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Presented by

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Sustainable energy solution in Algeria: A collection of good practices from SSB Japan's project to provide effective solutions for energy paradigm shift

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DEDICATION

I dedicate this work to my family especially my father **Djibrine Mahamat Hassane**, my mother **Kaka Abdoulaye** and my older brother **Adam Djibrillah**, without forgetting the other members of the big family and friends who supported me by all means to reach this level.

DECLARATION OF THE AUTHOR

By my signature below, I declare that this thesis is my work, which has not been submitted to any other institution for the purpose of obtaining a degree, diploma or certificate. I have followed the academic rules and regulations in completing at this work and that the sources used in this document have been cited to avoid plagiarism.

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ABBREVIATIONS AND ACRONYMS

AEC: Algerian Energy Company

ANDI: National Agency of Investment Development, National Fund for Energy Efficiency

A**PRUE**: National Agency for the Promotion and Rationalization of Energy Use

CDER: Renewable Energy Development Center

CEREFE: Office of the Commissioner for Renewable Energy and Energy Efficiency

CNI: National Investment Council

CNPC: China National Petroleum Corporation

CREAD: Centre for Research in Applied Economics for Development

CREDEG: Research and Development Centre of Electricity and Gas.

CRTSE: Research Centre in semi-conductor Technology for the Energetic

CSP: Concentration Solar Power

CSR: Corporate Social Responsibility

DC: Direct Current

EE: Energy Efficiency

EIA: Energy International Agency

ESCAP: Economic and Social Commission for Asia and the Pacific

FNME: National Fund for energy conservation.

FNRS: Fund for Scientific Research

GDP: Growth Domestic Purchase

GHG: Green House Gas

HTSC: High Temperature Superconducting Cable

IAER: Algerian Renewable Energy Institute

IBS: Corporate Incomes Tax

IEA: International Energy Agency

INDC: Intended Nationally Determined Contributions

IRENA: International Renewable Energy Agency

JICA: Japan International Corporation Agency

JSTA: Japan Science and Technology Agency

LNG: liquefied natural gas

LPG: of liquefied petroleum gas

MEM: Ministry of Energy and Mining

MENA: Middle East and North Africa

MESRS: Scientific Ministry for Higher Education and Scientific Research

MOU: memorandum of understanding

NEAL: New Energy Algeria

NEEF: National Environmental Education Foundation

NFEM: National Fund for Energy Management

NFRE National Fund for renewable energies

NFREC: National Fund for renewable energies and cogeneration

NGO : Non Gouvernemental Organisation

OPEC : Organisational Petroleum Exporting Countries

PAUWES: Pan African University of Water and Energy science

PPA: Power Purchase Agreement

PV: Photovoltaic

PVPS: Photovoltaic Power system

RE: Renewable Energy

REEEP: Renewable Energy and Energy Efficiency Partnership

RPI: Requests for Proposals to Investors

SATREPS: Science and Technology Research Partnership for Sustainable Development

SCJ: Science Council of Japan

SDG: Sustainable Development Goals

SoG-Si: Solar Grade Silicon

SONATRACH: National Society for Research, Production, Transport, Transformation, and Marketing of Hydrocarbons

SONELGAZ: National Company for Electricity and Gas

SSB: Sahara Solar Breeder, **SSBA**: Sahara Solar Breeder Academic, **SSBB**: Sahara Solar Breeder Business **SSBC**: Sahara Solar Breeder Cultural, **SSBF**: Sahara Solar Breeder Foundation, **SSERC**: Sahara Solar Energy Research Centre

TAP: Tax on Professional Activity

TOE: Ton Oil Equivalent

TW: Tera Watt

UCS: Union of Concerned Scientists

UNECA: United Nations Economic Commission of Africa

UNESCO: United Nations Education Scientific and Cultural Organisation

UNEVOC: International Centre for Technical and Vocational Education and Training

UREERMS: Solar Equipment Experimentation Unit in the Sahara Area

URER.MS: Research unit in Renewable energies in Saharan Medium

USD: United States Dollar

USTO: University of Science and Technology of Oran

VAT: Value Added Tax

VLS: Very Large Scale

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ABSTRACT

The global energy demand is projected to increase, even in the face of substantial declines in fossil energy intensity because of energy demand needs of population and economic growth. Fossils fuels could not no longer satisfy the increasing of the world energy demand. Solving the current energy crisis will necessitate long-term prospective initiatives for long-term development. Renewable energy resources appear to be critical in this regard, as well as one of the most efficient and effective alternatives for long-term development. As a result, a move to a more sustainable mix based on the utilization of renewable energy sources, increased energy efficiency, energy conservation, and greenhouse gas mitigation is required. The success of the global energy paradigm shift depends on the development of technological innovation in the energy industries. Solar energy is by far the largest untapped resource and key primary energy exploitable resource among renewable resources. Algeria receives the most solar radiation per square meter of any country on the planet. Under the Sahara Solar Breeder (SSB) project idea, a broad variety of intensive and promising research and development is being done in order to generate technology choices that can allow energy security, climate stabilization, and economic development from solar energy. The goal of this project is to propose effectives solutions for the paradigm shift. The SSB project offers an especially attractive approach in which solar energy must be dispatched to the end user on demand via High Critical Temperature Supra Conductor cables. The anticipated patterns of future energy use and the resulting environmental impacts are thoroughly discussed. Along with the adoption of the SSB project, potential solutions to current problems are identified.

Keys words: energy demand, economic growth, sustainable development **,** paradigm shift , High Critical Temperature Supra Conductor cable, Renewable energy, Sahara Solar Breeder.

CHAPTER I: GENERAL INTRODUCTION

1. Introduction

With the Global population growth, improved living standards and industrial developments will inevitably lead to an increase in energy demand worldwide. According to the International Energy Agency (IEA), global energy needs will increase by 30% by 2040 (IEA, 2017). The world economy is growing at an average rate of 3.4% per year; the world's population will exceed 9 billion in 2040 compared to 7.4 billion todays (Boughali et al., 2017). According to the U.S. Energy Information Administration (EIA), the world's demand for energy is going to increase by nearly 50 % by 2050. Based on EIA projections, this graphic Figure 1 shows that oil and natural gas is expected to supply 52 % of that energy, only slightly less than today's share (55 %) (Green, 2012).

Energy has been at the centre of political and scientific debate for many centuries. it is a central driver for economic and social development as well as environmental and climate issues (Spittler et al., 2019). For decades, the world's energy consumption has come from non-renewable energy sources, 80% of which are fossil fuels (Model, 2017). The energy dependence of countries on these energy sources is leading them towards the disappearance of these fossil resources, which cannot ensure energy security over time. Thus, the global instability of fossil fuel markets, the imperative of environmental protection, the reduction of greenhouse gas emissions and the depletion of non-renewable energy sources are leading countries to define new energy strategies to achieve their energy sector objectives such as the Paris agreements by 2030.

Nowadays, with the emergence of the debate on the sustainability of the energy sector and given the increasing importance of the energy system in achieving the multiple sustainable development goals, it is necessary to think about a sustainable solution of the energy sector (Spittler et al., 2019)

Furthermore, all forms of non-polluting energy and in particular renewable energies (Solar, biomass, hydro power, Wind as well as marine and geothermal power) are the sustainable solutions to ensure the transition. The Renewable energies are more than sufficient to meet all current and future human needs.

However, the transition from the current energy sources (fossil fuels) to the new renewable energy is complex. Due to its unique nature many countries around the world define new strategies energy policy to overcome the challenge of this transition (Model, 2017). One of the biggest concerns for countries dependent on non-renewable energy and seeking to transition to renewable energy is energy security.

