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Development of Renewable Energies in Tunisia

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Introduction

This article aims at highlighting development opportunities for renewable energies (RE) in Tunisia. It covers five RE sectors and their utilization possibilities: (1) overview about the situation and RE utilization perspectives across the world; (2) estimate of RE national potential; (3) evaluation of possibilities to substitute conventional energies by RE in Tunisia for different utilization areas; (4) review of the regulatory and institutional framework of RE in Tunisia, and (5) conditions for the success of an RE development policy.

I- Renewable Energies Across the World

There are five sectors in the field of renewable energies: solar, wind, hydraulic, geothermal and bio-energies. In 2014, RE represented 14% of world primary energy usages (versus 13% ten years before). Biomass contributes with the largest share (10%) followed by hydraulic energy (2.4%) then by other forms of RE (solar, wind and geothermal) with 1.3%. According to the medium forecasts of the International Energy Agency (IEA), with the exception of biomass and hydraulic energies, RE will represent 7% of the world primary energy consumption in 2030. According to the same forecasts, the most important RE developments expected in the next two decades worldwide will concern:

- The production of wind energy (27% of world RE production increments);
- The production of electrical power using biomass and organic wastes (23% of increments);
- Hydro-electrical production (13%);
- The use of bio-fuel in transportation (10%):
- The use of biomass and organic waste by industries to produce heat energy (9%);
- The use of solar energy for the production of electrical power (7%), and
- The use of solar energy by residential and tertiary sectors (5%).

According to IEA, removing barriers and implementing support measures would constitute the main success conditions for the development of renewable energies.

II- National potential in different renewable energy sectors

1. The current position of renewable energies in the national energy balance

In our analysis, we considered the resources-utilization report of 2014, the last one published by IEA. This report

shows that RE contributed to the national energy balance with 1,169 thousand tep (ktep), almost exclusively made up of traditional biomass: 1,075 ktep/year, or 10% of national needs for primary energy. Other forms of RE including solar and geothermal energies represent 0.9% of the national primary energy consumption. The electrical power production sector constitutes the first energy consumer in Tunisia with a share of 36.6% of the national primary energy. Once processed for the production of electrical energy and/or for refineries, energy is ultimately used mainly by the industrial sector (29%), the transportation sector (27.7%), and the residential sector (26.3%). This balance raises concern when it comes to the use of biomass, from an estimate based on a 1997 study mainly devoted to the use of housesolds. Said study shows much higher results than those generated by the five-year-interval surveys carried out by STEG since 1984. Moreover, the IEA balance is incomplete as it does not take into account the use of geothermal sources which impact is estimated at around 6 ktep/year nor the important quantities of smuggled fuel.

Simplified energy balance of the year 2014

(en ktep)	Oil	Natural gas	Hydro electricity	Bio energy	Solar	Wind energy	Electricity & Heat	Total
Production	2 902	2 575	5	1 075	45	44	63	**6 709**
Net imports	1 183	2 691					-8	**3 866**
Power production	-83	-3 737	-5		-2	-44	1 573	**-2 298**
Others	81	-207		-201			-322	**-649**
Final consumption	**4 083**	**1 322**		**874**	**43**		**1 306**	**7 628**
Industries	1 114	841		6			468	**2 429**
Transport	2 015	86					8	**2 109**
Residential & Tertiary	613	376		868	43		743	**2 643**
Agriculture & fishing	341	19					88	**448**

