From renewable to marine energies sources for sustainable development and energy transition in Morocco: current status and scenario

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Abstract:

The current energy policy recommends the idea of energy efficiency over fossil energy as a primary matter for the coming years. The kingdom of Morocco requires restructuring of its power equipment by increasing the percentage of renewable energy supplies, optimizing their systems and power storage. Therefore, increasing energy efficiency is an as important obligation as reducing the overall energy consumption. The purpose of this research is to present the energy transition in Morocco towards renewable energies and to assess the diversity of available marine natural resources. Recent research in conversion of ocean thermal energy, wave energy, tidal energy, offshore wind energy, and osmotic energy into power supply has started to encourage different technologies. This research has led to commercial deployment in some cases such as our 550 km long Mediterranean coast and 3000 km long Atlantic. This does not only result in fossil energies independency but also provides advantages like less cost and no pollution.

Keywords: Energy transition, Sustainable development, Efficiency energy, Renewable energy, Marine natural resources.

1. Introduction

The problem of energy also arises as a fundamental question that must be addressed in the framework of a forward-looking vision of the countries in the process of development as Morocco because of major challenges and promising that represent the energy for it [1-2]. In fact, the world is experiencing, today, a global systemic crisis triggered by the profound imbalance between the financial sphere and the real economy [3], in addition to the rapid developments that have marked recently the energy markets, in this case the volatility and the erratic fluctuations in prices. These are all factors which clearly show the need to profoundly change the current patterns of energy production and consumption [4] to make them viable and useful to bring well-being and prosperity to the whole of humanity. The challenge that arises as a matter of urgency to our world today is not so much lack of energy resources than to mobilize the necessary investments in the matter. It is, therefore, necessary to build the necessary energy infrastructure and to develop alternative technologies [5]. Starting from long-term vision, where are integrated trends and the mutations of the world energy situation which is outline in the next decades, it is necessary to put the security of supply, the

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availability of energy as well as the preservation of the environment in the head of future concern [6].

It would therefore be necessary to follow a policy combining, on the one hand, the rational management of energy products and, additionally, the choice of an efficient strategy to reduce the consumption of energy, without prejudice to the productivity. It is also necessary to ensure, in the framework of this approach, to the protection and the diversification of energy sources. Morocco has no other choice than to strengthen locally its capacity for the production of energy and to open the way for promising investments in energy supply. It must also resolutely pursue efforts to make alternative and renewable energies of the national energy policy [7-8].

That is why Morocco must prepare and adapt continuously to different changes to come to be able to ensure its economic and social development in responding on a sustainable basis to its growing energy needs, figure 1 [9]. Hence it is important the need to diversify the sources of energy and to focusing on the renewable resources. This should be done in the framework of the adoption of energy efficiency which is today with the renewable energy a new revolution in the energy field by new technologies and new societal behaviors that they imply [10-11].

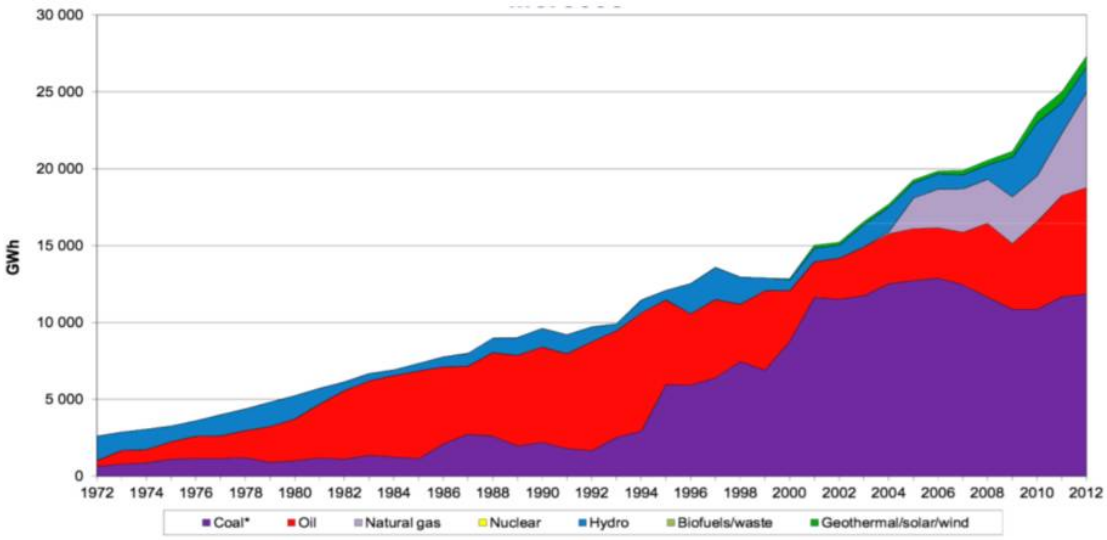

Figure 1: Increase of primary energy supply in Morocco from 1972 to 2012 (IEA, 2015a)

In this paper, we show that Morocco is following an ambitious energy transition, which aimed to provide the cost effective of the country with a sustainable development, secure and competitive energy sector. The country possesses the immense stores of energy in the ocean, able to cover a significant energy demand.

2. Geographic location of Morocco

Morocco is located in the Maghreb region of North Africa and geographic position has very advantageous as it is in the middle of two worlds: Europe and Africa, Figure 2, is situated at the northwest corner of Africa, rimming the North Atlantic Ocean and the Mediterranean Sea. Have a population of over 33,8 million and an area of 720,000 km^2. Morocco is committed to

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fully play its role at the regional level. It, thus, intends to integrate into the Mediterranean Solar Plan and submit an offer combining the availability of renewable resources, and accessibility to industrial parks and dedicated to the poles of skills [12].

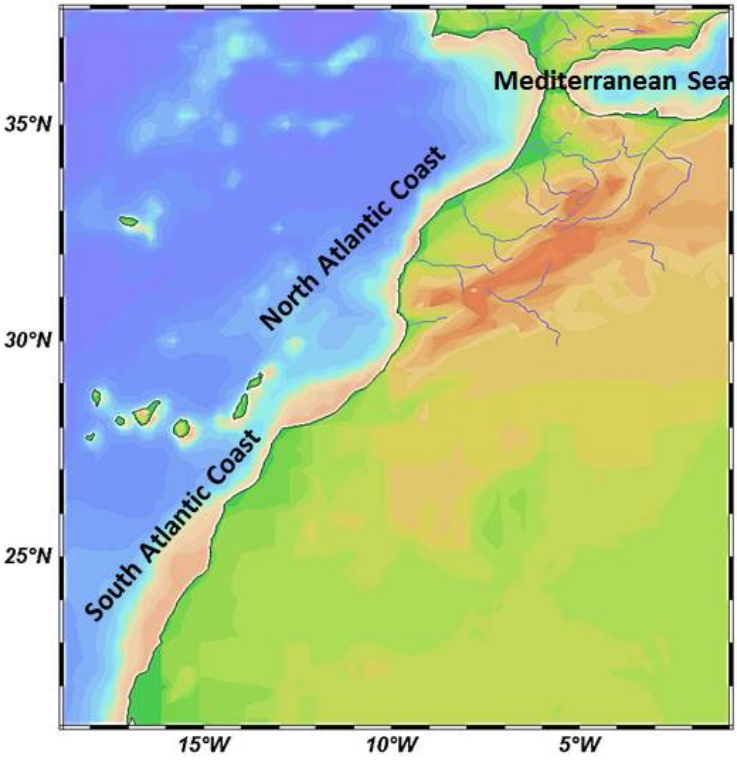

Figure 2: Geographic Location of Morocco

Its strategic position is very important to consolidate the regional role key which is the responsibility of Morocco in the energy field by giving this sector the necessary means to enable it meet the challenges it is facing so as to facilitate its integration in the Euro-Mediterranean energy market to grow a fundamental actor in the framework of Euro-Mediterranean energy cooperation including through the strengthening of electrical interconnections with neighboring countries and the establishment of major infrastructures necessary for the achievement of regional integration, with, in the first chief, "the loop Mediterranean electric" [13]. The advanced status which now Morocco enjoys with the European Union offers new prospects for cooperation in this sector [14].

