Energy White Paper 2011 (Strengthening the Foundation for Australia's Energy Future) provides an overview of Australia's future energy needs to 2030 and defines a comprehensive strategy policy framework to guide the further development of Australia's energy sector, with four priority action areas. The previous Energy White Paper was developed in 2004.

The Australian Government offers a number of programmes to encourage the development, commercialisation and deployment of renewable energy technologies. The Australian Co-operative Research Centre for Renewable Energy (ACRE) at the University of New South Wales is consolidating the following programmes:

- A Renewable Energy Demonstration Programme (competitive grants programme to support the development of large-scale renewable projects other than solar), with AU$ 235 million funding.
- A Second Generation Biofuels Research and Development Programme (with funding of AU$ 15 million).
- A Geothermal Drilling Programme (funded with AU$ 50 million).
- An Advanced Electricity Storage Technologies Programme (AU$ 20 million).
- A Wind Energy Forecasting Capability Programme (AU$ 14 million).
- A Renewable Energy Equity Fund (AU$ 18 million).

- New initiatives, (AU$ 150 million including funding from the formerly proposed Clean Energy Program).

Energy regulator

In July 2005, the Australian government formed the Australian Energy Regulator (AER). AER is responsible for economic regulation in Australian energy markets and compliance with the National Electricity Law and Rules and the National Gas Law and Rules. In addition, AER promotes investment to ensure supply security, while monitoring end user prices. AER is accountable to the Commonwealth Government as a constituent entity of the Australian Competition and Consumer Commission (ACCC).

Western Australia retains state-based regulation of its electricity sector and, while the National Gas Access Law came into effect in Western Australia on January 1st 2010, the WA legislation is limited to regulatory matters and adopts the local Economic Regulation Authority and Energy Disputes Arbitrator to regulate the market in Western Australia instead of AER.

The National Electricity Market Management Company Limited (NEMMCO) was established in 1996 to administer and manage the NEM, and improve its efficiency. The responsibilities of NEMMCO were transferred to AEMO on July 1st 2009.

The Office of the Renewable Energy Regulator (ORER) is a statutory authority established to oversee the implementation of the LRET and the SRES. The Renewable Energy Regulator is appointed by the Minister for Climate Change and Energy Efficiency to administer the Renewable Energy Electricity Act 2000, Renewable Energy Electricity Charge Act 2000 and the Renewable Energy Electricity Regulations 2001.

The Electrical Regulatory Authorities Council (ERAC) took over from the Electrical Regulatory Authorities Approvals Committee (RAAC) and Regulatory Authorities Licensing Committee (RALC) which were sponsored by the Electricity Supply Association of Australia (ESAA) as an independent body in 1995. ERAC is the council responsible for the liaison between the technical and safety electrical regulatory authorities of eight Australian States/Territories and New Zealand. As technical and safety electrical regulatory functions are largely responsibility of state and territory governments in Australia, a considerable amount of liaison is required to coordinate the activities in respect of regulatory strategies, polices and ongoing reforms. The council is constituted by representatives of the regulatory authorities responsible for electrical safety, supply and energy efficiency in New Zealand and the Australian states, territories and commonwealth. ERAC also provides a practical single point of regulator contact for unions, industry and other areas of government, at the national level. Although ERAC exists entirely through cooperative action and has no executive powers, it is recognised throughout the electrical industry as an authoritative voice for electrical regulators.

Degree of independence

AER was established as a separate legal entity, and a constituent part of the Australian Competition and Consumer Commission (ACCC), under Part IIIAA of the Trade Practices Act 1974. AER has 3 members who are statutory appointments, including a full-time chair. States will be able to appoint two AER members with the third coming from the ACCC. Chairmanship must be agreed by both the Commonwealth and five out of the seven states and territories (Western Australia is excluded). Appointments are for 5 years.

The AER may make decisions in relation to its functions under the National Electricity Law and National Electricity Rules, and may also seek an order from the Federal Court that a person is in breach of a relevant energy law. Decisions of the AER are subject to judicial review by the Federal Court of Australia. Under the 1974 Act, funds for the AER come from fees imposed on regulated bodies, and must not be such an amount as to be equivalent to taxation.

Regulatory framework

The National Electricity Code (Code) sets out the market rules applicable to market operations, power system security, network connection and access, and pricing for network services in NEM. When NEM started, the National Electricity Code Administrator (NECA) was responsible for the administration of Code provisions.

The Renewable Energy Electricity Amendment Bill 2009 and the Renewable Energy Electricity Charge Amendment Bill 2009 were passed in August 2009. The Renewable Energy Electricity Amendment Bill modified the Renewable Energy Electricity Act 2000 to allow the government to replace the Mandatory Renewable Energy Target (MRET) with the expanded Renewable Energy Target (RET) from the January 1st 2010.

In 2009, the Department of Environment, Climate Change, Energy and Water introduced the Australian Capital Territory's (ACT) Electricity Feed-In Tariff Scheme, which is available to all ACT electricity customers with generation facilities of no greater capacity than 30 kW. All renewable energy technologies are eligible for the tariff. The scheme will run for 20 years from connection of the generator and will be paid for gross generation.

Similarly, the Residential Net Feed-in Tariff for Western Australia was introduced by the Government of Western Australia in 2010. The scheme is available to residential applicants only (home owners), who will receive payments for 10 years for electricity generated by solar PV, wind or micro-hydro units. It will be administered by two utilities, *Synergy* and *Horizon Power*. The installed system size is limited to 5 kW for Synergy customers and 30 kW in total for Horizon Power customers.

Regulatory roles

Under the national electricity law and national electricity rules, the AER's key responsibilities at present include:

- Regulating the revenues of transmission network service providers by establishing revenue caps.
- Monitoring the electricity wholesale market.
- Monitoring compliance with the national electricity law, national electricity rules and national electricity regulations.
- Investigating possible breaches of provisions of the national electricity law, rules and regulations.
- Instituting and conducting enforcement proceedings against relevant market participants.
- Establishing service standards for electricity transmission network service providers.
- Establishing ring-fencing guidelines for business operations with respect to regulated transmission services.
- Exempting network service providers from registration.

Energy regulation role

The Department of Resources, Energy and Tourism (RET) and the Ministerial Council on Energy (MCE) function as regulatory bodies over Australia's oil and gas sector. The Department of Climate Change and Energy Efficiency (DCCEE) regulates for more efficient industries.

Australian Energy Market Commission (AEMC) was established as a separate legal entity in July 2005. It is the rule maker and developer for the nation's energy markets. As a national, independent body, it makes and amends the detailed rules for the NEM and elements of natural gas markets. It also provides strategic and operational advice to the MCN. The AEMC is a member of the International Confederation of Energy Regulators (ICER).

Regulatory barriers

Currently, the status of Australian energy regulation is good. A significant capacity in renewable energy is also being built, although the progresses in this field are slow. With abundant renewable energy resources, and a dedicated regulatory authority for the purpose, Australia is well-placed to increase its utilization of renewable energy considerably in the near future.

Analysis of the national economic system and politics

Strength and weaknesses

Australia is the sixth country in surface area and one of those with lower population density in spite of the, approximately, 23 million inhabitants in 2013 (World Bank). This, together with the abundant natural resources existent in the country, provide it with an important independence from other countries and contributes to creating a strong internal infrastructure and business environment. This source of natural resources is clearly oriented to solar energy, since Australia exhibits one the highest annually-averaged DNI, characteristic of special interest for the OMsOP project.

The proximity to the emerging Asia constitutes another interesting advantage of the Australian market, even if it can turn out to be a weakness because of its dependency on the Chinese demand. Amongst the risk factors, the chronic current account deficit (around 40 % of GDP in 2013 according to the World Bank) must be highlighted and, in a longer term, its high vulnerability to climate change.

The risk diagram of Euler Hermes shows a very favourable and secure environment for investments.

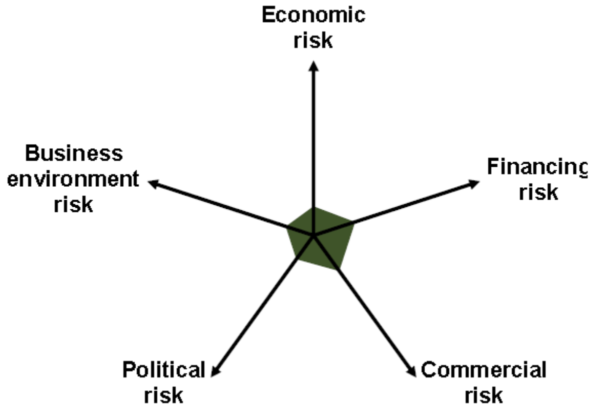

Figure A. 7. Risk dimensions estimated by Euler Hermes. Australia.

Economic structure

The Australian trade is well diversified, with 5 sectors sharing between 7 and 20% of product exportations, amongst which iron ores represent the principal exportation with 20% of the total. On the other hand, crude oil has the highest share on the imports with 9%. However, regarding destinations, the export market looks at east-Asia, where more than 70% of Australian exports go, and from which around 40% of the import come. The north-American market positioned far behind others, totalling 5% of the exports and 10% of the imports.

The effects of the global crisis have been much lesser or even negligible in Australia, 2014 being the 23rd year in continuous growth, at the expenses of an astounding growth of the government debt which has tripled from 2007 to 2013 to achieve 60% currently.

Economic forecast

As a consequence of the deceleration of the Chinese market together with the stabilization of low mineral prices, the third quarter of this year has confirmed a deceleration of the Australian market, growing 0.3% in lieu of the 0.5% expected.

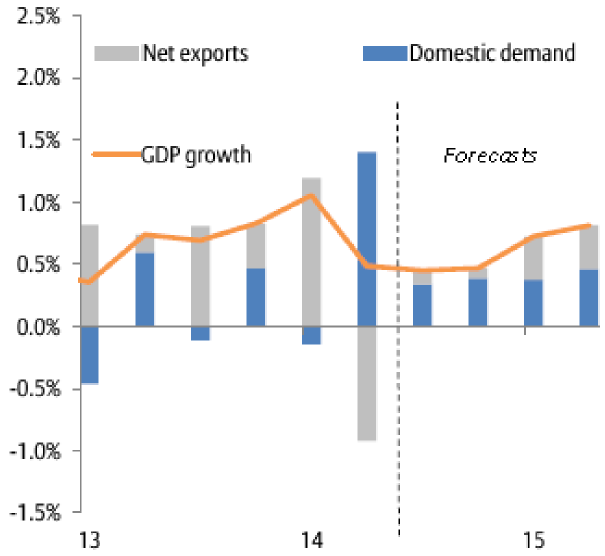

Figure A. 8. GDP growth estimation by Euler Hermes for Australia.

This situation coexists with the stabilisation of the unemployment rate in a high value of 6.2%, causing a certain loss of confidence from the consumers. Nevertheless, the country holds excellent international standards and, in spite of previous negative indexes in comparison to itself, the growth forecast is positive for the next quarter, years and even decades.

Maps

Population

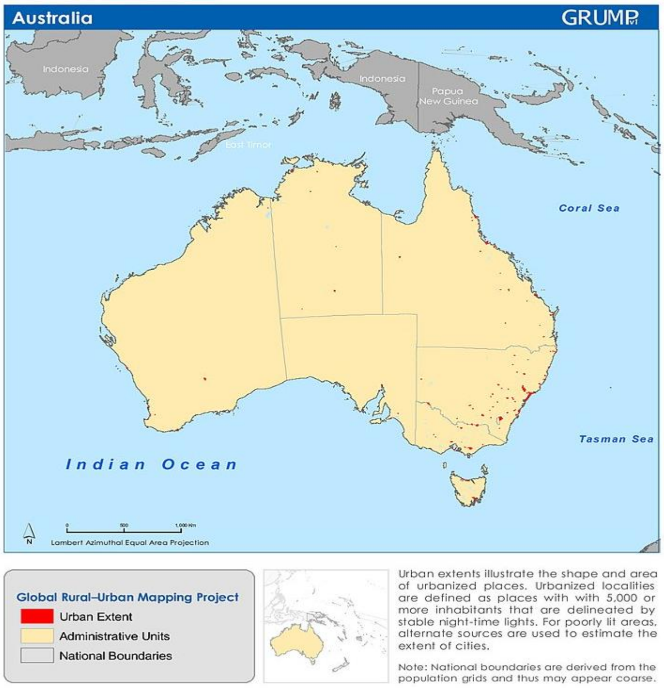

Figure A. 9. Australia population map.

DNI

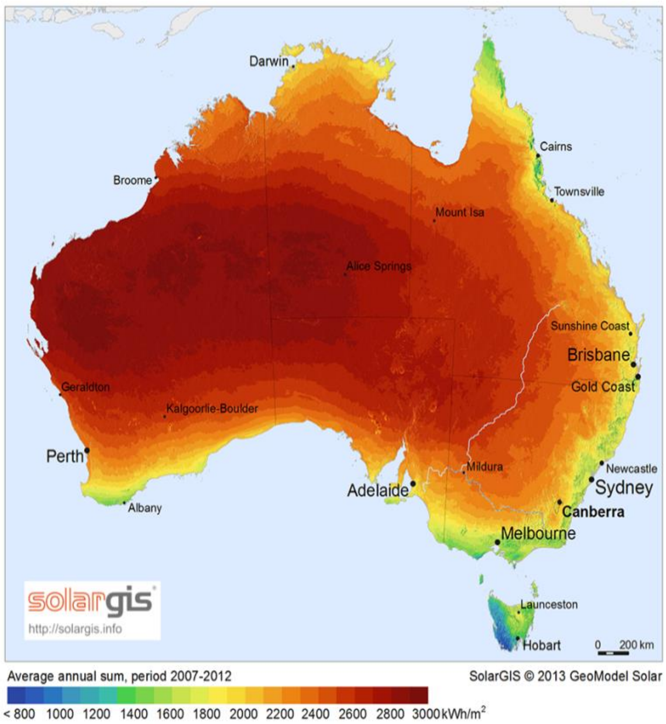

Figure A. 10. Australia Direct Normal irradiation.

Electricity grid

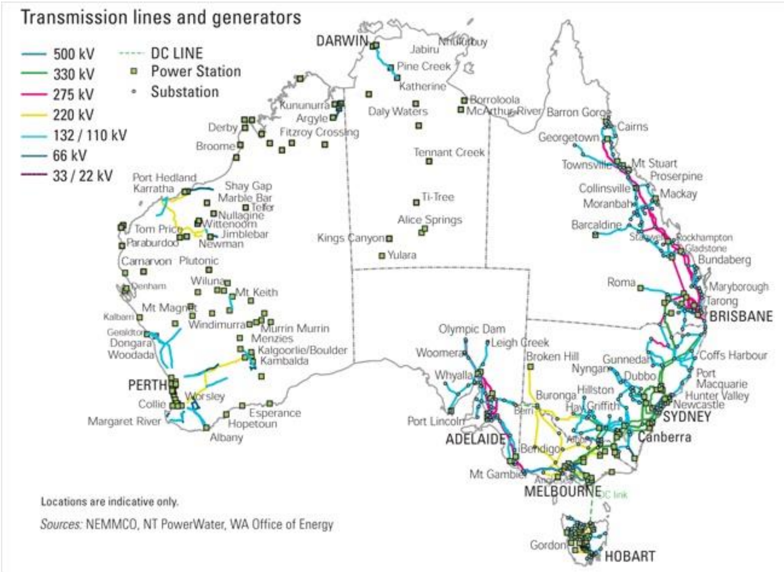

Figure A. 11. Australia electricity grid.

Maps overlapped

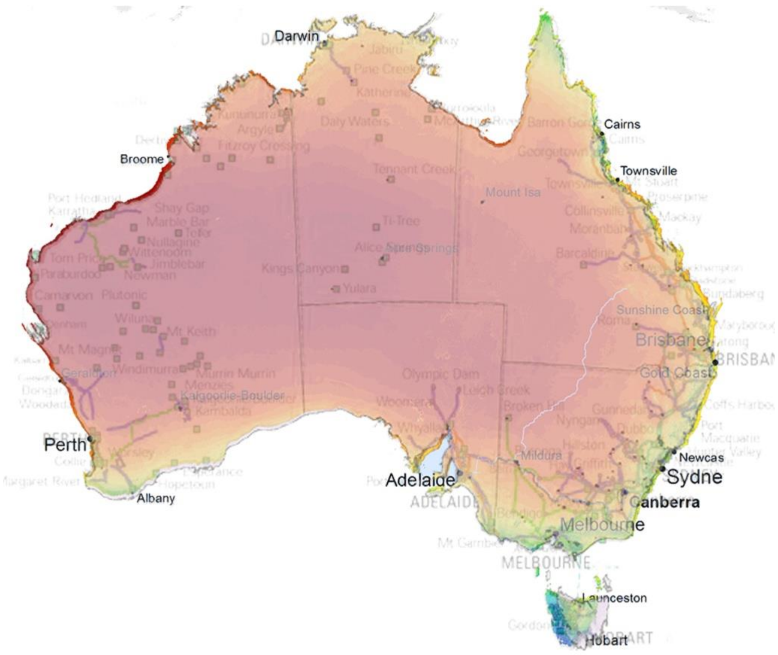

Figure A. 12. Australia overlapped maps.

Application of the method

- **GDP:** US$ 1560.60 Billion (in 2013)
- **Annual GDP Growth rate:** 3.00 % (in 2013)
- **Population:** 23.131 Million people (in 2013)
- **Annual population Growth rate:** 1.78 % (in 2013)
- **Annual electric consumption (per capita):** 10712 kWh (in 2011)
- **Government debt:** 20.48 % GDP (in 2014)
- **Accumulated external debt:** AUD 1593.88 Billion (in 2014)
- **Inflation rate (consumer prices):** 2.45 % (in 2013)
- **Country rating (Euler Hermes):** AA1
- **Annually averaged DNI:** 2387.66 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.8646	0.1729
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	1.0000	0.1000
		TOTAL	0.9479

Table A. 3. Farm arrangement. Australia.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	1.0000	0.1000
		TOTAL	0.7250

Table A. 4. Stand-alone configuration. Australia.

ANNEX 3. Brazil

Analysis of the national energy system

Brazil produces enough energy to cover the 80% of its demand and it is the largest consumer of energy in South America.

Brazil has vast hydro-electric resources, accounting with more than 60 hydroelectric facilities with installed capacities of at least 100 MW; actually, twenty three of these facilities have installed capacities larger than 1 GW. Together with Paraguay, Brazil operates by some measures the world's largest hydroelectricity complex, the Itaipú facility on the Paraná River, with a capacity of 13.6 GW. The remaining electricity generated in Brazil comes mostly from coal and gas-fired thermoelectric plants. In recent years, Brazil has run an overall power surplus, allowing exports to its neighbours.

In May 2012, Brazil produced 2.78 million bbl/d of oil and gas equivalent. According to the Oil and Gas Journal (OGJ), Brazil had 14 billion barrels of proven oil reserves in 2012, the second-largest in South America after Venezuela. Petrobras discovered large offshore Campos and Santos Basin oil fields in 2007, containing 5-8 billion barrels of oil, thus expanding the proven reserves of the country by 40-50%.

Brazil has also discovered enormous "pre-salt" oil fields, around 18000 feet below the ocean bed, under a thick layer of salt. Brazil pre-salt announcements immediately transformed the nature and focus of Brazil oil sector, and the potential impact of the discoveries upon world oil markets is vast. Some analysts estimate that there are more than 50 billion barrels of oil equivalent located in these reserves. However, considerable challenges must still be overcome in order to bring these reserves to fruition. The difficulty of accessing reserves, considering both the large depths and pressures involved with pre-salt oil production, represents technical hurdles that must be overcome.

Brazil has the largest coal reserves in Central and South America, with proven recoverable reserves around 10 billion tonne. Despite this, in 2006 Brazil produced 7 million tonne of coal whereas coal consumption reached 23.8 million tonne. Similarly, in 2009, Brazil produced 2,241 ktoe of coal, and imported a further 9,076 ktoe. Almost all of Brazil's coal output is steam coal, of which about 85 % is fired in power stations.

Brazil holds the sixth largest uranium reserves in the world. The country has two nuclear power plants, the 630 MW Angra-1 and the 1350-MW Angra-2. State-owned Eletronuclear, a subsidiary of Eletrobras, operates both plants.

Reliance

Most of the imported electricity comes from Argentina and Paraguay. Total electricity imports in 2009 were 41064 GWh, or roughly 8 % of total domestic supply, while the export totalled 1080 GWh.

Brazil is one of the largest coal importers in the world. Major coal suppliers of Brazil are the United States and Australia.

Extend network

In 2009, the national electrification rate achieved 98.9%, while in rural territories this rate was 92 % in the same year. In 2010, the Brazilian National Interconnected System (SIN) consisted of approximately 96,140 km of T&D lines, predominantly of 230 kV and below, and the T&D losses in the country stood at 16.4 %.

Capacity concerns

Although hydroelectric power is a very cost-effective source, in 2001 droughts caused power shortages and energy rationing. This situation was attributed to the lack of investment within the sector. Rationing lasted until May 2002. The consumption of electricity was drastically reduced, resulting in major economic consequences, with an estimated social cost close to 3% of the GDP.

A better integration of electricity and natural gas industries is needed to provide energy security in Brazil. It involves a redefinition of the role of thermoelectric plants, which must be dispatched on a regular basis to afford an attractive remuneration to natural gas infrastructure. Indeed, the very low rate of dispatch for gas power plants persists because Petrobras gives priority to fuel respect to other markets (industry and transport mainly). Therefore, only 30% of the existing natural gas capacity has sufficient fuel to operate nowadays.

As a result of the ongoing drought, Brazil is involved in the construction of additional natural gas plants in order to relieve the hydroelectric burden of the nation, as the level of dams is nearly achieving the critical capacity. Thermal power plants in the country are now operating at 70% capacity, with electricity costs in the country rising to ¢US$14.8/kh in October; nearly triple the cost of July.

Renewable energy

The potential for off-grid solutions in Brazil is huge, but largely untapped. The existing isolated diesel systems are often inefficient, unreliable, expensive to run and a continuous drain on government funds. The grid extension is not an economically feasible option for many remote and dispersed users. However, early off-grid pilot projects in Brazil have not been sufficiently focused on sustainable service models and productive uses, creating the wrong impression of high operation and maintenance costs and limited benefits.

Ownership of electricity

The electric sector in Brazil is dominated by the large government-controlled companies. Federally-owned Eletrobras holds about 40% of the capacity, whilst the remaining part belongs to several state-companies (*Cepel*, *CGTEE*, *Chesf*, *Eletronorte*, *Eletronuclear*, *Eletrosul*, *Furnas*, *Itaipu Binacional*, *Distribuição Piauí*, *Distribuição Rondônia*, *Distribuição Acre*, *Amazonas Energia*, *Distribuição Alagoas*, *Distribuição Roraima and Eletropar*). Currently, about 27% of the generation assets are in the hands of private investors. Considering the plants under construction, as well as the concessions and licenses already granted by ANEEL, this figure is expected to grow up to 31% in the medium term and to reach almost 44% over 5-6 years.

The *Operador Nacional do Sistema Eléctrico* (ONS) operates the national transmission grid, which consists of two large grids (one in the north, one in the southeast which were connected in 1999) and numerous smaller systems in isolated regions. Until 2007, transmission was almost exclusively under government control through both federal (Electrobras) and state companies (mainly Sao-Paulo-CTEEP, Minas Gerais-Cemig, and Parana-Copel). However, under the new sector regulatory model, there are about 40 transmission concessions in Brazil. Most of them are still controlled by the government, with subsidiaries under federal company Electrobras holding 69% of total transmission lines.

In 2010, there were 63 utilities with distribution concessions, all independent from state control. As of 2007, about 64% of Brazilian distribution assets were controlled by private sector companies.

Competition

In 2003, the federal government started promoting some changes which encourage private sector access to the energy market.

A wholesale market was created in 1998. A regulated pool that buys power from generators and shares the costs between distributors under set prices was launched in 2004 together with a free market where distributors and generators can negotiate their own contracts. Distributors buy electricity in the regulated pool via long-term contracts. Short-term differences between distributors' actual demands and purchases in the regulated pool can be negotiated in the free market. Big consumers can choose between buying directly in the free market and buying indirectly in the regulated pool through a distributor.

Energy framework

The Inter-American Development Bank (IDB), as of April 2008, was supporting several projects in the power sector in Brazil, especially the Renewable Energy Service Delivery Project. This project is a technical cooperation that seeks to implement several pilot projects on renewable energy services to isolated communities in Brazil.

Law No. 10438, from April 26th 2002, created an incentive programme for renewable energy called PROINFA (*Programa de Incentivo às Fontes Alternativas de Energía*), aimed at stimulating the development of wind, biomass and small hydro plant projects in Brazil. Such program provided for the guarantee of energy purchases by the state-owned corporation Eletrobrás, under 20-years' power purchase agreements, at attractive prices and exemptions or discounts in the payment of certain power sector charges. At the same time, the Brazilian Development Bank (BNDES, *Banco Nacional de Desenvolvimento Social e Econômico*) and other financial institutions, made these projects available by means of long-term credit facilities. PROINFA was originally conceived to include two phases, representing 144 renewable energy projects.

In the first phase, the Program calls for the generation of 3300 MW of renewable energy with a national business participation rate of 60%, aiming at maximizing the potential of country regions, creating jobs, reducing CO_2 emissions through thermal fossil fuels displacement and promoting energy contracts with differential conditions respect to conventional sources, as well as a specific tariff depending on the source. The second phase fixes a 90% nationalisation rate and a 15% Brazilian electrical energy annual consumption rate to be supplied by these sources. The goals of this phase are expected to be reached within 20 years, and the price will be a weighted average between competitive hydroelectric and thermoelectric (natural gas) prices.

PROINFA, as described in the Decree No. 5025, was established in order to increase the share of electricity produced by projects based on wind power, biomass and small hydro hydropower (SHP) in the National Interconnected System (SIN). According to Law No. 11,943 of May 28, 2009, the deadline for the start of operation of these projects ends on December 30, 2010.

The Alternative Energy Auction of July 2011 (Regulation Portaria MME 113 of Feb 1, 2011) authorises ANEEL, the national electricity regulator, to organise alternative energy auctions, and sets pre-qualification criteria for developers participating in the auctions. The Government has also sought to reform the biodiesel auction framework to include a resubmission procedure to stimulate competition, and an updated IT framework for ANEEL to process bids more efficiently, including a web-based bidding process.

Energy debates

Wide-ranging energy policy changes were introduced in 2013 in an effort to reorganise the electricity sector in order to attract private investment and ensure reliable supply, as a measure to promote economic growth. In particular, the costs of power to residential and commercial consumers are to fall by 18% and 32% respectively. An Energy Development Account (CDE) was also established with US$ 4.2 billion initial funding. This account was responsible for all subsidies to the electricity generation, transmission and distribution sectors. Finally, oil and gas auction blocks were expanded for the March 2013 auction round, with 68 % more acreage being offered than initially expected.

Energy studies

The World Bank, Energy Sector Management Assistance Program (ESMAP), Brazil Background Study for a National Rural Electrification Strategy: Aiming for Universal Access (March 2005).

Role of government

The institution responsible for energy issues in Brazil is the Ministry of Mines and Energy (MME, *Ministerio de Minas e Energía*). This Ministry, through the Secretary of Energy (SEN, *Secretaria de Energía*), formulates the guidelines and policies for the national energy sector and coordinates and supervises their execution.

Energy Planning is undertaken by *Empresa de Pesquisa Energética* (EPE). The final approval of Energy Planning is the responsibility of the *National Council of Energy Policy* (NCEP).

The *Comitê de Monitoramento do Setor Elétrico* (CMSE) monitors the trends in power supply and demand. If any problem is identified, measures are proposed by CMSE in order to avoid energy shortages, such as special price conditions for new projects and a reserve of generation capacity. The Ministry of Mines and Energy host and chair this committee.

Government agencies

One of the institutions associated to the Ministry of the Environment is *Ibama*, the Brazilian Institute for the Environment and Renewable Natural Resources, which is responsible for the execution of the environmental policies dictated by the Ministry.

The Power Research Company (*EPE*, www.epe.gov.br) was created in 2004 with the specific mission of developing an integrated long-term plan for the power sector in Brazil. Its work serves as an input for planning and implementing the actions proposed by the Ministry of Energy and Mines in the formulation of the national energy policy.

Energy procedure

The Brazilian National Energy Plan for 2008-2017, published by the Ministry of Mines and Energy, aims at increasing the installed power capacity from 99.7 MW to 154.7 MW.

The National Energy Plan for 2030 sets forth the long-term government strategies to meet the country energy needs in a sustainable way.

The annual Ten Year Energy Development Plans work with macro-economic, environmental, social and technological variables to assess the most sustainable course of action to meet Brazil future energy needs. The Plans indicate the appropriate deadlines for the implementation of new projects, and provide forecasts of supply and demand levels for the period covered.

Energy regulator

National Electric Energy Agency (ANEEL) created in 1996.

National Agency of Petroleum, Natural Gas and Bio-diesel (ANP) created in 1997.

Degree of independence

The Board of the ANEEL is composed by 5 Directors, including a General Director appointed by the President after being approved by the Senate.

The Board of the National Agency of Petroleum, Natural Gas and Bio-diesel is composed by 4 members appointed by the President and ratified by the Congress.

Regulatory framework

PROINFA is considered a milestone in the regulatory framework applicable to renewables in Brazil, and remains the dominant piece of legislation relating to renewable energy regulation.

Regulatory roles

National Electric Energy Agency (ANEEL): Regulation of prices and other aspects of the electricity industry, concession granting for the operation of electricity companies, supervision of concession agreements.

National Agency of Petroleum, Natural Gas and Bio-diesel (ANP): The ANP is responsible for all matters relating to the regulation of the upstream and downstream oil, natural gas and bio-diesel sectors, including an oversight role in the oil and gas bidding rounds.

Energy regulation role

The regulation of prices is delegated to the specific regulatory institutions in the electricity and petroleum industry.

Regulatory barriers

At present, the overall regulatory and policy planning framework for renewable energy has not been updated for nearly a decade, and whilst considerable attention has been given to the development of bio-diesel and the newly-viable pre-salt oil fields, limited development for the majority of other renewable resources has occurred.

Analysis of the national economic system and politics

Strength and weaknesses

The main reason for the solidity of the Brazilian economic system is the expansion of a large middle class in a democratic political system together with a well-diversified trade structure. The predominant shares are iron ores, 1 % of exports, and refined petroleum, 9% of imports. These factors attract the attention of the markets, bringing about a high level of foreign direct investments.

However, the lack of an equivalent domestic investment, infrastructures and a sufficiently qualified workforce impose limitations on the Brazilian economy growth, to which the political and social tensions because of insecurity, corruption and inequality issues also contribute.

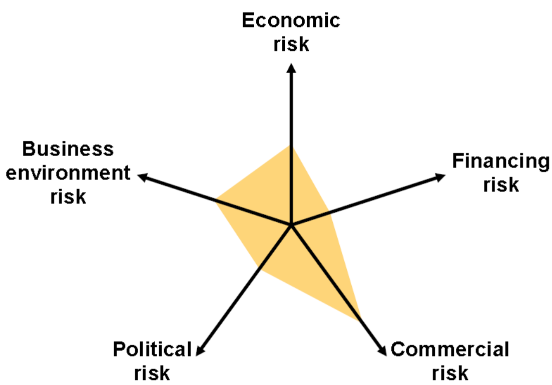

Figure A. 13. Risk dimensions estimated by Euler Hermes. Brazil.

Economic structure

The main trading relationship of Brazil are stablished with China, US and Argentina, these countries sharing around 36% of both the import and export markets. Regarding sectors, Brazil depends strongly on commodities, which makes it very vulnerable to their (volatile) prices.

The chronic underinvestment over the last decades has originated a decoupling between internal offer and demand. As an example, in 2005, retail sales grew eight times faster than the industrial production. This fact has been favoured by the recent Sport events organised in the country, which have given place to a high internal demand that cannot be satisfied due to precarious infrastructures.

Economic forecast

The Football World Cup has had a twofold impact on the nation: on one hand it has promoted the growth of the economy mainly due to the demand for intensive workforce to construct the necessary infrastructures and to provide services to the numerous visitors (tertiary); on the other, it has stablished a high inflationary pressure (slightly over 6%) that seems to persist in the next quarters and will expectedly produce a decrease of the GDP in 2015. The near future scenario seems to be dominated by recession and inflationary pressures.

Maps

Population

Figure A. 14. Brazil population map.

DNI

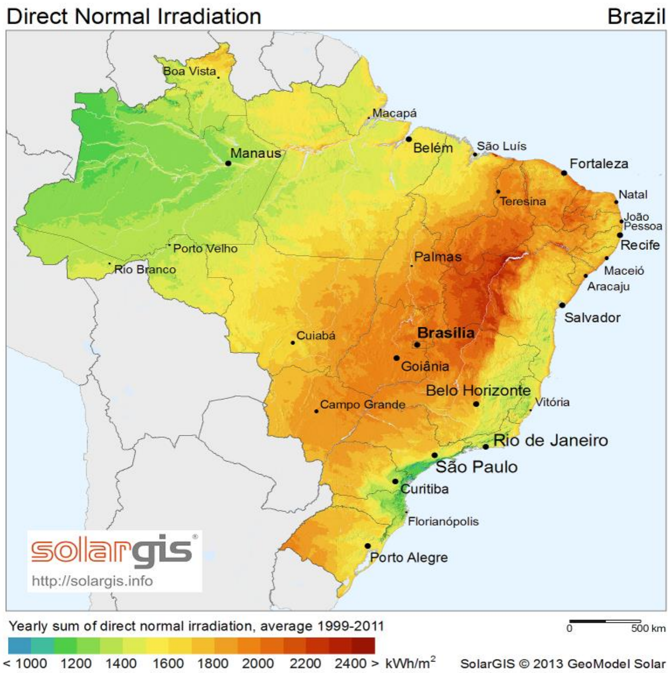

Figure A. 15. Australia Direct Normal irradiation.

Electricity grid

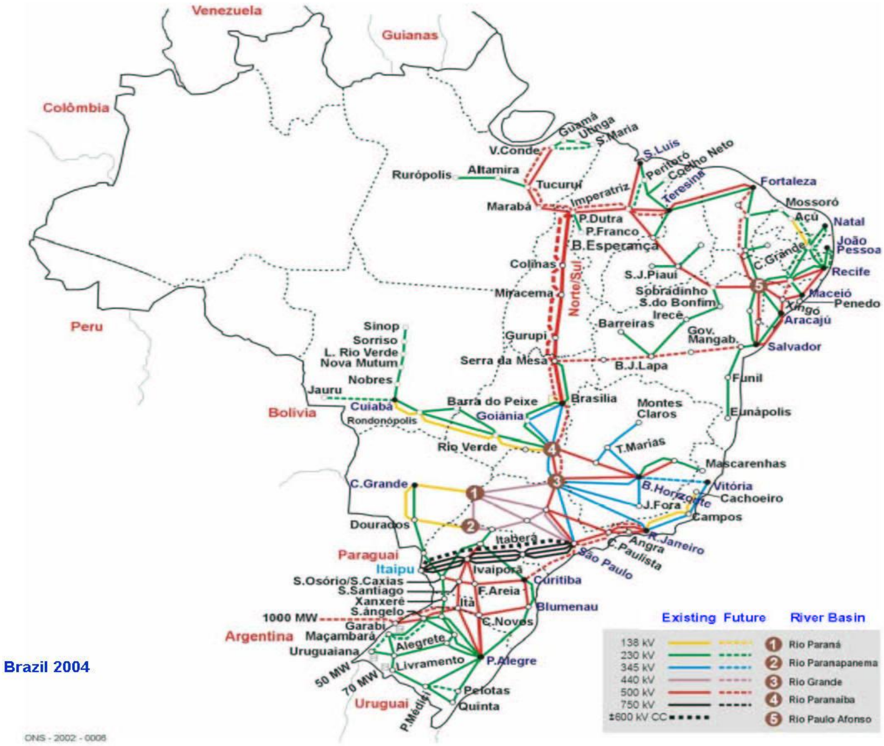

Figure A. 16. Brazil electricity grid.

Maps Overlapped

Figure A. 17. Brazil overlapped maps.

Application of the method

- **GDP:** US$ 2245.67 Billion (in 2013)
- **Annual GDP Growth rate:** 2.49 % (in 2013)
- **Population:** 200.362 Million people (in 2013)
- **Annual population Growth rate:** 0.86 % (in 2013)
- **Annual electric consumption (per capita):** 2437.96 kWh (in 2011)
- **Government debt:** N/A
- **Accumulated external debt:** US$ 440.48 Billion, 19.61 % GDP (in 2012)
- **Inflation rate (consumer prices):** 6.20 % (in 2013)
- **Country rating (Euler Hermes):** BB2
- **Annually averaged DNI:** 1478.32 kWh/m^2
- **Population with access to electricity:** 99.3 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.4783	0.1674
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	1.0360	0.2072
Energy policy	0.10	0.7700	0.0770
Financial risk	0.10	0.6146	0.0615
		TOTAL	0.7631

Table A. 5. Farm arrangement. Brazil.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.4783	0.1674
Demand	0.25	0.0070	0.0018
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7700	0.0770
Financial risk	0.10	0.6146	0.0615
		TOTAL	0.5076

Table A. 6. Stand-alone configuration. Australia.

ANNEX 4. Canada

This country report has been written applying different template due to its not high importance as the country with favourable solar conditions. Nevertheless, it has got very valuable and stable economy.

Analysis of the national energy system

The structure of the electricity sector has evolved over the past decade. In most provinces, there has been a shift from vertically-integrated electric utilities (often provincial Crown corporations) to various degrees of market liberalisation and/or unbundling of generation, transmission and distribution services.

Electricity in Canada is generated from a diversified mix of sources. Electricity produced from renewable and nuclear sources is considered primary energy because it is captured directly from natural resources, while electricity based on fossil fuels is considered secondary energy because it comes from primary energy commodities such as coal, natural gas and oil. In 2010, the electric utilities and industry in Canada generated $5.89 \cdot 10^5$ GWh, much higher than the $4.67 \cdot 10^5$ GWh in 1990. Canada is the third largest producer of hydroelectricity in the world with over $3.48 \cdot 10^5$ GWh in 2010, which represents 59% of the country's electricity supply. The hydropower installed capacity in Canada is more than 75 GW, which has been possible thanks to favourable geography and hydrography conditions, especially in the regions of Quebec, British Columbia, Ontario, Labrador and Manitoba. Other sources include coal, uranium, natural gas, petroleum and non-hydro renewable sources. During this year, more than $4.4 \cdot 10^4$ GWh were exported to the United States, while about 10^4 GWh were imported.

Fossil fuels are the second most important source of electricity in Canada, with 12.6% of electricity produced from coal, 8.6% from natural gas and 1.2% from petroleum. Fossil fuel generation is particularly important in Alberta and Saskatchewan, where several power stations have been built adjacent to large coal deposits. Fossil fuel generation is also important in the Atlantic Provinces, Northwest Territories and Nunavut. Ontario used to rely heavily on coal-fired generation, but the province plans to phase down all coal-fired generation plants by the end of 2014. In 2010 only 8.2% of total provincial generation was produced from coal.

Nuclear power is the third most important source of electricity in Canada. About 14.5% of electricity supply is generated in nuclear power plants using the Canadian-developed CANDU reactor. 20 of the 22 Canadian nuclear power installations are in Ontario, one is in New Brunswick and one is in Quebec.

Non-hydro renewable sources currently contribute with 3% of the Canada electricity supply. Wind has become the predominant non-hydro renewable source surpassing biomass (e.g., wood waste, spent pulping liquor). An emerging source, solar provides a still small but rapidly increasing amount of electricity.

Electricity demand in Canada has grown at an annual average rate of 1.2% since 1990. The industrial sector accounts for the largest share of demand, fuelled by the presence of a number of energy-intensive industrial activities. The residential and commercial-institutional sectors also consume large quantities of electricity.

Factors such as population growth and greater use of electrical appliances and equipment are expected to continue to drive electricity demand in the coming years, whereas the slower economic growth could reduce the electricity demand.

Canadian consumers benefit from some of the lowest electricity prices in the world. Prices are especially low in the provinces where the electricity sold to consumers originates primarily from hydroelectric dams.

Prices

Electricity prices differ across Canada due to several factors. The most significant of them are the market structure and the type of available generation. Alberta has a deregulated electricity market where prices are market-based. Ontario has partially restructured its electricity market. In other provinces and territories, electricity prices are set by electricity regulators.

The type of available generation is reflected in the cost of generating electricity, which is the most important element of electricity pricing. It varies between provinces or territories depending on the source employed to produce electricity. Hydroelectric stations currently provide some of the lowest-cost electricity in Canada. However, as the most economical projects were developed first, new hydroelectric projects may have higher production costs.

Hydroelectric and nuclear power plants are fairly capital intensive, which means that a major portion of the generation costs is due to the cost of building the production infrastructure. Operating and fuel costs are relatively low compared to other electricity sources.

In the case of natural gas and petroleum-based generation, the cost of fuel affects in a large portion the final generation costs. Because of this, the cost of generating electricity from fuels fluctuates with the prices of them. Coal-fired power plants fit in the middle of this spectrum, with mid-range capital costs and mid-range fuel and operating costs.

Other important elements for the electricity pricing, in addition to the market structure and the cost of generation, are the costs of its transmission and local distribution. These costs vary across Canada, depending on factors such as geography and population density.

Canadian consumers benefit from some of the lowest electricity prices in North America. In Canada, the lowest electricity prices are found in British Columbia, Manitoba and Quebec. These 3 provinces have access to low-cost hydroelectricity from large-scale projects. In 2011, average prices for residential customers in cents per kWh (¢CA$) were 6.82 in Montreal, 7.31 in Regina, and 7.68 in Vancouver, opposite to the highest ones in Calgary and Edmonton, 17.47 and 16.40 respectively.

Reliability

Because of the technical limitations on storing electricity, electric utilities and governments work to ensure that enough electricity is available to meet demand at any given time and to avoid power outages. Several actions are also taken to ensure the reliability of the electricity grid.

Having a generating capacity in excess of the expected peak demand is one way to ensure reliability. This allows electric utilities to still meet demand when some generation capacity may be offline because of routine maintenance or unexpected shutdowns. Utilities may also secure access to additional supplies by trading electricity with neighbouring utilities, including those in the United States.

Adequate transmission is also vital to ensure reliability. Transmission allows for moving electricity from areas with excess electricity to areas where electricity is needed. Electricity can be transmitted both within the area of distribution of a given utility and between utilities.

Several other actions are taken to ensure reliability, including the careful management of the electricity grid in real time and the adoption of standards and operation procedures.

Outlook

The electricity demand in Canada is expected to grow at an annual rate of 1% between 2010 and 2035. Most of the growth in demand would come from the industrial sector, where demand is expected to grow at a rate of 1.3%.

In order to meet the increasing demand, Canadian producers will increase their generation capacity. The sources of future supply increments will depend on the policy and business decisions made by governments and power producers. Hydroelectricity generation is expected to continue dominating the electricity supply. However, the share of wind power is projected to triple from less than 2% currently up to 6% in 2035, while the share of biomass, solar and geothermal will account for about 4% by 2035. Thus, over the forecast period, the share of renewable sources in total generation is expected to reach 68%. Natural gas-based generation is set to increase 2.3 times with its share in total generation increasing from 9 to 15% over the 2010-2035 period, while the generation from both oil and coal is expected to decrease. Nuclear generation is expected to remain at its current level, although the construction of new nuclear plants is being considered.

Analysis of the national economic system and politics

Strength and weaknesses

Canada ranks the 2nd position in country land areas behind Russia, and ahead of the U.S. This high extension has provided the country with a wide variety of natural resources: forestry, oil and gas, mining, fishing and mineral resources like coal, copper, iron ore, and gold. This together with the trade internationalisation and the transparency and stability in the business climate, has made Canada one of the world's most attractive investment destinations.

The biggest weakness of Canada's economic system is the aging of the work force. Despite having the 9th largest labour force participation rate in the world, between 1991 and 2001, the average age of the Canadian labour force grew from 37.1 to 39 years old. As such, Canada has since turned to immigration to compensate for its lack of skilled workers combined with an aging labour force.

An important character to highlight of the Canadian economy is the strong dependency on the US economy, after the signing of the 1989 US-Canada Free Trade Agreement (FTA) and the 1994 North American Free Trade Agreement (NAFTA). Besides, the US is also Canada's largest trading partner, in addition to its largest foreign investor through investments in mining, smelting, petroleum, chemical and machinery segments. The downside is that the Canadian economic policies have often been adjusted according to those of the US; nevertheless, it is very positive that the historically small changes in the US interest rates have hardly had economic repercussions in Canada.

Canada belongs to the OECD (Organization for Economic Co-operation and Development) and to the G8, getting the lowest government debt in the latter group. This is an indicator of the afore-noted stabilisation of the business climate in the country.

Economic structure

Canada's economy is dominated by the service industry, the primary sector being the most important one with logging and oil industries the two most important industries in the country. Canada also has a sizable manufacturing sector, centred in Central Canada, with the automotive industry especially important.

International trade makes up a large part of the Canadian economy, in particular natural resource trading. In 2009, agricultural, energy, forestry and mining exports accounted for about 58% of Canada's total exports; Machinery, equipment, automotive products and other manufactures accounted for a further 38% of exports in 2009. In 2009, exports accounted for approximately 30% of Canada's GDP.

The United States is by far its largest trading partner, accounting for about 62% of the exports and 46% of the imports. The second in the list is China with 7 and 14% respectively. Regarding sectors, there exists a more pronounced diversification of sectors both in exportations, where automotive is the leader with 22.3%, and imports, where machinery is the leader with a market share of 25.2%.

The top 5 sectors for both: import and export (vehicles, machinery, chemical products metals and mining), share only around 65% of the market, which definitely shows the diversification of the Canadian market.

Economic forecast

After World War II, Canada has experienced a very important economic change that has transformed its economic system based mostly on mining and fishing into one of the best industrialised countries. The influence of a powerful neighbour has been crucial for that, and it is expected to continue so.

During the US economic crisis of 2008-2010, Canada was negatively affected and suffered a significant decrease in GDP. After it, a number of measures implemented by the government contributed to recovering a positive growth rate that is being decelerated in the last quarters. In 2015, the GDP growth rate is expected to be around 0.7 % and improving in subsequent years up to the 0.75 % foreseen for 2020.

Maps

Population

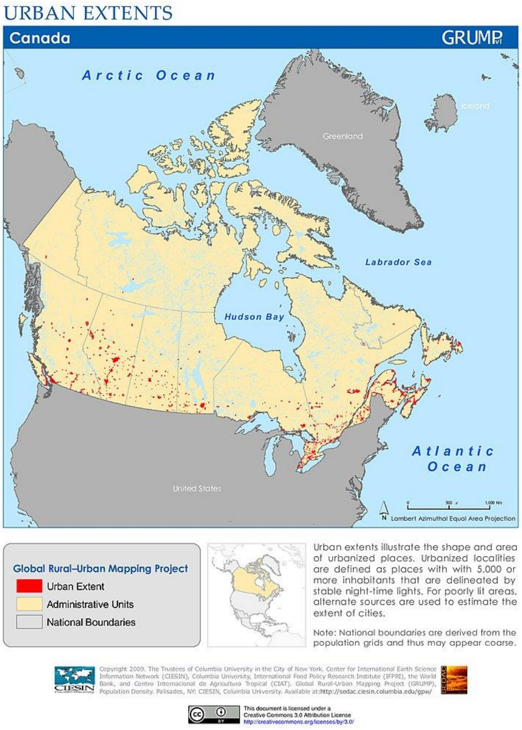

Figure A. 18. Canada population map.

DNI

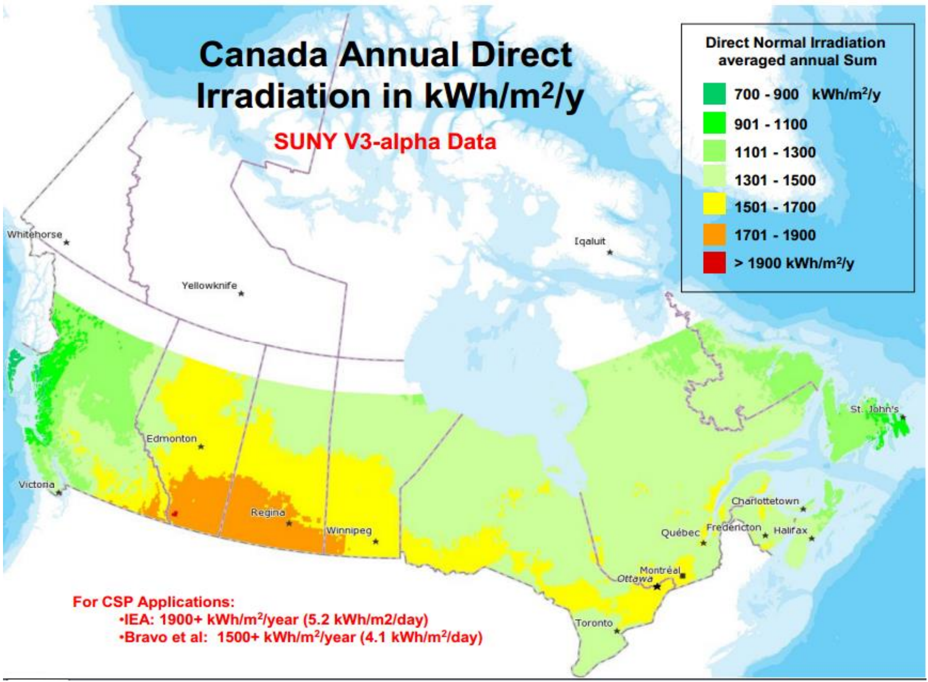

Figure A. 19. Canada Direct Normal irradiation.

Electricity grid

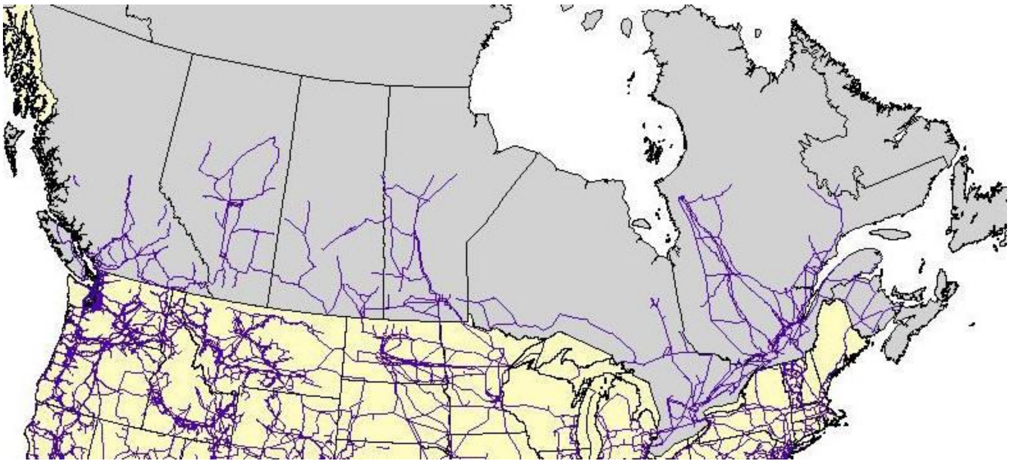

Figure A. 20. Canada electricity grid.

Maps Overlapped

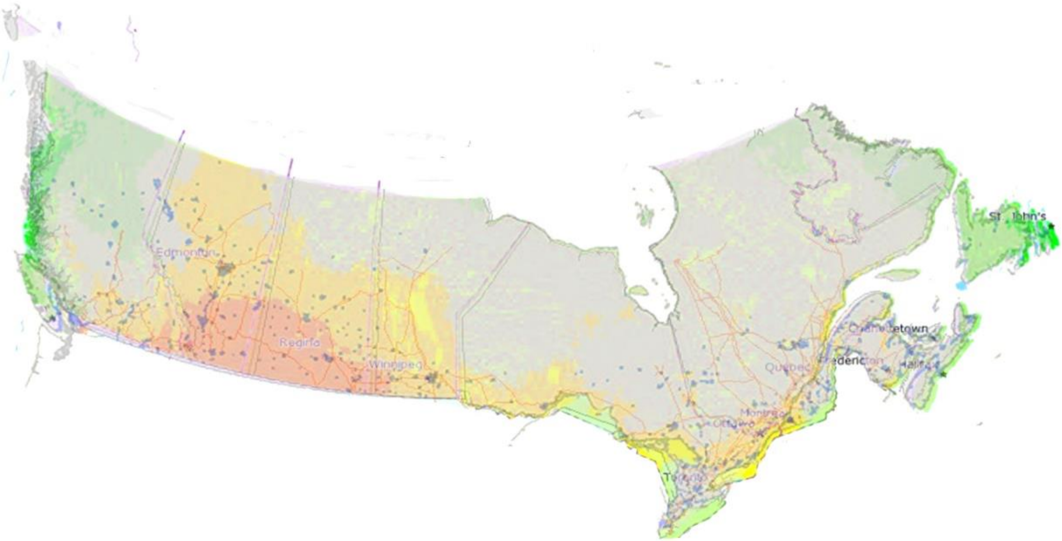

Figure A. 21. Canada overlapped maps.

Application of the method

- **GDP:** US$ 1825 Billion (in 2013)
- **Annual GDP Growth rate:** 0.7 % (in 2013)
- **Population:** 35.158 Million people (in 2013)
- **Annual population Growth rate:** 1.16 % (in 2013)
- **Annual electric consumption (per capita):** 16473 kWh (in 2011)
- **Government debt:** 51.85 % GDP
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 0.94 % (in 2013)
- **Country rating (Euler Hermes):** AA1
- **Annually averaged DNI:** 1312.13 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.3121	0.1092
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.9112	0.1822
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	1.0000	0.1000
		TOTAL	0.6915

Table A. 7. Farm arrangement. Canada.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.3121	0.1092
Demand	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	1.0000	0.1000
		TOTAL	0.4592

Table A. 8. Stand-alone configuration. Canada.

ANNEX 5. Chile

Analysis of the national energy system

Chile is a small oil producer that is bringing out 10800 bbl/day, as for 2009. Nevertheless, production has been declining over the past 20 years along with natural gas, while the consumption of these fuels has quadrupled.

Reliance

The dependence of Chile on imported energy had been increasing over the last 30 years. In 1980, approximately 58% of the energy consumed was supplied by indigenous production and 42% from net imports. However, in 2005, this proportion has reversed to 71% coming from imports and the remainder from indigenous production.

Chile has a mutually dependent relationship with Argentina. In Chile, hydroelectric generation from Andean rivers is the largest source of electricity, whereas in Argentina electricity is generated mostly by thermal plants. Chile exports energy to Argentina during the summer season, while Argentina exports thermally-produced electricity to Chile during winter. Argentina exports most of its surplus natural gas to Chile. In 2004, Chile relied on Argentinian gas to generate 30% of its power. However, this relationship was strained by the Argentinian energy crisis in 2004, when Argentina repeatedly reduced natural gas exports to Chile in order to make up for domestic shortages. Argentina is Chile's sole source of natural gas imports, and the continued supply disruptions have created considerable tension between the two countries.

Extend network

- National electrification rate (2007): 99%
- In urban areas: close to 100%
- In rural areas: 93.5%.

Capacity concerns

High diesel prices combined with droughts, natural gas restrictions, rising energy demand, and delay in the development of new projects will increase the likelihood of energy shortages and will keep electricity prices on an upward trend for the next couple of years. In order to mitigate this, thermal-electric power plants construction were initiated in 2009. Additionally, Chile is investing into the diversification of its power-generation infrastructure.

Renewable energy

Renewable energy has been mostly used for rural electrification or other small-scale power generation until very recently. Nevertheless, Chile has moved forward to exploit its huge solar, wind and geothermal potential. As a consequence of the recent impetus given to renewable technologies, Chile is widening its green portfolio with 836 MWe in wind and 400 MWe in photovoltaics currently in operation. Another 165 MWe wind, 833 MWe PV and 110 MWe solar thermal are also under construction as part of an ambitious project to reach 14.7 GWe capacity in biomass, biogas, wind, small hydro, solar photovoltaic, solar thermal and geothermal in the following years.

Solar energy

The Atacama Desert gets up to 9.28 kWh/m^2/day of sun, among the world's highest. Two 110 MW Concentrating Solar Thermal plants using tower technology and thermal energy storage for 17 hours are currently under construction by the Spanish company Abengoa (Cerro Dominador Atacama 1 and 2). This capacity is expected to be increased in the future with 360 MW coming from the parabolic trough CSP plant Pedro de Valdivia.

Ownership of electricity

Chile was the first country in the world to implement a comprehensive reform of its electricity sector in 1982 and the electricity industry is now fully privatised.

Competition

There is a high level of concentration in the generation field and also a degree of vertical integration between generators and distributors (no unbundling).

Privatisation included open access to the wholesale electricity market. But although the wholesale market is theoretically opened, the relatively small and large companies constitute a virtual monopoly.

The electricity generators compete for the supply of energy to electricity distribution companies. Since 2008, power generators are free to participate in public bids to sell power to distribution companies under long-term contracts (up to 15 years) at a fixed price. Also a ‘spot’ market exists for power transfers between electricity generators.

Finally, generators and distributors compete for the supply of energy to large end-users (with demands of more than 2 MW/year). Distribution networks must provide open access in exchange for a negotiated service fee.

Retail distribution (commercialisation) is considered a public service. A concession or permission is usually required for systems greater than 1500 kW. The Ministry of Economy authorizes concessions for an indefinite period. The distribution concessionaire is required to provide service to captive consumers (but not deregulated consumers) requesting it within the defined service territory.

Energy framework

The *Proyecto de Electrificación Rural* (PER) started in 1994 to overcome poverty, improve quality of life and integrate rural areas into the economic and social development of Chile. Under the umbrella of PER, a new project was developed between 2001 and 2008: *Removal of Barriers for Rural Electrification with Renewable Energies*, with the main goals of:

- Creating a market for renewable energies (including rural electrification).
- Standardising and certifying renewable energy equipment.
- Building capacity.
- Implement financing mechanisms to reduce investment risks.
- Introduce market evaluation.
- Collect data on renewable resources
- And developing rural electrification investment projects.

In order to complement the reform of the electricity sector, the new long-term program *Programa País de Eficiencia Energética* (PPEE) was launched in January 2005.

Energy debates

Debates turn around the energy crisis linked to the reduction of gas importations from Argentina and how to diversify Chilean energy sources.

In early 2003, the so-called “*Ley Corta*” law (Short Law) was debated in the parliament and passed in January 2004. This law addresses some of the most pressing shortcomings of the Chilean electricity system. The *Short Law 2*, passed in May 2005 defining a legal framework which favours the promotion of new investments in power generation, including alternative energy.

Apart from renewable energies, Chile may diversify its sources with nuclear. On this front, Chile interior and energy ministers claim that nuclear power could be a feasible, long-term solution for meeting energy demand. But they face formidable opposition from environmental leaders who consider nuclear energy development an unnecessary hazard given the abundance of other energy sources in the country.

There currently exists in the Senate a parliamentary motion that solves the limitations of the Law 20.257 (*modificaciones a la Ley general de servicios eléctricos respecto de la generación de energía eléctrica con fuentes de energies renovables no convencionales*), establishing a quota of 20% of Non-Conventional Renewable Energy (NCRE) in 2020, which would add 20000 GWh of renewable energy and clean national to the matrix on that date. Additionally, the legislative proposal incorporates the interconnected systems in providing medium NCRE, thus ensuring that all electrical systems incorporating renewable energy sources and clean.

Energy studies

There are various national and international research groups investigating the features and needs of the Chilean energy sector. The most relevant documents are issued by the Catholic University of Chile Power system group and the University of Cambridge (Michael Pollitt, Electricity Reform in Chile: Lessons for Developing Countries, University of Cambridge, September 2004) with other coming from the national administration (for instance, the book "Chile Needs a Great Energetic Reform" published by the *Comisión Ciudadana Técnico Parlamentaria para la Política y la Matriz Eléctrica* CCTP).

Role of government

The Ministry of Energy is the highest organ of cooperation of the President in the functions of government and administration of the energy sector.

The National Energy Commission (CNE, *Comisión Nacional de Energía*) and the Chilean Nuclear Energy Commission (CCHEN, *Comisión Chilena de Energía Nuclear*) report to the President of the Republic through the Ministry of Energy (*Ministerio de Energía*).

Government agencies

Chilean Energy Efficiency Agency (ACHEE, *Agencia Chilena de Eficiencia Energética*) created in 2005.

The Ministry of Environment is the environmental protection agency established in 2010 with jurisdiction over environmental issues for the sector.

Renewable Energy Center (CER, *Centro de Energías Renovables*).

Chilean Nuclear Energy Commission (CCHEN, *Comisión Chilena de Energía Nuclear*).

Energy procedure

The Ministry of Energy through the National Energy Commission (CNE) is responsible for planning functions. The CNE was created in 1978.

Energy regulator

Superintendence of Electricity and Fuels (SEC, *Superintendencia de Electricidad y Combustibles*) created in 1985.

Degree of independence

The National Energy Commission Board has 7 members and an Executive Secretariat appointed by the President. The size of staff and the budget is set annually by the Ministry of Finance.

The independence of CNE has been highly questioned. It seems to be impaired because of ministerial involvement, insufficient staffing and expertise, and because the regulatory role of CNE is not absolute, but depends on the ministries and shares responsibility with the SEC. In addition, SEC enforcement is not strict enough, probably due to the strong and vocal political influence wielded by sector enterprises. The regulatory agencies face difficulties in obtaining the necessary level of detailed information from sector enterprises, particularly regarding costs, that may prevent them from performing effectively on issues dealing with pricing and competition. Recent studies are focusing on changing the CNE structure, trying to provide it with more independence and reducing the influence of the different parties on its operation. A change in this condition would be slow due to the structure of the legal framework in Chile; the law is very detailed, which leaves the regulator little discretionary power.

The President appoints the Superintendent of SEC. The SEC has a relatively large technical staff.

Regulatory framework

In January 2006, new legislation was passed to apply the benefits included in Short Laws 1 and 2 to renewable energy production. The new regulation provided for exemptions in transmission charges for new renewable energy sources (i.e. geothermal, wind, solar, biomass, tidal, small hydropower and cogeneration) below 20 MW of capacity. It also simplified the legal procedures for projects below 9 MW.

A law of March 2008 obliges the new energy projects to generate an escalating percentage of total energy from renewable sources, or face fines. This initiative also follows the so called short law passed in 2004, which set standards and allowed small generators to connect to the national grids.

The law requires new energy generation contracts to include 5% generated from renewable sources starting in 2010, with possible fines in place starting in 2014. That quota of renewable energy will then increase, starting in 2014, by 0.5% each year through to 2025, when generators must secure 10% of power generated through renewable sources. The law gives a fairly broad definition of renewable energy, and includes hydropower projects under 40 MW of installed capacity. The National Energy Commission (CNE) has approved Resolution N.386, a piece of legislation that will allow regulated final consumers to receive economic incentives to reduce their electricity demand.

Regulatory roles

The CNE undertakes most of the regulatory functions for the energy sector, including proposing policies and strategies, tariff regulation, setting service standards, supervision of electricity dispatch and setting operational criteria for sector enterprises. It also undertakes indicative planning and may recommend state financing of generation or major transmission projects that are not being pursued by the private sector.

The Superintendence of Electricity and Fuels (SEC) has evolved over decades as an oversight authority under the Ministry of Economy for technical and operating (including safety) compliance of sector entities with legal and regulatory requirements.

Energy regulation role

The Ministry of Economy authorises concessions, approves and publishes tariffs proposed by National Energy Commission and generally oversees the economic regulation of the sector.

The Ministry of Finance handles privatization procedures as well as maintaining an oversight role in the financial performance of the enterprises in which the state has an ownership share.

Regulatory barriers

Most barriers are of a financial nature, combined till recently with the lack of, or insufficient, policy and legal frameworks.

Analysis of the national economic system and politics

Strength and weaknesses

Chile holds a solid natural resource base, as it is the largest copper producer in the world in addition to relevant productions of other minerals, forestry and agriculture resources. This abundance of resources, its location in an emerging region like South-America and the democratic political system consolidated after several peaceful transfer of power have brought about two positive features: (i) an expectedly sustained growth in the mediuim term, and (ii) a very strong business environment.

On the negative side, Chile shows a strong dependence on commodities, inasmuch as metal exportations represent more than 50% of the total exports.

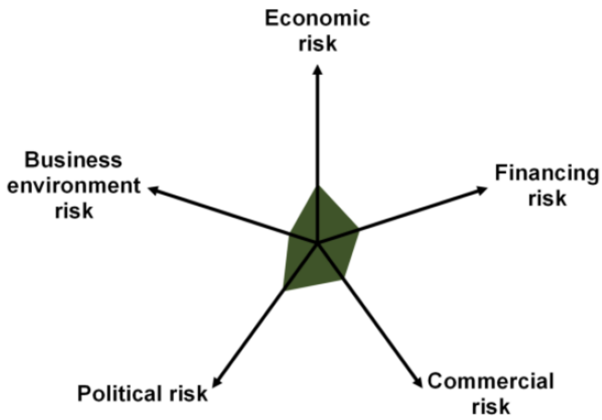

Figure A. 22. Risk dimensions estimated by Euler Hermes. Chile.

Economic structure

The economic structure of Chile is based on a well-distributed network of trade partners, with the top 5 import and export partner sharing around 50%. Asia (China, Japan and South Korea mainly) is an important destination for the Chilean market, while importations come mostly from the American continent: US with 20%, Brazil with 9% and Argentina with 7% import share. Regarding products, the exportation is more skewed to mining (Ferrous metals and ores – 57%) and agriculture and hunting with 12%. Nevertheless, Chile is seen as one of the most prosperous countries in South America thanks to its political stability and natural resources.