Source : IEA

2. National Potential of Renewable Energies

We hold no official and exhaustive inventory of RE potential deposits in Tunisia. Nevertheless, we can make the following statements:

a- Wind energy can be used to produce electricity. This is the most developed renewable energy in the world. In Tunisia, the wind Atlas published by ANME gives a statement on windy regions across Tunisia. ANME considers that Tunisia's onshore wind potential is 8,000 Megawatts (MW). The evaluation of the offshore wind potential still needs to be made. Wind energy is irregular and the exploitation rate of on-shore built facilities ranges between 25% and 30% ;

b- The thermal and photovoltaic (PV) solar energy may partially replace the thermal production of electricity. In addition, solar energy may replace conventional water heating systems in homes and civil buildings if solar panels are used. The solar energy potential in Tunisia is therefore quite high theoretically;

c- Bio-energy resources are estimated at 1.6 Mtep/ year and mainly include dendroenergy but also biogas, bio-fuel and waste. Its 10% impact on the energy overall balance should be reassessed.

d- The modest **hydro-electrical resources** are relatively well developed and very little potential can still be valued;

e- The **geothermal** potential has been subject to incomplete assessment studies. Identified resources have limited enthalpy and their impact on the energy balance is also very little.

III- Substitution Possibilities by Renewable Energies

We will examine in this section possibilities to use RE by different utilization sectors: production of electrical power, industry, transports, and for residential, tertiary and agricultural needs. The potential of hydraulic and geothermal sectors being very limited, we will focus our evaluation on the solar, wind and bio-energies.

1. Substitution Possibilities for the Electrical Sector

a. Current situation

The electrical power production sector is the main energy user with 37% of the overall national primary energy consumption. The national production of electricity amounted to 19 TWh in 2014 with an annual growth rate of +5% over the last decade. Consumption per capita and per year reached 1.46 Megawatthour (MHh), reflecting an average annual increase of +4%. The electrical intensity (power quantity consumed by gross domestic product unit) was 0.339 kWh per dollar-2010 of the GDP, and has slightly changed in the last ten years.

Facilities used for the production of electrical power are almost exclusively made up of thermal power plants, which have mainly been using natural gas (94%), nearly half of which was imported. The specific average consumption of primary energy in plants was 205 tep per GWh of produced power, reflecting slight decrease over the last two decades (-1.3% a year). The contribution of RE to the national power production is 3% including 0.3% of hydro-electrical energy and 2.7% of wind energy. Regionally, Tunisia is not efficiently making use of RE in the production of electrical power. We suggest below an approach used to estimate RE's potential contribution to power production in Tunisia.

b. Forecasts of the national needs for electrical power

In a reference case, considering a GDP annual growth rate of 4,5% and the current electrical intensity, the national power demand will amount to 19,8 TWh in 2020 and 31 TWh in 2030.

c. Forecasts of the national power production

The national power production depends on the national demand and on production not charged by the Tunisian electrical power and gas company (STEG), mainly including losses at the level of transmission and distribution. "Losses" are relatively high at the national level (16% in 2014) compared with achievements made in the nineties (10% in 1994) or in south European countries (8%). We will however consider that losses will be 10% in 2030. The national power production will therefore be 22 TWh in 2020 and 35 TWh in 2030. This production level also supposes that exchanges with neighboring countries will be kept at their current status of 2,8% of the national production.

d. Forecasts of the needs for fuel for the production of electrical power

National facilities used for the production of electrical power are almost exclusively made up of thermal plants. The specific consumption of plants considerably varies according to the type of equipment used for the production of power: 180 tep/GWh in combined cycle plants to the double in small gas turbines. In 2014, the average specific consumption of all different plants was 205 tep/GWh, which is less than the average of 1.3%/year over the last two decades. STEG will have to downgrade a number of old steam and gas turbines and to install new combined-cycle plants. Changes in the composition of electrical power production facilities will reduce the average specific consumption of thermal plants. By year 2030, the specific consumption will

depend on the effective composition of power production installations but will very likely continue to decrease to performance levels that are similar to combined-cycle consumption rates.

e. Technical and economic constraints for the production of renewable electrical power