As one of the largest countries in Africa and a major player in the world's oil and gas market, Algeria's economy is almost entirely based on oil and gas exports, and the electricity sector relies mainly on natural gas for power generation. Furthermore, energy consumption has been on a clear upward trend due to rapid population growth over the past decade.
Since the late 1990s, Algeria has joined the opinion of the international community and adopted an energy policy for the promotion of renewable energies and was formally introduced in the development of the national economy (Nouioua et al., 2019). The government has set a target to diversify the energy mix by installing more than 22 GW of renewable energy sources and by taking energy efficiency measures, the latter of which should avoid the installation of an additional 150 MW by 2030 (Brahim & Ferreira, 2019).
With the all problem highlighted above, sustainable energy and energy security become important ways for many countries in the world toward the sustainable development. thus each country has to supply in energy continuously without interruption, affordable for people and without damaging the environment to meet the demand.

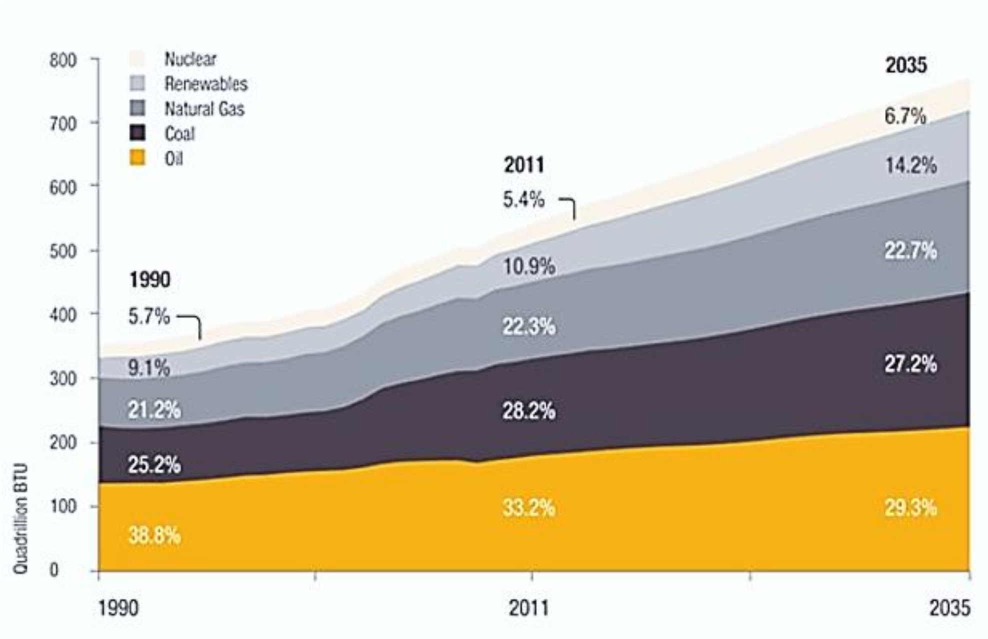


Figure 1: Global energy demand

Source: (Green, 2012)

2. Problem Statement

Global energy demand increased by around 30% from 2011 to 2018 and is expected to double in 2022. Therefore, many countries are moving towards RE to reduce their dependence on fossil fuels and reduce carbon dioxide emissions. They have an interest in RE sources in developing countries, large investments have been introduced along with new renewable energy policies and programs to diversify generation and move towards increased use of renewable energy. Today, the cost of renewable energy technologies is lower than ever compared to decades ago, and the abundance of renewable resources such as solar radiation, wind, geothermal, and biomass has led governments to rethink the use of renewable energy instead of conventional fossil fuels (Zahraoui et al., 2021).

Its large oil and gas reserves as well as its mere size of 2,381,741 km^2 and 43.8 million inhabitants make Algeria an important player in northern Africa as well as on international level (A. Boudghene Stambouli et al., 2012). Algeria is one of the top 5 and top 10 countries in the world for natural gas and oil production. Indeed, Algeria is heavily dependent on hydrocarbons and 94% of its energy currently comes from natural gas, which is 50% of the national GDP. Renewable energy source are still uderdevelopped.

The economic energy sector in Algeria occupies a predominant place in the Algerian economy; hydrocarbons alone represent 60% of budget revenues and 98% of export revenues. Algeria is in 2019 the 16^{th} oil producer, the 10^{th} producer of natural gas and the 7^{th} exporter of natural gas in the world. More than 99% of energy production and consumption, including in the electricity sector, is derived from hydrocarbons. Almost 100% of the population have access to electricity provided by non-renewable energy sources, oil and natural gas (Amine Boudghen Stambouli, 2021).

Conversely, current projections estimate that the country's oil reserves will only cover the next 50 years while those of natural gas will only be available over the next 70 years. According to the International Energy Agency (IEA), a 53% increase in global energy consumption is foreseen by 2030, energy security is becoming a serious issue as fossil fuels are non-RE and will deplete eventually in near future (Boudghene Stambouli et al., 2014). However, Algeria faces a mounting challenge between its dependence on fossil fuels and its capacity for exploiting vast renewable sources.

The country has the important renewable energy source which can allow the Algerian government to reach his objectives of sustainability in the energy sector. Since the sources of energy on which the country's economic activities are based on fossils fuels which deplete over the time. The Algerian government must think about the integration of renewable sources in the energy mix for a sustainable development of its energy sector. The combination of renewable energy from sun, wind, geothermal, and biomass as well as effective and sustainable power generation technologies can potentially contribute to the energy supply of these sectors and move the country towards a more sustainable position in terms of electricity supply. and consumption (Bouferrouk, 2013). Thus the Algerian state has started to consider green solutions by investing in Renewable energy sources. In the framework of the new Program for the Development of Renewable Energy, adopted in 2015, the Government raised the target for renewables to 22 GW by 2030; they will represent 37% of installed capacity and should cover 27% of the country's electricity supply to reach this target of clean energy by 2030 (Amine

Boudghen Stambouli, 2021). Some projects have been undertaken by the government. One of the important projects signed by the Algerian government is the Sahara Solar Breeder (SSB) project between Japan and Algeria for the exploitation of the solar potential of Algeria's desert. This project aims to be a strategic technology for solving the global energy and environment problem for contributing sustainable development. The project is coordinated by The University of Tokyo (TU) and University of Science and Technology of Oran (USTO). So how could the realization of this project solve the problem of sustainable energy development and energy security in Algeria.

3. Research questions and the working hypothesis

The main question of this work is how the SSB project will provide effective solutions for the paradigm shift for Algeria and lately for others countries.

3.1 Sub questions

- What is the role of the government in the energy paradigm shift?
- How to minimize the dependence on gas, a costly dependence?
- Is the SSB project can be reliable energy economic source of Algeria and how it can be profitable for others Africans countries?
- How to ensure energy control in Algeria, how to choose a new model of economic development for the energy sector in Algeria based on the SSB model?

4. Objectives

The main objective of this to provide effective solutions for energy paradigm shift from the Sahara solar Breeder project (SSB).

4.1 Sub objectives

- Identification of the available renewable energy sources and their potential use in electricity generation and identification of the energy major actors and stakeholders;
- Overview of the energy policy established by the Algerian government for energy paradigm shift;
- To provide the measures of the energy efficiency.
- To Assess the competitive advantage of the SSB project.

5. Relevance of your study

In this research, we state all the methods and tools that are used to meet the set objectives. Our project will provide effective solutions for the paradigm shift of Algeria and lately in Africa. Countries that address environmental issues and contribute to sustainable energy are witnessing economic growth because investors and consumers alike choose to invest in eco-friendly companies. Germany and the European Union are aiming for climate neutrality by 2050.To reach this goal, the economy has to be largely decarbonised by switching the energy supply from fossil fuels to renewables by 2050 (Appunn, 2020) . In a 2016 report, 98% of the electricity production in Norway came from renewable energy sources. Why not Algeria, as an example with this project, in the near future followed by other African countries starting from neighbours?