As a disadvantage, the small economy is very sensitive to commodity prices, especially copper, whose prices are expected to continue decreasing. This constraints the internal consumption and increases its vulnerability.

Economic forecast

Due to the deceleration suffered by the Chilean economy in 2013, the indicators of 2014 suggest that the activity is feeble, which has brought about downward reviews of the forecast. Despite this, a positive GDP growth is expected for 2015, in the order of 4%.

Maps

Population

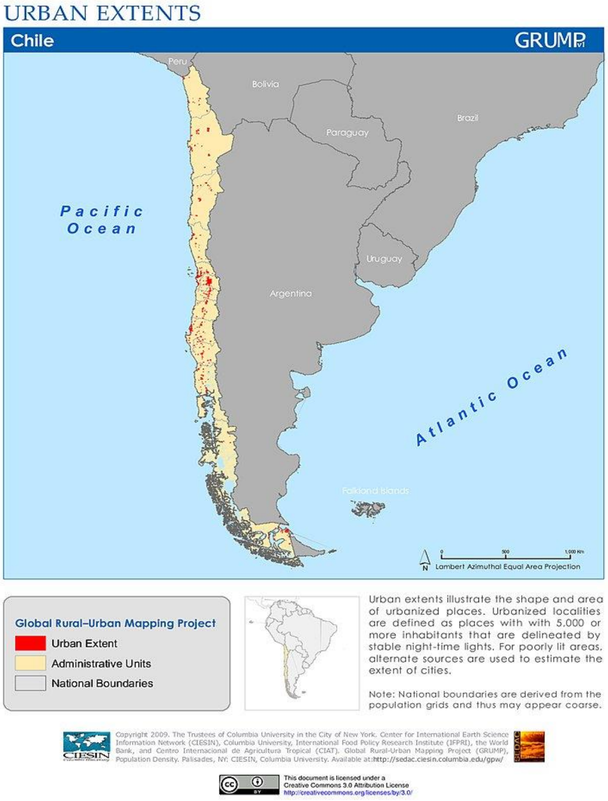

Figure A. 23. Chile population map.

DNI

Figure A. 24. Chile Direct Normal irradiation.

Electricity grid

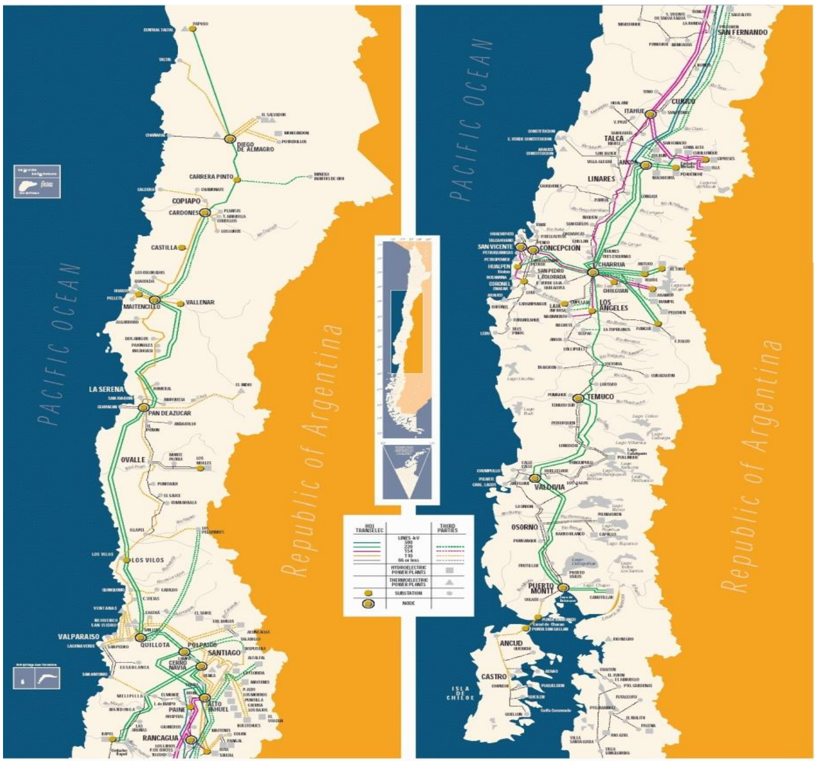

Figure A. 25. Chile electricity grid.

Maps Overlapped

Figure A. 26. Chile overlapped maps

Application of the method

- **GDP:** US$ 277.20 Billion (in 2014)
- **Annual GDP Growth rate:** 3.3 % (in 2014)
- **Population:** 17.62 Million people (in 2014)
- **Annual population Growth rate:** 0.9 % (in 2013)
- **Annual electric consumption (per capita):** 3568.08 kWh (in 2011)
- **Government debt:** 12.8 % GDP
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 1.79 % (in 2013)
- **Country rating (Euler Hermes):** A1
- **Annually averaged DNI:** 1954.88 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.9549	0.3342
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.8624	0.1725
Energy policy	0.10	0.9213	0.0921
Financial risk	0.10	0.8248	0.0825
		TOTAL	0.9313

Table A. 9. Farm arrangement. Chile.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.9549	0.3342
Demand	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.9213	0.0921
Financial risk	0.10	0.8248	0.0825
		TOTAL	0.7088

Table A. 10. Stand-alone configuration. Chile.

ANNEX 6. China

Analysis of the national energy system

China is currently both the largest energy producer and consumer in the world, since it overtook the United States back in 2010.

China is rich in energy resources, particularly coal. In fact, in 2008, it became the largest producer and consumer of coal in the world, an important factor in world energy markets. In 2009, China consumed an estimated 3.5 billion short tons of coal, representing over 46% of the world total and a 180% increase since 2000. Coal consumption has been on the rise in China over the last decade. Coal production, also rising, was estimated at almost 3.4 billion short tons in 2009. China is also the fifth-largest producer and second largest consumer of oil.

Whilst the growth rate in Chinese renewable energy capacity is the highest in the world, it only represents a small proportion of its overall energy sector. From the end of 2005 to the end of 2007, renewable electricity capacity and generation, increased by 30.6 % and 20.6 % respectively, though, it came along a decrease in the share of renewable capacity by 1.37%, which was later translated into a decrease of 1.23% in the share of electricity generation. That was due mainly to the fact that hydroelectricity development was much slower than traditional fossil fuel electricity generation. It is thus suggested that, in spite of the rapid development of renewable power, China electricity generation still relies heavily on fossil fuels. Without significant changes, this trend is likely to persist and carbon emissions will continue to grow. In 2009, net generation was 3446 BkWh, 82% of which came from conventional thermal sources. The installed capacity increased by more than 10% between 2007 and 2008 and is expected to grow in the next decade to meet rising demand, particularly from demand cores in the East and South of the country. Furthermore, China added an estimated 29 GW of grid-connected renewable capacity, for a total of 263 GW, an increase of 12% with respect to 2009. Renewables accounted for about 26% of China total installed electric capacity, 18% of generation and more than 9% of the final energy consumption in 2010. China now leads several indicators of market growth: in 2010, it was the top installer of wind turbines and solar thermal systems and was the top hydropower producer.

China is also actively promoting nuclear power as a clean and efficient source of electricity generation. Although nuclear capacity (around 11 GW) makes up only a small fraction of the installed, many of the major developments taking place in the Chinese electricity sector recently involve nuclear power. Following a review of China nuclear development plans after the Fukushima nuclear disaster in Japan, Chinese government now targets 58 GW of nuclear capacity by 2020, following a steady development with safety mode and in stark contrast to the positive development model followed since 2004. Yet, four approved new reactor units were postponed in 2011 following the Fukishima incident, with 2 (Fuqing 4 and Yangjiang 4) having been re-instated in late 2012.

In 2008, the total primary energy production reached 2600 million tonnes of coal equivalent (Mtoe), or 1820 Mtoe, from which coal accounted for 76.6%, oil for 10.4% and natural gas for 3.9%, while hydropower, nuclear power and others contributed 9.0%. China has become the world leader in renewable energy, now holding 8% of total primary energy.

Reliance

Energy importation only supplied 18.3% of China oil consumption in 1995, but the importation share reached 49.3% by 2007. As a result of that, China net imports of petroleum and products have more than doubled, from 75.8 million metric tonnes in 2000 to 183.9 million metric tonnes in 2007. As of 2009, net imports stood at 304.8 Mtoe, with crude oil alone accounting for 64.8 % of the total and refined oil products a further 6.4 %.

China emerged from being a net oil exporter in the early 90's to become the world's third-largest net importer of oil in 2008. The economy consumed an estimated 8.3 million bbl/d of oil in 2009, up nearly 500 million bbl/d from year earlier levels. During the same year, China produced an estimated 4.0 million bbl/d of total oil liquids, of which 96 % was crude oil. China net imports reached about 4.3 million bbl/d in 2009, making it the second-largest net oil importer in the world behind the U.S. With the expected growth in China, the future dependence on oil imports and the need for diversification of energy supply sources in mind, Chinese NOC's have sought interests in E&P projects overseas. China's overseas equity oil production grew significantly in the last decade from 140000 bbl/d in 2000 to 900000 bbl/d in 2008. Globally, overseas equity oil production represented roughly 23% of China's total oil production in 2008.

The natural gas production and demand in China have risen substantially. In 2009, China produced 2929 billion cubic feet (Bcf) of natural gas, up around 8% from 2008 figures, while the country consumed 3075 Bcf. In 2007, for the first time in almost two decades, the country became a net natural gas importer. Consumption for 2009 rose from 2008 levels by over 12% and the country imported over 140 Bcf of liquefied natural gas (LNG) to fill the gap. Although a majority of the gas consumption is dominated by industrial users (45% in 2007), the recent growth of gas consumption in the past few years stems from the power utilities and residential sectors. The Chinese government anticipates boosting the share of natural gas as part of the total energy consumption to 10% by 2030 to alleviate high pollution from the heavy coal use in the country. Given that the gas demand is expected to grow, China will expectedly continue importing natural gas in the future via LNG and so the country is considering a number of potential import pipelines from neighbouring countries to meet the anticipated shortfall.

China coal imports started growing after 2002 because the imported coal prices, including transportation, became competitive against domestic production prices, and the coal industry began suffering from frequent bottlenecks in transmission to consumer markets. In 2009, China, usually a net coal exporter, became a net coal importer from countries such as Indonesia, Australia, Vietnam, and Russia. Net imports of coal in 2009 stood at 54051 ktoe.

Extend network

The grid system run by the State Grid Corporation of China (SGCC) and China Southern Power Grid Co (CSG) is highly sophisticated, using high-voltage DC (1000 kV) and AC (800 kV). The UHV grid is expected to reach 40000 km by 2015, following CNY 500 billion (US$ 75 billion) of investment by SGCC. By 2020, the capacity of the UHV network is expected to increase to 300 GW. Transmission and distribution losses are also targeted to fall to 5.7% by 2020, from 6.6% in 2010.

There were 11.5 million households without electricity in 2006. Since then, the major state-owned transmission corporations have been implementing an electrification programme called '*Electricity for Every Household*' nation-wide. So far 520000 households (1.65 billion people) have benefited from this programme.

Households without electricity mainly reside in rural areas where grid expansion is considered too difficult technically and economically, although such expansion would be considered desirable to promote social justice.

The government aims at merging State Power Corporation from twelve regional grids into three large power grid networks, namely a northern and north-western grid operated by State Power Grid Company and a southern grid operated by the Southern Power Company by 2020. At present, China does not have a unified national electricity grid. Its current grid system is fragmented into six regional power grid clusters, all of which operate rather independently Inter-regional interconnections are also weak. There is a plan to build a unified and smart grid system nationwide by 2020, which should incorporate energy supplies from various sources, and large-scale smart grid construction is set to be included in the 12th Five-Year Plan.

Capacity concerns

China is facing two severe challenges, energy shortage and increased need for environment protection. Both challenges are mainly rooted in the characteristics of the China energy supply. Chinese petroleum consumption has been sharply increasing, particularly since the new millennium, but China has only limited petroleum reserves. On the other hand, while coal is abundant, being the major source of primary energy, its use causes severe environmental pollution. Therefore, in order to maintain fast and stable economic growth without severe environmental degradation, China has to find a sustainable policy for energy development and consumption.

The costs and policy implications of China growing energy dependence have been recognised. This growing reliance on the global market for its petroleum supply has also raised economic concerns and political tension for China energy security. China rising energy demand has increased global pressure to seek out new energy sources.

China electric power industry experienced a serious oversupply problem in the late 90s, due largely to demand reduction from the closure of inefficient state-owned industrial units, which were major consumers. However, a shortage of electricity supply developed as a result of rapid economic expansion after 2001. Since that time, generation capacity increased steadily at an annual average rate of 10% from 2001 to 2004. Since 2004, the installed generation capacity has increased at an annual average rate of 100 GW, and China currently has the world's largest installed electricity capacity, as well as the world largest installed wind and hydropower capacities. In 2009, the annual power generation reached 3734.7 TWh, compared to 3281.55 TWh in 2007.

China is steadily increasing its oil refining capacity to meet the robust demand growth in its coastal provinces. Installed crude refining capacity is estimated at over 9 million bbl/d.

Renewable energy

Renewable energy sources (RES) in China are distributed unevenly, mostly in the regions where there are spectacular landscapes, or in the regions where there is high dependency on imported energy. Therefore the potential to develop renewable energy generated power plants varies considerably as well. According to the Long to Medium Programme for Renewable Energy Development, China has substantial potential for sustainable energy mainly from wind and solar.

Solar energy

Chinese solar power potential is estimated at 1680 billion toe (equivalent to $1.95 \cdot 10^7$ TWh) per year. 1% of China's continental area, with 15% transformation efficiency, could supply 29304 TWh of solar energy. Solar photovoltaic (PV) cell production capacity was about 4 GW and PV module capacity was about 3 GW in 2008, and the cumulative capacity of installed PV power was 150 MW by the end of that year. Out of this, 55% were independent PV systems. Meanwhile, solar water heaters in China cover more than 125 million square metres (60% of the total worldwide). China is expected to reach a capacity of 300 MW by 2010, and 1.8 GW by 2020. It is nevertheless worth noting that the country exported almost 95% of the PV solar cells manufactured to other countries because the price remained too high to be competitive with other forms of energy within country.

Ownership of electricity

The State-owned Assets Supervision and Administration Commission (SASAC) is a special organization directly under the State Council. SASAC was established as the representative of the State to exercise the ownership of state-owned enterprises (SOEs). The two monopoly state-owned grid companies and the five state-owned power generation companies resulted from the 2002 power market reform, and they were created as an incarnation of the former State Power Corporation of China. The two grid companies are the State Power Grid and the China Southern Power Grid. The five power companies are commonly known as the Big Five (*China Guodian Corporation*, *China Huaneng Group*, *China Datang Corporation*, *Huadian Corporation*, and *China Power Investment Corporation*). Since the reform, China's electricity generation sector is dominated by these five state-owned holding companies, which generate about half of China's electricity. Much of the remainder is generated by independent power producers (IPPs), often in partnership with the privately-listed arms of the state-owned companies.

Similar to the central SASAC, local SASACs were set up by provincial and city governments to exercise all powers of ownerships on SOEs under their jurisdictions. The central SASAC has no direct hierarchical authority over local SASACs because the authority of local SASAC derives from their local governments, while that of the central SASAC derives from the State Council. According to the regulation, central SASAC can "provide guidance and supervision" to local SASACs. However, as there is no formal relationship between central and local SASACs, this influence only materialises if it is supported implicitly by the central government.

Competition

In 2002, the vertical monopoly of the State Power Corporation was dismantled. All the assets were divided into 11 new corporations: two grid operators, five independent power producers, and 4 auxiliary corporations. The two grid enterprises (the State Power Grid and the China South Power Grid) are still state-owned monopolies in their own regions. Deregulation and other reforms have opened the electricity sector to foreign investment, although this has so far been limited. While the generation sector has some market competition, the transmission and distribution sectors are heavily state-controlled by the Southern Power Company and the State Power Grid Company.

Energy framework

In the 80s, Chinese leaders acknowledged that industry was energy inefficient and an obstacle for economic development. Since then, the government has adopted the principle of "*equal treatment to development and conservation with immediate emphasis on the latter*", putting special emphasis on conservational aspects in energy policy. Measures have been adopted to promote efficient energy use. The national energy law and regulation system consists of two parts: those adopted by NPC and those issued by the State Council and related ministries. Crucial energy laws include the Electricity Law (1995) and the Energy Conservation Law (1998).

The Energy Conservation Law aims to strengthen energy conservation, particularly for key energy-using entities; and promotes a rational use of energy and technology for energy conservation. This law regulates energy conservation activities and promotes energy-saving. It led to over 164 state energy savings standards which help to reduce carbon emissions. For instance, the new energy efficiency standard for room air conditioners is expected to yield cumulative carbon emission reductions of over 300 million tons by 2020, which is about the size of the European commitment under the Kyoto Protocol.

In 2004, the State Council approved the Medium and Long Term Energy Development Plan for 2004-2020, and NDRC launched the first China Medium and Long Term Energy Conservation Plan. In 2005, NPC adopted the Renewable Energy Law, which set out duties of the government, business and others in renewable energy development and utilization. It also included measures relating to mandatory grid connection, price regulation, differentiated pricing, special funds and tax reliefs, and set the goal of 15% of China energy from renewable sources by 2020.

In February 2005, the Renewable Energy Law (REL) was passed by the National People's Congress. A number of supporting regulations and guidelines have been put into place to implement the law. Article 4 of the REL requires that a goal for the amount of renewable energy in the China energy portfolio be established. A series of administrative orders and guidelines, fundamentally the 11th Five-Year Plan for Renewable Energy Development (EFYPRED) and the Mid and Long-Term Plan for Renewable Energy Development (MLTPRED) were published to specify what the goal should be.

The goal for total RE capacity by 2010 was 300 million tce, from which 248.24 million would come from renewable electricity. Hydroelectricity is also counted as RE. In the 2010 and 2020 targets, hydroelectric represents 80% of the total renewable capacity. The goal for non-hydro renewables is 1% of grid-connected electricity generation by 2010 and 3% by 2020. Electricity investors whose capacity exceeds 5000 MW shall get 3% from non-hydro renewable sources by 2010 and 8% by 2020 (MLTPRED). The REL set up guaranteed grid access and cross-subsidisation to ensure that renewable electricity plants recover their operation costs. Article 14 stipulates that enterprises such as the State Power Grid and the China South Power Grid shall sign agreements with approved renewable electricity generators to purchase all their grid-connected electricity. The State Electricity Regulatory Commission's (SERC) executive order No. 25, Rules for Grid Enterprises to Purchase all Renewable Electricity, 2007, detailed grid responsibility for purchasing all grid-connected renewable electricity.

The price at which grid operators purchase renewable electricity is not decided by the market, but it follows government-guided prices. For wind, the wholesale price is based on bid prices from a government-organised tendering process. For biomass, solar, and other renewable electricity, prices are set by the government based on a rule similar to the rate of return principle. These prices are much higher than fossil fuel electricity. The purpose of guaranteed grid access at a government-set price is to ensure a market for renewable electricity which is still significantly higher than the cost of fossil fuel generation.

In order to ensure the access for renewable electricity, grid enterprises are allowed to recover the cost above purchasing conventional electricity through cross-subsidisation. According to the Article 20 of the REL and the "*Renewable Electricity Pricing and Financing*" published by the National Development and Reform Committee (NDRC) in 2006, grids may recover from customers: (i) expenses for getting renewable electricity connected, and (ii) the difference between purchasing renewable electricity and purchasing fossil fuel electricity of the same amount.

The REL also set up other economic incentives. The Article 25 encourages financial institutions to provide preferential loans. The Article 26 states that the government shall provide tax benefits to eligible renewable projects. So far, neither SERC nor NDRC has published administrative orders to implement these measures. As a result, they have been used in an *ad hoc* and limited manner.

According to the Administrative order No. 2001-198, issued by the Ministry of Finance (MOF) and the State Administration of Taxation in 2001, value-added tax for municipal solid waste for power generation is refunded. The value-added tax for wind power was reduced from 17% to 8.5%. As a result of the REL with feed-in tariffs, China's installed wind capacity has doubled every year since 2005 and reached number one for "*newly added capacity*" in 2009.

In 2006, the State Council issued the Decision to Strengthen Energy Conservation. In the same year, NDRC set 2 goals in the 11th Five-Year Plan (2006-2010): (i) Doubling the per capita GDP of the country by 2010 (compared to 2000) and (ii) Decreasing the energy consumed per unit of GDP by 20%, implying an annual savings rate of 4%. In line with this target, the government raised electricity prices for 8 energy-intensive industries.

In June 2007, NDRC issued China National Climate Change Programme, the 1st global warming policy initiative in the country. This indicated the need to adopt measures covering: GHG mitigation, adaptation, climate change science and technology, public awareness on climate change and institutions and mechanisms.

Regarding mitigation, the focus is on energy production and transformation, energy efficiency and conservation, industrial processes, agriculture, forestry and municipal waste. As to energy production and transformation, measures aim to strengthen the existing energy legal system, improve the national energy programme, implement the Renewable Energy Law, promote favourable conditions for renewable energy and GHG mitigation, stimulate energy price reform, optimise the energy mix, promote innovation and efficiency in generating technologies, renewable and non-renewable, including nuclear power. These policies are expected to have a major influence on the energy and utilities sectors. China is voluntarily committed to reduce its carbon intensity per unit of GDP by 40-35% by 2020 compared to the 2005 level. It has also announced plans to reduce its energy intensity levels by 31% from 2010 to 2020 and increase non-fossil fuel energy consumption to 15% of the energy mix in the same time period.

From June 2007, different tariffs (5-10%) were imposed on 142 export goods classified as energy intensive and polluting goods, and tax rebates were abolished for 553 so-called "*high energy-consumption, highly polluting, resource based*" products. The government has also supported energy conservation projects, and requires financial institutions to back them. However, state-led initiatives to increase energy efficiency have not yet received wide support from local governments and industry.

China 12th Five-Year Plan (2011-2016) on National Economic and Social Development, targets economic growth, innovation, competitiveness and social developments. The economic growth in the main 3 sectors (farming, industry and services), is the main objective. Specific emphasis is dedicated to Green development, environmental protection and energy conservation. The Plan includes binding global energy targets, with non-fossil fuel resources reaching 11.4 % of primary energy consumption by 2015, energy intensity decreasing by 16 % and CO_2 emissions per unit of GDP decreasing by 17 % by 2015. It also states that the country anticipates increasing the share of natural gas and other cleaner technologies as well as closing several smaller coal-fired plants that were less efficient and heavy pollutants. In January 2012, the government launched a pilot programme in 7 provinces and cities to place an absolute cap on carbon emissions, the 1st one for the country; in an effort to kick-start the development of a functioning carbon market in these areas, following unsuccessful "soft cap" programs in the past.

China ratified the UN Framework Convention on Climate Change (UNFCCC) on 5th January 1993 and the Kyoto Protocol on 30th August 2002.

In 2012, the government published a new Energy Policy White Paper, aiming at continuing the development of energy supply and provision, whilst addressing the need to balance a sustainable growing consumption. The white paper sets out a number of key policy goals, supporting the 12th Five-Year Plan. These include expanding the international collaboration in energy and promoting technical and scientific development, as well as improving a universal energy access and the broadening of institutional reforms in the energy sector. This will include the accelerated development of an improved legal framework for the sector, promoting market-oriented reforms, and improving administration of the sector, including simplifying administrative procedures and reducing direct government intervention, as well as establishing a comprehensive statistics, monitoring and forecasting agency for the sector.

Particular prominence was given to the continued development of new and renewable energy sources in the country, with specific policy goals for hydropower, solar, wind and biomass energy, as well as new nuclear development, with an increased focus on safety and sustainability. The white paper also sets out goals for increasing distributed generation in the country, aiming to construct 1000 new distributed generation systems by 2015.

Energy debates

It is reported that about one-third of wind generation capacity is not connected to the grid as grid enterprises are reluctant to build grids connecting wind power plants to the main grid network, even though required to do so by the REL and by SERC executive order 25. In its audits of renewable electricity pricing and sales, the SERC reported that it is commonplace for grid enterprises to refuse or delay building or expanding grids to connect to renewable power plants. As a result, a significant amount of wind capacity, especially in the provinces of Hebei and Gansu, was wasted. Some renewable power plants (for example, wind power in Inner Mongolia Autonomous Region, Heilongjiang Province, and Jilin Province, and hydroelectric power plants in Qinghai Province and Jiangxi Province) have had to build connecting grids themselves or to share the costs. Through a concerted effort by the government, the expected idle wind capacity in 2012 was 10%, compared to 25% in 2011.

In a speech to the National People's Congress on 10th March 2013, State Councillor Ma Kai stated the government aims to merge the NEA and the SERC, in an effort to restructure the administration of the energy sector. The new NEA remit will also be expanded to include drafting and implementing national energy development strategies, plans and policy, and the Agency will remain under the control of the National Development and Reform Commission. The news has had a mixed reception, with some groups claiming more wide-ranging reform is necessary, and that the creation of “super-ministries” enshrines the place of vested interests in the sector and its governing bodies, whilst hampering structural reform and deregulation.

Energy studies

As a country member of the Asia Pacific Economic Cooperation (APEC), China is an active member of the Asia Pacific Energy Research Centre (APERC). The APERC was established in July 1996 in Tokyo, as an affiliate of the Institute of Energy Economics, Japan (IEEJ), pursuant to the Action Agenda adopted by the APEC Economic Leaders at the Osaka Summit in November 1995. The primary objective of APERC is to foster understanding amongst APEC economies of global, regional, and domestic energy demand and supply trends, energy infrastructure development, energy regulatory reform, and related policy issues in view of the regional prosperity. APERC advocates rational energy policy formulation and enhances capacity building in energy research in the region, following the APEC Non-binding Energy Policy Principles for furthering energy security, economic growth and environmental quality.

The World Bank published a report based on its study on sustainable energy in East Asia and suggested that China has significant opportunities for energy efficiency while the country has been making progress.

Role of government

The National Development and Reform Commission (NDRC) is a department of the State Council of China, the highest entity of executive power in the country, and it is the primary policy-making and regulatory authority in the energy sector, while four other ministries oversee various components of the country oil policy. Nonetheless, multiple departments have long been a key feature of the energy administration in China. Policies are determined at a national level, they come from many sources and organisational functions are scattered among departments. For instance, the National Development and Reform Commission (NDRC), the Commission of Economy, and the Office of the National Energy Leadership Group are involved in the administration of energy. The NDRC includes roles relating to renewable energy and energy efficiency and there is a DRC in each Province to manage these policies.

Some other departments such as the Ministry of Water Resources and the China Atomic Energy Authority are also involved in policy making. Other departments which have input into the policy making and implementation processes are the National Land and Resources Ministry, Environmental Protection Bureau, National Statistical Bureau and the State Electricity Regulatory Commission.

This multiplicity of departmental roles has complicated the strategy coordination, led to inconsistency and limiting the availability and reliability of data. The plan of China to create a "super ministry" to steer the energy sector, was put on hold in 2008 due to the difficulty of reaching a consensus between major energy firms and the existing energy agencies. Instead, the national parliament approved the establishment of the National Energy Administration (NEA) to act as the key energy regulator and the National Energy Committee (NEC) in early 2008. The NEA was officially launched in July 2008 and integrated the NDRC functions on energy policy management, the functions of the National Energy Leading Group and the nuclear power management of the Commission of Science, Technology and Industry for National Defence. It is thus charged with approving new energy projects in China, setting domestic wholesale energy prices, and implementing the central government's energy policies, among other duties. However, the NEA lacked real power to carry out many of its assigned tasks inasmuch as responsibility for the energy sector remained dispersed among a number of departments.

In January 2010 a new National Energy Committee (NEC) was established to step up strategic decision-making, planning and coordination. The NEC is responsible for national energy development strategy, reviewing energy security and major energy issues as well as planning domestic energy development and international cooperation. The NEC committee has 21 members, consisting mainly of ministers from a wide range of ministries such as the Finance Ministry, the Commerce Ministry and the central bank.

The NEA undertakes the day to day work whilst the National Energy Committee provides the strategic oversight. The NEA has a wide range of responsibilities including:

- Formulating and implementing energy development plans and industrial policies.
- Promoting institutional reform in the energy sector.
- Administering energy sectors including coal, oil, natural gas, power (including nuclear power), new and renewable energy and energy conservation.
- Organising and carrying out research and development.
- Approving, reviewing or examining asset investments of the energy sector, in accordance with the authority stipulated by the State Council.
- Energy forecasting and participating in emergency preparedness.
- Formulating and implementing national oil reserve plans and polices.
- Taking the lead in international energy cooperation.
- Participating in the formulation of environmental protection and climate change policies.

Government agencies

US-China Clean Energy Research Centre: At the end of 2009, American and Chinese governments announced the creation of this centre. The Protocol establishing the Centre was signed at a ceremony in Beijing by US Energy Secretary Steven Chu, Chinese Minister of Science and Technology Wan Gang, and Chinese National Energy Agency Administrator, Zhang Guobao. The US-China Clean Energy Research Centre will facilitate joint research and development of clean energy technologies by teams of scientists and engineers from both countries, as well as serve as a clearinghouse for researchers in each country. Initial research priorities of the Centre will be:

- Building energy efficiency.
- Clean coal, including carbon capture and storage.
- Clean vehicles.

The Centre will be supported by public and private funding of at least US$ 150 million over 5 years, split evenly between the two countries.

Energy procedure

Chapter 2 of the REL defines the energy planning procedures at the national level as follows:

- The energy administrative department of the State Council organises and coordinates the efforts of relevant departments to investigate renewable energy resources. It also works with relevant ministries to formulate standards and criteria.
- Each relevant department investigates the possible sources of renewable energy. The data collected from the survey is submitted to the energy administrative department and is made public, except that data which needs to be kept confidential.
- The energy administrative department sets the mid to long term aggregated and quantified goals for renewable energy development and then submits this data to the State Council for authorisation. Once authorised, this data is made public.
- The aggregate quantitative figures are examined against those for each province or region, from which the regional/provincial energy figures are published.
- Based upon these quantified figures, the mid to long range plan for energy is formed and published once it is authorized. The state energy plan is the blueprint for provincial governments.

Regional, provincial and local issues can help to determine specific plans. For example, environmental quality concerns in Beijing encouraged the government to try and reduce energy and water consumptions. Therefore the planning focus shifted to the reallocation of some heavy energy consuming plants and the effective promotion of energy saving measures to energy intensive sectors. Such an approach is quite different from that in Shanghai, which chooses energy security as the priority for planning. In the case of Beijing, the initiative came from environmental pressure and the leadership of the municipal government played a key role. But for Shanghai, suggestions from experts had more weight in determining that approach.

Energy regulator

The State Electricity Regulatory Commission (SERC) of the State Council was established in 2002 and is the regulatory body for the electricity sector. It is split into six key departments, and it also has the regional branches of Northeast, Northwest, Central China, East, North, and South China; and city offices in Taiyuan (Shaanxi Province), Jinan (Shandong), Lanzhou (Gansu), Hangzhou (Zhejiang), Nanjing (Jiangsu), Fuzhou (Fujian), Zhengzhou (Henan), Changsha (Hunan), Chengdu (Sichuan), Kunming (Yunnan) and Guiyang (Guizhou). NDRC and NEA are also regulators in the energy sector. The government is currently planning to merge SERC and NEA, starting from 2013.

Degree of independence

Although it is not a ministry of the State Council, the SERC is delegated a leadership role by the State Council. It is a publicly funded department where government influence has significant impact upon decisions.

There are 5 commissioners who are appointed by the government. One is the *Chairman of the Commission* and the other 4 are deputies. Among the senior management group, there are: the Chief Inspector, Chief Engineer, and Chief Accountant. The 8 people form the leadership group for the Commission, and there are 9 departments, 5 associate units, 6 regional bureaus and 11 city-offices.

The wholesale and retail electricity prices are determined and capped by the NDRC which can limit the profit margin of generators. Also, the NDRC determines a plan price that coal companies should sell to power producers for a certain level of supplies. Typically, generators negotiate directly with coal companies for long-term contracts. In 2009, the agency allowed electricity producers and wholesale end-users such as industrial consumers to negotiate with each other directly. The latest power tariff changes were from June 2010 when the government raised rates for energy intensive industries by 50 to 100 % in order to achieve energy efficiency goals for the year.

Regulatory framework

Energy laws and regulation have recently assumed a higher profile in China. For example, the Energy Conservation Law was issued in 1998, revised in 2007 and reissued in 2008. Similarly, the Renewable Energy Law of the People's Republic of China was adopted at the 14th Meeting of the Standing Committee of the 10th National People's Congress in February 2005 and went into effect as of January 2006. One year after the Renewable Energy Law went into effect, China total renewable energy use reached 7.5% of total primary energy consumption.

The 4th session of the Standing Committee of the 11th National People's Congress adopted the Economy Promotion Law of the People's Republic of China on August 29, 2008, with effect from 1st January 2009. This law is closely correlated to the Renewable Energy Law and aims to facilitate recycling, raise resource utilisation efficiency protect and improve the environment and realize sustainable development.

Regulatory roles

SERC inspects almost every aspect of the electricity market:

- Market inspection: for example the rules that define the way of managing the auxiliary services, the trading of the generation permits, and rules of information disclosure for energy saving generation and allocation, etc.
- Price inspection: for example the price for electricity transmitted across regions.
- Security inspection: for example working environment safety.
- Customer service inspection: for example handling customer complaints.
- Permits for operation: for example the assessment to grant the permit for qualified generations or transmissions.

Energy regulation role

The SERC is considered to have limited authority, since the NDRC is an all-powerful department that regulates many industries. Given that jurisdiction over demand-side management and energy efficiency is split between SERC, NEA as the key energy regulator and NDRC as the primary regulatory authority, the SERC authority in this area is also limited.

Regulatory barriers

The development of renewable electricity in China in the past few years is an evidence of the government's strong commitment to clean energy, since the growth of renewable electricity generation capacity has been greatly boosted. However, there are still many challenges. First, new electricity generation capacity in China is still coming predominantly from fossil fuels. As a result, renewable electricity capacity and generation considered as a share of total capacity and generation decreased. Second, grid enterprises are reluctant to build new grids connecting wind power plants to the main grid network, which reduces investor incentives to develop renewable electricity. And finally third, compared to their US counterparts, China renewable electricity plants are running at a lower efficiency.

Although the MLTPRED states that electricity investors who own capacity of 5000 MW and above shall get 3% of their total capacity from non-hydro renewable energy by 2010 and 8% by 2020, these goals are suggestive rather than mandatory. Whilst the REL encourages electricity consumers to purchase from renewable electricity utilities, they have no obligation to offer their customers the choice of buying green electricity.

Analysis of the national economic system and politics

Strength and weaknesses

The Chinese economy exhibits a strong solidity as a consequence of a robust domestic economy and low public and external debts with important external surpluses. The manufacturing sector is very powerful in China, thus configuring the base of its solid economy which is complemented with the large domestic market. Under this economic scenario, experts foresee GDP growth around 7.4% in 2015 for the Asiatic giant.

However, in addition to this optimistic frame, there exists a downside, basically derived from the lack of transparency and the geopolitical tensions with key countries in the region. Also the non-formal financing comprises a non-negligible part of Chinese economy, which contributes to increasing the risk level for foreign investors. In this regard, the government is making efforts in curbing shadow banking and non-formal components, aiming at increasing the liquidity of the Chinese market and strengthening the status of the banking sector. That's why the level of public investment is high compared to the private one. In the negative side of the balance, it must be noted the problem of population aging in China as well.

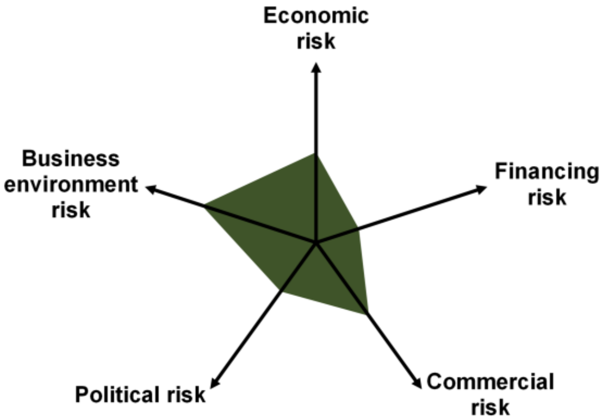

Figure A. 27. Risk dimensions estimated by Euler Hermes. China.

Economic structure

The Chinese economy is a decentralised collection of several regional imbalanced economies, with large differences between rural and urban regions. The large extension of this country (the 4th largest in the world) contribute to this disaggregation, but on the positive side, this huge extension and its location rank it first in proven deposits of 12 strategic minerals: tungsten, antimony, titanium, vanadium, zinc, rare earth, magnesite, pyrite, fluorite, barite, plaster stone and graphite. Additionally, with its vast mountain ranges, China's hydropower potential is the largest in the world.

Sector wise, manufacturing and industries comprise the largest part of China's GDP, around 45% of it, cementing China's position as the world leader in gross value of industrial output. Major industries include mining and metallurgy, machine building, armaments, textiles, petroleum, cement and others. But furthermore, China is the world's largest producer of agricultural products. It ranks 1st in the world for rice, wheat, potatoes, sorghum, peanuts and tea amongst others, representing around 35% of the Chinese labour force.

The most important trading partners for China are US, Hong Kong, Japan, Germany and South Korea regarding imports, representing less than 50%. With regard to exportations, Asian countries absorb 27% of China's export, with Japan being the main partner and USA and Germany also playing an important role in this sense.

Economic forecast

Although GDP will expectedly grow in next years, China is nowadays facing a deceleration of this growing. Given the deceleration at the beginning of 2014, the government put in practice some measured to stimulate the economy. In the past, these circumstances drove into public debt increment, which cast doubts regarding the public debt although it is expected to be under control close to 2% GDP.

As China has driven global growth, the effects of a Chinese slowdown on the global economy would be significant. The OECD reckons a two-percentage-point decrease in the growth of Chinese domestic demand for two years would reduce the world's GDP by 0.3 percentage points a year. Countries with stronger links to China, like Japan, would be more severely affected.

The central bank cut the required reserve ratio for banks mainly engaged in lending to small companies and rural borrowers.

Maps

Population

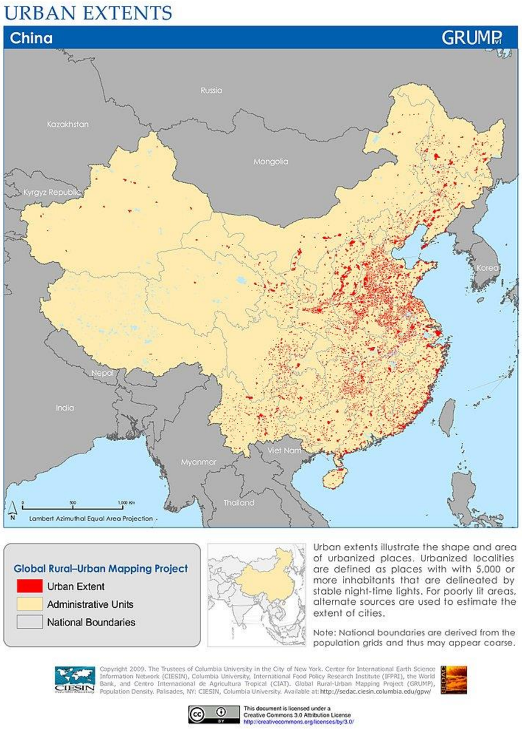

Figure A. 28. China population map.

DNI

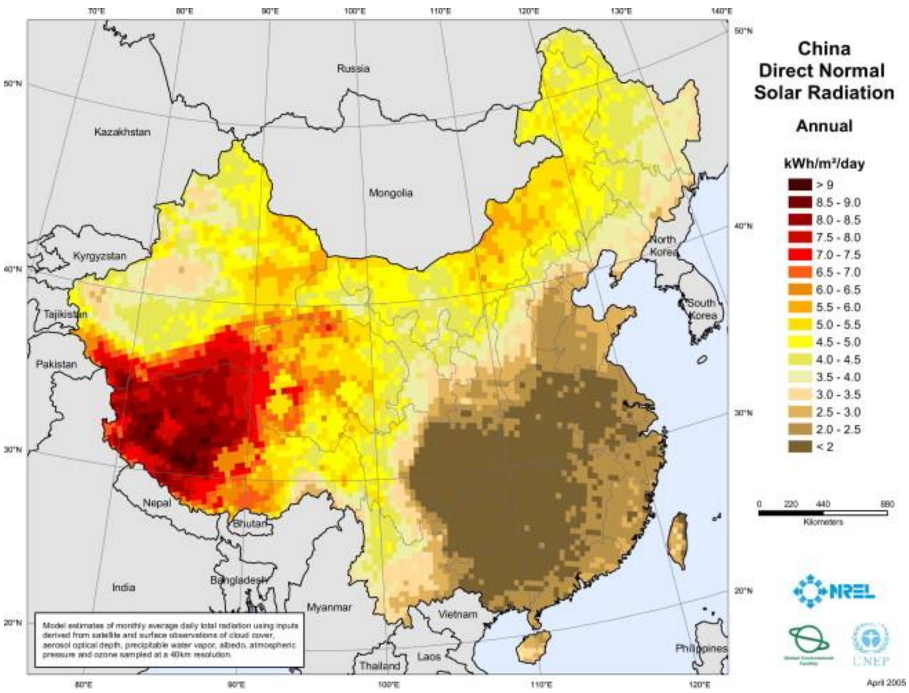

Figure A. 29. China Direct Normal irradiation.

Electricity grid

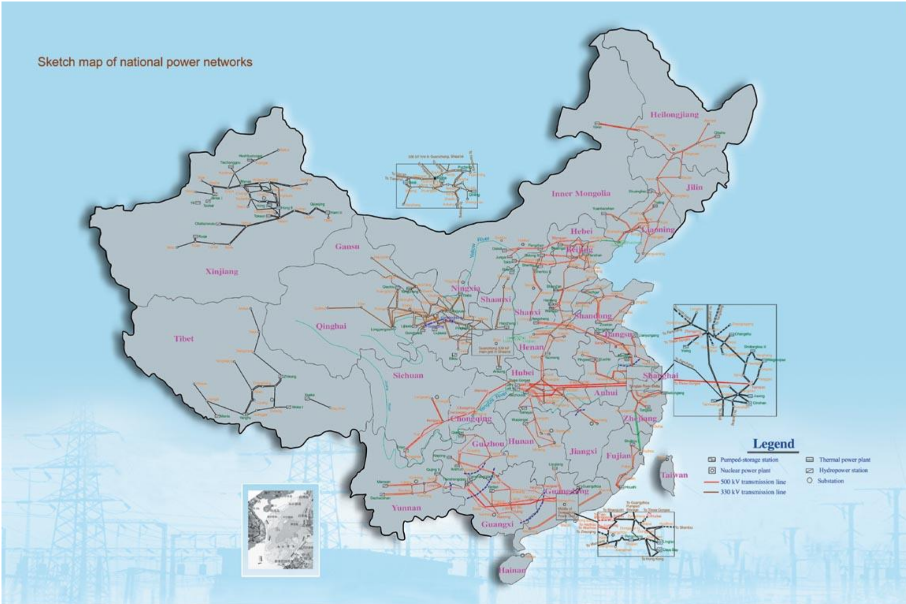

Figure A. 30. China electricity grid.

Maps overlapped

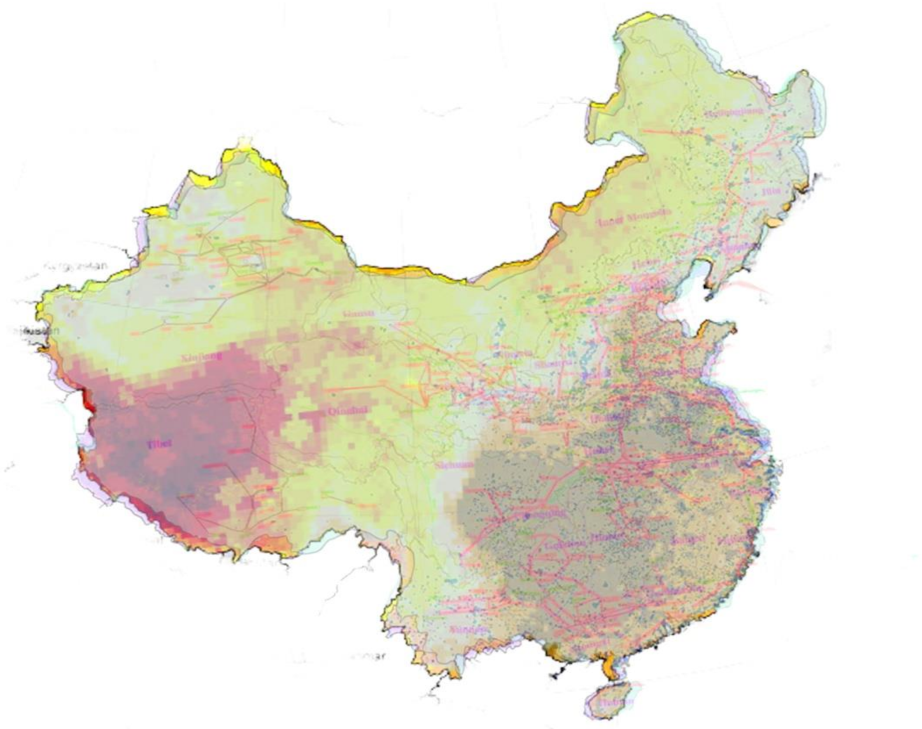

Figure A. 31. China overlapped maps

Application of the method

- **GDP:** US$ 9240.27 Billion (in 2014)
- **Annual GDP Growth rate:** 7.3 % (in 2014)
- **Population:** 1360 Million people (in 2014)
- **Annual population Growth rate:** 0.43 % (in 2013)
- **Annual electric consumption (per capita):** 3297.97 kWh (in 2011)
- **Government debt:** 22.4 % GDP
- **Accumulated external debt:** US$ 754.0 Billion (in 2013)
- **Inflation rate (consumer prices):** 2.63 % (in 2013)
- **Country rating (Euler Hermes):** B1
- **Annually averaged DNI:** 1500.87 kWh/m^2
- **Population with access to electricity:** 99.80 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.5009	0.1753
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.8865	0.1773
Energy policy	0.10	0.7868	0.0787
Financial risk	0.10	0.4844	0.0484
		TOTAL	0.7297

Table A. 11. Farm arrangement. China.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.5009	0.1753
Demand	0.25	0.0020	0.0005
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7868	0.0787
Financial risk	0.10	0.4844	0.0484
		TOTAL	0.5029

Table A. 12. Stand-alone configuration. China.

ANNEX 7. Egypt

Analysis of the national energy system

The electricity demand is increasing at about 7% annually and is expected to continue growing at this rate in the near future. The peak electricity demand in Egypt reached 21330 MW for the fiscal year 2008/2009 (fiscal year June-July). Energy is essential for Egypt's economic growth due to two main reasons: (i) it is a direct driver of domestic development, and (ii) it represents a source of foreign currency associated with fuel exports.

With respect to renewable sources, approximately 11.2% of Egyptian power comes from hydropower facilities. When the Aswan Dam was developed in the 60s, it met the vast majority of Egypt electricity demand. Hydroelectricity still represented 50% in 1980 but, due to major increases in demand, it had fallen to less than 15% by 2006. Hydro capacity has been constant at 2842 MW since 2007/08.

The Aswan Dam was constructed to control the Nile water discharge for irrigation. This 2.1 GW High Dam hydropower plant was commissioned in 1967, followed by the commissioning of the Aswan 2 power plant in 1985, the commissioning of the Isna hydropower plant in 1993 and that of Naga-Hamadi in 2008. Power generation from gasification of sewage sludge in waste water treatment plants is already being used (for example, the El-Gabal El-Asfer 23 MW plant), with a potential generation of 1000 MW from agricultural waste.

Less than 1% of Egypt's current energy mix comes from wind, despite an abundance of wind resources, particularly in the Suez Gulf area: Western Egypt (west bank of the Nile), Kharga region, Eastern Egypt (east bank of the Nile) and the Gulf of Aquaba area.

Reliance

Egypt has traditionally been a net exporter of energy. Oil was exported until the late 90s, when production declined from its peak to roughly match local consumption. Also, as a consequence of the discovery and exploitation of large reserves of natural gas, Egypt became a significant exporter of gas, both by pipeline and as liquefied natural gas (LNG).

Nevertheless, Egypt now buys a large proportion of its foreign partners share in crude oil to meet increasing local consumption. The proportion of oil products in total imports increased from 3% in 1990 to 8% in 2004, reflecting a continuous increasing trend.

Extend network

The electrification rate in Egypt was approximately 99.4% in 2008, according to the International Energy Agency (IEA). This rate is among the highest in the continent with total urban access to electricity, and a 99% access rate in rural areas. However, approximately 500000 people still lack access to electricity.

Currently, grid connected renewable energy projects in Egypt enjoy priority to access and dispatch their production.

The national grid consists primarily of 500, 400, 220 and 66 kV transmission and distribution lines.

Capacity concerns

The fossil fuels dependence of Egypt, with its depleting oil resources, controversial estimates for natural gas reserves, and rising electricity demand and energy generation; represents a clear call for action. Currently, the peak demand is estimated to be 21.3 GW. Ageing infrastructure and rising demand have led to intermittent blackouts. The summer of 2010 highlighted these problems, as the country experienced rolling nationwide blackouts. Egypt's electricity consumption is increasing much faster than capacity expansions and the government is planning to invest over USD 100 billion in the power sector over the next decade, while also seeking financing from external sources.

Solar energy

Despite undergoing radical advances, the solar technology penetration is negligible considering that Egypt receives some of the highest solar radiation in the world and 96 % of the country is desert, making it a prime location for a variety of solar energy technologies and applications. Egypt is located within the Sun Belt countries with annual global solar insolation ranging from 1750 to 2680 kWh/m^2/year from North to South and annual direct normal solar irradiance ranging from 1970 to 3200 kWh/m^2/year from North to South, with relatively steady daily profile and small variations making it very favourable for utilization.

Both the Solar Radiation Atlas and the German Aerospace Centre estimate that its economically feasible solar potential is around 74 billion MWh/year, much higher that Egypt current electricity production. The Energy Research Centre at Cairo University's Faculty of Engineering estimates that 6 MW of solar photovoltaics are currently installed in Egypt. In addition, a 150 MW integrated-solar combined-cycle power plant is under construction in Kureimat, with a solar component of 30 MW.

Ownership of electricity

Egypt power sector is dominated by the Egyptian Electricity Holding Company (EEHC), a state-owned organisation that comprises 16 affiliated companies (6 producers, 9 distributers, and the Egyptian Electricity Transmission Company). Growing electricity demand in the late 90s spurred industry restructuring and limited privatization of the sector.

EEHC continues to own over 90 % of Egypt generating capacity. Transmission and distribution also remain a monopoly under the EEHC umbrella. Generation facilities have been built using the Build, Own, Operate and Transfer (BOOT) model or financed as independent power provider projects.

A number of independently-owned new gas generation plants were built under Build, Own, Operate and Transfer (BOOT), thus their ownership will be transferred to the state after 20 years. The most important are 3 natural gas-fired plants, with a total capacity of just over 2 GW. These are now owned by PowerTech of Malaysia, and can only sell their electricity to the government-owned transmission network. A limited number of small-scale generating utilities were licensed to operate since the establishment of the electric regulatory agency in 2001, their overall capacity and number of customers is growing gradually, currently around 100 MW of capacity.

Competition

The power sector market is being liberalized. Wholesale electricity trading is based on a single buyer model, with the Egyptian Electricity Transmission Company procuring electricity from generation companies and selling it to 9 distribution companies and direct customers (those connected to the transmission network directly as opposed to via a distribution network). This single buyer market relies on dispatch based on production cost curves of the plants and thus, offers limited space for commercially-based competition for dispatch among the incumbent generation companies. This is intended as an intermediate step towards the establishment of a more liberalized electricity market, which is to begin gradually, with the liberalization of supply to large industrial consumers.

Energy framework

In the early 80s the Egyptian government noted that the traditional energy resources would be inadequate to meet future needs. In 1982, a national strategy for the development of energy conservation measures and renewable energy application was adopted and in 1986 the new and Renewable Energy Authority was established in order to be the focal point for renewable activities in Egypt.

The Renewable Energy Strategy of 2008 marked a vital step in this effort, setting a target of reaching 20 % of total electrical energy mix from renewable energy (RE), including hydropower by 2020. Taking into account current hydropower capacity, and projections for that hydropower, it is expected that 12 % of contribution from renewable energy sources other than hydropower will need to be added by 2020 (i.e. equivalent to installed capacity of 7200 MW). The Strategy identifies concrete steps, including large pilot implementation of solar projects and electrification of rural areas, development of mini and micro hydropower plants with capacity of less than 100 MW, assessing potential for geothermal and developing 1 GW of biomass from agricultural and municipal waste. The Strategy also promotes the local manufacturing of RE equipment, including incentives for activities supporting localization of RE technologies. As part of its efforts to implement the Strategy, EgyptEra coordinates with Egypt's Industrial Modernization Centre (IMC), which is responsible for direct contact with manufacturers.

A proposed feed-in tariff is also available for wind projects, specifically those under 50 MW, in order to promote private-sector participation in the renewable energy sector. The Government hopes that the private sector will contribute roughly 2500 MW with the country renewable energy capacity by 2020.

Under the Egypt five-year plan (2007/2008 - 2011/2012), Egypt intends to add 7750 MW of power generation capacity to meet the expected average annual demand growth rate of 6.38 %. For the five-year plan (2012/2013 - 2016/2017), an additional 11100 MW will be needed to meet the expected average annual demand growth rate. Thus Egypt is looking at a portfolio of resources to increase supply, including rapid addition of thermal plants, most of which are combined cycle gas. In January 2010, the Egyptian government announced that it was considering constructing five independent power projects, with a total capacity of 3500 MW. Recently built combined cycle plants include Cairo North (1500 MW), Nubaria (1500 MW), Talka (750 MW) and El-Kureimart (750 MW).

The Egyptian National Plan (2012-2017) includes the implementation of:

- 100 MW concentrated solar power plant, in South Egypt.
- 20 MW photovoltaic grid connected plants, 4 MW every year.

The next Egyptian National Plan (2018-2022) has set a target of 23 % renewable energy sources by 2022. It will be split into:

- Installation of 2550 MW of concentrated solar power.
- Installation of 500 MW photovoltaic (PV) arrays.
- Installation of 1.2 million m^2 of Solar Water Heaters (SWH).

Energy debates

Egypt is launching a tender offer for the installation of wind farms on the Gulf of Suez with a capacity of 200 MW. The tender represents the second and third phases of the expansion of Egypt wind farming plans under a renewable energy programme. The first phase of the initiative was signed last July. The offer involves supplying and installing the wind farms as well as maintenance.

Energy studies

Egypt is a member of the international cooperative organization SolarPACES established under the umbrella of the IEA. The SolarPACES focuses on the development and marketing of concentrating solar power systems (also known as solar thermal power systems).

In 2008, Egypt became host to the EC, Denmark and Germany funded Regional Centre for Renewable Energy and Efficiency for Middle East and North Africa countries.

In addition, the Egyptian electricity grid has been connected to those of Libya and Jordan since 1998. In 2009, Egypt started to export electricity to Lebanon through Jordan and Syria. An upgrading of the undersea cable to Jordan is foreseen. There are plans to increase interconnections noticeably with the creation of the Mediterranean Power Pool, a project that will connect the power grids of Northern Africa (Algeria, Egypt, Libya, Morocco and Tunisia) Spain, Middle East Countries (Jordan, Syria, Iraq) and Turkey. In December 2008 the EU-Egypt Memorandum had assigned, among other priorities, the development of energy networks including the electricity network to improve security of supply of both parties, based on EU-Egypt Memorandum of understanding in 2008.

Role of government

Ministry of Electricity and Energy: The energy sector in Egypt is managed through two different ministries, the Ministry of Electricity and Energy (MOEE) and the Ministry of Petroleum (MOP). Among the major activities of the former is to settle the General Plan of the Energy Generation, Transmission and Distribution and to supervise the study and execution of essential electrical projects. In addition, they suggest the electric energy prices for all the various voltage levels and customers. The power sector in Egypt is represented mainly by MOEE, and is operated by seven executing authorities, namely:

- The Egyptian Electricity Holding Company (EEHC)
- The Rural Electrification Authority (REA)
- The Hydro Power Plants Authority (HPPA)
- The Atomic Energy Authority (AEA)
- The Nuclear Power Plants Authority (NPPA)
- The Nuclear Materials Authority (NMA)
- The New and Renewable Energy Authority (NREA).

Government agencies

The New and Renewable Energy Authority (NREA): The NREA was established in 1986 to undertake research and to develop renewable sources of energy in Egypt on a commercial scale, as well as to implement energy conservation and efficiency programs. Under the direction and leadership of the NREA, there has been considerable research works about the feasibility of renewable energy systems in Egypt, especially related to solar power and wind power systems. In 1996, NREA produced the first wind atlas for the Gulf of Suez, and in 2003 published an update for the atlas, and then a wind atlas for Egypt as a whole in December 2005. The NREA is also involved in the Mediterranean Renewable Energy Program (MEDREP), which aims to provide modern energy services to rural populations, and increase the share of renewables in the energy mix of the member countries.

Egypt has been successful in tapping international support for renewable energy projects. The African Development Bank (AfDB) is playing an important role in financing both wind and solar programs. Other direct foreign investments, including KfW, EIB, the World Bank and the International Finance Corporation, are equally involved in supporting the required investments. The Clean Technology Fund (CTF) provides support through the AfDB and the World Bank for the development of wind and solar plants and the associated transmission projects. The wind program has been supported by Germany, Denmark, Spain and Japan. Plants under construction and preparation are also being financed by Germany, Japan and Spain, as well as the European Investment Bank.

Energy procedure

Egypt already has a plethora of wind farms in the Zafarana region along the Red Sea, with a total installed capacity of 430 MW. Meanwhile, a solid plan for an additional 280 MW of installed capacity in this region is under way. The plans for two 120-MW plants each and a 200-MW one are also being pursued in Zafarana and Gulf El-Zayt, receiving assistance from Germany, Japan, and Spain, respectively. A long-term plan for increasing national wind-farm capacity to 7500 MW by 2020 exists and has been approved by the Egypt Supreme Council of Energy (SCE).

The current energy strategy (the resolution adopted by supreme council on energy in 2007) aims at increasing the share of renewable energy up to 20 % of the energy mix by 2020. This target is expected to be met largely by scaling-up wind power, as solar is still very costly and the hydro potential is largely utilized. The share of wind power is expected to reach 12 %, while the remaining 8 % would come from hydro and solar. This translates into a wind power capacity of about 7200 MW by 2020. The solar component is at this stage considered to start with 100 MW of concentrated solar power and 1 MW of photovoltaic power.

The Government is also proposing a dedicated transmission body for solar energy, the Solar Energy Trader (SET). This body will be responsible for administering the advantages conferred to consumers who, under the National Solar Initiative, qualify for accreditation that 5 % of their energy needs are met through solar sources. The SET will be responsible for signing power purchase agreements (PPAs) with contract suppliers, and will be established through financial institutions. Funding for the SET will come from a duty on energy trading. The SET scheme is set to run alongside a feed-in tariff for solar energies to be established by the regulator. The regulator is also responsible for ensuring the transparency of PPAs signed through the SET, licensing solar energy producers and issuing certificates of origin, and ensuring fair access to the system.

Energy regulator

The Electric Utilities and Consumer Protection Regulatory Agency (EEUCPRA) was established by Presidential Decree No. 339/2000 under the supervision of the Minister of Electricity and Energy. The Agency mandate is to regulate and revise the techno-economic feasibility of all electricity generation, transmission, distribution and consumption activities. Its mandate also includes ensuring the availability of supply to different end-users at fair prices. The role of the agency is still limited.

Degree of independence

The Minister of Electricity and Energy is also Chairman of the Board of Directors of EEUCPRA, with the other 9 members of the Board appointed by the Prime Minister and selected to represent the various stakeholders in the industry. Funding is allocated via the state budget, although this is currently not used, in favour of operational revenues derived from licensing and services to electricity utilities.

Regulatory framework

In sum, there are 4 avenues by which renewable energy is now incentivized in Egypt:

- **Plants Built through Competitive Bidding**: Under this approach, the grid operator will issue tenders requesting power supply from RE sources. This is directed at large size installations, such as a 250 MW wind farm. These tenders will be designed (i) to control the increase in RE capacity matching the transmission and absorption capacities of the market, (ii) to increase local manufacturing, (iii) to encourage private investment, (iv) to drive down costs and (v) to provide investors with guarantees through long-term power purchase agreements (PPAs). The goal is to reach 2500 MW in capacity through long-terms PPAs, in blocks of 250 MW, targeting large international developers with strong financial status and high capacity for technology transfer. The evaluation criteria will include additional points for a high share of locally manufactured components. The role of EgyptEra's with respect to the competitive bidding process is to review power purchase agreements, issue licenses, help the investment review process, and auditing.

- **Feed-in Tariffs for Smaller RE Projects**: Feed-in tariffs will be introduced for smaller capacities (less than 50 MW installations), again with a goal of reaching 2500 MW capacity, and will work in parallel with the competitive bidding process. The tariffs are to be set for 15 years, and development of the tariff design and PPA contract is underway. As with the competitive bidding process, the role of EgyptEra is to review power purchase agreements, issue licenses, help the investment review process and audit projects.
- **The Solar Initiative**. Recognizing the natural resource potential, the Egyptian government has identified the growth of solar energy as a priority. Solar energy can benefit from the recently adopted European directive (2009/28/EC), which enables European countries to build renewable plants in a third country, providing that electricity will be physically exported to Europe. There are currently two regional solar initiatives that Egypt will be able to participate in, the Mediterranean Solar Plan and Dii, though both are inhibited by existing transmission capacity limitations. To accelerate the establishment of solar power implementation and to mitigate the lack of transmission capacity in the short and medium terms, Egypt may need to consider alternative methods. One such option would be to export the natural gas quantity equivalent to the electricity generated from RE sources, while using the actual generated electricity from RE domestically. Under the solar initiative, a registered and internationally recognized logo will be issued by the regulator which accredits solar energy consumers, offering holders better financing terms, export advantages and potential tax credits. Interested consumers will voluntarily commit themselves to consume up to 5 % of their electricity from solar energy. A Solar Energy Trader, or "SET," will be established to consolidate the committed inquiries and contract suppliers through long-term PPAs to satisfy these demands. SET will be owned and operated by a financial institution(s); committed consumers can have shares in SET, while suppliers cannot. Transactions will be conducted according to a feed-in tariff which will be a pass through cost to consumers.

EgyptEra is expected to play a prominent role in:

- Issuing the solar energy logo/certification.
- Developing a committed consumer register.
- Setting up mechanisms to guarantee consumer payments through electricity supply contracts and transactions between SET and distribution or transmission networks operators.
- Licensing SET and monitoring its operation to ensure transparency, free competition and non-discrimination.
- Issuing the solar feed-in tariff, approving the PPAs and ensuring their transparency.
- Licensing the solar energy producers; issuing certificates of origin.
- Ensuring third party access and priority of dispatching.
- Ensuring exemption from transmission or distribution fees as well as energy banking as a requirement for Public Social Obligation (PSO) of network operators.
- Conducting dispute resolution.
- Hosting a steering committee of representatives of the stakeholders (the committee would promote the initiative among different business communities and refine the initiative as well as follow up its progress).

- Projects Led by the New and Renewable Energy Authority (NREA). Established in 1986, NREA is both a national agency for developing and planning the technology transfer and a developer that must seek and receive a license from the regulator in order to operate its new facilities. Construction is being completed on an integrated solar combined cycle power plant with 9,150 total MW (30 MW solar) at Kureimat. A $327.5 million financing capacity from the World Bank, using the Global Environmental facility, offsets the cost differential between solar and thermal resources; with added support from the Japanese Bank of International Cooperation and the National Bank of Egypt. In February 2010, NREA signed an agreement with Masdar to build a 200 MW wind farm in the east.

The draft Electricity Law also envisions a Renewable Energy Fund, derived from the state public budget, endowments, donations, grants and investments, which will provide support to purchase electricity from plants using renewable energy. The Fund would cover: full or partial deficit between the RE cost and market prices, exchange rate risk, guarantee of transmission company payments, financial support to pilot projects, and research and development of renewable energy technologies locally. The Fund would be financed by the state budget, some amount of the subsidies that currently go to existing energy industry, donations and, ultimately, the investment of Fund money.

Regulatory roles

The EEUCPRA mandates include:

- Ensuring that all activities of electric power generation, transmission, distribution, and sale, are carried out in compliance with the laws and regulations in effect in Egypt, especially those relating to environmental protection.
- Reviewing plans for electricity consumption, production, transmission and distribution, including the investments necessary, to ensure availability of power.
- Setting regulations that ensure lawful competition in electricity production and distribution, in the best interests of the consumer.
- Ensuring that the costs of power production, transmission and distribution to guarantee the interests of all parties involved in these activities.
- Guaranteeing the realisation of a fair return on electric utilities.
- Ensuring the quality of the services provided by the utility to consumers.
- Publishing such information, reports, and recommendations that assist the electricity utility and the consumers to gain awareness of their rights and responsibilities, and of the role played by the EEUCPRA.
- Investigating consumer’s complaints and settlements of any disputes.
- Issuing licenses for the construction, management, operation, and maintenance of electricity generation, transmission, distribution, and sale.

Energy regulation role

The Ministry of Petroleum (MOP) is responsible for regulation within the petroleum sector, including tariff setting for petroleum products. The Ministry is also responsible for the development and restructuring of the mineral resources sector.