The use of RE for the production of electrical power faces various types of constraints: availability and quality of renewable resources, quality of the electrical power transmission network, increase of fossil energies' international price (mainly gas and coal) … In Tunisia, RE utilization potential to produce electrical power varies according to the activity sector. The production potential of renewable electrical power based on hydraulic, bio-fuel and geothermal sources is almost not known. However, the potential of wind and solar power is considered to be relatively high. The production of wind-generated electrical power is nevertheless limited due to its irregular character. Some countries have been able to achieve relatively significant integration rates; more than 20% of the wind electrical power production in Denmark, Portugal and Spain. In Tunisia, the contribution of RE in the production of electrical power amounts to a few percents; the quality and isolation of the electrical power transmission network constitute barriers impeding the development of wind energy. According to ANME, the share of RE in the production of electrical power would reach 30% in 2030. The competitiveness of the wind electrical power of solar electricity will still depend on the international prices of natural gas and equipment required for power plants. Progress made over the last decade is very promising as the cost-price of renewable electrical power is constantly decreasing.

f. Contribution of renewable energies in the production of electrical power

The **Tunisian Solar Plan** in its last 2015 version considered several projects to produce electrical power using RE: wind, solar and biogas. By year 2030, wind and solar energies will constitute the main renewable energy areas in the production of electrical power. In this report, the potential of RE-based electrical power production in the year 2030 is estimated as follows: 14% will be generated by wind power, 14% by solar energy and 2% using biogas and organic waste. In case various constraints are removed, and considering that the international price of fossil energies remains similar to 2014 prices and that costs of wind power and solar energy technologies will continue to fall, we may state that the contribution potential of RE to the production of electrical power may amount to 30%. This level is comparable to rates defined by IEA for OCDE and European countries, not considering hydro-electricity. The contribution of RE in the production of electrical power will therefore contribute to saving fossil energy for initially up to 2 Mtep in 2030, or the equivalent of about 12% of the national needs for primary energy.

2. Substitution Possibilities for Other Usage Sectors

The national energy balance that was published is incomplete, therefore our estimates concerning RE contribution to Tunisia's future primary energy needs may be approximate. Below is a review of substitution possibilities of fossil energies by renewable energies for different activity areas using energy:

a- **Industry:** The industrial sector uses oil products, natural gas, electrical power and very little biomass. The decentralized production of electricity using PV cells is currently the main substitution method that can be considered for the years to come;

b- Transport: The transport sector uses almost exclusively oil products. Some countries have successfully developed the use of bio-fuel. Tunisia does not yet hold favorable conditions for the development of this resource.

c- Residential & tertiary: Homes and public or commercial buildings offer several substitution possibilities:

- Use of the traditional biomass for heating and baking needs;
- Use of solar water-heating systems for sanitation water needs;
- Use of photovoltaic cells for the decentralized production of electrical power.

The residential and tertiary sectors offer the most important development potential for RE after the electrical power production sector.

d- Agriculture & fishing: The agriculture and fishing sector offers several possibilities to use RE, mainly PV solar energy to produce electrical power, as well as wind energy, for water pumping purposes. Nonetheless, these applications will have little impact on the national energy overall balance.

e- By year 2030, the contribution of RE is estimated at 3 Mtep, or 22% of the national demand for primary energy. The electrical power production sector and the residential sector are the main users of RE. Wind energy, solar energy and biomass will be contributing the most.

Table summarizing contributions and RE possible usages by horizon year 2030

SECTORS	Activity Areas	Wind	Solar	Bio-energy	Hydro-electricity	TOTAL
Electricity	Mtep	1,0	1,0	0,1	<0,1	**2,1**
Industry	Mtep		0,1	<0,1		**0,1**
Residential & Tertiary	Mtep		0,2	1,0		**1,2**
TOTAL	**Mtep**	**1,0**	**1,3**	**1,1**	**0,0**	**3,4**

3. Export Opportunities of Renewable Electrical Power

a. An enclosed electrical system

There are five electrical interconnections with Algeria and two connections with Libya. Exchanges with Algeria are made on a nil-balance base and represent almost 10% of exchange capacities and 2,8% of the national production. Due to the instability of the Libyan electrical network, exchanges with Libya have been very limited, and confined to bordering aras. The interconnection project between El Haouaria and Sicily by means of a submarine cable is still under study. Opening up the Tunisian electrical system will contribute to the development of wind and solar renewable electrical powers.