The energy paradigm shift and the protection of the environment are the most important issues facing the world these days. Many countries are endeavouring to invest in RE industries and environmental projects to promote the recovery of their economies as well as create jobs for the unemployed.

Globally, there are more than 759 million people in developing countries without access to electricity (Odarno, 2017). The off-grid electrification proposed by the SSB project can provide energy for private, productive and public purposes. Electrification can directly improve productivity, and therefore income and well-being, in rural areas.

This project aims to solve four keys problem:

- ✓ Energy renewable and safe
- ✓ Water by desalination
- ✓ Create new jobs in a strong future market
- ✓ Peace keeping by development and economic cooperation

6. Tentative thesis chapter outline

This study consists of the following chapters:

- ✓ Chapter 1 Introduction

This will introduce the background information, statement of the problem, knowledge gap, objectives, research questions scope and relevance of this work.

- ✓ Chapter 2 Literature review

This chapter will present the literature review which will include a presentation of the actual energy sector situation and the issues facing it; on renewable energy sources and their potential use; on policy and regulations in the energy sector with emphasis on their weaknesses, strengths and gaps; and finally on the actors and stakeholders with emphasis on the role they can play in the success of the SSB project and energy paradigm shift.

- ✓ Chapter 3 Methodology and description of case study areas

The third chapter will briefly describe the methods and means used to carry out the study and the detailed description of the assessment of the SSB project.

- ✓ Chapter 4 Results and discussions

To present the main possible perfectives solution in the energy sector from the SSB project model.

- ✓ Chapter 5 Conclusions and Recommendation

To highlight the key results of this study in relation to the overall problems, research and questions.

CHAPTER II: LITERATURE REVIEW

This chapter will present the literature review which will include a presentation of the actual energy sector situation and the issues facing it; on renewable energy sources and their potential use; on policy and regulations in the energy sector with emphasis on their weaknesses, strengths and gaps; and finally on the actors and stakeholders with emphasis on the role they can play in the success of the SSB project and energy paradigm shift.

I. Defining energy concepts

For the understanding of the content of this work, the definition of some important concepts used in this study is necessary. These concepts can have a diverse meaning depending on the context in which they are used. Thus, an overview can facilitate the understanding of the context of this work.

I.1 Energy paradigm shift

According to (Will Kenton, 2019), the term paradigm shift refers to a major shift in the concepts and practices of how something works or is achieved. A paradigm shift can take place in a wide variety of contexts. In technology, paradigm shifts often occur when a new technology is introduced that radically changes the production or manufacturing process of a good or service. paradigms are important because it define how we perceive reality. In the context of the energy paradigm, this term also refers to the energy transition, means the change or integration of new production or transformation technologies in the energy sector. With the problems caused by the fossils fuels, the new energy paradigm shift is about to increase the capacity of renewable energy in the global energy mix. All the countries around the world look for a new energy system model based on renewable energy sources.

I.2 Energy transition

The process of energy transition means moving from a national model of energy production and consumption to another model, according to a comprehensive vision. It is the change from one mode of energy production and consumption to another more efficient mode of energy production and consumption. This transition model is correlated with the availability of country-specific energy sources, environmental protection, the culture of society and the political will of governments (Boughali et al., 2017). The energy transition represents a way to transform the global energy sector from a fossil sector to a carbon-free sector by the second half of this century. The focus is on the need to reduce energy-related CO_2 emissions to limit climate change impact (IRENA).

Energy concerns, due to fear of losing export capabilities and growing domestic demand, have led to the opening of the discussion in recent years about the necessity of an “energy transition," especially after half a century of Algeria's energy independence and nationalization of its fuels. Respond to the requirements of sustainable development and the new international standards for changes.

The energy transition has become a necessary and inevitable matter for Algeria due to the internal changes related to the decline in the national reserves of oil and gas and the increase in the domestic demand for energy, and the external variables, especially the global shift towards renewable energies, are pressing on the Algerian decision-maker to respond to these changes.

On this basis, Algeria has approved an energy transition program that seeks to promote the use of renewable energies, avoid energy deficit and increase production. The renewable energies program aims to achieve a mix of energy in electricity production in which the contribution of renewable energies is within 27%; This means that by 2030, about 40% of the total electricity production for domestic consumption will come from renewable energies (Chahar, 2018). Because the future will be towards renewable energies, any investment in it is a long-term investment in the future.

The energy transition is based on technological progress and political will in the broad sense (governments, populations, NGOs, economic players, etc.). The programs put in place are based mainly on the gradual replacement of fossil and nuclear energies by an energy mix favoring renewable energies, as well as on a reduction in consumption, a policy of energy savings and reduction of energy waste, in particular through the improvement of energy efficiency and behavioral changes in terms of consumption. The transfer of certain energy uses to electricity (such as the electric car) is also part of the energy transition as announced by the Minister of Energy (Transition Énergétique : Définition, Enjeux - Tout Savoir Sur La Transition Énergétique, 2019).

The concept of energy transition first appeared in Germany and Austria in 1980 in the form of a white paper, followed in Berlin by the first congress on the subject. The gradual shift from carbon-based, polluting or risky energies to clean, renewable and safe energies (solar, wind, geothermal, hydraulic and tidal) responds to a series of complementary issues:

- Reduction of greenhouse gas emissions;
- Securing of energy systems (in the long term, abandonment of nuclear power);
- Decentralization and redevelopment of infrastructure, with a better distribution of jobs that cannot be relocated;
- Reduction in consumption (energy efficiency);
- Reduction of inequalities in access to energy and progress in energy independence
- Protection of the health of populations.

I.3 Sustainable energy solution

Sustainable Energy Solutions encompass renewable power received from wind, solar, biofuels, biomass and waste, geothermal and small hydro in addition to technology and strategies that lower the quantity of power used consistent with unit of financial output. One of the important thing factors of sustainable improvement is to make certain commonplace get entry to affordable, reliable, sustainable and cutting-edge power, a purpose that SDG-7 asserts concretely (United Nations Industrial Development Organization, 2018).

Energy is a crucial engine of modern economies. As shown in Figure 2, companies use primary energies such as nuclear energy, fossil fuels and renewable energies to generate a usable energy stream in the form of heat, energy and work that provides the energy services, on which we depend. Faced with the serious problems of climate change related to the use of nuclear and fossil fuels, society is moving towards sustainable energy solutions, which are combined with the drive to make the most of the resources consumed by energy efficient technologies. Energy efficiency and renewable energy sources offer opportunities that will certainly be part of any green growth policy.

