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**Renewable Energies to Provide Sustainable Development Perspectives for North Africa:
The Sahara Wind Project.**

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Abstract : The trade winds that blow along the Atlantic coast from Morocco to Senegal represent one of the largest and most productive wind potentials available on earth. Because of the extremely harsh climatic conditions, populations in these areas are concentrated in a few remote cities where economic activities such as mining or fishing can be sustained. Although growing, the local electricity demand remains very low, and will remain so for some time. Unless this vast renewable energy resource can be utilized in a broader context as to supply regional electricity markets, economic development alternatives within the region will remain limited. This by itself can be considered a threat to regional security, as a lack of economic development over these vast desert areas increases exposure of the region's population to illegal activities such as trafficking which could eventually to grow into broader transnational security threats. While local urban centers are witnessing very high unemployment rates, the region is also under pressure from sub-Saharan migrant population fluxes. Ideally, the supplying of regional electricity markets could pave the way for an integrated development of the region. Trade-wind generated renewable electricity generated on a larger scale can be effectively transferred via High Voltage Direct Current infrastructures at relatively low costs. Such energy options are likely to reduce the reliance on fossil fuel generated electricity for Spain and Portugal which boast Europe's highest CO₂ emission increases from Kyoto's reference year levels. In creating an integrated, job generating, socially acceptable renewable energy industry, such option could also eliminate the need for countries like Morocco or Portugal to consider Nuclear Energy as a viable option for meeting their growing electricity needs. Spain already suspended the construction of new nuclear power plants for over two decades. This paper aims at describing the renewable energy options for the countries of North Africa integrated to a Euro-Mediterranean power market, and their positive impact on the region's economy, providing prosperity, stability, and long term security.

Keywords: security threats, energy security, nuclear energy, distributed energy, capacity building, Sahara trade winds, climate change, sustainable development, energy options, High Voltage Direct Current transmission technology, Union for the Mediterranean Solar Plan.

1. Current status – Security and Development challenges in the Saharan regions

1.1. LIVING CONDITIONS

While quality of life may be considered to be improving in Morocco, living conditions in Mauritania and throughout the Sahara desert remains overall fairly scarce and difficult. Access to electricity, water and other services is significantly limited by the natural conditions under which these regions are subject to. The extreme dryness and high solar radiation prevent any vegetation from growing, making human presence and traditional economic activities such as agriculture hardly possible. Because of the extremely harsh climatic conditions, the population densities in these areas are less than 1 hab/km². Most of the population is concentrated around water supply sources that constitute attraction poles, shaping communities into a few cities spread within a very large region.

1.1.1. Economy

As the local economy can hardly sustain itself through agriculture, the main economic activities tend to focus on the mining, fishing and fish processing industries where possible. Within such context, it is important to note that fishing and agriculture -North West Africa's main economic drivers- are under severe physical constraints. The first constraint, linked to demographics has led to the overexploitation of fishing stocks while the effect of climate change contributes to furthering the erosion and desertification of these region's few agricultural areas. As most mineral resources remain largely untapped within this vast region, mining and mine processing industries are likely to become fields of activities bearing the most promising future economic development perspectives.

1.1.2. Demography

From a nomadic life based on daily subsistence, the improved living conditions made available in the cities, have led the population within the Sahara to grown significantly and concentrate in urban centers. Boasting one the world's highest demographic growths, the population densities have risen in urban areas, and as a result, most cities or administrative centers have outgrown their natural carrying capacities. New challenges, such as infrastructure planning, access to electricity and fresh water supplies need to be reassessed to accommodate with these changes. Difficulties in meeting the rising demand with power generation shortages and the construction of pipeline projects to bring water supplies from hundreds of kilometers away as the Senegal River Project that supplies the city Nouakchott, located, is for that matter quite edifying.

1.2. NATURE OF SECURITY CHALLENGES

Besides infrastructure problems created by population concentrations, significant other challenges need to be addressed within growing cities located in the Sahara desert. Being mostly nomadic by tradition, living conditions of populations concentrated in urban centers require significant social, cultural and behavioral adjustments. The necessity to maintain economic activities and employment figures at higher levels may be -in context-, a critical element to be taken in consideration in order to protect the region's security environment. In order to foster a stable environment with long term political stability, economic opportunities for the creation of jobs remains very important. It must be noted that providing artificial rents or incomes without any decent economic activity, as is the practice in some wealthy oil North African or Gulf States does not necessarily contribute to the security of the region in this particular context, as has been witnessed in recent years. Furthermore, and in today's interconnected world, local security issues can have global security ramifications. These constitute global security threats that have to be addressed.

