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THE FATE OF ENERGY AND WATER AFTER THE COVID-19

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Abstract

The world is going through a health crisis which has triggered an unprecedented economic crisis, according to economists, unprecedented and worrying in its origin, nature, course, and geographic coverage.

The confinement of populations, the blocking of logistics chains, the stoppage of economic activity imposed by COVID-19 health crisis, has highlighted the vulnerability of value chains. Nowadays, the limits of the "just in time" strategy can be observed. To remedy this, it is necessary to understand the characteristics of this economic crisis in its current context. In addition, the pandemic with its effect in prolonged waves caused a more or less severe recession depending on the country, which led to a drop in global energy demand by 6% and 8% decrease in greenhouse gas emissions. Also, the forecasts are not optimistic for the water sector, which is no exception. Climate change models indicate that precipitation could decrease by more than 20% in 2050.

The challenge for Algeria in the years to come is to adapt to a decrease in renewable water resources. The country must mobilize unconventional water resources (desalination and reuse of wastewater) which will be a strategic component in water management. In addition, the development of unconventional resources leads to an increase in electrical energy demand of 12% by one which must be taken into account in the national energy balance.

The objective of this work is to offer practical solutions to current energy challenges, defeat the post COVID-19 energy battle, and face the future water stress that threatens our country.

1. Introduction

Water and energy, two rare resources in Algeria

Algeria's annual water needs by 2030 will rise to 12.9 billion m³ against 10.4 billion m³ currently, or around 260 m³ per capita per year, far from the threshold of 500 m³ per capita per year, which is widely recognized as a scarcity threshold indicating a development of water deficit and underlying crises [1].

To cover this demand, a national water plan for 2030 was put in place, based on the continued mobilization of conventional and unconventional water resources by focusing on regions with a deficit through the exploitation of all the available supplies in order to intensify and expand the connection and transfer network between large complex reservoirs in the country [1].

These constraints and problems mainly concern the decrease in water resources due to the impact of climate change which has become a reality in Algeria and whose effects on our environment are already visible.

The future development of water resources is highly dependent on the availability of electric energy. For example, the desalination of seawater, the recycling of wastewater and the introduction of drip irrigation require very high amounts of power.

This sector must conduct a large-scale study program to understand the current and future impact of climate change, identify and quantify the associated costs and their interactions with water and energy and find well-adapted solutions.

The objective of this work is to provide an inventory of resources, water demand, as well as energy need, on one hand. Also, this study aims to propose practical solutions, in the short and medium term, to meet the current energy and water challenges, and to win the battle of the energy transition "EnT" of the post COVID-19, to face the development of the water resources sector in Algeria, with an analysis of the interactions between water and energy.

To achieve this, Algeria must first adopt plans and programs, simplify the methods and the value chains, and shorten the time by hooking the wagons to the locomotives of nations possessing the expertise, the technology, the know-how in the field of EnT.

2. Water in Algeria

The water resources in Algeria are illustrated in Figure 1 and Table 1:



Fig.1. Five major hydraulic basins in Algeria

- 10 billion m³ in the northern regions: 7.4 (water surface), 2.6 (underground resources);
- 5.37 billion m³ in the Saharan regions: 0.37 (water surface), 5 (underground resources).

The following table provides information on the resources in the five major hydraulic basins in Algeria:

Table.1 Water resources in Algeria

Basin	Water surface (billions of m ³)	Underground Water (billions of m ³)	Total (billions of m ³)
Oranie Chott-Chergui	0.65	0.6	1.25
Cheliff - Zahrez	1.71	0.83	2.54
AlgéroisHodna –Soummam	1.69	0.74	2.43
ConstantinoisSeybouse - Mellegue	3.00	0.43	3.43
Sahara	0.37	5 Albien	5.37
Total	7.42	7.6	15.02

Source: Documents from ministère des Ressources en eau (MWR), updated February 2012

The structures of the sedimentary basins of the Sahara are mainly constituted of large and deep reservoirs which have been fed by the rains of the Quaternary period. The groundwater table of the Continental Terminal (100-400 m deep) and the Continental Intercalary "Albian"

water table (1000-1500 m deep) contain significant reserves (30,000 to 40,000 billion m³), but their exploitable potential is very limited (5 billion m³ per year) because they are non-renewable[2].