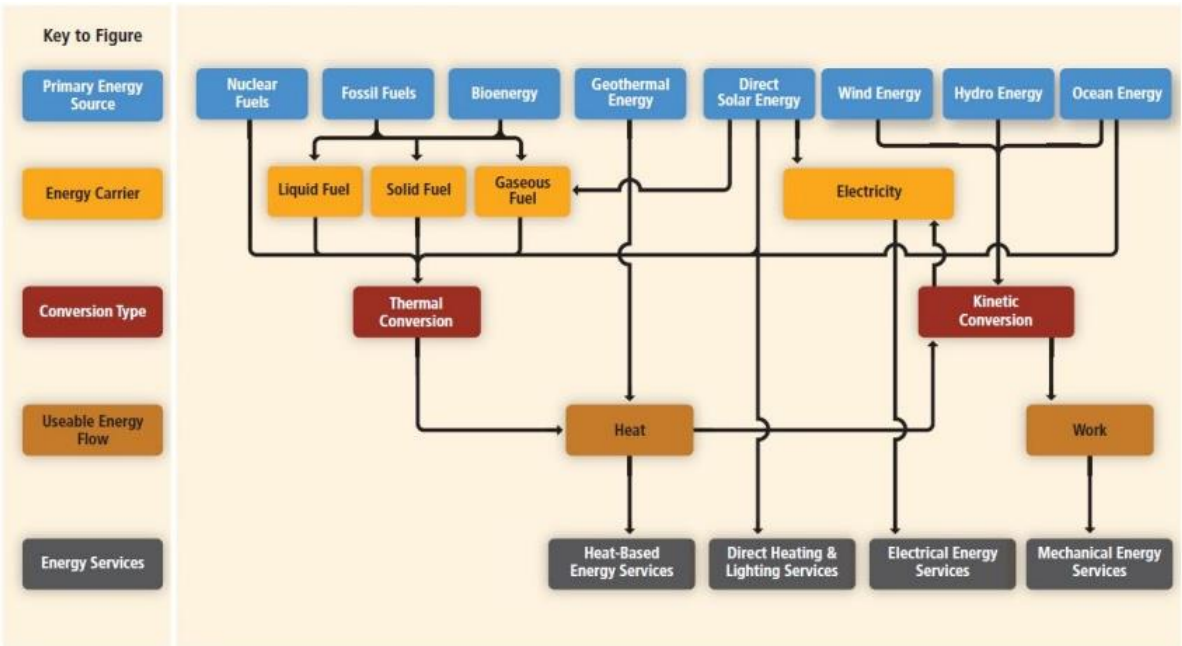


Figure 2: The paths of energy from source to service

I.4 Energy Security

In recent years, energy security concerns have moved to the fore on the global agenda for two main reasons: The first is unpredictable supply: the region's economies have faced high and often volatile energy prices, associated with energy, particularly oil and gas Disruptions in supply caused by political instability in some of the major supplier countries. The second reason is the increased demand: Rapid industrialization and impressive economic growth, for example, are increasing oil consumption, and China and India in particular have developed into economic powerhouses (ESCAP, 2008).

According to the analysis of (Azzuni & Breyer, 2017), energy security, as a universal concern, has received great attention and has been the subject of many studies within different fields of science, policymaking, national energy policies, politics, international relations, and as a national security issue. The concept of energy security that prevailed for nearly forty years (after the 1970s energy crisis) was based on the relatively plentiful availability and easy access to fossil fuels, while the greatest threat to the world's energy source was disruption of the production of fossil fuels. Although there is no internationally agreed definition of the term, a country is generally understood to have energy security if it is protected against shortages of affordable fuel and energy resources (ESCAP, 2008).

Hence, the old paradigm could be briefly summarized as "stable and continuous supply at affordable prices". The importance of this problem was indicated by the joint statement by geopolitical strategists, investment bankers, geologists and physicists about the foreseeable depletion of oil and natural gas, as well as the "final countdown" that had begun in extracting oil resources to an acceptable "energy price"(Milina, 2013). For (BAUMANN, 2008) energy security usually is defined as “reliable supplies at reasonable price of energy. In other words, stability, energy security is all about security. It implies the diversification of producers and energy supply channels (Falaras et al., 2018). Any prolonged interruption in a steady and abundant flow of energy would cause great harm to a nation's economic performance, political stability, and the personal well-being of its citizens. Our societies are completely addicted to energy services like gas stations or electricity.

However, energy security goes beyond the supply of affordable energy without any interruption. There are some dimensions and parameters that need to be taken into consideration in order to address the most essential aspects of energy security. Thus, as Algeria wishes to address the issue of energy security, the government can address the most important aspect of energy security that will solve the problem. (Azzuni & Breyer, 2017) stated that any dimension or parameter that has a relationship with energy security should be addressed. These parameters are summarised in the table (Appendix).

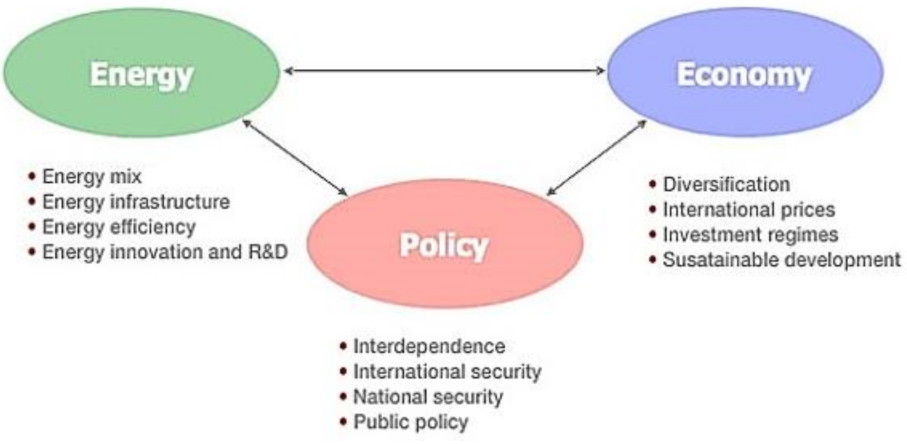


Figure 3: elements of energy security

Source: (cambridge insight, 2017)

II. Global Energy mix

Because three-quarters of the world's greenhouse gases come from energy generation from the combustion of coal, oil and gas. we need to make a swift transition from them to low carbon sources. As we continue to add renewables, most of the world's energy is still fossil fuel sources, 84% of the energy in 2019. Renewable energies and just over 4% nuclear energy (Ritchie & Roser, 2020). The Figure 4 is shown in the chart which gives a breakdown of the global energy mix by source.

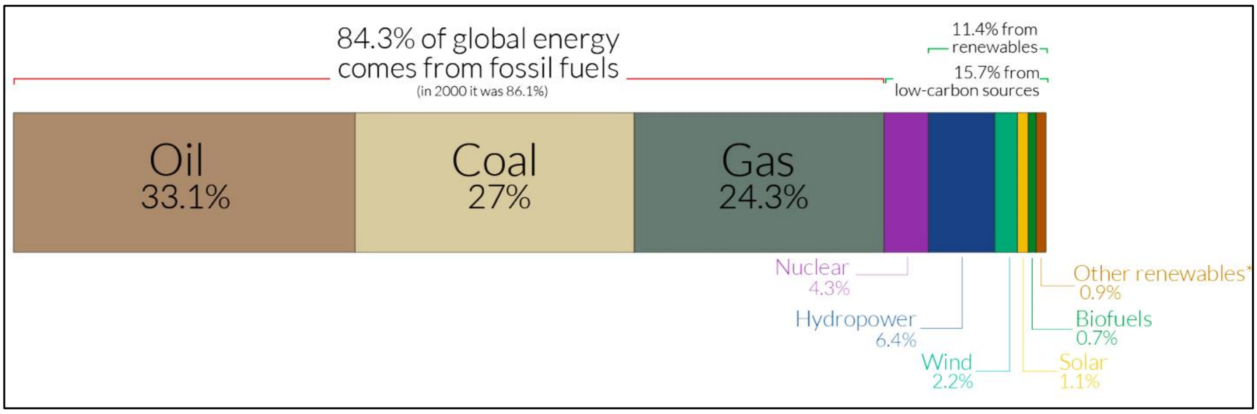


Figure 4: global energy mix by source

Source: (Ourworldindata, 2020)

III. Energy sector of Algeria

Algeria's energy sector is dominated by fossil fuels. Algeria is one of the largest producers and exporters of oil and gas. In recent years, the government has undertaken several policy programs and regulations to promote renewable energy in the energy sector in order to avoid being affected by the contingencies of non-renewable energy. The country has all the necessary sources to achieve its goals. However, there are some obstacles and challenges that hinder the progress of these programs.