1.2.1. Terrorism (safe heavens)

Current transnational security threats are hardly better characterized in the context of areas with very little governmental control or authority, and where subsistence can only be guaranteed through some form of illegal activity. The impingement of these activities on the notion of human dignity and self esteem along with the psychological frustrations they induce can be very easily exploited to shatter

one's own identity, in the radicalization of minds to enhance one's sense of belonging or becoming part of a global ideological struggle. This is particularly true when fundamentals or moral grounds of an activity (such as trafficking) may be questioned. Providing a sense of purpose is important to all human beings. Absent the legitimacy of a natural struggle for ensuring one's survival in difficult conditions -as witnessed in region's traditional settings- a lack of purpose will in such cases be particularly effective in providing fertile grounds for the radicalization of minds. It unfortunately must be mentioned that these are not exclusively confined to isolated or remote environments as those existing in the Saharan desert. The main problem there however, lies in the fact that these areas are much more difficult to access, making such threats very difficult to contain, or even assessed before effective solutions can be developed. This uncertainty, transforms such threats into very serious hazards that communities in the region have to live with.

1.2.2. Hostile natural environments

The Sahara Desert is the world's largest desert where subsistence from agricultural resources is very difficult to achieve. As these areas have been artificially divided for administrative purposes during the colonization period, the subsequent decolonization process has created many independent countries that currently dispose of very limited resources to rely upon. In fact, the possibility for these states to have an access to their own remotely located resources is what is most lacking today. Access to these resources is critical as incomes sources are needed to support and strengthen the capacities of governments of these countries to assert their own authorities within their vast territories.

1.2.3. Geographic remoteness

Handling security issues within larger geographical scales and throughout desert territories is quite a challenge. As has been witnessed during past colonization processes, low population densities and the remoteness of these areas have made it difficult for any colonizing power to effectively secure territories of these sizes. This remains a challenge even for the most advanced economy to effectively secure its own territory. A glimpse of this phenomenon can be seen in parts of the South and Western United States of America, where federal authorities need to intervene with limited levels of successes to support local States in helping with the control of their international border areas.

1.2.4. Weak central governance

In hindsight and as a result of historical, geographical and sometimes conjectural challenges, central authorities in the Saharan countries are either weak -enabling thereby the emergences of security threats- or rely on some form of traditional allegiances for delegating the central authority. The latter option can be either seen as an effective, legitimate form of governance or, in some cases, as a rather controversial tool that can be used to dilute any form of governmental responsibilities in case of a conflict where exactions are being committed (for instance). Hence, the idea of territorial governance is a very sensitive issue in conflictual contexts, where responsibilities need to be clearly drawn and assumed.

1.2.5. Frozen conflicts, lack of regional cooperation

The fact that most countries in the Sahel region have had artificial border delimitations established with fairly limited historical considerations -where rationales for drawing borders were justified by economics or administrative control considerations of the colonizing power- these often times do not even reflect the countries' own ethnic groups. This thereby weakens significantly the notion of belonging to a country and the sense of a country's own identity. As borders are by nature incompatible with the regions more traditional and nomadic ways of living, it must be recognized that conflicts between neighboring countries are often times the norm rather than the exception in this vast area.

1.2.6. Drug trafficking

In such context, government resources for insuring territorial oversight are fairly limited in the Sahel region. Hence more lucrative contraband and smuggling activities have recently superseded century old traditions of Trans-Saharan caravanning commerce. Indeed, the extension of Latin American drug-

trafficking smuggling routes, have recently enabled the establishment of solid bases in several Sub-Saharan countries. Taking advantage of weak governmental resources of some sub-Saharan countries, Latin American drug-smuggling cartels have almost taken control of entire countries. Provided nothing is being done to prevent this, it is expected that the level of lawlessness in this vast Sahara desert is likely to spread and threaten the stability of neighboring countries. The deployment of integrated sub-regional or even continental strategies to prevent this from happening is critical.