The Sahara represents 36,57% of the total surface of Morocco. In these regions the solar potential is important and the density of the population is medium .The use of conventional energy sources requires high costs. The rate of rural electrification rose steadily to 97, 4% by the end of 2011 [15]. The tariff of consumption of the electricity varies between 0.9010 MAD/kWh for up to 100 kWh, and 1,542 MAD /kWh for up to 500 kWh .In the rural areas, diesel generators are used in most cases for power generation, although these devices have unwanted environmental effects [16].

Morocco has a Mediterranean climate that is generally hot and dry for most of the year. Geographical location has several advantages for development renewable energies (solar, wind, hydro...). , particularly that it has climatic conditions widely favorable [17].

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I. Renewable energies potentials

The development of renewable energies is a major component of Morocco's new energy strategy aimed at securing supply, ensuring availability and reducing the nation's energy dependence [18]. Morocco has significant potential for renewable energy [19], the exploitation of which will cover a substantial part of growing energy needs and provide the preservation of the environment by replacing fossil fuels with a wide range of their uses [20]. The contribution of renewable energies to the energy mix will be gradual according to the maturity of the technologies and the competitiveness of their cost of production [21].
In terms of its existing installed base, the kingdom is previously a regional leader, with 32% of its established capacity obtained by renewables energy, mostly hydropower [22].
Promoting renewable energy is a principal priority to gain energy security, sustainable development and job creation by investing in renewable energy.

1) Solar energy

Solar energy is one of the main sources of renewable energy in Morocco because it has a large and considerable deposit with more than 3000 h / year of sunshine, an irradiation of 5 kWh / m2 / day [23-24]. The installed capacity of the solar power stations was zero, until the opening of the first integrated solar complex of Ouarzazate "NOOR" with a total power of 500 MW is realized in 2 stages: the first of 160 MW in 2015 and the second Of 340 MW, for a global commissioning in 2017, it will house a total capacity of 580 MW by 2018 within the framework of the Moroccan integrated program of solar energy - 2000 MW [25]. With an area of 3000 hectares, see in Figure 3. This should result in a reduction of 240000 tons of equivalent CO2 emissions per year. This first phase will use solar thermal technology (CSP) with Cylindro-Parabolic sensors on a surface of approximately 450 hectares with a thermal storage capacity expected of 3 hours at full power [26].
Based on this experience, ONEE has launched a plan for the development of solar power plants Medium-sized photovoltaic (20 to 30 MW) at the end of the line, which aims to solar array in different regions of the Kingdom while enhancing security In these localities located far from the points of production of electricity [27].

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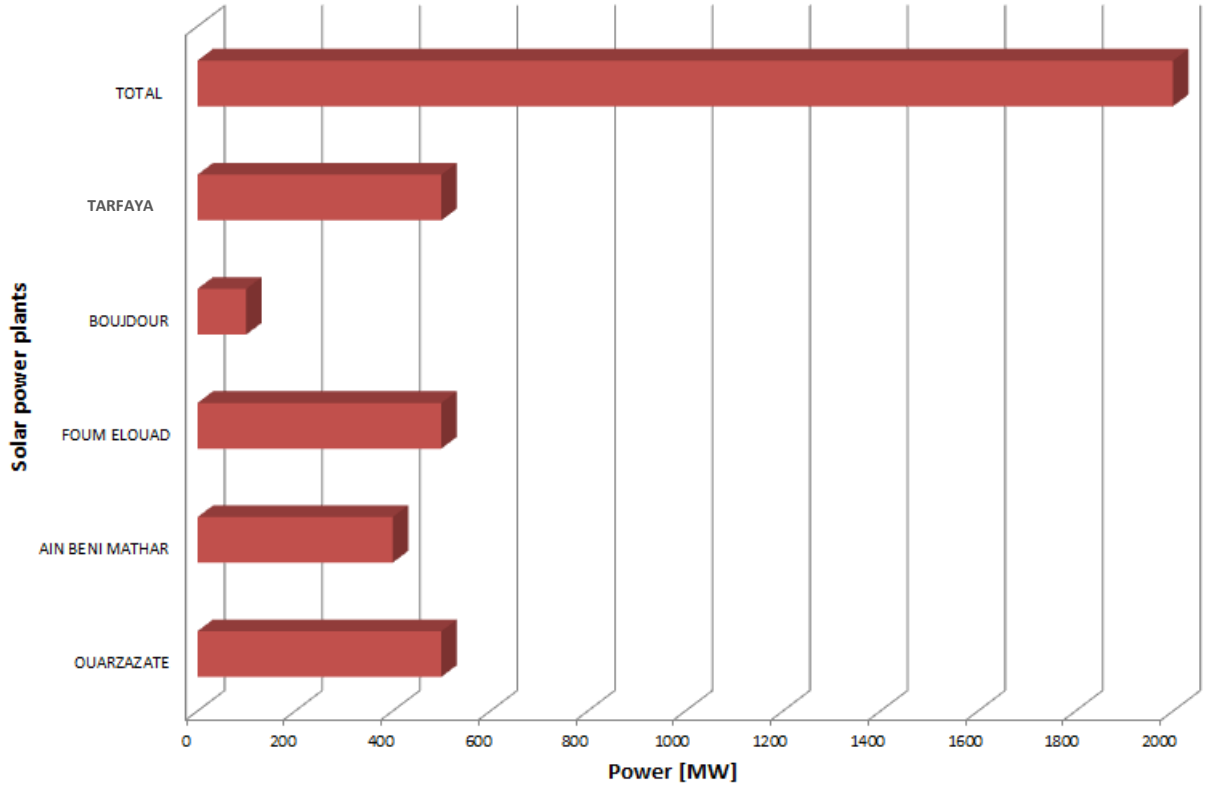

Figure 3: Various projects under the program of solar energy in 2020

2) Wind energy

In wind power, Morocco has a very significant potential, particularly of its ribs with wind speeds greater than 6,5 m/s and up to 10 m/s [28]. The technical potential certainly exceeds 10,000 MW of installed capacity [29]. However, this potential is principally defined by the capacity to combine into the electricity grid in the future, ie by 2020.