III.1 Energy resources in Algeria

III.1.1 Fossils fuels energy

In Algeria, as on a global scale, the energy sector is one of the main drivers of climate change. According to the report of the Union Economic Commission for Africa and its North Africa office in 2011, Algeria has large reserves of oil and natural gas and depends heavily on these resources to generate export revenues. The oil and gas sector accounts for 45.9% of Algeria's GDP. Total hydrocarbon exports accounted for almost 98% of total exports in 2007 (Hasni & Malek, 2021). With an export turnover of nearly USD 56.1 billion in 2010 by SONATRACH, Algeria is the 4th largest exporter VLS (LNG) in the world, the 3rd largest exporter of liquefied petroleum gas (LPG) and the 5th largest exporter of natural gas. In addition, the North African country's energy consumption is increasing due to economic growth, population growth and increasing energy consumption per capita. Between 2002 and 2011, average energy consumption increased by 5.7% (UNECA 2011) (Minister, 2020).

III.1.1.1 Oil

It is undeniable that oil, christened “black gold”, fuels the global economy. Oil converted into petrol and diesel fuels our various modes of transportation that allows for the movement of goods and people around the globe (Darkwah, 2010).

Despite the fact that Algeria first discovered oil in 1956, the National Energy Council believes the country still has great hydrocarbon potential. Algeria is considered to be little explored. In recent years, SONATRACH has made significant oil and gas discoveries. in collaboration with foreign companies who now expect to significantly increase Algeria's crude oil production capacity in the coming years (Dib et al., 2012). The national energy company Sonatrach plays (by mandate) an important role in the exploration, production, marketing and transport activities in Algeria and has foreign branches in ten countries.

Therefore, Algeria plays a significant and strategic role geopolitically and within OPEC**.** Algeria's proven oil reserves remain at 12.2 billion barrels, but are expected to be revised upward in coming years. Algeria should also see a sharp increase in crude oil exports over the next few years due to a rapid shift towards domestic natural gas consumption and planned increases in oil production. Algeria's Saharan Blend oil is among the best in the world (Dib et al., 2012). The exploitation of fossil resources is 95% managed by Sonatrach. The table 1 below shows the main refineries that exploit oil.

Table 1: Oil refinery of Algeria

Refinery	Owner	Distillation capacity (Kb/d)
Adrar	CNPC/Sonatrach	13
Algiers	Sonatrach	58
Arzew	Sonatrach	90
Hassi Messaoud	Sonatrach	27
Skikda	Sonatrach	462
Total		**650**

Source: (El Ghazi et al., 2021)

III.1.1.2 Natural Gas

Algeria's hydrocarbon reserves are dominated by its larger natural gas reserves compared to crude oil. A declining or, at best, stagnating natural gas production and rapid domestic gas consumption growth have combined to constrain Algeria's gas export potential (Ouki, 2019). The country has been producing, consuming and exporting natural gas for several decades. The largest natural gas field, Hassi R'Mel, was discovered in 1956 and has proven reserves of approximately 85 trillion cubic feet (Tcf) in the center of the country, northwest of Hassi Messaoud, more than half that of Algeria. Proven natural gas reserves Algeria's remaining natural gas reserves are located in the southern and southeastern regions of the country (US Energy Information Administration, 2019). Algeria has almost 160 trillion cubic (figure 7) feet of proven natural gas reserves, ranking it in the top 10 worldwide (El Ghazi et al., 2021). Natural gas is the fastest growing fuel of choice for electricity generation (99% of electricity is produced from natural gas) and has also gained an increasing importance in emerging economies (about 98% of exportation and contributes 50% of GDP). The three main segments of Algeria's domestic natural gas consumption are power plants, the public gas supply sector (household, commercial and small/medium-sized industrial customers) and large-scale industry. Currently, the electricity sector, where natural gas accounts for 98% of total fuel consumption, makes up the majority of total domestic gas consumption. Similar to oil, gas is a non-renewable resource, the reserves and production of which are concentrated in a few countries and regions, and most nations rely on imported supplies. However, there are important differences between the energy security concerns associated with the oil and natural gas traded around the world. Energy sources (Hain, 2002). Algeria was the second LNG exporter in 1998 with 22% of the world's total volume, but after a complete renovation of its LNG facilities, Algeria's LNG production capacity will be even higher (Dib et al., 2012).

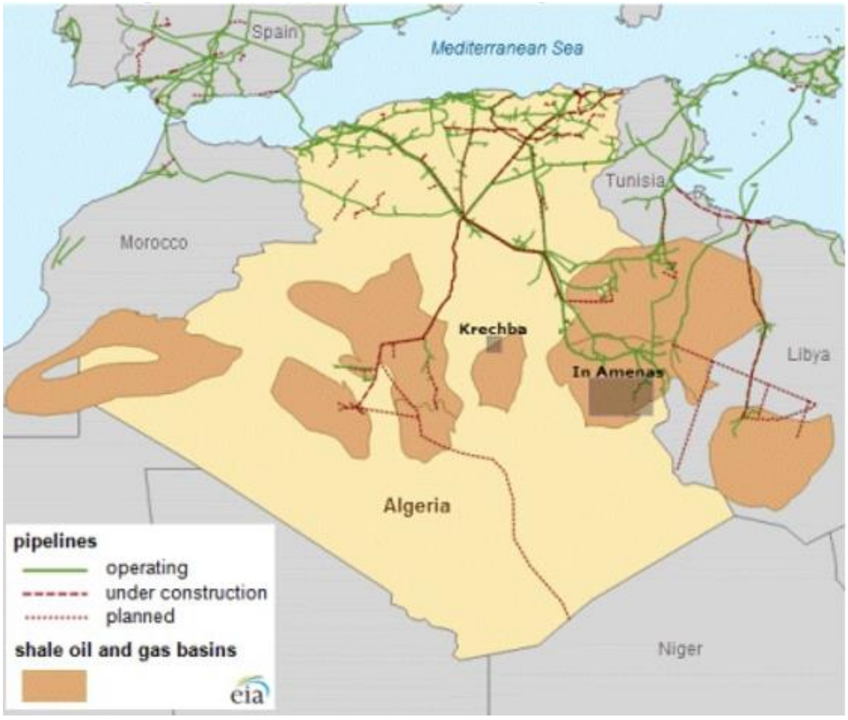


Figure 5: Oil and Gas Pipelines

Source:(SouthFront, 2018)

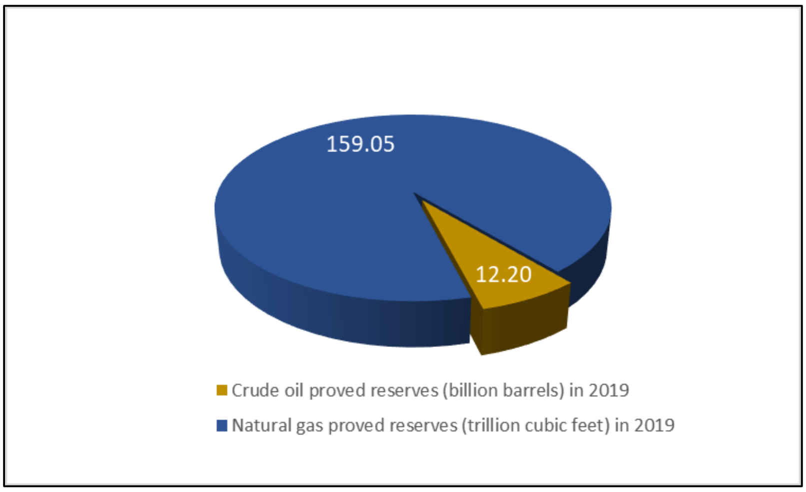


Figure 6: Fossils Fuels Reserves

Source: (El Ghazi et al., 2021)

III.1.2 Renewables energy potentials

(Holt & Pengelly, 2008) defined renewable energy as energy sources that are continually replenished by nature the sun, the wind, water, the Earth's heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy most often electricity, but also heat, chemicals, or mechanical power. Renewable energies are also referred to as "green" or "clean" energies. The low environmental impact of their exploitation makes them a major element of companies CSR strategies for sustainable development.