1.2.7. Illegal immigrations

Tackling the global consequences of climate change, environmental degradations and rampant desertification on largely agricultural based societies currently under high demographic pressure is a key social priority, as they do generate economic distress leading to mass migration. Being net exporters of immigrants, Morocco and Mauritania for instance are located on the main routes of migrant populations from Sub-Saharan Africa which constitutes a significant security threat to the stability of the region and their European neighbors. The North African continent is currently a “protection zone” for southern European borders [1] and migrant populations have already altered the workforce and demographics of entire economic sectors. The construction sector in Morocco or the fishing industry in Mauritania already employs significant numbers of sub-Saharan migrants. In the context of the wider illegal immigration trends that the region has been witnessing, it is unfortunate to come to the conclusion that human trafficking is likely to remain a lucrative market niche. Hence, if nothing is being done to alter the current situation, the prospects for peace and stability within the region may be affected. This in turn can have dangerous consequences on the broader, global security scheme.

2. Renewable energies and the development of a new energy economy:

2.1. RENEWABLE RESOURCES AND CONTEXT

Since this region is located on the edge of one of the largest electricity grids, namely that of the European Union, its large renewable energy potential could produce significant amounts of cheap renewable energies that could be gradually developed locally. These could ultimately end-up supplying larger, remote electricity markets.

2.1.1. The trade winds

The trade winds that blow along the Atlantic coast from Morocco to Senegal represent one of the largest and most productive wind energy potentials available on earth.



Figure 1: A vast renewable resource potential: global Trade Winds over North West Africa

2.1.2. Challenges of developing a green economy

Renewable energies have a strong social component and tend to generate local industrial activities through the creation of “green jobs”. Although this concept impinges on the economics of countries relying on their hydrocarbon extractive economies and their associated support sources, developing mechanisms to initially firm this energy locally is very important as they lie on the critical path of major alternative, sustainable energy developments.

Due to the geographical dimensions of the areas involved, only isolated distributed grid infrastructures are currently capable of supplying power to the cities of the Sahel region. These are very difficult to integrate in a renewable energy system, as their larger size tends to exceed smaller wind or photovoltaic distributed generation systems that are generally in the kW range. Solar photovoltaic cells are still very expensive, and because of the erratic nature of winds, wind energy cannot be integrated locally on any significant scale unless coordinated deployments of these technologies are initiated in the region. These will enable a gradual introduction of renewable energy technologies and their integration within the local economy, namely through the supplying of urban centers and mine processing industries. Provided an effect of scale can be achieved, these could pave the way to major renewable energy developments. Indeed, the saturation of the larger North African electricity grids to further wind developments –essentially due to grid stability problems- will quickly highlight a need to develop a more comprehensive and integrated approach involving electricity transfers towards larger integrated regional markets.

The example of Denmark, as one of the world’s wind energy leader is quite edifying in that regard. While relying on a highly interconnected grid, the country has not managed to cover more than 25% of its domestic electricity consumption through wind before encountering major grid stability problems. The country has frozen its domestic wind development activity for many years focusing its wind

turbine manufacturing business -one of Denmark's main industrial employers- towards the servicing of export markets. The export of expensive European made wind turbines to lucrative markets (such as in the USA) may not be meant to provide a solution to Africa's electricity access challenges. Although 25% of Denmark's domestic electricity consumption may be quite significant, the same proportion (if achievable...) in the Saharan or Sub-Saharan context will translate into very little quantities of wind turbines installed. Furthermore, the limited numbers of large wind turbines and their remoteness will make their maintenance extremely difficult to handle. With about 120 MW of total installed capacities, decentralized and distributed over territories that are twice the size of France, countries like Mauritania, Mali, Niger and Chad to name a few, will hardly make it possible for any imported wind energy technology from Europe to become commercially viable. Hence, developing alternative wind energy technologies to feed smaller electricity markets could be essential in addressing the region's decentralized energy access issues while enabling the development of a local, viable wind energy industry. This industry could in turn become an essential component for tackling most of the region's economic, social and security challenges.

2.2. ENERGY SUPPLY, ENERGY ACCESS: A DEVELOPMENT IMPERATIVE

With a 96% energy dependency from fossil fuel imports absorbing a great share of Morocco's export revenues, the impact of such dependency on budgetary spending is quite significant. Since close to 30% of National budgets are dedicated to education in the countries of the region, one can easily understand how critical the development of sustainable energy consumption schemes can be. While Mauritania enjoys a slightly improved situation regarding its energy dependency due to small gas deposits recently uncovered, its scarce population is distributed over a vast territory in which access to electricity is virtually impossible to grant through conventional grid infrastructures. Within such context, granting basic access to energy services such as electricity is essential to develop local, sustainable economic activities capable of preventing illegal immigration and fixing migrant populations.