Within the framework of the objective set by Morocco to increase its installed capacity based on renewable energy to 42% by 2020 and in addition to the wind capacity of 1000 MW currently in operation or in progress [30], The Moroccan Integrated Wind Energy Program with a capacity of 1000 MW was launched in June 2010 in Tangier, Figure 4. This program involves the production of green electricity, through the realization of several wind farms totaling a power of 1000 MW, in order to reach the installed capacity of 2000 MW [31].

The Integrated Wind Energy Program (IEP) will be carried out under Public-Private Partnerships, where ONEE will partner with one or more strategic partners in the wind and power industry. In addition to the associated benefits in terms of strengthening the production base, reducing energy dependence and preserving the environment, the program also includes components related to industrial integration, training and research and development. The "Integrated Wind Project "consisting of 6 wind farms, to be commissioned between 2017 and 2020 [31].

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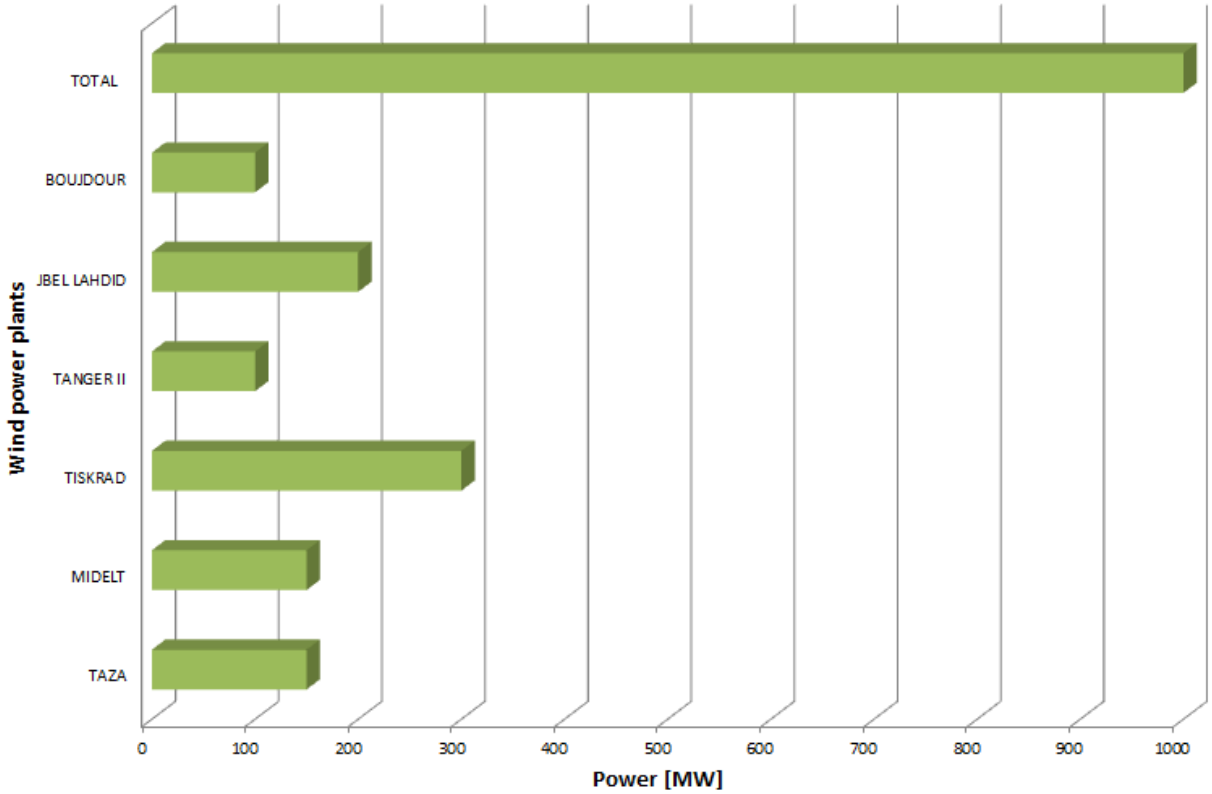

Figure 4: Various projects under the program of wind energy in (2017-2020)

3) Hydroelectricity potential

Morocco has 128 dams and is building 12 large dams. The current storage capacity is 17 billion m^3. By 2030, there are plans to build 50 new dams. Securing water resources remains a priority for Morocco. The primary purpose of dams is to irrigate more than one million hectares and meet all drinking water requirements [32]. The number of dams used for electricity production is only a small part of the national water supply. Hydroelectric power stations in Morocco have a total installed capacity of 1770 MW [33]. The largest hydraulic developments in the Kingdom are those installed in Al Wahda Dam and Allal Alfassi Dam with an installed capacity of 240 MW each.

ONEE is considering the construction of a Pumping Energy Transfer Station (STEP) of 350 MW at the Abdelmoumen site in the region of Agadir, Hydraulic capacity installed at 2120 MW in 2020, thus achieving the 2000 MW target. It is scheduled to be commissioned in 2019, on the other hand, the construction of a 300 MW STEP at El Menzel on the Upper Sebou. In addition to these structures, Morocco has an important potential in micro-hydraulic plants, Figure 5, mostly located in the Oum-Errabia, Sebou and Moulouya basins, with powers varying between 100 kW and 1500 kW. The completion of an inventory study revealed 125 sites with a total capacity of 300 MW, 70% of which are located in the Oum-Errabia basin [34].

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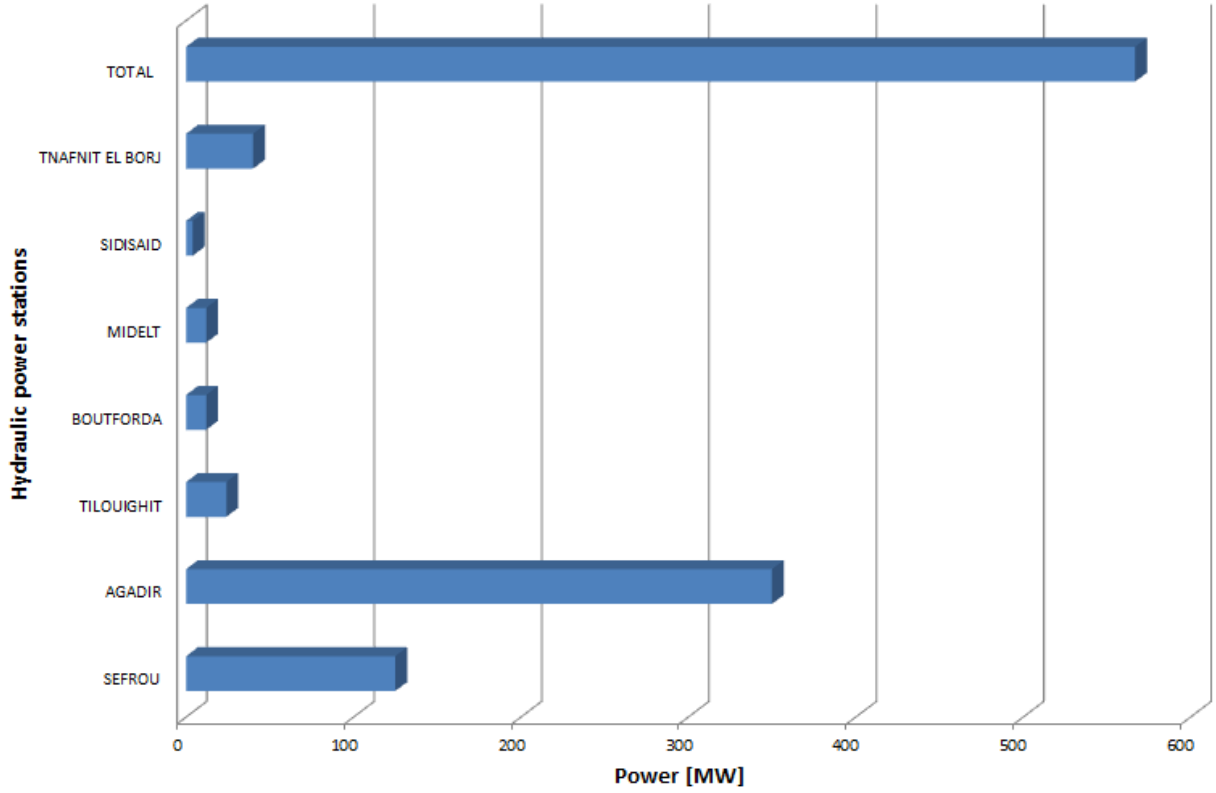