2.1. Potential renewable and unconventional water resource.

2.1.1. Renewable water resources.

Renewable water resources (surface water and groundwater) have been estimated at around 16.5 billion m³ for an average year based on climatic data (annual database - before the 1980s). This estimate has been revised to about 12.3 billion m³ given the droughts suffered by Algeria since the 1980s, with a decrease in resources of about 25%.

Water availability has fallen to less than 350 m³ per capita per year, which is significantly lower than the “scarcity threshold” of 1,000 m³ per year set by UNDP. This is below 500 m³ per inhabitant per year, the “absolute scarcity threshold”.

A. Surface water resources

The volume of terrestrial water in solid, liquid and gaseous form is estimated at 1.384 billion km³ of which only 0.26% is directly exploitable fresh water. It is estimated that there is theoretically enough fresh water to supply some 20 billion people. Unfortunately it is not evenly distributed, as evidenced by the vast arid and semi-arid regions [3]

Surface water inflows reach several million cubic meters as measured by meters for the basins with the least amount of water on an annual average: the Sahara basins Djorf Torba-Bachar (350 hm³) and Brézina-el bayath (122 hm³), and billions of cubic meters measured for the areas with the most amount of water: Beni Haroun –Mila (1000 hm³) and Kissir-Jijel (680 hm³) [4]. This runoff is largely due to rapid and powerful floods.

They are generally recorded over an estimated average period of 20 to 30 days for the basins of southern Algeria and two to three months for the basins of northern Algeria.

Surface water resources are estimated at around 8.376 billion m³ for an average year. These water resources are characterized by their variability - the resources for nine out of ten years or for four out of five years are well below this average.

In a year of drought, the inflow of water can drop to less than 25-30% of this average value. Managing the uneven distribution of water resources in time and space has involved the construction of large dam reservoirs for the storage of inflows from wet years and use them in dry years and transfer of water from regions with a surplus of water to regions with water scarcity in order to encourage balanced economic and social development throughout the Algerian territory.

B. Underground water resources

The potential groundwater resources are estimated in 2011 at around 2,602,822,992 m³ per year, of which 794, 213, 270 m³ per year comes from the irrigation water returned via surface water in particular [5].

2.1.2. Unconventional water resources

Unconventional water resources offer potential for water resources in Algeria. They involve recycling of wastewater, artificial recharge of groundwater and production of fresh water by seawater desalination or demineralization of brackish water. The Algerian National Strategy for Water Resources estimates the volume of water that could be exploited from unconventional water resources represents more than 2 billion cubic meters.

A. Potential of wastewater [6, 7]

Wastewater is a resource that can be treated to provide recycled water suitable for irrigation, commercial and industrial uses. In Algeria, the actual treated water is 800, 000 cubic meters and expected to reach 1.2 billion cubic meters in 2014. Actually, a total of 145 wastewater treatment plants are operating with a total capacity of 12,000,000 EQH (Equivalent inhabitant), and the treated volume reaches 800 hm³ per year. Also 106 treatment plants are under implementation to achieve in 2012 a total treatment capacity of 7,965,058 EQH. At the completion of the actual program in 2014, a total capacity corresponding to 1.2 billion cubic meters per year was to be achieved.

B. Seawater desalination

Desalination has overcome technological difficulties, and is now economically competitive. Today, it represents a technologically feasible alternative for drinking water or agriculture and irrigation of certain profitable crops.

The reverse osmosis technique consists of passing seawater at a pressure of 70 bars through a membrane to produce fresh water. This technology has made a significant contribution to reducing operational costs, and it has been adopted by a large number of countries as the technique of choice. The advantages of this technology are:

- Desalination plants can be built using a Build, Own, Operate and Transfer (BOOT) system.
- Desalination plants can be built quickly (12 to 24 months, including the design phase). Algeria started producing fresh water by desalination or demineralization in 2005, the overall production capacity is around 2,310,000 m³ per day.

Desalination of seawater may be the most appropriate solution to the situation in many regions of Algeria to bridge the gap between water demand and supply.

The national strategy estimates the contribution of the sea to water desalination at around 1000 Mm³ by 2030 [8].

C. Brackish water

In Algeria, about a quarter of groundwater is, either entirely or partially, brackish water. This water is mainly located in the desert and semi-desert regions of the country.

The exploitation of brackish water resources began in 2000. The volume of brackish water mobilized is estimated at 510,160 hm³ / year, of which 160 hm³ / year are used to satisfy the drinking water supply. Twelve (12) plants operate in the provinces of Tlemcen, Oran, Tizi Ouzou, Bejaia, Illizi, Biskra, Ouargla, Medea and Ain Defla. The production of drinking water is 24.2 hm³/year [9].