2.3. WIND POWER: A SOCIAL ENERGY ECONOMY

In the Sahara desert, to supply power in isolated urban environments, local diesel units or thermal power plants are used to provide basic electricity services (if the demand is large enough). This solution is costly as the maintenance needed for supporting these units along with fuel and spare part logistics is a challenging issue. In these areas, distances between cities that represent marginal electricity markets in terms of sizes can stretch over thousand kilometers. Developing alternative wind energy solutions to feed smaller electricity markets is essential for tackling the region's decentralized energy access issues. Unless mechanisms are developed for integrating renewable energy technologies such as wind power, that is relatively easy to manufacture for small capacities and inexpensive to generate, no basic electricity service can be secured on a sustainable basis.

Initially encouraged to provide employment in the relatively poor North Sea regions of Germany, the wind energy industry has emerged in the last 10 years, as a major business providing competitive prices of electricity even when operated under marginal European wind conditions. As the trade winds that blow along the Atlantic coast from Morocco to Senegal represent one of the largest and most productive wind potentials available on earth, this may open a realm of possibilities for a sustainable development of the region. As these countries face similar social pressure from domestic and sub-Saharan migrant populations fleeing deteriorating environmental conditions, fostering collaboration on integrating clean and more sustainable energy technologies for tackling energy access could be achieved on a regional base. As mentioned previously, the import of expensive European made wind turbines may not provide a solution to Africa's electricity access challenges. However, since this region is located on the edge of one of the largest electricity grids, local capacity buildup could enable its large renewable energy potential to produce significant amounts of cheap wind energy that could ultimately end up supplying larger electricity markets as well. This however, will require an effect of scale. Developing initial mechanisms to progressively firm these intermittent energy sources locally is

an imperative first step as it lies on the critical path of major alternative, sustainable energy developments.

2.4. SECURITY AND ACCESS TO BASIC SERVICES WATER, ELECTRICITY, COMMUNICATIONS

Although providing access to energy and basic services in a secure environment remains the fundamental responsibility of state authorities and governments in these regions, least cost solutions and adequate support systems have to be provided for local populations distributed over very large areas. Conducting applied research on renewable energy technologies within Morocco and Mauritania's research institutions together with local industries is critical as this will foster collaboration for regional synergies to be developed among these developing countries that face common security threats in their loosely controlled remote areas. Indeed, areas of great economic importance are currently lost due to security considerations, particularly in the Sahel region where states rarely dispose of the material means to secure their vast territories. It is therefore important that scientific communities integrate the security costs that this lack of alternatives represents to their own countries.

2.5. SAHARA WIND'S BOTTOM-UP RENEWABLE ENERGY DEPLOYMENT STRATEGY

The first applications to be considered are energy access solutions and applications relevant to communication infrastructures and permanent power supply systems in remote sites. Mobile phone networks and basic security infrastructures do rely on permanent power systems that have to be deployed within broad areas. The development of these infrastructure services and systems contribute to the prevention of security related problems which ultimately falls within the responsibility of central states and governments. In the Sahara desert, Mauritania is twice the size of a country like France as are Mali, Niger, Chad and other Saharan countries further to the east. This makes any logistics to service infrastructures for access to electricity, water or communication very challenging to secure due to logistics. Utilizing wind or any other intermittent renewable energy source for distributed electricity supply solutions, while looking into energy integrated applications, such as producing hydrogen, oxygen, chlorine for water treatment, caustic and various other chemicals that could be relevant in local mine processing operations is important. Using hydrogen as alternative fuels could also be explored as well, knowing that these technologies will require adequate training and a local capacity build-up in the field of scientific education. This is a fundamental step for the creation of skilled job aimed at harnessing renewable energies and their associated technologies. High tech storage of renewables in the form of hydrogen that can power everything from electronics to life support systems or even vehicles, open perspectives for integrated mine processing applications. Mobilizing academia in fulfilling these objectives may be appropriate, since complex hydrogen related technologies are likely to have greater importance in the future. These will encourage researchers of the region to identify local synergies and specific applications where these technologies may be relevant.