Figure 5: Various projects of hydraulic power station

3. Renewable marine energies potential

The marine energy industry presents important economic challenges for the littoral zones of the Kingdom. It constitutes an inexhaustible source of energy to guarantee the sustainable development of the country and to release the vice of the oil bill. As it can embody a project of mobilization of human aspirations in the southern provinces and a means for the Kingdom to extend its geographical presence by conquering a new territory, that of its seas.

The renewable marine energies has the advantage of providing a flexible production which can be used in the advanced, to know when the demand is highest on the national network of electrical distribution, a good track therefore for the organizations of energy production [35]. In effect, the marine plants benefit from permanent flows throughout the year. The environmental consequences of marine renewable energies are objectively limited compared to the impacts of other modes of energy production [36]. While Morocco has assets to succeed in these fields where the divine blessing and geography have offered it a limitless natural resource, it is totally absent on the industrial and scientific level. On the other hand Morocco controls vast oceanographic areas with its 3500 km of marine coast over which it has sovereign rights up to 200 nautical miles defining the Exclusive Economic Zone (EEZ) [37], the marine energy industry is non-existent. At the same time, its traditional partners are already mastering the energies of the seas on a large scale thanks to their investments in R&D and their support of industrial sectors. World leaders in marine energies include the United Kingdom, which hosts the world's largest hydroelectric power reserve in the Pentland estuary,

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and has 3300 MW of offshore wind, followed by Canada, an exceptional natural potential of 35,7 GW in marine energies (excluding offshore wind). New entrants have invested in this sector and have strong ambitions to develop their production capacities, such as the United States, China, Denmark, Spain, Portugal and France [38].

Morocco is among the countries with the longest river system in North Africa [39]. The main rivers that flowing the south or west into the Atlantic Ocean are the Rebia (555 kilometers / 344 miles long), Sebou (Sebu; 500 kilometers / 310 miles long), Bouregreg (250 kilometers / 155 miles long), Tensift (270 kilometers /167 miles long), and Drâa (1,200 kilometers / 744 miles long). The Drâa is Morocco's longest river, but it is seasonal see in Figure 6 [40-41].

Figure 6: Map of Morocco with its main rivers

3.1 Potential of Wave energy

Today, wave energy has become one of the most promising renewable technologies for two main criteria: its vast energy resource, in addition to its reliability in relation to most renewable energy resources. Indeed, the availability of wave power at a given site is estimated up to 90% of the time, while solar and wind availability is generally estimated to be between 20% and 30%. There are figured more than 1000 different proposals for the patented wave energy devices [42], and many have demonstrated the potential of commercially viable electricity production. [43]

In Morocco, the greatest potential for wave energy is located where there are the strongest winds, Figure 7. Until now, and despite its great potential for wind and solar energy, only 10% of Morocco's energy production comes from renewable sources, mainly hydro and wind. The results obtained by Sierra et al. [44] from the average power of the waves is important (up to 30 kW/m with an annual energy Average waves up to 262 MWh/m) in Atlantic coast.

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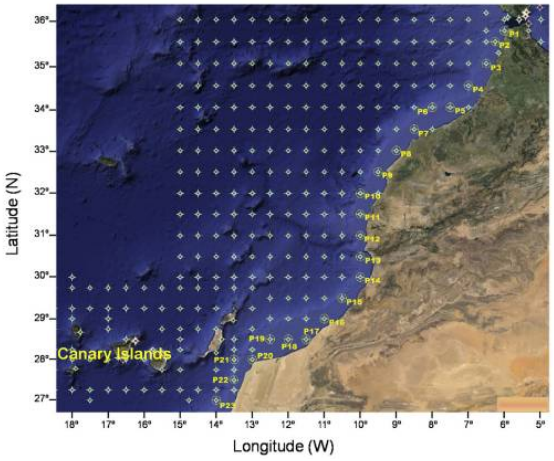
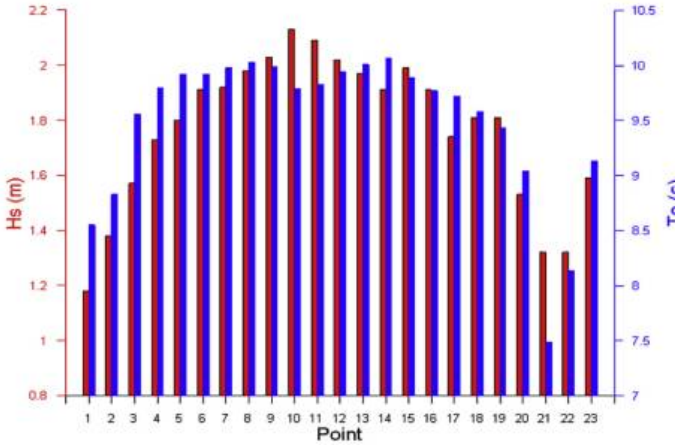
In some studies, wave energy resources have been assessed throughout the Mediterranean. Thus, Liberti et al. [45] deduced that the energy potential on the Mediterranean coast of Morocco is estimated between 2 kW/m and 6 kW/m, while Arena et al. [46] considered an average power of the waves which can reach 6,3 kW/m at a point in the Moroccan Mediterranean. Concerning the islands in the proximity of Morocco in the Atlantic Ocean, such as the islands: Madeira , the Canaries, or the Azores, or all these more Iceland [47], a number studies have evaluated the corrugated resource [48]. Other research has been concentrated on the North-East Atlantic, essentially in Europe as United Kingdom, France, Portugal and Spain [49-50].

These studies have demonstrated a notable wave energy potential in these areas. Moreover, due to the currency of winds from west to east, it was considered that the annual theoretical wave power is greater on the western coasts of continents including Morocco [44]. Given the results obtained in these areas, wave energy could be a good alternative to reduce Morocco's dependence on fossil fuels and to help reduce greenhouse gas emissions. Moreover, in addition to energy benefits, energy farms can be used for tidal protection to limit erosion processes.