Regulatory barriers

Egypt faces considerable challenges in bringing renewable energy sources to market and is tackling many of these issues through advances to its regulatory framework, which is supported by various market actors, including the regulator. These challenges include:

- At present, Egypt has some of the lowest retail prices for fossil fuel electricity in the world, making the challenge to make renewable energy cost-competitive all the greater.

- Oil and gas are subsidized upstream, with the transmission company, which buys from generators and then redistributes power to distribution companies, buying electricity at a low rate. Given that fossil fuels, absent recognition of societal costs and externalities, remain less expensive than renewable alternatives, these oil and gas subsidies exacerbate the distortions in the market, making renewables uncompetitive.
- The Ministry of Finance also provides social subsidies, distorting market signals to end users and discouraging conservation.
- RE projects also tend to have intensive capital costs, often requiring technology and parts not produced in Egypt. Solar, which uses some of the most expensive kinds of technology, is particularly vulnerable to the price differential.
- Most RE sources have low power intensity, presenting problems for the power system, which is currently structured with centralized plants, and requires the use of distributed generation.
- With regard in particular to harnessing wind resources, many high wind speed resources are concentrated in discrete and/or state-owned land areas, requiring attention to land use regulations.

Analysis of the national economic system and politics

Strength and weaknesses

In general, GDP fell sharply in North Africa in 2011, particularly, in Egypt from over +5 down to +1.8 %. The strikes, periods of government demonstration and other social instabilities made to contract important sectors of the economy such as tourism. The uncertain government of 2012 had negative impact on investment and consumption as well as in foreign investment.

Nonetheless, the large domestic market and its strategic location between Africa and Middle East give to Egypt an important sustenance for its economy. Additionally, apart from the penalized tourism since 2011, the Egyptian economy is reasonably diversified thanks to the oil and gas resources, Suez Canal, workers remittances and the manufacturing sector.

Definitely, the Egyptian scenario is dominated by the political instability, contributing to prospect of poverty and lack of jobs together with regional uncertainty, since the relationship with Israel seems to be incompatible with Syria and Iran. Therefore, although the Solar potential in this country is very high, the unstable business climate should also be taken into account.

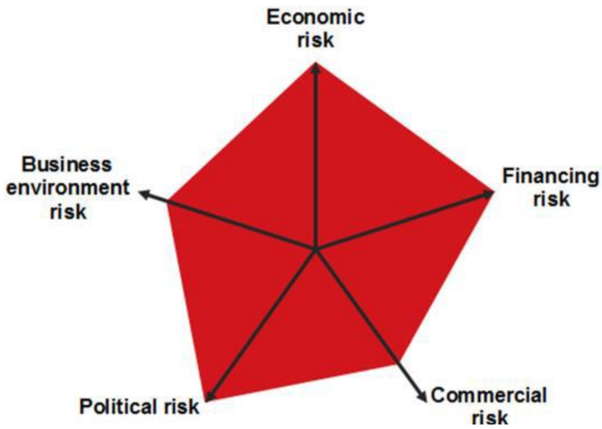

Figure A. 32. Risk dimensions estimated by Euler Hermes. Egypt.

Economic structure

The diversification of economic sectors is more pronounced in imports, since the export market is dominated by the 40 % of crude oil, after which chemical products, textiles, metals and agriculture are also important in this order. For imports, crude oil is also the most important sector, only sharing 17 %, similar to the 14 % shared by Machinery and Agriculture. After them, metal represents the 9 % of imports, and chemical products, transport and plastics are other non-negligible sectors.

Regarding trading partners, the Egyptian market is much more diversity, sharing the top 5 partners 31.6 % and 34.8 % of export and imports market respectively. Italy and United States receive around 8 % or Egypt exportations, with India, Germany and Saudi Arabia completing the top five of the list. Whereas China is the main Egyptian provider with 10 % of the import market and after it, United States, Russia and Ukraine shares around 6.5 % of it and Turkey closing the top five of the list with 5.1 %. By continents, Asia and Europe represent more than 70 % of the export market and more than 80 % of imports.

Economic forecast

Many factors limiting the GDP growth after the Arab spring, remain still evident during 2014, in fact the GDP was contracted 4.80 % in the last year. Some experts expect still negative growth of the GDP, but noticeably lower: -1.69 % for 2015 and 1.06 % for 2016. Furthermore, forecast for mid-term are also pessimistic, as negative growth are even expected for the horizon of 2050.

Maps

Population

Figure A. 33. Egypt population map.

DNI

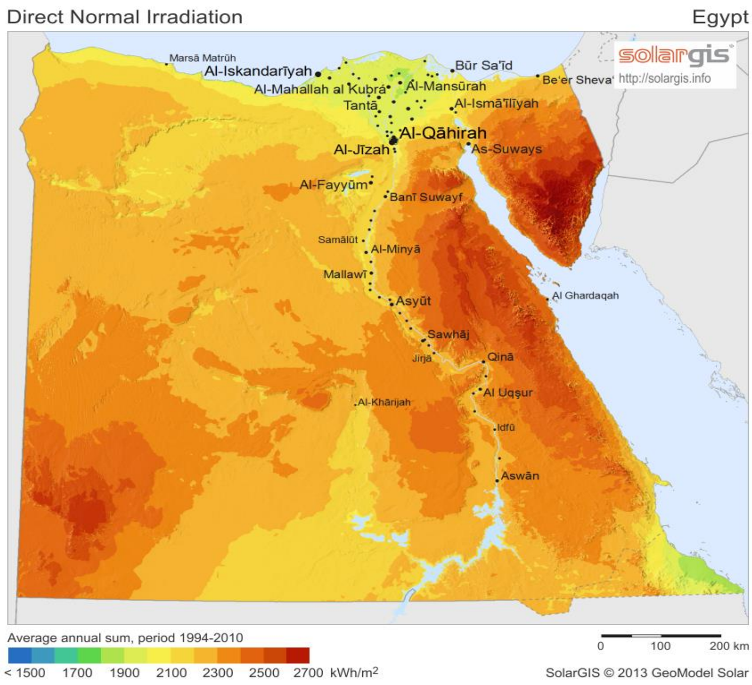

Figure A. 34. Egypt Direct Normal irradiation.

Electricity grid

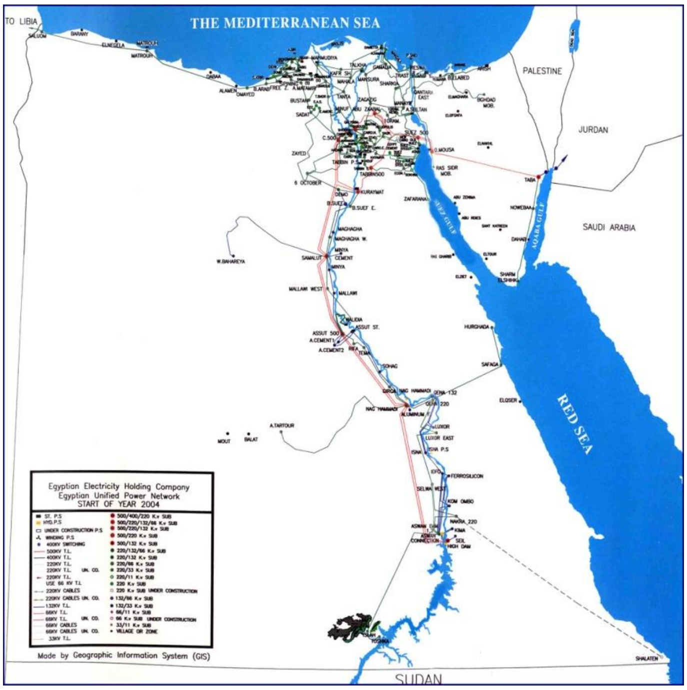

Figure A. 35. Egypt electricity grid.

Maps Overlapped

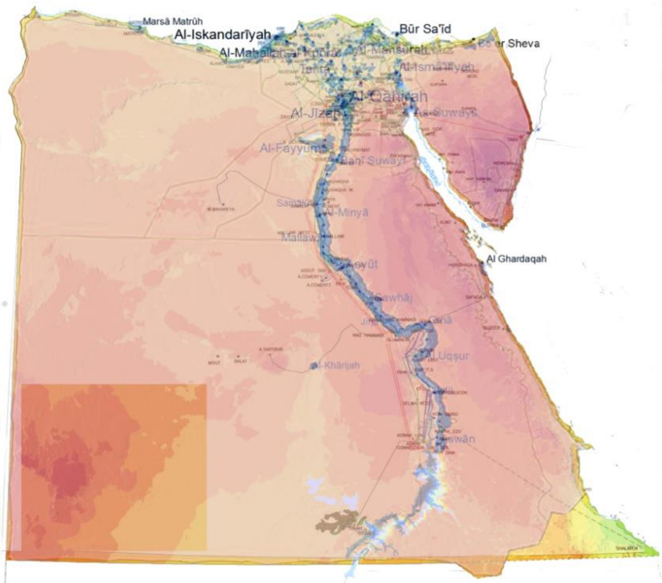

Figure A. 36. Egypt overlapped maps

Application of the method

- **GDP:** US$ 271.97 Billion (in 2014)
- **Annual GDP Growth rate:** -4.8 % (in 2014)
- **Population:** 82.06 Million people (in 2014)
- **Annual population Growth rate:** 1.66 % (in 2014)
- **Annual electric consumption (per capita):** 1742.91 kWh (in 2011)
- **Government debt:** US$ 236.89 Billion, 87.1 % of GDP
- **Accumulated external debt:** US$ 46.07 Billion, 16.94 % of GDP
- **Inflation rate (consumer prices):** 10.13 % (in 2013)
- **Country rating (Euler Hermes):** D4
- **Annually averaged DNI:** 2238.16 kWh/m^2
- **Population with access to electricity:** 99.6 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	1.0000	0.25
Electricity grid	0.20	0.8925	0.1785
Energy policy	0.10	0.6667	0.0667
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.8452

Table A. 13. Farm arrangement. Egypt.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0040	0.0010
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.6657	0.0666
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.6176

Table A. 14. Stand-alone configuration. Egypt.

ANNEX 8. India

Analysis of the national energy system

With 1.1 billion inhabitants in 2006, India is the second most populated country in the world and is expected to be the first one in 2050. It is the world's fourth highest energy consumer after US, China and Russia. The country is also one of the world's top five greenhouse gas (GHG) emitters, even though it produces about 17 times less GHGs than US. Moreover, considering usage of an average Indian citizen, it uses about 15 times less energy and 30 times less electricity, in comparison to US citizen. Nevertheless it has a great impact upon the world's energy consumption.

The latest analysis shows that the usage of renewable energy sources (excluding large hydropower) reaches 12.2 % of the overall power generation capacity in India. According to the MNRE (Ministry of New and Renewable Energy) research, the country has a potential to generate around 90 GW of energy from renewable sources, which present as follows: 48561 MW from wind power, 14294 MW from small hydro power and 26367 MW from biomass. This rate is estimated to be achieved by 2022. Nowadays most of the generated power comes from coal, due to its high domestic availability and global security of supplies. In addition, considering the database from 2009, the total power produced for electricity purposes was 888.9 TWh, where the thermal power (coal) contributed 755.8 TWh, which is 84% out of total. The remaining 14% was obtained from hydropower and nuclear power, reaching 12% and 2% respectively. As it can be noticed, the proportions are still changing, as the participation of renewable sources is increasing.

Reliance

The Indian fast-growing economy and rapidly increasing population tend to raise serious concerns about energy security. In 2009 India was obliged to import 181973 ktoe of primary energy and 10014 GWh (1.1% of total domestic supplies) of electricity. The fuel production from indigenous resources, has since then, failed to keep pace with the continuously rising demands and is being met increasingly by imports. This is making India more dependent on, and vulnerable to, foreign energy supplies.

Extend network

According to the World Coal Institute, India takes sixth position amongst the largest electricity generators, as well as consumer. However, the electrification rate is only 75 % after which there is a large fraction of the population suffering from lack of access to electricity; this means around 288.8 million people. Most of these habitants are those who live on the countryside. There are only 14000 villages out of 58600 with electrification. And for those which have supply of electricity, the quality of service is not as good as it should be, which generates another energy problem concerns. It is assessed that about 625 million people do not have access to modern cooking fuels. Moreover traditional fuels provide about 80-90% of total demand. There is another factor that contributes to uneven distribution, which is geography of the country.

Capacity concerns

As mentioned before, the Indian rapidly growing economy and population lead to a relentless increase in electricity demand. The IEA predicts that by 2020, 327 GW of power generation capacity will be needed, which would imply an addition of 16 GW per year. This urgent need reflects on the work of government, which has set so called Five-Year Energy Plans to achieve the missing numbers. In the 11th plan, which took place in years 2007 and 2012 envisaged an addition of 78.7 GW, whereas 50.5 GW is coal. The 12th Five-Year Plan (2012-2017) assumes major increases in energy imports, with import dependence on coal and oil set to increase to 22.4 % and 78 % respectively. Also the renewable capacity is meant to increase to 54503 MW by the end of the plan.

It is noticed that State electricity boards (SEBs) have significant financial problems due to thievery of electricity by end-users. The income losses are estimated to be about one third of the total. In addition, a large number of agriculture facilities across India are provided with free (or very low cost) electricity. For these reasons the Electricity Act from 2003 envisaged a reform in restructuring SEBs policy in order to increase the participation of private sector. Unfortunately not all of the states joined in reforms, which led to stratification.

Renewable Energy

According to the MNRE (Ministry of New and Renewable Energy) research, the country has a potential to generate around 90 GW of energy from renewable sources. Currently, its installed capacity has reached 27.7GW, as of Jan 2013. Also the cumulative off-grid RE capacity has reached 819.08 MW.

The leading renewable is wind, constituting the majority of share. The capacity of energy production of the 447 wind farms obtains 16.42 GW, while more is about to be added soon. Presently, there are three more wind farms under construction that will provide additional energy of 0.28 GW.

The generation from small hydro reaches 3.5 GW. In India there is a classification of small hydro according to its capacity. The first type is Pico or watermill with capacity range up to 5kW. Then there are Micro with energy production up to 100 kW, and Mini ranging 101-2000 kW; lastly, the Small ones with a range of 2001-25000 kW. At present, country is having almost one thousand stations and projected 327 more.

As of 2014, India had 2.6 GW of grid connected solar power projects which were commissioned under Jawaharlal Nehru National Solar Mission (JNNSM). This included 687, 8 MW projects by Ministry of New & Renewable Energy (MNRE), 1322.59 MW under various state government policies, 90 MW under renewable purchase obligation (RPO), 490.685 under renewable energy certificate (REC) scheme, 15.6288 MW by private initiative (roof-top) and 25.2 MW by central public sector undertakings (CPSUs). This was an increment of 947.5 MW over last year which ended with 1684.4355 MW as of 2013.

Solar Energy

The annual solar radiation over India ranges from 1200 to 2300 kWh/m^2, with most of the country having radiation greater than 1900 kWh/m^2 per year, whereas over 80% are marked as clear sunny days. Compared to Germany, India ranges from 400 to 1100 kWh/m^2 annual solar radiation more, which indicates that radiation in India is more reliable and gives great opportunities to use the solar power. Considering the demand of energy in India, for example from 2005, when it ranged at around 620 billion kWh, an installation of photovoltaics panels with efficiency of 10% covering the demand would take about 3000 km^2 (60 km by 50 km) which is 0.1 % of the land area of the country. This example shows explicitly the benefits of installation of solar power plant.

Ownership of electricity

The power sector is dominated by government utilities both at the central and state levels. Central and state sectors dominate electricity generation with 39 % and 45 % shares respectively. On the contrary, the private sector contributes 18.74 % of all grid connected capacity only.

Major central and state sector utilities involved in power generation include the National Thermal Power Corporation (NTPC), the National Hydroelectric Power Corporation (NHPC) and the Nuclear Power Corporation of India Limited (NPCIL). Besides there are several operators more involved in power generation, such as SEBs mentioned before, the Maharashtra State Electricity Board (MSEB), the Kerala State Electricity Board (KSEB), the MGVCL, PGVCL, DGVCL, and UGVCL (four distribution companies), one controlling body (the Gujarat Urja Vikas Nigam Limited, GUVNL), and one generation company (GSEC) in Gujarat.In spite of these many different establishments, the Power Grid Corporation of India Limited (PGCIL) has the monopoly status for transmission of electricity, as well as the SEBs, which owns nearly 95 % of the distribution network. It leaves little room to privatize this sector, this being possible in a few states only.

Competition

The electricity consumers in India have long been served by vertically integrated SEBs. The reformed model adopted, by a number of states, resulted in the restructuring of some of the SEBs, leading to separation of the generation, transmission and distribution segments, and their corporatisation. Regulatory reform included the establishment of the Central Electricity Regulatory Commissions (CERCs) and State Electricity Regulatory Commissions (SERCs). The monopoly of bulk supply as well as retail supply has been abolished, with the enactment of the Electricity Act 2003. The new Act provides for non-discriminatory open access to the transmission network, and the de-licensing of generation, including captive power generation. The Act also recognises trading as a distinct activity. Such provisions provide an enabling environment for development of the bulk power market in India. Phased open access of the distribution network by respective state utilities provides consumer choice, subject to open access regulations, including the cross-subsidy surcharge.

Energy framework

The Electricity Act (2003)

The Act consolidates the laws relating to generation, transmission, distribution and trading, and use of electricity. It also promotes rural electrification through renewable energy sources stand-alone systems.

National Action Plan on Climate Change (2008)

It addresses the critical concerns of the country through directional shift in the development pathway, including the enhancement of both current and planned programmes.

Jawaharlal Nehru National Solar Mission (JNNSM) (2009)

The programme goals include creating an enabling policy framework for the deployment of 20 GW of solar power by 2022.

National Mission for Enhanced Energy Efficiency

Apart from creating an energy efficiency market, the mission aimed to cut down the country annual energy usage by 5 % and CO_2 emissions by 100 million tonnes every year. The goal of the mission was to reduce energy usage of 10 GW.

India Energy Policy (IEP)

The IEP, adopted by the Indian government in 2006, is India's comprehensive energy road map. Prepared by the Planning Commission of India, the IEP identifies multiple energy challenges, including meeting energy demands, securing supply, mitigating climate change, and promoting renewable and alternative energy. Moreover IEP is cooperating with RE program, excluding large hydropower, for more than two decades, and has policies to support RE at the central and state level. These domestic policies have been combined with participation in the Clean Development Mechanism (CDM) by renewable project developers with reasonable success. However, given the overall size of the energy system, the contribution of renewables is still small. For example, electricity from RES (excluding large hydro) in 2008 was 13 GW, out of a total of 168 GW. Nevertheless, the government is making efforts to increase renewable energy supply. It has launched over 2000 RE projects under the

CDM, adopting policies to promote RE. For example, the National Policy on Biofuels, adopted by the Ministry of New and Renewable Energy, favours the IEP recommendation to substitute traditional fuels with biofuels. Not only are the biofuels promoted, but also solar and wind energy power. For these reasons there have been established specialised centres of technology development.

Energy conservation Act 2001

The Energy Conservation (EC) Act, signed in 2001, provides the legal and institutional framework for the government of India to promote energy efficiency across all sectors of the economy. A coordinating body called the Bureau of Energy Efficiency (BEE) was created to implement the EC Act. The need to improve energy efficiency was further emphasized in the National Action Plan on Climate Change (NAPCC), adopted in 2008. Furthermore, the Energy Conservation Act was amended in2010 to empower BEE and Central Government Also a National Mission for Enhanced Energy Efficiency (NMEEE) is an established organisation to recognize the importance of addressing issues related to climate change, as well as considering economic and social development. It cooperates with National Action Plan for Climate Change, which introduced 8 National Missions in order to make complex investigations of climate change in India, which are as listed:

- National Solar Mission.
- National Mission on Enhanced Energy Efficiency.
- National Mission on Sustainable Habitat.
- National Water Mission.
- National Mission for Sustaining the Himalayan Eco-system.
- National Mission for a Green India.
- National Mission for Sustainable Agriculture.
- National Mission on Strategic Knowledge for Climate Change.

Each National Missions is institutionalized by a respective Ministry. The National Mission for Enhanced Energy Efficiency (NMEEE) operates under BEE. The Prime Minister's Council on Climate Change approved draft principles of the NMEEE on August 2009 and the Union Cabinet approved its implementation framework on 24th June 2010, with dedicated funds to the tune of USD53 million.

The draft of the 12th Five Year Plan (2012-2017) was published in 2012.The energy sector is covered in extensive detail, beginning with the achievements of the 11th Plan, including the total number of electrified villages increasing to 560000, capacity additions of 54964 MW, and the installation of a further 70,286 circuit km of transmission lines. A total capacity addition of 118, 536 MW is planned for the 12th Plan period, including 30 GW of grid-connected renewable capacity of which 15 GW is wind power,10 GW solar, 2.1 GW small hydro and 2.9 GW of biomass/fuels. In addition, the 12th Plan targets the creation of a National Grid, through the development of a HVDC connector to the Southern electricity grid of the country, as well as increasing HVDC and 765 kV links throughout the grid to improve capacity. Extensive energy policy reforms are recommended in the 12th Plan, including the strengthening of provisions for increasing renewable energy capacity, and incentives for low-cost transmission development to connect new renewable capacity. Finally, the plan sets notable new targets for energy efficiency in all sectors of the economy, with a projected yearly energy saving of 11430 ktoe, compared to a business-as-usual scenario, as of 2016-17.

Energy debates

India is setting up a company with an initial capital of 20 billion rupees (USD406 million) to build federal solar projects and help the country reach a target of 20 GW of solar energy capacity by 2022. The decision to create the company comes at a time when some solar and renewables experts are worrying that due to a shortage of funds and a relative lack of interest by commercial companies, India might miss solar energy targets set under a federal program.

Following the largest power system failure in history on July 30-31, 2012, caused by numerous failures in load balancing and detection systems in the Northern grid of the country, led to a number of recommendations to prevent such an event occurring again. These included an immediate audit and review of grid protection schemes and measures, the implementation of islanding schemes for key services and industries, and the strengthening of the inter-state transmission system.

Energy studies

India is part of the South Asian Regional Initiative for Energy under USAID (SARI/E), a program that promotes energy security in South Asia through three focus areas: Cross border energy trade, Energy market formation and Regional clean energy development.

Through these activities SARI/E facilitates more efficient regional energy resource utilisation, works toward transparent and profitable energy practices, mitigates the environmental impacts of energy production, and increases regional access to energy. SARI/E countries also include: Afghanistan, Bangladesh, Bhutan, Nepal, the Maldives, Pakistan, and Sri Lanka.

- The Energy and Resources Institute (TERI) on energy security: Energy Security insights
- Energy Conservation Building Code

Role of government

The Ministry of Power is responsible for:

- General Policy in the electricity sector and issues relating to energy policy.
- Matters relating to hydroelectric (except small/mini/micro hydro projects of and below 25 MW capacities) and thermal power, and the transmission system network.
- Research, development and technical assistance relating to hydro-electric and thermal power, and the transmission system.
- Administration of the Electricity Act, 2003, the Damodar Valley Corporation Act, 1948 and the Bhakra Beas Management Board as provided in the Punjab Re-organisation Act, 1966.
- Matters related to both the Central Electricity Authority and the Central Electricity Regulatory Commission.
- Rural Electrification, Power Schemes in Union Territories, and issues relating to power supply in the States and Union Territories.
- Administrative control of Public Sector Undertakings, Statutory and Autonomous Bodies functioning under the Ministry.
- Other Public Sector Enterprises in energy except projects specifically allotted to any other Ministry or Department.
- All matters concerning energy conservation and energy efficiency pertaining to the sector.

The Ministry of New and Renewable is the nodal Ministry of the government of India for all matters relating to new and renewable energy and the administrative ministry for policies and programs in this area. The Ministry itself is organised into several divisions dealing with different technologies and applications. The programme of the ministry is largely implemented through State Nodal Agencies. All major States have set up energy agencies for the non-conventional energy programme.

The Ministry of Coal is responsible for policies and strategies with respect to exploring and developing coal reserves, sanctioning important projects and deciding related issues.

The Ministry of Oil and Gas has the overall responsibility of exploration and production of oil and gas, along with their refining, distribution and marketing, import, export, and conservation.

The Central Electricity Authority (CEA) assists the Ministry of Power in all the technical and techno-economic matters.

Government agencies

Indian Renewable Energy Development Agency (IREDA) The IREDA was established in 1987 as a non-banking financial company under the administrative control of the Ministry of Non-Conventional Energy Sources (MNES), to provide loans for renewable energy projects. Subsequently energy efficiency and energy conservation projects were added to its portfolio.

Bureau of Energy Efficiency (BEE) The BEE, established under the Energy Conservation Act of 2001, has introduced labelling requirements and building codes to reduce the energy intensity of GDP growth. For instance, the Energy Conservation Building Code (ECBC) is aimed at maximising energy utilisation in commercial buildings, by using Leadership in Energy and Environmental Design (LEED) certification standards, and customising buildings based on location temperatures. The BEE is comprised of ministers from Central and State energy-related agencies. The BEE is working with key industries, including cement, aluminium, and paper and pulp, to establish voluntary EE practices. It is also drafting standards for energy-labelling, building codes, and certification programs, among other initiatives.

In February 2011, The Bureau of Energy Efficiency (BEE) of India adopted new quality standards for solid state lighting, a process greatly accelerated as a result of SEAD, facilitated technical exchange between BEE and the United States Department of Energy. These standards are in the process of being notified through the Bureau of Indian Standards. In March, India also launched new internationally harmonized efficiency labels for laptops, drawing from the Energy Star programme.

Energy procedure

The policies and plans are developed on a five-year basis, apart from the annual plans. Each department/ministry prepares plans, which go as inputs to the Five-Year Plan prepared by the Planning Commission of India. By 2017, the Indian government is planning to add an extra 30 GW of renewable sources. In its 10th Five-Year Plan, the Indian government had set itself a target of adding 3.5 GW of renewable energy sources to the power generation mix. The result, though, was nearly double that figure in actual terms. In this period, more than 5.4 GW of wind energy was added to the generation mix, as well as 1.3 GW from other renewable energy sources. The target set for the period from 2008 to 2012 was to increase the energy production from renewable resources up to 14 GW, 10.5 GW of which 10.5 GW was new wind generation capacity.

Also the government is developing a scheme for energy efficiency trading as part of its National Action Plan on Climate Change. Under the proposed scheme of Perform, Achieve, Trade (PAT), specific industries would be required to commit to energy-intensity reductions, and the government will give trading certificates to entities successful in meeting their goals. Penalties for non-compliance are mentioned under the proposed plan, but not mandated.

In addition we have Ultra Mega Power Projects (UMPP), which are a series of ambitious power projects planned by the Government of India. The UMPPs, are being developed with an aim to bridge the current supply gap... Furthermore, the Ministry of Power, in association with the Central Electricity Authority and the Power Finance Corporation Ltd., has launched an initiative for the development of coal-based UMPPs in India. Nine projects were set up, which are expected to generate 100GW of electricity during 12th Plan period (2012-17).All of them are a part of competitive binding for developers.

In the solar energy sector, some large projects have been proposed, and a 35000 km^2 area of the Thar Desert (Rajasthan), has been set aside for solar power projects, sufficient to generate

700 GW to 2100 GW. A complete package has been proposed to propel the power sector into solar reforms that could lead to annual production of 20 GW by 2020 by occupying an area of only 20 million m^2 with collectors. The country annual capacity to generate power from sun is 976.904 MW, as in 2012.

Energy regulator

The government created the Central Electricity Regulatory Commission (CERC) vested with jurisdiction by incorporating the Electricity Laws (Amendment) Act 1998, to regulate the tariff of bulk electric power, i.e. the generation and inter-state transmission of power, with effect from 15th May 1999.

It has been followed by the institution of 24 other State Electricity Regulatory Commissions (SERCs) in the states, excepting Nagaland and Arunachal Pradesh, with the authority to decide intra-state transmission and distribution/retail tariffs. This step was a key to a series of reforms in the power sector.

The Petroleum and Natural Gas Regulatory Board (PNGRB), was established in June 2007.

Degree of independence

The CERC was set up as an Independent Regulatory Commission. It consists of a Chairperson and 3 other members, appointed by a central governmental committee. Furthermore, the foundation of The Central Electricity Regulatory Commission Fund was established under the same act as CERC to function as the funding mechanism for the Commission, and to administer all funds received by the Commission under the Electricity Act, as well as all loans and grants dispensed from the government.

Regulatory framework

In keeping with its aim of having a holistic, sustainable energy policy, the government of India is encouraging investment in non-conventional energy sources. The 11th Plan it has proposed a financial outlay of $44.79 million on R&D in the wind energy sector. However, this input is not destined to set up wind power plants. Instead, it aims to concentrate on R&D only, developing small plants in remote areas and setting up demonstrative projects. The disadvantage of wind energy power plants is being provided with continuous support, due to its difficulties with maintenance. Also the average pay back period from wind power is 25 years. In spite of this, the advantage is that, manufacturers do not have to worry about technological obsolescence. Keeping all these considerations in mind the government has formulated a strategy of providing incentives to private manufacturers in this sector. The Indian Government is giving income tax holidays, concessional custom duty, duty free import, and accelerated depreciation, to investors in this field. The various State Governments are providing support in the form of energy buy back, power wheeling and banking facilities, sales tax concession benefits, electricity tax exemption and capital subsidy.

The government has also come up with a Generation Based Incentive (GBI) Scheme. The features of the scheme are as follows:

- The GBI Scheme is applicable only for those power producers who do not avail of the accelerated depreciation benefits under the Income Tax Act.
- All grid integrated projects of capacity of more than 5 MW are eligible for this scheme. The project has to be synchronized with the grid and certified by the utility.
- Wind site has to be validated by C-WET.
- Electricity generated from the project should be sold to the grid.
- The MNRE will provide the GBI of Rs. 0.50 per unit for a period of ten years to the eligible project promoters through IREDA. This scheme is currently valid for wind farms installed before March 31st 2012. This incentive shall be in addition to the tariff determined by the State Electricity Regulatory Commission (SERC).

- The IREDA will disburse the generation based incentive to the generator on half yearly basis through e-payment.
- Not applicable for those who have set up capacities for captive consumption, third party sale, or merchant plants.
- The component of the scheme will be reviewed when projects aggregating to 49 MW, which are estimated to generate around 0.9 billion units of electricity, will get registered by IREDA.

The SERCs in Andhra Pradesh, Gujarat, Haryana, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, and West Bengal have announced preferential tariff for purchase power from wind power Many States have also announced renewable energy purchase obligations, which catalyses the growth in the wind power generation. In 2007, BEE issued the Energy Conservation Building Code (ECBC) which provides minimum energy performance standards for design and construction of commercial buildings with a connected load of 500 kW and above. ECBC takes into account the five major climatic regions of India and is currently a voluntary programme. However, a number of states have recently announced that they will adopt it as a mandatory requirement.

Regulatory roles

The CERC has passed regulations to promote growth in the renewable sector, such as the regulation on certificates for generation of RE, the regulation designating the National Load Despatch Centre as the implementing agency, and regulations on renewable energy tariff-determination. The Indian administration has passed laws to promote renewable energy. The National Electricity Policy of 2005 and the Tariff Policy of 2006 promote RE investment by pricing it competitively with conventional energy. The Electricity Act of 2003 requires state electricity boards to facilitate the supply and distribution of RE, along with traditional electricity.

The CERC has notified tariff regulations for the determination of tariffs for RES projects. The regulations are formulated to promote the development of RE projects, to remove ambiguity on project returns, debt repayment assurance, etc. The regulations complement the National Action Plan on Climate Change, which specifies that minimum renewable purchase standards be set at 5 % for total power purchases for FY10, and should be increased by 1 % each year for ten years.

SERCs roles include tariff regulation and promotion of co-generation, and electricity generation from renewable.

Energy regulation role

The role of government departments is to prepare policies and legislations in the energy sector. No government department takes an active role in energy regulation.

Regulatory barriers

Although the central government intends to promote RE, its efforts are hampered by inconsistent implementation by the States and by the lack of a central RE law. Some States have set relatively high renewable portfolio standards (RPS - renewable energy targets), some have set low targets, and some have not yet set any targets. Enforcement could also be stronger. The co-existence of RPS schemes and feed-in tariffs needs to be well-managed. A misalignment of state targets with national objectives has also been identified as a key barrier, as well as the limited framework for regulation of inter-state renewable power transmission, based on resource availability.

Analysis of the national economic system and politics

Strength and weaknesses

This country is very vulnerable to natural disasters like tsunamis, floods and earthquakes, and to social conflicts, especially in the Kashmir region, where the poverty is pervasive and the distribution uneven. This scenario brings about enormous uncertainties when it comes to doing business.

Historically, the political system tends to be coalitions, making it difficult to implement economic reforms. Despite this, the democracy is nevertheless very stable and changes in government are usually peaceful. On the positive side, there is a large internal consumption and a successful industrial diversification into manufacturing and automotive. With respect to macro-economy, the annual GDP is normally very high (+7.9 % in 2012) and the external debt is low in relation to it.

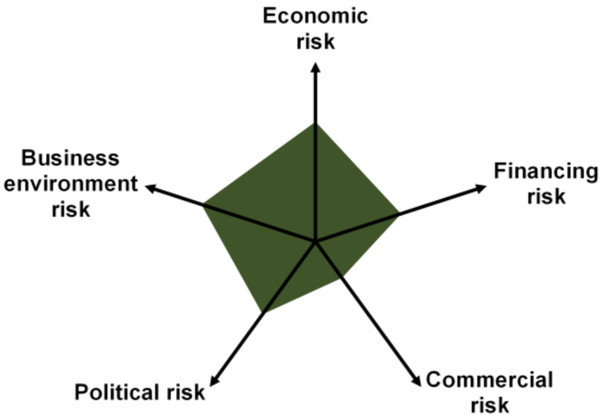

Figure A. 37. Risk dimensions estimated by Euler Hermes. India.

In this certainly risky scenario, it must be said that capital inflows are expected to increase in the long term, since investor confidence is rising together with the credibility of the Reserve Bank of India (RBI).

Economic structure

Although diversified, the Indian economy relies on the trading relationships with its continental neighbours based on the crude oil sector, which shares 22 % of exports and 40 % of imports. Considering export market, its economic sector shared with six other sectors (chemical products, textiles, machinery, ores, metals and agricultures in this order) constitute 58 % of the market, while in the case of import the top four list (crude oil, ores, machinery and chemical products) share around 80 %.

In comparison with other countries, the Indian market is also diversified in terms of export and import destinations. Thus, the main destinations of Indian goods are the United States (with 12 % share), United Arab Emirates, China, Singapore and the United Kingdom (all of them accounting for almost 40 % of the total exports). On the contrary, most of the imports come from China (11 %), followed by the United Arab Emirates, Saudi Arabia, Switzerland and United States (with a cumulative share of 35.4 % of these five countries).

Economic forecast

GDP growth increased moderately in 2014. Data reveal that activity gained traction in the first half of last year, since industrial production growth started being positive on a year basis, exports accelerated and capital inflows recovered. Additionally consumer and business confidence levels are rising simultaneously.

The newly elected government is expected to drive structural reforms, especially by making the economy more business friendly, but its effects into economy will take time to materialize. However, the existing domestic vulnerabilities, the persistently high inflation, the high government deficit and a low private investment rate are against the optimistic growth prospect.

Maps

Population

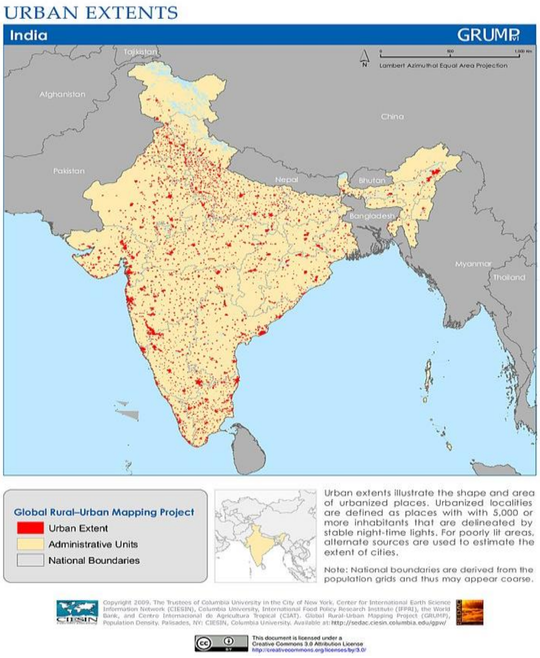

Figure A. 38. India population map.

DNI

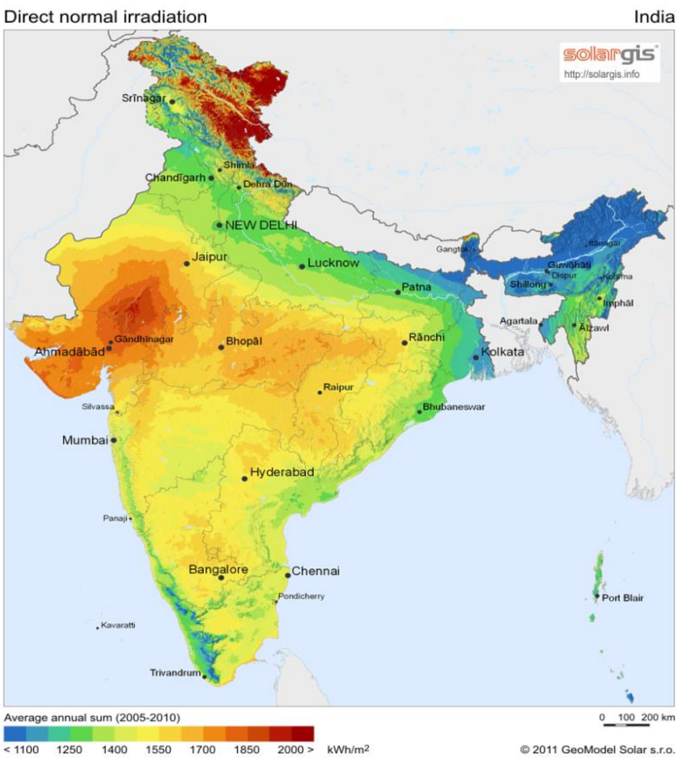

Figure A. 39. India Direct Normal irradiation.

Electricity grid

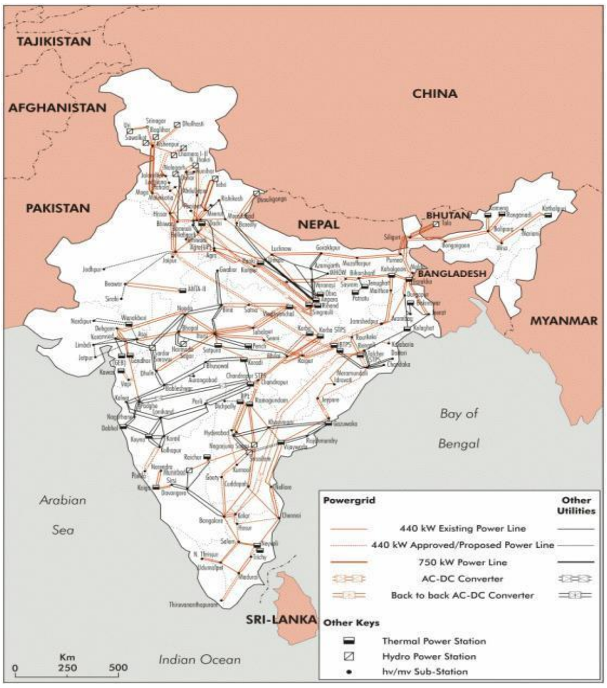

Figure A. 40. India electricity grid.

Maps Overlapped

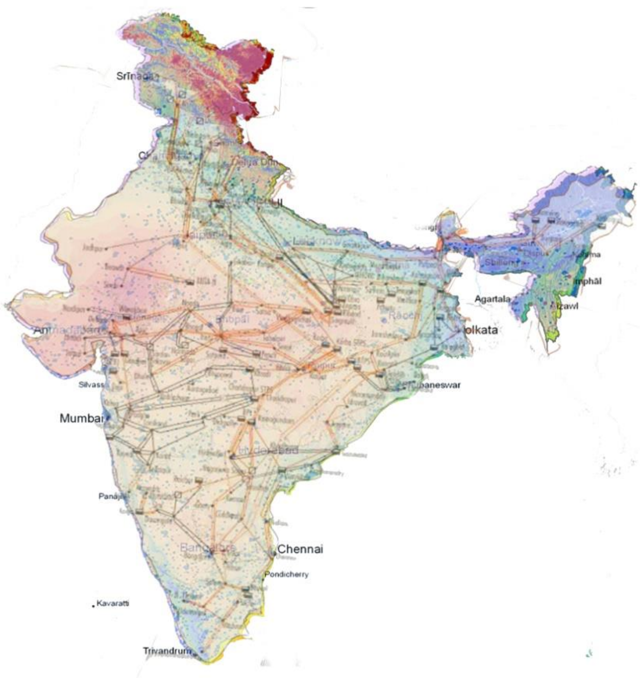

Figure A. 41. India overlapped maps.

Application of the method

- **GDP:** US$ 1876.8 Billion (in 2014)
- **Annual GDP Growth rate:** 1.2 % (in 2014)
- **Population:** 1233 Million people (in 2014)
- **Annual population Growth rate:** 1.31 % (in 2014)
- **Annual electric consumption (per capita):** 684.11 kWh (in 2011)
- **Government debt:** US$ 1271 Billion, 67.72 % of GDP
- **Accumulated external debt:** US$ 455.9 Billion, 24.3 % of GDP
- **Inflation rate (consumer prices):** 5.0 % (in 2013)
- **Country rating (Euler Hermes):** B1
- **Annually averaged DNI:** 1395.11 kWh/m^2
- **Population with access to electricity:** 75.3 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.3951	0.1383
Population	0.25	1.0000	0.2500
Electricity grid	0.20	0.7044	0.1409
Energy policy	0.10	0.8303	0.0830
Legal certainty	0.10	0.4709	0.0471
		TOTAL	0.6593

Table A. 15. Farm arrangement. India.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.3951	0.1383
Population	0.25	0.3280	0.0820
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.6553	0.0655
Legal certainty	0.10	0.4709	0.0471
		TOTAL	0.5329

Table A. 16. Stand-alone configuration. India.

ANNEX 9. Italy

Analysis of the national energy system

To begin with, the Italian government has made substantial progress in several sectors in the last decade. It reorganized and continued reform of the electricity and natural gas sectors, investigated on new carbon capture systems as well as implemented incentive schemes for renewables. These are only some of the achievements that are most noticeable.

As a unique member of G8 without nuclear power, Italy has recognised the need to diversify its energy portfolio in order to reduce the dependence on fossil resources and also to reduce the emission levels. In spite of the interest on nuclear energy, the entrance of new government has shortened it by a decree 'Omnibus' (introduced in 2011), which forbade the construction of nuclear power plant. On the other hand, the liberalization of the energy market has established a solid framework for the development of a competitive Italian energy market and the secure and efficient provision of electricity for long term.

Moreover, the EU's climate and energy package increases the challenges of Italian policy makers for the 2020 horizon in regard to greenhouse gas emissions, renewables and energy efficiency. This frame together with the Kyoto Protocol constrains will influence the Italian energy policy.

Reliance

A country-wide electricity blackout in 2003 in addition with a growing dependence on electricity imports and lack of entry into the generation market, stimulated the government into taking further measures to strengthen energy security in both the natural gas and electricity sectors. The development of new generating capacity was encouraged by simplifying the processes for granting permits for new power plants and the introduction of new measures to attract investment into import in infrastructure as well as internal transmission infrastructure.

Extend network

The high-voltage ('HV') and ultra-high-voltage ('UHV') electricity transmission grid is mostly owned and operated under a concession regime by Terna SpA which is publicly listed company. Together with Cassa Depositi and Prestiti SpA (the Italian state investment arm) holds a 29.85 relative majority stake. Also Terna is responsible for dispatch.

The medium-voltage ('MV') and low-voltage ('LV') distribution grid is operated by 144 (in 2010) distribution service operators ('DSOs') under a concession regime. In 2010 Enel Distribuzione SpA accounted for 86.3 % of volume distributed, followed by A2A Reti Elettriche (4.0 %), Acea Distribuzione (3.4 %) and Aem Torino Distribuzione (1.3 %). All other DSOs have marginal market shares.

Renewable energy

According to latest studies the share of production from renewable sources has increased greatly. The power generated from the renewable sources doubled in respect of year 2008. It is due to EU climate and energy package policy, setting the achievement of the 20/20/20 objectives through stimulation of feed-in- premium policy for solar plants and green certificates in case of other renewable sources. Furthermore under the same EU organisation, Italy is obliged to generate 17 % and 26% energy from renewable sources for the purpose of the primary energy consumption and electricity respectively. The predictions are to produce around 100 TWh per year in 2020 from the renewable technologies; however it already reached 94 TWh in 2011.

Solar Energy

The growth in energy from renewable sources is mostly attributed by PV installations, which rose dramatically from 0.432 GW in 2008 to 12.750 GW in 2011.

A large share of the installed capacity benefits from the 20-year feed-in premium that the second Conto Energia granted to photovoltaic plants commissioned between 2007 and the second quarter of 2011. During the third quarter of 2010 and the second quarter of 2011 there was introduced enactment of third Conto Energia, which in combination with Salva Alcoa Law gave the most beneficial period (supposedly in energy production).

Moreover it is expected that additional solar installations will reach and stabilise at generating 2.5 to 3 GW per year. In case of PV technology the assumption is to reach grid parity no later than 2016.

Ownership of electricity

There are no restrictions on ownership of new and existing assets or service providers, other than the instructions that the antitrust authorities may require the parties to comply with for antitrust clearance.

Competition

A company established by 'Gestore Servizi Energetici-GSE S.p.A.' called 'Gestore dei Mercati Energetici S.p.A.' is responsible for organisation and economical management of the Electricty Market. The main requirements are to mainatin neutrality, transparency objectivity and competition between or among producers together with economically managing an adequate of reserve capacity. In general, the electricty market is divided into the spot and forwarded one. The spot electricty market is comprised by three subsections:

- The Day-Ahead Market (MGP),
- Intra-Day Market (MI),
- Ancillary Services Market (MSD).

The MGP and MI are so-called Energy Markets, which host most of the electricirty sale and purchase transaction while in the MSD Terna procures the resources it needs to manage and control the system. Also, under the GSE is established Acquirente Unico AU, with the mission of procuring continuous, secure, efficient and reasonably-priced electricity supply for households and small businesses. For the electricty dispatch is responsible Terna company. It owns and manage all the national grid lines. Considering the energy production the majority of the market constitute Enel Group. Than with much lessened contribution are Edison Group, Edipower, Endesa Italia and many other minor companies.

Energy framework

Considering year 2010, the total consumption of electricity was 346,223 GWh of which 12.9 % was imported, while the maximum net installed capacity was at rate of 106,938 MW. Conventional power plant constituted 67.2 % of the demand, despite most of the fossil fuels were imported (a massive shift towards natural gas has occurred only in recent years). Furthermore, renewable sources contributed to generate 20.6 % of total. The main generation market players were ENEL (27.9 % of net generation), Edison (11 %), ENI (10 %), Eon (5.7 %) and Edipower (5.5 %). Currently the participation in power generation is changing in favour of renewable sources.

As mentioned before, Italy is transferring a great amount of fossil fuels from abroad; that is why it takes 4th place as an importer of natural gas in the world. The most important suppliers are Algeria and Russia, insignificant share is from Libya, the Netherlands, Qatar and Norway.

It is worth to mention that the markets of electricity and gas are fully liberalised, which has a beneficial effect in public and private market. Retail customers and small business may opt between free market contracts and 'protected categories service'. Both electricity and gas are traded on exchanges organised and managed by Gestore dei Mercati Energetici SpA ('GME'). Trading on exchanges is carried out by generators, producers or importers, Acquirente Unico SpA (a single buyer, procuring energy for resale through the distributors to protected categories), energy and gas wholesalers, and gas shippers. Bilateral contracts may be entered into by all market participants.

Energy debates

In Italy the share of clean energy is a current issue. According to the GSE report from 2012 the contribution of renewables into electricity share is 23.5%, while the estimated value to achieve by 2020 is 26.4%. Therefore, this is being revised upwards. However, into the energy share the renewable constitutes only around 11%, which is considered poorly. Moreover, the Energy Efficiency Action Plan is another important matter. According to the report from European Commission the improvement is not as expected, but still one of the best in Europe. The other hot debate is about the nuclear power. Even though it is prohibited since 2011, there are objections from the public side.

Energy studies

The main leader in energy innovation and strategies is ENEA. The current research and development programme activities are:

- Energy efficency : Support to Public Administration, Information and Training; Advanced Technologies for Energy and Industry
- Renewable energy sources: Concentrated Solar Thermal Energy; Photovoltaics; Biomass and Biofuels; Solar Thermal Energy at low and medium temperatures; Hydrogen, Fuel Cells and Energy Storage Systems
- Nuclear energy: Nuclear Fusion; Nuclear Fission
- Climate and the environment: Environmental Characterization, Prevention and Recovery; Environmental Technologies; Energy and Environmental Modeling; Marine environment and Sustainable Development; Antarctic Expeditions and Research in Polar Areas
- Safety and health: Seismic Protection; Radiation Biology and Human Health; Radiation Protection; Metrology of Ionizing Radiation
- New technologies: Materials Technologies; Radiation Applications; Sustainable Development and Innovation of the Agro-Industrial System; ICT
- Electric system, research: Studies and research, under a Programme Agreement with the Italian Ministry of Economic Development, aimed at innovating the National Electric System to make it cheaper, safer and more environmentally-friendly.

Role of government

There are three basic organisations constituted to manage the energy issues in Italy.

The Ministry of Economic Development (MSE)

It is responsible for national energy policy.

Department of Energy

It is a new department under which function three different general directories of Energy and Mineral Resources, Security of Supply and Energy Infrastructures and Nuclear and Renewable Energy.

The Ministry for the Environment, Land and Sea

It is responsible for climate change policy co-ordination. Additionally, in co-ordination with the MSE it is responsible for the promotion and the development of renewable energy and for energy efficiency.

Government agencies

In addition to the ministries indicated before, the regions have the power to enact legislation, provided that it does not conflict with the framework principles adopted at state level. Nonetheless, energy infrastructure must be authorised by the competent ministries in agreement with the relevant region.

The Regulatory Authority for Electricity and Gas (Autoritá per l'Energia Elettrica e il Gas, AEEG) is an independent body established under Law no. 481 of 14 November 1995 to regulate and maintain oversight of the electricity and natural gas sectors.

The Competition Authority (Autorità Garante della Concorrenza e del Mercato, AGCM) is an independent authority established by Law no. 287 of 10 October 1990. In the energy sector, its main tasks are to examine claims made against abuse of dominant position and to review government and the Parliament on the impacts of possible market restricting on competition. A decision of the AGCM can be subject to appeal by the regional administrative court of Lazio and the Council of State.

Energy procedure

The market is operated by GME, a state-owned private company. An electricity market has been in operation since 2004, and it consists of the following:

- A spot electricity market, where energy blocks are traded over a period of 9 days prior to the date of delivery; the market operates on an auction basis as bids/offers are accepted under the economic merit-order criterion and taking into account transmission capacity limits between zones;
- A forward electricity market, where trading of base-load and peak-load contracts with monthly, quarterly and yearly delivery periods are carried out on a continuous basis, with GME acting as central counterparty; and
- A platform for physical delivery of derivative contracts concluded on the IDEX segment of the Italian stock exchange.

Energy regulator

The energy market is regulated by the Energy and Gas Regulatory Authority, the AEEG, an independent authority led by five commissioners appointed by the government with the approval of a 2/3 majority of the competent parliamentary commissions. The AEEG is responsible for, inter alia, overseeing access of market operators to the gas and electricity grids and storage facilities, setting tariffs for access to the gas and electricity grids, promotion of fair competitive practices, protecting consumers' interest, promoting market transparency and energy efficiency. The AEEG may issue regulations that apply to market operators, and orders and decisions affect single operators. The main sources of regulation in the energy market are state laws, regional laws and administrative regulations issued by the AEEG.

Degree of independence

Italy produces small volumes of NG and oil but most fossil fuels are imported and improved by local production energy from renewable sources. Import dependence is increasing and is particularly high for electricity. In 2008, imports net of exports accounted for 89 % of TPES. Compared to the OECD average, oil use is high (around 40 % of TPES in 2008), while coal use is low (around 9.7 % of TPES in 2008)

Regulatory framework

Though in the past the Italian energy policy was marked by the absence of a clear integrated long-term vision for the development of the sector, the new National Energy Strategy developed by the implementation of Law no. 99/2009 will expectedly provide Italy with a clear integrated long-term vision.

On 3 March 2011 the government approved Legislative Decree No. 28/2011, which provided a comprehensive framework for incentives for renewable energy going forward ('the Renewables Decree'). One of its effects was the reduction of the availability of the 3rd *Conto Energia* to plants commissioned on or before 31 May 2011. It led to the approval of the 4th *Conto Energia*, which provided for further cuts and introduced annual and cumulative caps in terms of additional installed capacity for larger plants commissioned after August 2011. Access to the feed-in premium by larger plants was granted or denied according to a ranking system based on several different criteria including the enrolment with a registry kept by GSE.

The 4th *Conto Energia* called for a review of the incentive scheme once the aggregate annual expenditures for feed-in premiums approached €6 billion. This amount is now being approached and on 12 April 2012 the government disclosed the terms of the draft 5th *Conto Energia*, which provides the incentives, now in the form of a feed-in tariff, from the earlier of 1 July 2012 until 2016, or the reaching of an aggregate cap in additional expenditure equal to €500 million.

Regulatory roles

The electricity and gas markets have both been liberalised in furtherance of the objectives set by the EU liberalisation directives enacted at the end of the 1990s.

In the electricity market, no licence is generally required to carry out generation, import, export, purchase, supply and metering businesses. The operation of the distribution grid is carried out by DSOs under a state concession regime. The transmission grid is a natural monopoly mostly owned and operated under a concession regime by Terna SpA, a publicly listed company.

In the gas market, no licence is generally required for production, import, and sales of natural gas. Storage, transport and distribution activities are operated under a concession regime.

The development and construction of new facilities (transmission lines, power plants and gas storage facilities) require permits mandated by state and regional legislation to ensure compliance with, inter alia, health and safety standards, environment protection and compatibility with existing infrastructure.

The process for obtaining such approvals is regulated by a combination of state and regional legislation and depends on the nature and location of the facility to be realised and of the permits required. The process is most often led by the regions, which coordinate the process involving all the agencies and authorities whose consent or opinion is required to finalise the permission process.

Energy regulation role

The energy and gas markets operate under market rules approved by the Ministry of Economic Development in consultation with the AEEG and as well as a number of technical rules issued by the GME.

The electricity markets and each of M-Gas, P-Gas and PB-Gas have their own set of market and technical rules. Market rules include criteria and procedures for admission of market participants, trading and settlement rules, as well as sanctions and sanctioning procedures in the event of a breach of market rules by or default by the market participants. GME is generally responsible for market operations and oversight as well as for the enforcement of market rules.

Regulatory barriers

Despite progress, Italy's renewables and energy efficiency policies have lacked a general long-term vision. Management of the incentive systems for energy efficiency and renewables involves a number of different agencies and institutions, which results in co-ordination difficulties and increasing transaction costs. There has been a multitude of overlapping measures, which have also changed several times within a few years. This has created unnecessary complexity and regulatory uncertainty, although recent measures have addressed some of these problems. In addition, the interaction between energy efficiency and renewables' incentives and the EU-ETS requires ongoing evaluation, as these initiatives could further depress the CO2 allowance price and lead to displacement of emissions. A long-awaited national energy strategy was released for consultation in 2012, and provides the opportunity to address all these issues in a comprehensive way.

Analysis of the national economic system and politics

Strength and weaknesses

In spite of the contraction of the GDP experienced in 2014, an important effective contribution to GDP comes from export that is based on a well-diversified structure; which grew by 0.4 % in 1Q 2014 while GDP fell by 0.1 % in the same period. The Italian manufacturing sector together with its strategic geographical position, are important strengths of its economic system. On the negative side, an economic structure based on a huge number of micro-enterprises (less than 10 employers) and SME (Small and Medium Enterprises) has made it very vulnerable to the actual crisis. Particularly, the number of micro-enterprises represents the majority of Italian companies, with a higher proportion than in the rest of UE; while the average size of Italian SME is around half of the German one.

As a consequence of the crisis, business insolvency is one of the main concerns of the business environment in Italy, bringing about a climate of non-confidence that has ended up producing the actual recession period.

The political stability gained in the elections of 2014, when Matteo Renzi got the powered; is a positive factor. But the excessive public debt (over the GDP) and the fiscal pressure on companies because of the problems at the banking sector contribute with the weak business environment.

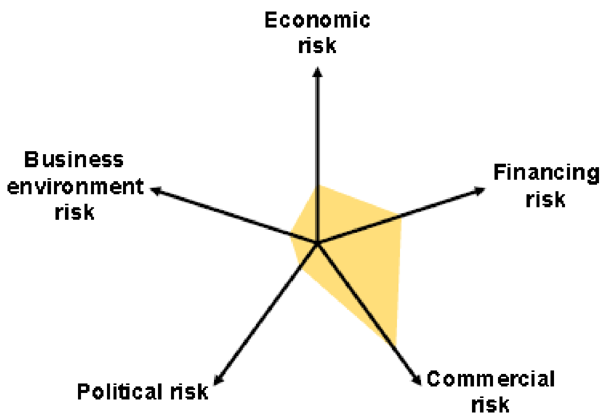

Figure A. 42. Risk dimensions estimated by Euler Hermes. Italy.

Economic structure

The diversification of the Italian economic system can be observed in its trading structure, where Germany is its main partner both for exports and imports representing respectively 13 and 16 % of its market, the EU sharing around 62 % of both imports and exports. The top five export and import partners of Italy don't shared half of its market, representing 41 and 43 % respectively.

Regarding products, the machinery sector is an important one in the Italian trading structure, since it represents 25 % of exports (1st position) and 16 % of imports (2nd position). Crude oil is the most important import of Italy, sharing the 22 % of it. Strategic sectors like metals, chemical products and transport represent important parts of the Italian market, sharing around

30 % in both import and export. Other sectors like plastics, textiles and foods share non-negligible fractions of imports and exports market, with around 15 % in both cases.

Economic forecast

After contracting during most of 2014, the economy is projected to return to growth by mid-2015 and accelerate somewhat further in 2016. ECB monetary policy support is expected to ease financial conditions and facilitate a resumption of bank lending, which should raise investment. The projected revival of Italy's export market will also support stronger growth. The overall impact of fiscal policy will be small in 2015, as tax cuts will be offset by spending reductions. Unemployment will begin to decline in 2016, but is set to remain at high levels, while wage gains look set to remain modest.

To support economic growth, the government has appropriately delayed fiscal consolidation and has completed some initial steps in its comprehensive programme of structural reforms. This programme, along with effective implementation of earlier reforms, needs to be pursued with determination if stronger growth is to be sustainable. The very high public debt ratio poses a significant vulnerability, and as growth improves higher tax revenues should be channelled entirely to deficit reduction.

Maps

Population

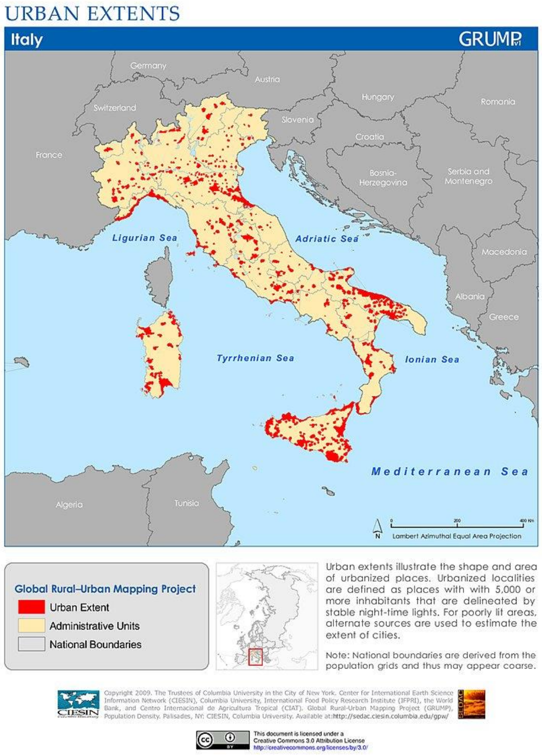

Figure A. 43. Italy population map.

DNI

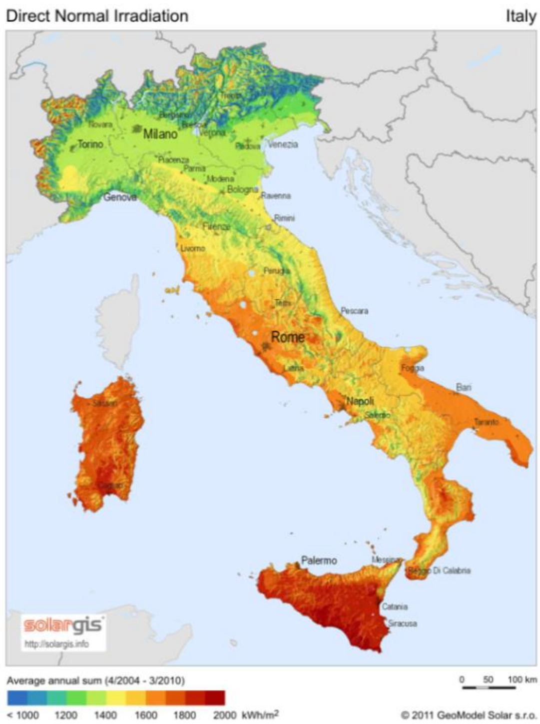

Figure A. 44. Italy Direct Normal Irradiation.

Electricity grid

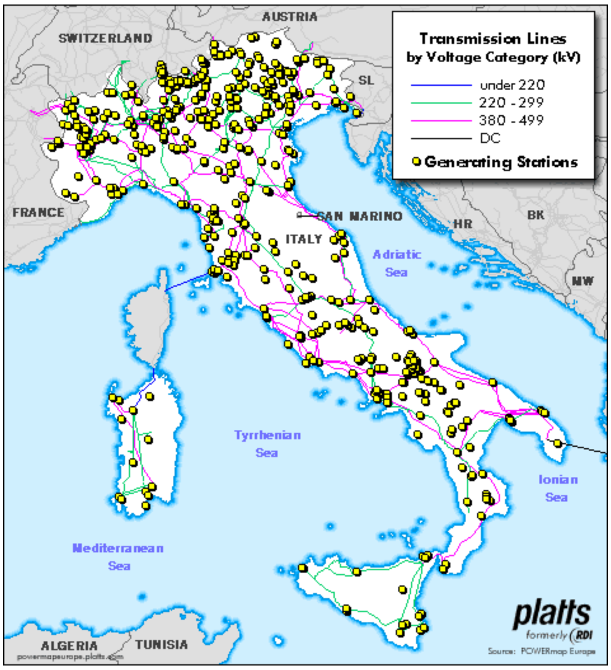

Figure A. 45. Italy electricity grid.

Maps overlapped

Figure A. 46. Italy overlapped maps.

Application of the method

- **GDP:** US$ 2071.31 Billion (in 2013)
- **Annual GDP Growth rate:** -1.85 % (in 2013)
- **Population:** 59.83 Million people (in 2013)
- **Annual population Growth rate:** 0.49 % (in 2013)
- **Annual electric consumption (per capita):** 5514.79 kWh (in 2011)
- **Government debt:** US$ 2715.14 Billion
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 1.22 % (in 2013)
- **Country rating (Euler Hermes):** A2
- **Annually averaged DNI:** 1346.93 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.3469	0.1214
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.8763	0.1753
Energy policy	0.10	0.6850	0.0685
Financial risk	0.10	0.7734	0.0773
		TOTAL	0.6925

Table A. 17. Farm arrangement. Italy.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.3469	0.1214
Demand	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.9350	0.0935
Financial risk	0.10	0.7734	0.0773
		TOTAL	0.4923

Table A. 18. Stand-alone configuration. Italy.

ANNEX 10. Kenya

Analysis of the national energy system

The electricity demand in the country is rising significantly mainly due to the accelerated investment in production sector and the increasing population. Historically, the energy demand has been positively correlated with the economic and population growth rates. Currently the electricity demand is reaching around 1191 MW, while an effective installed capacity, during the normal hydrology levels obtains 1429 MW. This gives a reserve margin of 238 MW or 20 % of demand. In other case, while Kenya is suffering from poor water reserves, the additional supply diminishes needing a load shedding and procurement of expensive emergency power. The peak load is expected to grow to about 2500 MW by 2015 and to 15000 MW by 2030. To meet this demand, the projected installed capacity should increase gradually to 19169 MW by 2030.

A study conducted by the Stockholm Environment Institute (SEI) about the economic impacts of climate change in Kenya (2009), found that the GHG emissions were relatively low, both in total and per capita terms. However, Kenya GHG emissions are rising quickly and the energy sector emissions are estimated to have increased not more than 50 % over the last decade.

Over 85 % of the population rely on traditional fuels such as wood, charcoal, dung, and agricultural residues for cooking and heating.

- Firewood remains the predominant fuel for cooking. Nationally 68.3 % of all households use firewood as their main sources of cooking fuel. Over 80 % of households in the rural areas rely on firewood for cooking compared to 10 % of urban households.
- Charcoal is the second most popular type of cooking fuel used by 13.3 % of households.
- Kerosene is ranked the third predominant cooking fuel, but is the most common type of fuel for cooking among 44.6 % of urban dwellers.

Reliance

Kenya relies heavily on imported petroleum for local consumption. In 2007, Kenya imported 57000 bbl/day of crude oil. The primary energy supply is dominated by indigenous biomass use, which mainly supplies households and SMEs (small and medium sized enterprises) in the country. Biomass supply is currently viewed as unsustainable.