For (Nouioua et al., 2019) all renewable energies are generated by non-fossil energy sources that are inexhaustible: solar, wind, biomass, hydroelectric, underground, wave and tidal.

Therefore, renewable energy is an energy resource that is automatically generated and renewed in nature at a rate equal to or faster than the consumption rate of this resource. The term renewable energy is not a new term known to the world recently, but energy available in nature, it has been taken care of for centuries instead of fossil energies.

The development and use of renewable energies has seen strong growth in recent years, and by 2030 every sustainable energy system will be based on the rational use of traditional sources and greater use of renewable energies. For (Belmili et al., 2008) the decentralized generation of electricity from renewable energy sources offers more security of supply for consumers while at the same time protecting the environment.

REs sources are an essential part of a comprehensive strategy for sustainable development**.** RE**s** offer our planet a chance to reduce carbon emissions, clean the air and put our civilization on a more sustainable footing. They help ensuring a sustainable supply and climate protection. In addition, REs sources can help improve the competitiveness of industries in the long term and have a positive impact on regional development and employment. REs will provide a more diverse, balanced and stable source. This is what many countries around the world are targeting to meet their energy need. (Amine Boudghen Stambouli, 2021).

Through the national RE program, Algeria intends to position itself as a major player in the production of electricity from photovoltaic and wind energy sectors by integrating biomass, cogeneration, geothermal energy and beyond 2021 the solar thermal. These energy sectors will be the engines of sustainable economic development capable of stimulating a new model of economic growth. The general objective of this program is to reach 37% of the installed capacity by 2030 and 27% of the production of electricity intended for national consumption from renewable sources (Amine Boudghen Stambouli, 2021).

IV.1.2.1 Solar energy

The geographic location of Algeria offers to the country one of the highest solar potential in the Mediterranean region as well as in the world (Brahim & Ferreira, 2019). The solar potential in the world is estimated at 13.9 TWh per year. The solar energy has been used in the past. According to (Amine Boudghen Stambouli, 2002), the history of using solar energy in Algeria backs to 1954 with the solar furnace built by the French for ceramic fabrication purpose. The insulation time over the quasi-totality of the national territory exceeds 3000 hours annually and may reach 3500 hours (high plains and Sahara) (Unies, 2012). The country receives annual sunshine exposure equivalent to 2,500 kWh/m^2. Which corresponds to a capacity 8 times higher than the natural gas reserves of the country, and the largest solar fields in the world (Abada & Bouharkat, 2018). Daily solar energy potential varies from 4.66 kWh/m^2 in the north to 7.26 kWh/m^2 in the south (Zafar, 2020).

If we were to compare solar energy to natural gas, Algeria's solar potential is equivalent to a volume of 37,000 billion cubic metres, i.e. more than 8 times the country's natural gas reserves, with the difference that solar potential is renewable, unlike natural gas (Unies, 2012).

Table 2: Algerian solar potential in sunshine duration and energy received

	Coastal Region	Highlands	Sahara
Area (%)	4	10	86
Average sunshine duration (hour/year)	2650	3000	3600
Average received energy (kWh/m^2/year)	1700	1900	2650

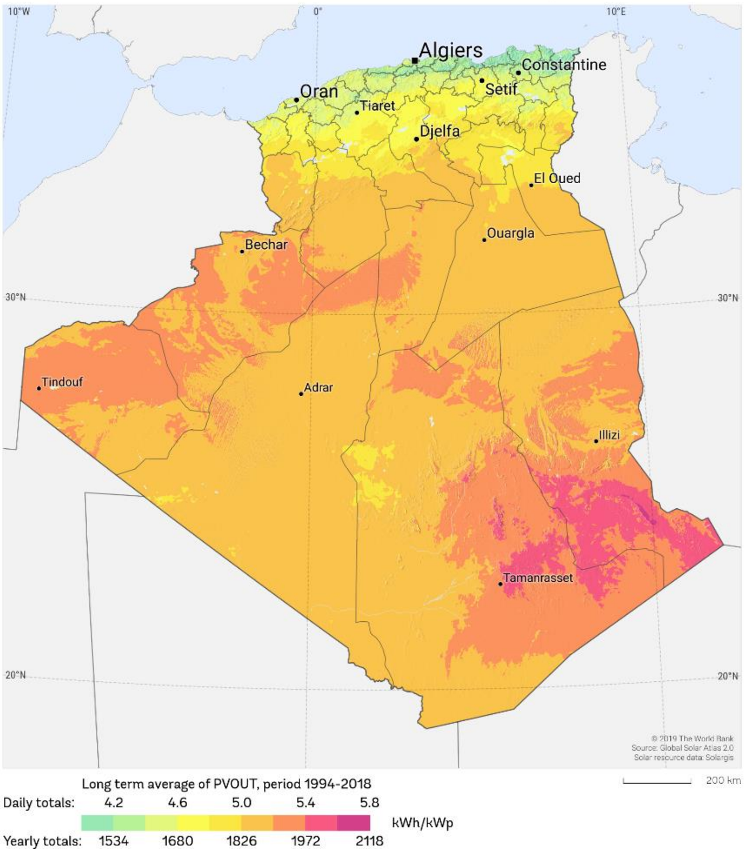


Figure 7: Photovoltaic power potential of Algeria

Source: (Solargis, 2020)

III.1.2.2 Wind

wind energy is the energy produced by wind (Dib et al., 2012). This amount of energy produced by a wind turbine depends primarily on the speed of wind but also on the area swept by the blades and the air density. Wind power usually ranges from a topographic area to another, also it depends on the climate too. Algeria’s climate ranges greatly between the northern and the southern halves of Algeria. The northern half is unique because it acquires an ideal location on the Mediterranean, it has the Atlas Mountains and other high plains. But the northern winds aren’t as strong as the southern ones. The southern wind speeds range from 4m/s - 6m/s, but most southern lands are lower in latitude than the northern region, whereas desert represents more the 70% of the total Algerian surface area.

Algeria has a promising wind power potential of around 35 TWh / year. Almost half of the country has significant wind speeds. The country's first wind farm is being built in Adrar with an installed capacity of 10 MW with substantial funding. of the state company Sonelgaz. Adrar is considered to be the most suitable place as it’s famous for operating, and providing strong winds. Having strong winds around a high hill or ridge can provide a good power plant (Hadji, 2016).