Providing access in exposing researchers, Engineers and PhD students to these technologies may open a realm of opportunities for them, as well as for their countries. Besides preventing any technological gaps to widen in time, fields of specialization and excellence can be developed regionally, provided a targeted support and appropriate focus can be put on such installations. As these technologies involve increased levels of intellectual properties with their associated intellectual property rights, this could also provide an ideal setting enabling the building local scientific capabilities to support industrial applications.

The need for instance to develop decentralized energy storage mechanisms is fundamental when dealing with intermittent renewable energies. If basic electricity service cannot be secured, local economies cannot thrive. Exactly this lack of local economic future leads to employment and population instability which represents a common security concern to both NATO and the countries of the region.

Building regional scientific capacities, and developing a common vision that can generate economic growth in integrating an environmentally friendly and sustainable energy industry (wind energy has 25% growth rates worldwide focused in Europe, the USA and China in the last 20 years) could in the long term, become an alternative in fixing migrant population, and contribute to their social integration.

Hence, involving local scientific communities, industries and end user groups to participate into our regional applied research program aimed at developing exploitable energy systems to integrate widely available renewable energies is essential in addressing this problematic. Coordinated by Sahara Wind inc., the NATO Science for Peace SFP-982620 project deployed for that matter applied research platforms within Morocco and Mauritania's main research/educational centers around a far ranging, comprehensive strategy aimed at integrating intermittent sources of renewable energies in the weak grid infrastructure of the Saharan/Sahel region.

The hydrogen economy and its perspectives, will amongst others, enable North Africa's scientific communities to take a comprehensive look at energy systems to adopt a more holistic, integrated approach to energy technologies which are linked to development issues. These have been thus far driven mostly by external market forces that have provided rather unsuited ready-made solutions with little local integration. Experiences in North Africa have shown indeed that efforts aimed at introducing (new) wind energy technologies in these countries amounted ultimately to the simple import of turn-key equipments through concessionary sources of financing and export credit packages. These policies have done very little in terms of local impact for a technology that could have been promising in terms of economic returns, in addressing energy access, energy security, and the creation of an accessible integrated industrial activity.

3. The EU neighborhood policy and the Mediterranean Solar Plan

3.1. THE MEDITERRANEAN SOLAR PLAN

In the field of renewable energies, the European Union neighborhood policy has been strongly influenced by the Mediterranean Solar Plan. This plan represents one of six projects of the Union For the Mediterranean (UPM – Union Pour la Méditerranée). The UPM, launched with 43 Member States, by the President of the French Republic under the French Presidency of the European Union on July 13th, 2008, aims at implementing common projects with the countries of the two shores of the Mediterranean. To this end, the UPM seeks to foster a new cooperation and development policy in the whole region of the Mediterranean basin. Its presidency was at first held jointly by the President of the Arab Republic of Egypt, Mohammed Hosni Mubarak, and the President of the French Republic, Nicolas Sarkozy. The Mediterranean Solar Plan (PSM – Plan Solaire Méditerranéen) is the flagship project of the UPM. Its goals are the development of new energy production capacities using renewable energy, in particular solar technologies, on the southern side of the Mediterranean, in order to satisfy demand at local level and to export part of the production towards Europe, as well as the implementation of major progress in reducing energy demand and increasing energy efficiency in the whole region. The concrete target is the construction, by 2020, of 20 GW of new electricity production capacities using low carbon technologies.

3.2. THE SAHARA WIND PROJECT

Under the preparation phase of the Mediterranean Solar Plan -whose protagonists the Sahara Wind Project helped inspire- in order to support this political initiative Sahara Wind inc. submitted a pilot project under this specific framework. The deployment of such pilot scale project is aimed at enabling the testing, configuration and adaptation of wind turbine technologies which could subsequently be manufactured locally and gradually deployed in the region as part of a larger project. In a first stage, taking into account the current Moroccan regulation, the Sahara Wind Energy Development Project's installed power capacity will be limited to 50 MW. Then, in subsequent clusters, the wind farm

capacities will be progressively developed and extended in order to tap the whole 100 km² of land which has been reserved for the project in the region, for a capacity of 500 MW.