To address the energy crisis, Kenya has increased the import of electricity from Ethiopia, which offers cheap prices and, since 2009, has good hydro-electric sites.

Extend network

It is estimated that in Kenya 77 % habitants do not have electricity connections. Moreover, the electrification rate is being 51 % and 4 % in urban and rural areas respectively. These small indexes are due to that inhabitants from urban and rural poverty are not reached by grid-based electrical power, as well as there do not exist adequate distribution of gas or other cooking and heating fuels.

The national grid is operated as an integral network linked by a 220 kV and 132 kV transmission network. There is a limited length of 66 kV transmission lines.

Capacity concerns

Kenya electricity mix is dominated by hydro generation (over 50 %), thus is highly vulnerable to weather conditions and climate change. The climatic conditions of 1998-2000 and 2008-

2009 curtailed hydropower generation and led to severe energy shortages, which culminated into power rationing.

A weak transmission and distribution network, low countrywide electricity access and over-reliance on hydropower, are main problems of electricity sector. To face these challenges the Government has formulated strategies, which aims to expand rapidly installed electricity capacity; expand and upgrade the transmission and distribution networks; and develop renewable energy sources such as geothermal, solar, wind, biomass and small hydro power.

Renewable energy

With average altitudes ranging from 1500 m to 1700 m, Kenya is rich in wind and solar energy resources.

Solar energy

Kenya receives daily insolation of 4-6 kWh/m^2. Solar utilization is mainly for photovoltaic systems (PVS), drying and water heating. The usage of Solar PV systems can be found in field of telecommunication, cathodic protection of pipelines, lighting and water pumping. Current installed capacity is approximately 4 MW. There are also approximately 140000 solar water heating systems installed in the country.

In the Nairobi suburb- Kibera, young Kenyans are producing small solar panels, which can generate enough electricity to operate a radio, and charge batteries of mobile phones. The price of such a panel is $US5, while the average income in Nairobi is around $US1 a day. For now on around 100.000 households are served with solar energy. The majority of these consist of a small 12-14 W photovoltaic panel.

Ownership of electricity

Kenya Electricity Generating Company (KenGen) is the leading electricity generator, providing over 70 % of the effective generating capacity to the national grid. The company is listed on the Nairobi Stock Exchange with 70 % shareholding in Government and 30 % private. Currently six independent power producers (IPPs) are operating in the country contributing approximately 30 % of the effective generating capacity to the national grid.

Kenya Power and Lighting Company (KPLC), is the national power utility responsible for electricity distribution and supply. It purchases power in bulk from KenGen and IPPs currently in operation through Power Purchase Agreements approved by the Energy Regulatory Commission.

Kenya Electricity Transmission Company Ltd (KETRACO) is a corporation entirely owned by the Government and mandated to plan, design, construct, own, operate and maintain high-voltage (132kV and above) electricity transmission infrastructure that will form the backbone of the national transmission grid and regional interconnection.

Competition

The competition market is at very low rate. KenGen generates over 70 % of the country power output, and is in direct competition with only 6 independent power producers, who between them produce about 30 %. On the contrary, there is no share in the distribution and transmission of electricity in the country. The monopoly is possessed by KPLC.

Despite the liberalization of the oil industry, there are only a few companies actively trading due to tariff and non-tariff barriers to entry.

Energy framework

Considering renewable energy development strategy, it is stipulated in several decrees. The majority is as follows: the Least Cost Power Development Plan (LCPDP), Rural Electrification

Master Plan, Sessional Paper No. 4 of 2004 (The energy policy document), the Energy Act of 2006, the Feed-in Tariff (FiT) Policy, the Kenya National Climate Change Response Strategy, Gender Audit of Energy Policies and Programmes in Kenya (June 2007) and Kenya Vision 2030 (the National economic development blueprint).

The LCPDP envisions that Kenya's electricity peak demand will increase from 1302 MW in 2011 to 15026 MW by 2030, in line with the Vision 2030, which envisages energy as a key enabler for economic growth across the country. Accordingly, through the Rural Electrification Master Plan, the Government seeks to have 100 % connectivity across the country through grid extensions and off-grid systems. To meet the increased electricity demand due to the enhanced economic activities, various generation sources have been considered, targeting 5110 MW from geothermal, 1039 MW from hydro, 2036 MW from wind, 3615 MW from thermal, 2000 MW from imports, 2420 MW from coal and 3000 MW from other sources. The investments required for generation, transmission and distribution to meet this demand are enormous.

As a measure of mitigation and adaptation to climate change, the Government of Kenya has been spearheading promotion of development and use of alternative sources of energy by developing the National Climate change Response Strategy of 2010. Kenya is pursuing an energy mix that greatly emphasises carbon-neutral energy sources such as geothermal, wind, solar and renewable biomass. In addition, the building codes are being reviewed to incorporate measures that will encourage climate-proofing and the construction of energy-efficient buildings.

The Kenya Vision 2030 is a long-term development strategy aiming at creating a globally competitive and prosperous economy. As a consequence Kenya will be transformed into a newly-industrializing, middle-income country providing high quality of life in a clean and secure environment. Simultaneously, the strategy aspires to achieve the Millennium Development Goals (MDGs) for Kenya by 2015. Infrastructure, including energy, is identified as one of enablers of the envisaged socio-economic transformation of the economy with a vision to provide cost-effective, world class infrastructure facilities and services.

In keeping with the Millennium Development Goals, Kenya is committed to reduce by half the number of people who are suffering from lack of access to modern energy services by 2015 and by half the number of people living in poverty. Access to affordable energy is an essential prerequisite to accomplish economic growth and poverty reduction in Kenya. The majority of people who rely on biomass for thermal energy and who require access to electricity are in rural areas. This problem affects especially woman and also girls, because of their traditional roles, household responsibilities, and low socio-political status. The Government, in collaboration with development partners, is expanding the access of electricity in rural areas through the rural electrification programme covering both grid extension and off-grid systems. Additionally, non-Governmental Organizations and the private sector, are promoting the growth of wood fuel as well as the efficient and sustainable use of biomass resources. The Government is also formulating a strategy to make the country *kerosene free* by replacing this fuel with renewable energy for lighting.

Under the Feed-in Tariff policy, a total of 2050 MW of capacity from 47 separate projects (13 small hydro, 16 wind, 6 biomass, and 1 solar) have been approved for development. Five of these have finalised their feasibility study. Also two power purchase agreements have been signed. The tariff itself varies depending on whether the power is firm or non-firm, and ranges from US$ 0.06/kWh to US$ 0.12/kWh, with a special rate of US$ 0.85/kWh applied for geothermal power. These tariffs are secured for 20 years.

Energy debates

The Government intends to set up a Green Energy Facility. It is supposed to be established under the National Task Force on Accelerated Development of Green Energy whose mandate is to promote and fast-track the development of renewable energy projects. The main tasks of this so-called facility are to pool donor contributions, helping finance Government equity participation and loan contributions. All of this in order to help firms and other institutions to develop clean energy projects. Furthermore, the Facility will lend funds to feasible projects at concessional rates. The Hybrid Mini-grid Project proposes to increase the proportion of renewable energy (solar and wind) in existing and planned mini-grids to 30 %. The Government has initiated incorporation of solar PV and wind systems in existing off-grid diesel power plants in arid and semi-arid areas to substitute part of the generation provided through fossil fuel. The proposed project would result in increased renewable energy in the system, as well as increased energy generation. The 'Scaling-UP Renewable Energy Program' funds would enhance the ongoing and planned hybrid projects. The private sector will be invited to participate in the hybrid projects under the Feed-in-tariffs in order to complement Government efforts in the program.

Energy studies

Technical & Economical Study for the Development of Small Scale Grid Connected Renewable Energy in Kenya

In general, the Government, with the assistance of the World Bank, seek to create a framework which will encourage greater RE investment. It aims to relieve the capacity constraint and allow more Kenyans to connect to the grid, while avoiding high tariff increases being imposed on existing electricity consumers.

Energy performance baselines and benchmarks; and the designation of industrial, commercial and institutional energy users in Kenya

The Energy Regulatory Commission (ERC) has established the Energy Management Regulations 2012 through the Energy Act 2006 that require energy efficiency and conservation measures to be put in place across facilities countrywide. This implies that energy performance benchmarks by which industries, institutions and commercial facilities will be graded against be developed in order to determine performance and compliance. Such benchmarks do not currently exist in Kenya. This study aimed to develop energy performance baselines and benchmarks using current and historical energy use data from energy audits and other statistical information. Industries have also been designated as high, medium or low energy consumers. The scope of the study was limited to industrial, commercial and institutional energy users.

Assessment of a net metering programme in Kenya

Net metering allows grid-connected electricity consumers who also generate their own power to store their electricity in times of over-production. The programme appliance is envisaged in all of the renewable energy sector, but with majority in solar PV. It is due to easier adjustment, maintenance, installation of the PV.

Project Design Study on the Renewable Energy Development for Off-Grid Power Supply in Rural Regions of Kenya

German Development Cooperation, through KfW (Financial Cooperation) and GIZ (Technical Cooperation), intends to assist Government of Kenya in promoting the development of new medium-sized hybrid mini-grids (PV-/Wind-Diesel) focused on nascent small and medium-sized growth centres. To assist in identifying and preparing this project, KfW Development Bank contracted Economic Consulting Associates (ECA) of the UK, in conjunction with Trama Tecno Ambiental (TTA) of Spain and Access Energy of Kenya to undertake this project.

Role of government

The Ministry of Energy is in charge of development and implementation of energy policy. In addition, the Ministry is partly responsible for the operation of the state-owned utilities in the country, and the Rural Electrification Program.

Government agencies

The Renewable Energy Department under the Ministry of Energy

It has the mandate of promoting and developing appropriate renewable energy technologies. It also plays a lead role in renewable energy policy formulation, review and analysis.

Rural Electrification Authority (REA)

Under the Energy Act 2006, the REA is mandated to develop and update the rural electrification master plan and promote of the use of renewable energy sources. The authority reports to the Ministry of Energy.

Geothermal Development Company (GDC)

It is realizing the need to reduce the long gestation periods in the development of geothermal projects; the Government has set up the GDC to undertake integrated development of geothermal through initial exploration, drilling, resource assessment and promotion of direct utilization. The GDC is 100 % owned and funded by the Government. By undertaking the initial project activities, GDC will absorb the attendant risks associated with geothermal development and therefore open up opportunities for both public and private participation.

Energy procedure

The Climate Investment Funds (CIF) have approved funding for Kenya investment plan to scale up and develop its renewable energy sources, which will enhance their energy security, increase electricity access, reduce supply costs and bring socioeconomic benefits to local communities.

It is expected that the US$50 million grant will aid in catalysing private sector financing, decrease market risks and absorb many of the high start-up costs associated with renewable energy. The plan, which obtained funding through CIFs "*Scaling Up Renewable Energy Program in Low Income Countries*" (SREP), was developed to overcome the economic, financial and technical barriers that have hindered Kenya in exploiting its solar, geothermal and wind resources. Kenya has also made a number of institutional and policy reforms, which will assist in catalysing the market.

With the guidance of the African Development Bank (AfDB), Kenya is preparing to construct a geothermal plant that will provide a quarter of total energy demand by 2018. The project is the first to be solely developed by Kenya newly established Geothermal Development Company, which will be primarily responsible for developing Kenya geothermal resources. The power produced will be fed directly into Kenya national grid. The SREP funding is also expected to fund capacity building initiatives.

As part of the Kenya power development plan, a target of 300 MW of co-generation capacity is about to be obtained by 2015, while by 2011 only one fifth of this amount has been produced. It leads to conclusion that a lot of investments awaits. Nevertheless, a photovoltaic (PV) manufacturing facility was established in 2011, producing PV modules ranging from 13 Wp to 125 Wp.

Energy regulator

The Energy Regulatory Commission (ERC), which came into effect in July 2007, was formerly the Electricity Regulatory Board established under the Electric Power Act of 1997. The ERC is responsible for the economic and technical regulation of electric power, renewable energy and downstream petroleum sub-sectors.

Degree of independence

The chairperson of the ERC is appointed by the president. The Minister of Energy appoints the seven commissioners of the ERC. Independence of authority is listed as a core value of the

Commission. Financing comes from government stipends and tariffs imposed on electricity, petroleum, and other sources.

Regulatory framework

The Sessional Paper No. 4 of 2004 and Energy Act of 2006 are the policy and legal frameworks for energy development in Kenya. Through these acts, the Government is committed to promoting electricity generation from Renewable Energy Sources (RES). In addition, a Feed-in-Tariffs (FiT) Policy has been formulated to promote RES and improve the rating of Kenya's renewable energy sector as an attractive destination for substantial private sector investment. Under the FiT system, investment security and market stability for investors in electricity generation from RES is provided whilst encouraging private investors to operate their power plants prudently and efficiently to maximize returns. This will facilitate the exploitation of the abundant RES available in the country. The FiTs were introduced in 2008 and revised in 2010 to accommodate additional RES and review the tariff prices.

The Government has a zero-rated import duty and removed VAT on renewable energy, equipment and accessories. The ERC has prepared Solar Water Heating Regulations. These steps are intended to mitigate the challenges faced in exploiting the solar energy resource.

Regulatory roles

The Energy Regulatory Commission is mandated to:

- Regulate all forms of energy.
- Protect stakeholder interests.
- Maintain a list of accredited energy auditors.
- Ensure principles of fair competition.
- Provide information to the Minister of Energy when required.
- Collect and maintain energy data and prepare a national energy plan.

Energy regulation role

The Ministry of Energy is responsible for overseeing the actions of the ERC, without direct involvement. The ERC is responsible for aiding the Ministry in the formulation of national energy policy with statistics and information as necessary.

Regulatory barriers

Insufficient data on renewable energy (RE) resource availability, potential and utilization:

- Lack of coordination among RE stakeholders and regulatory authorities.
- Lack of specific RE Policy, regulations and technical standards.
- Limited trained and qualified personnel to implement and support RE initiatives and technologies.
- Lack of appropriate and affordable financing option or knowledge thereof.
- Maintaining competitive, efficient and equitable tariffs especially for green energy projects.
- Attractive incentives to mobilize investments in energy infrastructure projects.
- Delivering committed projects on time and within budget.

Analysis of the national economic system and politics

Strength and weaknesses

The Kenyan economy depends on two pillars: the horticulture and the tourism sectors, the latter being certainly volatile. However, the intense domestic market helps to give stability to the economy, as well as the fact that Kenya belongs to the East African Community, which is expanding and offers good business opportunities. Moreover, the energy sector has an enormous potential, regarding both direct and indirect resources. Directly, because of Kenya is not an oil and gas producer, the country counts on transferred reserves. And indirectly due to its strategic geographical situation, which leads Kenya to be viewed as important transit country in East Africa Community. As consequence, the nearby countries depend on crude oil and refined products imported to Kenya's Mombasa Port.

However, the business environment in Kenya is surrounded by uncertainties. Firstly, the rivalries in terms of politics, ethnics, tribal and religions has provoked violent conflict similar to the one from 2008. Continuing the unstable business market is also caused by Somalian pirates and terrorist activities. Another important weakness of Kenya's economy is the strong dependency on external assistance, since it is classified as a low income economy by the World Bank.

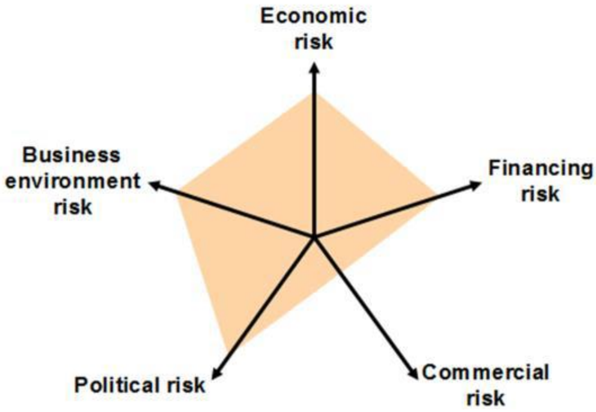

Figure A. 47. Risk dimensions estimated by Euler Hermes. Kenya.

Economic structure

Kenya is one the most developed country in East Africa. Agriculture is being the majoritarian sector regarding export, sharing around 50 % of the market, especially Tea and Flowers. The remaining 50 % is very dispersed, with partial contributions of the 2nd (foods), 3rd (textiles) and 4th (chemical products) sectors around 7 %. The importation market is dominated by strategic sectors more equally shared: Crude oil (20.3 %), Machinery (16.6 %) and Transport (10.5 %).

Africa and Europe are the principal destinations of Kenya's production accumulating 75 % of this market. Two neighbouring countries are the best partners of Kenya: Uganda and Tanzania, the top 5 list being completed with Netherlands, UK and US. However, Asia is the main provider of Kenya, sharing 63 % of importations. India and China share around 50 % of the market and South Africa, Japan and UK are the 3 principal origins for Kenya's economy.

Economic forecast

Although nowadays there is a certain politic stability in Kenya, it has sickened because of ethnic, tribal, religious divisions and other nature problems. . It constituted a great impact upon the economy, for instance the GDP growth rate has been unstable, obtaining peaks and valleys throughout the years. Finally, its maximum was noticed in the end of 2010. Even though, the GDP growth rate has always been positive, and in particular, since 2010 is over 4 %, for 2014 being 5.5 %. Some experts, point out growth over 5 % for this country, or even higher due to the domestic sensation of political stability since 2013. In spite of the optimistic prognosis, the terrorist threat in Kenya should be taken into account. Also the volatility of the main economic sectors (mainly agriculture that represents 50 % of exports) is another reason to be cautious about.

Maps

Population

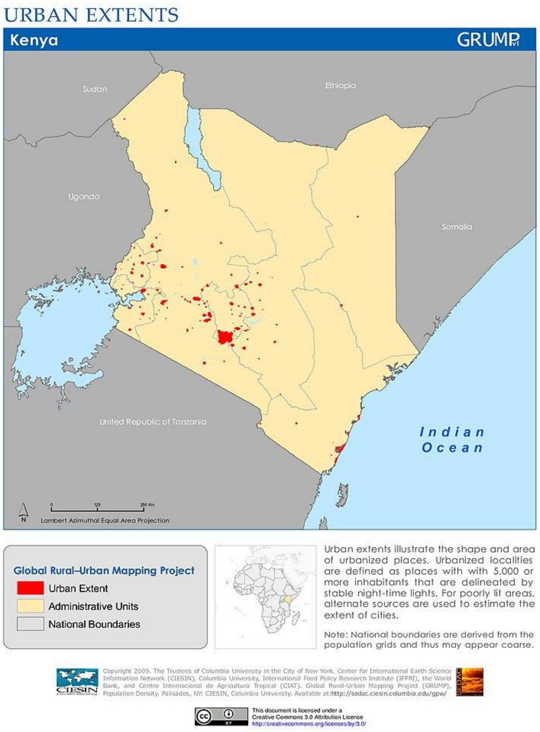

Figure A. 48. Kenya population map.

DNI

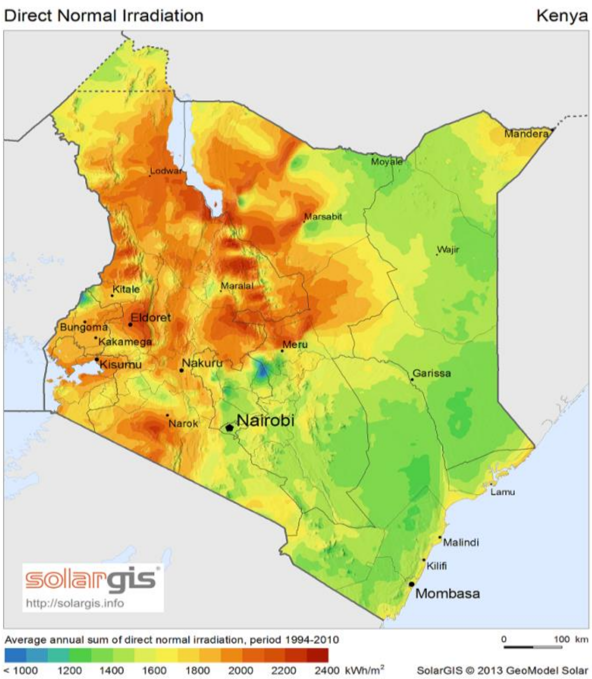

Figure A. 49. Kenya Direct Normal Irradiation.

Electricity grid

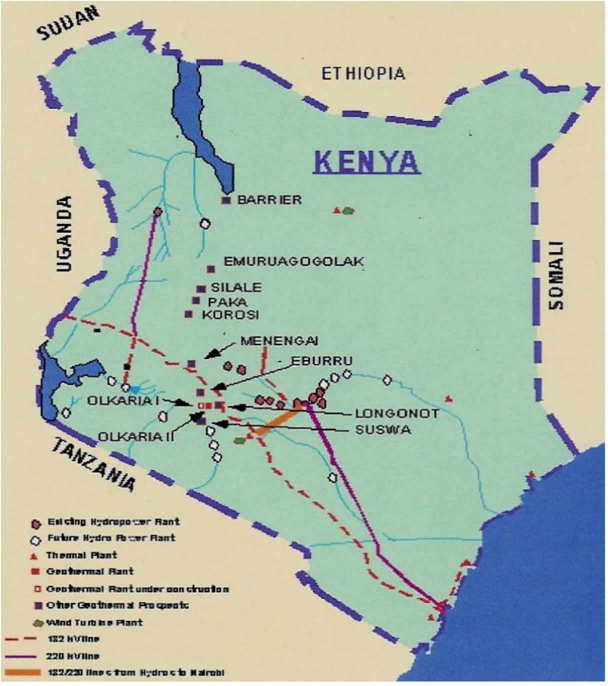

Figure A. 50. Kenya electricity grid.

Maps overlapped

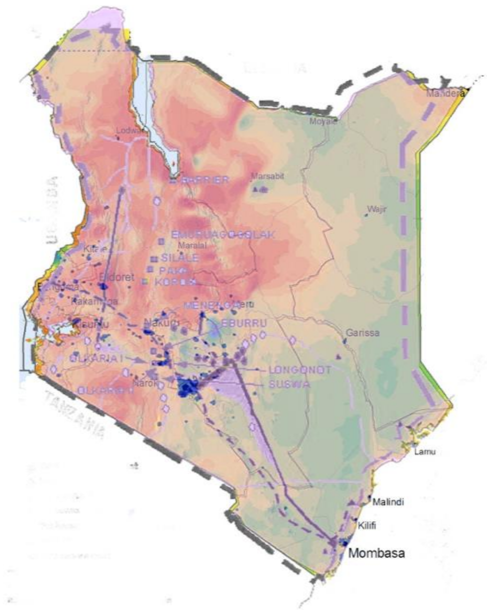

Figure A. 51. Kenya overlapped maps.

Application of the method

- **GDP:** US$ 55.24 Billion (in 2014)
- **Annual GDP Growth rate:** 5.50 % (in 2014)
- **Population:** 44.35 Million people (in 2014)
- **Annual population Growth rate:** 2.71 % (in 2014)
- **Annual electric consumption (per capita):** 155.02 kWh (in 2011)
- **Government debt:** US$ 28.56 Billion 51.7 % GDP
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 6.02 % (in 2014)
- **Country rating (Euler Hermes):** C2
- **Annually averaged DNI:** 1606.27 kWh/m^2
- **Population with access to electricity:** 19.20 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.6063	0.2122
Demand	0.25	0.1741	0.0435
Electricity grid	0.20	0.1943	0.0389
Energy policy	0.10	0.7587	0.0759
Financial risk	0.10	0.2812	0.0281
		TOTAL	0.3986

Table A. 19. Farm arrangement. Kenya.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.6063	0.2122
Demand	0.25	0.7325	0.1831
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.5584	0.0558
Financial risk	0.10	0.2812	0.0281
		TOTAL	0.6793

Table A. 20. Stand-alone configuration. Kenya.

ANNEX 11. Libya

Analysis of the national energy system

Libya in comparison with other North African countries (Algeria, Egypt, Morocco and Tunisia) is not very populated, does not have extensive agricultural potential or a well-established industrial base. However, it does have abundant energy resources. Given its small population (6.5 million in 2010) and its large oil and gas reserves, the energy situation in Libya resembles the small oil-exporting Gulf countries more than its North African neighbours. The oil sector provides about 70 % of GDP, having risen from 50 % in 2002 in line with rising oil prices.

Continuing, electric power is produced from 30 power stations, which are largely oil-fuelled steam turbines, even though there are a handful of gas-fired plants, and some turbines converted to gas to increase oil capacity available for export and other uses. The peak load in 2006 was 4005 MW, indicating that a comfortable buffer existed between capacity and demand. Electricity consumption per capita in 2009 was 4068 kWh, far above the North African average. Total electricity generation in the same year was 30426 GWh.

After the civil conflict and revolution of 2011, the majority of energy infrastructure in Libya remained intact. Crude oil and natural gas exports fell naturally during the conflict, though some analysts predicted only two-year decline of production of both resources. It is foreseen that after this period it will maintain at pre-revolution levels, predominantly due to efforts made on both sides in the conflict to protect the crude oil/natural gas production and distribution infrastructure.

Reliance

Libya imports certain oil products such as gasoline due to its outdated refining sector, but it is a net exporter of energy sources by a vast margin. Total crude oil exports in 2009 were 53123 ktoe, with 5812 ktoe of refined products being exported in the same year. Natural gas exports in the same period were 7488 ktoe. With the country holding the largest crude oil reserves in Africa, the domestic oil market is likely to remain export-focused for the foreseeable future. Electricity imports in 2009 were 73 GWh, whilst exports reached to 124 GWh.

Extend network

The electrification of all Libyan towns and cities reached almost 100 % of the population as of the year 2005. The Libyan grid is connected to Algeria, Egypt and Tunisia, which have further connections to other networks in Turkey and Morocco with onward links to Europe. The national power utility has indicated that power links with these countries may be developed further, including DC links to European networks, particularly Italy.

The Libyan power grid comprises of roughly 1037 km of 400 kV lines, 13548 km of 220 kV transmission lines, with 20634 km of 66 kV and 30 kV lines, and 32000 km of 11 kV distribution lines.

Capacity concerns

Almost 80 % of the electricity consumed is based on oil. An important goal is to alleviate the dominance of oil-based power production by constructing new natural-gas fired power plants. This would, at the same time, serve the objective to renew the national power generation infrastructure. According to power inspection from 2003, about two-thirds of the installed power generating capacity was more than 20 years old. Hence, the efficiency of the already installed power plants is far below the OECD standard. Moreover, in 2006, the average conversion efficiency of Libyan thermal power plants was less than 29 %. Compared to the most industrialised countries it is far below the average (36-40%). It also contributed to transmission and distribution losses, which in 2009 stood at 14 %.

In addition the noticed blackouts in 2004, that were caused by unassimilated generators led to interest in increasing power capacity.

Whilst power infrastructure has mostly been maintained by post-revolution government (with a limited level of destruction, which is being quickly repaired) the nation power grid is still a target for dissenting elements of Libyan society, particularly loyalists to the former dictator.

Renewable energy

At present, Libya is preparing many projects to use renewable energy sources. As it comes to wind energy, it was utilized for water pumping in many oasis since 1940. However, it was not developed extensively due to lack of sufficient wherewithal. The country has a great potential to use wind and solar energy. There has been commissioned Renewable Energy Authority of Libya (REAOL) to manage the RE situation in the country. Currently it is envisaged to obtain the 10% share of RE by 2020.

Solar energy

The solar regime in Libya is excellent; the daily solar radiation on the horizontal plane reaches 7.5 kWh/m^2, while 3000-3500 hours are clear sunny days a year. In spite of, the problem is that 88 % of Libyan land area is considered desert, and much of this is relatively flat. Moreover areas with excellent solar characteristics are lacking of water access. Nevertheless, the lands near the coast can be considered as a potential space for the solar installations, even though the solar regime is less favourable. As in 2006, 1865 kWp of PV capacity were installed in Libya and the amount is increasing significantly, in particular the decentralised electricity generation in rural areas is being encouraged. PV systems are also used in agriculture to supply water pumps with electricity instead of using diesel.

Ownership of electricity

The General Electricity Company of Libya (GECOL), the state-owned electricity company, is responsible for power generation, transmission and distribution in Libya. The company owns 100 % of the long-range transmission grid and 90 % of the distribution grid. GECOLs power plants produced 25.5 TWh in 2007.

Competition

There have been previous attempts to liberalise the sector by preparation of law, which provided the legal unbundling of GECOL into companies for generation and transmission, along with several distribution companies. Also it stated for creation of a regulatory agency, allowance for the participation of private power producers in generation and operation and maintenance contracts with private contractors. However, this law was never submitted to the legislature, which can be recognised as a very unfortunate decision for private sector and the country itself. Such industrial reform would have been helpful for renewable energy, RE, as it would have created a clear legal framework for independent power producers (IPPs) under which a power purchase agreement might be signed with the transmission company. However, in the current situation, the electricity market in Libya is entirely under the purview of GECOL, the state-owned, vertically-integrated national utility. The monopoly that the NOC holds over the up- and down-stream oil industries is also total.

Energy framework

The Renewable Energy Authority of Libya (REAOL) has created a RE roadmap up to 2030, that has been approved by the former Ministry of Electricity and Energy. The long-term plan envisage to cover 25 % of the Libya energy supply by RE by the year 2025, rising up to 30 % by 2030. Intermediate targets are 6 % by 2015 and 10 % by 2020. Other targets have also been set for electrical generating capacity from renewable resources, which are meant to be 10 % by 2020, and 30 % by 2030.

There is no formal government procedure for ensuring that physical development of infrastructure and buildings follows an energy efficient and sustainable path. The Libyan "*Five Points Company for Construction and Touristic Investment*" has announced that it will sign a contract with the Gulf Finance House to build an "*Intelligent Energy City*" in Libya, at a cost of US$5 billion. Libyan institutions will bear 40 % of the cost, and the Gulf Finance House 60 %. The project will contain centres for databases, environmental assessment and RE, in addition to special compounds for oil and natural gas producing companies, energy sector services and manufacturing industries. Whether this development will actually occur, given the present financial climate and the recent political instability, is uncertain. The lack of concern for EE in transport and spatial planning is another factor to be considered in the future energy plan of the country.

Energy debates

There is no energy efficiency law in Libya. Some considerations regarding energy efficiency were included in a previous draft electricity law, but this law never reached the statute book and was withdrawn when the Ministry of Energy was disbanded. It is understood that a new law on energy efficiency is in preparation, but its contents are as yet uncertain.

Currently, the majority of energy development in the country is focused on re-establishing normal, pre-conflict grid operation, and re-establishing oil production, to return exports (which account for the majority of the foreign revenue) to pre-conflict levels.

Energy studies

Libya is a member of the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE), formally established in 2008 as an independent regional think tank based in Cairo, dedicated to the promotion of RE and EE and formed by 10 North African countries. In the current start-up phase the Centre is financed by Denmark (DANIDA), Germany (Federal Ministry of Economic Cooperation and Development), the European Union and Egypt. Amongst the activities of the RCREEE one can find: promotion of RE and EE by means of policies including the formulation and dissemination; support for the development of new technologies in the fields of RE and EE; and encouragement of the private sector to actively participate in the development and production of RE and EE.

Libya is also a member of the Arab Maghreb Union, and is hence involved in COMELEC, the regional power project aimed at increasing inter-connection between the Maghreb states, as well as further development of inter-connections with Europe for the purposes of power trading.

Role of government

Prior to the 2011 revolution, the institutional setting was not favourable for sustainable long-term policies and strategies. In 2008, the Ministry of Electricity and Energy was disbanded, and its responsibilities shifted to the Energy Council. Formally established by the Prime Ministerial Decision of 8 September 2009, the Council is chaired by the Prime Minister and is confirmed by the Ministers of Industry and Economic Development, Planning and Finance, and Municipalities together with the Chairmen of the Environmental General Authority, REAOL, GECOL, the NOC, the Atomic Authority, the Solar Energy Research Centre, the Libyan Bank and the National Security Council. The Ministry of Transport is a noticeable omission. The Council is to meet every three months.

The Energy Council has the mandate to organise the broad range of all energy matters. It serves as a mechanism for decision making in areas where inter-ministerial cooperation is crucial, e.g. strategy and pricing. It also performs tasks that would normally be done by a Ministry of Energy which, as mentioned, has been suppressed, e.g. structuring of the sector, investment management, and the provision of information. Lastly it micro-manages the operating entities, creating conflicts of function, risks of confusion and delays. Generally, the policy-making process lacks transparency and inter-institutional communication structures.

It is currently unclear whether the Energy Council is still functioning within the post-revolution government. The initial plan of the National Transitional Council for governance during the transitional period does take into account the continued existence of public utilities, hence it can be inferred that the majority of the former government organs were to be maintained through the transitional period.

Government agencies

The Renewable Energy Authority of Libya (REAOL)

It was established in 2007 as a management of research and planning the introduction of renewable energy. The authority has been provided with US$ 487 million of funding for the period until 2012. The REAOL' current target is to achieve a 10 % share of energy from renewable sources in the energy mix by 2020, from recent negligible levels. It was originally a solar research centre within GECOL. The GECOL was asked by the government to develop proposals for concrete projects concerning renewable energy, and so the research centre was upgraded to a Department within the GECOL. Subsequently the Department was separated from the GECOL and became a dedicated agency depending on the Ministry of Electricity. Afterwards the Ministry of Electricity was suppressed and the REAOL (along with other agencies such as the GECOL) was transferred to the direct supervision of the General Peoples Committee for Electricity, Water and Gas. The Centre is responsible for research studies on solar energy and wind. It has no direct policy role.

The Centre for Solar Energy Studies (CSES)

It is based in Tripoli, and performs studies and research programs in the field of solar energy, and promotes use of both PV and solar thermal technology within the country. Its main objectives are to promote and perform solar desalination projects, as well as the research and development of solar water heating technology in the country. The organisation works closely with GECOL in the promotion of PV technology, in particular.

Energy procedure

The National Plan was set up to focus on renewable energy development and provide funds for the REAOL. Furthermore, no investments are foreseen other than a wind plant at Dernah. The plan is essentially indicative. Budgets for entities funded through the Plan are allocated annually. This makes long-term planning very difficult. It is likely that preparations for the subsequent plan will be postponed, until the current issues of governance are solved.

Currently a new draft electricity law is in preparation. It is aimed to have similarities to the Egyptian one. In spite of containing explicit provisions for RE and EE, it appears to be that these two topics may be removed from the draft and treated later in special purpose laws. The strategy will purportedly restructure REAOL to take care of EE as well as RE, and will distribute any physical assets of REAOL into a separate company. It is in order to avoid conflicts of interest between regulatory and commercial functions.

The REAOL prepared a medium-term plan (2008-2012) to promote RE in Libya and to meet these targets. The Plan was addressed to projects in solar and wind and stimulating local manufacture of equipment for RE. This plan comprised several wind farms with a total proposed capacity of marginally less than 1 GW, including:

- The Dernah wind farm (120 MW in two stages).
- The Al Maqrun wind farm (240 MW in two stages).
- Western region farms at Meslata, Tarhunah and Asabap (250 MW).
- South Eastern region wind farms at Gallo, Almasarra, and Alkofra, Tazrbo (120 MW).
- South Western region wind farms at Aliofra, Sabha, and Gatt, Ashwairef (120 MW).

The solar component includes PV and solar thermal technology:

- Three large-scale PV plants connected to the grid at Aljofra, Green Mountain, and Sabha (5-10 MW each).
- Extending the use of PV technologies in remote areas (2 MW).
- 1000 PV roof top systems for residential areas (3 MW).
- A feasibility study for a CSP plant in unspecified location (100 MW).
- The development of a joint venture with local and foreign investors for the manufacture of solar water heaters for the local and export markets (40.000 units/year).
- The development of a joint venture with local and foreign investors for the assembly of PV systems (50 MW).

However, these RE targets and strategy do not seem to be fully shared by all involved parties, despite the approval of the target by the Cabinet. The lack of consensus means that the REAOL programs and targets may not be realised on the time-scale envisaged.

Libya is currently involved in the planning of a number of regional interconnection projects, being located in a unique geographical position between Europe, North Africa and the Middle East. Considerations include several options, which are: submarine connection (500 kV DC) with Italy under the Euro-Maghreb interconnection project; a second 400/500 kV AC overhead line to increase interconnection capacity with Egypt; and a third, 400 kV line connecting the country with the Tunisian power network.

Energy regulator

There is no regulatory agency in the country. The Energy Council was responsible for all operations in the sector, including such regulatory measures as are necessary for the operation of the sector, prior to the 2011 conflict.

Degree of independence

The Energy Council was conformed entirely by government agencies and was chaired by the Prime Minister. Funding for the council and its constituent members came directly from the national budget, and operating revenues of the involved government companies.

Regulatory framework

There is no legislation covering financial support for renewable energy, and addressing the issue of the additional costs of renewable energy compared to the least cost alternative should be investigated. Furthermore, there is no clear legislative basis for the participation of private capital in the power sector. Current drafts of the electricity law are hypothesised to contain measures for the promotion and financing of RE and EE, but no definite measures are currently in place.

Regulatory roles

The Energy Council was responsible for all activities in the energy sector prior to the 2011 revolution, including regulatory functions for both the oil and electricity sub-sectors. Previously, under the former Ministry of Energy, tariff- and standards-setting was the responsibility of the respective national utilities. Since the establishment of the Energy Council, responsibility for these activities has been transferred directly to the government, and current trends appear to suggest a more state-oriented regulatory approach for the future.

Energy regulation role

The tasks of the Council included:

- Preparing and suggesting policies and strategies for the energy sector, and to promote coordination among stakeholders.
- Developing the energy sector structure.
- The establishment of policy to manage demand.
- Establishing a strategy for pricing.
- Collecting available information.
- The evaluation of sources of energy, especially solar.
- Energy forecasting.
- Establishing procedures for investment in the energy sector.
- The approval of contracts with foreign companies.

Regulatory barriers

Previously, government entities in the energy sector formulated policy independently and pursued their own interests, with little consideration for co-operation. The NTC appears to be firmly committed to changing this, taking such measures as to release revenue statistics from national oil sales for transparency purposes, in mid-2011. However, whilst the situation in the country is improving, the current lack of a coherent government precludes the ability to formulate policy for the energy sector, and the establishment of a stable and accountable body responsible for the energy sector is a vital first step to regulatory reform in the country.

Analysis of the national economic system and politics

Strength and weaknesses

The main weakness of the Libyan economic system is its export market, which relies on oil almost entirely (99%). The remaining sectors are just anecdotic. The GDP growth rate has mostly been positive until the revolution (2011), which contributed to its decline. This strong dependency on oil brought about economic recession due to disruptions of oil production, which was the consequence of protests at the main oilfields and export terminals.

Regional and tribal issues imply additional difficulties to a stable social atmosphere and the military control of politics, the low presence of institutions and the infrastructure limitation contribute to create a non-confidence business environment.

On the positive side it must be mentioned the immense natural resources of the country and its strategic location, which could favour a rapid growth with the corresponding political and institutional stability.

Economic structure

Apart from export, the majoritarian import sector is refined petroleum, with a contribution of around 19 %. The top five list of import markets in Libyan is completed with Machinery, Transports, Foods and Agriculture, with contributions of 15, 10, 7 and 7 % respectively, thus sharing around 68 % of total imports.

Also regarding countries and continents, the import market is more diversified than the export one, since Europe shares 79 % of exports and 49 % of imports, whereas Italy being the main partner in both cases. After Italy, the main country markets for Libyan exportations are Germany, China, France and Spain, while for importations are China, Turkey, Egypt and South Korea.

Economic forecast

The strong dependency of Libyan economy onto the European markets and the deceleration expected for this continent will penalize the economy of this country. On the other hand, there are initiatives to restore social stabilities by drafting a new constitution, formulating strategic policies for non-oil economy and diversifying the economic sectors, which potentially will bring about a more comfortable social, political and business ambient. However, there are no promoting renewable policies; it seems likely the existence of them in a mid-to-long term scenario, with the consolidation of institutions.

After the GDP sharp fall to -12.6 %, there have been made steps to increase growth rate in 2014. It was estimated to obtain 23 % and further to grow around 5% consequently through the next three decades.

Maps

Population

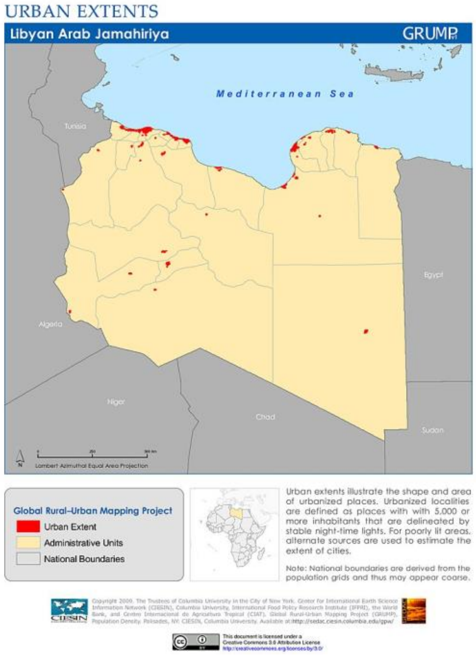

Figure A. 52. Lybia population map.

DNI

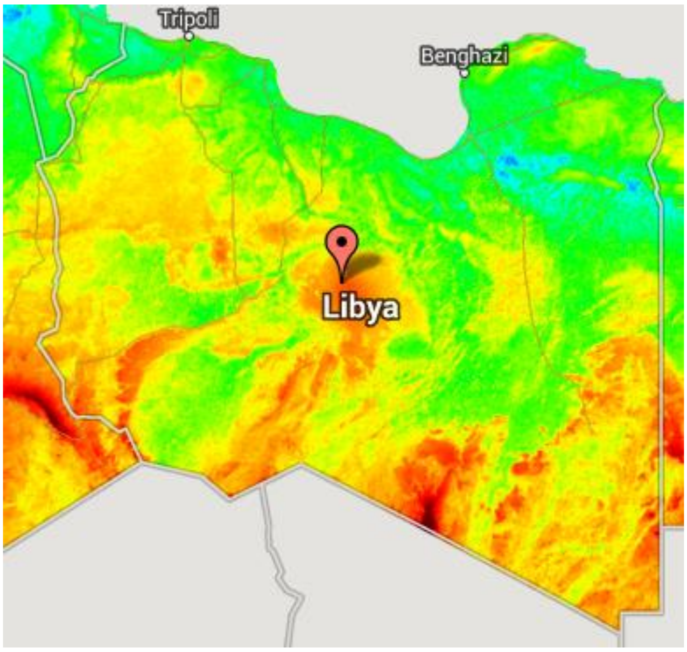

Figure A. 53. Lybia Direct Normal Irradiation.

Electricity grid

Figure A. 54. Lybia electricity grid.

Maps Overlapped

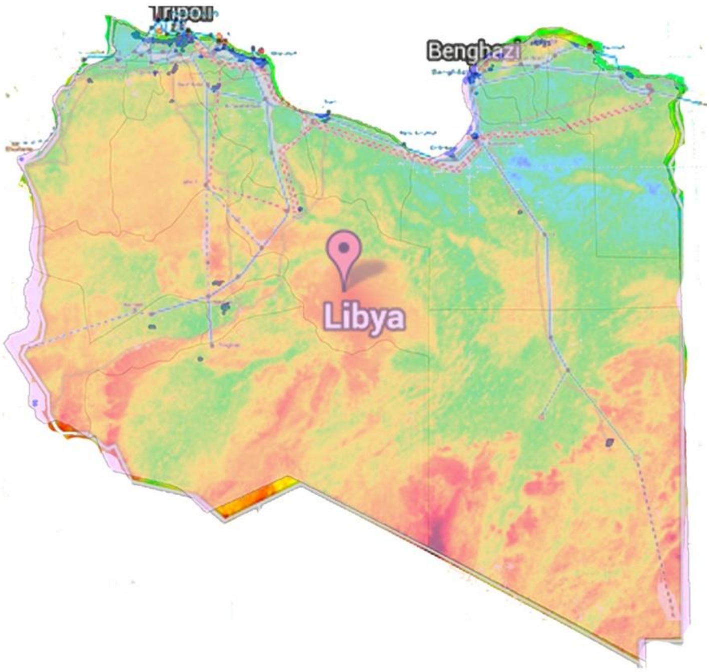

Figure A. 55. Lybia overlapped maps.

Application of the method

- **GDP:** US$ 75.46 Million (in 2014)
- **Annual GDP Growth rate:** -12.06 % (in 2014)
- **Population:** 6.20 Million people (in 2014)
- **Annual population Growth rate:** 0.81 % (in 2014)
- **Annual electric consumption (per capita):** 3926.44 kWh (in 2011)
- **Government debt:** US$ 5.13 Million, 6.8 % of GDP (in 2014)
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 2.4 % (in 2013)
- **Country rating (Euler Hermes):** D4
- **Annually averaged DNI:** 2189.66 kWh/m^2
- **Population with access to electricity:** 99.8 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.6165	0.1541
Electricity grid	0.20	0.7785	0.1557
Energy policy	0.10	0.2500	0.0250
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.6848

Table A. 21. Farm arrangement. Lybia.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0012	0.0003
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.6003

Table A. 22. Stand-alone configuration. Lybia.

ANNEX 12. Mexico

Analysis of the national energy system

To begin with the general trend in thermal generation in Mexico is a decline in petroleum-based fuels and a growth in natural gas and coal. Given that Mexico is a net importer of natural gas, higher levels of natural gas consumption (i.e. for power generation) are likely to depend upon higher imports from either the United States or via liquefied natural gas. According to year 2009 the national consumption of electricity reached 201.1 TWh of which residential sector took 49.21 TWh. Furthermore, the commercial and public services sector demand was rising to 21.40 TWh per year, which is 10.6 % of the total electricity consumption of the country. Industry is the main consumer and can be divided into large industries and medium-sized businesses. The latter are authorized to produce their electricity supply. Taking into account government installed power plants, 58.2 % were thermal plants and 28.8 % hydraulic. Moreover Mexico has a single nuclear power plant, the 1400 MW nuclear reactor, “Laguna Verde” which is operated by CFE (Federal Committee of Electricity).

In 2008 primary energy production was 10522 PJ, oil-generated (89.9 %), hydraulic energy (4.4 %), biomass (3.3 %) and coal (2.4 %). Mexico primary energy structure is made up of coal, oil (crude and condensed), natural gas, nuclear energy, hydraulic, geothermic wind and biomass (bagasse of sugar cane, wood and forest waste). The main secondary energies are coke and the liquid gases from oil, gasoline, naphtha, kerosene, diesel, gasoil, dry gas and electricity.

The state company Petroleos Mexicanos (PEMEX) is the sole producer of the oil and gas resources largely found in the sea of the Gulf of Mexico and the coastal land areas adjacent to the Gulf. Between 2000 and 2004, the average annual oil production (crude, naphtha and condensed) was more than 3000 barrels a day. From 2005 onwards there was a slight reduction in crude oil production and in 2008 it was down to 2793 barrels a day, an 8.3 % drop on that recorded in the previous year. At the current rate of production the known reserves of crude oil will be exhausted in about nine, while natural gas is expected to hold on one year longer. .

Reliance

In 2007, Mexico produced 173 million tonnes of crude oil, representing the 4.4 % of the total production in the world. As of 2009, Mexico is a net exporter of crude oil. Before in 2006, the country exported 99 million tonnes of crude oil. Unless new sources of oil are found, Mexico might become a net oil importer by 2018. Despite its status as one of the world’s largest crude oil exporters, the lack of downstream refining capacity forces provoked the country being a net importer of refined petroleum products. Approximately 80 % of all refined petroleum and 25 % of gasoline and diesel fuels are imported from the United States. Petroleum products imports have undergone a marked growth and reached 40 % in 2006.

In 2007, the country exported 1.3 TWh of electricity to the United States, while importing 0.6 TWh. Companies have built power plants near the border between both countries with the aim of exporting generation to the United States. The external electricity trade is carried out through nine interconnections between the United States and Mexico and one interconnection with Belize. These connections have been mainly used to import and export electricity during emergencies. There are also plans to connect Mexico with Guatemala and Belize as part of the Central American Interconnection System. The 400 kV interconnection line, Mexico-Guatemala, was commissioned in April 2009 and has an estimated transmission capacity of 200 MW from Mexico to Guatemala and 70 MW in the opposite direction. The grid is part of the project SIEPAC, a power transmission grid which should connect the countries between Mexico and Colombia, bringing them more energy security.

In 2009, Mexico imported 38712 ktoe of energy, predominantly in refined oil products (24440 ktoe, 63 %). Net electricity exports were 903 GWh.

Extend network

The national electrification rate in 2008 was 97 %, more than 3 million inhabitants, living for the most part in areas difficult to access, still lack electricity.

Capacity concerns

High growth in demand for electricity is narrowing the gap with available power supply, and the various stopgap measures adopted to attract investment (and delay closure of old plants), are running out of steam. Even budgets envisaged to maintain old plants have been slashed. Although it is difficult to assess, the competitiveness of the country is probably harmed, perhaps substantially, by the continued gridlock.

Renewable energy

Currently, the renewable energy contributes to 26% of electricity generation in Mexico, which is 44 176 GWh. The majority is obtained by hydro power (31, 855 GWh); then there are geothermal (5, 817 GWh), wind (3, 644 GWh), primary solid biofuels (2 700 GWh). There is also a small contribution from biogases (91 GWh) and solar PV (69 GWh). Furthermore, Mexico's Federal Electrical Commission (CFE) estimates wind energy potential at 71 GW. Moreover, Mexico is the world's fourth largest geothermal energy producer. According to the International Geothermal Association, Mexico's installed geothermal capacity is 958 MW from 37 units, currently operating in four geothermal fields: Cerro Prieto (720 MW), Los Azufres (188 MW), Los Humeros (40 MW) and Las Tres Vírgenes (10 MW). In addition, Mexico's National Association of Solar Energy (ANES), Mexico produced in 2010 28.62 MW of solar power but has the potential to reach 6,550 MW given its solar resources.

Solar energy

Around 75 % of the territory receives an average 5 kWh/m^2 a day of solar radiation. Compared to other countries, where radiation achieve 3 kWh/m^2 a day, the states close to the Pacific Ocean coast exhibit the highest radiation reaching 7 kWh/m^2 a day,. In 2006, 839686 m^2 of solar collectors were installed for sanitary hot water and the power capacity from photoelectric modules amounted to 17633 kW for purposes such as rural electrification, communications and water pumping. It is expected that there will be 25 photoelectric MW available to generate 14 GWh/year.

The most important installation in the country is part of the hybrid, electric, wind, solar, diesel plant in San Juanico (state of Baja California South). It is made up of 17 photovoltaic kW, 100 wind kW and a diesel motor-generator of 80 kW. In Agua Prieta, Sonora, the Government is planning to build a facility that would operate in combination with a natural gas combined cycle plant.

Ownership of electricity

The Mexican electricity sector is controlled by the mentioned before state-owned company *Comisión Federal de Electricidad* (CFE), which generates and sells electricity across the whole country. Due to taking over in 2009, the other state-owned utility *Luz y Fuerza del Centro* (LYFC), which was responsible for producing and selling electricity only in the Mexico City metropolitan area, the CFE has a monopoly. Private sector involvement is limited and began in the late 90s, when CFE developed an Independent Power Producer (IPP) scheme, whereby private companies build and operate plants and sell 100 % of the generated power back to

CFE. Another scheme is the Self-Consumption Scheme, in which IPPs are allowed to generate energy for their own consumption, with the possibility of selling any excess capacity to CFE or to clients outside Mexico. Currently, many international companies are now participating as IPPs: Mitsubishi, Intergen, AEC, Iberdrola, Transalta, Union Fenosa, etc. Between 1997 and 2009, CRE had awarded 22 permits for Independent Power Producers (IPP), a total of 13 GW.

All the major hydro-electric facilities are owned and operated by CFE. CFE also operates 15 plants in the 20 to 60 MW range, accounting for a capacity of 685 MW, and 37 plants under 20 MW, with a capacity of 285 MW. The only privately owned hydro-electric plant is the 6 MW El Plantanal, operated by SKF Sverige AB.

Competition

The 1992 reform of the Power Public Services Law carried out a partial liberalization of the Mexican electricity sector. It modified the regulatory framework in order to favour new investors. The reform permitted the private sector to generate electricity under six new modalities, and stipulated that electricity generated under these six modalities would not be considered as a public service avoiding thus a contradiction with Constitutional Article 27, which concedes the Mexican Nation exclusive title to generate electricity. The modalities defined by the Power Public Services Law are: self-supply, cogeneration, small production, independent production, export, and import.

In 2006 the private sector participation had increased from 30.4 to 35 %. The increments for each modality were: independent production 22.8 %; self-supply 6 %; cogeneration 3 %; and export 2.7 %. Control over activities of transmission, transformation and distribution of electricity were kept by the CFE and also in this time by Luz y Fuerza del Centro As of mid-2012, private generators (known as Productores Independientes Energia (PIE)), held about 12.2 GW of generating capacity, mainly in the form of combined-cycle gas turbines.

Energy framework

The National Development Plan 2007-2012 set the rational and sustainable use of natural resources and the progressive diminution of greenhouse effect gas emissions as a priority goal. The energy policy of Mexico aims to secure supply of energy, to diversify primary energy sources, reducing their environmental impact and to improve the efficiency and competitiveness of public companies. The installation of the most developed RE (hydraulic, biomass, wind and sun) as soon as possible is considered as essential to obtain.

The National Development Plan 2013-2018 is currently being drafted by the government. Key points will include establishing indicators to measure the effectiveness of the government in all sectors of the economy, and measures to improve the democratisation of national productivity.

On the 27th June 2007 in the official federal bulletin, the contract for interconnection to solar energy on a small scale was published. It is applicable to all solar energy generators with capacity equal to or less than 30 kW. The Law for the Promotion and Development of Bio energies, passed in February 2008, encourages the use of ethanol and other liquid bio-carburets.

In November 2008, the Renewable Energy Development and Financing for Energy Transition Law constituted the Renewable Energy Law. The Bill was mandated to SENER to produce a National Strategy for Energy Transition and Sustainable Energy Use and a Special Programme for Renewable Energy. The main objective of the Law is to regulate the use of RES and clean technology, as well as to establish a national strategy and financing instruments to allow Mexico to scale-up electricity generation based on renewable resources. Continuing, SENER and CRE are responsible for defining those mechanisms and establishing legal instruments to allow the increase of renewable power generation.

In the same time (November 2008) one more law, the Sustainable Use/Energy Efficiency Law, was approved. Its objective is to provide incentives for the sustainable use of energy in all processes and activities related to its exploitation, production, transformation, distribution and consumption, including EE measures. More specifically, the law proposes:

- The creation of the National Programme of Sustainable Energy Usage -Programa Nacional para el Uso Sustentable de la Energía- is targeting in energy efficiency. Also it focuses on electricity consumption activities in the industrial, residential along with commercial and public sectors (e.g. replacement of appliances, old refrigerators, and incandescent bulbs by CFLs, EE investments in municipalities, industrial motors EE, cogeneration in the cement, steel and iron industries, water pumping EE, etc.).
- The establishment of the National Committee of Energy Efficiency Usage -Comisión Nacional para el Uso Eficiente de la Energía (CONUEE)- as a decentralized body of SENER that advises the National Public Administration and promotes the implementation of best practices related to EE.
- The creation of an Advisory Council of Sustainable Energy Usage -Consejo Consultivo para el Aprovechamiento Sustentable de la Energíaas- as a part of the above mentioned Committee is to evaluate the compliance of objectives, strategies, actions and goals of the programme. The creation of the National Information Subsystem -Subsistema Nacional de Informacion- under EE is to register, organize, update and disseminate information about energy consumption and its end-uses in: sectors that use this energy; distinct geographical regions of the country, as well as examining; factors that impel these uses and; indicators of EE.

In this context, the government is carrying out the following activities: a programme aimed at replacing incandescent bulbs (IBs) for Compact Fluorescent Lamps (CFLs) in the residential sector, targeting over 200 million CFLs over a five year period; an appliances replacement programme targeting more than 5.5 million appliances over a 5-year period; the modernization of the public transport system for long distances and surroundings; a programme for EE in municipalities including the substitution of lamps for more efficient public lighting; (v) industrial and commercial EE programs; supply side EE in the electricity sector; and (vii) EE in PEMEX.

Energy debates

The division of politics in Mexico has exacted a considerable toll on the process of reform. Not only has debate over reform left the technical arena and become a completely politicized issue, but the constant debate and the lack of control by any single party in the Chamber has undercut any continuity in the energy reform strategy and made it difficult for critical investors to anticipate outcomes.

Moreover, available data shows that public opinion opposes privatization, even private investment in the energy sector. Mexicans who are aware of the existence of reform proposals (a small minority of the public) believe that the essence of the most comprehensive reform is a privatization that will undermine Mexican sovereignty.

Throughout 2009, the government issued and implemented a number of regulations, administrative fiats, and energy policy instruments aimed at promoting EE and increasing the number of RE projects in the country installed generation capacity. These include the publication of the National Strategy for the Energy Transition and the Sustainable Use of Energy and the Program for the Use of Renewable Energies. Furthermore, in February 2011, a National Energy Strategy (2011-2025) was sent to congress for ratification.

Role of government

Energy policy is regulated by the Secretary of Energy (SENER). Its department drew up several laws: the organic law for Federal Public Management, the law for the Regulatory Energy Committee, Internal Regulations for the Energy Secretary, Internal Rulings for the National Committee for the Efficient Use of Energy and the official Mexican regulations with respect to electricity matters, energy efficiency, thermal efficiency natural gas and nuclear safety. Under the SENER, the National Energy Council (CNE, Consejo Nacional de Energia) is responsible for the development of the fifteen-year National Energy Strategy and the production of the yearly revisions to this strategy.

According to the Renewable Energy Law, the following functions are the responsibility of SENER among others:

- Defining a national program for ensuring a sustainable energy development both in the short and the longer term.
- Creating and coordinating the necessary instruments to enforce the law.
- Preparing a national RE inventory.
- Establishing a methodology to determine the extent to which RES may contribute to total electricity generation (such a contribution must be expressed in terms of minimum percentages of installed capacity and minimum percentages of electricity, and should take into account different kinds of renewables and regional available sources).
- Defining transmission expansion plans to connect power generation from RE to the national grid.
- Promoting the development of RE projects to increase access in rural areas.

Government agencies

- National Committee of Energy Conservation (CONUEE, Comisión Nacional para el Uso Eficiente Energía).
- Trust for Electricity Savings (FIDE, Fideicomiso para el Ahorro de Energía Eléctrica)
- Institute of Electricity Investigation (Instituto de Investigaciones Eléctricas -IEE-)
- The Secretary for the Environment and Natural Resources (SEMARNAT), who draws up environmental and natural resource conservation policies.
- The Secretary for Social Development (SEDESOL), who promotes projects for the exploitation of renewable energies.

Energy procedure

It is worth mentioning the following among the actions taken to promote RES:

- Plan for Renewable Energies on a large scale of the SENER to install 100MW from wind and 300MW from hybrid installations (generation using mixed renewable sources, or renewable and fossil).
- Action Plan to Remove Obstacles to the Installation of Wind Energy (GEF/PNUD/SENER-IIE) in which the SENER by means of the IIE looks at the development of the Regional Centre of Wind Technology in Ventosa, Oaxaca.

There is the decree, Factors for a Policy to Promote Renewable Energies, to stimulate projects with the CDM in the Framework of the Kyoto Protocol and the drawing up of a National Programme for Rural Electrification by way of RES, in the states of Oaxaca, Veracruz, Guerrero and Chiapas.

In early 2013 year, the National Energy Strategy was finally ratified and is set to introduce a framework for the aggressive expansion of conventional and renewable energy sources. Concerning renewables, the main target is a wide-scale reform of the current legislative framework of electricity use and to better promote renewable capacity development. This will include the introduction of cost-reflectiveness into the highly-subsidised electricity tariff structure, and the consideration of “externalities” in determining the true cost of energy, including carbon emissions and social impacts. At last new internal financing mechanisms to incentivise renewables will be developed.

Energy regulator

The Energy Regulatory Commission (CRE, Comisión Reguladora de Energía) is in charge of regulating energy and is responsible for granting licenses in the management of activity development in the sector. This control is under federal jurisdiction and looks at technical and economic matters, among which is market stimulation. It was created in 1995.

Degree of independence

Section 1 of the Law of the CRE provides that it is a decentralized body of the Secretariat Energy, and is technically and operatively autonomous. The Commission Board is composed of one chairman and four members who are nominated by the Energy Minister and appointed by the President of Mexico. The commissioners are appointed for overlapping five-year terms, with the possibility of extension on ratification by the government.

Regulatory framework

The new Law for the Development of Renewable Energy and Energy Transition Financing, and Law for the Sustainable Energy Development, enacted in relation to the power sector, promote and regulate RES, clean technologies and EE. Their most important assumptions are:

- The state-owned public utilities (including CFE) shall enter into long-term contracts with private power generators using RES (i.e. back-up, power excess sales and others).
- The state-owned public utilities (including CFE) will now be able to award contracts to private companies wanting to produce their own electricity, while excess energy will go into the National Grid using renewable sources and render wheeling, back-up, and other services in accordance with the terms and conditions established by the CRE, as well as receive excess power input from such facilities.
- A governmental Renewable Energy Fund will be created to promote the use of RE and EE, including providing financial guarantees and support.

Moreover, the CRE is now working on a new model, Interconnection Agreement for the interconnection of RE projects to the national grid and a new "postage stamp" methodology to determine the charges payable to the CFE for the wheeling of power generated by RE facilities.

Regulatory roles

According to the Renewable Energy Law, CRE is responsible for developing rules and norms regarding the implementation of the Renewable Energy Law, including provisions for promotion, production, purchase and exchange of electricity from renewable sources. CRE, in coordination with the Secretary of Finance (SCHP) and SENER, will determine the price that suppliers will pay to the renewable energy generators. Payments will be based on technology and geographic location. In addition, CRE will set rules for contracting between energy generators and suppliers, obliging the latter to establish long-term contracts from renewable sources.

Energy regulation role

The Mexican electrical system is co-ordinated by the Secretariat for Energy (SENER), the Regulatory Board for Energy (CRE), and the National Board for the Efficient Use of Energy (CONUEE).

The SENER is the body dependent of the Federal Government and in charge of co-ordinating the national energy policy. The function of the CRE is to regulate private participation in the electrical and natural gas sectors.

The CONUEE has the goal of fostering energy savings and efficiency and promoting renewable energies.

Regulatory barriers

While the new Renewable Energy Law provides the basic framework to scale-up RE in Mexico, substantial secondary legislation is required to define the modalities and mechanisms needed for the implementation of the Law. In this context, SENER and CRE require assistance to define a specific target regarding the renewable capacity and energy which might displace fossil-based generation in the near and long term, and establish a new set of regulations to implement the Law.

For example, while the costs of wind generation in Mexico are among the lowest in the world – due to the high-quality wind resources in the Isthmus of Tehuantepec; several factors have inhibited the successful development of the enormous wind resources of the country. Among the barriers for wind and other RES are the excessively low planning prices that CFE assumes for new fossil fuel-based power generation, the lack of recognition for the portfolio effect in power planning that would increase the share of RE interventions based on their lower fuel-risk, and the inability to adjust procurement procedures to the particularities of RE projects. For co-generation and other small-scale projects, new contracting procedures are needed to reduce the risks and transaction costs of small power producers.

Analysis of the national economic system and politics

Strength and weaknesses

As one of the main emergent economies, Mexican government has provided the creation of a durable pro-business policy framework. As a consequence, the GDP growth ratio was truncated only during 2008-2009 because of the global crisis, but after positive rates has been obtained. Also in the positive side, debt ratios are moderate.

It is both geographical and economical relationship with United States (more than 70 % of exports and around 50 % of imports) that gives stability to its economy. Nevertheless, that makes it very sensitive to US business cycles. On the contrary, there are though some priority sectors, where exists a good diversification of both import and export markets with other partners.

The social stabilization issues come from three main causes which are as follows: the skewed income distribution that has produces high poverty levels, the security relating to drug-trafficking, and the influence of corruption on institutions and government.

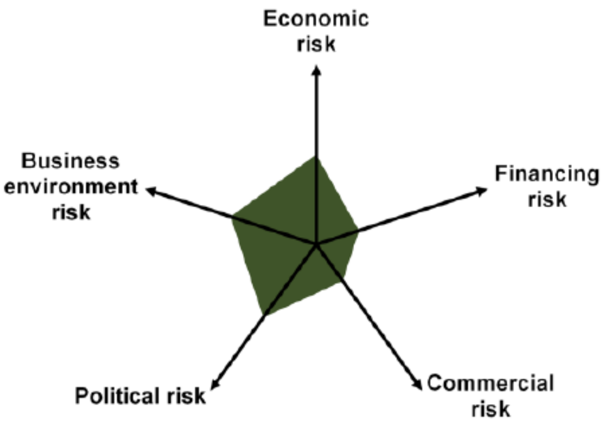

Figure A. 56. Risk dimensions estimated by Euler Hermes. Mexico.

Economic structure

Together with US, the main export and import trading partner of Mexico are North American countries, sharing 78 and 50 % respectively. Than the export market belong to Europe (8.3 %) and South America (6.4 %), while Asia together with imports contributes to 32 % of market sharing, from which China takes one half The Europe shares the rest 14% of the import market. More precisely, concerning all countries, the top list of export partners is composed by US, Canada, Spain, China and Colombia, and the import one by US, China, Japan, Germany and South Korea.

When it comes to the products sector, the diversification is more meaningful. Continuing, machines are taking the first place in both import and export with a share of 35.5 and 42.4 % respectively, whereas the non-negligible contribution to the export is Crude oil (13 %). The transportation sector also plays a significant role in export market, whereas crucial for import are metals, chemical products and plastics.