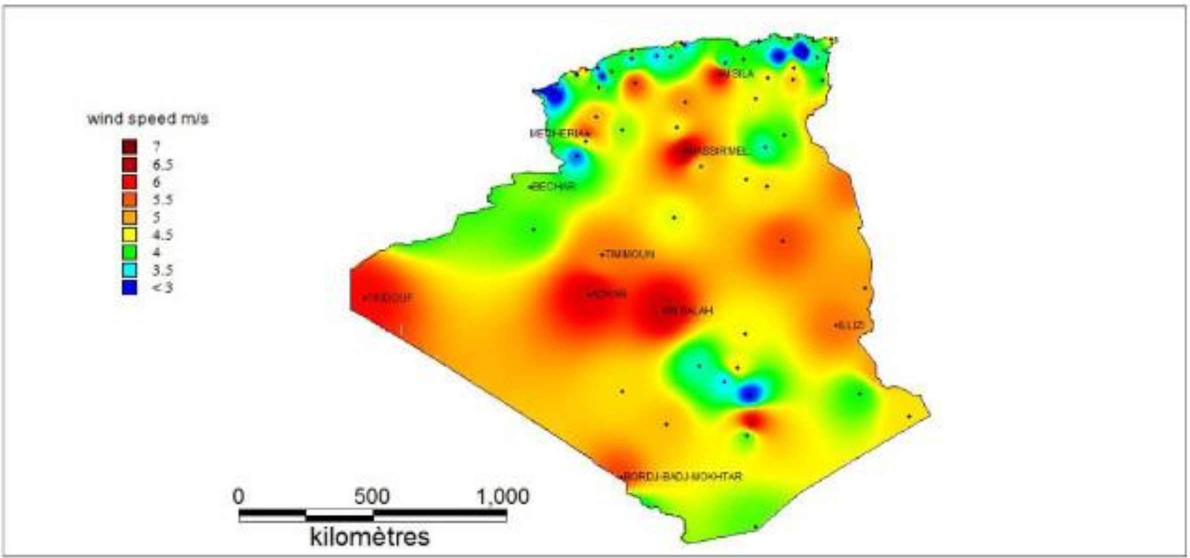


Figure 8: Wind energy potential

Source: (Energy minister, 2010)

The potential for wind energy generation in Algeria depends on the availability of the wind resource that varies with location. Understanding the site-specific nature of wind is a crucial step in planning a wind energy project. The Figure 8 show the places where wind has a good power output.

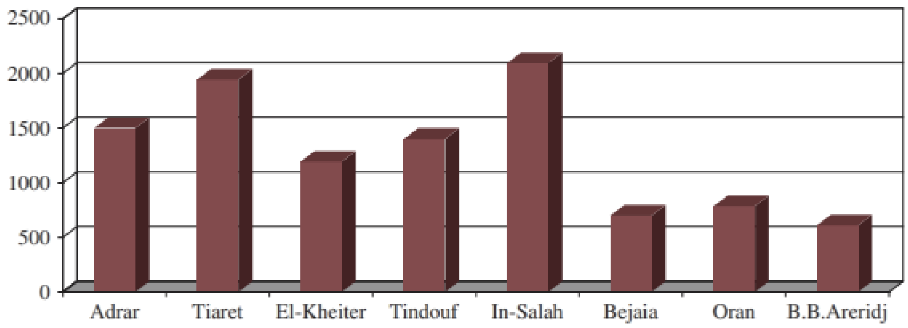


Figure 9: Average power output in the eight identified windy places

III.1.2.3 Hydropower

Algeria has a promising potential for hydropower production due to the availability of dam sites and high average rainfall. The overall quantities falling on the Algerian territory are significant, but benefit the country little: reduced number of days of precipitation, concentration on limited areas, high evaporation, rapid evacuation towards the sea. Schematically, surface resources decrease from north to south. The useful and renewable resources are currently estimated at around 25 billion m^3, of which about 2/3 are surface resources (Energy minister, 2010).

Currently, very few studies have examined the potential for hydropower in the country. In a study by (Zahraoui et al., 2021), it was found that the average rainfall in Algeria is estimated at 65 billion cubic metres per year, 103 potential sites for dams were identified. More than 50 dams are currently in operation.

Figure 10: Potential dam and river locations in Algeria for hydropower generation.

The government has decided to close the country's hydropower plants on a long-term basis and dedicate the electricity-generating dams to irrigation and drinking water supply for the population. This decision to stop generating electricity from the dams is due to the fact that the production level of the hydropower plants remains "negligible", which adds very little to Algeria's energy balance (ArabToday, 2014). 99% of the energy consumed come from naturel gaz. Now, only two dams generate power in Algeria, namely Ighil Emda Dam in Kherrata (Bejaia) and Erraguen Dam in Jijel (Arabtoday, 2014).

Table 3: Hydropower plants stations

No	Station	Capacity (MW)
1	Draguina (Bejaia)	71.5
2	Ighil emda (Bejaia)	24
3	Mansoria (Bejaia)	100
4	Erraguene (Jijel)	16
5	Souk el djemaa (Relizane)	8.085
6	Tizi meden (Tizi ouzou)	4.458
7	Ighzenchebel (Algiers)	2.712
8	Ghrib (Ain defla)	7
9	Gouriet (Bejaia)	6.425
10	Bouhanifia (Mascar)	5.700
11	Oued fodda (Chlef)	15.6
12	Beni behdel (Tlemcen)	3.5
13	Tessala (Algiers)	4.228
	TOTAL	269.208

III.1.2.4 Biomass Energy

Algeria has good biomass energy potential in the form of solid waste, date palm biomass, crop residues and forest residues. Solid waste is the country's best source of biomass potential. Solid waste in Algeria, annual municipal waste generation is more than 10 million tonnes. Solid waste is usually dumped in open landfills or incinerated for no reason (Zafar, n.d.).

The biomass in Algeria potentially offers great promises with bearing of 3.7 million of Toe coming from forests and 1.33 million of Toe per year coming from agricultural and urban wastes (365 kg per Algerian as urban wastes); however, this potential is not enhanced and consumed yet. In recent time, they are starting to use recycled jute bags to minimize the impact of solid wastes.

A pre-survey showed the feasibility of production of electricity by modals of 2 MW that can reach a peak of 6 MW from the discharge of Oued Smar in Algiers which interested the regulations from the MEM. This is seen as a first step in stimulating much faster the use of biomass in Algeria.

Biogas is also an attractive and relatively inexpensive energy source. In addition, the elimination of biogas through combustion is imperative to protect the environment; specially to protect the atmosphere from the emission of unburned methane contained in biogas. In the UREERMS (Solar Equipment Experimentation Unit in the Sahara Area), a gradual increase in the use of biogas, especially from landfills, has begun, which is seen as an advance in the use of biogas in Algeria. Biomass gasification is a promising alternative to combustion. Proven and efficient technologies such as gas turbines and combined heat and power plants can be used with gaseous biogenic fuels. Algeria has a lot of high-quality arable land and uncontaminated soils that are absolutely rich in minerals, which makes it a good choice for growing soybeans, corn and wheat, etc. The Deglet Nour date originally comes from Algeria, which is still the world's largest producer of Deglet Nour dates and is mainly grown in the Algerian province of Biskra, in the Tolga and M'Chouneche oases. since their wastes are generally responsible for many pollution problems, but they can be solved by generating renewable energy from them. Animal or vegetable waste can eventually become a high-calorie source of energy (Hadji, 2016).

III.1.2.5 Geothermal

The hot spring inventory was updated with more than 240 identified springs, the highest recorded temperatures were 68 ° C for the west zone, 80 °C for the central zone and 98 ° C for the east zone. The thermal springs have an average temperature of 50 °C. The northeastern part of the country is still the potentially most interesting geothermal area with an area of 15,000 km^2, with the Barda spring 100 L / s and another spring in the area with the highest temperature of the country (98 °C). An estimate of the heat output from about 30% of the country's sources is 642 MW, in another study it is 700 MW (REEEP, 2012); based on a mean annual atmospheric temperature of 18 °C for the northern areas and 30 °C for the central or Sahara area. Some greenhouses at Ouargla and Touggourt in the central region are reported to be using about 60°C geothermal water for heating (Saibi, 2009). The figure 11 below show the potential of areas of geothermal energy source. There are high temperature springs that can reach 118 °C in Biskra. Studies on the thermal gradient have identified three areas with a gradient exceeding 5 °C/100m (REEEP, 2012).