Map of the Moroccan Coast with the location of the 23 studied points



Values of the mean Hs and mean T_e at the 23 studied points

Figure 7: Wave potential along the Atlantic coast of Morocco [44]

3.2 Potential and advantages of Tidal energy

Morocco has two maritime frontages with stable and predictable marine currents with a total length equivalent to 3500 km (Figure 8) [51]. All these resources make of Morocco a country with several sites allowing the development of hydroelectric turbines. These natural energy sources provide very good opportunities to innovate and improve the performance of current models from 20% to 30%. The development of a hydroelectric sector will complement and diversify the Kingdom's renewable energy .Given the great wealth of marine energy that stretches over 3500 km, Morocco is now working to evaluate marine resources, with the intention of launching a new sector of hydroelectric power. In order to characterize the potential of marine energy, this would require the installation of measuring and prospecting

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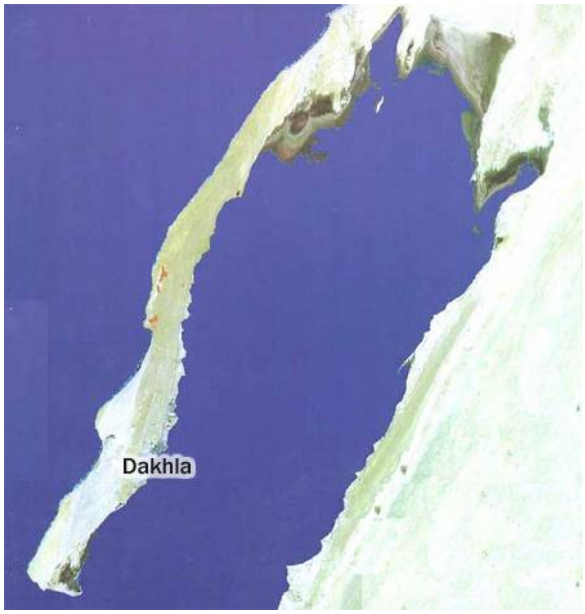
equipment, furthermore, to acquire the capacities required for the mastery and the valorisation of this technology it is necessary to carry out the implementation of a demonstration project of a hydro-turbine. The project chosen by the main actors and partners involved in the project (ADEREE and ONEE) is composed of two main phases: identifying the tidal energy potential of the chosen sites and setting up a pilot plant to test and develop the technology of a tidal current turbine. Studies have shown great interest in installing a tidal current generator in the Strait of Gibraltar. Given the great advantages of this zone, characterized by exceptionally coherent and solid currents, the potential for electricity generation is considerable. Currently, despite the advantages of the Gibraltar's zone, which makes it a natural energy distinction, this project is quite hypothetical and no planning has begun. However, in the future, tidal production in the Strait of Gibraltar could be an important asset for Moroccan efforts in renewable energy [52].



(a) Dakhla bay (23°30'N-16°W) [31]

(b) Oualidia lagoon (32°45'N; 9°3'W) [32]

(c) The southern coast of the Strait of Gibraltar [33]

Figure 8: Potential areas for tidal power generation in Morocco.

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Submerged systems such as tidal flows combine several advantages in contrast to wind energies: they have more benefit relating to inhabitants close to coastal zones as providing a very low or even non-existent sound [53]. And contrary to the wind turbines of the land, tidal turbines of marine currents have the distinct advantage of being highly predictable in the long term, because the current tide depends on the combined effects of the gravitational forces due to the Moon and the Sun and the rotation of the earth whose Trajectory are known [54]. In addition, regarding wind turbines, it is necessary to know that the winds are more constant at sea than on land, because the intermittence of the wind is smoothed by its complementarity with the intermittent feeding of the hole and of the current Marine. As a result, the minimum production is guaranteed. The other priority for the establishment of channels of marine renewable energy concerned the cost of anchors, the speed of the procedures of facilities and maintenance, the industrialization of manufacturing processes and mounting, the repatriation of the energy to the continent, the resistance to corrosion and to fouling , as well as the efficiency of generation [55]. The regularity of the tides and the large and predictable energy potential contribute to making the development of tidal power attractive. The architecture of the first tidal dams resembles dams constructed through the mouth of estuaries to exploit the energy of the tidal stream except that the tidal dams must allow water to flow in both directions as opposed to the hydroelectric dam Which captures only the energy of the water that flows from the estuary of the high tide to the low [56]. Tidal energy can be captured either as potential energy by exploiting changes in sea level or as kinetic energy by exploiting tidal currents that can be captured by tidal turbines resemble underwater wind turbines [57].

The capture of the kinetic energy of tidal currents by tidal turbines is currently being investigated because to exploit tidal energy with tidal turbines, currents must exceed 1,5 m/s for significant durations, with lower speeds; tidal turbines are not profitable, while higher speeds can damage the turbines [58]. The most suitable areas for the capture of tidal energy are very few; they are concentrated in areas where the amplitude of the tidal wave is amplified, as in the case of the Bay of Mont-Saint-Michel in France and the Bay of Fundy in Canada where the tidal current exceeds 10 km/h.

3.3 Potential and advantage of Offshore wind energy

Offshore wind energy is one of the most mature and cleanest technologies available to produce clean energy [59-60], and among the advantages of offshore wind turbines versus land-based wind turbines what the wind is very strong and regularly blow on the oceans. The winds on the ocean reach higher speeds and are less turbulent than the winds on the ground and no form of relief blocks the access of the wind to the ocean [61].

Morocco is among the countries of the world that are well positioned in terms of wind at sea because it offers two wide ranges. Recently, a study by the Moroccan Center for the Development of Renewable Energies (CDER) showed that wind positioning offshore wind farm can radically change the overall productivity of an offshore wind farm. As part of

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Morocco's strategic vision, it plans to diversify its energy mix. Morocco is the second country in Africa in terms of wind power, although it uses only about 1% of its technical capacity. And with nearly 12 million km^2 of waters under its jurisdiction, Morocco has an immense potential for developing renewable energies at sea. The wind is still young in the business plan, but many studies already devoted to possible ways of improving its performance [62].

Morocco has considerable, or inexhaustible, assets in the field of renewable energies. On the one hand, the wind potential is estimated at 25000 MW, of which nearly 6000 MW are achievable by 2030 in identified onshore regions and where the wind speed exceeds 9 m/s at a height of 40 meters ground. For the offshore Moroccan wind potential, the first estimates along the 3,500 km of coastline are of the order of 250 GW, equivalent to 10 times the national on-shore wind potential [63].

3.4 Salinity gradient energy

The salinity gradient energy is defined by the inequality in salt concentration between two fluids, commonly seawater and river water at the estuaries or more frequently in the river mouths. Its energy reserves depend mainly on the volume of river water flowing into the seas. Morocco has several large rivers, whose river mouths are located in the Atlantic Ocean and the Mediterranean Sea, which have rich sources of energy with a salinity gradient. The main rivers of Morocco are listed in table 1.Morocco can benefit in its potential rivers for example a study made the estuary of Oued Loukkos shows that the salinity and the temperature determine the density of the water and the variations of density can lead to a vertical movement of the masses of water. Differences in the salinity of surface and bottom waters may be important. Oued Loukkos estuary, located between the mouth of the river and 15 km upstream of the mouth, in three zones which are based on the characteristics of the vertical salinity gradient [64].