Economic forecast

Due to the crisis the GDP growth declined rapidly, reaching the low point in 2009. Afterwards the increase was immense, and in 2010 stood at its highest peak. Nevertheless, since then were noticed some up and falls, but never obtaining the negative growth. The growth rate varied at around 4% until now. Despite, the forecast are more optimistic as a result of recovery of US economy. Also the reforms made by the government contributed to the increment of market confidence and are aiming to expectedly reduce unemployment, favouring the domestic consumption; as well as sustaining the investment in the short-term.

Maps

Population

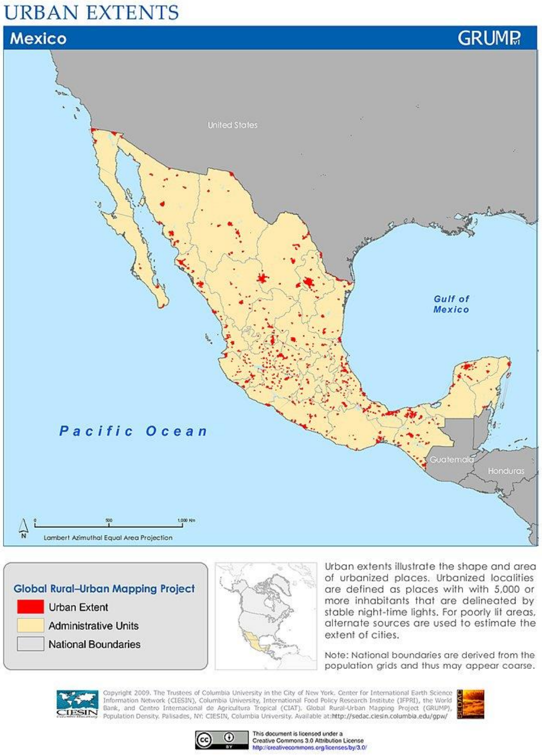

Figure A. 57. Mexico population map.

DNI

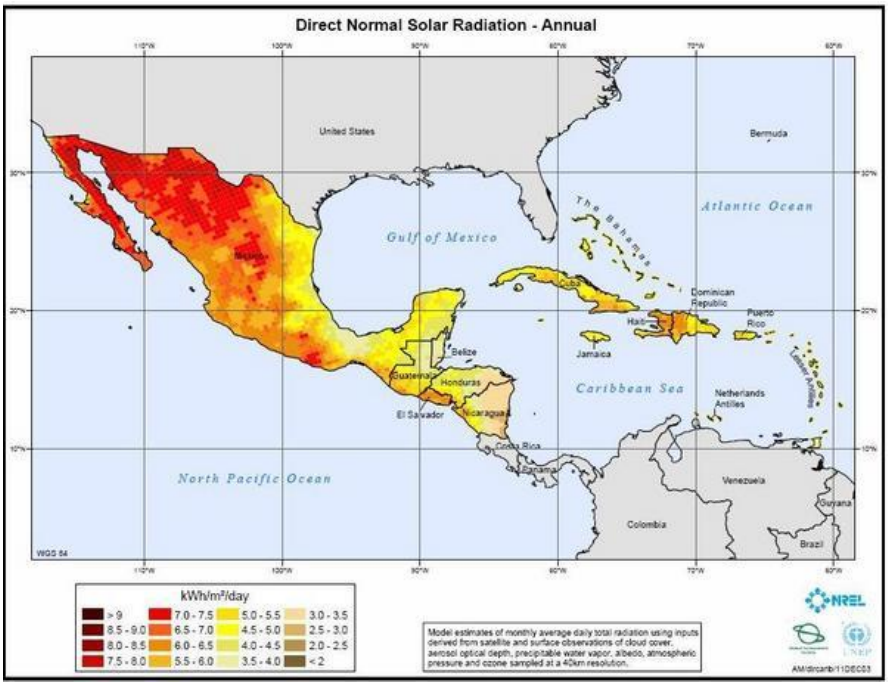

Figure A. 58. Mexico Direct Normal Irradiation.

Electricity grid

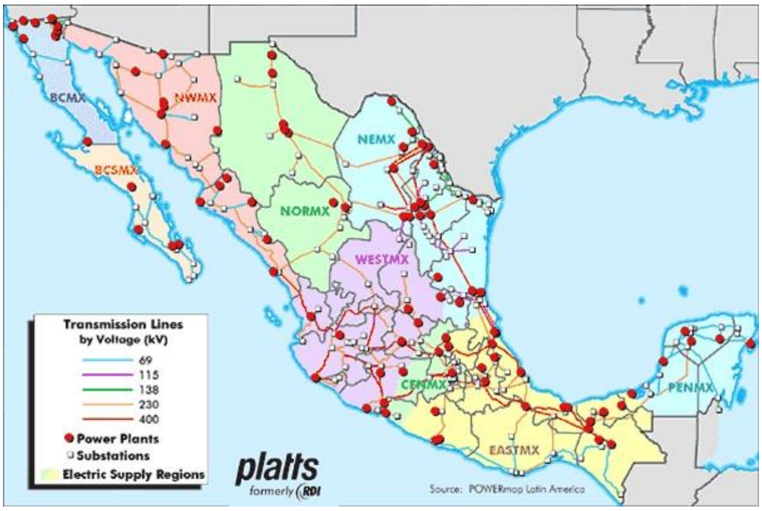

Figure A. 59. Mexico electricity grid.

Maps Overlapped

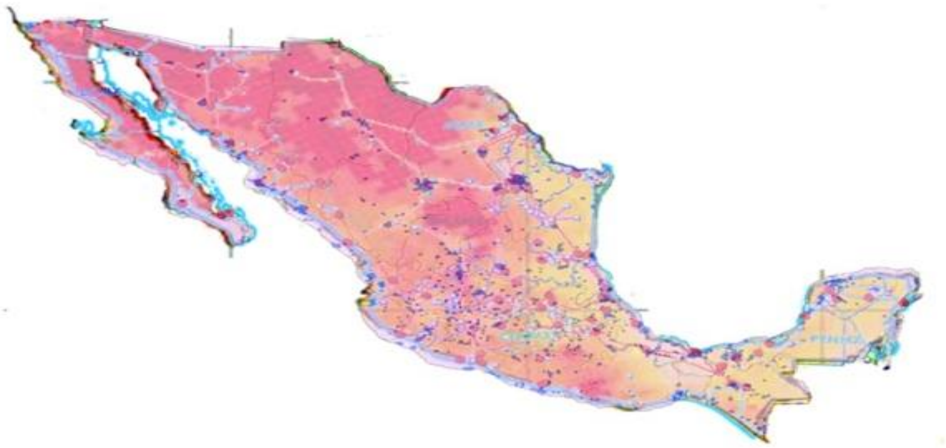

Figure A. 60. Mexico overlapped maps.

Application of the method

- **GDP:** US$ 1261 Billion (in 2014)
- **Annual GDP Growth rate:** 2.2 % (in 2014)
- **Population:** 122.33 Million people (in 2014)
- **Annual population Growth rate:** 1.22 % (in 2014)
- **Annual electric consumption (per capita):** 2091.69 kWh (in 2011)
- **Government debt:** US$ 465 Billion, 36.9 % of GDP (in 2014)
- **Accumulated external debt:** US$ 355 Billion, 28.2 % of GDP (in 2012)
- **Inflation rate (consumer prices):** 4.08 % (in 2014)
- **Country rating (Euler Hermes):** BB1
- **Annually averaged DNI:** 2103.90 kWh/m^2
- **Population with access to electricity:** 98.9 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.8536	0.1707
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	0.6475	0.0648
		TOTAL	0.8855

Table A. 23. Farm arrangement. Mexico.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0111	0.0028
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	0.6475	0.0648
		TOTAL	0.6925

Table A. 24. Stand-alone configuration. Mexico.

ANNEX 13. Morocco

Analysis of the national energy system

The traditional energy sources (wood, charcoal and plant waste) are used extensively, especially in rural areas. In addition they do not appear in the national energy balance. Due to the over-consumption of firewood approximately 30000-50000 ha of forests disappear every year. Morocco possesses more than 15 % of the world reserves of oil shale. However, the exploitation has not been undertaken because of cost-benefit factors.

In 2008, the total electricity consumption in Morocco was around 24 TWh, of which more than 80 % was produced from coal, oil and gas. The share of renewable energy such as hydro and wind power constituted the remaining amount. Moreover the bulk of electricity produced by the public utility “Office National de l’Electricité” (ONE) and the 3 independent power producers JLEC, EET and Théolia achieved only 20, 3 TWh (one third by ONE, two thirds under concession), which means lack of 4 TWh. Continuing, thermal power generation accounts for 92 % of the national electricity generation, hydropower accounted for 7 % of electricity supplies, and wind power for 1.5 %. The primary energy consumption reached 14.7 Mtoe in the same year.

Reliance

Currently, Morocco imports about 96 % of its supplies of energy resources. It constitutes an amount of 71 billion Dirhams (USD 8 billion) of the budget. Furthermore, it is about 330% more invested money in supplies imports, compared to year 2003. The electricity production by coal-power plants is 54% of total. It means high dependence on coal imports, which is transferred from US, Colombia and South Africa.

According to the National Energy Strategy 2020-2030 published by the government in 2008, coal will remain the primary fossil fuel used in power generation for the next decades. However, through the Moroccan Solar Plan and Morocco Wind Energy and Hydropower Development Project, renewable energy plants will account for 42 % of overall electrical power capacity in 2020, while solar energy, wind energy and hydropower will each represent 14 %.

With almost 54 % of its electricity demand produced by coal-powered plants, Morocco is heavily dependent on coal imports. Coal is mainly imported from the United States, Colombia and South Africa.

Extend network

As a result of the “*Programme d'électrification Rurale Globale*” (PERG, Global Rural Electrification Programme), which government launched in 1995, the rural electrification level rose from 18 % to 96 % in 2008.

In 2006, the transmission grid was owned by the state utility ONE and consisted of 18920 km of 400 kV, 225 kV, 150 kV and 60 kV lines. It covers the entire country and is connected to the Algerian and Spanish power grids via regional links.

Capacity concerns

Being the largest energy importer in Northern Africa, Morocco is highly exposed to international oil price fluctuations, destabilizing its balance of payments and a negative effect on the trade balance. Recently, Morocco was a non-producer of energy resources and dependent on outside sources for almost all of its supply. Thus, energy mix diversification is a priority area of intervention to alleviate such dependency, notably by developing local renewable energy resources.

Renewable energy

Morocco plans to reduce its dependence on foreign imports by developing renewable energies to meet domestic electricity needs. The state-owned Office National de l'Electricite (ONE) plans to harness solar and wind energy by generating about 42% of the country's electricity needs by 2020. However, these sources represented less than 4% of the country's electricity generation in 2011. As in 2012, according to IEA, in the energy mix the only participation is of wind and hydro, contributing to electricity production share of 728 GWh and 1816 GWh respectively. Currently there are commissioned 13 wind power plants.

Solar energy

The coefficient of radiation in this country is very intensive. The annual duration of sunshine hours ranges from 2700 h in the north to over 3500 h in the south, which is equivalent to an average of 5.3 kWh/m^2 a day.

The governmental initiative called "*Chourouk programme"* proposed the installation of 1400 micro photovoltaic (PV) power stations of 0.5-1 kW in the regions of d'Errachidia, Benguerir and Ouarzazate. These PV stations are about to be connected to the low voltage grid. At the moment, the programme cannot proceed due to awaiting approval of new renewable energy law. As it comes to solar thermal collectors, at the end of 2007 the occupied area was 200000 m^2, which is supposed to increase in the future.

Ownership of electricity

The Moroccan electricity utility; The *Office National d'Electricite* (ONE), was established as a legally and financially autonomous public entity with a responsibility to provide electricity service provision in Morocco. Moreover, it operated as a single buyer, and owned the entirety of the transmission network, and the majority of the distribution grid. Later on the power market was opened to independent power producers (IPPs) in 1994. Continuing, ONE was financially autonomous at inception, but the government has traditionally used subsidies to absorb fluctuations in energy prices and shield consumers from electricity tariff increases, and to expand the distribution network to reach rural populations.

However by 2008, the ONE was experiencing challenges related to transmission and distribution system overload, resulting from rapid demand growth and increased electrification rates, which quickly outpaced the growth in sector infrastructure investments. It is estimated that demand will grow at an annual rate of 8 % until 2015, threatening the long term security and reliability of electricity supply.

To address this challenge, the ONE is preparing to operate in an increasingly liberalised market, as called for by a draft law under discussion, and in line with the plans to increase regional market integration with the Maghreb and the European Union.

Competition

The generation is controlled by the ONE and private concessionaires (JLEC, CED, and EET), while the transmission is the exclusive responsibility of the ONE. Also electricity is distributed by the ONE (45 % of the domestic market), but it shares with the municipal electricity boards and private distribution companies. Nevertheless, the retail to the final consumers is in the responsibility of the ONE for most of the country, which are 7 local municipal authorities "*Régies*" (Marrakech, Fès, Meknes Tétouan Safi, El Jadida-Azemmour and Larache-Ksar El Kébir).The rest is serviced by four private companies, in spite of they are using the ONE grid. The state share of electricity generation has fallen to about 35 %. Law No. 16-08, enacted in October 2008, raised the self-generation threshold from 10 to 50 MW. The ONE still has a monopoly on the installation of means of production of electrical energy with a capacity of more than 50 MW. However, it is authorised to conclude agreements with private operators for the generation of electricity in excess of 50 MW under concession, provided that the generator supplies the power generated exclusively to the ONE and the economic balance clauses in the agreement are respected. In such cases, competitive tendering is compulsory. The ONE is also authorised to enter into private contracts with producers for the concession of electricity generation from domestic energy sources (fossil or renewable) for their own use, any surplus being sold exclusively to the ONE.

Energy framework

Against the background of rising energy demand and limited domestic fossil fuel reserves, the use and development of renewable energy technologies have become a major policy incentive in Morocco. Various measures have been formulated to accelerate the development of renewable energy technologies to manage the long-term energy security of the country and to contribute to the global reduction of climate change.

The National Energy Strategy of Morocco and the related National Priority Action Plan (PNAP), both launched in 2008, set a target to meet 10-12% of the primary energy demand by 2020 and 15-20% by 2030 with renewable energy sources.

Renewable energy became a part of mainstream policy, as evidenced during the First National Energy Conference (Assises De l'Ènergie) held on March 6, 2009 in Rabat. As consequence, the new energy strategy was announced. The two main objectives of the strategy are to provide sufficient and reliable energy to the economy and the population, as well as to mitigate the harmful environment effects stemming from the energy supply and the use of energy. The axes of this strategy are:

- To ensure the security of the energy supply by diversification of fuel types and origins.
- To ensure availability and access to energy for all segments of society at affordable prices.
- To mobilize indigenous energy sources, mainly renewable energy, but also the intensification of hydrocarbons exploration and oil shale valorisation.
- To promote energy efficiency.
- To promote regional energy integration among the Euro-Mediterranean markets through enhanced cooperation and trade with Maghreb and EU-countries.

After liberalization of production and marketing of electricity from renewable sources, finally in 2014 Morocco launched four major wind power plants that contributed to enormous money saving, which are equivalent to $140 million worth of imported oil per year. This wind project represents 10% of the national target to produce 2,000 MW of wind energy by 2020. Moroccan Wind Energy (EEM) has allocated an investment budget of 3 billion dirhams [$365.8 million] for the development of the three farms. Moreover, the investment payback period, which is theoretically 10 years, may extend if the project is not completed within the time frame fixed in advance or if additional costs are incurred.

The National Program of Development of Renewable Energy and Energy Efficiency (PNDEREE) aims at increasing the contribution of RE up to 20 % of national electricity. This program provides rural electrification of 10000 villages, renewable energy equipment in 3000 water points, 400000 m^2 of solar water heaters, and achieving annual savings of 150000 Toe in the services and residential sectors, and 360000 Toe in industry. Furthermore, by 2020, RE is projected to account for 42 % of the 14580 MW power capacities in Morocco, compared to 26 % of the 5292 MW capacity in 2008. The total renewable energy production will be equally shared by solar, wind and hydro power. This includes the "Moroccan Solar Plan", a 2000 MW solar power project launched on 2nd November 2009. The investment cost of approximately USD 9 billion will be covered by public as well as private national and foreign contributions. These contributions include concessional and non-concessional financing that is available from multilateral and bilateral financial cooperation. For grid-connected photovoltaic (PV) electricity, a smaller program was set out by ONE in 2007 targeting 150MW of distributed PV capacity by 2015. This program, however, has suffered from delays, making realization of the goals by 2015 seem unlikely.

Energy debates

The Government of Morocco requested in April 2011 that CTF (Clean Technology Fund) financing be focused on, mentioned before, ONE Wind Energy Plan (WEP). Of the 2000 MW in wind power that ONE aims to commission by 2020, WEP includes support for transmission infrastructure and water pumping and storage facilities in combination with wind energy for pumping. The target date of financial closing of all projects under the WEP program is 2015.

Energy studies

As Libya, Morocco is a member of the RCREEE. Furthermore, Morocco has signed the statute of the International Renewable Energy Agency (IRENA), participates in the Solar Plan for the Mediterranean (MSP) and has expressed support for the Dii project.

Role of government

Ministry of Energy, Mining, Water and Environment (MEMEE)

The task of the MEMEE is developing those conditions that ensure energy security and access to energy for both the rural and urban populations. Furthermore, it is responsible for the proper functioning of the energy market and for the elaboration and implementation of a strategy for the development of the energy sector. It has, among others, a Directorate for Electricity and Renewable Energies (DEER) with divisions for: electrical equipment and rural electrification, distribution and electrical markets, renewable energies and nuclear safety. In 2008, the MEMEE had a budget of around €46 million, an increase of 8 % from 2007. Of this, a constant amount of €2.1 million is assigned for the Moroccan Centre for Renewable Energy Development (CDER).

Government agencies

Development Centre of Renewable Energies (CDER)

Established in 1982, the CDER has employees active in studies, disseminating knowledge, performing quality-control checks on equipment (in particular PV), and training specialists in the renewable energy sector. Furthermore, CDER initiates pilot projects to spread knowledge on the implementation of renewable energy (RE) technologies. The CDER is promoting the establishment of the *Maisons de l'Energie*. These "*maisons*" (houses) are small rural enterprises that help local residents to organise their own energy supplies. The CDER and the "*United Nations Development Programme*" (UNDP) provide technical and financial assistance. So far about 200 such small enterprises have been established. In these enterprises, technical equipment for RE and other types of fuels, as well as energy saving components, can be bought. Installation work and technical assistance can be offered and information about governmental programmes like the "*Programme d'électrification Rurale Globale*" (PERG) is distributed.

Information Centre for Renewable Energies and the Environment (CIEDE)

Since 2000 the centre has been a cooperation project of the CDER, the MEMEE, the Ministry of the Territory Planning, the United Nations Program for Development/Global Environment Facility (UNDP/GEF) as well as other Departments within the National Committee on Climate Change. The CIEDE primary tasks are to acquire, collect and disseminate information about sustainable use of energy, and the impacts of energy generation on the environment. It can also be contacted for advice on new cooperation opportunities, technology transfer and funding available to actors in the fields of environment, energy and development.

Association of Solar and Wind Power Enterprise (AMISOLE)

It is an umbrella organisation representing the interests of companies and individuals with a professional involvement in RE. Founded in 1987, the association now represents about 40 companies.

Moroccan Solar Energy Agency (MASEN)

The commitment of Morocco with respect to RE development is being realized in dual paths: firstly a slow but steady effort to build a legal framework with licensing, quality of supply and tariff rules, and secondly an accelerated path to build large solar projects that will go into operation by 2020. To do this, the Moroccan government has established MASEN, an agency dedicated to seeing through 2000 MW solar projects (5 different projects are envisioned, with the first plant to be commissioned by 2014). MASEN is leading the projects, inviting expressions of interest and responding to these with a governmental mandate to oversee the entire procurement, construction and operational development process from start to finish. MASEN was founded in 2009 by Law N° 57-09 within the framework of the "Moroccan Solar Energy Project."

Agency for the Development of Renewable Energy and Energy Efficiency (ADEREE)

ADEREE was established by Law N°16-09 and its role is to contribute to implementing government's Renewable Energy and Energy Efficiency Policy.

Energy procedure

Morocco goals target a strong increase in the number of both wind and solar power plants. Most of the projects will be located along the Southern Atlantic coastline of the country, which features excellent wind conditions comparable with off-shore sites in Europe. Concentrating solar power (CSP) is the second axis of the Moroccan government RE development plans.

In addition, ONE has recently launched two important initiatives: the "*1000 MW initiative*", aiming at installing wind farms in 14 sites, and *Energipro*, offering industrial opportunities to produce RE.

Dii Industrial Initiative

It is an organisation active since 2009. Nowadays it accounts with 18 shareholders, most of them being energy suppliers, service providers and solar companies from European countries. However, a first step towards a larger involvement of industry partners from the Middle East and North Africa has been taken with the admission of Nareva (Morocco) and Cevital (Algeria). The DII has further accelerated its efforts to engage with countries and companies from this region. The main objective of DII is to create favourable conditions for the implementation of the Dii concept, which proposes large scale implementation of sun and wind power facilities to supply a substantial part of the Middle East and North Africa (MENA) region electricity demand and 15 % of European electricity demand by 2050. Its short-term goals include the development of a rollout plan to last through to 2050, the selection of reference projects and further research on issues such as the cost and technology surveys. Dii fosters exchange and cooperation especially between the state and private actors by providing a platform for discussion. It is however unclear, which role the DII plays in the actual implementation of RE goals in the MENA countries and in particular in Morocco. Its contributions so far seems to focus on raising awareness of the issue of renewable energy in MENA and providing knowledge and research with regard to technical issues, reference projects and policy incentives for RE.

Clean Development Mechanism (CDM)

The relevance of the CDM in Morocco lies mainly in the fields of knowledge and technology transfer as well as contributing to the financing of renewable energy projects. Morocco quickly established the institutional setup for CDM in Morocco (2003-2005) with the support of a UNEP/UNDP program and is considered one of the front runners in the CDM. Today, RE, especially wind energy, is dominating the CDM context in the country. Of the 13 projects currently underway, nearly half are focused on the use of wind energy, including three in Tangier-Tetouan, two in Laayoune and one in Marrakech-Tensift-El Haouz. There is currently only one solar-related CDM project, which provides photovoltaic kits for lighting in rural households (capacity of 7.7 MW).

Energy regulator

Until now there has been no agency for the regulation of the electricity market. The government is purportedly planning legislation for the establishment of an independent regulatory body for the energy sector, but as of yet, the electricity market for large-scale industrial is largely unregulated, with limited regulation being applied to the low-voltage residential market, primarily overseen by the Directorate for Electricity and Renewable Energies (DEER).

The DEER is a subsidiary division of the Ministry of Energy, Mining, Water and Environment (MEMEE), with funds being allocated directly from the national budget for its operations.

Degree of independence

To reach its renewable energy goals, Morocco has started introducing a modern legal and regulatory framework for the energy sector. In early 2010, relevant legislation and regulations were defined. Among these, the following laws should be noted:

- **The Renewable Energy Law** (13.09 of 11th February 2010) aims at fostering and promoting renewable energy and regulates the commercialization and exportation of renewable energy. Furthermore, it outlines a procedure for the authorization of renewable energy installations. However, the law does not provide for financial incentives for renewable energy producers, such as a feed-in tariff or fiscal incentives. The latter are envisaged under the fiscal law and were still subject to parliamentary debate in October 2010.
- **The law for the creation of the National Agency for the Promotion of Renewable Energy and Energy Conservation (ADEREE)** (16.09 of 13th January 2010) defined the reorganization and renaming of the existing Centre for the Development of Renewable Energy (CDER). Among others, the tasks of ADEREE comprise the development of national, regional and sectorial plans for renewable energy and energy efficiency, the realization and coordination of renewable energy and energy efficiency programmes and projects as well as the provision of advice to the authorities for site selection and the formulation of legislation.
- **The law for the creation of the Moroccan Agency for Solar Energy (MASEN)** (57.09 of 14th January 2010), which is the prime contractor for the envisaged solar power projects. Other activities of the agency include the conception of these solar power projects, their promotion towards domestic and foreign investors, as well as the development of technical and economic feasibility studies.

The laws instructed, inter alia:

- Public institutions, private companies and individuals may all produce electricity from renewable sources.
- Authorization is required to implement renewable energy projects that will produce 2 MW or more of electricity.
- For smaller projects, the promoter only needs to make a preliminary declaration that it will produce between 20 kW and 2 MW of electricity from renewable sources.
- The electricity generated from these projects may be connected to the national grid at medium or high voltage at conditions to be defined by later regulation.
- If the capacity generated is less than 20 kW, a single promoter may generate electricity from renewable sources at one or more sites, free of all conditions.

- Private renewable energy promoters may export electricity through the national transmission grid.
- Should the capacity of the national transmission grid be limited, private renewable energy promoters may construct dedicated high-voltage direct current transmission lines for exports, in line with the conditions defined by the law on renewable energy.

Regulatory framework

In relation to the legal framework, the Royal Decree no. 1-63-226 from 1963 and its amendments set the framework for the electricity market. Here, the creation of ONE as a state-owned utility and grid operator was established. At present, a law about the restructuring of the power sector is discussed but there is no official deadline for its presentation to the parliament. This restructuring law will cover aspects on liberalisation.

RES are not explicitly dealt with in the general law for the electricity market, but a law on them has passed the Council of Ministers in April 2009. This law is still a draft, and currently awaits approval from parliament.

Regulatory roles

The DEER is responsible for ensuring the security of supply of electric power to the country, as well as demand-side management activities, and the promotion of energy efficient means of living. The directorate is also responsible for monitoring development programs in the electricity sector.

Energy regulation role

The tariff rate for electricity is fixed by the government directly, through the Prime Minister office. In the event of delegated management, for example in independent power provider projects, the tariff is determined on a contractual basis.

Regulatory barriers

So far, Morocco research and scientific capacities in the fields of renewable energy technologies and policies are still low. Furthermore, there is a need for capacity-building programs that address legal and economic frameworks, planning and permitting procedures, incentives and support schemes, technology assessments and grid infrastructure planning, as well as management of public acceptance.

The new energy law in Morocco contributes to rendering framework conditions more favourable for the development of RE projects. However, further elaboration is still needed. The regulations in Morocco will be an essential factor for attracting foreign investors to provide the capital necessary to implement the technology required to reach Morocco RE capacity.

Analysis of the national economic system and politics

Strength and weaknesses

The monarchy seems an acceptable form of governance for the majority of the population, although there are lingering concerns that the government is merely a vocal expression of palace authority. Commercial and diplomatic relations with Europe and United States are good, which facilitates a high potential market for international investors and traders.

On the negative side, the high levels of poverty and unemployment are the main causes of social discontent, providing a potential breeding ground for religious militancy. The record in relation to human rights and press freedom are not so satisfactory.

Compared to North African countries, the inflation in Morocco is very comfortable, with averages in the last decade of around 2 %. However, the dependency of its economy onto agriculture has brought increases of the inflationary pressure because of drought periods. As long as other sectors develop, as currently encouraged; this vulnerability will tend to disappear.

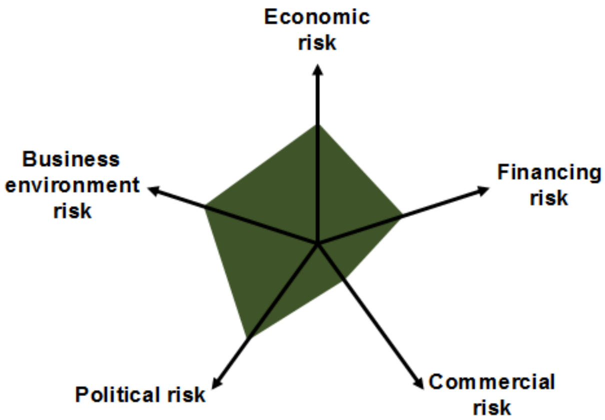

Figure A. 61. Risk dimensions estimated by Euler Hermes. Morocco.

Economic structure

The Moroccan economic system of exportations comprises 4 important sectors (chemical products, textile, machinery and mineral products) with a contribution of around 16 % each. Considering the agriculture sector, it is sharing the 8 % of exports. In 2012, due to long drought periods, the agricultural outputs were reduced. This is the reason of its lower relative importance nowadays. Nevertheless, the resilience of this Moroccan sector keeps it significant for its economy.

As it comes for imports, this market is dominated by refined petroleum, which together with others mineral products, shared 27 %, being the most important sector in this regard. Then the shares are divided into five other important sectors: machinery (1.7 %), transportations (9.6 %), metals (7.8 %), textiles (7.1 %) and chemical products (6.5 %).

Regarding countries and regions, Europe is the principal Moroccan partner for both imports, where Spain is the 1st one with a share of 13 %; and exports, where France is the 1st destination with 18 %.

Economic forecast

Due to the foreseen growth of the Eurozone (especially of its 1st partner-Spain) Morocco's GDP is expected to grow for next years at a rhythm above 4 %.

The growing importance of other sectors such as construction and tourism; will presumably remain at the inflationary pressure on affordable averages around 2.7 and 2.8 % for next years. Also the external debt to GDP ratio is considerably low, 36 %; and will expectedly remain in similar values.

Maps

Population

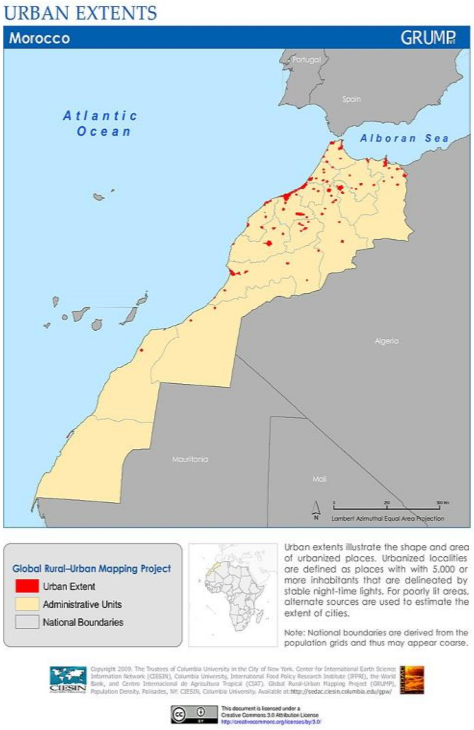

Figure A. 62. Morocco population map.

DNI

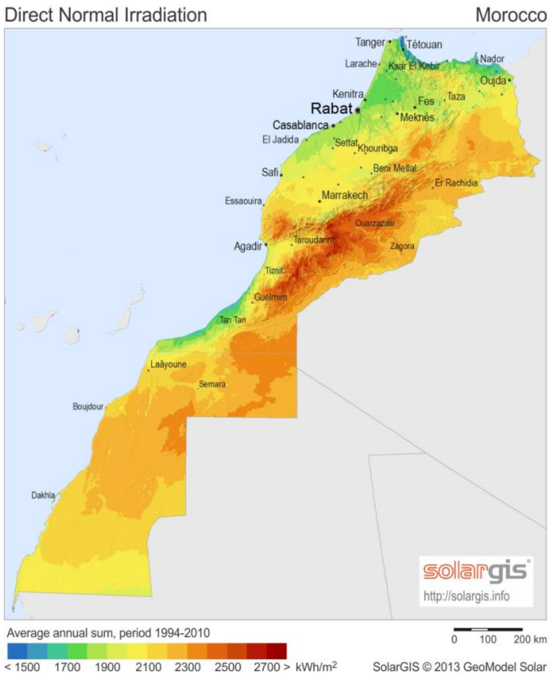

Figure A. 63. Morocco Direct Normal Irradiation.

Electricity grid

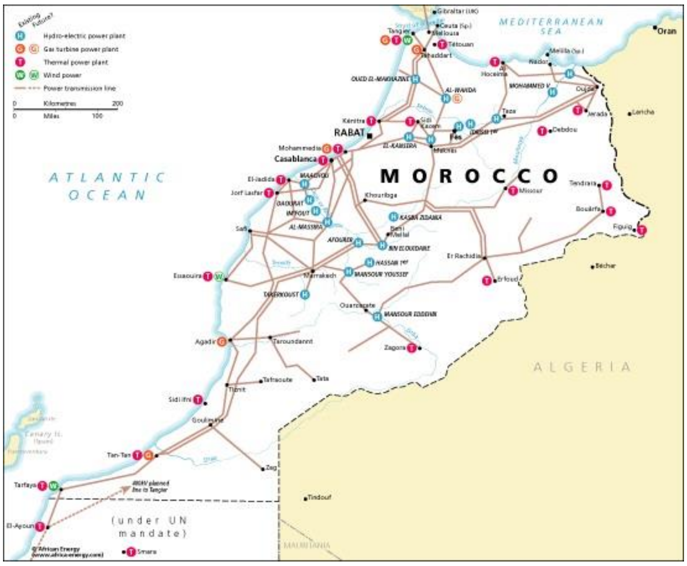

Figure A. 64. Morocco electricity grid.

Maps Overlapped

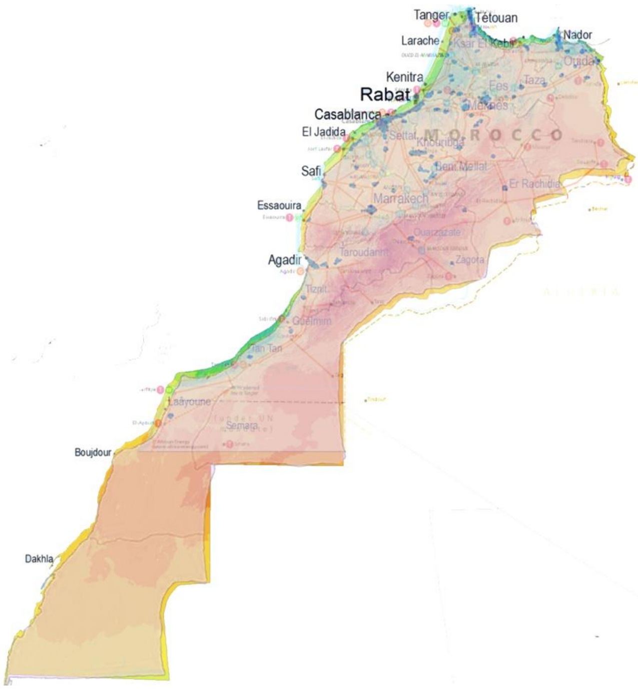

Figure A. 65. Morocco overlapped maps.

Application of the method

- **GDP:** US$ 104.37 Billion (in 2013)
- **Annual GDP Growth rate:** 2.7 % (in 2014)
- **Population:** 32.95 Million people (in 2014)
- **Annual population Growth rate:** 1.07 % (in 2014)
- **Annual electric consumption (per capita):** 826.40 kWh (in 2011)
- **Government debt:** US$ 64.40 Billion, 61.7 % of GDP (in 2013)
- **Accumulated external debt:** US$ 33.82 Billion, 32.40 % of GDP (in 2012)
- **Inflation rate (consumer prices):** 1.2 % (in 2014)
- **Country rating (Euler Hermes):** B1
- **Annually averaged DNI:** 2049.11 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.6906	0.1727
Electricity grid	0.20	0.9488	0.1898
Energy policy	0.10	0.9883	0.0988
Financial risk	0.10	0.5153	0.0515
		TOTAL	0.8628

Table A. 25. Farm arrangement. Morocco.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.8937	0.0898
Financial risk	0.10	0.5153	0.0515
		TOTAL	0.6909

Table A. 26. Stand-alone configuration. Morocco.

ANNEX 14. Namibia

Analysis of the national energy system

At present energy production is estimated at 2.69 TWh, with net imports of 10.01 TWh and electricity consumption of 3.22 TWh. The peak demand was noticed in 2008, with a value of 500 MW. However, about 60 % of the population residing in the North of Namibia encounter poor electrification rate. Moreover a strong majority of the rural population, roughly 80 %, relies on wood fuel. The national utility NamPower only has the capacity to produce 360 MW of available power, which is often not obtained.

The electricity is currently generated by three main power stations relying on coal, diesel, and hydropower. Furthermore, the country is heavily dependent on energy imports from Zambia and South Africa. Speaking of power plants the most powerful is the hydro powered Ruacana station in northern Namibia, generating approximately 240MW and distributing the entire country except the north-eastern Caprivi region. The smaller one Van Eck power station, outside of Windhoek, operates on coal power and generates roughly 120 MW of power. The Paratus station on the western coast of Namibia is used mostly as a standby station for the coastal area with four diesel powered generators producing at maximum 6.4 MW of power each.

As mentioned before, the dependence on nearby countries is through transmission line extended into South Africa to several of its power stations. Even though, the Katima Mulilo coal station belongs to terrain of Namibia (is situated in the easternmost portion of the Caprivi region) it is fully dependent on coal from Zambia and from major hydro power station located in Victoria Falls in Livingstone, also belonging to Zambia. These outside power sources, which Namibia has to rely on, are offered through its membership in the association of Southern African Power Pool (SAPP).

	Total Installed Electricity Capacity	**Total primary energy supply**
Natural gas	-	-
Oil	6.4	71.8 %
Coal	120	6.8 %
Nuclear	-	-
Hydro	240	8.0 %
Renewable	-	13.4 %
Total	**366.4 MW**	**1713 Ktoe**

Table A. 27. Namibia energy sources.

Reliance

The electricity supply mix is made up of a combination of domestic hydropower and thermal energy, combined with yet pointed out imports from the Southern Africa Power Pool member countries: Zambia, Zimbabwe, Mozambique and South Africa. For the period 2000-2009, the contribution of energy imports to the national energy requirements averaged 49.8 % annually, varying from 36 % in 2000 to 60 % in 2009.

Extend network

The existing grid network currently supplies only about 30-40 % of the rural population and about 98 % of the urban population. The 2 % lacking access is a result of mushrooming informal peri-urban settlements stemming from rural-to-urban migration. Due to the vastness of the country and low population density, it is extremely difficult to extend the grid to un-electrified areas.

As it comes to electricity, its access is at very low rate as a result of difficulties connected to extending the line grids to thousands of small rural areas and its high cost. Nevertheless, the transmission and distribution of already existing systems are considered well-developed. Moreover, the transmission infrastructure from South Africa is currently strengthened by the Caprivi inter-connector, which will link Namibia to Zambia and Zimbabwe.

Capacity concerns

Over time, static growth in domestic generation has caused the volume of imports to rise in order to meet demand. This has made Namibia increasingly dependent on power supplies from beyond its borders and control. The country has to rely on outside sources to obtain the majority of their energy, leaving Namibia vulnerable to problems resulting from policy changes and resource depletion in the countries on which it depends.

Renewable energy

The renewable energy in Namibia is not yet well developed and used. Even though, the country is rich in solar, wind and biomass sources. Nevertheless, the Renewable Energy and Energy Efficiency Institute (REEEI) in collaboration with MME (Ministry of Mines and Energy) launched two energy shops in the Karas and Erongo regions, bringing the total of the shops launched to thirteen. The energy shop is using the PV solar power and aims to encourage entrepreneurship together with enhancing access to modern energy services in the off-grid rural and informal settlements of Namibia.

Solar Energy

Namibia has one of the highest solar radiation regimes in the world. It is therefore logical to make use of the abundance of photovoltaic energy as has been done for the last forty years or so. Solar energy is increasingly used for off-grid electrification in the vast rural and, until independence, neglected areas in the country. The first two villages which have been totally energized by solar power (with Indian donor assistance) Spitzkoppe and Shianshuli in the Caprivi Region.

Ownership of electricity

The key players in the electricity distribution and supply business are NamPower (the state-owned power utility responsible for generation and transmission of electricity), the regional electricity distributors (state-owned legal entities tasked with the supply and distribution of electricity in a dedicated region) and local authorities.

Competition

The NamPower is vertically integrated in generation and transmission. Its responsibility is to through the Single Buyer Business Unit, to buy electricity outside Namibia and sell inside the country. Distribution is developed by regional distribution companies. A ‘single buyer’ model has been proposed as a first step in a market reform.

Energy framework

As early as 1998, Namibia recognized the value of renewable energy as part of its energy portfolio. The White Paper on Energy Policy (1998) sets out specific national energy policy goals for the electricity supply industry as promoting or enhancing:

- Effective governance.
- Security of supply.
- Social benefits, including upward mobility for poorer populations.
- Investment and growth.
- Economic competitiveness and efficiency.
- Sustainability.

Although the promotion of renewable energy technologies (RET) is not mentioned as a special target of energy policies, the White Paper identifies renewable energy technologies as contributing to meeting several targets like energy security and sustainability. The White Paper identifies the "*Programme on the Promotion of the Use of Renewable Energy Sources*" as responsible for directing Namibian available resources for maximum social and economic benefit, taking into account long-term environmental concerns while giving priority attention to the development needs of the country.

Building upon these objectives, in 2005, the Government of the Republic of Namibia initiated a Renewable Energy Programme with support from the Global Environment Facility (GEF). The Namibia Renewable Energy Programme was designed to increase affordability and access to renewable energy services and accelerate market development for renewable energy technologies by reducing existing barriers, including human capacity, financial, technical, awareness and other market limitations.

In the short term, Namibia is focusing on demand side management programs and construction of the new Caprivi Link, creating a new electricity wheeling corridor to mitigate against transmission capacity constraints or the Namibia-Republic of South Africa interconnector. For the longer term, it is looking to build its domestic portfolio with renewable energy.

The idea of Feed-in Tariffs for renewable energy sources are also being considered by the government, although there is no current plan to introduce them.

Energy debates

Plans are underway to transform the national power utility NamPower into a modified single buyer to make the market more competitive. The Electricity Control Board (ECB) is currently engaged as part of a stakeholder group in a consultation process to determine the renewable energy (RE) incentive structures best suited to Namibia.

Namibia regulator and other stakeholders are currently looking at support mechanisms that will drive forward investment in RE, with the understanding that optimum utilization of RET requires a combination of appropriate polices and a favourable investment environment.

Energy studies

A UNDP programme will look at various barriers that prevent the wider use of solar energy technologies through an ongoing study for designing a strategy for using biomass resources. The Ministry of Mines and Energy, through the Namibia Renewable Energy Program (NAMREP), released a study in August 2006 entitled "*Feasibility Assessment to replace Diesel Pumps with Solar Pumps*".

Role of government

The Ministry of Mines and Energy (MME) enforces compliance with legal requirements on energy legislation and regulations, as well as conducting research on renewable sources for energy. MME also issue petroleum licenses, set petroleum prices, administers the National Energy Fund, regulates the oil industry, oversees rural electrification and administers the Solar Electrification Revolving Fund. Environmental matters are the responsibility of the Ministry of Environment and Tourism through its Directorate of Environmental Affairs. Also there is a National Steering Committee on the National Biomass Energy Conservation Program.

Government agencies

Renewable Energy and Energy Efficiency Institute (REEEI) is an arm of the Namibian Ministry of Mines and Energy created in collaboration with the Polytechnic Institute of Namibia 2006 to serve as a national information resource centre for renewable energy and sustainable energy use and management.

Energy procedure

The proposed Baines hydropower station on the Kunene River is at the feasibility study stage. Namibia also has a hydropower energy resource development master plan based on studies performed on its major rivers. Funding for the feasibility studies and construction of the proposed 400 MW $7 billion, Baines hydropower plant is an equally shared responsibility between the governments of Angola and Namibia. Moreover, in line with the Namibia National Renewable Energy Programme (NNREP), there are currently efforts undertaken to implement the pilot project on gasification of wood to be derived from 26 million hectares of invader bush.

The biggest change following the NNREP enactment is in solar power, the main focus of the Programme. Solar energy generation has increased from 685 MWh in 2004 to 14941 MWh in 2008. In addition, MME has introduced a revolving fund to support families and individuals not connected to the electricity grid that want to invest in solar home systems. Solar energy is increasingly used for off-grid electrification. As part of Government efforts to roll out use of solar water heaters, a 2007 Cabinet Directive marked the beginning of the enforcement of the resolution requiring all public buildings to meet their water heating needs through solar thermal technology. The solar hot water project is part of a larger demand side management project (DSM) with six project options, on which the regulator contributed as part of a working committee dedicated to enhancing energy efficiency. Also as part of the DSM project, the City of Windhoek distribution company is installing ripple control switches in all new homes.

As solar power continues to develop, initiatives for wind power are also taking hold, though the overall outcome of early wind energy studies was that the exploitation of wind energy was not commercially viable. Despite this, developments that took place between 2005 and 2010 indicate that the likelihood of having 40-45 MW wind resource capacity integrated into the grid is considerably high. Pilot projects included the installation of a 220 kW test turbine at Walvis Bay with technical and financial assistant from DANIDA, with the option to extend the planned park up to 60 MW having been licensed by the Electricity Control Board. Interested private parties include Aeolus Energy, who is also involved in other areas of the country. The Polytechnic of Namibia and NamPower are currently working to promote integration of wind resources and the regulator has issued three licenses already for wind development, as well as one for biomass energy development at Otavi. With these efforts in place and the study consultation well underway, the momentum to develop Namibia RE technologies is being advanced in order to meet the country energy needs and sustainability objectives.

In an effort to speed the electrification process and provide basic electrical services to as many people as possible, the Government is supporting two energy initiatives:

- The Regional Energy Distribution Master Plan (REDMP), which envisages to connect a large number of rural settlements to Namibia main distribution grid over the next 20 years. It is not economically feasible or technically possible to electrify all off-grid settlements. Approximately 1543 rural communities will be electrified over the next 20 years by the REDMP, as outlined by the Ministry of Mines and Energy, while there will remain 4315 un-electrified communities. For those settlements that will remain un-electrified, there is the OGEMP.

- The Off-Grid Energization Master Plan for Namibia (OGEMP). This organisation proposes installing solar powered energy shops in rural, un-electrified areas throughout the country. Such energy shops would provide basic energy services such as cell phone charging and haircutting, and sell energy products such as paraffin gas, candles, and eventually solar panel systems. Although the OGEMP was supposed to begin in 2009, as of April 2010 the government had not yet installed any energy shops in Namibia. The goal of these energy shops is to provide charging services for cell phones, hairclippers, and 12-volt car batteries with electricity produced by a photovoltaic (PV) system. The Desert Research Foundation of Namibia (DRFN) installed Namibia's first energy shops in October 2009 through a program entitled 'Business Opportunities with Solar Energy in Un-Electrified Areas'. As this is a new program, it is thus far unknown whether or not these shops can be economically effective and what kind of impact they may have had on the surrounding community.

Energy regulator

The Energy Control Board (ECB) was created under the Electricity Act (2000). The Electricity Control Board (ECB) regulates the electricity sector in terms of generation, transmission, distribution, supply, import and export. It is also pursuant to powers given to it by the Electricity Act promulgated in 2000 and amended in 2007, following the enactment of the Namibia Renewable Energy Programme.

Degree of independence

The regulator has a fair level of independence. The ECB is funded by appropriations from Parliament, license application fees and a levy imposed on electricity consumers. The ECB Board consists of five members. Board Members are appointed by the Minister. The CEO is appointed by the Board.

Regulatory roles

Since its inception in 2000, the ECB has concentrated on licensing, setting and implementing tariff methodologies, designing and enforcing quality of supply and service standards. ECB is assisting the Government with the restructuring of the Namibian electricity supply industry, currently operating under a single buyer model. The ECB has devoted increasing attention to evaluating and monitoring licensee performance and it is also on the verge of being transformed from an electricity regulator into an energy regulator.

As part of the regulator growth, it has assumed responsibilities in the renewable energy sector, having already issued three licenses for wind power development.

Energy regulation role

The Minister has executive responsibility for the electricity industry. Ministry of Mines and Energy is the policy recommendation body. Electricity Control Board has statutory responsibility to advise the Minister on electricity matters.

Regulatory barriers

Ongoing work is required to lessen fragmentation of the regulatory framework and modernize it, in order to encourage investment in renewable energy, among other issues. Currently, financing has stemmed essentially from either grants or consumers that generate electricity for their own localized consumption.

RE usage for off-grid electrification still remains a regulatory challenge and as part of its consultation process the ECB is looking at ways to develop an RE procurement support mechanism. This will incorporate RE in mainstream electricity supply as well as provide electricity to off-grid customers in rural areas who are not likely to be connected within the next 20 years, in light of infrastructure limitations.

Analysis of the national economic system and politics

Strength and weaknesses

The political climate is very stable since independence in 1990. However there are severe problems of poverty and unemployment. In fact, the high proportion of HIV/AIDS infections together with the limited arable area of the country, have brought on a meagre population.

Both the current and fiscal accounts are very volatile, and foreign reserves provide a limited part of import cover. This weak economic frame is common in the South African region, and as a consequence, the inflationary pressure is kept at high levels. However, the natural resources of the country are important, especially diamonds. Finally, also in the positive side, it must be mentioned that the external debt ratio is manageable, representing approximately 28 % of GDP.

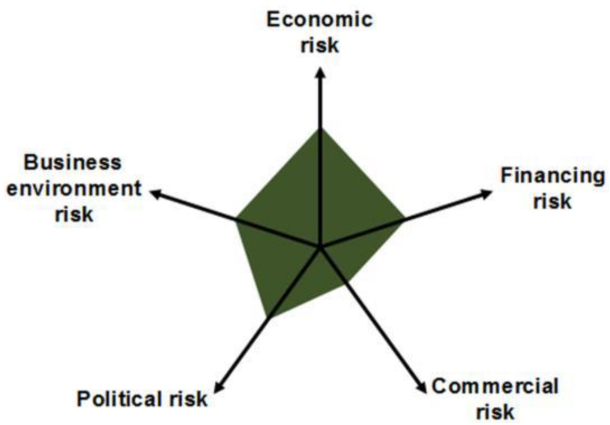

Figure A. 66. Risk dimensions estimated by Euler Hermes. Namibia.

Economic structure

The main Namibian exports are diamonds, gold and uranium. Thus, mining together with food industry and government services are crucial for this country's economy. On the other side, imports are principally food, petroleum products, machinery and chemical products.

Regarding countries, the top five list of main partner are: South Africa (16 %), UK (12 %), Angola (11 %), Spain (8 %) and USA (8 %) for the export market; and China (16 %), Peru (13 %), Germany (12 %), Bulgaria (12%) and USA (8 %) for imports

Economic forecast

The trend of Namibian economy closely follows the one of South Africa, whose GDP grew at a rate of 5 % on average between 2000 and 2008. Later on in 2009 there was noticed a fall into recession due to the consequence of the global crisis. Nevertheless it rose rapidly and gained almost a growth of 7%, same as South Africa, in 2011. For the near future, positive growth rates are also expected, driven by growth in diamond and uranium output. Also the willingness of government will contribute to growth in the near-future scenario, as it is the expected aim of the “Targeted Intervention Program for Employment and Economic Growth”, which emphasises job creation through the creation of infrastructures.

In fiscal terms, the perspectives are also optimistic. External deficit has historically been low (e.g. -3.8 % of GDP in 2013), which will remain at low level according to some experts opinions in the next years. The dependency of import market on South Africa has been currently reduced, from the values over 85 % in 2004, which makes the country less vulnerable.

Maps

Population

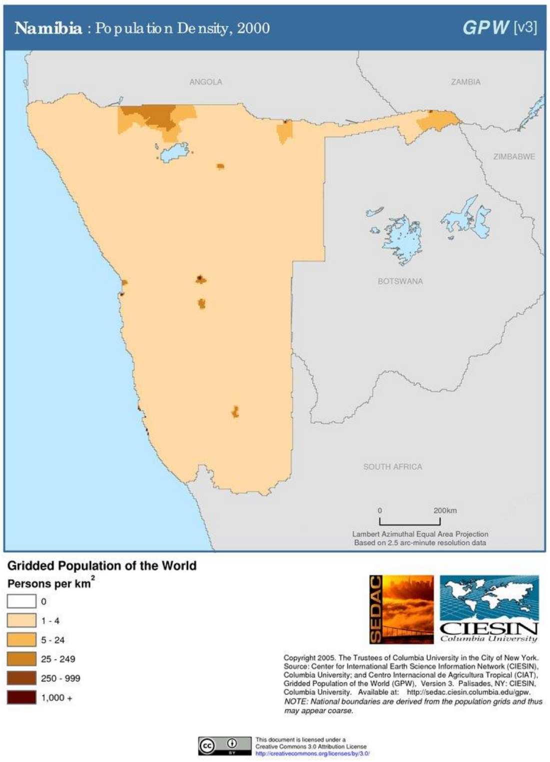

Figure A. 67. Namibia population map.

DNI

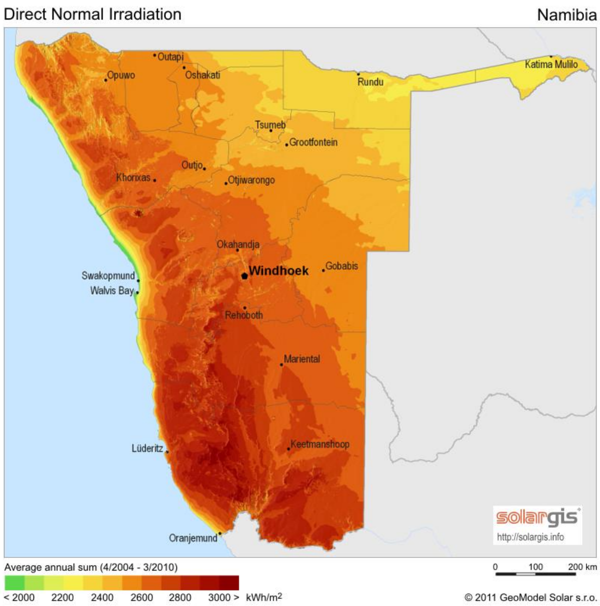

Figure A. 68. Namibia Direct Normal Irradiation.

Electricity grid

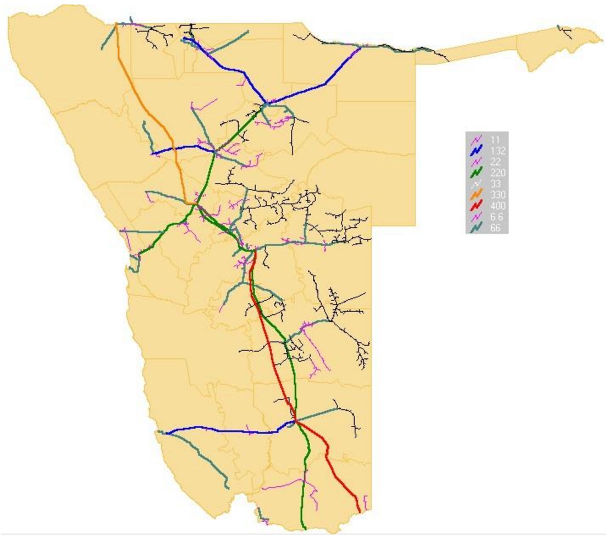

Figure A. 69. Namibia electricity grid.

Maps Overlapped

Figure A. 70. Namibia overlapped maps.

Application of the method

- **GDP:** US$ 12.58 Billion (in 2013)
- **Annual GDP Growth rate:** 2.3 % (in 2014)
- **Population:** 2.3 Million people (in 2014)
- **Annual population Growth rate:** 1.77 % (in 2014)
- **Annual electric consumption (per capita):** 1548.96 kWh (in 2011)
- **Government debt:** US$ 3 Billion, 23.9 % of GDP
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 4.97 % (in 2014)
- **Country rating (Euler Hermes):** B1
- **Annually averaged DNI:** 2527.01 kWh/m^2
- **Population with access to electricity:** 60.0 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0903	0.0226
Electricity grid	0.20	0.5298	0.1060
Energy policy	0.10	0.6932	0.0693
Financial risk	0.10	0.5648	0.0565
		TOTAL	0.6043

Table A. 28. Farm arrangement. Namibia.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Demand	0.25	0.0602	0.0151
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.6932	0.0693
Financial risk	0.10	0.5648	0.0565
		TOTAL	0.6909

Table A. 29. Stand-alone configuration. Namibia.

ANNEX 15. Nigeria

Analysis of the national energy system

The available capacity represents about half of the installed capacity. For this reason, government plans to boost power production through new gas plants and further promotion of Independent Power Producers (IPPs). Currently, IPPs account for approximately 20 % of installed capacity. It is envisaged to obtain 4755 MW together with National Integrated Power Projects (NIPP), funded by the Government and commissioned on Operation and Maintenance contracts prior to full privatisation.

Reliance

The Nigeria refining capacity is currently insufficient to meet domestic demand, requiring the country to import petroleum products. The Nigeria national electricity utility is already considering the importation of 5 GW of electricity (beginning in 2015) through Calabar from the INGA hydropower project (western corridor). . However, negotiations are required, as Nigeria need is considerably greater than that provided by this project. Nigeria import balance in 2008 was entirely covered up by petroleum product imports, achieving 6205 ktoe. Total energy exports from the country in 2008 obtained 121645 ktoe, predominantly in the form of crude oil (85%). Despite significant coal deposits in the country, consumption is insignificant.

Extend network

In 2009, approximately 50.6 % of the population had access to electricity, whereas, it is estimated that only 10 % of the rural population are connected to the grid.

Primary transmission of electricity is facilitated by 330 kV and 122 kV lines, with 33 kV and 11 kV distribution feeders supplying major population centres.

Capacity concerns

With the exception of urban supplies that are catered for by commercial dealers, fuelwood is freely collected by rural dwellers. There is a significant disparity between the rate of wood consumption and the rate of reforestation.

Moreover, there is an 80 % demand and supply gap in Nigeria.Most businesses self-generate their power. In addition, the transmission network is overloaded, with a poor voltage profile in most parts of the network. There are frequent system collapses and exceedingly high transmission losses, which often reach about 30-35 %. Particular issues identified include stagnated power generation capacity growth, inadequate maintenance procedures, and a lack of human capacity development.

A major cause for concern in the upstream oil sector of the country is the lack of facilities to produce natural gas from major oilfields. Approximately 40 % of the natural gas production from oilfields in the country is flared.

Renewable energy

The government has an ambitious plan to increase the renewable energies share in electricity mix to 20% through the Vision 2020-20. However, since 2005 there have not been much done, and the usage of renewable is limited. The small and large hydropower has the capacity to generate 14, 750 MW; while exploited is only 1964.2 MW. Nigeria has a good insolation rate, but the generation of power is only through dispersed solar PV installation estimated at range of 15 MW. As it comes to wind there is a Katsina wind farm of 10 MW in the progress.

Solar energy

Average solar insolation stands at roughly 5.25 kWh/m^2 a day. Resources in the North of the country provide a more viable potential for photovoltaic use, with insolation of 7 kWh/m^2a day. Solar photovoltaic technologies are used for small-scale power supply in some rural electrification programs for some States of the federation. It is estimated that approximately 500 PV installations are in use in the country, with capacities ranging from 7.2-35 kWp. Most are government-owned while the rest are installed by private companies as NGOs and individuals. If solar energy appliances with just 5 % efficiency are used to cover only 1 % of the country surface area, then over 269 MWh of electrical energy can be obtained from solar energy. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day.

Ownership of electricity

The Electric Power Sector Reform Act 2005 adopted a wholesale competition model as opposed to the single-buyer model or retail competition. In this arrangement, distribution companies buy power directly from generators, and the transmission company is a pure electricity transport and dispatch company. Adoption of this model has paved way for the breaking down of NEPA, the former National Electric Power Authority, into 18 companies, including 6 generators, 11 distributors and one transmission company. In addition, the Act made provision for the reform to occur in phases. First, a 100 % state-owned Power Holding Company of Nigeria (PHCN) was created and vested with the assets and liabilities of NEPA. This company co-exists with Independent Power Producers (IPPs), with which NEPA had signed power purchase agreements.

Competition

The electricity sector has been liberalized, leading to private sector participation in the generation sector, and a number of operational IPPs in the country today. The reform has so far led to the incorporation and unbundling of the national state-owned utility, now known as the Power Holding Company of Nigeria (PHCN). The unbundling has led to the establishment of 18 successor companies from NEPA. Each of the 18 companies has its own management that is self-accounting and not dependent on government funding. The Bureau for Public Enterprise (BPE) is now preparing each of these companies for privatization.

The Nigerian National Petroleum Corporation (NNPC), which in 1988 was divided into twelve subsidiaries, manages the state-owned oil industry, and is responsible, through its subsidiaries, for all operations in the sector. The NLNG Company, and its subsidiary company Bonny Gas Transport Ltd, are responsible for all operations within the natural gas sector of the country.

Energy framework

The National Energy Policy was approved by the government in 2003 with the overall theme of optimal utilization of the nation energy resources; both conventional and renewable, for sustainable development, and with the active participation of the private sector. The policy articulated, amongst other things, that:

- Extensive crude oil and natural gas exploration and development shall be pursued with the view to increasing their reserves base to the highest level possible,
- The nation shall continue to engage extensively in the development of electric power with the view to making reliable electricity available to 75 % of the population by 2020, as well as to broaden the energy options for generating electricity.

The Policy also specifies a number of plans with regard to renewable resources, including the full harnessing of the large and small hydro potential of the nation, the pursuit of enhanced solar energy integration into the national energy mix, the promotion of efficient biomass conversion technologies, and the commercialisation of the nation wind resource.

The Renewable Energy Master Plan for Nigeria (REMP) from 2006, with support from the UNDP, articulates:

- Nigeria vision for achieving sustainable development.
- A road map for renewable energy to help achieve this vision.

The Plan also envisions:

- Gradually moving from a fossil economy to one driven by an increasing share of renewable energy.
- Exploiting renewable energy in quantities and at prices that will promote the achievement of equitable and sustainable growth.
- An energy transition from crude oil to a less carbon intensive economy increasingly powered by gas and RE.

The Plan institutes a number of fiscal and market incentives for the increased use of RETs. In the short term, the plan includes a moratorium on import duties for renewable energy technologies, and in the long term, the plan advises the design of further tax credits, capital incentives and preferential loan opportunities for renewable energy projects.

With the reform of the Oil and Gas Framework in 2007, and the establishment of the Oil and Gas Implementation Committee, a Biofuel Policy Framework was also endorsed. Under the framework, the NNPC is responsible for the development of a domestic ethanol industry, while a Biofuels Energy Commission has been established for the implementation of the provisions of the framework.

Renewable energies are also promoted in the 2001 National Power Policy Document, which states that rural electrification programs are to take into full account the role that renewable energy sources could play.

Energy debates

The lack of a stable energy supply (in this case electric power) is the primary challenge to the country in its race to become one of the world's top twenty economies by 2020. At the same time, it is also evident that methods to find a permanent solution to this problem have remained a top priority of government, at least in the past ten years.

Gas flaring in the Niger delta has long been a concern for environmental and energy groups in the country and internationally. The changes to the natural gas utilization policy in 2009 failed to establish specific legislation for the abolition of gas flaring, and concerns continue to be raised by many in the sector, including in 2009 by the Director of the National Centre for Energy and Environment, Dr Lawrence Ezemonye.

Feed-in Tariffs for solar energy, wind power and small-hydro have been developed by the Renewable Energy Research and Development (RRD) division of the NERC. Consultations with shareholders on major reviews to the tariff methodology, including the institution of the FIT, took place in March 2011, and the reviewed tariff methodology came into effect in July the same year.

Energy studies

A feasibility study on solar PV in the country was carried out in 2004, and it was found out that solar PV is the most efficient and economical way to electrify villages in this region.

The Community Research and Development Centre have produced a guide entitled "*Energy Efficiency Survey in Nigeria: A Guide for Developing Policy and Legislation*".

Nigeria is a member of the Economic Community of West African States (ECOWAS), one of the regional economic communities responsible for realising the objectives of the African Union. The West African Power Pool (WAPP), under the auspices of the ECOWAS, aims to expand trade in electricity between the 15 member countries (energy being one of the primary constraints on sub-regional supply), by coordinating the investment projects submitted to donors.

Role of government

The Energy Commission of Nigeria (ECN) was established by Act No. 62 of 1979, as amended by Act No. 32 of 1988 and Act No. 19 of 1989, with the statutory mandate for the strategic planning and co-ordination of national energy policies and all its ramifications. By the Mandate, the ECN is empowered to carry out overall energy sector planning and policy implementation, promote the diversification of energy resources, including the introduction of new and alternative energy resources, for example solar, wind, biomass and nuclear energy.

In 2007, the new Federal Ministry of Energy came into existence as a result of the merger of the power sector, the Petroleum Ministry and other relevant parastatals. The newly created Ministry of Energy streamlines the activities of the sector, and eliminates the problem of unnecessary overlap and varying standards in the handling of matters relating to the sector. It also has a role to ensure that the activities of all energy related agencies are coordinated. The Ministry of Petroleum Resources under the Ministry of Energy is responsible for all legislative and policy decisions for the oil and gas sector.

The Rural Electrification Agency has been re-established as a government organisation following the disbanding of the agency in 2009, following discovery of widespread fraud. The Agency is responsible for the government-led rural electrification program, which has recently been viewed as unnecessary by many, including the Electricity Regulatory Commission, due to the actions of the 11 private distribution companies in electrifying rural areas.

Government agencies

There are five Energy Research Centres under the Commission with specific technical/research roles. These are:

- The National Centre for Energy Research and Development (NCERD), at the University of Nigeria, Nsukka (responsible for research in solar and renewable energy).
- The Sokoto Energy Research Centre (SERC), at Usmanu Danfodiyo University, Sokoto (also responsible for research in solar and renewable energy).
- The National Centre for Energy Efficiency and Conservation (NCEEC) at the University of Lagos (responsible for research in energy efficiency and conservation).
- The National Centre for Hydropower Research and Development (NCHRD) at the University of Ilorin (responsible for research in hydropower).
- The National Centre for Petroleum Research and Development (NCPRD) at the Abubakar Tafawa Balewa University (responsible for research in petroleum, oil and gas).