2.2. Future demand for water

According to figures published by the Ministry of Water Resources, the volume of annual needs forecast for 2030 consists of 4 billion m³ for household consumption (3.3 billion m³ currently), 8.3 billion m³ for agriculture (6.8 billion m³ currently) and 0.6 billion m³ for industry (0.3 billion m³ currently) (Table 2) [1]:

Table.2. Evolution of the future water demand regardless of climate change [1]

Area of use	Water needs in 2019 [billion m ³]	Water needs in 2030 [billion m ³]
Drinking (rural and urban) and industrial water	3.3	4.0
Industry and tourism	0.3	0.6
Irrigation water+ Agriculture	6.8	8.3
Total, including isolated industry and tourism	10.4	12.9

2.2.1. Water demand for drinking water and industrial water supply

Forecasts of future domestic water use are based on population growth, rural-to-urban migration and water demand projections per capita. Algeria's drinking, industrial and tourist water needs are estimated at 0.6 billion m³ by 2030.

2.3. Balance of resources-demand supply

The current balance between water supply and demand is analyzed by river basin (the analysis is done basin by basin). This involves comparing water resources and demand in order to obtain a representative image of the water situation on a given date. The assumptions taken into account can be summarized as follows:

- The water demand taken into account corresponds to the demand expressed by users, mainly in the consumption of water and irrigation;
- The value of the water resource taken into account in this balance corresponds to the volume of water regulated by dams and water withdrawals directly from rivers and groundwater.

2.4. Surface water forecast

Algeria currently has 75 dams with a total capacity of 6.5 billion m³, and intends to increase the total number of dams to 139 by 2030 in order to secure the supply of Algeria's water needs [10].

The volumes exploited and the exploitable surface water data come from the Algerian Report of the national debate on water, the national water plan and specific studies carried out for the construction of project dams.

The planned dams are intended to be built further from the place of use of the water, and their construction is increasingly complex and costly in technical and economic terms. They will allow the exploitation of additional water in the region of 5 billion cubic meters. These projects mainly consist of increasing irrigation for areas already equipped for irrigation, and will not make any significant difference in water balances.

2.5. Underground water forecast

The groundwater forecast takes into account the impact of the national water resources strategy measures on inputs and outputs. This mainly involves:

- Implementation of the irrigation water saving program, which will lead to a significant reduction in water withdrawals and irrigation returns;
- Use of surface resources to replace extraction of groundwater. A volume of about 100 billion m³ extracted for drinking water from groundwater is delivered, and replaced by surface water (100 billion m³ per year by 2025);
- Artificial recharge of groundwater. The national water resources strategy has estimated this recharge at around 200 billion m³ per year by 2030, with around 100 billion m³ of treated wastewater;

- Reinforcement of the monitoring system and penalties for over users and the restriction of groundwater pumping (revised pricing framework, removal of subsidies encouraging overuse, implementation of measures for the establishment of protected and prohibited areas, etc...). All these measures are aimed to improve groundwater recharge and reduce water withdrawals in order to help contain demand. Under these conditions, the groundwater balances will slowly balance out, mainly by a decrease in the outflow through natural outlets.

2.6. Unconventional water resources forecast

The unconventional resources mainly consist of groundwater recharge, seawater desalination and wastewater treatment.

The Algerian national strategy for the development of water resources gives an important place to the exploitation of unconventional water resources.

This strategy has estimated the proportion of this resource at around 1.624 billion m³ per year, including 824 billion m³ from seawater desalination and about 800 billion m³ from wastewater.

This water potential is intended to be used for watering green spaces and sports fields and for developing irrigation around urban areas.

3. The use of primary energy in Algeria

The Algerian population is around 45 million people and is expected to reach 50 million by 2030; more than 60% live in the coastal area. Population growth and rapid urbanization have an impact on energy demand and the environment.

Algeria reached 59.6 billion toe in 2017, an increase of + 2.1% compared to 2016 in total national consumption, represents more than a third (35.9%) of total production, this increase is driven mainly by that of final consumption which recorded an increase (+ 4.1%) to reach 44.6 billion toe, driven in particular by natural gas (+ 7.9%) and electricity (+ 6.4%), and 14.9 billion Toe for other non-energy consumption as illustrated in figure 2[11].