Name of river	**Continent**	**Estuaries**	**Average flow at Estuaries (m^3/s)**	**Length outside tributaries (km)**	**Watershed area (km^2)**
Bouregreg	Africa	Atlantic Ocean	23	240	10 000
Draâ	Africa	Atlantic Ocean		1 100	29 500
Moulouya	Africa	Mediterranean Sea	50	600	74 000
Oum Er R'bia	Africa	Atlantic Ocean	117	600	32 000
Sebou	Africa	Atlantic Ocean	137	614	40 000

Tableau 1: List of rivers of Morocco

The effects of the development of salinity gradient energy on the environment have been less studied, although influences on ocean economic activities (such as water transport, fishing

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and marine engineering) and the ecological environment in the estuary areas are relatively significant [65].

3.5 Temperature gradient energy

Conversion of ocean thermal energy (or OTEC) generates electricity from the temperature difference between deeper and warmer or shallower bottom waters [66]. OTEC is one of the first systems studied and implemented (since 1880) with a first French project implemented by (Georges Claude) in Matanzas [67], Cuba in 1930 and a second one off the coast of Brazil in 1935. The thermal power generation of the seas is done by exploiting the difference in temperature between deep water (located at about 1000 meters depth) equivalent to 20 °C and surface water, heated by solar radiation at 24 °C [68]. These conditions are predominant in intertropical areas and especially in the Pacific. Closed-cycle power plants use ammonia as a temperature-sensitive fluid that vaporizes at 24 °C and drives an electric turbine. The fluid is subsequently cooled by sea water from the depth which will be reintroduced into the circuit [69]. Some of the energy produced is used for pumping. Environmental assessment is apparently positive, since pumping cold water contributes to the stimulation of biological activity by reproducing a natural upwelling movement that raises locally nutrient-rich deep water [70]. The principle is still used in the United States, India and Japan (by Saga University), the most advanced countries in research on the subject [71].

In Morocco the highest values of near-surface temperature were typically observed in area by [72] and [73] on the Oued Sebou and Oued Bouregreg, on the Atlantic coast of Morocco 115 km and 147 km south, respectively, of where the Oued Loukkos connects with the Atlantic Ocean at Larache.

4. Regulatory framework

The legal framework for the generation of electricity is principally supervised by [74]:

Law	Objective
Law no. 13-09 published about renewable energy production on 11 February 2010	This law releases investment in the renewable energy sector either through the realization and operation of facilities for the production of electricity from renewable energy sources and marketing and export [12].
Law No. 57-09 relating to the establishment of the Moroccan Agency for Solar Energy "MASEN" on 14 January 2010[74].	Study and design of projects; Promotion, placement, financing and implementation of projects; Contribution to the development of expertise, research and the solar industry, Piloting and monitoring of the implementation of the solar program [74].
Law no.47-09 promulgated on 29 September 2011 relating to energy efficiency [8].	Energy performance of equipment and buildings; Mandatory energy audit at a

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	threshold defined by decree; Energy impact study, Establishment of energy services companies [8].
Law no. 16-09 relating to the establishment the National Agency for the Promotion of Renewable Energy and Energy Conservation (ADEREE) on 13 January 2010 [8].	Promotion of Renewable Energy Projects; Strengthening energy efficiency; Wind and solar atlas; Demonstration for Applied Research [8].
Draft law on Public–Private Partnerships (PPPs)	This project is based on the UK experience with the Private Financing Initiative and strongly inspired by the French PPP Ordinance of 17 June 2004.

Table 2: Several legal relating to the national energy strategy

To reinforce the legal reforms, new legislative and institutional framework attractive and oriented towards the private investor [75-76].The Investment Charter: sets an attractive legal framework for foreign investments in Morocco (notably with regard to the granting of tax and customs advantages).

- **Moroccan Agency for Solar Energy "MASEN"**
- **Energy Investment Company**
  - ✓ Investor of reference for the energy strategy; Strengthening of production capacity; Financing of Renewable Energies
  - ✓ Acquisition of active participations in companies running Renewable Energies and Energy Efficiency projects
- **Establishment of the Energy Development Fund***
- **Institut of Research in Solar Energy and New Energies (IRESEN)**
  - ✓ Consolidate the needs of the various players in the sector and ensure the realization and valorization of the various research projects

5. Projects authorized under Law 13-09 on Renewable Energies

Among the projects that will be carried out as part of the liberalization of the renewable energy sector (wind, hydro) are companies (SGTM, Platinum power, Enegie J2 Terre) and (Wind energy in Morocco, UPC Renewable, Innovent Morocco) the projects of realization of the hydraulic stations and the wind farms [76]. (See Figure 9,10)

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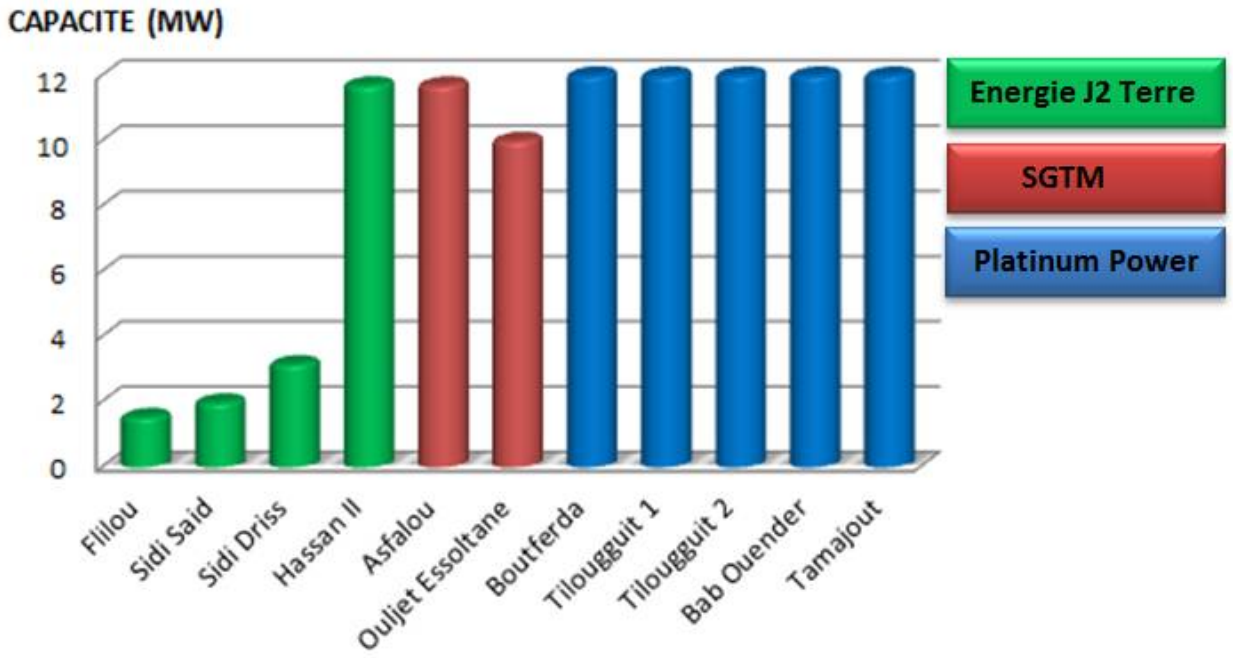