The Renewable Energy Division (RED) under the NNPC was established in 2005, and is responsible, with the Biofuels Energy Commission, for the implementation of the automotive biofuel program.

Energy procedure

National Energy Development Project funded by the World Bank launched in 2005 and lasted to 2010. The main purposes of the project were to support the government energy sector reform effort and facilitate the sector's smooth transition to the new market and institutional structure.

The next donation of the World Bank was to Electricity and Gas Improvement Project that started in 2009 and ended in 2014. The most important aims were to: improve the availability and reliability of gas supply to increase power generation in existing public sector power plants; improve the power network capacity and efficiency to transmit and distribute quality electricity to the consumers.

Also the a Renewable Energy Master Plan, from 2006, sets capacity targets for a number of renewable energy technologies, to specify::

- Small-hydro: 600 MW in 2015 and 2000 MW by 2025;
- Solar PV: 500 MW by 2025;
- Biomass-based power plants: 50 MW in 2015 and 400 MW by 2025;
- Wind: 40 MW for wind energy by 2025.

Additionally, electrification is taken into account. It is targeted to improve from the 2005 level of 42 % to 60 % in 2015, and 75 % by 2025.

Energy regulator

The Nigerian Electricity Regulatory Commission (NERC) is responsible for regulating the electricity sector. The legislative framework, though delayed, is being finalised.

The oil industry is regulated by the Department of Petroleum Resources (DPR), a department within the Ministry of Petroleum Resources.

Degree of independence

The Electric Power Sector Reform Act 2005 provides for the tenured appointment of seven Commissioners for the NERC. Funding for the commission comes from operational revenues, for example from the granting of licenses, money allocated by the government for the Commission operation or provided upon request of the Commission.

Regulatory framework

The NERC is currently working on appropriate feed-in tariffs and other regulatory incentives for prospective investors, to promote renewable energy generation in the country. Besides this, the commission is also establishing a legal and regulatory framework for embedded electricity generation, as well as Independent Electricity Distribution Networks to encourage the establishment of off-grid generation/distribution plants in the country, to improve the population access to electricity.

Other recent enhancements to the regulatory framework include standards and guidelines for solar home systems, as well as standards for wind power and appropriate sites for its development. The Commission has also developed placement guidelines for IPPs wishing to engage in power generation, inclusive of RE sources. In addition, the creation of a bulk purchaser for electricity is planned, to remove some bottlenecks in the off-take arrangements currently in place.

Regulatory roles

The Energy Commission of Nigeria is charged with energy policy formulation and coordination. The NERC is responsible for ensuring safe, reliable electricity access for as much of the populace as possible, as well as encouraging private-sector participation in the electricity sector, the monitoring of sector actors and standards of fairness promotion, and the protection of consumer rights. The DPR ensures compliance with industry regulations, processes applications for licenses, leases and permits, establishes and enforces environmental regulations.

Energy regulation role

The Rural Electrification Agency of Nigeria was first inaugurated in March 2006 to rapidly expand rural and peri-urban access to electricity in the country in a cost-effective manner, employing both grid and off-grid options. It emphasizes the application of subsidies, primarily on access expansion rather than consumption, since the intention is to encourage greater participation of the private sector providers.

Regulatory barriers

The development of renewable energy technologies in Nigeria has been slow. However, with the wide range of measures proposed in the REMP, it is hoped that the sector will continue to grow in the country. The finalisation and implementation of a legislative framework for the energy sector, with consideration for the use of RETs and their dissemination, would further enable the development of the renewable energy resources of Nigeria. The NERC is actively seeking to promote RE development through the introduction of more comprehensive licensing arrangements for private-sector operators, ensuring that the FIT is appropriately-set as an RE incentive mechanism, and clarifying market rules for RE and EE services and products.

Analysis of the national economic system and politics

Strength and weaknesses

Nigeria has become the African largest economy since the last GDP estimated revision (USD510 billion). Its natural energy resources (crude oil and natural gas) together with the high oil prices in recent years have boosted export earnings, providing current account surpluses and accumulation of international reserves. However, this dependence on oil and gas (over 90% of export revenues) makes the Nigerian economy susceptible to volatility in global markets.

Furthermore, the country is considered at high risk levels in terms politics and business environment. The federal government cannot guarantee personal and corporate security, hampered by the strength of state and tribal authorities and the criminal gang activities. In addition, long history of economic mismanagement and corruption continue to affect perceptions of doing business in the country.

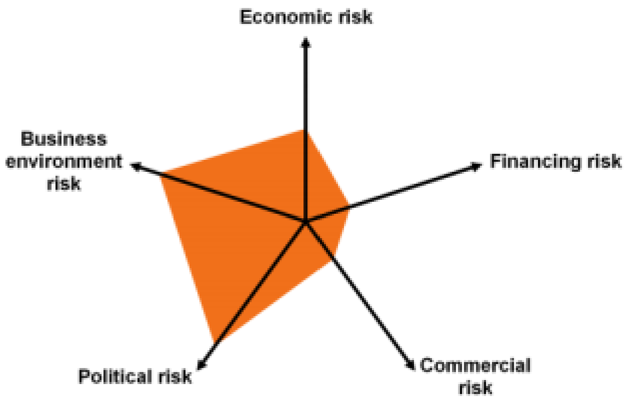

Figure A. 71. Risk dimensions estimated by Euler Hermes. Nigeria.

Economic structure

As a crude oil net exporter, Nigerian economy is mainly based on petroleum and related products, which represent an 87% of total exports. The breakdown of GDP shows the importance of the oil and gas industry, where mining represents 33% of the whole economy. Despite the strength of this industry, Nigeria still shows a relatively underdeveloped economic structure, with excessive importance of primary sector (agriculture, hunting, forestry and fishing together is a 33% of total GDP), while the service sector still does not represent a significant part of the whole economy.

Economic forecast

In the last years to end 2013, average annual GDP growth was 7.1%, higher than any other country in the sub-Saharan region. Such a high value was obtained because ofrises in oil price. Nevertheless, it the country does not grow according to its potential. It is due to losses of output and revenues provoked by industrial disputes and actions of criminal gangs that siphon off considerable crude oil flows through official pipelines. Moreover, ongoing disputes between federal and state authorities relating to oil revenue sharing agreements continue to provide uncertainties and have a negative effect on foreign investment plans.

The oil and gas sector represents around 33% of GDP, providing around 80% of government revenues and over 90% of export earnings. However, the government adopts a policy of economic diversification away from oil and gas, with investment in non-hydrocarbon sector, including mining, agriculture, financial services and manufacturing.

Like others economies dependent on oil and gas, the forecast for Nigeria is affected by the new situation of international prices. With the old conditions with oil price over USD100/barrel, the growth of GDP should maintain at around 7% a year together with positive current account balances and comfortable external debt repayments. Nevertheless, forecasts are subject of wide revision as a result of external influences.

Maps

Population

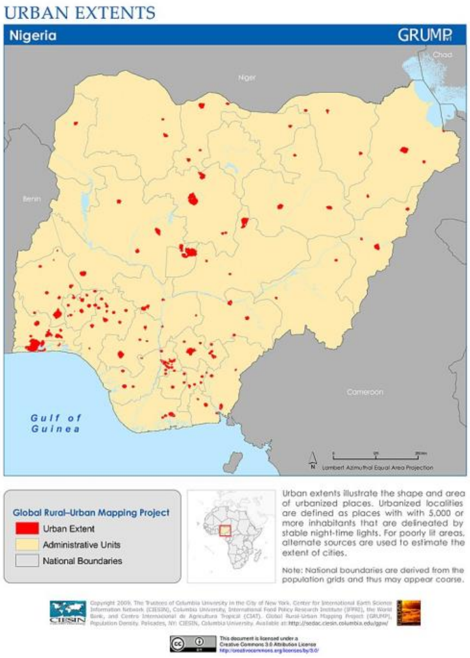

Figure A. 72. Nigeria population map.

DNI

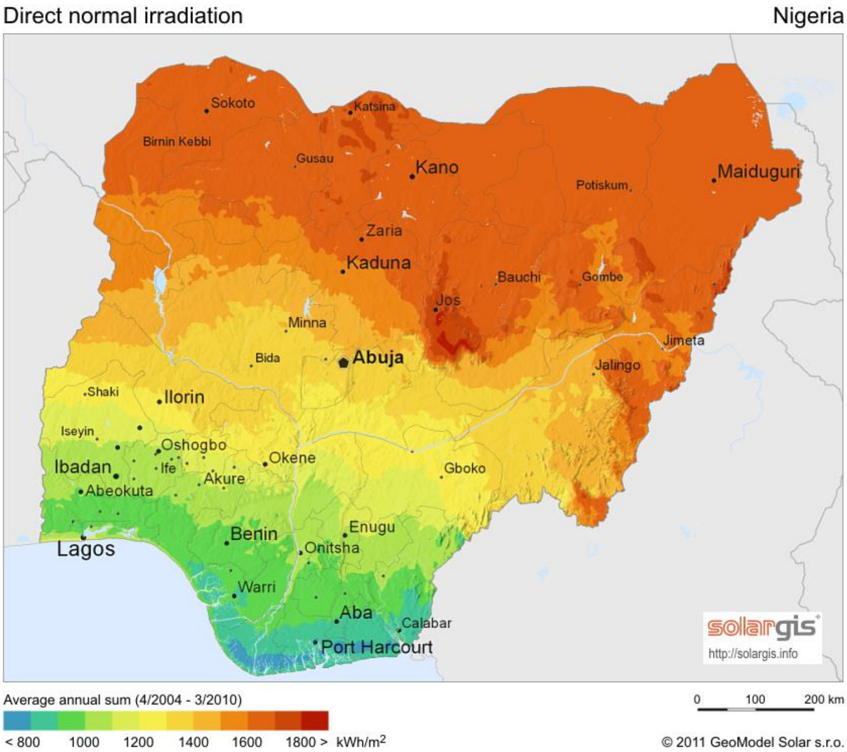

Figure A. 73. Nigeria Direct Normal Irradiation.

Electricity grid

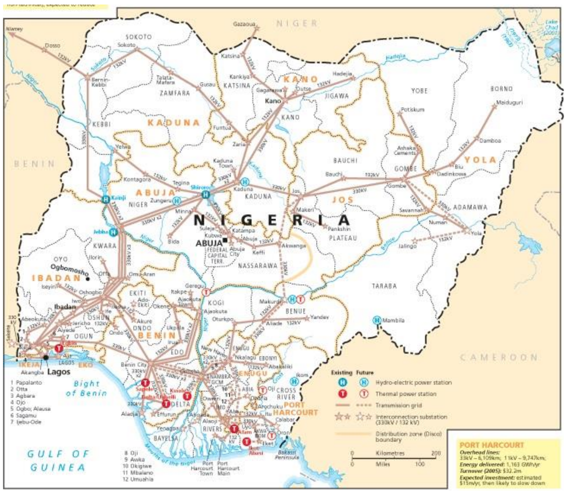

Figure A. 74. Nigeria electricity grid.

Maps Overlapped

Figure A. 75. Nigeria overlapped maps.

Application of the method

- **GDP:** US$ 521.80 Billion (in 2013)
- **Annual GDP Growth rate:** 5.39 % (in 2013)
- **Population:** 173.62 Million people (in 2013)
- **Annual population Growth rate:** 2.79 % (in 2013)
- **Annual electric consumption (per capita):** 148.93 kWh (in 2011)
- **Government debt:** US$ 54.37 Billion (in 2012)
- **Accumulated external debt:** US$ 10.08 Billion, 1.93 % GDP (in 2012)
- **Inflation rate (consumer prices):** 8.48 % (in 2013)
- **Country rating (Euler Hermes):** D3
- **Annually averaged DNI:** 1398.86 kWh/m^2
- **Population with access to electricity:** 48.0 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.3989	0.1396
Demand	0.25	0.6546	0.1637
Electricity grid	0.20	0.4625	0.0925
Energy policy	0.10	0.7500	0.0750
Financial risk	0.10	0.0269	0.0027
		TOTAL	0.4734

Table A. 30. Farm arrangement. Nigeria.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.3989	0.1396
Demand	0.25	0.7091	0.1773
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.6503	0.0650
Financial risk	0.10	0.0269	0.0027
		TOTAL	0.5846

Table A. 31. Stand-alone configuration. Nigeria.

ANNEX 16. Saudi Arabia

Analysis of the national energy system

The might of the country in oil reserves is impressive. Saudi Arabia possesses 16% of the world's proved oil reserves. It maintains to be the first exporter of total petroleum liquids as well as producer of crude oil in the world. Also there can be found the largest oil field in the world; Ghawar, which estimated remaining reserves are 75 billion barrels. Moreover, Saudi Arabia has the world's fifth-largest natural gas reserves, but its production remains limited. The source as coal is not utilized. The net production of electricity is 255, 380 GWh, while consumed is 91%. According to government estimates, the anticipated demand for electricity in the Kingdom is expected to exceed 120 GW in 2032.

In the country there cannot be found any domestic problems supplies, though it is playing a significant role in providing the primaries to other countries. That is why its pipelines can be endangered with terrorist attacks. The last one was noticed and prevented in 2006. Following the incident, the government increased the National Guard and military security force. In addition to direct security, Saudi Arabia to ensure export security is maintaining redundancy (i.e., multiple options for transportation and export) in its oil system, in part as a form of indirect security against any one facility being disabled.

Reliance

Saudi Arabia is a net exporter of energy sources, most notably being the most prolific oil and petroleum product producing country in the world. According to the world's rankings from 2010 it is the largest producer and exporter of total second largest crude oil producer. It is under the possession approximately one-fifth of the world's oil reserve, and the fourth-largest natural gas reserve in the world. The only major imports in the energy sector come from petroleum products (3846 toe in 2007).

Extend network

Network extended in Saudi Arabia distributes electricity to cities, towns and villages giving an access to 97% of habitants.

Capacity concerns

The Saudi Arabian electricity generating capacity has a reserve margin of roughly 3 %, compared to a global average of 10 %. Demand has also continued to outstrip growth in supply, leading the Saudi Electric Company (SEC) to withhold supplies to some areas during peak demand times.

Renewable energy

Currently, except the solar PV installation, there is no other renewable source converted into energy. According to IEA (International Energy Agency), the PV contributes to 1 GWh of the electricity share. Nevertheless, Saudi Arabia due to increasing energy demand and sources limitations is standing up on renewable energy to provide the safety of supply.

Solar energy

The country has good potential for solar energy use, with an average irradiance of 5.8 kWh/m^2/day, which is annually 2200 kWh/m^2 of solar radiation. The national science agency announced a new initiative to construct solar-powered desalination plants, envisaging a first stage construction of a 30000 m^3/day. . In addition, under the terms of an agreement signed in June 2010, Saudi Aramco is about to develop a pilot solar power plant that will have a capacity of 10 MW, which is already under construction. . To another 20 MW obtained from solar power will contribute a plant projected by King Abdullah University of Science and Technology cooperating with a centre devoted to PV technology.

Ownership of electricity

The Saudi Electricity Company (SEC) was established as a Saudi joint stock company through the merger of several companies in 2000. It is responsible for the vast majority of generation, as well as the entirety of transmission and distribution activities in the country. Some large consumers have on-site generation, and the market is open to independent power producers (IPPs), some of which supply the SEC.

Competition

The SEC is a joint-stock vertically-integrated company in majority owned by the state. However, generation activities are partially unbundled, with the market being open to IPPs, with some success.

Saudi Aramco is under the direct supervision of the government through the Supreme Council for Petroleum and Minerals and the Ministry of Petroleum and Mineral Resources.

The Saudi domestic natural gas market, traditionally the sole domain of Saudi Aramco, is slowly being opened to private investment, in exploration and distribution. Foreign consortia are exploring for onshore gas and condensate (natural gas liquids) in the Rub al-Khali, which supposed production of 2 Bcf/d in 2011 finalized with limited success.

Energy framework

Demonstration projects, along with some research and development projects, have been implemented in several academic bodies across the region, including the KACST, to study the potential for renewable energy transition, under the guidance of the Gulf Co-operation Council.

The King Abdul Aziz City for Science and Technology (KACST) recently announced a new initiative to construct solar-powered water desalination plants, reducing energy costs in the sector by up to 40 %. While the other university, the King Saud University in the Kingdom, has established a sustainable energy technology masters and PhD program, initially focusing on wind, solar, hydrogen and nuclear energy sources. .

Moreover, mentioned King Abdulaziz City for Science and Technology (KACST) started a National Energy Efficiency Program (NEEP) in 2003 with a technical support by the UN Department for Economic and Social Affairs (UN-DESA) and funding by Saudi ARAMCO, Saudi Electricity Company and Saudi Basic Industries Corporation. The programme implemented energy auditing in the industrial and commercial sectors and utility load management. It also sets policies and regulations for residential buildings and energy-consuming appliances efficiency such as: energy efficiency labels and standards for air conditioners, electric motors and lighting and energy efficiency codes for new residential buildings. More purposes of the programme are as follows: improvement of energy efficiency information exchange, promotion of energy services and private sector investments and utilization of efficient technologies. The programme was ended with a total success in 2009.Second phase of NEEP started in 2012 with a support by the United Nation of Development Programme (UNDP). The project focuses in four major outcomes with overall goal of capacity development for the new Saudi Energy Efficiency Centre: design of the first Energy Conservation Law and related action plans and regulations; design and establishment of a new national energy information system; design and implementation of extensive training programmes for energy manager and leaders; lastly design and implementation of nation-wide campaign on energy conservation.

The Saudi government and its agencies, in cooperation with the Riyadh-based King Abdulaziz City for Science and Technology (KACST), have begun building a mentioned before desalination plant using solar power. The plant will have a capacity of 10 MW and a reverse osmosis plant that utilizes solar energy technologies.

Energy debates

Current sustainable policies, particularly energy conservation, led to peak load savings of more than 871 MW in 2001, mainly as a result of collaborations between the Ministry of Water and Electricity and the SEC. Policies and programs are being developed for public awareness, energy regulation and legislation, and energy information and programming.

ECRA is currently working with international consultants to develop a National Renewable Energy Policy (NREP).

Energy studies

There are two main energy studies in Saudi Arabia: Renewable Energy Scenarios for the Kingdom of Saudi Arabia-Tyndall Centre and Renewable Energy Potentials in Saudi Arabia - S. A. M. Said, I. M. El-Amin and A.M. Al-Shehri

Role of government

The government has direct influence on oil and gas policy through their involvement with Saudi Aramco.

The Ministry of Water and Electricity (MOWE) is responsible for setting electricity sector policy, as well as long-term energy plans, and overseeing private investment in the sector, for example through IPPs, and possible further unbundling activities.

Government agencies

The King Abdullah Petroleum Studies and Research Centre (KAPSARC)

It is a research and policy centre committed to energy and environmental exploration and analysis.

The Centre

It promotes the development of solutions that will shape a sustainable energy future for the Kingdom. Furthermore, it hopes to motivate companies and policy-makers to achieve: more efficient petroleum use, reduced carbon footprints, sustainable energy solutions, adoption of new energy and environmental technologies.

The King Abdullah City for Atomic and Renewable Energy (KACARE)

It was created by Royal Decree of 17/4/2010 with a mandate to contribute to sustainable development in the Kingdom through developing an alternative energy capacity. It serves as a centre for renewables research and for co-coordinating national and international energy policy.

The King Abdullah University for Science and Technology (KAUST)

It has been given the task of making Saudi Arabia a key energy researcher in the world, and co-operating with other scientific bodies globally to promote renewable and sustainable technologies.

Energy procedure

The Ministry of Petroleum and Mineral Resources is responsible for national planning in the area of energy. The Ministry of Water and Electricity is responsible for setting long-term energy plans.

Saudi Arabia is preparing to introduce nuclear power by 2020. This action is undertaken to meet growing domestic power needs and to free up oil and natural gas for export and higher-end uses. In the interim, Saudi Arabia is participating in the Gulf Cooperation Council efforts to link the power grids of member countries in order to reduce shortages during peak power periods.

Energy procedure

The Saudi Arabia Distribution Code has been developed to define the rules and regulations for various participants for accessing and using the Distribution System. The objective is to establish the obligations of the distribution service providers (DSP's) and other system Users- TSP, Embedded Generators, other distribution service providers and Customers – for accessing and using the Distribution System, more specifically to:

- define obligations, responsibilities, and accountabilities of all the parties for ensuring open, transparent, non-discriminatory, and economic access and use of the system while maintaining its safe, reliable and efficient operation;
- define minimum technical requirements for the participants;
- set out the information exchange obligations of the participants.

The ECRA is providing a careful and gradual process of unbundling and restructuring the electricity market to a competitive one with multiple suppliers, service providers and buyers.

Energy regulator

The Electricity and Cogeneration Regulatory Authority (ECRA) was established in 2002, and is responsible for regulation of the electricity and water desalination industries, in order to provide such services to the country at the lowest price, whilst maintaining the highest standards and quality of service.

The Ministry of Petroleum and Mineral Resources (MOPM) was established in 1960 to execute the general policy related to oil, gas and minerals. The Ministry supervises its affiliate companies working in the fields of petroleum and minerals, including Saudi Arabian Company (Saudi Aramco), Saudi Texaco, Aramco Gulf Operation Ltd. (AGOC), Saudi Arabian Mining Company (Ma'aden) and Saudi Geological Survey.

Degree of independence

ECRA is supervised by a board of directors chaired by the Minister of Water and Electricity, with the Governor of the Authority as deputy chair, 6 members from senior government officials representing the ministries of Water and Electricity, Finance, Petroleum & Mineral Resources, Commerce & Industry, Economy & Planning, and the Saline Water Conversion Corporation (SWCC) and 5 members selected on their own merits. The ECRA is 100 % funded through license fees, and financially and administratively independent.

Regulatory framework

The Electricity Law, adopted and issued by Royal Decree No. M/56 on in 2005, is central in the regulation and development of the electricity sector in the Kingdom, including the outline of the restructuring of the electricity industry and the deregulation of the electricity market.

Regulatory roles

The responsibilities of the ECRA include:

- Preparation of a restructuring plan for the electricity industry, to end vertical integration, and create non-discriminatory independent market operators.
- Continuation of promoting private-sector participation in the generation sector through IPPs.

- Promotion and effect the "*Parallel Market*", that permits large consumers to obtain their electricity services directly from the suppliers of their choice on the basis of mutually agreed prices and other commercial terms.
- Setting and adjusting as necessary tariffs for electricity.
- Preparation of system of key performance indicators (KPIs) for the electricity industry.

Energy regulation role

The Saudi Arabian government is responsible for setting the natural gas tariffs and pricing in the region. This is often seen as an indicator for other regulatory authorities in the region, and a guideline for their natural gas tariffs.

Regulatory barriers

While raising domestic energy prices is supposed to encourage greater energy efficiency. It creates a serious problem in the Kingdom as the basis of the political system is an unwritten social contract between ruler and ruled through which the population receive various benefits including low energy prices and virtually inexistent taxes in return for accepting to be ruled.

Analysis of the national economic system and politics

Strength and weaknesses

Saudi Arabia is one of the main oil and gas producers, if not the biggest in the world, with a strategic importance in the global economy due to its capacity to influence international markets and oil prices. Its large asset base and FX reserves, together with the registered annual fiscal and current surpluses, allows the country to act as a net creditor in the international market, with multiple investments all over the world. On the other hand, this high dependence to international oil prices could be seen as a weakness of the country, which has a limited economic diversification. The external economic strength is in contrast with internal situation of the country, with a high unemployment and under-employment rates, lack of political representation, and poor data transparency compared with others high income economies.

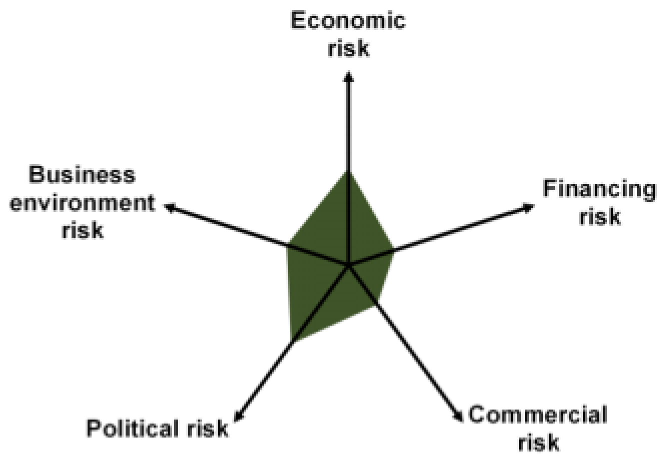

Figure A. 76. Risk dimensions estimated by Euler Hermes. Saudi Arabia.

Economic structure

The Saudi Arabia economic structure is mainly based on crude oil industry, which represents over 50% of GDP breakdown. The manufacturing industry is also related with the oil industry since all the main export products are petroleum derived (Refined petroleum products, plastic articles and basic organic chemicals), representing 10% of the GDP. Great efforts have been made to boost housing and tourism, but it still does not represent a significant contribution to the whole economy. All of these reasons results in a net export trade structure, where the main import products are cars, engines, and iron steel.

Economic forecast

Saudi Arabia has benefited from the high oil prices in the last years, allowing the government to apply large social-support packages and relevant infrastructure projects, providing a further boost to the domestic economy. Arab Spring has had a short term positive impact to the Saudi economy as oil output was increased to substitute for disrupted supplies in the region. As a consequence of high prices and lack of oil supply from some natural producers, the Saudi current account has registered strong double-digit surpluses in 2010-13 (+23.7% in 2011), leading the hard currency foreign exchange reserves around USD60 billion and total FX reserves (including financial assets) over USD660 billion, which gives Saudi Arabia an import cover of at least 15 months.

This strong financial position may have had some influence on the new and unexpected oil price policy adopted by Saudi Arabia at end of2014. Moreover, all the forecasts made by the economical observers were based on that international oil price remain around USD100/barrel, so predictions about GDP growth (5% in 2015), public debt (below 3% by 2015) or fiscal surpluses (7.5% in 2014 and 4.5% by 2015) do not have much validity with the actual oil prices below USD60/b. As a consequence, new analysis and economic forecast are needed to do taking into the account not only the economic issues, but also a new and complex geo-political situation.

Maps

Population

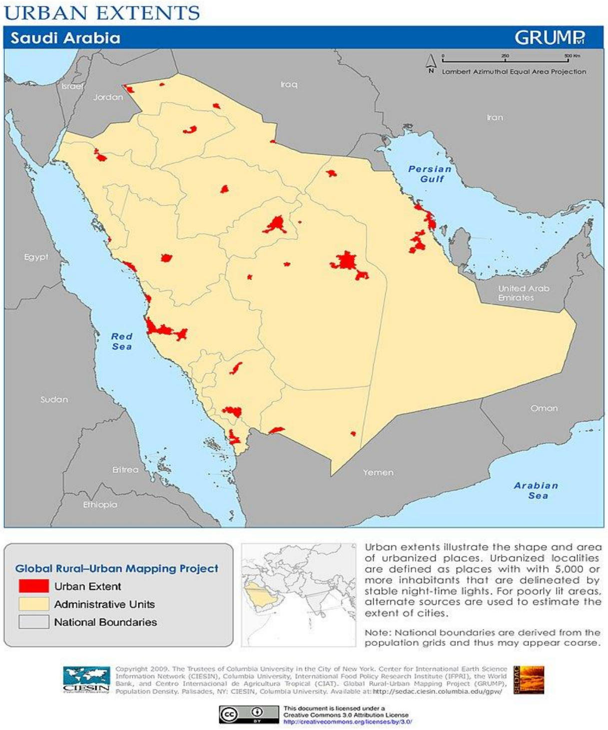

Figure A. 77. Saudi Arabia population map.

DNI

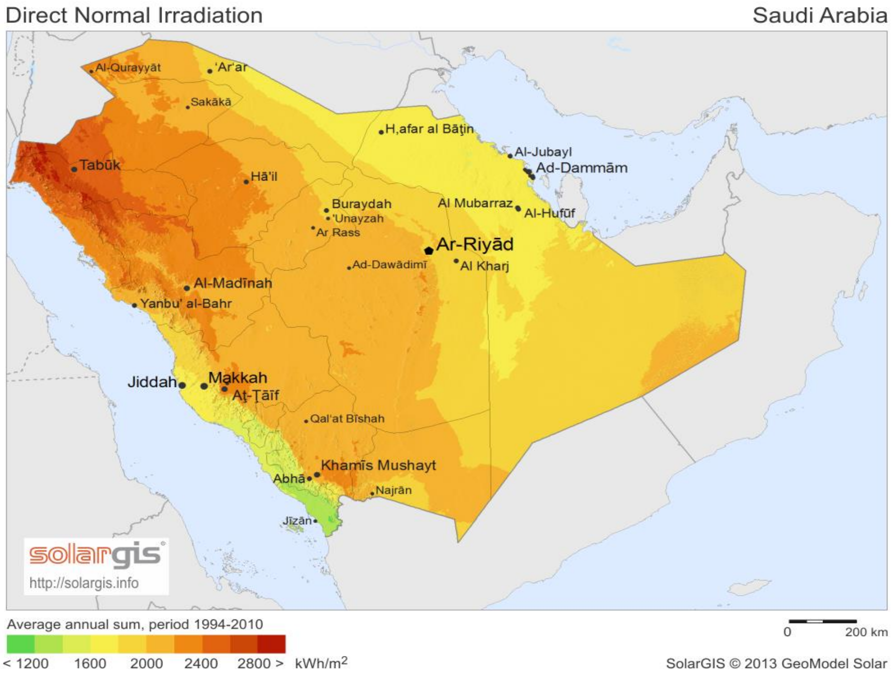

Figure A. 78. Saudi Arabia Direct Normal Irradiation.

Electricity grid

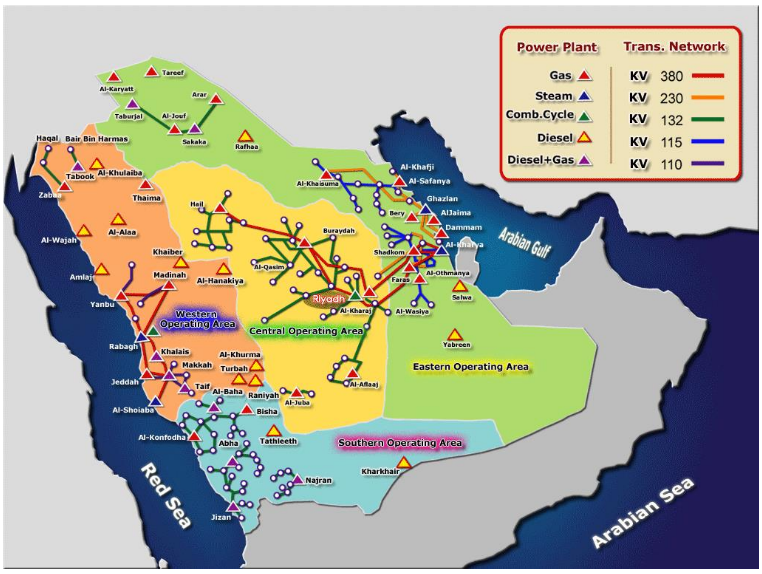

Figure A. 79. Saudi Arabia electricity grid.

Maps overlapped

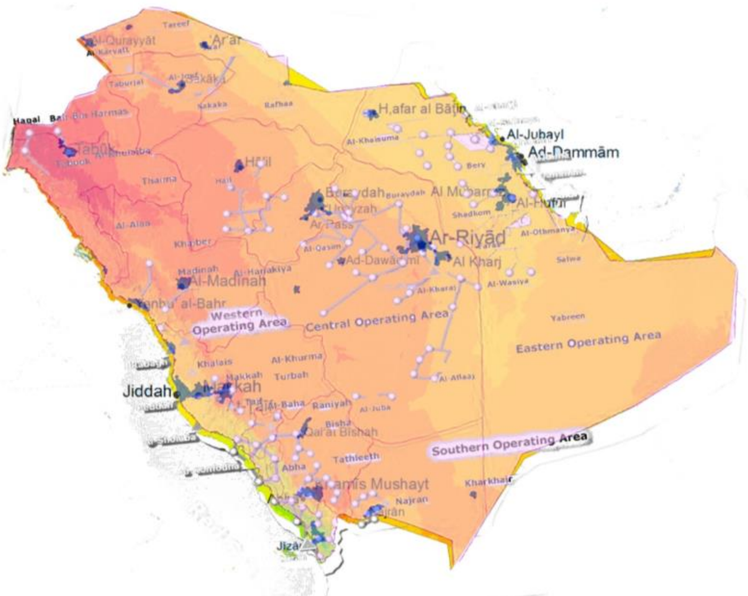

Figure A. 80. Saudi Arabia overlapped maps.

Application of the method

- **GDP:** US$ 745.27 Billion (in 2013)
- **Annual GDP Growth rate:** 3.80 % (in 2013)
- **Population:** 28.828 Million people (in 2013)
- **Annual population Growth rate:** 1.89 % (in 2013)
- **Annual electric consumption (per capita):** 8161.20 kWh (in 2011)
- **Government debt:** N/A
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 3.51 % (in 2013)
- **Country rating (Euler Hermes):** BB1
- **Annually averaged DNI:** 1953.52 kWh/m^2
- **Population with access to electricity:** 99 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.9535	0.3337
Demand	0.25	1.0000	0.2500
Electricity grid	0.20	0.7795	0.1559
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	0.6889	0.0689
		TOTAL	0.8585

Table A. 32. Farm arrangement. Saudi Arabia.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.9535	0.3337
Demand	0.25	0.0101	0.0025
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.5000	0.0500
Financial risk	0.10	0.6889	0.0689
		TOTAL	0.6552

Table A. 33. Stand-alone configuration. Saudi Arabia.

ANNEX 17. South Africa

Analysis of the national energy system

South Africa uses coal, its major indigenous energy source, to generate most of its electricity and a significant proportion of its liquid fuels. It sets South Africa on the 14th position as a highest emitter of greenhouse gases globally.

Energy contributes about 15 % of South Africa gross domestic product (GDP). Eskom is one of the world 10 biggest electricity generators, and is in the top eleven in terms of sales. Not only it generates around 95 % of the electricity used in South Africa, but also the power produced is exported to other African countries. In addition to the functioning generation capacity, a number of previously-mothballed generating facilities are being re-commissioned, including a further 3800 MW of coal-fired capacity.

ESKOM operates South Africa unique nuclear power station, Koeberg (1800 MW), two gas turbine generators (340 MW), six conventional hydroelectric plants (600 MW), and two hydroelectric pumped-storage stations (1400 MW).

The electricity production in 2009 was 249.6 TWh, mainly from thermal generation (93 %). Renewable energy currently only produces approximately 1 % of the electricity generation.

South Africa has proven coal reserves of 48000 million tonnes. It produces 283 million short tons of coal, while consuming 203 million short tons, whereas exports approximately 28 % of all coal mined. Another energy source found in South Africa is oil, which is estimated as a reserve of 15 billion barrels since year 2008. Considering year 2010, the production of oil reached to 192 100 bb a day, while the consumption was 553 000 bb a day. Furthermore, there is one more energy source, natural gas. Its proven reserves as in 2007 were assessed at 27.16 million cu m. As stated in 2009 the production reached 1.9 billion cu m and consumption 5.4 billion cu m.

Reliance

According to 2009 South Africa has traditionally been a net exporter of energy, with total energy exports of 2068297 TJ. Export energy commodities included coal (45234 ktoe) and electricity (1057 ktoe). Moreover, a small amount of indigenously-produced biomass (263 ktoe) is also exported. As it comes to imports, South Africa is a net importer of crude oil and natural gas, transferring 24384 ktoe and 2858 ktoe respectively.

In same year electricity exports in 2009 reached 14052 GWh, whilst the country imported 12295 GWh.

Extend network

The national transmission grid covers 27000 km of South Africa. There has been a massive drive through the Integrated National Electrification Programme (INEP), since 1994 to increase the extent of the population with access to electricity(from 36 % to approximately 71 % in 2004) in order to address the imbalance of electricity supply due to apartheid. As of 2009, total population access to electricity had risen to 75 %. High-voltage transmission in the country occurs at 765 kV, 400 kV, and 132 kV.

Capacity concerns

ESKOM is suffering from generation capacity problems due to demand outstripping supply. The supply/demand gap in early 2008 rose to 4 GW, threatening to collapse the majority of the country electricity network. Unplanned outages due to equipment failure, as well as a dwindling reserve margin caused by robust economic expansion, which has not been mirrored in power sector development, have been blamed for the crisis. As a result, ESKOM introduced "*load shedding*", or scheduled black outs that try to preserve the grid when demand is too high.

The power supply crisis has accelerated the need to diversify the country energy mix and its move towards alternative energy sources such as nuclear power and natural gas, as well as various forms of renewable energy. Generation infrastructure improvements have included the de-mothballing of 3800 MW of coal-fired generation capacity, as well as the proposed construction of two 4800 MW coal plants, which (since being proposed in 2008) are waiting for its finalization. . A further 22 % of new generation capacity developments by 2030 are to come from nuclear power, according to the Integrated Electricity Resource Plan of 2010, revised 2011.

Transmission and distribution losses stood at approximately 9.7 % in 2009, equating to 24280 GWh.

Renewable energy

South Africa has a high level of renewable energy potential and, presently has in place targets of 10 000 GWh of renewable energy. According to the Minister, 3 725 MW is about to be produced by renewable energy. This amount supposedly will cover the energy gap in the country.

Solar energy

Solar energy has the potential to provide 14 % of the country electricity supply by 2050, with solar thermal being able to contribute approximately 43 TWh by 2030. South Africa has good solar resources, as its direct normal irradiance is 7.0 kWh/m^2/day on average for many areas of the country; in particular in areas with close access to the electricity grid, such as in the Northern Cape. Total available potential is estimated at 548 GW.

Ownership of electricity

Although ESKOM does not have exclusive generation rights in South Africa, it does have the practical monopoly on the bulk of electricity in the country, and it maintains the national grid.

In 2002, ESKOM was converted into a public company, though it is de facto a parastatal. In 2003, the Cabinet made a decision to increase private-sector participation in the electricity industry by dividing power generation between ESKOM and independent power producers, or IPPs, even though ESKOM still has the majority of the generation rights. Currently, ESKOM generates approximately 95 % of the electricity consumed in South Africa.

Distribution activities were unbundled from ESKOM in 2003 and the creation of Regional Electricity Distributors (REDs) was begun under the newly-formed Electricity Distribution Industry Holding Company (EDIH). In 2010, after a number of issues relating to backlogs and poor performance, Cabinet decided to terminate the electricity distribution industry restructuring and to discontinue the process of creating REDs with immediate effect. Although the EDIH had made significant progress in establishing the REDs, Cabinet approved the recommendation that the Department of Energy takes over the programmes previously executed under the EDIH mandate. Full transfer of responsibility occurred on the March 1, 2011.

The REDs buy electricity from ESKOM at a tariff set by the National Energy Regulator of South Africa (NERSA) and aim to offer electricity at a competitive price, with efficient service.

Competition

The electricity sector in South Africa is essentially totally vertically integrated, due to the continued existence of ESKOM monopoly of approximately 95 % of the market. ESKOM is involved in practically every area of the electricity sector, from generation to transmission, and retail. In July 2002, ESKOM was converted into a public, limited liability company, wholly owned by government.

Currently, distribution continues to be handled by the 175 re-distributing municipalities that were left after the restructuring efforts of the EDIH. The Department of Energy is investigating further methods of reform to effectively restructure the distribution sector.

There is also SASOL, which is considered to be vertically integrated, while another organisation PetroSA is not due to not having a retail presence.

Energy framework

A number of policy documents have been produced governing energy development, including:

- White Paper on the Energy Policy of the Republic of South Africa, 1998, describes the government general policy for the supply and consumption of energy until, approximately, the year 2010. This policy sets out the path for development of renewable energy and improvement of energy efficiency with the ultimate goal of reaching a more sustainable energy mix, in order to achieve South Africa macro-economic goals. A successor to this policy was released in September 2009 and aims to overhaul the fiscal, legislative and regulatory regimes in the energy sector, to further promote renewable energy development, and reduce carbon emissions.
- White Paper on Renewable Energy, 2003, lays the foundation for the widespread implementation of renewable energy and sets a target (currently not mandatory, only a policy objective) of ten thousand (10000) GWh of renewable energy contribution to final energy demand by 2013.
- Energy Efficiency Strategy of the Republic of South Africa, 2005 (reviewed 2008), sets out a national target (currently not mandatory, only a policy objective) for energy efficiency improvement of 12 % by 2015 and provides for a number of "*enabling instruments*".
- Biofuels Industrial Strategy of the Republic of South Africa, 2007, proposes the adoption of a 5 year pilot program to achieve a 2 % penetration level of biofuels in the national liquid fuel supply. It further proposes the utilization of certain crops for the production of biofuels, and excludes others on the grounds of food security. It recommends the use of a fuel levy exemption for biodiesel and bioethanol.
- National Cleaner Production Strategy, 2004, seeks to "*enable SA society and industry to develop its long term, full potential by... adopting the principles of Cleaner Production... and promoting the practices of sustainable consumption*."
- The 2009 Energy Act, focused on ensuring that diverse energy resources are available, in sustainable quantities and at affordable prices in support of economic growth and poverty alleviation. It further provides for energy planning, increased generation and consumption of renewable energies, contingency energy supply, and a variety of other measures to promote energy development.

Other pieces of legislation include:

- Integrated Energy Plan (2003).
- Mineral and Petroleum Resources Development Act (2002).
- Electricity Act (1987).
- Gas Act (2001).
- Gas Regulator Levies (2002).

- National Energy Regulator Act (2004).
- Conservation Act (1989).
- National Environmental Management Act (1998).
- Water Act (1998).

There are also several programmes promoting sustainable energy, such as:

- Urban Sustainable Energy for Environment & Development programme (SEED), focusing on energy efficiency.
- Renewable Energy Market Transformation programme (REMT), run by the Department of Energy, focusing on removing barriers and reducing the implementation costs of renewable energy technologies, and promoting on-grid electricity for renewable energy sources.
- The Renewable Energy Feed in Tariff programme (REFIT), run by the National Energy Regulator of South Africa, focuses on remunerating independent power producers for renewable power they feed into the national grid.

The REFIT programme was first introduced in 2009, and provided a set of tariffs for renewably-generated electricity. This aimed to create an enabling environment for further renewable energy developments and to support the government targets of 10000 GWh of renewable electricity in the national grid. Tariffs were introduced for wind, small hydro, concentrated solar power and parabolic trough systems, and landfill gas. The National Energy Regulator of South Africa reviewed and reduced the rates for Feed in Tariffs in March 2011, in order to bring them in line with falling technology costs and fluctuations in the exchange rate.

In 2011, the Department of Energy released the first round of renewable energy bids (REBIDs) for independent power providers. In December, the 28 preferred bidders in the state’s independent power producer procurement programme were announced, and the second round of bidding closed in March 2012. The first 1451MW allocated out of a total 3725MW were divided across wind, solar photovoltaic and concentrated solar power.

Energy debates

State energy company ESKOM has embarked on a massive programme to upgrade and expand the electricity infrastructure of the country.

Firstly, it plans to double its total generating capacity to 80 GW over the next two decades, with nuclear power making up about half of the new capacity. Secondly and lastly, the state supplier is considering bids from France’s Areva and the US's Westinghouse Electric to build a new conventional nuclear power plant that could start generating electricity from 2016, and has said that it could build more nuclear stations by 2025.

Even though renewable energy has been receiving much attention both from the government and from the media, no new legislation or policy has been created to give effect to the White Paper on Renewable Energy of 2003, except for the publication of the REFIT Guidelines in March 2009.

The development of a biofuel industry is still to be debated, due to concerns around food and water security; this is despite the fact that the Biofuels Industrial Strategy of the Republic of South Africa (released in 2007), calls for maize to be excluded due to its status as a staple food source.

Proposals to create an Independent System Market Operator (ISMO) as an autonomous, state-owned entity to operate the national transmission grid, have been gaining ground politically as of 2013. Key factors identified as having hampered the development of independent power production include the perceived conflicts of interest in ESKOM, which would be assuaged through the creation of a new transmission network entity.

Energy studies

Major networks include:

- The Sustainable Energy Society of Southern Africa (SESSA) a non-profit organization dedicated to renewable energy and energy efficiency.
- AfriWEA, which promotes and supports wind energy development on the African continent by facilitating the exchange of information, expertise and experience in the wind energy sector.
- Sustainable Energy Africa.
- Energy Research Centre, University of Cape Town.

South Africa is also a key player in the Southern African Power Pool (SAPP), which was created with the primary aim of providing reliable and economical electricity, to supply to the consumers of each of the SAPP members, consistent with reasonable utilisation of natural resources and environmental impact.

Beyond the White Papers on Energy Policy and Renewable Energy, these studies are also relevant:

- The National Biofuels Feasibility Study, 2006.
- "*Renewable Energy in emerging markets and developing countries: Current situation, market Potential and recommendations for a win-win for EU industry, the Environment and Socio-economic development*" (RECIPE), Country Report on South Africa, 2006.
- The Department of Energy, Integrated Resource Plan 2010.
- Sustainable Energy and Climate Change Project (SECCP), Carried out by Earthlife Africa.

Role of government

The Department of Minerals and Energy was split, in 2009, into the Department of Energy and the Department of Mineral Resources. The Electricity and Nuclear branch of the Department of Energy is responsible for electricity and nuclear-energy affairs, while the Hydrocarbons and Energy Planning branch is responsible for coal, gas, liquid fuels, energy efficiency, renewable energy, and energy planning, including the energy database.

Government agencies

The Central Energy Fund Group (CEF (Pty) Ltd.)

It is involved in the search for appropriate energy solutions to meet the future energy needs of South Africa, the Southern African Development Community and the sub-Saharan African region. This includes gas, electrical power, solar energy, low-smoke fuels, biomass, wind and renewable energy sources. Subsidiaries of the CEF Group include PetroSA, and the National Energy Efficiency Agency (NEEA). NEEA was created in 2006 as a wholly-incorporated division within the CEF Group, responsible for the implementation of demand side management and energy efficiency projects in the country; the management of strategies for improving efficiency; awareness-raising campaigns and training programs in energy efficiency, and co-operation with all agencies involved in the sector to ensure best practice.

The Energy Development Corporation (EDC)

Was established in January 2004 as a division of CEF, and supports the development of renewable energy and alternative fuels through investment. The corporation targets market sectors where there is insufficient private sector activity as well as where the government, for strategic reasons, believes state investment is required. The EDC is also involved in sectors where renewable energy and energy efficiency require catalysing and developing.

The South African National Energy Research Institute (SANERI)

A wholly-owned subsidiary of the Central Energy Fund (Pty) Ltd, is the public entity tasked with coordination and undertaking of public interest energy research, development and demonstration. It is under the joint custodianship of the Department of Energy and the Department of Trade and Industry.

Energy procedure

The National Energy Bill (2008) has been published. This bill gives legislative effect to the Energy White Paper on Renewable Energy, approved during 2004.

In 2010, the Department of Energy published the national Integrated Resource Plan (IRP) for the electricity sector, as a subset of the Integrated Energy Plan. It seeks to consider alternatives to large-scale, capital-intensive, supply facilities for the future development of the South African energy sector. The IRP purpose is the identification of investments in the electricity sector which will allow the country to meet the forecasted demand with the minimum cost to the country. Various options are explored within the IRP, including further developments to the country nuclear capacity, import options for electricity from neighbouring countries, and the potential for distributed/off-grid generation as a solution for rural electrification.

The 2012 Strategic Plan of NERSA, the National Energy Regulator of South Africa, included streamlining the regulatory processes in the licensing and analysis of tariff applications, as well as introducing more IPPs, and continuing renewable energy development. R12.2 billion (US$1.33 billion) has been set aside for the development of renewable energy IPPs in the Multi-Year Price Determination 2010/11 to 2012/13 (MYPD2).

Energy regulator

The National Energy Regulator of South Africa, established in 2004, is responsible for regulating the electricity, natural gas and petroleum industries.

The Nuclear Sector is regulated by the National Nuclear Regulator (NNR), established by the National Nuclear Regulatory Act 47, 1999.

Degree of independence

NERSA consists of four full-time and five part-time members appointed by the Minister of Minerals and Energy (including the Chairperson).

The Regulator is funded by monies set aside by Parliament, levies imposed by or under separate legislation, funds collected under separate legislation, charges for dispute resolution and other services rendered in terms of the National Energy Regulator Act, as well as a licence fee.

Regulatory framework

In 2009, NERSA approved the Renewable Energy Feed-In Tariff (REFIT) to achieve Government target of producing 10 TWh of electricity per year, and sustain growth beyond this target.

The tariff for wind energy, 1.25 ZAR/kWh ($0.14 USD/kWh) is greater than that offered in Germany (€0.092/kWh) and more than that proposed in Ontario, Canada ($0.135 CAD/kWh).

The tariff for concentrating solar, 2.10 ZAR/kWh ($0.27 USD/kWh), is less than that in Spain (€0.278/kWh), but offers great promise in the bright sunlight of South Africa. NERSA revised program followed extensive public consultation. Reductions to the feed-in tariff were made with the 2011 review.

Regulatory roles

Functions of the NERSA include issuing licences, setting and approving tariffs and charges, mediating disputes, gathering information pertaining to gas and petroleum pipelines, and promoting the optimal use of gas resources.

Energy regulation role

The Department of Energy is the primary government institution responsible for energy regulation. No other government department takes an active role in the energy sector.

Regulatory barriers

Possible barriers include the fact that the target set by the White Paper on Renewable Energy is too low to stimulate investment, while there are too few fiscal incentives for energy efficiency and renewable energy. The cheap electricity available in South Africa is a further barrier to the implementation of more expensive renewable energy technology. There is also a need for clearer direction from national government on the future of renewable energy and energy efficiency, in terms of legislation and regulations, as well as greater co-operation between the government departments and the private sector.

It is hoped that the recently-introduced IRP (2010) will enable the improved development of renewable energy and energy efficiency in the country. The lack of non-discriminatory open access to infrastructure, such as the national electricity grid, is also impeding the development of independent power producer installations, including renewables, as delays in grid connections can be seen as a disincentive to new developments.

Analysis of the national economic system and politics

Strength and weaknesses

A feature of the post-transition era in South Africa is the adoption of relatively orthodox economic policies, aligned with western ‘norms’, and perceptions (accepted by multilateral agencies) that the economic management has been generally good in the last years. In spite of Nigeria rebasing of its GDP data, South Africa still plays its role as a regional leader. The South Africa economy is reasonable well diversified, taking advantage of its natural resources (gold, platinum, chrome) but with a growing importance of manufacturing and industry. In addition, the ANC government has achieved an exemplary exodus from foreign debt problems in the 1990s, keeping it at reasonable levels relative to GDP.

Nevertheless, the South African economy still has some important structural weakness, as unemployment, rural poverty and weak educational standards. In spite of the benefits of opening its economy, it exposes the country to currency and external account pressures, and makes its major industry (mining) vulnerable to commodity price fluctuations. Other country weaknesses are labour market flexibility, current and fiscal account deficits or lack of investment in power generation.

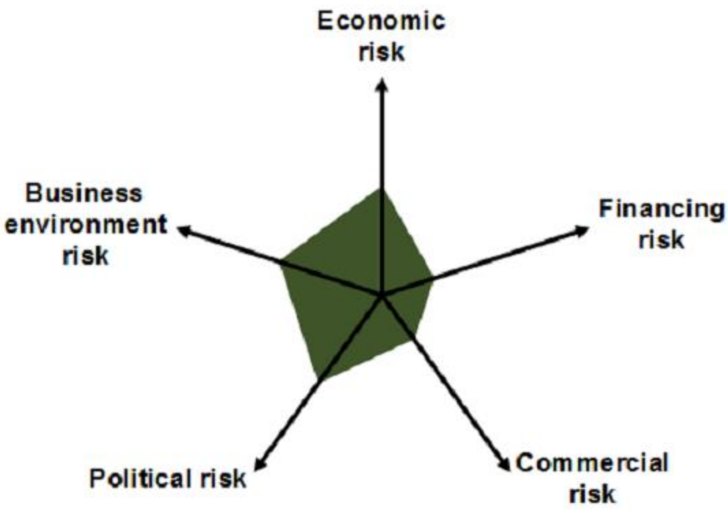

Figure A. 81. Risk dimensions estimated by Euler Hermes. South Africa.

Economic structure

South African's economy has traditionally been based on mining, taking advantage of its natural resources, like nonferrous materials, metalliferous ores and metal scrap. Despite the significant contraction in the mining industry, the country remains a major exporter in the international market, with net exports to the most industrialized regions in the world, which are those with higher demand of raw materials (China, USA and Japan). South Africa also has a significant industry of iron and steel, which, together with the manufacture of vehicles, make an important contribution to exports (8% each). Unlike mineral resources, country does not have its own energy resources, so petroleum and related materials are its main import (21% of total).

Economic forecast

The GDP growth average in last ten years is 3.4%, which is a realistic benchmark for economic predictions. Rate of expansion of 5% is needed to make a significant improvement in live conditions, but the South African economy has some structural weakness, which are limiting the GDP growth below that rate. The main reasons for of these limitations are: lack of skilled workforce, rural poverty or high unemployment rates. In addition, European weakness has affected negatively South African exports, with a large lost output in the mining industry (-24.7% q/q). Taking this into the account, economic observers revised downwards theirs GDP forecast to +3% in 2015.

The rand (ZAR) is an open trade currency and is susceptible to periodic volatility, and downgrade in public ratings making it weak in the international market. There is a strong correlation between depreciation of the ZAR and price pressures, so the currency is likely to weaken. Inflation rates are expected to be about the official target range of 3-6%.

Since the 90's South Africa has starred in an exemplary exodus from external debt problems, reflecting the sound economic management that carried over into the post-transition period. External debt stock is around 40% of GDP and 110% of total export earnings, while the external debt service ratio is below 8%.

Maps

Population

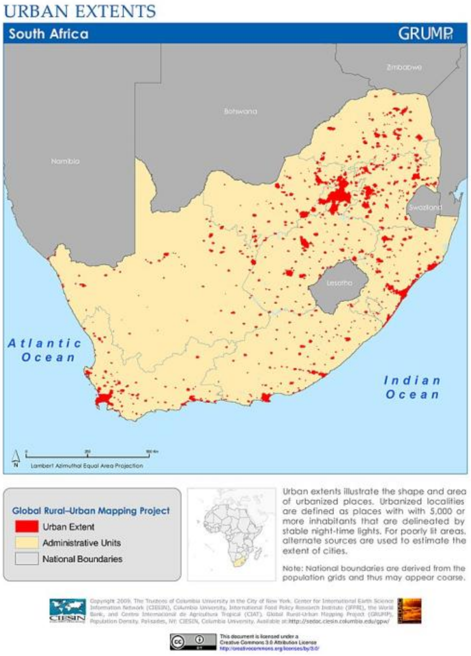

Figure A. 82. South Africa population map.

DNI

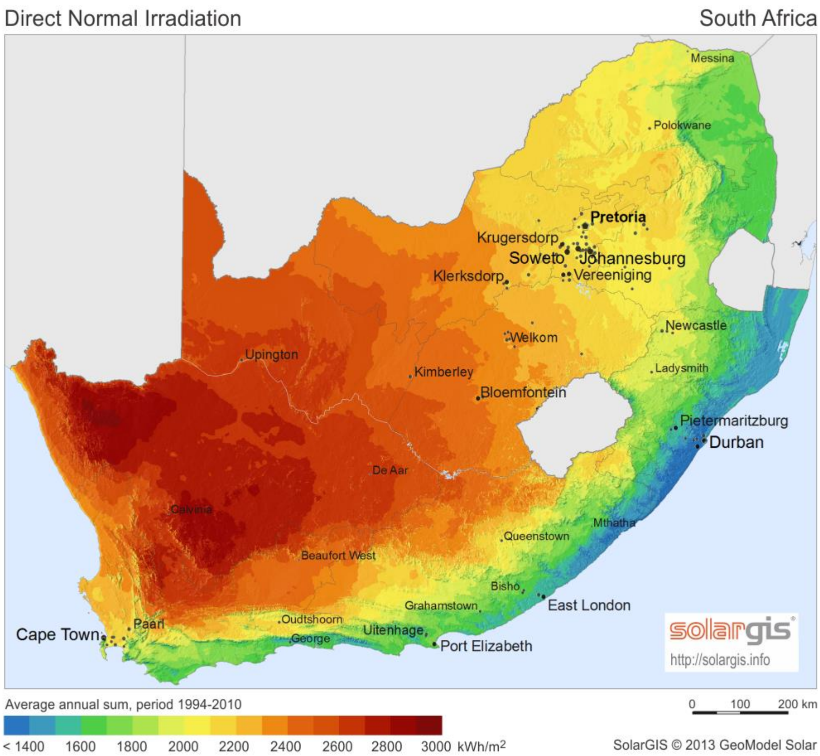

Figure A. 83. South Africa Direct Normal Irradiation.

Electricity grid

Figure A. 84. South Africa electricity grid.

Maps Overlapped

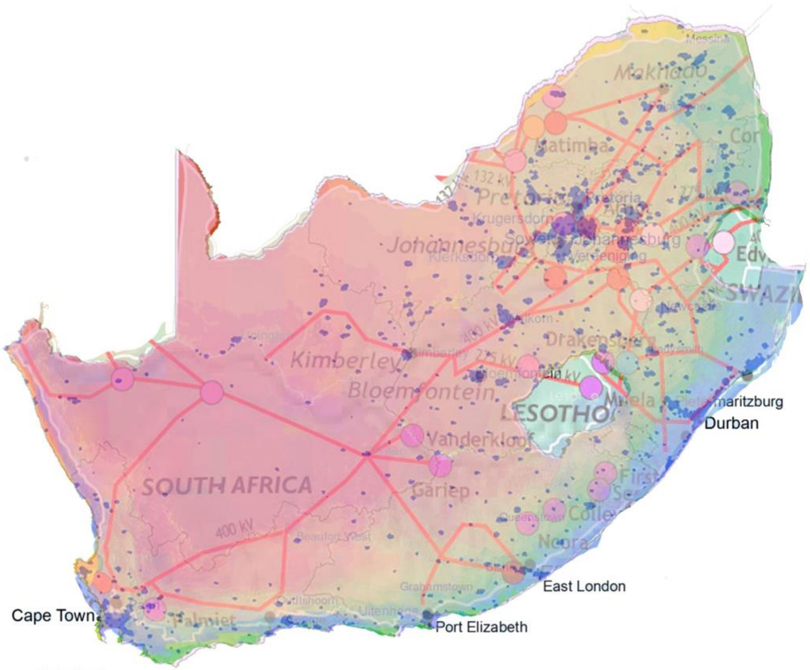

Figure A. 85. South Africa overlapped maps.

Application of the method

- **GDP:** US$ 350.63 Billion (in 2013)
- **Annual GDP Growth rate:** 1.89 % (in 2013)
- **Population:** 52.98 Million people (in 2013)
- **Annual population Growth rate:** 1.34 % (in 2013)
- **Annual electric consumption (per capita):** 4603.87 kWh (in 2011)
- **Government debt:** N/A
- **Accumulated external debt:** US$ 137.5 Billion, 39.22 % GDP (in 2012)
- **Inflation rate (consumer prices):** 5.71 % (in 2013)
- **Country rating (Euler Hermes):** BB1
- **Annually averaged DNI:** 2199.56 kWh/m^2
- **Population with access to electricity:** 84.7 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Population	0.25	1.0000	0.2500
Electricity grid	0.20	0.7129	0.1426
Energy policy	0.10	0.6250	0.0625
Legal certainty	0.10	0.6889	0.0689
		TOTAL	0.8740

Table A. 34. Farm arrangement. South Africa.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	1.0000	0.3500
Population	0.25	0.1806	0.0452
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7500	0.0750
Legal certainty	0.10	0.6889	0.0689
		TOTAL	0.7391

Table A. 35. Stand-alone configuration. South Africa.

ANNEX 18. Spain

Analysis of the national energy system

The population of Spain is around 46.7 million, which sets the country at fifth place in EU. Following the IEA reports, the energy consumption per capita reaches 5 964 kWh, while the average of the IEA members countries is 9 301 kWh/capita. Furthermore, the net imports of electricity are -6 731 GWh. Nevertheless, Spain is dependent on imports of primary energy supplies as oil products, crude oil, natural gas, coal. It puts Spain at low rate of energy self-sufficiency, obtaining only 29%. Moreover, due to the crisis oil consumption as a whole has dropped from its peak in 2007 of 1.61 mb/d to 1.29 mb/d in 2012, although demand for middle distillates has remained relatively strong. Considering natural gas, its demand stood at 32.5 bcm in 2012, below 2005 figures and far from 2008 data, when demand reached 40.3 bcm. Spain imposes a stockholding obligation on both its oil and gas operators, and as such has emergency reserves of both oil and natural gas. In general, it has a large and relatively complex refining industry, with nine refineries and a total nameplate capacity of 76.530 kilo tonnes (approximately 1.5 mb/d).

As it comes to renewables (solar, wind, hydro power; and biofuels and waste), they play an important role in Spanish electricity production, constituting around 40% of the total, while in total primary energy supply they contribute to 14.6 % of the share. Then nuclear power is providing 20% of the total electricity and 13% of the primary.

Considering total consumption by sector, the transport and industry are almost equivalent with a share of 35% and 31% respectively. The remaining two commercial and residential are as well similar (16% and 18%). As a whole, the total consumption reached 84.6 Mtoe.

Even though CO_2 emissions increased since 1990 around 29%; currently reaching 267 $MtCO_2$; Spain is below the IEA average. The country per capita is producing around 5.7 tCO_2. Nevertheless, this amount is needed to be declined in order to accomplish the 20-20-20 targets.

Reliance

As mentioned before, Spain is relying heavily on imports due to very little domestic primary energy supply. The crude oil production reaches 0.4 Mt, while crude oil net imports are 57.9 Mt with main providers from Mexico (15%), Saudi Arabia (14%) and Russia (14%). Then production of oil products is 60.5 Mt and net imports stand at 31.5 Mt transferred from US (14%), Portugal (10%) and Italy (10%). Considering natural gas, the country obtains 0,1bcm, but net imports are 29.9bcm mainly from Algeria (53%), France (12%) and Qatar (10%). Lastly the coal production reaches 2.5 Mt, while its net imports are 13.0 Mt from Indonesia (25%), Colombia (18%) and Russia (17%). As it can be noticed Spain is dependant from countries from all over the world.

However, in 2012 Spanish exports of refined products increased by 31.2% compared to 2011. In fact, the country became a net exporter of petroleum products since July 2012.

Extend network

Spain is a developed country; the electrification rate reaches 100%, according to the World Bank data. Regarding transmission infrastructure, 621 km of new lines were commissioned in 2014, meaning that at the end of the year the national transmission grid totalled 42,760 km of circuit. Furthermore, transformer capacity rose by 3,535 MVA, increasing the total national transformer capacity to 84,779 MVA. Amongst the projects concluded in 2014, noteworthy is the Brovales-Guildford 400 kV line (237 km), which completes the construction of the Almaraz-

Guillena axis; whose main objective is to ensure the quality of supply of the demand expected in the regions of Extremadura and Andalusia. In addition, this axis gives continuity to the Puebla de Guzmán-Tavira 400 kV line, the new interconnection line with Portugal, commissioned in 2014.

Capacity concerns

Spain's diversification of climate and high demand on air-conditioning or heating, during the extreme temperatures period, are making the country very vulnerable to backup energy systems. There is a complication with energy peak demand management. As the country is capable to produce energy from renewable sources, especially wind, its distribution is not constant and not always can be used to cover the peak demand. As well renewables have priority over other energy production plant. It means that the other power plants are not working with a constant efficiency, in other words their power generation is not according to their purpose. Spain main problem is to decline the reliance on backup systems and manage the power division in order to maintain the economical sustainability, and control the environmental pollution. The country also aims into providing security supply while lowering the share of nuclear power in energy mix.

Renewable energy

Main renewable source used in Spain is wind. According to IDAE (Institute of Diversification and Saving Energy), the generated energy from 400 wind power plants reached 8 155 MW and the power input to the national grid was 16 000 GWh (6.5 % national demand) in 2014.

The following renewable is hydro, which is not very sustainable in terms of development and produced power. In general, small and large hydro generate 3 646 MW of energy, with stations in Andalusia, Aragon, Castile and Leon, Catalonia and Galicia. In the dry periods the produced electricity reaches only 25 000 GWh, while the humidity ones are able to almost double this value.

Even though, renewables has its high potential to contribute to energy mix, they are still very costly and dependant on weather conditions.

Solar energy

The average annual insolation in Spain is reaching around 1600 kWh/m^2 on a horizontal surface. Compared to other EU countries, it is the highest value. Even though US has got higher insolation rate in specific regions, Spain has developed more technology and uses more power generated from solar energy. It makes the country a world leader in this field. Currently, there are 50 CSP connected to grid, generating 2 300 MW of power. As it comes to PV technology, in 2006, the industry production grew by over 40%. It reached a world-wide production volume of 2520 MWp of photovoltaic modules. In 2010 photovoltaic energy capacity reached 3 787 MW, of which 6 279 GWh was converted into electricity. This field is consisted of more than 500 companies of which 10% is the production.

There have been also commissioned new policies for training and certificating installers of solar panels; and new requirements for buildings that obliges them to have a minimal solar energy contribution to warm sanitary water. Spain has a national training system for installers and an obligatory certification for solar thermal panels.

Ownership of electricity

There are three major companies that produce electricity in Spain; Ibedrola, Endesa and Gas Natural Fenosa with shares of 24, 6 %; 22, 5 % and 16, 2 % respectively. The other companies together with E.ON and Edp –HidroCantabrico are constituting the remaining part.