3.2.1. UNDP-GEF: Sahara Wind Phase I/Tarfaya (400-500 MW)

The initial building phase of the large-scale Sahara Wind Project “PIMS#3292 Morocco: Sahara Wind Phase I/Tarfaya (400-500 MW) on –Grid Wind Electricity in a Liberalized Market”, presented to the United Nations Development Program (UNDP) and the World Bank’s Global Environment Facility (GEF), with the support of several other multilateral institutions would thereby be achieved under enhanced field conditions. This multilateral backed framework would thereby allow for a quick development of additional capacities while guaranteeing effective, transparent regulations for the project’s long term implementation. This in turn will pave the way to the phased deployment of the High Voltage Direct Current transmission line infrastructure that will link the region’s vast wind resource to major regional electric markets and load centers. At the final stage of the project, 5000 MW will be installed in the region of Tarfaya (500 MW for the first 100 km² land). An interconnected 33/90/225 kV wind farm network will be developed; HVDC system will be used for long distance transmission lines whose technical terms of references -for assessing optimal transfer capacities- have already been established with ONE, the Moroccan State owned electric utility company operating the local grid infrastructure. These on-going developments will be further developed and expanded upon insuring the sustained wind energy developments in the region.

3.2.2. NATO Science for Peace Sfp-982620: Sahara Trade Winds to Hydrogen

Since efficient power transfers over long distances are currently only available for large-scale integrated projects worldwide, the hydrogen production component added in the initial building phase of the Sahara Wind Project is likely to provide an alternative that could enhance the prospects and phasing of this large-scale project. As its original concept developer, Sahara Wind Inc. highlighted hydrogen production processes as an integrated complementary component of the Sahara Wind Project that enhances local industrial synergies, prospective uses, perspectives and overall energy efficiencies of large scale renewable energy systems located in remote areas and operating in weaker grid infrastructures. These objectives along with the wind resource assessments of the region are currently being funded by the North Atlantic Treaty Organization under its Science for Peace and security program (under NATO Sfp-982620), and the United Nation’s Industrial Development Organization under UNIDO assignment post TF/INT/03/002/11-68.

4. Energy options available in the region

4.1. GROWING ENERGY NEEDS

Among European Union countries, both Spain and Portugal have in recent years boasted the highest electrical consumption growth rates. Taking these in consideration together with growth rates of North African countries, where yearly growth rates of up to 8% have been reached, as in Morocco [2], the need for deploying rapidly additional electric generation capacities becomes quite obvious. Among the options that are sought, and because of their lower costs to the kW/hr generated, large coal fired power plants represent the main alternatives that are currently envisioned. Although no coal deposits are available in the region, coal fired power plants relying on imported coal purchased on the international market, remains one of the most competitive alternative. Within this context, and while North African countries are not bound by Emission limitations under the current Kyoto agreement, it is important to mention that Spain and Portugal have witnessed the highest growth rates within the EU’s country greenhouse gas emissions since 1990. Reducing the carbon footprint on the Iberian Peninsula is a particularly important issue as these countries will be among the few ones that will need to benefit from of the EU-wide carbon trading/compensation mechanisms.

4.2. NATURAL GAS NETWORKS

While the GME natural gas pipeline supplies most of Spain and Portugal from the Algerian gas fields, Algeria represents the main natural gas supplier of the Iberian peninsula via its pipeline networks. This has raised some concerns over energy dependencies. It is interesting to note to this extent, that the Iberian Peninsula disposes, of as many Liquefied Natural Gas (LNG) terminals then are currently available in the rest of the EU [3].