b. The export potential of wind and solar power is considerable

The available potential of solar and wind energies that can be exported is valued at thousands of MW. Tunisia may take profit of its geographic location to develop its potential of renewable electrical power. Exports via the future cable connecting Cap Bon to Sicily may enhance Tunisia's potential of renewable power energy. For this reason, it will be necessary to review the European Directive 2009/28/EC as this directive seriously limits, until 2020, import possibilities by the European Union's countries of renewable electrical power from neighboring countries.

4. Which Renewable Energies and at what Cost?

Production costs of RE can be compared to the cost-price of similar conventional energies in Tunisia with no subsidies. The cost of substituted Tep must be compared to the cost of natural gas for wind electrical power and PV electricity. Substitution by solar and bio-gas water heating systems must be compared to natural gas, either with GPL or diesel.

The international price of raw oil products started to decrease since 2015. Specialized international

agencies predict a recovery of world prices as of 2018 and a Brent barrel price of 80 $ in 2020.

Electricity produced by wind energy or photovoltaic solar energy is irregular and cannot be economically stored. Its cost-price must be compared with the avoided cost of electricity produced by a gas-based thermal plant. This cost almost corresponds to the cost of non-consumed natural gas for the production of electricity by a thermal plant. Therefore, the avoided production cost of a MWh will be equal to:

{Non-subsidized cost of a natural gas tep} * {average specific consumption of STEG's gas turbines}[1]

The price of wind-generated power and especially that of photovoltaic electricity have considerably dropped over the last ten years. In the future, if the price of wind-produced electrical power stabilizes, the price of wind generated electricity will continue to drop during the next decade. If trends and projections of the Brent price are confirmed, the development projects of wind generated power and photovoltaic electricity will considerably grow in the coming years.

Concerning the use of solar water heating systems by average households, investments will be depreciated in a matter of few quarters.

IV- Legal and Institutional Framework

The energy sector is managed by the Ministry of Energy. The Ministry defines the Government's energy policy and monitors the enforcement of legislation in force in terms of energy. The Energy General Department (DGE) is charge, within this Ministry, of the execution of Tunisia's energy policies.

[1] The specific consumption equals the quantity of gas used in the production of one unit of electricity; it is 0.22 tep per MWh in average over the last few years.

Since the mid-eighties, Tunisia developed an energy control policy. The implementation of this policy is based on four main instruments: institutional, legislative, financial and fiscal.

The National Agency for Energy Control (ANME) is the institutional tool in charge of implementing the State's policy in terms of RE promotion and the rational use of energy. Since its creation in 1985, its name, authority, prerogatives and organization have frequently changed. Presently, ANME's attributions are defined by Law n.2004-72 dated August 2, 2004. ANME is also in charge of promoting and following up the execution of the "Tunisian Solar Plan".

On the other hand, Tunisia developed since the middle of the eighties a suitable regulatory framework for the development of RE, which has been constantly enhanced to support the Government's policy in this domain.

Law n. 2005-106, dated December 19, 2005, provides for the creation of the National Fund for Energy Control (FNME). It constitutes the financial instrument supporting RE promotion policies. It can be used to provide direct financial incentives granted in the framework of the energy control law and related legal texts. Direct subsidies granted by FNME have been complemented by specific fiscal incentives allocated to the purchase of equipment and products used in RE production: application of minimal customs fees and VAT exemption. These benefits come in addition to the investment code's general system which also offers incentives and subsides related to investments, according to geographic areas and activities.

The Tunisian Solar Plan, initiated in 2009, includes a number of projects to implement before the year 2016. It was reviewed in 2012 and in 2015 but achievements have been well below expectations.