The national grid is managed by so called company Red Eléctrica de España (The National Grid of Spain - REE). The main aims of the company are to guarantee the correct functioning of the electricity system and to ensure the continuity and security of the electricity supply at all times. They also supervise and coordinate the generation-transmission system and manage the development of the transmission grid.

Competition

The competitiveness in Spain generally does not exist. All of the institutions are private one and the market prices do not vary so much. Moreover the retail market is fully liberalised, which means that the end-user is entitled to contract with a chosen company to buy the electricity or can agree with the government prices. Nevertheless, the large industries are obliged to buy from the market, whereas only small consumer has allowance of election (by means of TUR-tariff of last resort). However, there are three most important companies producing energy and electricity. Their shares summed up constitute 75 % of the market. These are Idedrola, Endesa and Gas Natural Fenosa. As it comes to distribution the monopoly has got the REE.

Energy Framework

In fact, Spain as a member of European Union is obliged to achieve the assumption of Climate Action Plan. This plan is supposed to finalize in 2020, with every European country declining their greenhouse gases emissions (GHG) by 20%; increasing renewable shares to 20 % of which 10% has to supply the transportation sector; and providing a grew by 20% of energy efficiency.

In the frames of the Plan, Spanish basic support scheme for share of renewable energy in electricity (RES-E), so called “Régimen Especial”, was operated until the end of 2011 and suspended at the beginning of 2012. Currently, no other support is being undertaken for this purpose. Nevertheless, there is in preparation a tax regulation system for investments related to RES-E plants. Moreover, the operators of RES-E plants have priority against grid operators and are authorised to connect to and expansion it. There are settled tax credits for solar thermal energy and biofuels in transport sector. In addition, a RD&D plan is undertaken to direct support to RES-E, RES-H&C and RES-T.

Energy debates

Currently the price of electricity in Spain has almost doubled since 2006 and reaches 14, 27 c€/kWh. Compared to other EU countries the prices are not steady, which contributes to economic instability. The fault of this lies with the thermal and PV solar system rapid growth of installation without considering the economic aspects; as the subsidies exceeds the market price of the electricity. This provoked a tariff deficit boost, which government and energy companies are trying to recompense with increasing the taxes or energy prices. However, the power capacity from these systems is worth to be considered, as the CSP is 7000 MW and PV reaches 4000 MW. The main dilemma lays in maintaining the solar power systems. From the standpoint of energy management and global warming issues, this clean energy is worth to be maintained. On the other hand there is an economic barrier to do so.

Energy studies

National Renewable Energy Centre (CENER)

It is a technology centre specialised in research, development and promotion of renewable energy in Spain. Currently, their studies involve six areas: wind, solar thermal and solar PV, biomass, energy in buildings, and renewable energy grid integration.

The Investigation Centre of Energy, Environment and Technology (CIEMAT)

The responsibilities of the centre are to contribute to sustainable development of the country, and to the quality of life of its citizens through the generation and application of scientific and technological knowledge. Its main goal is to maintain its position as a centre of excellence in energy, environment and technology and in basic research.

Role of Government

Ministry of Industry, Energy and Tourism

This complex ministry is responsible for energy issues in the country. They are ordered to manage the energy and price policies, control the competitiveness between the companies, maintain the security supply of the country, and manage all the energy matters.

Ministry of Agriculture, Food and Environment

It is a ministry of which one secretary is obliged to control the environment safety. Their main task is to contribute to environmental protection in respect of energy production.

Government agencies

City of Energy Organisation CIUDEN

It is a foundation established in 2006, working under the government. Their main duties are to execute Spain program of R&D+I (Research& Develop +Innovation) related to energy and environment, and to contribute to development of Bierzo region. The CIUDEN is subordinated to Ministries of Industry, Energy and Tourism; Economy and Competitiveness; and Agriculture, Food and Environment.

CENER-CIEMAT Foundation

The Foundation was established in 2002 under the Ministries of Economy and Competitiveness; Industry, Energy and Tourism; and a Government of Navarra. Their main missions are to:

- Provide support for R&D+I activity of firms by rendering technological services, executing R&D projects under contract and in a consulting capacity,
- Develop production technologies and exploit energy sources through research and development
- Facilitate maximum penetration of renewable energies in the energy system by generating the necessary tools and services to provide solutions to technical problems and relational difficulties between various agents within the system

The Institute of Diversification and Saving of Energy (IDEA)

It is working under the Ministry of Industry, Energy and Tourism. The main strategies are to improve efficiency of renewable energy as well as energy itself, and to contribute to develop new technologies of carbon capture system to lower the emission. To achieve these aims the Institute is providing the scientific and economic supply base.

The National Committee of Energy (CNE)

The main role of the committee is to provide energy regulations. It is aiming to ensure effective competition in energy systems (electricity, and liquid and gaseous hydrocarbons market) together with objectivity and lucidity of its activity in order to provide benefit for the operator and consumer. Currently, the organisation is assigned to Ministry of Industry, Energy and Tourism.

Energy procedure

In general, the Spain installed power capacity according to 2014 was around 103 MW, while the peak demand reached a value of almost 40 MW. Moreover, the year was closed with total electricity generation of 243,486 GWh. Spain has got a lot of additional power supply. The only problem is to manage its usage. Also the renewable share in power production is, as indicated before, 14, 6 % which makes it a sufficient rate.

Lately Spain has opened new pipeline of natural gas transfer from Nigeria, called MEDGAZ. This action has lowered the reliance on Algeria, as a main import country of natural gas. It is very important for the country's security supply to continue energy supply diversification.

Until 1995, Spain's emergency oil reserves were held only by industry, after which an agency was created for holding public stocks – the Corporation of Strategic Reserves of Petroleum Products (CORES). The stockholding obligation in Spain is distributed between industry and CORES, with each holding approximately 50%. This provides the Spanish system with flexibility at the time of releasing stocks. In the event of a gas emergency, Spain obliges natural gas shippers to maintain strategic stocks equivalent to 20 days of consumption in accordance with what the regulations define as "firm sales" during the preceding calendar year. The stocks must be maintained by traders and self-supplied consumers at any moment, and must be kept in underground storage only. The government assumes control of the strategic stocks in emergency situations.

Energy regulator

In general there are three organisations providing regulations; one of them is national:

- The Council of European Energy Regulator (CEER)
- The Agency for the Cooperation of Energy Regulator (ACER)
- The National Committee of Energy (CNE)

Degree of independence

The European agencies are working under the EU Parliament, while the National one is assigned to Ministry of Industry, Energy and Tourism.

Regulatory framework

According to the REE, in the field of electricity the regulatory framework at European level is the following:

- Directive 2009/72/EC of the European Parliament and of the Council, which concerns common rules for the internal market in electricity and repealing Directive 2003/54/EC.
- Regulation (EC) No 714/2009 of the European Parliament and of the Council, on conditions for access to the grid for cross-border exchanges of electricity and repealing Regulation (EC) No 1228/2003.

Nationally, the REE is regulated by the new Electricity Sector Act 24/2013, while the Law 54/1997 regarding the electricity sector confirmed its role as key in the operation of the system, and Law 17/2007 confirmed the REE as the sole transmission agent and operator of the Spanish electricity system carrying out its functions under a regime of exclusivity. In addition, the remuneration for electricity transmission is fixed administratively. During 2012 and 2013, the establishment of four laws (Royal Decree-Law 13/2012, Royal Decree-Law 20/2012, Royal Decree-Law 2/2013, and Royal Decree-Law 9/2013) aimed at correcting the imbalance between revenues and costs of the electricity sector. They also formulate measures that modify the remuneration methodology for the transmission activity carried out by the REE. Moreover there is a broad regulation in order to manage the technical and instrumental sector. Most of this legislation addresses the Operating Procedures, although its scope also covers the following elements of the technical regulation of the electricity sector: operating procedures, power measurement, special regime production, interruptibility service, and procedures for access and connection to the transmission grid.

The EU Legislation of energy concerns consists of:

- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators.
- Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC.

- Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005.
- Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency (REMIT).
- COMMISSION IMPLEMENTING REGULATION (EU) No 1348/2014 on data reporting implementing Article 8(2) and Article 8(6) of Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency (implementing acts).

Nationally, the feed-in tariff and premium tariff are currently suspended due to Royal Decree Law (Real Decreto Ley) form January 2012 that also stopped the mentioned before support scheme for RES-E. The reason of these breaks is because a part of the consumers' electricity bill is not able to fully balance the costs incurred by the State arising from the support scheme, envisaged to obtain in 2013 (accordingly to decree from June 2009).

Regulatory roles

The objective of REMIT is to detect and to deter market manipulation. For the first time, energy trading will be screened at EU level to uncover abuses. Market integrity and transparency are essential for well-functioning energy markets and for promoting the confidence of market participants and final consumers. In general, the Regulation are established in order to unite all the Europe in providing energy security supply as well as making sure the countries energy development will assure the future estimations.

Energy regulation roles

Spain as the member of EU except of its national regulator (CNE) also is obliged to accomplish the regulation provided by the Council of European Energy Regulators (CEER). The Council was commissioned in order to facilitate cooperation of the independent energy regulators of Europe. It assists the progress of the creation of a single, competitive, efficient and sustainable EU internal energy market. However, the CEER is a complementary organisation to the ACER (Agency for the Cooperation of Energy Regulation), which focus on the current requirements in the legislation. For instance the major plan for 2015 is to enable efficient infrastructure investments to take place, with a particular focus on cross-border investments. Such investments should help to integrate the internal energy market further, as well as to increase security of supply. In particular, they should contribute to the elimination of the so-called energy islands.

Regulatory barriers

In fact, there are no regulatory barriers. Nevertheless, it is worth to mention the complexity of Spain legislation procedure, which makes any kind of initiative tough to accomplish, making it costing more time and money than it is necessary. The country is divided into 17 regions, which constitute their own regulation system.

Analysis of the national economic system and politics

Strength and weaknesses

Spain is starting to recuperate positive GDP growth after a long period of recession. This economic improvement is supported by some deep structural reforms in the banking sector, pensions system and labour market, which has made Spain more attractive for business and foreign investments. It is also remarkable the modern infrastructure network created in the

years of economic prosperity, the large companies with international presence and the relatively high-skilled workforce, besides the traditional country potential as tourism destiny.
On the other hand, Spain economy has some important weaknesses. In spite of the fiscal adjustment process made in the last years, fiscal deficit and public debt remains at high levels, together with high private sector debt. Banks' restructuring has stabilized the financial sector and improved their balance sheets, but they still do not have capacity to make credit flow. Furthermore, there are downside pressures on prices with possible risk of deflation, and very elevated unemployment rate (one of the highest in the Eurozone).

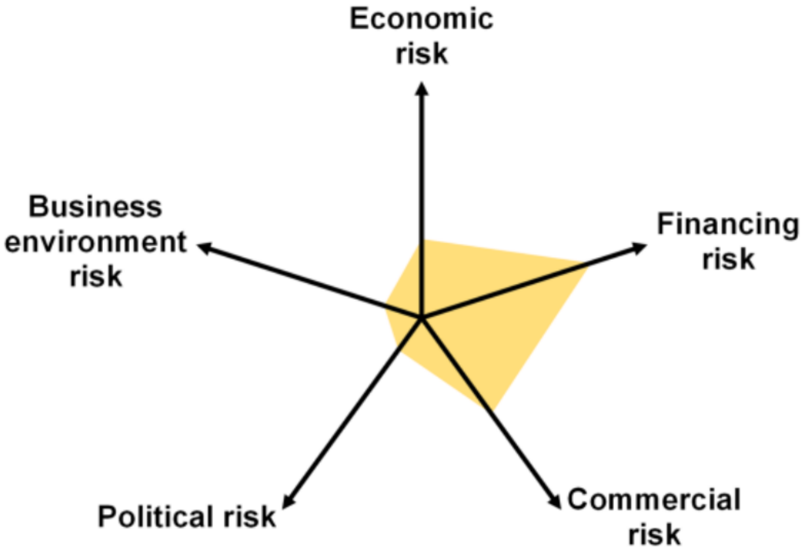

Figure A. 86. Risk dimensions estimated by Euler Hermes. Spain.

Economic structure

After the fall in housing as main economic engine, the trade structure has acquired a great importance in the Spanish economy, with potential of positive net export values thanks to the competitiveness gained in the last years. The automotive sector is one of the most important, with a contribution of 15% of total exports, and it is attracting foreign investment due to its highly skilled workforce and favourable labour market. Others competitive sectors within Spanish economy are a highly productive agriculture, pharmaceutical industry and tourism. As an energy dependant country, Spain needs to import primary energy resources in order to satisfy its energy demand, making a negative contribution to the trade structure.

Economic forecast

The positive GDP growth observed since mid-2013 will continue for the next years, marking a weak but definitely rising trend in the Spanish economy. The downside pressure on wages in the labour market has reduced the unit labour cost, reducing the export prices and improving the country competitiveness. Economic observers predict a GDP growth of +1.3% in 2015, outperforming Italy and France. Nevertheless, the Spanish economy remains weak, with one of the highest unemployment rates in the Eurozone (26.1% in 2013), which will slowly decrease in the following year (25.4% in 2015).

Some stimulus measures are being applied to support the economic recovery, mainly through tax reductions. Despite the positive effect of these measures on the private economy, it raises serious concern about public finance, with a fiscal deficit expected to remain high and public debt rising to above 100% of GDP in 2014.

The downside pressure on prices and the continuous real wages contraction are driving inflation to low levels, which is rising concern since long-lasting low inflation rate (+0.8% in 2015, markedly below the ECB inflation target of 2%) is an important downside risk for the whole economy.

Maps

Population

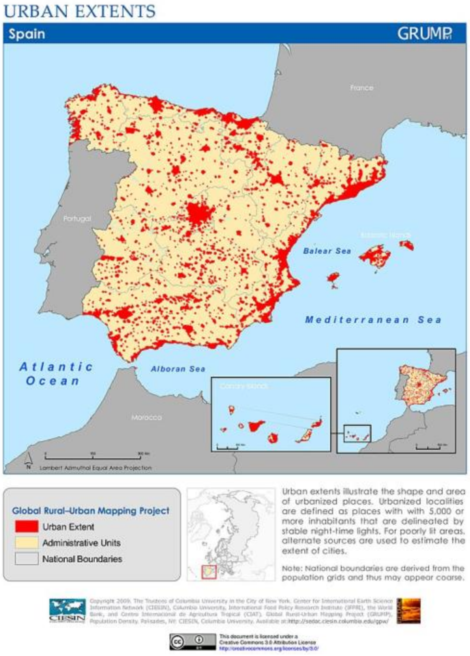

Figure A. 87. Spain population map.

DNI

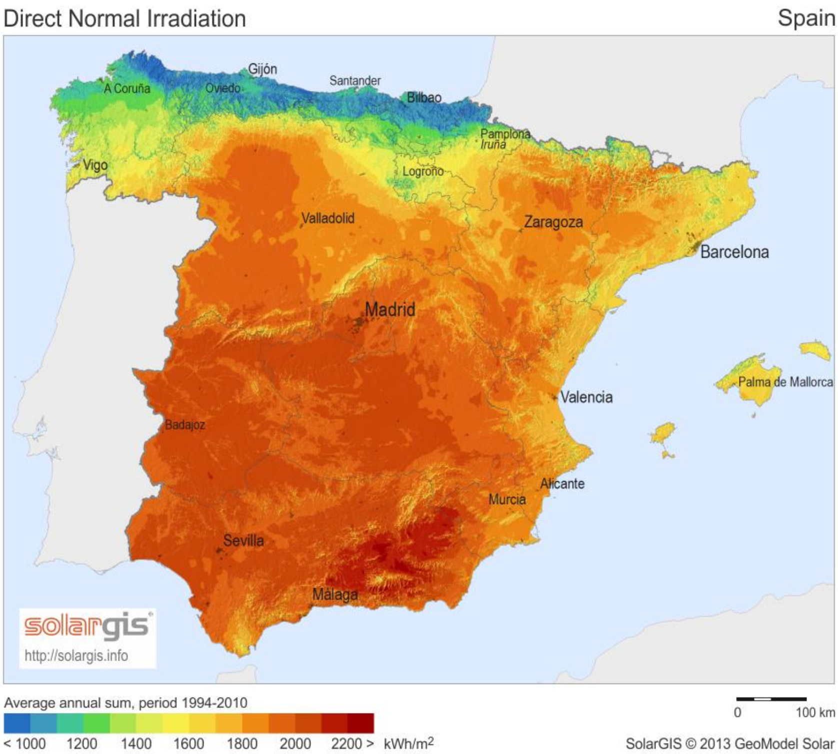

Figure A. 88. Spain Direct Normal Irradiation.

Electricity grid

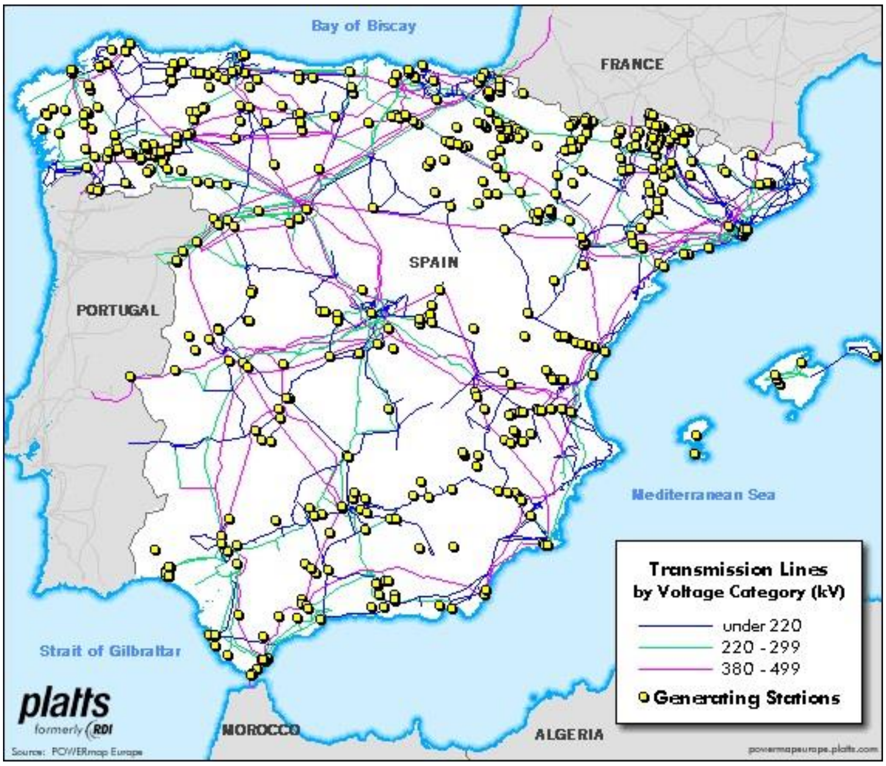

Figure A. 89. Spain electricity grid.

Maps Overlapped

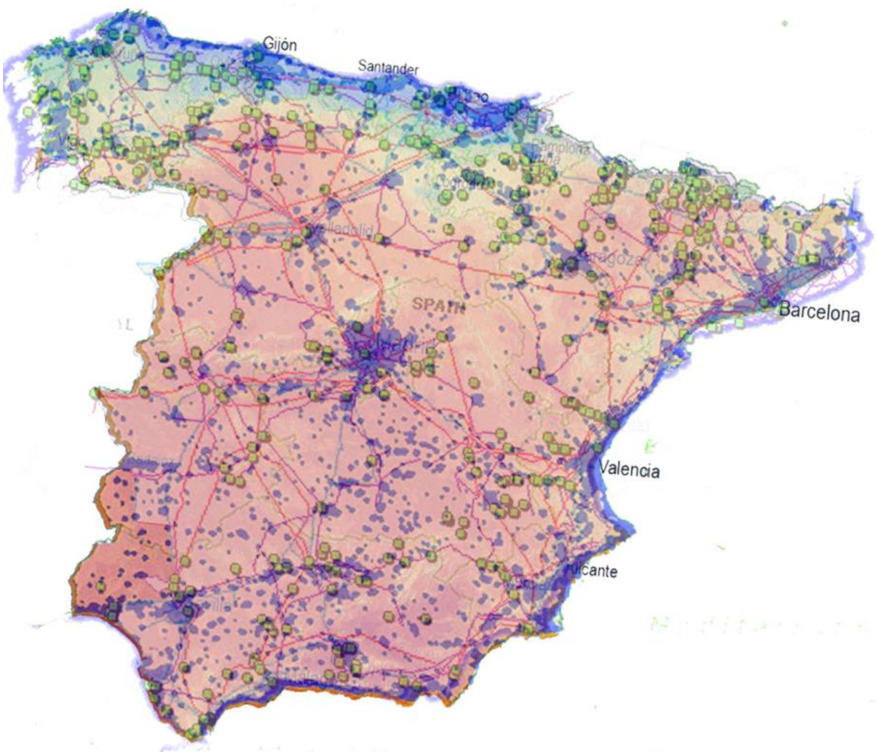

Figure A. 90. Spain overlapped maps.

Application of the method

- **GDP:** US$ 1358.26 Billion (in 2013)
- **Annual GDP Growth rate:** -1.22 % (in 2013)
- **Population:** 46.65 Million people (in 2013)
- **Annual population Growth rate:** -0.24 % (in 2013)
- **Annual electric consumption (per capita):** 5529.76 kWh (in 2011)
- **Government debt:** US$ 917.78 Billion, 67.57 % GDP (in 2012)
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 1.41 % (in 2013)
- **Country rating (Euler Hermes):** A2
- **Annually averaged DNI:** 1766.74kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.7667	0.2683
Population	0.25	1.0000	0.2500
Electricity grid	0.20	0.7947	0.1589
Energy policy	0.10	0.6471	0.0647
Legal certainty	0.10	0.7732	0.0773
		TOTAL	0.8193

Table A. 36. Farm arrangement. Spain.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.7667	0.2683
Population	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.8971	0.0897
Legal certainty	0.10	0.7732	0.0773
		TOTAL	0.6354

Table A. 37. Stand-alone configuration. Spain.

ANNEX 19. Sudan

Analysis of the national energy system

The high proportion of usage of biomass is due to a large population, located in rural areas with little or no access to the electricity grid. These inhabitants rely heavily on biomass to meet heating and cooking needs.

Oil plays a major role in the Sudanese economy. In 2008, according to the IMF, oil represented 95 % of export revenues and 60 % of government revenues. After the declaration of independence of South Sudan in 2011, significant proportions of the country's oil reserves have been transferred out of the control of the Khartoum government. Before the revolution, in 2009, there appeared announcements of natural gas discoveries, but yet not determined as viable. .

Total electricity generation in 2009 was 6800 GWh, of which renewable resources accounted for 3288 GWh (47.8 %).

Reliance

Sudan is an oil producing country, largely self-sufficient and able to export refined as well as crude petroleum products. The country proven oil reserves are 5 billion barrels according to year 2011. Total petroleum exports in 2009 were 19507 ktoe. However, Sudan still needs to import jet fuel.). Continuing, oil exports were estimated at 383 900 bbl/day in 2009, while in the same year Sudan imported 11 820 bbl/day, which is only 3% of exported amount. Sudan is buying electric power from Ethiopia, after grid installations were completed in July 2009.

Extend network

The national electrification rate in 2009 stood at 35.9 %. Approximately 27.1 million people lack access to electricity in the country, while urban electrification in same year reached roughly 52 %, with rural electrification at 28 %.

The National Electricity Corporation, which is the main electricity utility in the country, transmits electricity through two interconnected electrical grids, the Blue Nile Grid and the Western Grid, which cover only a small portion of the country. Regions not covered by the grid often rely on small diesel-fired generators for power. Transmission in the country operates at 300 kV, 220 kV and 110 kV, and distribution networks operate at 33 kV, 11 kV and 415 V.

Capacity concerns

The power sector in the country is a problematic issue as a consequence of poor infrastructure and frequent outages. More than 70 % of the population live in rural and isolated communities with limited economic activities.

The current electricity distribution reflects that most of the Sudanese rural communities are not connected to the national grid system, and are also by-passed by the petroleum supply pipelines. Many villages connect small generators to the ubiquitous diesel-powered irrigation pumps. This way of generating electricity is inefficient and expensive, and causes environmental problems. Domestic power consumption dominates the market, with approximately 65 % of electricity consumption being attributable to the sector. Erratic power supplies (outages stood at 19 days per year on average in 2009) have contributed to a high level of private generator ownership, particularly in the commercial and industrial sectors. Approximately 41 % owned and used private generators in 2009. Transmission and distribution losses in the same year stood at 22 %, an average figure for the region, but still high enough to cause constraints on economic efficiency for the national utility.

Renewable energy

Wind energy in Sudan is currently used for pumping water from deep and shallow wells to provide drinking water and irrigation through the use of wind pumps. More importance has got geothermal energy. Its potential is estimated at 400 MW of power generation capacity. The plants are located near Jabel Marra volcano, the Tagbo and Meidob hills, the Bayud volcanic field and the Red Sea coast.

The biomass installed capacity is estimated at 55.5 MW. There are plans to further expand cogeneration in sugar production with more advanced plant equipment. In addition, plans are currently being developed to use an agricultural pest, the Mesquite shrub, for household energy production.

Potential for hydropower is estimated at 4,920 MW. However, only 10% of the hydroelectric power is currently utilised. There are more than 200 suitable sites for the use of in-stream turbines along the Blue Nile and the main Nile. The total potential of minihydro can be considered to be 67 GWh/year for the southern region of the country. The country's main hydroelectricity generating facility is the 280-MW Roseires dam located on the Blue Nile river basin, approximately 315 miles southeast of Khartoum. The facility has frequently been attacked by rebel groups, and low water levels often cause its capacity to fall to 100 MW. The solar energy is in development.

Solar energy

Average solar insolation in the country is approximately 6, 1 kWh/m^2/day. This is a very favourable condition to use solar energy Total potentials over the course of a year have been estimated at 10, 1 GJ/m^2. A recent Global Environmental Facility (GEF) and UNDP-funded project utilised PV to electrify 13 rural and peri-urban communities, with some 45000 households in the country already using PV systems.

Competition

The Electricity Law 2000 offered the possibility of private sector investment in electricity generation, transportation or distribution. Through the Investment Law of 2001, private and foreign investments have been encouraged, resulting in the construction of new thermal plants with Chinese and Malaysian financing. However, there is little competition in the electricity sector. Each of the five state-owned entities in the electricity sector has a practical monopoly on its sector. There are a few privately owned diesel-powered generators that provide electricity in regions outside the coverage of the national grid.

Energy framework

National Strategic Plan for Sudan

It is the first Plan since the signing of the Comprehensive Peace Agreement (CPA), and provides a framework for the peace in the country and development efforts between 2007 and 2011. It gives priority to the construction of electricity distribution networks and rural electrification projects to promote sustainable economic development, as well as capacity building within institutions.

The Sudan Renewable Energy Master Plan

It was drafted in 2005 in order to promote the use of renewable energy sources, including priority projects such as PV installations and biomass co-generation; and to avoid technological dependence on an oil-based market in energy sector development. Funding allocations for the program reached approximately US$ 9.1 million, half-funded by bilateral/multilateral donors through grants or soft loans. Of this, US$ 4.25 million is allocated for the promotion of solar PV and SWH in the short term, with a further US$ 1.05 million for wind pumping. The medium-term plan for 2015 is estimated to require US$ 15 million of funding and targets a wide range of renewable options, including small-hydro power for rural mini-grids, development of the geothermal resources, and modern and improved bio-energy options.

Government priorities in the renewables sector include:

- Reducing unsustainable biomass use.
- Increasing wind energy use for rural on- and off-grid electrification, as well as in water pumping and agriculture.
- Increasing the dissemination of community-scale PV projects.
- Assessment of the geothermal and small-hydro potentials of the country, and the identification of priority projects.

Energy debates

The government in Khartoum has announced plans to raise the country electrification level from an estimated 30 % to about 90 % in the mid-term. Large investments into the medium and low voltage distribution grids will be necessary, but not sufficient to reach this ambitious goal within the government's allocated time limit. For example, the foreseeable increase in power consumption would require new generating capacity. Significant capacity additions have been made in recent years (1980 MW from 2003-2011), however, the government current target of 3383 MW of total capacity by 2016 is still appearing overly ambitious.

The country has recently put into place a comprehensive policy on sustainable charcoal production, enabling exports of charcoal made from an invasive tree species.

Considerable diplomatic conflict has arisen since the declaration of independence of South Sudan in 2011 over the continued interdependence between the oil infrastructures of these two countries. The CPA did not set guidelines on post-independence oil sharing mechanisms or transit fees, and South Sudan suspended oil production in January 2012, following disagreements over the exceptionally high transit fees imposed by the Khartoum government (US$ 32-36 per barrel, compared to the international average of US$ 1).The non-release of considerable Southern crude, held in the North for transfer to the international market. Southern officials say that the North has misappropriated approximately US$ 815 million of oil revenues since independence. The diplomatic disagreement is ongoing.

Energy studies

The government formulated a 10-year strategic plan for the period 1992-2003, which set overall goals for economic development. This plan included the supportive role of the power sector in achieving these goals.

Sudan is a member of the Common Market for Eastern and Southern Africa (COMESA), and is also a member of the East African Power Pool, a regional organisation created to promote integration of electricity networks, to improve energy security and increase energy access in all member states.

Role of government

The Ministry of Energy and Mining (MEM)

It has the responsibility for formulating and implementing the energy policies in the country, as well as promoting and disseminating renewable energy technologies, and conducting energy and environmental studies.

The Ministry of Electricity and Dams (MED)

The MED within the MEM is responsible for the management of the electricity sector. The state-owned companies within the electricity sector report directly to the MED.

Government agencies

The Ministry of Science and Technology is involved in scientific research to promote sustainable economic development in the country. Within the MED, the Dams Implementation Unit (DIU) acts as the governmental body in project management for the hydropower projects. The Energy Research Institute (ERI) undertakes renewable energy research and development programs as well as pilot project implementation. The Forestry Research Institute is involved in biomass energy technologies. Khartoum University and the University of Science and Technology have both undertaken research on renewables.

Energy procedure

Final commissioning of the 1250 MW Merowe Dam project was achieved in 2009. Agreements were signed in 2008 to expand capacity in the Elroseris Dam. These dams are supposed to increase the generation of electricity, and will also expand irrigated agriculture in the Gezira and Rahad Schemes and in the River Nile State in the North. An additional 905 MW of conventional thermal capacity is also under construction, consisting of the steam plants at Alfula and Kosti, commissioned in 2013 and 2012 respectively. A further 600 MW of coal-fired capacity is awaiting contract signatures, for construction near the Red Sea. Furthermore in 2013 was completed a work undertaken to expand the 280 MW Roseires Dam. The modifications doubled the generating capacity of the dam, increasing its reservoir size to 7.3 billion m^3 from 3 billion, and also doubled the capacity of the 15 MW Sennar Dam on the Blue Nile as a result.

For the Roseires Dam expansion and the White Nile sugar project authorities secured in 2009 a US$ 93 million loan from the Saudi Development Fund. Also, the Kuwait Fund for Arab Economic Development agreed to lend USD$ 52 million for the same dam project, while earlier the Saudi Development Fund contributed loans and grants amounting to USD$ 150 million to the Merowe Dam project.

Developments are currently under-way to inter-connect the power grids of Sudan, Egypt and Ethiopia, in an effort to promote cooperation and trade in the region. Arrangements for Sudan to import power from Ethiopia were fully completed in February 2012, and the country is set to import 100 MW from Ethiopia via two transmission lines (of 230 and 296 km) running from Bahir-Da and Metema in Ethiopia to Gedaref near the border in Sudan. The project is also set to reduce the country's carbon emissions, allowing it to replace thermal generation with Ethiopian hydropower.

Energy regulator

Sudan energy sector has three main regulatory bodies dealing with electricity, petroleum and mining:

- Electricity: Electricity Regulatory Authority (ERA).
- Petroleum: Sudanese Petroleum Cooperation (SPC).
- Mining: Public Geological Research Authority (PRA)

Degree of independence

All of the regulatory bodies in the country are wholly owned by the state.

Regulatory framework

Sustainable energy falls under the purview of the Ministry of Energy and Mining, which regulates the Sudanese energy sector. The Renewable Energy Master Plan does not detail specific regulatory mechanisms for the promotion of sustainable energy.

Regulatory roles

The Ministry of Energy is composed of several institutions which are responsible for formulating and reviewing processes and plans to incorporate views of energy suppliers, i.e. market actors and representatives of consumers, in addressing the complex nature of the sector.

Energy regulation role

No government department, other than the Ministry of Energy and Mines, takes an active role in energy regulation.

Regulatory barriers

The current lack of any form of framework or regulation pertaining to sustainable energy in the country is a barrier to increased uptake. For instance, the formation of a clear framework for private-sector actor participation in the energy sector, using renewable energy sources, such as IPP structure, would create a more favourable environment for investment in the sector.

Analysis of the national economic system and politics

Strength and weaknesses

Sudan is an extremely poor country, and the rate of 29% of access to electricity illustrates that. The lack of transparency of official economic data and the important fraction of “informal” economy do not help to gain the confidence of external market. Thus, The Sudan’s economy is fragile, characterized by high unemployment rates, non-properly diversified economies and incredibly high inflation rates, which achieved levels over 40 % in 2013.

Security and political stability, rather than real problems are important concerns of the populations because of the proximity of the separation of the country in July 2011.

On the bright side, this is the country of potentials. It is true that it is necessary to convince the world that social problem form part of history, but in that possible future scenario, Sudan’s potential could favour a sustained development with interesting business environment. In first place, though the agriculture is an important sector for Sudan, only around 20 % of arable land areas (84 million hectares) are being cultivated. Natural potential are also important: Gold and oil are main exports. Moreover, in July 2011, with the secession of South Sudan, it lost three quarters of oil sources. Also the touristic potential is important. Currently, tourism is not being exploited because of security and instability issues, but it could be thought that its geographical location and its cultural richness could attract tourist interest in a more stable social climate susceptible to achieve in the near future.

Economic structure

Nowadays, Asia is the principal region for Sudan markets, both imports and exports, particularly, China for the former and United Arab Emirates for the latter. China, Afganistan, Japan and India complete the top five list of export partners, while India, Egypt, Saudi Arabia and Uganda the import one.

Regarding products, only gold and crude oil shares around 82 % of exportations, then agriculture is another important sector with 8 % of the market. Importations are dominated by strategic products like wheat and raw sugar and of course refined petroleum, comprising these three products 16 % of imports. The majoritarian sector is machines (from all kinds of vehicles to electronic devices) with 17.4 % of imports and then the agricultural inputs are also important for Sudan’s economy with 11.7 %. The top five import sectors are completed with chemical products, metals and minerals.

Economic forecast

The perspectives for inflation are a bit more moderate but still very high. It is assessed to reach levels of 23 % in 2015, as a result of the continued devaluation of the Sudanese pound and the high fuel costs consequence of austerity measures driven by the government in September 2013.

Agriculture has historically been the main driven force of Sudanese GDP growth. Before the secession, growth rated around 4 %, but after July 2011 it was declining and stood at 1.9% in January 2012. Now the increasing incomes of gold and oil revenues are helping to recover the high levels of growth, which achieved 3.6 % in January 2014. The forecast by some experts for next years point that GDP will keep growing at similar rhythm; in particular around 3.8 % in 2015.

Maps

Population

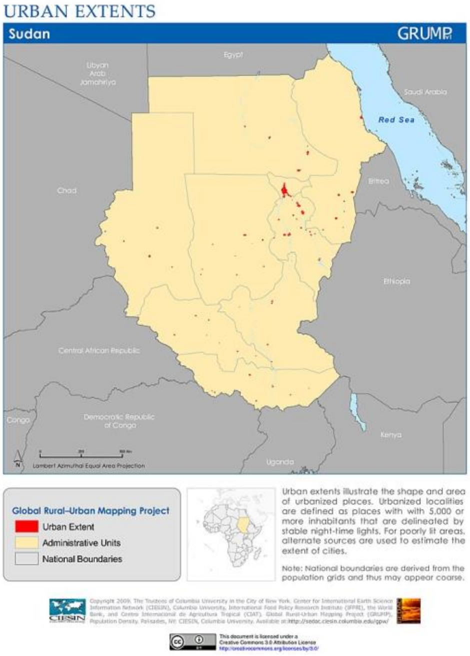

Figure A. 91. Sudan population map.

DNI

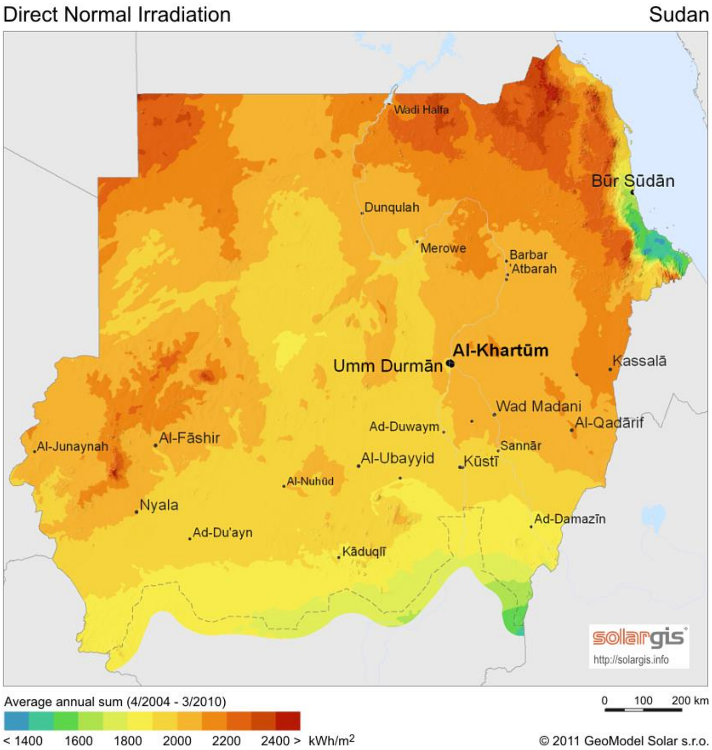

Figure A. 92. Sudan Direct Normal Irradiation.

Electricity grid

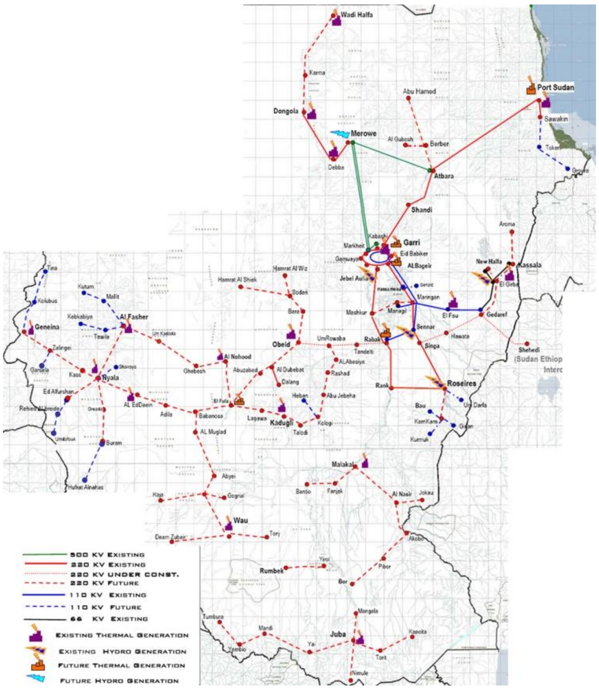

Figure A. 93. Sudan electricity grid.

Maps Overlapped

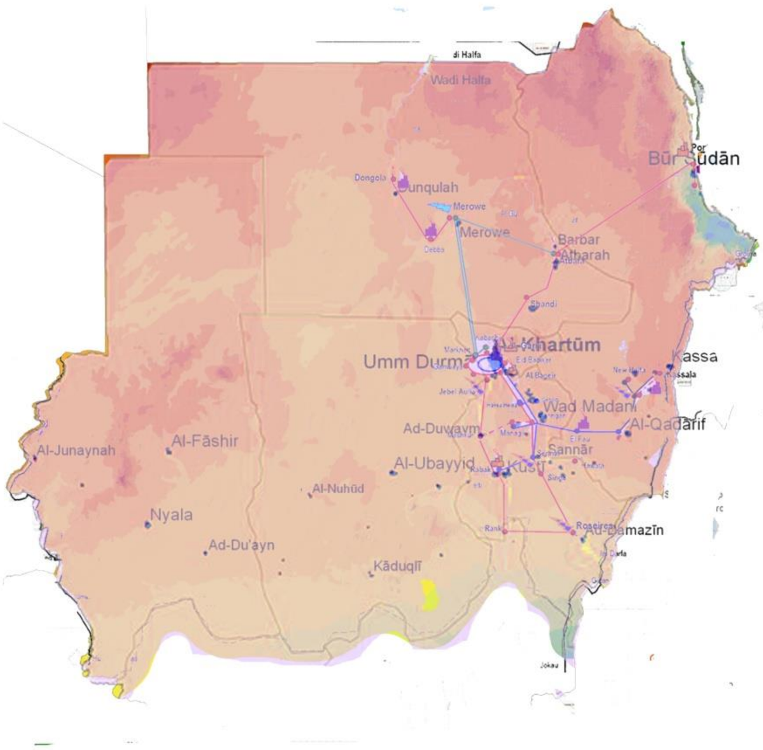

Figure A. 94. Sudan overlapped maps.

Application of the method

- **GDP:** US$ 66.55 Billion (in 2013)
- **Annual GDP Growth rate:** 3.6 % (in 2013)
- **Population:** 37.96 Million people (in 2014)
- **Annual population Growth rate:** 2.04 % (in 2014)
- **Annual electric consumption (per capita):** 143.45 kWh (in 2011)
- **Government debt:** US$ 41.26 Billion, 62 % of GDP
- **Accumulated external debt:** US$ 21.84 Billion (in 2013)
- **Inflation rate (consumer prices):** 25.6 % (in 2014)
- **Country rating (Euler Hermes):** D4
- **Annually averaged DNI:** 1993.17 kWh/m^2
- **Population with access to electricity:** 29.0 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.9932	0.3476
Demand	0.25	0.1379	0.0345
Electricity grid	0.20	0.2804	0.0561
Energy policy	0.10	0.2500	0.0250
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.4632

Table A. 38. Farm arrangement. Sudan.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.9932	0.3476
Demand	0.25	0.3375	0.0844
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.3376	0.0338
Financial risk	0.10	0.0000	0.0000
		TOTAL	0.6658

Table A. 39. Stand-alone configuration. Sudan.

ANNEX 20. Tunisia

Analysis of the national energy system

The country deposit of oil constitutes a 0, 09% of the world. Tunisian production of average 79 500 oil barrels a day in 2010 was a significant fall of 4, 6% compared to previous year. The other energy source as biomass is used predominantly in rural areas. Considering electricity, total domestic supply was 1460 GWh according to 2008. In the following year the supply increased around 7%, giving 15693 GWh. In general, the state-owned power utility has primarily relied on gas-fired power plants for generating electricity, fuelled by natural gas from the country's own reserves, and by imports from Algeria. The 11 % of the installed capacity comprises combined-cycle gas turbine (CCGT) power plants. Independent Power Producers (IPPs), feeding electricity into the public grid, account for approximately 500 MW, the 12 % of the available capacity.

Reliance

As stated in 2009, Tunisia imported 5838 ktoe of energy resources, predominantly refined petroleum products (47.3 %) and natural gas (31.9 %). Exports, mostly crude from the upstream oil national industry, were 4239 ktoe. The contribution of net imports to the primary energy balance was 17.4 %. Tunisia receives natural gas from a pipeline between Algeria and Italy that runs across Tunisian territory.

Extend network

According to estimates by the state-owned utility company, the degree of electrification for the country was 99.5 % in 2008. In rural areas the figure was 99 %, while it was 99.8 % of the urban areas. In the south-east of the country, the grid coverage is the poorest. This high connection rate is the result of a constant effort by the government over the past 30 years. In the 70s, only the 6 % of the rural population were connected to the power grid, while around 1990 the figure was still only about 50 %.

In the following year, 2009, the transmission network length of the country reached 5787 km, of which 2787 km were 225 kV, 1812 km were 150 kV, and 1188 km of 90 kV. Distribution networks covered 142513 km of lines, 50654 km of medium voltage, and 91859 km of low voltage. The transmission network is connected to Europe through networks in Algeria and Morocco. Interconnection with Libya will allow for the possibility of interconnection from Syria through Libya, Egypt and Jordan.

Capacity concerns

The growing economy of Tunisia and rising living standards led to a significant increase of electricity consumption, resulting in the saturation of the grid. In addition, some power plants and facilities are no longer appropriate to the actual load of the network. As a consequence, overload, losses and high voltage drops occur on a frequent basis. To address these issues, the Electricity Distribution Network Rehabilitation and Restructuring Project have been launched. Transmission and distribution losses in 2009 were 2045 GWh, or 13 % of the total domestic supply.

The energy demand in Tunisia is rising as a result of the growing economy. Compared to its neighbouring countries, domestic fossil energy sources in Tunisia are limited. In 2009, the peak load in public supply was 2.66 GW, representing an increase of 193 MW or 7.8 % compared to 2008.

Renewable energy

According to 2013, energy from wind power stood at 104 MW, which constitutes 59, 4 % of total capacity of RE. In addition the PV installation, despite a great potential of solar power in the country, obtained only 5 MW (2, 3% of total RE) in the same year. The remaining share belongs to hydropower, which installed capacity reaches 66 MW.

Solar energy

Surprisingly, renewable energy in Tunisia is not based primarily on solar power, even though this would seem to be the most abundant national renewable resource. Although the country has a very high solar potential with more than 3200 hours of sunshine per year, and an average daily insolation of 5.0-5.5 kWh/m^2, the solar energy production is still not considered cost competitive enough, and is largely limited to use in domestic water heating systems and in certain community projects. It is only now that the private sector is beginning to explore the commercial applications for solar power in Tunisia, which until recently were not sufficiently cost-effective. Solar water heaters contributed approximately 44 ktoe to the primary energy supply in 2011, and targets set in 2008 were to achieve a total solar water heater capacity of 740000 m^2 by the end of 2011. The 2010-2016 Solar Plan covers 40 potential solar projects, and when completed, is expected to reduce national energy consumption by 660 ktoe per annum, compared to a business-as-usual scenario.

Ownership of electricity

Until 1996, the monopoly on electricity generation and marketing was held by the Tunisian Company of Electricity and Gas ("*Société Tunisienne d'Electricité et du Gaz"*-STEG). Since then, liberalisation of the energy market has taken place, and the market was opened for IPPs. However, with a market share of 88 %, the STEG still is the largest player in the power market. Since 1999, it has also been permitted for gas extraction companies to operate gas-fired power plants without a preceding bidding procedure, and to sell the generated electricity to the STEG.

Next to the STEG, Large Energy Consuming Industries (IGCElec.) were encouraged to produce power for their own needs. The surplus they produce is fed into the national grid. Installed capacity is contributed to by the following IGCElec. Companies:

- Cimenterie d'Oum Klil
- Cimenterie de Bizerte
- Cimenterie de Jbel Ouest
- Ciments Blancs (SOTACIB)
- Cimenterie de Gabes
- El Fouledh

Two IPPs generate electricity for feed-in to the national grid:

- **Carthage Power Company** (CPC, 471 MW in 2008) is an independent power project formed by PSEG Global and the Marubeni Corporation. It owns and operates a generation facility located in Rades in north-eastern Tunisia. The power plant, which meets about one-quarter of the country's electricity needs, is a combined-cycle co-generation facility that uses natural gas as the primary fuel, with diesel fuel as backup. Gas is sourced from Algeria and BG Tunisia's Miskar concession. The state-owned STEG buys all the output under a 20-year power purchase agreement. PSEG sold its stake in the company in May 2004 to BTU Power Company, a regional energy investment group.
- **Bibane Electricity Company** (Société d'Electricité d'El Bibane- SEEB) containing 2x27 MW gas turbines, is the second power plant in Tunisia constructed under legislation allowing independent operations to utilise natural gas as fuel. Electricity

generated from the plant is sold to the STEG under a long term power purchase contract.

Competition

After withdraw of the STEG monopoly, in 2002, the first IPP project commenced operation in Tunisia, with the Rades power project, operated by the Carthage Power Company. The SEEB plant commenced commercial operations for the first time in 2003. STEG, a state-owned utility, is still the sole organisation responsible for transmission and distribution (and retains control of the existing power generation facilities).

The Tunisian National Oil Company (ETAP), Company for Refining Industries (STIR) and Company of Oil Distribution (AGIL S.A.) are owned entirely by the Tunisian state. Whilst petroleum sector activities are unbundled, each company holds a monopoly in its sector.

Energy framework

National target, according to the expert studies, is to achieve by 2030 6, 5% of the RE shares (excluding biomass). Tunisia signed the statute of the International Renewable Energy Agency (IRENA) in April 2009. Energy policy with regard to renewable energies and energy efficiency is drafted mainly in the Four Year Programme for Energy Management 2008-2011. Expected consequences of this strategy include: a reduction of the subsidies granted by the state to the energy sector (in 2007, Egypt and Tunisia announced a plan to phase out energy subsidies), a reduction of CO_2 emissions, and future profits from the Clean Development Mechanisms. Moreover in previous year, Tunisia National Agency for Energy Conservation released the Renewable Energy and Energy Efficiency Plan.

The main renewable capacity developments were expected to be 180 MW of wind energy by 2011. Nevertheless this number, according to 2013, was not yet achieved and energy from wind power stood at 104 MW, which constitutes 59, 4 % of total capacity of RE. In addition the PV installation, despite a great potential of solar power in the country, obtained only 5 MW (2, 3% of total RE) in the same year. In fact large wind projects are currently being developed, or are in the application process. Also Energy Efficiency (EE) is recognised as important, and is being addressed in energy policies. Public interventions via financial support from the state and the mobilisation of international financial resources have been decisive in the development of energy conservation in Tunisia.

The law introduced in 2004 (Law No. 2004-72) on the rational use of energy, defines the sensible use of energy as a national priority, and as the most important element of an effective policy for sustainable development. It states three principal goals: energy saving, the promotion of renewable energy sources, and the substitution of forms of energy currently used for renewable/sustainable options, wherever this offers technical, economic and ecological benefits.

Since 2005, and with the adoption of above mentioned law and the creation of a national energy fund (subject to the Law N° 2005-106), Tunisia has set the political framework to increase energy efficiency and develop renewable energy sources. The de-carbonisation of the energy sector and the de-coupling of economic growth and GHG emissions have occurred.

Under the 2008 Renewable Energy Plan, a major effort was planned to develop renewable energy applications as a means for rural electrification, and for use in the agricultural sector. The specific objectives that were defined are as follows:

- Installation of 63 pumping stations and water desalination.
- Installation of 200 water pumping stations for irrigation systems by hybrid.
- Equipment of 200 farms with biogas units for domestic use.
- Installation of two industrial units connected to the network for the combined heat and power from biogas.

Specifically for rural electrification:

- Electrification of 1000 rural households by hybrid systems.
- Electrification of 1700 rural households by PV systems.
- Electrification of 100 farms and tourist centres by hybrid systems.

The 2010 Energy Efficiency and Biomass Project, in collaboration with the World Bank, seeks to develop biomass energy sources as an alternative to fossil fuels in the country, through the promotion of EE/cogeneration by way of facilitation to disbursement of existing WB EE/Cogeneration credit line to commercial banks; and the development of biomass potential with implementation of a pilot project and capacity-building activities by means of technical assistance, direct investment funding and capacity building. Decree 2009-262 establishes financial incentives with a range of options for the introduction of renewable energy in rural and agricultural facilities. Grants are paid to the supplier of the equipment after installation. For electricity generation in agriculture, a grant of 40 % of the investment cost, with a maximum project cost of 20000 TND, is available for lighting and water pumping in rural areas when make use of solar or wind energy. Financial assistance is available for biogas through a grant of 40 % of the investment cost, also with a 20000 TND project ceiling, for the production of biogas in farms, and 20 % subsidy of the investment cost with a ceiling of 100000 TND is offered for combined heat and electricity from biogas plants. For solar buildings, a subsidy of 30 % of the investment is offered with a maximum of 3000 TND/kW and 15000 TND/house.

Energy debates

A number of developments are being made in the Tunisian Energy Sector. In April 2009, France signed a €80 million aid deal to help Tunisia develop civil nuclear technology. The STEG is improving power distribution by constructing overhead and underground lines. Also, a €2 billion joint venture between STEG and Italy's Terna will integrate the countries' electrical grids. STEG will construct a power plant in El Haouaria, and a submarine connection with Sicily. Those power plants with 1200 MW capacities will be split into 400 MW for the domestic market and 800 MW for export to Italy. STEG will also encourage consumers to install photovoltaic panels by covering about 20 % of the installation cost, and the organization plans to have a solar power plant operational by 2015 with a capacity of 50MW.

Energy studies

A huge boost for Tunisian RE is the Mediterranean Solar Plan (MSP), set out as part of the Union for the Mediterranean project (UPM), which has finished in 2011. The UPM underlying idea is to set out a policy framework for renewable energy and energy efficiency, in light of potential climate change issues the region might face in the future. Following this pilot phase, the MSP will go through a deployment phase (2011-20), which is expected to be financed by the World Bank and the European Development Bank, with the ultimate goal of setting up an effective green electricity import-export framework under the Trans-European Networks initiative. As part of this framework, Tunisia will develop some 26 RE projects, which are expected to enable a five-fold increase in the electricity generated from renewables.

Tunisia is also a member of the African Maghreb Union, a regional grouping of North African countries, to promote regional integration and co-operation in terms of trade, including electrical inter-connection. The Maghreb Countries Interconnection Project included connecting the Libyan grid to the Tunisian grid, using 220kV transmission lines; interconnecting the Tunisian grid with the Algerian grid, on 400kV, and interconnecting the Algerian grid to the Moroccan grid, using the same voltage.

Role of government

The Ministry of Industry and Energy (TMIE, Ministère de l'Industrie, de l'Energie et des Petites et Moyennes Entreprises)

It is the main governmental actor in the energy sector. The General Directorate for Energy of the Ministry of Industry and Energy is responsible for energy infrastructure planning and the implementation of national energy policy.

Most of the state actors in the energy sector are accountable to the Ministry. These also include the Superior Commission of Independent Electricity Production (CSPIE, Commission Supérieure de la Production Indépendante d'Electricité)) and the Interdepartmental Commission of Independent Electricity Production (CIPIE, Commission Interdépartementale de la Production Indépendante d'Electricité), which were both set up in 1996.

The Ministry of Agriculture, Environment and Water Resources (*Ministère de l'Agriculture et des Ressources Hydrauliques*)

It is responsible for the exploitation of hydropower. The CSPIE decides public tender processes and awards contracts to IPPs. It also passes rulings on tax incentives for investors. The inter-ministerial CIPIE carries out preliminary work for the CSPIE by selecting projects for tendering, contractual negotiations between the IPPs and the Energy Ministry, and securing public subsidies on a case-by-case basis.

Government agencies

National Agency for Energy Management (ANME, *Agence Nationale pour la Maîtrise*)

The former Tunisian agency for renewable energies, the *Agence Nationale des Energies Renouvelables* (ANER), was founded in 1985. Under Law No. 2004-72 of 2004, the national Tunisian energy agency, the *Agence Nationale pour la Maîtrise del'Énergie* (ANME, The National Agency for Energy Management), succeeded ANER. ANME is accountable to the Ministry of Industry and Energy. Its tasks comprise translating ministerial policy directives into practice, including the safeguarding Tunisian energy supplies in the long term.

Tunis International Centre for Environmental Technologies (CITET, *Centre International des Technologies de l'Environnement de Tunis*)

Has the task of promoting environmental technologies. It is accountable to the Tunisian Ministry of the Environment.

Energy procedure

Tunisia recently built two wind-power facilities (Metline and Kchabata) in Bizerte with a combined production capacity of 190 MW that was completed in two phases. Futheromore, there has been commissioned another wind farm in Sidi Daoud with a potential to produce 34, 32 MW. All of these three power plants are able to contribute to savings of fuels, during the lifetime project, reaching 4 091 204 and 500 000 tons of oil by the ones in Bizerte and one in Sidi Daoud respectively. . In addition the carbon dioxide emissions are about to reduce on average 353 863 (Bizarte) and 57, 929 (Sidi Daoud) a year.

Italian-owned Moncada Energy has proposed plans to build a 500 MW wind farm in Tunisia with an undersea power link to Europe, as well as 200 MW of solar installations over a four-to-five year time period.

Further financial schemes applicable to the energy market are the National Fund for EE and RE of 2005, and the PROMO-ISOL program financed by the National Fund for Energy Conservation (FNME). However, according to local sources, PROMO-ISOL is still at the planning stage. Finally, the National Fund for Energy Conservation (FNME), subject of Law N° 2005-106, offers financial resources for supporting EE and RE investments, based on the granting of allowances.

In 2009, the government launched the Tunisian Solar Plan (TSP), comprising of 40 projects, several of which aim to produce electricity through solar and wind power, with the view to saving some 660 metric tonnes of oil a year, representing 22 % of the total production of energy by 2016. Twenty nine of these projects will be implemented by the private sector and five by the public sector, of which three are already being implemented by the STEG. The international cooperation will finance five projects, one of them being the establishment of an international training centre and an international laboratory for solar energy technologies, mainly for photovoltaic and solar thermal technologies. The final project is the creation of a new enterprise. STEG Renewable Energies, which aims to guarantee the smooth implementation of the whole plan. TSP aims to reduce carbon dioxide emissions by 1.3 million metric tonnes a year.

Energy regulator

The National Agency for Energy Management (ANME) established by the Law No. 2004-72 of 2nd August 2004; as a part of its mandate, has responsibility for regulating the energy sector in the country.

Degree of independence

The ANME is a non-administrative public entity, accountable to the Ministry of Industry and Energy. Funding for the organisation comes from the state budget, and from any foreign grants and loans accrued by the organisation.

Regulatory framework

The law on energy conservation, dated August 2004, has been amended by the law of 9th February 2009, to allow independent production of electricity based on RE. It gives allowance to large consumers of electricity to produce electricity for their own consumption from renewable sources, and sell their electricity surplus into the grid. In fact the sold surplus can reach 30% of total production. The STEG will buy this electricity at domestic market prices; however, no specific incentives are available to promote mass-scale production. Article 7 of Act 2009-7 (February 2009) gives to any institution or group of institutions engaged in industry or in the service sector, equipped for its own use with an energy efficient cogeneration facility, the right to transport the electricity produced on the national grid to its consumption points and the right to sell surpluses exclusively to STEG, up to a given upper limit in the frame of a standard contract approved by the ANME.

Moreover, the following tax incentives are in place for EE and RE:

- Reduction of customs duties to the minimum rate of 10 % (from a general rate of 18 %) and exemption from VAT for imported equipment used for EE or RE, for which no similar equipment is manufactured locally.
- Reduction of customs duties and exemption from VAT for imported raw materials and semi-finished products entering into the production of equipment used in the field of EE and RE.
- Exemption from VAT for locally manufactured raw materials and semi-finished products entering into the production of equipment for EE and RE.
- Exemption from VAT for equipment manufactured locally and used in the field of energy conservation or of renewable energies.

Regulatory roles

The activities of the ANME in the sector include the design and implementation of national energy conservation programs:

- Preparing and implementing the legal and regulatory framework for energy conservation and efficiency.
- The management of the National Energy Conservation Fund (FNME), and the management of financial incentives for sustainable energy use, capacity-building and awareness-raising of energy conservation issues, as well as for renewable energies.
- Encouraging investment in the energy sector through the granting of tax and financial incentives.

Energy regulation role

The CSPIE and the CIPIE are both indirectly involved in regulation of the energy sector, due to their involvement in license-granting for IPP projects, as well as the formulation of financial incentives for the establishment of such projects.

Regulatory barriers

Programmes such as the Mediterranean Solar Plan represent a huge opportunity for the country to develop its alternative energy market. However, now that Tunisia has its renewable plan defined, and the political will has been mobilised, the challenge will be to ensure that investments are made in a constructive and beneficial way, by, for example, developing a local industry, encouraging knowledge transfer, and fostering a research and innovation.

If Tunisia is looking at developing RE on a large scale and exporting sustainable power to Europe, the price for electricity generated by renewable sources needs to be set up above market rates. While ELMED interconnection cable is being built, such a policy would convince many investors to enter the market, and prepare the country to respond to the higher demand by developing production capacity.

Any detriment to the development of the Tunisian energy sector due to the 2011 revolution appears to have been limited. New power projects are continuing to be implemented, and operation of the country's electricity sector appears to have been unaffected. Whilst a range of financial mechanisms are available for the promotion of renewable energy sources in the country, STEG does not offer a guaranteed purchase price for self-generated electricity within the framework of a standard feed-in tariff, and as such, the current purchase agreement program that STEG operates for self-producers of electricity offers no real incentive to renewable energy producers.

Analysis of the national economic system and politics

Strength and weaknesses

Tunisia is into a political transition within the political phenomena of the Arab spring. Such a political instability brings about important consequences to economic situation. Although, the transition has been relatively peaceful compared to other countries along with the consensus in the Tunisian society giving hope for progress in socioeconomic conditions for next years, dramatic political changes as has been produced in Tunisia have inherent uncertainties and risks associated. One of the main Arab spring causes was low employment rate, especially in the youth sector. Nevertheless, the social discontent could continue due to insignificant improvements of government in job creation.

In spite of recent political upon the economy, Tunisia has a lot of strong fundaments from the previous management, like a relatively well diversified economy structure, that can reactivate the GDP growth. However, the Tunisian dependency on Europe economy is highly affecting it.

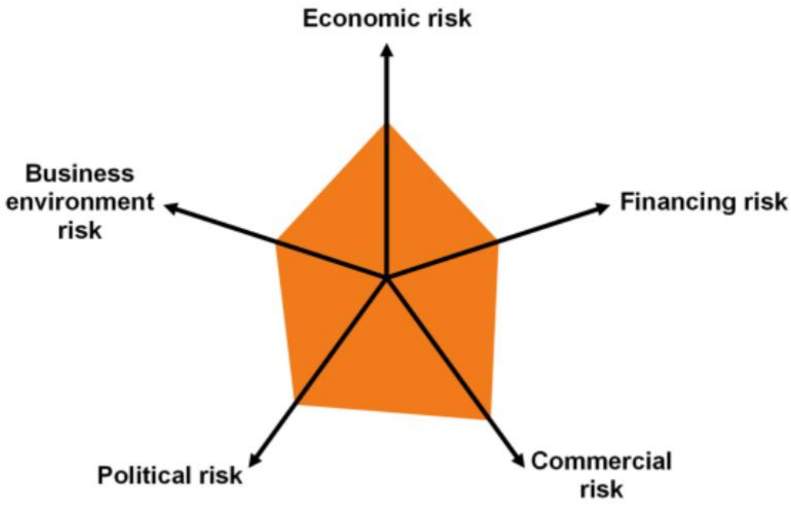

Figure A. 95. Risk dimensions estimated by Euler Hermes. Tunisia.

Economic structure

As indicated before, Tunisia has a reasonable well diversified economy, with a special importance of textile sector (all together represents more than 20% of exports). It's a crude oil exporting country, with a high importance in the trade structure (about 9% of exports), but does not have its own refinery industry. It contributes to the refined petroleum products being the most important part of imports (10% of total). Services sector and domestic trade together represents around 27% of GDP.

Economic forecast

The GDP growth rising was noticed in 2012, when it reached +3.7%, after the contraction suffered in the crisis of 2011. This incensement was mostly supported by the agriculture and tourism recovery. Nevertheless, this restoration has been slower than expected because of the decline in confidence prevailing in the early days off the transition, as well as by continuing weakness in Europe, which represents around 80% of whole exterior trade and the major source of tourists (50% of total). Taking this into account, stronger GDP growth is possible in 2015 based on industrial recovery and improvement of some key European markets, but it depends on the political transition capacity to provide stability and an adequate business environment. The growth is expected to obtain 5%.

The rising prices of food boosted inflation in last years. The economic observers expect inflationary pressures easing in 2015. However, high inflation risks will persist, particularly in relation to the impact of government attempts to reduce its fuel subsidy cost.

The annual fiscal deficit has experienced deterioration since the beginning of political transition, increasing to -5.2% of GDP in 2012 and -6.1% in 2013 (the average deficit in the period 2000-08 was just over -2% of GDP). The economic recovery will pick up the public revenues, but there are no predictions for lower deficits, with -5.4% in 2015. Also the public debt has been deteriorated, increased from 40% in 2010 to over 50% in 2013, with only a moderate improvement in 2015.

Maps

Population

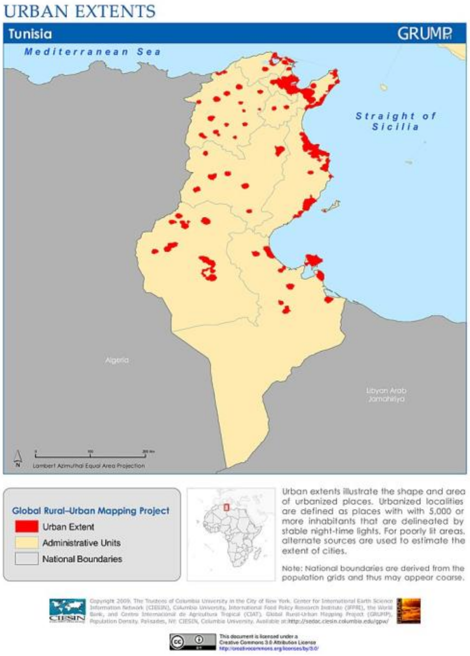

Figure A. 96. Tunisia population map.