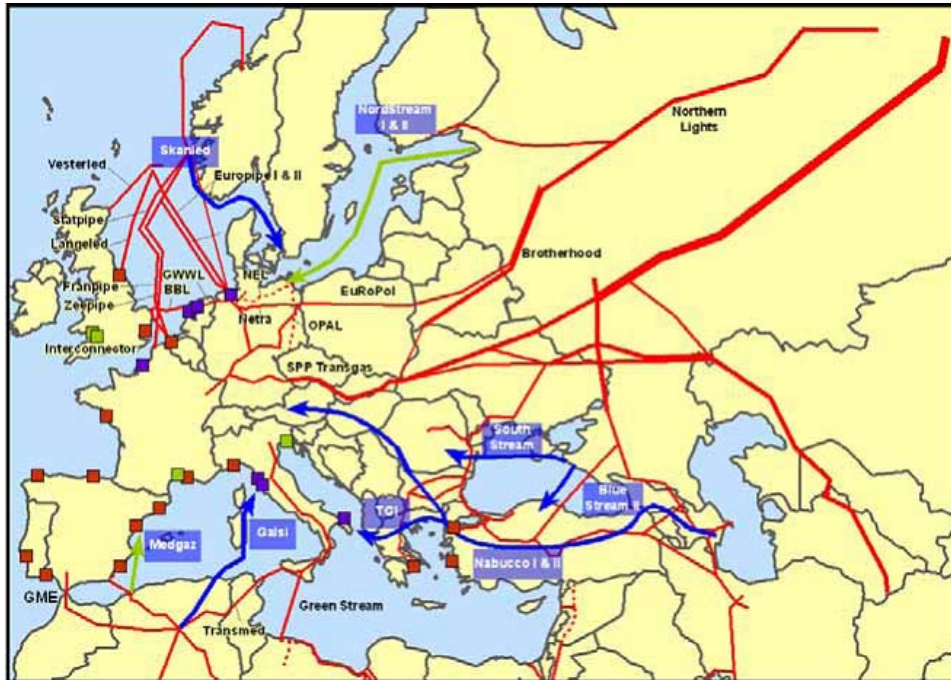


Figure 2: European Gas Networks with LNG Terminals (source: EU-DG TREN)

As the main characteristics of electricity generation from natural gas remains its high fuel costs, and considering the operational flexibility of gas fired turbines, this makes its use quite relevant in supplying peak power loads. It is important to note that Spain and Portugal have made significant investments in the wind energy sector, which provides a growing share of the region's demand. Some studies have for that matter illustrated that the purchase price premium provided to wind generated electricity, was lower than the actual cost of gas imports that would have been needed to generate the same amount of electricity produced. Hence, one could conclude that the combination between gas turbines and wind generated electricity appears to be quite a complementary electricity mix, as the burning of natural gas resources can be matched as fuel savings from wind energy. The limit of such energy savings must be made however within the realm of the electric grid and the system's stability. This is particularly relevant, when the operational advantages and thereby complementarities of both systems are taken in consideration. As some wind electricity curtailment has already taken place in some areas of Spain because of grid stability concerns, the possibilities for expanding the grid to enhance the dispatching of wind generated electricity beyond the Iberian Peninsula must be seriously considered. Hence, the prospects of integrating the Iberian Peninsula's electric generating capacities into regional electricity markets via enhanced interconnections to both North African and France will enable the perspectives of increased renewable energy utilization to become quite compelling. Besides environmental considerations met through this option and the long term saving of fossil fuels, the energy security of all interconnected countries will, in that case, be significantly enhanced.

4.3. NUCLEAR ENERGY OPTION

In Spain, an incident has occurred in the final construction stages of a nuclear power plant located close to the Ria de Gernika estuary, in the Basque region. As a result of a terrorist action (bomb attack), the concrete reactor dome of the plant shown in the picture had been partly damaged. This

incident has effectively halted the construction of the plant, bringing the Spanish nuclear energy program effectively to a standstill.



Picture 1: Abandoned Nuclear Plant in Spain's Basque country (Photo: Sahara Wind Inc.)

It may be relevant to note that this event occurred in the mid 1980's when oil prices hit record lows. However, the more recent peaking of oil prices have not had any impact on the position of the Spanish government which remains opposed to the implementation of a nuclear energy program, preferring instead to support the development of a green energy industry.

4.4. THE RENEWABLE ENERGY OPTION: A GREEN ECONOMY

The green economy is often referred to by the current government as a promising example for the future. Spain, along with its neighbor Portugal is very active on the manufacturing and the deployment of renewable energy technologies domestically and abroad. The social dimension of the renewable energy industry may in fact represent one of the key drivers playing against nuclear energy. Indeed, and as the sector has grown, the employment levels from renewable energy industries gained in significance, hence popular support. Most importantly, their geographic distributions are spread in areas where economic activities are most needed. Desolated country sides are indeed one of the main areas benefiting from new wind turbine installations, and local wind manufacturing/assembly plants. These tend to generate local jobs, and most importantly tax revenues that remain within the region where the systems have been installed. As jobs created by the nuclear industry are generally concentrated in larger industrial centers or abroad where nuclear power plants parts are designed and built, renewable energies provide local employments and tax revenues that are geographically much better distributed. Once installed and operational, a nuclear power plant requires fairly limited human attendance, in comparison to the power it generates. This, off-course translates into very little employment positions at the plant level. As a comparison, in Germany the Nuclear Industry, which provides over 20% of the country's electricity supply, employs some 30,000 person. The German renewable energy sector, has, only in the year 2008, created 30,000 new jobs. It is important to mention that in the German context renewable energies account for less than 10% of the overall