Repurchase tariffs offered by STEG of surplus made by electricity self-producers were defined in a decision issued by the Ministry of Energy on June 1st, 2010 then reviewed in 2014. Decree 2002-3232, dated December 3, 2002,

then modified by Decree 2009-3377, authorizes cogeneration facilities to sell their surplus to STEG and to transmit their production via the national network. Law n. 2015-12, dated May 11, 2015, related to the production of electrical power through RE complements the existing legal framework. It takes on provisions related to self-production and authorizes the creation of specialized companies in the production of power designed for local consumption (STEG) or for exports.

V- Success Conditions of a Renewable Energies Development Policy

The success of the development policy of national RE potentials will depend on (1) the State's sustainable commitment towards RE (2) removing barriers impeding RE development (3) enforcement of an inciting framework in favor of RE, and (4) mobilization of the main stakeholders around federating programs.

1. State's sustainable commitment towards renewable energies

Investments in the field of RE are risky due to the ever-changing prices of hydrocarbons and relatively long periods for the amortization of investments. Nevertheless, for an energy net-importing country, the diversification of the energy basket may contribute to improving its energy safety and independence. For Tunisia, any diversification decision must take in consideration on the one hand, the evolution perspectives of hydrocarbons' and alternative technologies' international prices, and on the other, the national resources of fossil and renewable energies, as well as the availability of natural gas at the regional level. Over the last two decades, the Government's policy to promote RE seems to have been wavering. The option for a "least regret strategy" has enabled the Government to show a reasonably ambitious engagement in terms of objectives, quotas and RE repurchase tariffs.

2. Removing barriers impeding the development of renewable energies

Tunisia's performances in the development of RE are rather modest compared to other countries in the region (mainly Portugal and Morocco). In a changing international context, the Tunisian authorities have been evolving with caution by keeping tight control over the future development of RE. Various types of barriers still impede the development of RE:

- Incomplete knowledge of the national RE potential ;
- A constantly changing legal framework;
- An enclosed electrical power transmission network;
- RE repurchase tariffs lower than avoided costs;
- Generously subsidized conventional energies;
- The quasi-monopoly of the public operator STEG.

Removing these barriers constitutes a requirement for the subsequent deployment of RE.

3. Enforcement of an inciting framework in favor of renewable energies

In order to launch the RE development process, incentive measures are also necessary. The incentive framework includes financial and fiscal incentives, actions to promote the Tunisian RE potential, programs for the mobilization of resources and measures favoring technological transfer. The total amount allocated to FNME represent few percents of the overall funding needs. The study conducted by the World Bank in 2008 called "Acceleration of the energy control policy" already stressed the **need to reinforce FNME's funding capacity.**

The Tunisian Solar Plan constitutes a first manual of projects and ideas. Knowing and promoting RE potentials constitute the first phase in the development of this potential. For this reason, the elaboration and distribution of an **RE Atlas for Tunisia** would constitute an interesting endeavor.

Campaigns to promote this potential among credible investors must be undertaken highlighting Tunisian sites' comparative advantages. In order to take profit of opportunities offered by the development of RE worldwide and in Tunisia, the following actions and measures should be launched to reinforce **technological control processes** in the field of RE:

- Create an RE specific technological watch unit;
- Implementation of a pilot demonstration project, in partnership with equipment suppliers, which would also be an opportunity to better control new technologies;
- RE offer real opportunities to generate know-how and to create jobs. The involvement of Tunisian industrials alongside world leaders may enhance outsourcing opportunities of this industry.

4. Mobilizing the main stakeholders around federating programs

The synergy between the main stakeholders around **common national goals and programs** will reinforce the success of an RE development strategy. The launch of federating programs around technologies and relatively mature markets should be considered in the short term. Priority should be given to the following programs:

- A specific wind energy plan ;
- An integrated program to deploy solar water heating systems;
- A master plan for the development of biomass and organic waste in the energy sector;
- A roadmap to export renewable electrical power.