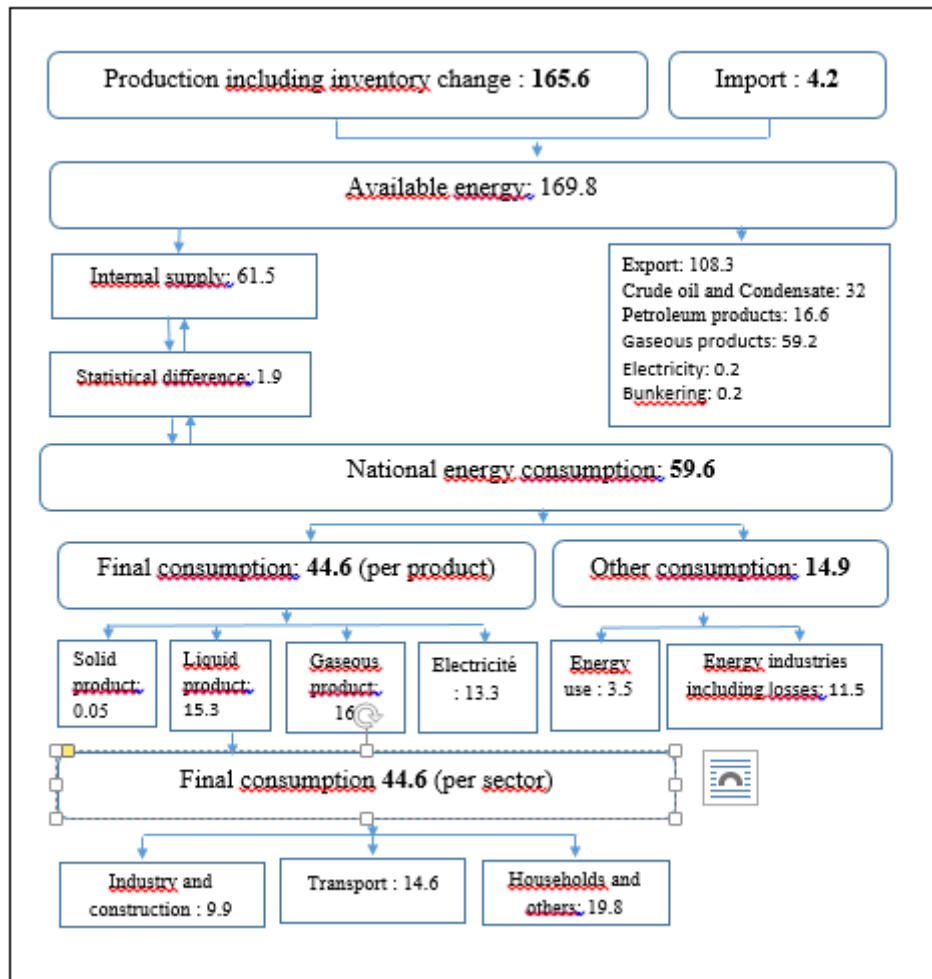


Fig.2.Summary of energy flows in 2017 [billion Toe]

The structure of national consumption remains dominated by natural gas (37%) followed by electricity (30%) and petroleum products (27%), as illustrated below:

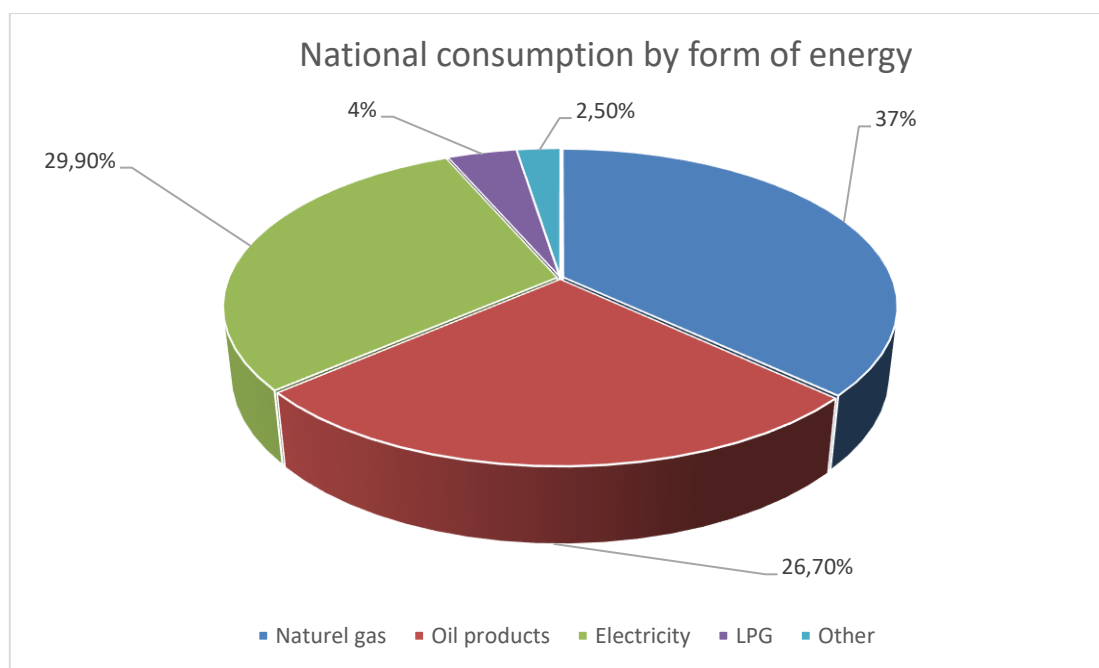


Fig.3. Breakdown of national consumption by form of energy

Also, it should be noted the continued significant increase (7.9%) in the consumption of natural gas to 13.7 billion Toe, induced by the growing needs of customers, especially those in the household sector, where the total number of subscribers reached 5.3 million in 2017, or more than 345,000 new customers. And an increase in electricity consumption (6.4%) to reach 13.3 billion toe, due in particular to the increase in demand from high and low voltage customers (mainly households), including the total number of subscribers exceeded 9.2 million at the end of 2017, as compared to 8.8 million at the end of 2016, representing an increase of more than 4.3% [11].

In addition, the distribution of consumption in the manufacturing industry sector by sector shows the predominance of the building materials industry sector with 60% followed by the chemicals, rubber plastic and the food industry with 17% and 12% successively (Figure 4) [12].

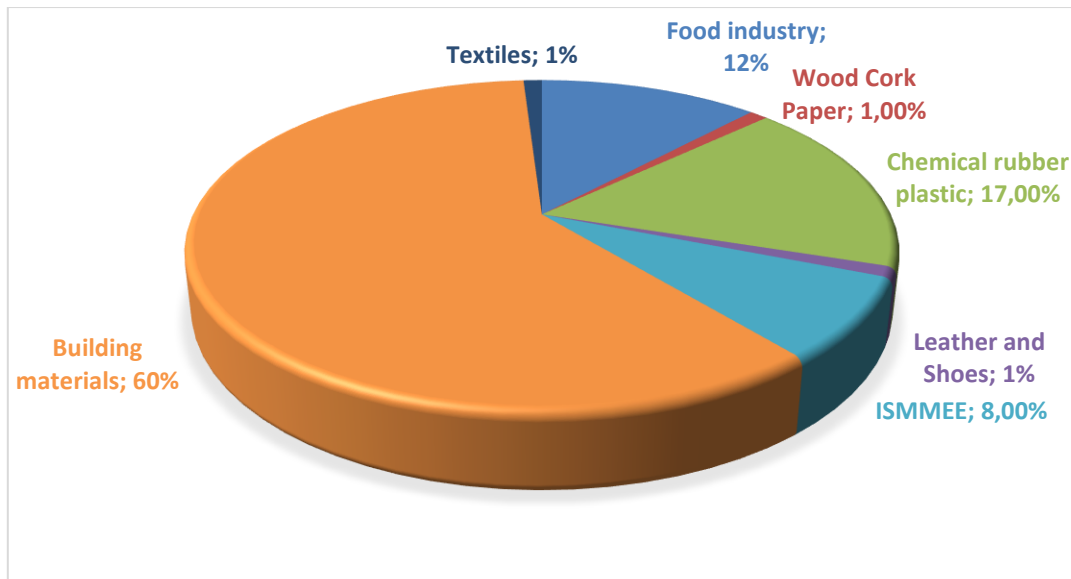


Fig.4. Breakdown of consumption in the manufacturing industry sector by sector

The consumption analysis illustrated in the graph of Figure 2, reveals that consumption is absorbed by the housing, transport sectors and construction industries, respectively 19.8 billion Toe, 14.9 billion Toe, and 9.9 billion Toe. These three sectors represent an extraordinary source for the control of EnM energy, and the EnT energy transition. Indeed, several sectors and several ministerial departments are concerned by this EnT. This means that EnT is a horizontal process, in which the value chains have to be simplified and shortened.