Figure 9: The hydraulic stations Law 13-09 (2014-2017)

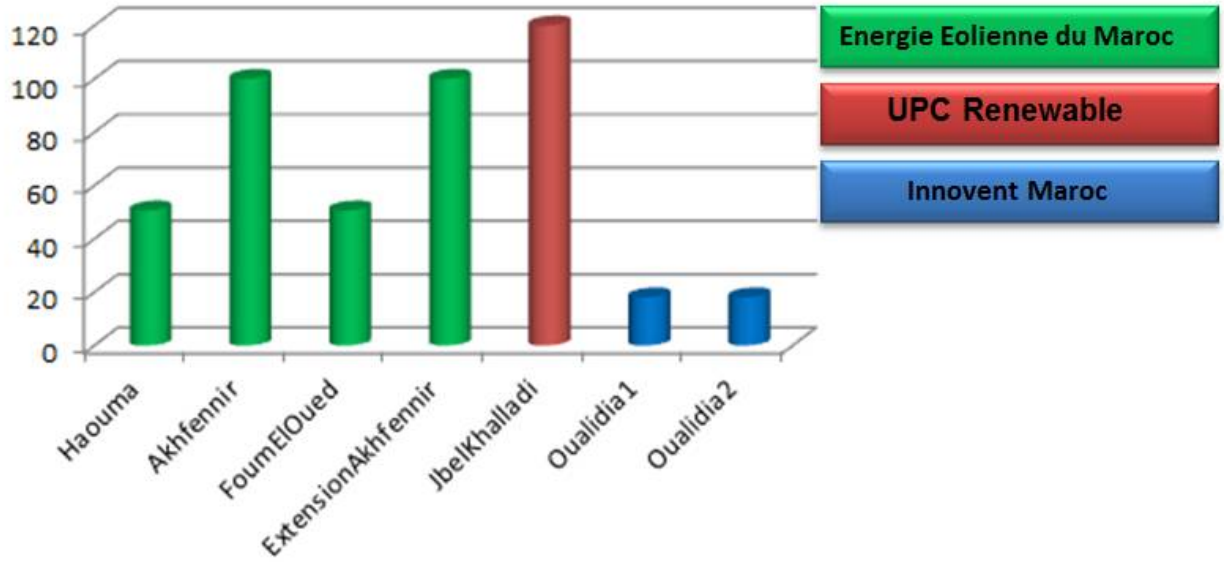

Figure 10: The wind parks law 13-09 (2014-2017)

6. Scenario energy 2030

Moroccan electricity consumption growth is currently growing by around 6% per year and is expected to continue until 2030 to finish at 81 TWh see in Figure 14 and 15. So an installed power of 24 GW at the moment Morocco produces 8000 MW, so we need 16 GW [77].
Energy transition strategy adopted by Morocco reconciles economic development and the fight against climate change. The main objectives that focalize to achieve are:

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- The Kingdom's will have to increase the share of renewable energies from 42% installed capacity for 2020 to 52% for 2030
- Global investment Quarantine of billions of dollars in the energy sector between 2016 and 2030 of which approximately $ 30 billion For Power Generation Projects from Renewable Sources
- Morocco will have to develop (between 2016 to 2030) An additional capacity of 10100 MW:
    - ✓ 4560 MW Solar Power
    - ✓ 4200 MW Wind Turbine
    - ✓ 1330 MW Hydro
- Reduce carbon dioxide emissions by 32% from 2005 levels by 2030.

The energy sector is exposed to the risk of oil shortages. The main strategic objectives are to ensure security of supply, seek better costs, generalize access to energy and improve sector efficiency and profitability. But it is above all the dependence of the foreigner that it is a question of diminishing. The dependency rate remains today between 96 and 97%, far too much to maintain a viable deficit. Especially, since the growth forecasts point to an increase in consumption by 2020 of the order of 5 to 6%.

The development of natural gas would limit the use of coal:

- Coal would then see its share almost stagnate at around 28 to 30% until 2030.
- The share of natural gas would increase from 4.9% in 2012 to 13.5% in 2030.

Figure 16 present different pillars of sustainable development are then affected. It is social, through the impact of energy prices on the vulnerable population and the environment, by the pollution generated by the consumption of hydrocarbons. These negative effects on sustainable development should be substantially corrected if a major development of renewable energy production is incorporated ". Still, this scenario, one easily conceives it, requires significant investments. Substantial efforts are needed in research and technological innovation to ensure that this approach can be "a stimulating factor for the country's productive activity". For the second scenario called "energetic voluntarism", this one takes into consideration the mobilization of investments for the development of renewable marine energy [78,79] especially Morocco has a very important deposit of marine resources with 3500 km of coast.

This option would constitute a new engine for development and rapid growth, since around these activity clusters of industrial companies and services favored by the abundance of energy at competitive prices would be formed. This approach has virtually all the advantages of sustainable development. This ranges from competitive growth to the distributional effects of access to energy at lower cost, including the development of renewable energies, with reduced CO_2 emissions.

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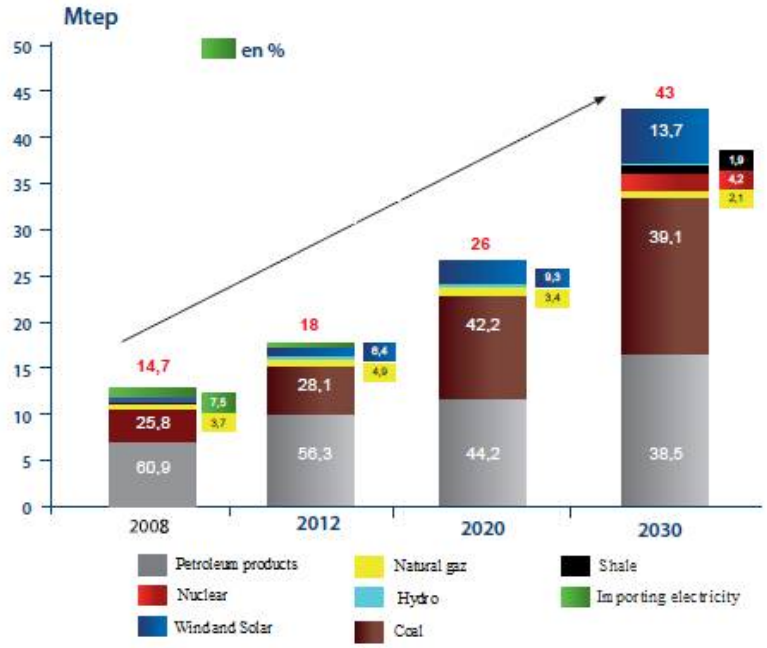