electricity supply whereas 280,000 people are currently employed in the renewable energy sector, according to the German Ministry of Economy [4]. The figures in Spain are likely to boast similar ratios if not better and one can easily understand why the new Obama administration in the US has singled out renewable energies and related technologies in its stimulus package by providing it with 78 Billion US dollars of funding, with the objective to generate thousands of “new green jobs”. It is important to mention that the Chinese government is putting the finishing touches to a 440 Billion US dollars incentive package designed to boost amongst others the use of solar and wind power in the country [5]. Hence, the social dimension and growth of the renewables sector will definitely play a key role in the energy options of countries that have initiated industrial programs toward the building of their renewable energy economies.

4.5. ENERGY CHOICES FOR NORTH AFRICA

In the case of North Africa, the Nuclear Energy option will provide very little added value in terms of industrial and economic impact as the high costs of a nuclear power plant is likely to be spent on a turnkey plant imported from abroad. The fact that these plants are hardly duplicable, due to the exiguity of the local electricity markets (smaller grids) will make any industrial integration hardly justifiable whereas stringent and mandatory procedural safety costs for running a single plant cannot be distributed over to other plants. It is also important to mention that the base load generated nuclear power will not match very well with intermittent sources of renewable energies either, where more flexible systems relying on expensive fossils fuels will be burned. Funding for such type of plants is not likely to be easily available due to high upfront investments and the type of guarantees required from local operators. Although this may less likely to be an issue for countries like Algeria which disposes of large foreign currency reserves derived from its gas revenues, Morocco may find some difficulties in financing such a program. Seen the high upfront capital costs and the delays associated to the implementation of a nuclear energy program before nuclear power plants can effectively be built and put on-line, alternative options may have a stronger influence on such long-term decisions. The renewable energy options pursued by the region’s northern European neighbors, who dispose of larger electricity markets, will make a nuclear option very difficult to justify in North Africa. The ease for instance, with which a renewable energy industry can be built or transferred in countries of North Africa on the basis of what has been achieved in Spain some 13 years ago, when the country did not dispose of any wind energy industry for instance, is likely to favor this alternative. This will be furthermore justified as local renewable energy resources such as wind and solar energies are capable of providing much higher productivities on the North African continent (www.saharawind.com) then on the Iberian Peninsula. The potential of these resources are vastly higher, as the main limitations relative to their access will remain a weak grid infrastructure network. The lower local electricity demands, and the distance that separates the vast Saharan Trade Wind resources to North Africa’s load centers constitutes a major challenge which will require a larger consolidated market. The access to these renewable energy potentials will in fact require the use of different technologies currently available for much higher energy transfer capabilities that the size of North African load centers simply cannot absorb.

High Voltage Direct Current (HVDC) transmission lines for instance, can allow vast amounts of electricity (in the GW range) to be transported over long distances at minimal losses. If we were to connect the North African renewable energy resources into a Euro-Mediterranean electricity market as envisioned through the 5000 MW Sahara Wind Project, then a non-negligible share of Europe’s wind energy production would be complemented by these large productive sites, making wind energy more affordable.

5. Conclusion

Comparative advantages rather than a mere displacement of European wind energy productions could be achieved, as the High Voltage Direct Current (HVDC) transmission technologies used would contribute to stabilize surrounding grids on both ends, enabling them to integrate more wind energy. The advantages of integrating wind resources on a continental basis become even more obvious, as the

seasonal distribution of winds in terms of peak power production are quite complementary. While winter highs are characteristics of European wind energy generations, the Saharan Trade Winds have their peak production in the summer season. This is particularly relevant as in Southern Europe; tourism driven economies and the increased use of air conditioning, induce higher electricity consumptions at this time a year, which would, in such cases, be matched by a carbon-free renewable source of wind energy made available at competitive costs.

These perspectives, highlighted by the 5000 MW Sahara Wind Project, which was presented at the European Parliament in 2002, will contribute to improve economic prospects of marginal desert regions that currently dispose of very limited endogenous development possibilities. In the light of the energy, security and environmental challenges that both Europe and North Africa are confronted to, and as a market based energy alternative, the Sahara Wind Project provides significant advantages likely to contribute to a more secure environment and an increased stability for the entire region.

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