3.1. How is the energy situation in Algeria?

Algeria has 2,500 billion m³ of gas in reserve, and consumption is around 60 billion m³ per year, which means that in 40 years, there is a risk a serious problem of availability of this essential product for the Algerian citizens. Therefore, the kinetics of the natural gas consumption must be quickly curbed.

3.1.1. But how to brake?

- There can be no braking if the focus is not redirected on renewable energies, because Algeria has a huge solar resource, whose solar irradiation is around 3000 kWh / m² / year, and the solar kWh is today, cheaper than thermal kWh.
- It really is a scandal, if natural gas is kept in use in the same way, and with this trend, nothing will be left for future generations.
- The energy sector is moving in parallel on thermal energies, and the partnership with the leader General Electric GE, is the best proof, with this partnership thermal energy in Algeria is confirmed. The time has come, to say; stop, braking and giving way to solar photovoltaic PV and wind power plants.

- The objective for 2021 is to put into service 1000MW PV, this is equivalent to 1.5 billion m³ of natural gas NG which will be saved, the financing of these investments will be made by the funds of the NG not consumed (saved) in 2021.

In addition, the analysis of consumption in general, illustrated in the graph of Figure 2, reveals that consumption is absorbed by the housing and transport sectors, and construction industries, of respectively 19.8 billion Toe, 14.9 billion Toe, and 9.9 billion Toe, these three sectors represent an extraordinary source for the control of EnM energy, and the EnT energy transition [11].

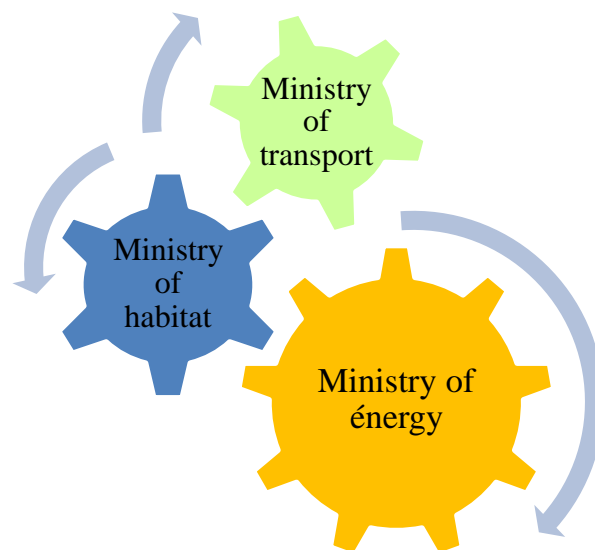


Fig.5. diagram illustrating the horizontal responsibility of several ministries

Indeed, several sectors are concerned by this EnT. This means that the EnT is a horizontal process (figure 5).

3.1.2. What about electricity?

In Algeria, the electricity demand forecast is established by the System Operator (OS), a subsidiary of the Sonelgaz group.

Based on the country's energy policy, OS calculates supply and compares it to demand in two steps:

- A first step in studying the demand for electricity.
- A second step to define an equipment program in order to meet this demand at the lowest possible cost.

It should be noted by analyzing the curves below, that the electricity consumption of the hydraulic sector is 77% (curve on the right), the share of pumping and irrigation is 39% (curve on the left).