DNI

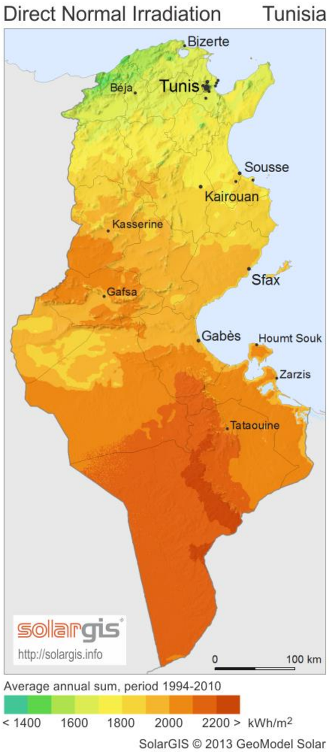

Figure A. 97. Tunisia Direct Normal Irradiation.

Electricity grid

Figure A. 98. Tunisia electricity grid.

Maps Overlapped

Figure A. 99. Tunisia overlapped maps.

Application of the method

- **GDP:** US$ 47.13 Billion (in 2013)
- **Annual GDP Growth rate:** 2.81 % (in 2013)
- **Population:** 10.886 Million people (in 2013)
- **Annual population Growth rate:** 1.01 % (in 2013)
- **Annual electric consumption (per capita):** 1297.10 kWh (in 2011)
- **Government debt:** US$ 20.96 Billion, 44.47 % GDP (in 2012)
- **Accumulated external debt:** US$ 25.48 Billion, 54.05 % GDP (in 2012)
- **Inflation rate (consumer prices):** 6.10 % (in 2013)
- **Country rating (Euler Hermes):** B3
- **Annually averaged DNI:** 1896.32 kWh/m^2
- **Population with access to electricity:** 99.5 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.8963	0.3137
Population	0.25	0.3575	0.0894
Electricity grid	0.20	0.7423	0.1485
Energy policy	0.10	0.7127	0.0713
Legal certainty	0.10	0.3880	0.0388
		TOTAL	0.6616

Table A. 40. Farm arrangement. Tunisia.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.8963	0.3137
Population	0.25	0.0018	0.0005
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7625	0.0763
Legal certainty	0.10	0.3880	0.0388
		TOTAL	0.6292

Table A. 41. Stand-alone configuration. Sudan.

ANNEX 21. Turkey

Analysis of the national energy system

According to year 2009, Turkey produced 194 TWh of electricity, while consumed 81% of the total. Their main source of electricity production is thermal power plants, by consuming coal, lignite, natural gas, fuel oil. Other also important sources are geothermal energy, hydropower plants and recently explored wind energy.

Reliance

Turkey due to growing energy demand since 2004, when firstly imported over 800 Bcf of natural gas, became a net importer of energy. According to 2008 the transfer reached 79503 ktoe which is 80% of the total primary energy supply.

Extend network

Almost all of the country is having constant access to electricity; with an electrification rate reaching approximately 99.9%. The Turkish transmission network consists of 14453 km of 400 kV lines, 86 km of 220 kV lines, 31716 km of 154 kV lines, and 508 km of 66 kV lines. In addition, there are 200 km of 154 kV cables, and 22.8 km of 380 kV cables.

Capacity concerns

Security of supply is a priority for the Turkish electricity sector. It is now a common perception that if there are no new investments, Turkey will suffer from electricity shortages in a few years. As well as the need for additional capacity there is also a specific shortage of peaking capacity. Moreover, the transmission and distribution losses amounted to 13.2 % in 2009, indicating the need for efficiency improvements in the electricity network.

As indicated before, the limits of the Turkish domestic energy sources in light of its growing energy demand have resulted in dependency on energy imports, primarily of oil and gas. At present, around 20 % of the total energy demand is being met by domestic resources, while the rest is being satisfied from a diversified portfolio of imports. By 2018, peak load demand is forecast to increase by 7.4 %.

Turkey aims at fully utilizing its indigenous hard coal and lignite reserves, hydro and other renewable resources such as wind and solar energy to meet the demand growth in a sustainable manner. Considering hydropower, due to the current trend for sup-optimal hydrological conditions in the country, the generation is forecasted to decline up to 20 % in the near future. Nevertheless, integration of nuclear energy into the Turkish energy mix is also about to be one of the main tools in responding to the growing electricity demand while avoiding increasing dependence on imported fuels. The forecasted two nuclear plants are about to be connected in 2023, giving 10 GW of power. However, presently it is able to commission only one until this time.

Renewable energy

The renewable energy sources in Turkey are plentiful and extensive, and represent the second-largest domestic energy source after coal. Primary renewable energy resources in Turkey are: hydro, biomass, wind, biogas, geothermal and solar.

Solar energy

Turkey lies in a sunny belt between 36º and 42ºN latitudes. The yearly average solar radiation is 3.6 kWh/m^2/day, and the total yearly radiation period is approximately 2640h, which is sufficient to provide adequate energy for solar thermal applications. Technical solar potential stands at 76 Mtoe. Photovoltaic applications in the country currently stand at around 1000 kW, and are mainly installed in areas where electricity transmission is not economically feasible. In spite of this high potential, solar energy currently is not widely used, except for flat-plate solar collectors. In 2007, solar water heating produced roughly 400 ktoe in the country.

Ownership of electricity

In March 2001, the Turkish government enacted a new Electricity Market Law, which sets the stage for liberalisation of power generation and distribution activities. Under the law, the state-owned Turkish Electricity Generation and Transmission Corporation (TEAS) were split into separate generation, distribution, and trade companies as follows:

- Turkish Electricity Transmission Joint Stock Company (TEIAS), responsible for operating the national grid.
- Turkish Electricity Generation Joint Stock Corporation (EUAS), responsible for operating power-generation facilities.
- Turkish Electricity Trading Joint Stock Corporation (TETAS), responsible for purchasing electricity.

The EUAS currently holds 60 % of the installed generating capacity in Turkey, while the TEIAS has a legal monopoly on transmission in the country, with legislation in place to ensure fairness of transmission to all entities. The Turkish Electricity Distribution Joint Stock Corporation (TEDAS) is the state-owned distribution company, established in 2004. The company owned a 75 % market share across Turkey in 2006. According to the Electricity Market Law, the TETAS may conduct wholesale activities, as well as private sector wholesale companies. In practice, the TETAS which is also state owned enterprise operates as a national monopoly.

Later on, in 2006, the Balancing and Settlement Regulation (BSR) started to be implemented financially. With the BSR, a new market is formed where the private sector also could take part actively, and sell energy to the public sector indirectly under market conditions. By the balancing market rules, the market participants had the opportunity to sell/buy the electricity in the balancing market in addition to their bilateral contracts. The balancing market has developed quickly, and the share of energy produced through it is 13 % (by volume-MWh) on the average of the total electrical energy produced in Turkey.

As result of the passing of the BSR, the EMRA (Turkish energy regulator) approved the privatization of 20 regional electricity grids. The EMRA has approved a new electricity tariff structure, the final step before Turkey can invite tenders to auction the distribution grids. The power grids are expected to be sold in groupings of up to 6 regional grids at a time to encourage economies of scale and greater efficiency.

Competition

Under the Electricity Market Law, no generation company can have more than 20 % of the market and no wholesaler can have a market share greater than 10 %, leading to an effective monopoly for the TETAS on the wholesale market. Auto-producers can sell no more than 20 % of their output to the market unless they have a generation license. Whilst unbundled, the majority of the Turkish energy market continues to be held by state-owned companies.

Retail competition was introduced following the passing of the Electricity Market Law (no 4628) in 2001. Consumers directly connected to the transmission network (electric intensive industry) and consumers using more than 9 GWh per year were no longer required to buy from the incumbent retailer. In January 2004, the limit was reduced to 7.8 TWh, in January 2005 to 6 GWh and January 2007, to 3 GWh. The EMRA expects these limits to be further reduced.

Energy framework

Whilst Turkey does not have a specific national energy strategy document, objectives including securing energy supply, diversification of the energy mix (including renewable energy development), and the opening of the electricity market to all consumers by 2015, are contained within the Institutional Strategic Plan 2010-2014 of the Ministry of Energy and Natural Resources.

The Renewable Electricity Law was adopted in 2005, as the transposition of EU Directive 2001/77/EC. The law which enables government to purchase a maximum of 20 % of electricity from renewable energy sources by was fully operational by 2007.

Biodiesel and bioethanol are being developed under the Petrol Markets and Tobacco Markets Laws respectively.

An Amending Law to the Renewable Energy Law was prepared in 2008, in order to provide further incentives to the renewable energy sector. According to the amending law, different minimum purchase prices varying between 5 c€/kWh to 18 c€/kWh are stipulated for electricity produced from different types of renewable energy resources. The purchase obligations are provided to be extended to facilities established prior to 1st January 2016.

The Energy Efficiency Law (EEL) of Turkey was developed as a result of the tasks of complying with the EU directives. The law, expected to achieve 25-30 % savings in total energy consumption, came into force on 2nd May 2007 through the law number 5627. The law exploits the efficient use of energy and covers administrative structuring, energy auditing, financial instruments and incentives, awareness raising and the establishment of an Energy Service Company (ESCO) market for energy efficiency (EE) services.

The Law No. 5686 on the Law on Geothermal resources and natural mineral waters (3rd June 2007) to set forth the rules and principles for exploring, producing and protecting geothermal and natural mineral water resources this law is enforced.

The Law No. 5346 on the Use of Renewable Energy Resources for Electricity Production Purposes (18th May 2005) was created to ensure the widespread use of renewable energy sources, increase resource diversification, reduce greenhouse gas emissions and protect the environment. Within the scope of this law were conditions for the creation of a feed-in tariff system, combined with guaranteed purchase agreements for electricity generated from renewable energy sources, in addition to a guarantee-of-origin certificate system. Differentiation of tariff structure for different renewable energy sources was introduced in 2008 with the Amending Law. The tariff is valid for the first ten years of plants set up before 31st December 2011. Further amendments to the Law were made in 2011, further diversifying feed-in tariff structure, whilst limiting total production capacity of licensed solar energy companies to 600 MW by December 2013. Additional incentives will be offered to companies that utilise local manufacturing in the production of renewable energy infrastructure.

Energy debates

Industry observers in 2011 described the new feed-in tariff law for renewable energy sources as “insufficient” to promote the growth in manufacturing necessary to achieve the country’s renewable energy targets. The Turkish government have responded by saying they are confident that investors will do business at the current prices.

Discussion is underway within the EMRA as to a timeline for the privatization of natural gas distribution companies, as well as the unbundling of the state company BOTAS.

Energy studies

Turkey is struggling with fast growth of energy demand together with need of natural gas. The Ministry of Energy and Natural Resources (MENR) and Energy Market Regulatory Authority (EMRA) are trying to achieve the progressive liberalisation of the domestic market by increasing the role of public sector in providing natural gas.

In addition, Turkey is working on improving the energy efficiency. Under the TSKB there have been launched projects concerning: waste heat recovery, facility modernization, energy consumption optimization, isolation, lighting and logistics.

Role of government

The Ministry of Energy and the Natural Resources General Directorate of Energy Affairs are the key governmental institutions in energy planning.

Policy issues related to energy are within the responsibility of the Ministry of Energy and Natural Resources (MENR). Energy planning studies, taking into account short, medium and long term policies and measures, are carried out by the MENR. The General Directorate of Energy Affairs (EIGM) is the main policy making body within MENR, and is in charge of carrying out all studies related to energy policies and coordination. The EIGM is responsible for coordination of the energy policy measures, and natural gas and electricity sector reform programs. It conducts long term energy planning, and develops different policy scenarios. Furthermore, it is also responsible for general studies on energy and environmental policies, renewable energy and energy efficiency.

Government agencies

The main institutions involved in the definition of research and development of priorities and programmes of energy are:

- The Ministry of Energy and Natural Resources and its related bodies and enterprises.
- The State Planning Organisation.
- The Ministry of Environment.
- The TUBITAK (Scientific and Technical Research Council of Turkey), established in 1960.
- The TAEK (Turkish Atomic Energy Authority), founded in 1956.

The Supreme Council for Science and Technology (the highest body for science and technology policy making) issues periodic plans for setting research and development priorities.

The Energy Efficiency Co-ordination Board consists of high-level representatives from ministries concerned with energy efficiency, as well as those from NGOs and private sector companies. The Board main task is to prepare energy efficiency strategies, as well as make decisions on energy policy.

A number of non-governmental organisations exist in the fields of renewable energy and energy efficiency, including the Turkish Cogen Association, dealing with co-generation; the Geothermal Association of Turkey, and the Alternative Energy and Biodiesel Producers Union.

Energy procedure

Law 5710 of November 2007 dictates rules for the construction and operation of nuclear power plants in Turkey. Government energy strategy, in part, calls for the necessary developments for the construction of Turkey's first nuclear plant. Application has been made for construction and operating licences for this purpose. The construction of the first nuclear is about to start in 2015 at Akkuyu.

The Energy Strategy Paper, which aims to ensure that 20 % of Turkey electricity is generated from renewable energy sources by 2020, was created in 2009 and is ongoing. Other goals of this paper include the utilisation of all technically and economically viable hydro-power sources by 2023, and minimum targets for installed wind and geothermal electricity generation capacity to 20 GW and 600 MW respectively.

In 2008, the Turkish Prime Minister announced the National Energy Efficiency Movement, which seeks to provide information to all sectors of the economy on energy efficiency, as well as building capacity for EE improvements. Measures instituted under the movement include the development of institutional and administrative capacity for energy auditing, the training of energy managers for companies and organisations, and voluntary industrial agreements.

Energy regulator

The Energy Markets Regulatory Authority (EMRA) became fully operational in 2001. The regulatory functions are defined in the Energy Laws of 2001. It subsequently became the Energy Market Regulatory Authority when the natural gas (2001) petroleum (2003) and LPG markets (2005) came under its jurisdiction. Its main duties are to: issue licenses; monitor and supervise the market; approve, amend and enforce performance standards; set pricing principles and regulations for tariffs; and settle disputes.

Degree of independence

EMRA is fully independent, but the activities of the authority are overseen by the Ministry of Energy and Natural Resources. Financing for the Authority comes from the licensing of regulated bodies, grants provided by international institutions, and surcharges on electricity transmission.

Regulatory framework

The Energy Market Regulatory Authority has issued numerous legislations on electricity, oil, LPG and natural gas, including:

- Law on Electricity Markets (2001).
- Law on Natural Gas Markets (2001).
- Law on Oil Markets (2003).
- Law on LPG Markets (2005).

The Energy Efficiency Law (Law No. 5627) of 2007 covers energy efficiency in industry, as well as building regulations and the tertiary sector. It also provides conditions for the mandatory appointment of an energy manager to oversee efficiency savings. Law No. 5686 on Geothermal Resources provides rules for the exploration and production of power from geothermal resources.

An update to the Regulations regarding the Promotion of Renewable Energy Resources and the Certification of Origin of RES was made in July 2011. This regulation clarified the procedures for the acquisition of support for renewable energy systems, instituted the system for certification of origin of renewable energy sources, and provided mechanisms for determining billing obligations for energy companies.

Regulatory roles

The EMRA is responsible for:

- Undertaking a monitoring and auditing of electricity and gas sectors on behalf of public in accordance with the new legal framework.
- Ensuring the formation of Energy Market Regulatory Board which will represent and govern the Energy Market Regulatory Agency.

The Energy Market Regulatory Board, issued 35 licenses of natural gas distribution in 2004 and regulations related to the transfer of importing licenses to private sector were completed in 2005.

In accordance with the changes made with the Law dated October 10, 2006 (clause 9), cross subsidies have become legal. With this modification, the authorization of EMRA on the tariffs for scrutiny and auditing were cancelled. Decisions on tariffs will now be made by the Council of Ministers.

The Law allowed distribution companies to use cross subsidies until the end of 2010. A price equalization mechanism applies with a nationwide uniform tariff. However, cost reflective tariffs are employed for transmission.

The EMRA issued all necessary legislation, and approved the distribution and retail tariffs (to be valid till 2011), although the provisional article enables the government for extending the provisional regime beyond 2011. EMRA recently approved the end user tariffs and revenue requirements of each distribution company for the transition period.

Energy regulation role

The Ministry of Energy and Natural Resources

It is responsible for defining the overall policy in the energy sector. It oversees the activities of EMRA.

The Ministry for the Environment and Forest

It is primarily responsible for providing information, policy-making, and legislation development in the field of the environment and renewable energy development.

The General Directorate of Electrical Power Resources Survey and Development Administration (EIE)

It defines the technical potential of renewable energy sources. It also conducts trainings, prepares legislation and performs public awareness campaigns for energy efficiency in end-use sectors.

Regulatory barriers

The framework for sustainable energy development in Turkey is well-established, but actual progress so far has been slow. The development of practical sustainable energy base is dependent on accomplishing targets set out in current energy policy and the conditions of the current energy strategy Moreover, the provisions for the support of renewable energy improvement in Turkey have been criticised in recent years for being inadequate to, actually, stimulate new one.

Analysis of the national economic system and politics

Strength and weaknesses

Historically, Turkey has had a geostrategic position, between Europe, MENA and Asia, which still nowadays gives to this country an important role in the commercial relationships among these regions. Turkey made some efforts to make its economy competitive and created an adequate business environment, with a well-balanced public finances, well-educated workforce and a mostly solid financial sector. Consequently, the country has experienced an important GDP growth since the 2001 local crisis.

In spite of this, the Turkish economy still has some important imbalances, as an erratic monetary policy which derived in an exchange rate vulnerability to internal and external shocks. The economic policy is characterized by a sluggish responsiveness to financial issues, and seems unable to solve the large current account deficits, mostly financed through short-term external debt, which is rapidly rising. The country also has problems with private sector credit growth, with significant risk of debt refinancing of weaker companies and banks.

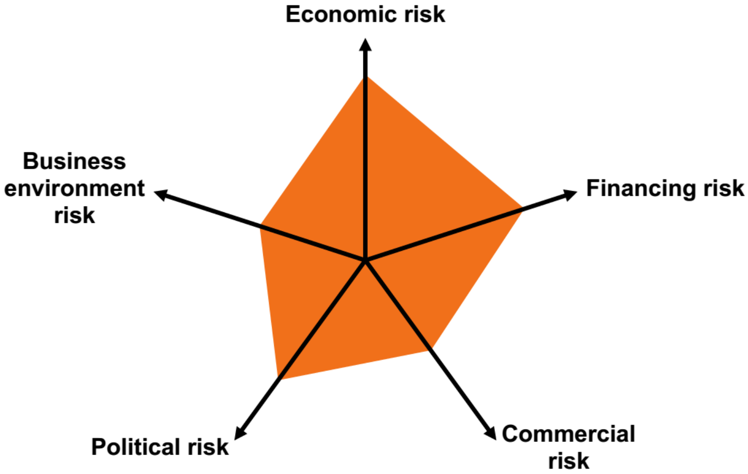

Figure A. 100. Risk dimensions estimated by Euler Hermes. Turkey.

Economic structure

Turkey has a well-diversified economic structure, without a sector clearly hegemonic over the others. Since this country has no significant primary energy sources to export, its production is based on an important manufacturing industry (19% of GDP), which allow it to export machinery, appliances, textiles, etc. The internal trade also represent an important part of Turkish economy (16%), aided by a thriving tourism. Services sector (transport, storage and communication) also has a significant contribution to the GDP (15%). Finally mining, which has a less important role in terms of GDP (9%), represent the most important part of exports (22% of total) helping to improve the trade structure of the country.

Economic forecast

In the first quarter of 2014, real GDP grew by a strong +4.3% y/y and +1.7% q/q, thanks to a one-off boost by soaring gold exports (+53% y/y), trying to maximize profits of gold reserves before gold prizes may drop. This movement has distorted the real situation of Turkish economy in Q1 2014, lifting overall export growth to +11.4%, with a large positive contribution to GDP growth. Since the exports surge is unlike to continue for the remainder of the year (exports would have grown just +3.4% without gold boost), domestic demand may take major importance if the central bank relaxes its monetary tightening, while government spending and public investment growth will continue to have an important contribution to the global economy. A GDP growth of +4.2% in 2015 may be expected.

Turkey has applied unorthodox monetary policy since 2010, with low interest rates and high bank reserve requirements in order to control short-terms foreign capital inflows and control credit growth. This strategy seemed to be successful for some time, but in 2013 the financial turmoil has evidenced the vulnerability of the Turkish economy, with uncontrolled credit growth and a depreciation of the Turkish lira (TRY) about 30% against USD-EUR. Inflation has also accelerated. For this reason central bank has finally returned to orthodox monetary policy in 2014, and the TRY re-gained about 10% since then. Inflation moderated slightly to 7.8% in end-2014. Despite all the efforts to control the situation, the TRY exchange rate risk still remains a cause of concern, because of the volatility and vulnerability to external and internal shocks appearances in the last years.

Maps

Population

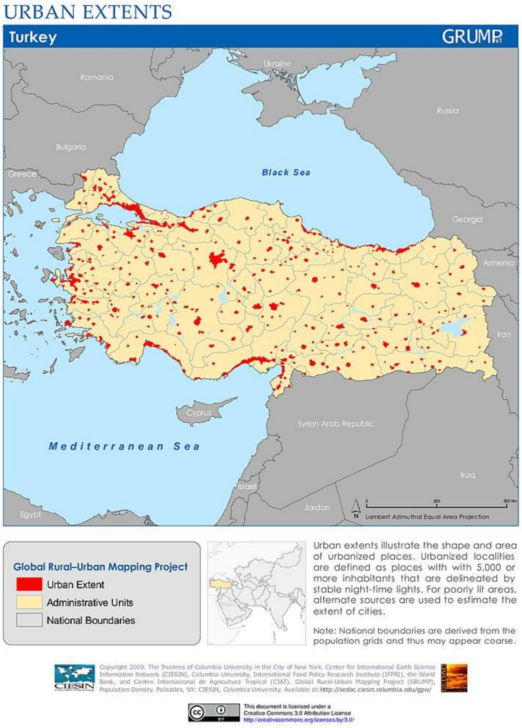

Figure A. 101. Turkey population map.

DNI

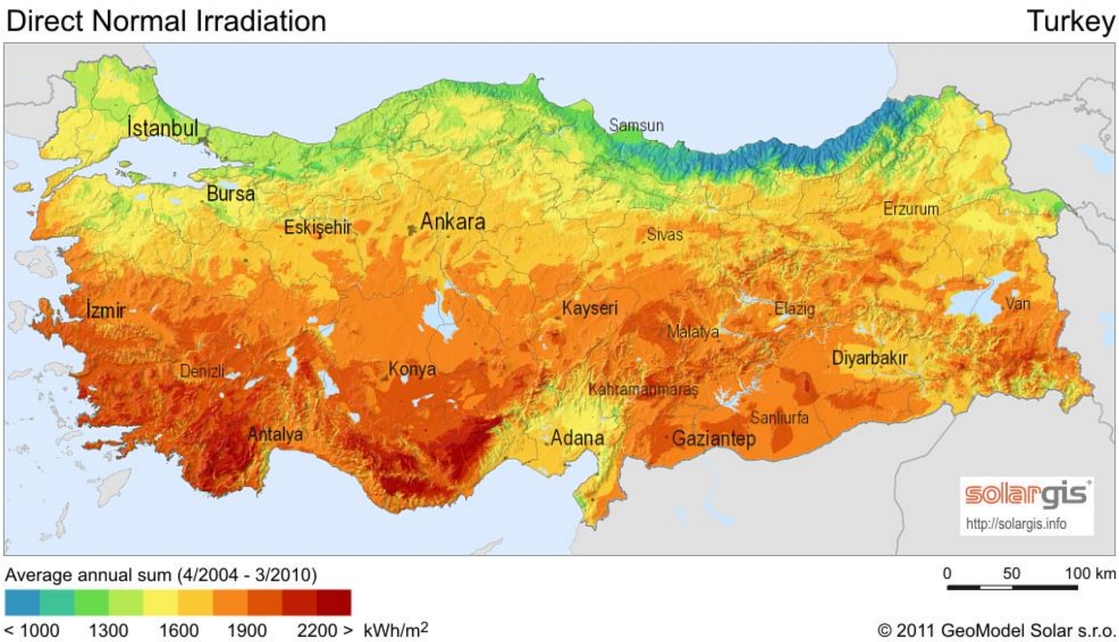

Figure A. 102. Turkey Direct Normal Irradiation.

Electricity grid

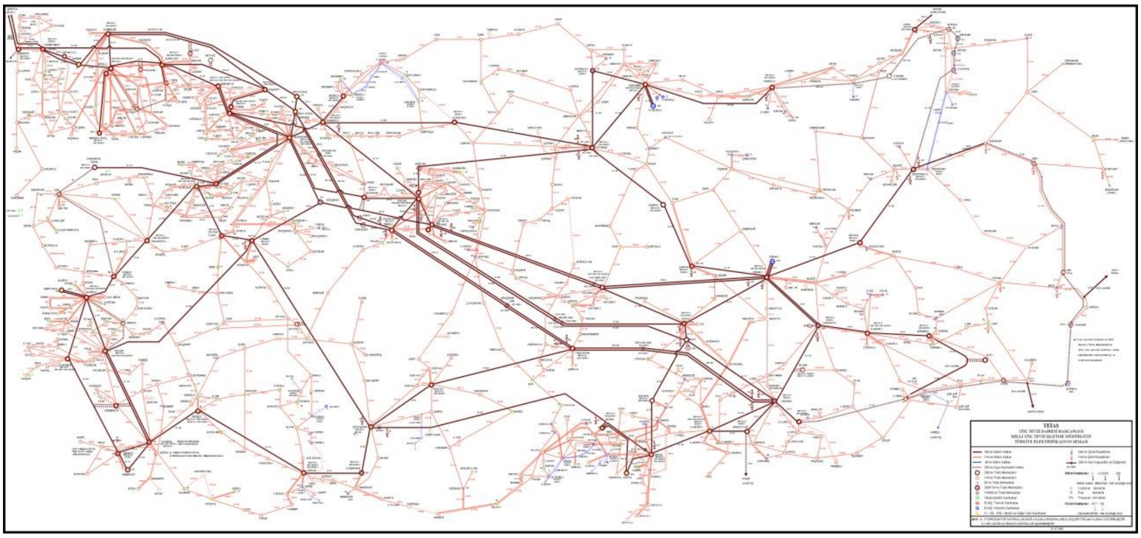

Figure A. 103. Turkey electricity grid.

Maps Overlapped

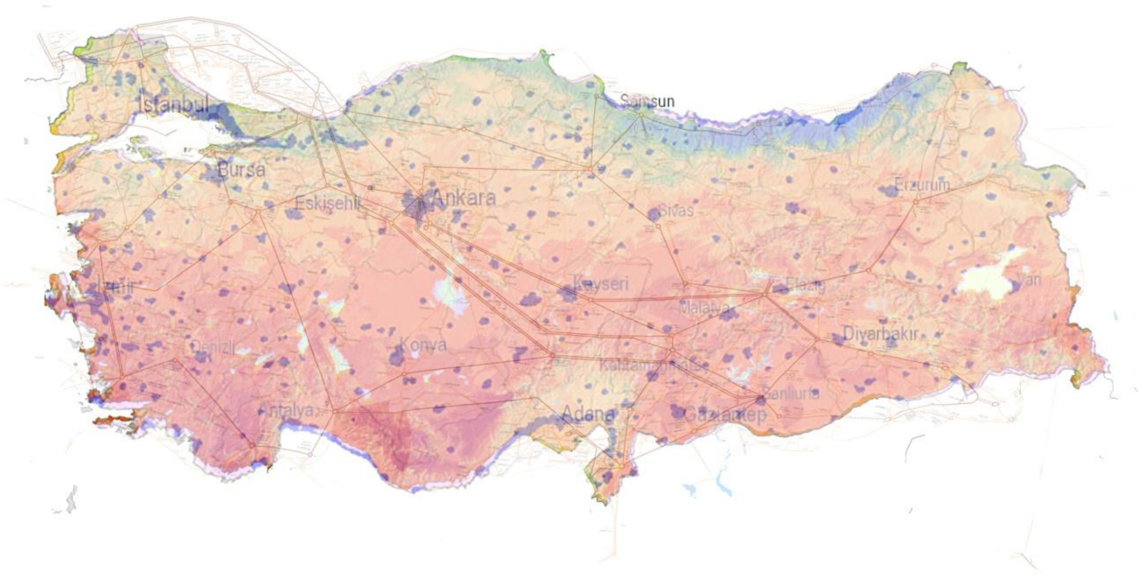

Figure A. 104. Turkey overlapped maps.

Application of the method

- **GDP:** US$ 820.21 Billion (in 2013)
- **Annual GDP Growth rate:** 4.05 % (in 2013)
- **Population:** 74.932 Million people (in 2013)
- **Annual population Growth rate:** 1.26 % (in 2013)
- **Annual electric consumption (per capita):** 2709.26 kWh (in 2011)
- **Government debt:** US$ 370.24 Billion, 45.14 % GDP (in 2012)
- **Accumulated external debt:** US$ 337.49 Billion, 41.15 % GDP (in 2012)
- **Inflation rate (consumer prices):** 7.49 % (in 2013)
- **Country rating (Euler Hermes):** C3
- **Annually averaged DNI:** 1655.16 kWh/m^2
- **Population with access to electricity:** 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.6552	0.2293
Population	0.25	1.0000	0.2500
Electricity grid	0.20	0.9923	0.1985
Energy policy	0.10	0.9280	0.0928
Legal certainty	0.10	0.2201	0.0220
		TOTAL	0.7926

Table A. 42. Farm arrangement. Turkey.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.6552	0.2293
Population	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.9280	0.0928
Legal certainty	0.10	0.2201	0.0220
		TOTAL	0.5441

Table A. 43. Stand-alone configuration. Turkey.

ANNEX 22. United States

Analysis of the national energy system

The United States, as its name indicates, unites 52 different states and creates one country, which is the fourth one in the world considering area. Moreover it is one of the most populated with 320,549,000 inhabitants. For these reasons the energy demand and consumption is incredibly high. Nevertheless, United States can be considered as the most developed country in the world that is able to meet the current energy needs. However, the country is not fully independent in energy production and requires imports. It is due to a climate change and rising energy demand.

The primary energy in the US, according to EIA (Energy Information Administration) from 2014, is produced from fossil fuels constituting 79.5 % of the total production of 7.29011 quadrillion Btu. The renewable and nuclear energy contribute to 11.1 % and 9.4 % of the share respectively. Furthermore, the consumption of the primary is divided into six sectors: transportation, industrial, residential, commercial, and electric power, which depletes 36.6 % of the total primary energy. As the power is a secondary energy source, keeping its flow is a critical necessity for everyday life and economic vitality. The Energy Department works to keep the grid secure from cyber and physical attacks and supports efforts to increase grid efficiency and energy storage as more renewable energy sources come online.

Reliance

The US intends to be fully independent in energy production. In November 2013 America hit a milestone of energy independence; for the first time in nearly two decades, the US produced more oil domestically than it imported from foreign sources. Currently the import rate of oil is very low and is declining. Furthermore, the country became a leader in natural gas production.

According to year 2013, The United States imported approximately 9.9 million barrels per day (MMbbl/d) of petroleum from about 80 countries. Petroleum includes crude oil and refined petroleum products such as gasoline and diesel fuel, and biofuels including ethanol and biodiesel. In the same year, about 78% of gross petroleum imports were crude oil, and about 51% of the crude oil that was processed in US refineries was imported. Furthermore, the United States exported 3.6 MMbbl/d of crude oil and petroleum products, resulting in net imports (imports minus exports) of 6.2 MMbbl/d. Net imports accounted for 33% of the petroleum consumed in the United States. The top five source countries providing US petroleum imports were Canada, Mexico, Russia, Saudi Arabia, and Venezuela. Their respective rankings vary based on gross petroleum imports or net petroleum imports (gross imports minus exports). Net imports from Organization of the Petroleum Exporting Countries (OPEC) countries accounted for 56% of US net imports.

Extend network

The electrification rate in the country reaches 100%, according to the Worlds Bank database. The US power grid is actually comprised of three smaller grids, called interconnections. The Eastern Interconnection operates in states east of the Rocky Mountains, The Western Interconnection covers the Pacific Ocean to the Rocky Mountain States, and the smallest is the Texas Interconnected; system that covers most of Texas.

Currently, the electric grid is aging. Infrastructure requires extensive upgrades to effectively meet the nation's energy demands. Moreover, severe weather is the number one cause of power outages in the United States, costing the economy between $18 and $33 billion every year in lost output and wages, spoiled inventory, delayed production and damage to grid infrastructure.

Capacity concerns

Energy has re-emerged as an issue of national concern as the United States confronts the challenges of economy recovery, energy affordability, climate change, and energy security.

Renewable energy

United States takes the second place worldwide in total electricity generation form renewable energy; the first one is China. In spite of being second, United States produces the most electricity from non-hydroelectric renewable sources; and in this category is the first one.

The largest share of electricity generated by renewable sources in 2013 came from hydroelectric power (52%), followed by wind (32%), biomass wood (8%), biomass waste (4%), geothermal (3%), and solar (2%). Each of these sources has different history of development and distant evolution of contribution to the electricity generation in individual state.

Nearly all hydroelectric capacity was built before the mid-1970s, and much of it is at dams that are operated by federal agencies.

Biomass waste is mostly municipal solid waste that is burned in waste-to-energy power plants.

Most electricity generation from wood biomass occurs at lumber and paper mills. These facilities use wood waste to provide much of their own steam and electricity needs.

The amount of electricity generated by wind has increased substantially in the past decade. This increase is largely attributed to the availability of federal financial incentives and renewable portfolio standards mandated by state governments.

Unlike other sources of renewable electricity generation, solar generated a significant amount of power at small-scale installations. According to the Annual Energy Outlook 2014, these small solar installations (often located on private rooftops) are estimated to generate 9.86 billion kWh of electricity in 2013.

Solar Energy

The insolation level in US in some of the states like New Mexico or Nevada reaches around 7 kWh/m^2 a day; while in California and Arizona it is approximately 8 kWh/m^2 a day. In fact, the solar abundance and potential throughout the United States is staggering. To make usage of this there are being commissioned concentrating solar power (CSP). Moreover, seven states have technical potential and land area to site enough CSP to supply more than four times the current US annual electricity demand. Also PV panels on just 0.6% of the nation’s total land area could supply enough electricity to power the entire United States.

In 2008 the amount of solar power installed in the U.S. reached 1.2 GW. Currently it is estimated to be 17.5 GW as of the end of the third quarter of 2014. That is enough to power the equivalent of 3.5 million average American homes. This high increase was provoked with new incentives provided by current government. Despite this impressive progress, significant work remains before solar becomes as affordable as conventional energy sources and meets its full potential throughout the country. Solar hardware costs have fallen dramatically, but market barriers and grid integration challenges continue to hinder greater deployment.

Ownership of electricity

Individual utilities or utility consortia are responsible for most power generation, with some coming from federal agencies and an increasing amount from independent, non-utility suppliers. Additionally, in states that have restructured their retail electric markets, separate companies exist to sell commodity electricity to local individual consumers. Some companies specialize in selling 'green' power from renewable energy, while others specialize in residential, commercial, or industrial service. These suppliers may own their own power plants, buy from entities that do, or buy from marketers and brokers.

Competition

About 75 % of the US population is served by investor-owned utilities, so called 'IOUs'. These are private companies, subject to state regulation and financed by combination of shareholder equity and brother holder debt. Most of the IOUs are large (in financial terms), and many have multi-fuel (electricity and natural gas) or multi-state operations. Quite a few are organized as holding companies with multiple subsidiaries, or have sister companies controlled by a common parent corporation.

The remaining 25 % of US population is served by consumer-owned utilities (COUs); including both cities and many large rural areas. In addition, there are a small number of consumer-owned natural gas utilities. These utilities include: city-owned (municipal); the investor-owned; public utility districts; cooperatives (co-ops); and others.

Energy framework

The Climate Action Plan

Introduced by the President Obama became a priority in US to achieve its goals. The main assumptions of the plan are as listed below:

- Reducing Dependence on Foreign Oil

Due to All-of-the-Above Energy Strategy commissioned in 2013, US is on the way to reduce dependency on foreign oil and being self-sufficient in energy production. The introduction of the plan has already brought positive consequence.

- Carbon Capture and Sequestration Technologies

Continued progress in reducing pollution to improve public health and the environment can be accomplished while supplying the reliable, affordable power needed for economic growth and advancing cleaner energy technologies such as carbon capture and sequestration (CCS). The CCS is technologically feasible for implementation at new coal-fired power plants, and its core components (carbon dioxide capture, compression, transportation, and storage) have been implemented successfully at commercial scale.

- Safe and Responsible Domestic Oil and Gas Production

In 2010, in response to the Deepwater Horizon oil spill in the Gulf of Mexico, the Obama administration launched the most aggressive and comprehensive reforms to offshore oil and gas regulation and oversight in US history and put in place new safeguards to protect the environment. These measures help to ensure that nation can continue to safely and responsibly develop offshore energy resources.

- Advancing Clean Energy

President Obama has also taken an all-in approach to innovation that starts with a strong commitment to basic and applied energy. That is why this Administration has made the largest investment in clean energy in American history and has launched several initiatives to advance clean energy deployment. Due to these incentives US has increased solar electricity generation by more than ten-fold, and tripled electricity production from wind power. Additionally, in May 2014, the Obama administration launched a process for securing commitments from the public and private sectors to cut energy waste and deploy more renewable energy.

There are three primary types of policies used to increase the use of renewable energy sources:

- Tax credits. The Renewable Electricity Production Tax Credit, a federal incentive, has encouraged increased generation from wind and other eligible renewable sources.
- Targets. Many states have implemented Renewable Portfolio Standards (RPS). These standards require electricity providers to generate or acquire a certain portion of their power supplies from renewable sources. Many RPS programs have "escape clauses" if renewable generation exceeds a specific cost threshold.
- Markets. A number of states have built Renewable Energy Certificates/Credits (RECs) into their Renewable Portfolio Standards. These programs allow electricity providers to sell renewable energy certificates/credits. Some states have made REC markets mandatory.

- Advancing Energy Efficiency

The Obama administration has taken several actions that advance energy efficiency in vehicles and homes. Additionally, DOE develops energy conservation standards for appliances and equipment, which have cut consumers' electricity bills by hundreds of billions of dollars. Taken together, the final energy conservation standards completed during this Administration add up to more than 2 billion metric tons of carbon emissions by 2030, and US is on track to meet the Climate Action Plan's goal of cutting 3 billion metric tons of energy waste by 2030.

- Developing Clean Fuels

Biofuels are a key component of President Obama's All-of-the-Above energy strategy and play an important role in reducing America's dependence on foreign oil. The Obama administration has supported research and engaged in public-private partnerships to pursue new innovations in biofuels technologies, increase production of US biofuels, strengthen American energy security, and create jobs.

- Investing in Coal Communities, Workers, and Technology: The POWER+ Plan

The United States is undergoing a rapid energy transformation, particularly in the power sector. Booming natural gas production, declining costs for renewable energy, increases in energy efficiency, flattening electricity demand, and updated clean air standards are changing the way electricity is generated and used across the country. These trends are producing cleaner air and healthier communities, and spurring new jobs and industries. At the same time, they are impacting workers and communities who have relied on the coal industry as a source of good jobs and economic prosperity, particularly in Appalachia, where competition with other coal basins provides additional pressure. To help these communities adapt to the changing energy landscape and build a better future, the President's FY 2016 Budget proposes the POWER+ Plan. The POWER+ Plan invests in workers and jobs, addresses important legacy costs in coal country, and drives development of coal technology.

Weatherization Assistance Program (WAP)

The US Department of Energy (DOE) Weatherization Assistance Program provides grants to states, territories, and some Indian tribes to improve the energy efficiency of the homes of low-income families. The program since its opening helped a lot of American families to lower their energy bills.

ENERGY STAR

It is a US Environmental Protection Agency (EPA) voluntary program that helps businesses and individuals save money and protect climate through superior energy efficiency. ENERGY STAR has been instrumental in reducing energy use in order to realize significant greenhouse gas (GHG) emission reductions; contributing to important health and environmental benefits by addressing the challenges of climate change while strengthening US economy. Moreover, benefits have grown steadily over time, nearly tripling compared to the last decade. Furthermore, EPA has developed so called third-party certification requirements and testing in order to maintain consumer trust and improve the oversight of ENERGY STAR certified products, homes, and commercial facilities. Under EPA's leadership, American consumers, businesses, and organizations have made investments in energy efficiency that are transforming the market for efficient products and practices, creating jobs, and stimulating the economy. Since 1992, the ENERGY STAR program has boosted the adoption of energy efficient products, practices, and services through valuable partnerships, objective measurement tools, and consumer education.

Energy debates

Energy policy in the United States has focused on three major goals: assuring a secure supply of energy (Smart grid), keeping energy costs low, and protecting the environment. In pursuit of those goals, government programs have been developed to improve the efficiency with which energy is utilized, to promote the domestic production of conventional energy sources, and to develop new energy sources, particularly renewable ones. Implementing these programs has been controversial because of varying importance given to different aspects of energy policy. For some, dependence on imports of foreign oil, particularly from the Persian Gulf, is the primary concern; for others, the continued use of fossil fuels, whatever their origin, is most important. The contribution of burning fossil fuels to global climate change is particularly at issue. Another dichotomy is between those who see government intervention as a positive force and those who view it as a necessary evil at best. Also there is a lot of enthusiasm about the Keystone XL pipeline, which is about to provide Canadian oil in the safest and most advanced way to North America. In the ongoing debate over approval of the proposed Keystone XL the Northern Route Approval Act declared that a presidential permit would not be required for its construction.

Energy studies

Nowadays, there are a lot of money invested into research and development of carbon capture and storage (CCS) technologies, including those aiming to develop innovative; second-generation technologies that will help improve the efficiency and drive down the costs of carbon capture processes for new and existing coal-fired power plants.

The United States have got the most developed energy studies supply base in the world. In general, there are a lot of investigations conducted in all kind of fields. The most important one, which are focused on achieving currently goals are supervised by Office of Science and Technology Policy (OSTP). It is responsible for ensuring that the best science, research, data, tools, and technologies are brought to bear to implement the President's Climate Action Plan, including by overseeing the activities of the US Global Change Research Program (USGCRP), which is a coalition of 13 Federal agencies conducting rigorous science to predict future climate change, understand climate change impacts, and provide the tools needed to address them.

Moreover, the important role plays also the U.S. Department of Energy (DOE), which currently (in solar field) leads a large network of researchers and other partners to deliver innovative solar photovoltaic and concentrating solar power technologies that will make solar energy cost competitive with traditional sources of energy.

The Administration continues to develop and implement a series of standards that will make oil and gas production and transportation safer, including in hydraulic fracturing, arctic drilling, and rail safety.

The Department of Energy's Office of Energy Efficiency and Renewable Energy, in addition to the $2 billion appropriated in the FY2009 regular appropriations bill, received $17 billion in ARRA, of which $11.5 billion was for grants to states for energy, efficiency, and weatherization programs. The Office of Electricity Delivery and Energy Reliability, which had historically been funded at about $150 million per year, received $4.5 billion in ARRA, directed at establishing "Smart Grid" technology for the electric power industry.

Role of government

Department of Energy (DOE)

It is responsible for advancing the national, economic and energy security of the United States through the implementation of policies regarding nuclear power, fossil fuels, and alternative energy sources. The DOE promotes scientific and technological innovation in all of the aforementioned energy sectors and is charged with the environmental clean-up of the national nuclear weapons complex. One of its key duties is the formulation and implementation of the National Energy Policy. This comprehensive and wide ranging document covers energy challenges facing the US; impacts of high energy prices; protecting America's environment; increasing energy conservation and efficiency; increasing domestic energy supplies; increasing America's use of renewable and alternative energy; America's energy infrastructure; and enhancing national energy security and international relations.

The Office of Electricity Delivery and Energy Reliability (OE)

It provides national leadership to ensure that the Nation's energy delivery system is secure, resilient and reliable. The OE works to develop new technologies to improve the infrastructure that brings electricity into US homes, offices, and factories, and the federal and state electricity policies and programs that shape electricity system planning and market operations. OE also works to bolster the resiliency of the electric grid and assists with restoration when major energy supply interruptions occur.

Environmental Protection Agency (EPA)

The Environmental Protection Agency, with a mission to protect people and the environment from significant health risks, sponsors and conducts research and develops and enforces environmental regulations. The most recent priorities are: making visible difference in community across the country; addressing climate change and improving air quality; taking action on toxic and chemical safety; protecting water; landing a new era of state, tribal and local partnership; embracing itself as a high performing organization; and working towards sustainable future.

Domestic Policy Council

This office in 2011 took over the responsibilities of already not existing White House Office of Energy and Climate Change Policy (established in 2008). The main responsibilities were to coordinate administration policy on energy; climate change; and providing support to the DOE.

Government agencies

The US Department of Energy's Federal Energy Management Program (FEMP)

It plays a critical role in reducing energy use and increasing the use of renewable energy at federal agencies. The US federal government is the nation's largest user of energy, and it has both a tremendous opportunity and an acknowledged responsibility to lead by example in saving energy. Thanks in part to the technical assistance provided by FEMP, the energy intensity of federal facilities has decreased by roughly 45% since 1975. FEMP also helps federal agencies with funding mechanisms for their projects, such as energy-saving performance contracts (ESPCs).

The US Department of Energy's Energy Savings Performance Contracts (ESPCs)

They allow federal agencies to complete energy-savings projects without up-front capital costs and special Congressional appropriations. A contractor pays the up-front cost of improvements and is repaid through a portion of the energy savings. From 2009 to 2011, FEMP arranged ESPCs that saved taxpayers more than $3.5 billion in federal energy costs. An ESPC is a partnership between a federal agency and an energy service company (ESCO).

The Energy Service Company ESCO

It conducts a comprehensive energy audit of federal facilities and identifies improvements to save energy. In consultation with the Federal agency, the ESCO designs and constructs a project that meets the agency's needs and arranges the necessary funding. The ESCO guarantees that the improvements will generate energy cost savings to pay for the project over the term of the contract (up to 25 years). After the contract ends, all additional cost savings accrue to the agency.

The US Department of Energy's Electricity Advisory Committee (EAC)

The mission of the Electricity Advisory Committee is to provide advice to the US Department of Energy in implementing the Energy Policy Act of 2005, executing the Energy Independence and Security Act of 2007, and modernizing the nation's electricity delivery infrastructure.

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE)

It relies on an objective and credible analysis underpinning for corporate decisions and program implementation. To support EERE decision-making, Policy and Analysis team generates a variety of analysis resources and findings. It strives, as part of government transparent data initiatives, to increase the rigor, utility and accessibility of EERE data and analysis tools.

The Federal Smart Grid Task Force

Was established under Title XIII of the Energy Independence and Security Act of 2007 (EISA) and includes experts from eleven Federal agencies. The mission of the Task Force is to ensure awareness, coordination and integration of the diverse activities of the Federal Government related to smart grid technologies, practices, and services. The Task Force will collaborate with DOE's Electricity Advisory Committee and other relevant Federal agencies and programs.

Energy procedure

Federal Power Marketing Agencies (PMAs)

These federal PMAs include the Bonneville Power Administration, the South eastern Power Administration, the South western Power Administration, and the Western Area Power Administration. The Tennessee Valley Authority is technically not a PMA, but operates in much the same way. Generally the PMAs only sell power at whole sale to local, vertically integrated utilities or local distribution utilities. However, BPA and TVA also operate extensive transmission grids, serving numerous local distribution utilities.

Federal Agency Regulatory Commission

The FERC (Federal Agency Regulatory Commission) has clear authority to regulate wholesale power sales, except when the seller is a public agency. The federal power marketing agencies, such as the Tennessee Valley Authority and Bonneville Power Administration, and local municipal utilities are specifically exempt from general regulation by the FERC. Hundreds of companies are registered with the FERC as wholesale power suppliers. While some own their own power plants, marketers often do not; instead they buy power from multiple suppliers on long-term or spot-market bases, then re-sell it. Brokers arrange transactions, but never actually take ownership of the electricity.

Non-Utility Generators (NUG)

A non-utility generator (NUG), or independent power producer (IPP), owns one or more power plants but does not provide retail service. It may sell its power to utilities, to marketers, or to direct-access consumers through brokers. Sometimes a NUG will use a portion of the power it produces to operate its own facility, such as an oil refinery, and sell the surplus power. Some enter into long-term contracts, while others operate as merchant generators, selling power on a short-term basis into the wholesale market. Some NUGs are owned by parent corporations that also operate utilities; in this situation, the regulator will normally exercise authority over affiliate transactions.

Consumer-Owned Utilities (COUs)

Consumer-owned utilities, including munis, co-ops, and public power districts, are often distribution-only entities. Some procure all of their power from large investor-owned utilities, some from federal power-marketing agencies. Groups of small utilities, mostly rural electric cooperatives and munis, have formed generation and transmission cooperatives (G&Ts) or joint action agencies to jointly own power plants and transmission lines. By banding together, they can own and manage larger, more economical sources of power, and the G&Ts may provide power management services and other services for the utilities. Such G&Ts typically generate or contract for power on behalf of many small-sized member utilities, and often require the distribution cooperatives to purchase all their supply from the G&T.A significant number of COUs do own some of their own power resources, which they augment with contractual purchases, market purchases, and/or purchases from G&Ts. A few COUs own all their supply, and sell surplus power to other utilities.

Retail Non-Utility Suppliers of Power

The term retail electricity service is widely used overseas to mean the business that actually interacts with the consumer, issuing bills and collecting revenues. In the US, distribution utilities perform these functions almost exclusively. After 1994 the British experiment was followed by some US states, now including California, Illinois, Texas, and most of New England. In most cases, investor-owned utilities in these states had previously owned power plants, but sold them to unaffiliated entities, or transferred them to non-regulated subsidiaries of the same parent corporation. These states made provisions for a default supply (also referred to as basic service) for those consumers that do not choose a competitive supplier, or whom the competitive market simply does not serve. While a significant percentage of large industrial-power users are direct-access customers, most residential and small-business consumers are served by the default supply option.

Energy regulator

The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. The FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines as well as licensing hydropower projects. Beneath the FERC there are state regulations. Each state is able to provide its own policy under the condition of previous consideration of the federal law.

Degree of independence

As mentioned before the FERC is fully independent, while the state regulation is subordinated to FERC

Regulatory framework

Energy policy historically has often been legislated in large, complex bills that deal with a wide variety of issues, with debate spanning several sessions. Also there are around twenty crucial acts established since 1984 until 2014. Beneath are presented the most important ones that had a revolutionary impact upon energy regulation. All of these Acts were ordered by the FERC.

The Energy Policy Act of 2005 (EPAct 2005; P.L. 109-58)

It was the most recent comprehensive general legislation, with provisions and authorizations in almost all areas of energy policy. EPAct 2005 also set up in DOE the program of energy project loan guarantees which became a source of controversy and debate following the bankruptcy of the Solyndra solar system manufacturing facility in 2011.

The Energy Independence and Security Act of 2007 (EISA, P.L. 110-140)

The Act set new target fuel economy standards for cars and light trucks of 35 miles per gallon by 2020, and expanded the renewable fuels standard (RFS) to require 9.0 billion gallons in 2008 and rise to 36 billion gallons by 2022. EISA also included new efficiency standards for appliances and for light bulbs, the latter being particularly controversial in the 112th Congress.

The American Recovery and Reinvestment Act of 2009 (the "Stimulus" Act, ARRA, P.L. 111-5)

It had major energy policy provisions, including expansion of the loan guarantee program and large increases in funding for renewable energy programs. It contributed to 'Smart grid' development.

Regulatory roles

The Energy Policy Act of 2005 gave FERC additional responsibilities and updated Strategic Plan. As part of that responsibility, FERC:

- Regulates the transmission and wholesale sales of electricity in interstate commerce;
- Reviews certain mergers and acquisitions and corporate transactions by electricity companies;
- Regulates the transmission and sale of natural gas for resale in interstate commerce;
- Regulates the transportation of oil by pipeline in interstate commerce;
- Approves the siting and abandonment of interstate natural gas pipelines and storage facilities;
- Reviews the siting application for electric transmission projects under limited circumstances;
- Ensures the safe operation and reliability of proposed and operating LNG terminals;
- Licenses and inspects private, municipal, and state hydroelectric projects;
- Protects the reliability of the high voltage interstate transmission system through mandatory reliability standards;
- Monitors and investigates energy markets;
- Enforces FERC regulatory requirements through imposition of civil penalties and other means;
- Oversees environmental matters related to natural gas and hydroelectricity projects and other matters; and
- Administers accounting and financial reporting regulations and conduct of regulated companies.

Each state has to cooperate with the FERC. Nevertheless, state public utility commissions are responsible for regulating:

- retail sales of electricity and natural gas
- construction of energy facilities and local pipelines
- local and regional power systems and cooperatives
- nuclear power plants
- pipeline safety
- electric transmission and reliability
- abandoned oil facilities

Energy regulation roles

Even though the FERC has independence, it is obliged to follow the orders of the annual US Congress and is fully subordinated to Energy Policies Acts while it is required. The energy regulations are supposed to assure a secure supply of energy (Smart grid), keeping energy costs low, and protect the environment.

Regulatory barriers

In general, the complexity of the US environmental policies and regulation due to having federal and a state one; reflects on high start-up costs. For example the regulations for CO_2 emissions contribute to investments in high technology, which always results as costly. Moreover, the end-user lack of any knowledge of used equipment contributes to increased losses of energy efficiency. Currently an individual customer is challenging monthly bills without any awareness of generating his equipment at most efficient rate. The government as well is failing in providing sufficient incentives. However, the most limiting factor occurs to be market due to lack of its competitiveness.

Analysis of the national economic system and politics

Strength and weaknesses

The United States, as first world economy in terms of GDP, has a solid economic fundamentals mainly based on high-income economy and strong domestic market. The accommodative monetary policy applied by the Federal Reserve in the last years and the flexibility of the labour market has provided a favourable environment for business, which should continue for a while. In terms of BOP, the re-industrialization of the country, decreasing energy dependence and low labour cost compared to others industrialized countries has improved the external sector behaviour, supported by the role of the dollar in the international market.

Moreover, the U.S. economy still has some structural weaknesses and uncertainties about its future evolution. As main we can refer to the high structural unemployment or the declining participation rate in the labour market. The expansive policies adopted by the government have resulted in a rise in public debt, and the housing market is still an important risk for the whole economy, all of which has resulted in a certain lack of confidence.

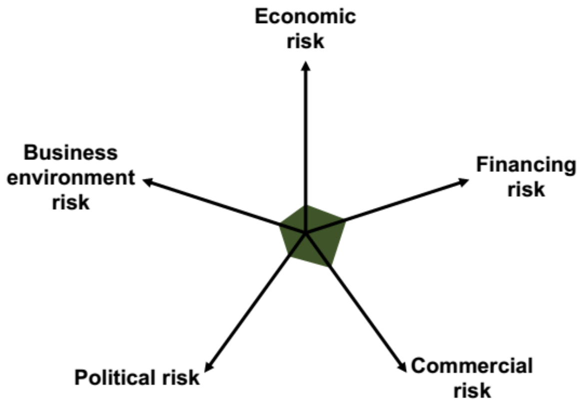

Figure A. 105. Risk dimensions estimated by Euler Hermes. United States.

Economic structure

As mentioned before, the U.S. economy is mainly based on internal market, with a high consumer and a moderate public spending compared to other industrialized countries. Together with this high internal demand, the energy dependence results in a trade structure with negative net exports.

The main export products are N.E.S. products, petroleum derived products and technology products as engines or precision instruments, while the imports are composed mainly by crude oil and refined petroleum products (20%), and technology equipment as computer or telecommunications devices (10%).

Economic forecast

The severe winter in 2014 lead to a sudden drop in GDP growth in first quarter of 2014 (-2.9% q/q annualized). This unusual occurrence had negative impact upon economic activities as investment (-4.2%), mainly due to construction, the exports (fell -8.9%) and the imports (growth +1.8%). As a result, the forecast has been revised down by the economical observers.

Considering 2015 with not so harsh weather conditions, the economy can get close to (+2.9%) due to stronger domestic demand.

The monetary policy will remain focused on maintaining low interest rates, with short-term rates at 0% for the next year, while controlling the inflation at an acceptable level around 2%. This accommodative monetary policy should boost business activities. In addition, the Fed tapering of asset purchase may result in a rise of long-term rates, and a significant increase in bank lending profits. Therefore, banks should be able to facilitate access to credit, providing benefit for the entire economy.

The labour market has shown a good evolution in the last months, whit a significant drop in the unemployment rate (7.9% in early 2013 to 6.3% in April 2014). However, this positive behaviour must be compared with the evolution of the participation rate, which has decreased since 2008 and partially explains the fall in unemployment rate. Taking it into account, a slight rise in unemployment rate will be expected in 2015 (6.8%).

Maps

Population

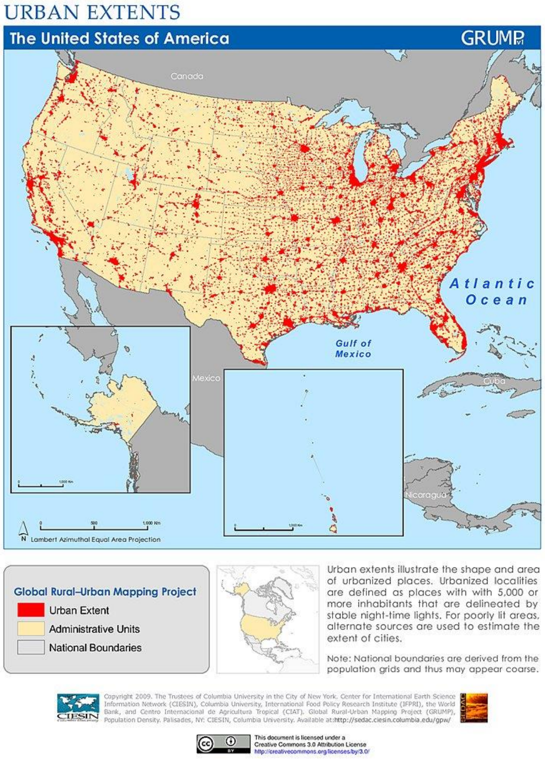

Figure A. 106. United States population map.

DNI

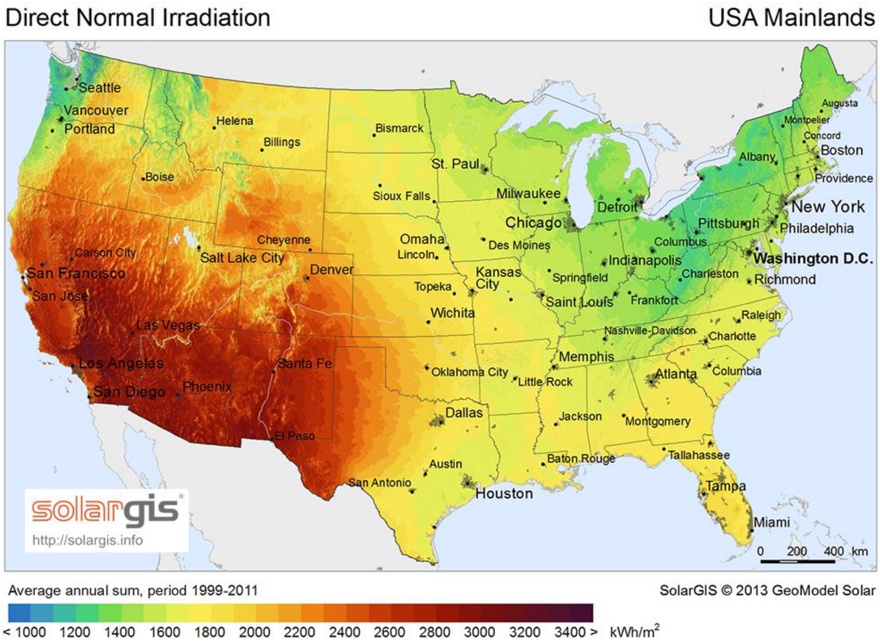

Figure A. 107. United States Direct Normal Irradiation.

Electricity grid

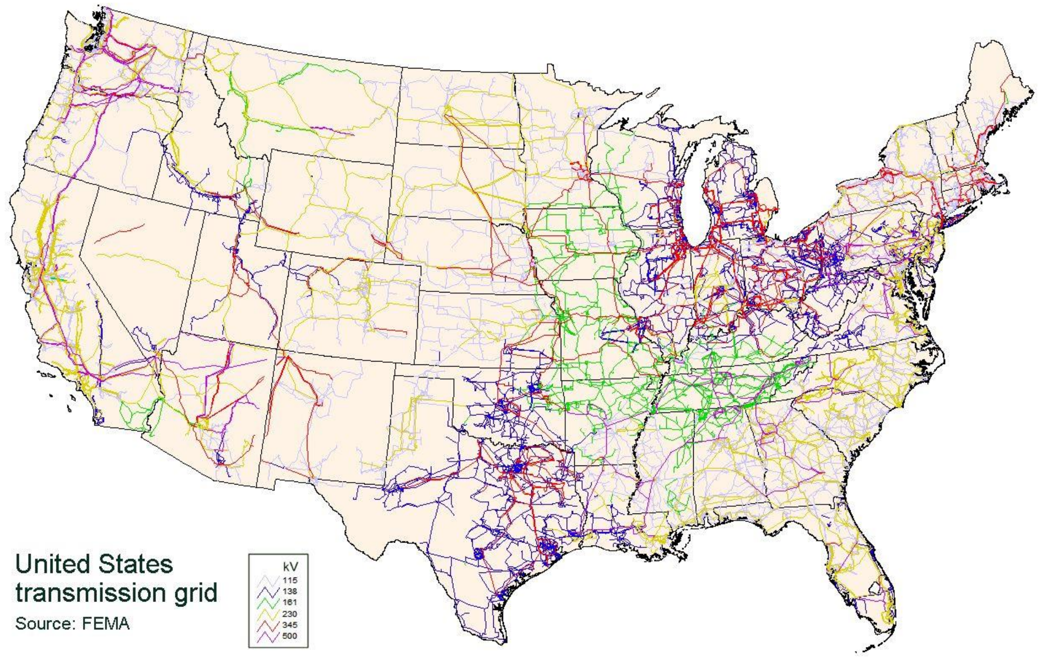

Figure A. 108. United States electricity grid.

Maps Overlapped

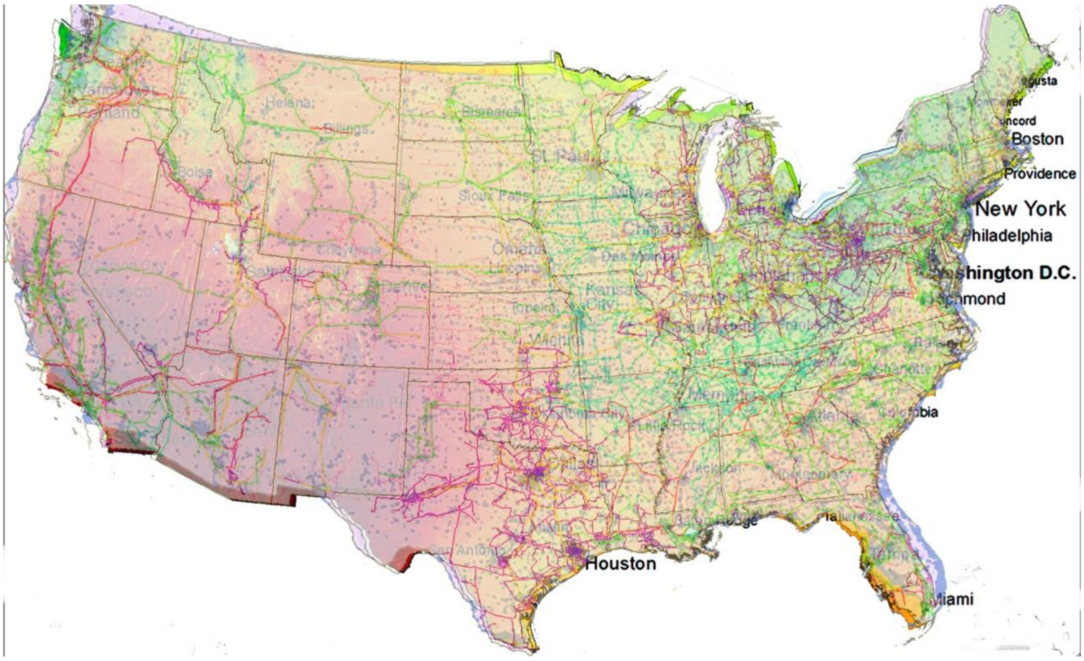

Figure A. 109. United States overlapped maps.

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Application of the method

- **GDP:** US$ 16800 Billion (in 2013)
- **Annual GDP Growth rate:** 1.88 % (in 2013)
- **Population:** 316.13 Million people (in 2013)
- **Annual population Growth rate:** 0.72 % (in 2013)
- **Annual electric consumption (per capita):** 13246.27 kWh (in 2011)
- **Government debt:** US$ 16121 Billion, 95.96 % GDP (in 2012)
- **Accumulated external debt:** N/A
- **Inflation rate (consumer prices):** 1.46 % (in 2013)
- **Country rating (Euler Hermes):** AA1
- **Annually averaged DNI:** 1783.04 kWh/m^2

Population with access to electricity: 100 %

Farm arrangement

Factors	Weight	Value	Result
Irradiance	0.35	0.7830	0.2741
Population	0.25	1.0000	0.2500
Electricity grid	0.20	0.8900	0.1780
Energy policy	0.10	0.6925	0.0683
Legal certainty	0.10	1.0000	0.1000
		TOTAL	0.8713

Table A. 44. Farm arrangement. United States.

Stand-alone configuration

Factors	Weight	Value	Result
Irradiance	0.35	0.7830	0.2741
Population	0.25	0.0000	0.0000
Electricity grid	0.20	1.0000	0.2000
Energy policy	0.10	0.7758	0.0776
Legal certainty	0.10	1.0000	0.1000
		TOTAL	0.6516

Table A. 45. Stand-alone configuration. United States.

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