Figure 14 : Evolution in primary energy demand without natural gas development

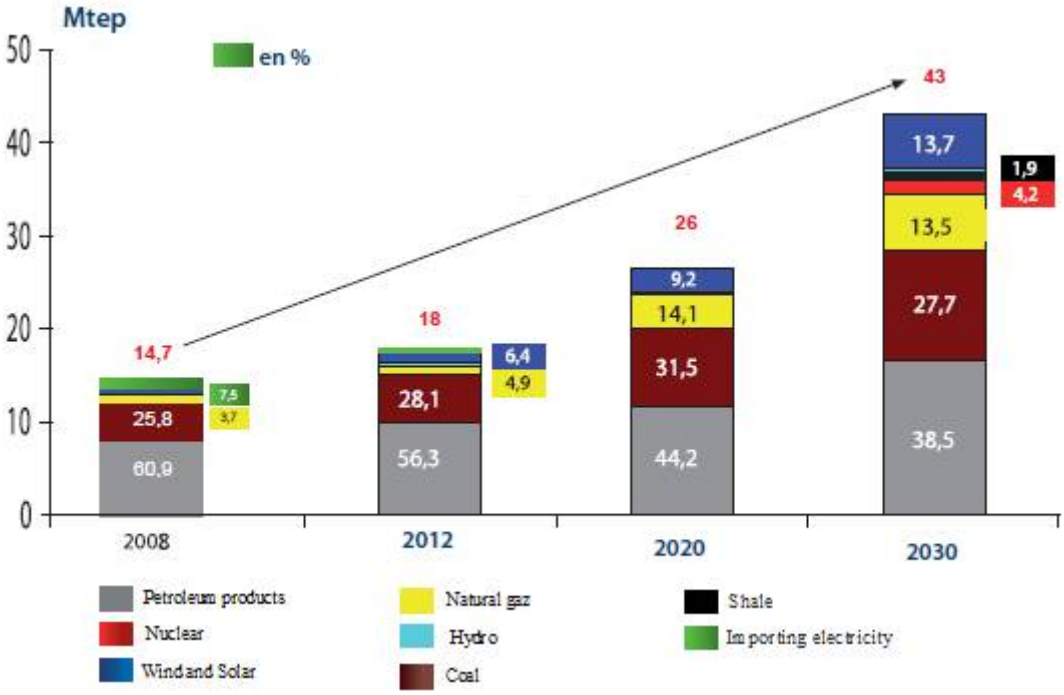

Figure 15 : Evolution in primary energy demand with natural gas development

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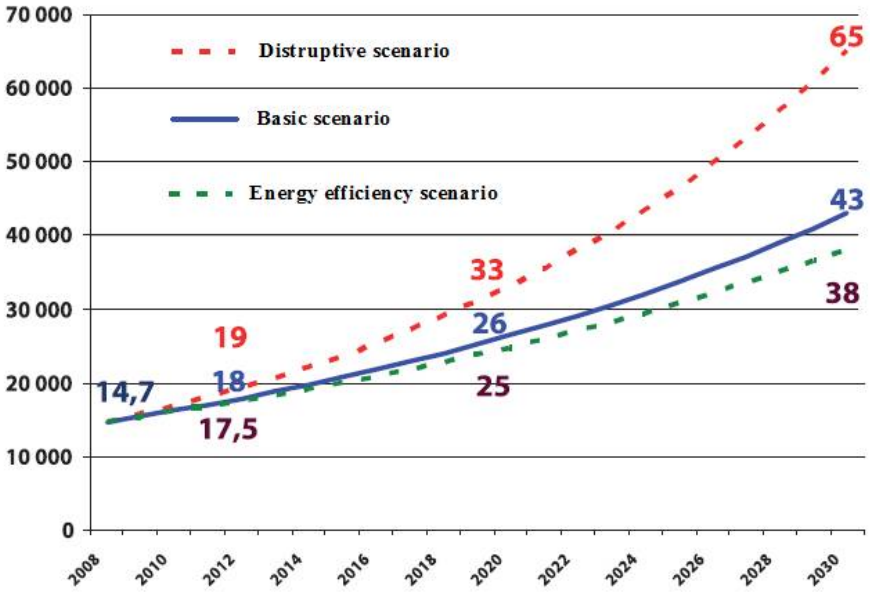

Figure 16: Evolution of primary energy demand

7. SWOT matrixs

A technical and environmental analysis of the market of renewable energies in Morocco to identify all the opportunities and threats that appears in the environment as well as the strengths-weaknesses-opportunities-threats (SWOT) of the renewable energy sector (Figure 17). This SWOT analysis shows that the renewable marine energies sector is very promising for the case of Morocco and especially the energy of the waves because Morocco possesses a geographical strategic and climatic position largely favorable, these conditions will allow it to be a key player in the development and use of renewable energies for sustainable development.

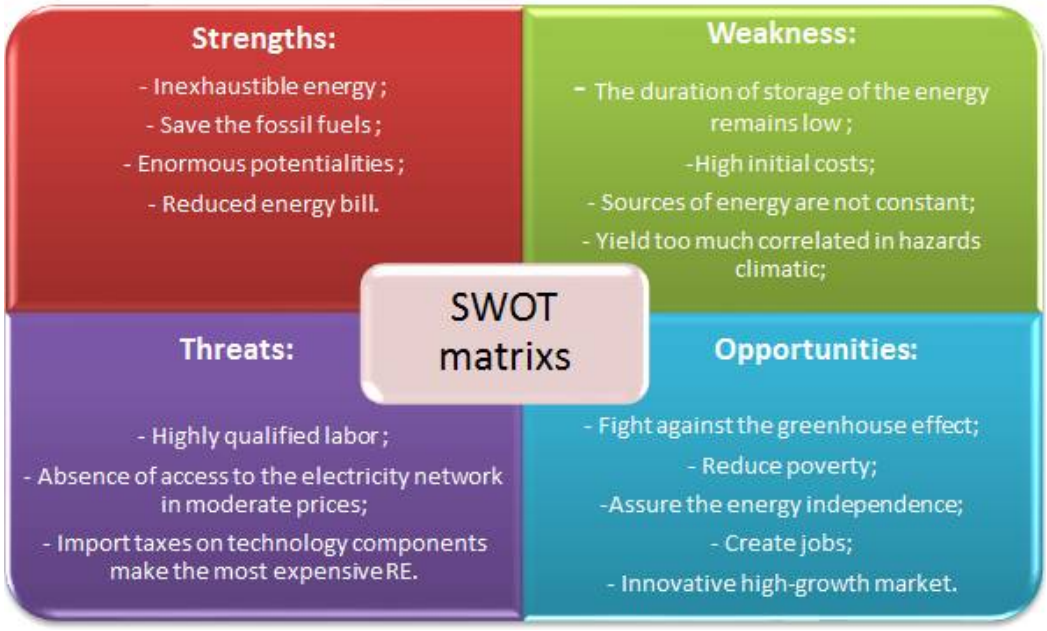

Figure 17 : SWOT matrix analysis

8. Conclusion

From renewable energies to marine energies, a new development frontier for the energy transition in Morocco, which has an important maritime deposit that can help it to produce clean energy to meet the growing demand for energy while reducing its Dependence on fossil fuels, and as long as competitiveness through a low cost of electricity that would improve its trade balance through reduced energy imports. Renewable marine energies, therefore, appear to be a tremendous opportunity and a real ecological, energy and industrial choice, giving rise to a new industrial sector at the crossroads of blue growth and green growth and the creation of sustainable jobs. Accelerating the energy transition.

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