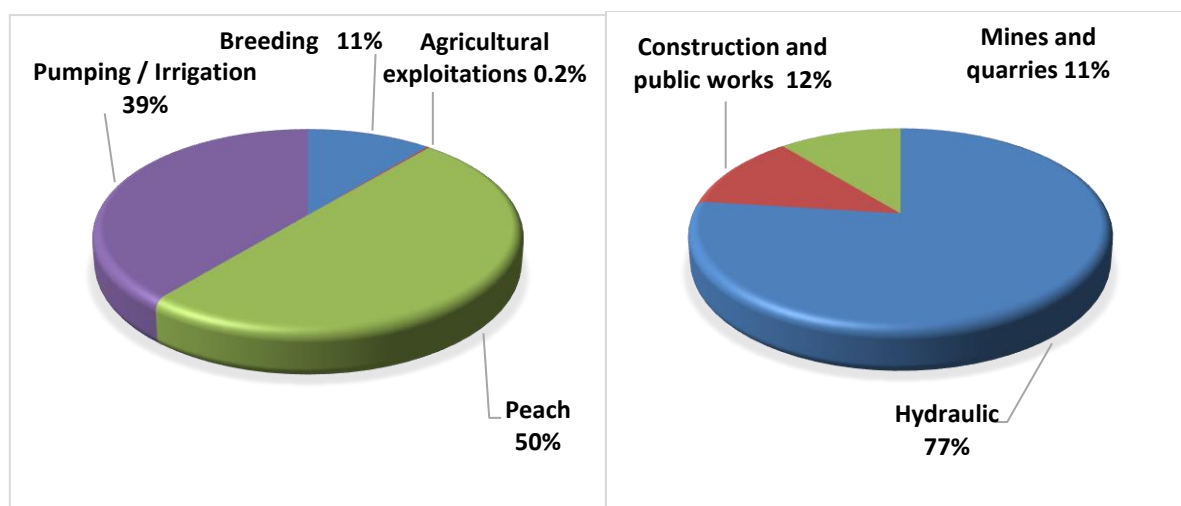


Fig.6.Breakdown of electricity consumption by activity sector "2017"[12]

3.2. Energy requirements for water

As shown in figure 6, electrical energy is mainly used for the operation of pumping and injection stations intended for drinking water, industry and irrigation, as well as treatment stations for drinking water and wastewater treatment plants. It is also used for lighting and for pumping in marine outlets.

The water needs of this sector will have to increase to 16,090 GWh by 2030 (0.7-0.8 kWh / m³). This expected increase is mainly due to:

- The use of energy-intensive solutions eg sea water desalination and water transfer project.
- Use of conventional systems with high energy consumption resources to meet the demand for water. This is the case of water pipes for supplying drinking water to cities.
- Development of sanitation and wastewater treatment activities.

4. Actions to be taken for a successful EnT in Algeria

4.1. Water resources sector

- Introduce new less energy-consuming techniques such as "Reverse freezing-OSMOS hybrid process".
- Encourage the use of solar pumping at agricultural perimeter levels.
- Generalize photovoltaic solar systems in the auxiliary motors of pumping and purification stations

4.2. Housing sector

- Knowing that for domestic hot water represents 400kg of oil per year per house, solar water heater are placed in new homes, an unimaginable number of tons of oil will be saved. Also a solar-heater industry is starting in Algeria, this industry will boost subcontracting towards small and medium-sized businesses, as well as startups.
- Another very important action in the economy of energy is that of thermal insulation that must be required in the new specifications, and no authorization, or building permit, will be issued in the absence of documentary holdings in conformity with this provision in new constructions.
- Impose double glazing in new constructions, with the same guardrail as the insulation
- Establish an incentive system for old dwellings, concerning insulation, and double glazing.
- It is found that the consumption of gas and electricity at mosque levels is far from rational. An operation to replace incandescent lamps with low-consumption lamps, as well as an operation to rehabilitate 1,800 mosques nationwide is proving to be more than strategic.
- Generalize individual and collective photovoltaic systems on buildings, buildings, schools, universities, and all state institutions, and thus, the citizen becomes a producer of the electrical energy he consumes, and the surplus will be injected into the conventional network, and the lessee is responsible for purchasing this energy.

4.3. Transport sector

- The other most important deposit is that of transport, a great waste is seen in this sector, a volume of 15 million tons of oil are consumed annually, of which 12% are imported from abroad. What do we have to do? Should we continue to import as usual?
- The answer is no, the four major sources of energy saving in the transport sector must be found out
- Converting cars to LPG. In fact, 80,000 cars were converted this year 2020, for the year 2021, a program of 200,000 vehicles has been launched, this action will save 200,000 tons of gasoline.

- Algeria will set up a first experiment in its history in the coming days, with diesel / LPG bus vehicles will emerge, which will lead to a saving of 30% in diesel consumption.
- The other niche we need to tap into is CNG, which needs to be generalized quickly.
- Finally, an opportunity to be exploited is electric locomotion. Algeria must include clauses on future vehicle import specifications for this new nature-friendly technique.
- Another action which is not the least, in collaboration with Naftal and the Ministry of Mines, to set up electrical terminals on the gas stations of the EAST / WEST motorway supplied by photovoltaic systems, and prepare thus the ground for electric vehicles that can be charged via a simple socket. The first step is to start with electric buses and electric trains.
- The management is to be guided by the facts, and put in place these terminals at the points where there is representativeness, and where the feasibility and reliability can be demonstrated to road users.
- Knowing that 100kms by an electric car costs 100DA, on the other hand 100kms by a thermal vehicle costs 300DA, this is a coefficient cost of 5 times.
- In addition, combustion vehicles are increasingly being downgraded in Europe.

4.4. Energy sector

- Sonelgaz must be forced to stop commissioning thermal power stations.
- In addition, another company "Sonelgaz Bis", or "Sonelgaz Renouvelables" must be created, because practically all international firms have changed to cope with this new situation of EnT, as an example GE, EDF, ENGIE... etc. "Sonelgaz Bis" will be responsible for supporting the energy transition and bringing the 2020/2035 solar plan to fruition, drawing on its experience of PV plants built and put into service.
- Also, the new "renewable Sonelgaz" must invest in wind energy and geothermal energy, because Algeria has 280 thermal springs which represents a considerable deposit.

4.5. Construction industry sector

- Revise electricity and gas tariffs, lifting state subsidies on these two products.
- Encourage industrial operators to switch lighting parts and less energy-consuming manufacturing processes to photovoltaic systems.

- Require filtration, neutralization, and regeneration systems for gaseous, liquid, and solid wastes.
- Generalize the establishment of systems for detecting and controlling GHG emission levels and liquid waste at the level of all the industrial operators concerned, public and private.

5. Conclusion

Algeria is a semi-arid country, even Arid (200 h 400mm) and water resources are weak, irregular, and located in the coastal strip. The total amount of precipitation would be of the order of 100 billion m³ of water per year, including 12.4 billion m³ in surface runoff, and only 6 billion m³ can be mobilized, The fall in the costs of non-conventional energies on the one hand, and the decommissioning of thermal energy, could stimulate efforts to create and innovate new, less expensive processes for the desalination of seawater, such as renewable energies (solar, wind power, etc.).

The triplet (i) Energy Transition, (ii) the Environment, and (iii) the health crisis are inseparable.

As such, the air of fuel is behind us. By 2030, diesel and gasoline will no longer have the vocation to remain in current civilization, because climate change has already been established for a long time, all nations are heading towards de-carbonization. And very likely, it will be imposed on us in the coming years.

Also, it is high time to evaluate the strategy put in place. Today, the alarm bells have been sounded, and time is playing against us, if we return to our level of gas consumption which is one billion cubic meters per week, that means that by 2040, Algeria we will no longer be able to export, everything will be consumed internally. And at that point, a choice must be made, either we consume what we produce internally or we export it.

The 2020/2035 solar program must be adopted by everyone because it is everyone's business. To meet the current energy challenges, and defeat the energy battle of the post COVID-19. We have to put 1000 MW of solar photovoltaic into service each year, and therefore succeed in the 15000MW solar plan by 2035. To do so, we must find the means to slow down conventional energy, without compromising the standard of living and the availability of energy for citizens. This solar program must imperatively be by a new society that the public authorities must create.

References:

- [1] Zoheir Siouane « Economie- Algérie » Ressources en eau : La demande annuelle à 12,9 milliards de m³ à l'horizon en 2030 Publié le Mercredi, 16 Janvier 2019.
- [2] Chareb Yssaad Ismahane, **Gestion intégrée et économie de l'eau**, janvier 2018.
- [3] Ahmed Kettab, **Les ressources en eau en Algérie : stratégies, enjeux et vision**, August 2000.
- [4] Updating the inventory of national sewerage network ; **document of Algerian Ministry of Water Resources**, September 2012.
- [5] Benblidia Mohamed et al, The efficiency of water use and economic approach; **National Study Algeria**, in June 2011.
- [6] Bouchaala et al, **Ressources hydriques : Traitement et réutilisation des eaux usées en Algérie**, May 2017.
- [7] <https://doi.org/10.24084/repqj14.217> 28 **RE & PQJ**, n ° 14, mai 2016
- [8] Energy Efficiency in the use of hydraulic systems, presentation of the national agency for the promotion and rational use of energy, **International Symposium of the 9th edition SIEE-Pollutec**, May 2013.
- [9] Moncef BOUROUGA, Déminéralisation des eaux de forage de la région d'Ouled Abbès et son impact sur l'environnement Souk Ahras, **extrême Nord-Est Algérien**), 2015.
- [10] Eco-Business Ressources en eau/ **L'Algérie comptera 140 barrages en 2030**, 25 juillet 2017.
- [11] Ministère de l'Energie, **Bilan Energétique National**, Année 2017.
- [12] Rapport annuel de L'Agence Nationale pour la Promotion et la Rationalisation de L'Utilisation de l'Energie « Aprue », **consommation finale**, 2017.

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