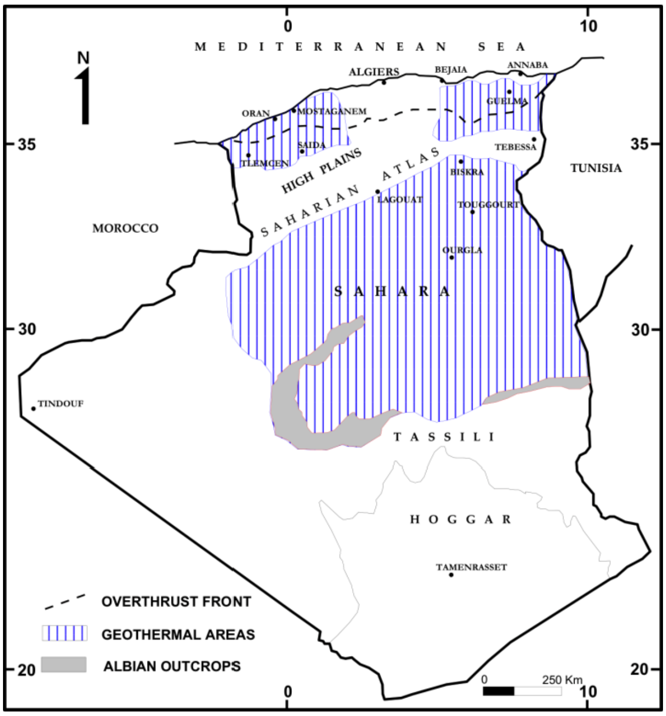


Figure 11: Potential geothermal areas

III.2 Electricity supply and demand

III.2.1 Installed electricity capacity

According to the latest data from the Sonelgaz website, Algeria has an installed electricity capacity of 22,979 MW (Sonelgaz, 2020). The structure of installed capacity of 2018 which was 20,964 MW by origin is dominated by the share of gas turbines (55%), followed by combined cycle (29%), and steam turbines (11%).The remaining 5% is shared between diesel, hydro and RE (Ministery of energy, 2019). This installed capacity is projected to grow up to 36 GW in 2028, representing an annual increase of six per cent. This is due mainly to structural changes in the national load curve, shift from winter peak to summer peak demand, primarily as a result of climate change and the large-scale use of air-conditioning (Ouki, 2019).

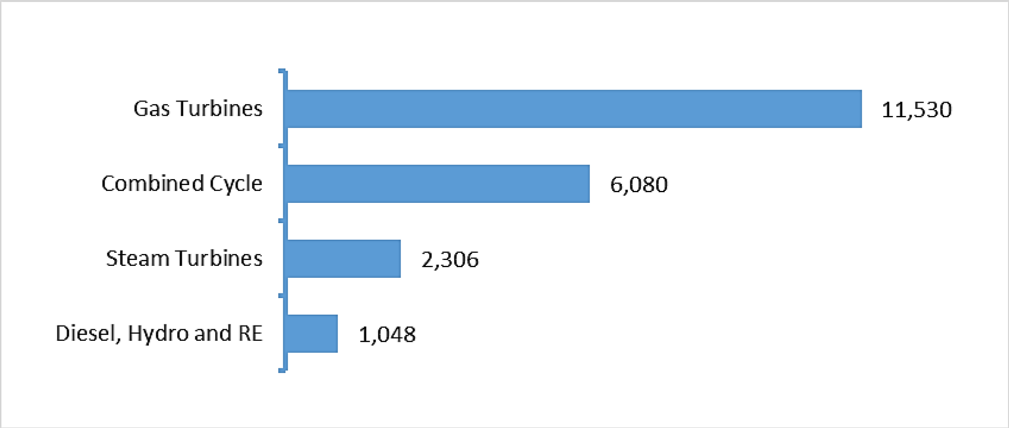


Figure 12: Installed Electricity Capacity by Source in Algeria (MW), 2018

Source: (Ministery of energy, 2019)

According to the REN21 initiative's Global Renewable Energy Status Report, Algeria ranked third in Africa in terms of installed renewable energy capacity at the end of 2020, after South Africa and Egypte, the REN21 report, which brings together scientists, governments, NGOs and industry, said. Through its national renewable energy program to achieve 22 GW by 2030, Algeria has initiated several projects and partnerships for the construction of renewable energy plants, particularly solar. According to IRENA statistics, the country has a total renewable energy capacity of 686 MW in 2020 (IRENA, 2021). The following Table 2 shows the different capacities by renewable energy source.

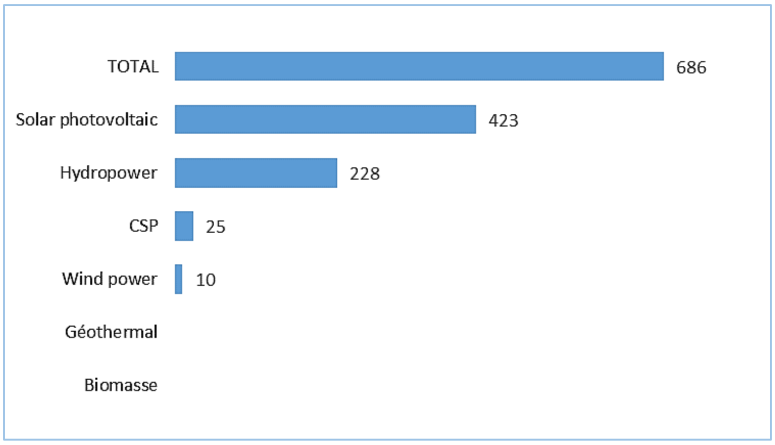


Figure 13: Renewable energy capacity installed (MW),2020

Source : (IRENA, 2021)

The same report (IRENA, 2021) states that 433 MW (about 63%) of the total installed capacity is off-grid. Some localities in the country are very far from the electricity grid, particularly those in the southern region. However, this has not prevented 99% of the population from having access to electricity. The main solar stations are shown in Table 4.

Table 4: Installed solar generation stations

	Station	Location	Capacity (MW)
1	SPP1	Hassi R'mel	25
2	SPE	Adrar	10
3	Ghardaïa	Ghardaïa	11
4	Djanet	Illizi	3
5	Adrar	Adrar	20
6	Kabertene	Adrar	13
7	Tamanrasset	Tamanrasset	13
8	Tindouf	Tindouf	9
9	Z.Kounta	Adrar	6
10	Timimoun	Adrar	9
11	Reggane	Adrar	5
12	In-salah	Tamanrasset	5
13	Aoulef	Adrar	5
14	Ain EL-Lbel	Djelfa	20
15	Khang	Lghouat	20
16	Oued EL-Kebrit	Souk Ahras	15
17	Sedrate Leghzal	Naama	20
18	Ain EL-Melh	M'sila	20
19	EL-Hadjira	Touggourt	10
20	Ain Shouna	Saida	30
21	E.B.S Chikh	El Bayadh	24
22	Telga	Telemcene	12

Source: (Zahraoui et al., 2021)

III.2.2 Electricity production

The production of electrical energy keeps growing with the demand for energy. In 2016 the total electricity production was 66,891.220 GWh (EIA, 2021). According to data from the national energy report, the electricity production reached 87,034 GWh in 2019 figure14. Which

81,384 GWh (about 94%) of this production comes from state-owned power plants (Sonalgaz) and independent power producers (SPP1, Kahrama…) and the remain (6%) came from autonomous production (Ministry of Energy, 2020). This means an increase in energy production of 20142.78 GWh (i.e. an evolution of 1% every year) as stated the ministry of energy (Algerie Presse Service, 2019).

More than 99% of energy production and consumption, including in the electricity sector, is derived from natural gas and produced from 33 stations located in the southern region of the country (Algerie Presse Service, 2019). As part of the renewable energy development program, the Energy Minister of Energy Transition and Renewable announced on Monday that the first solar kilowatt-hour (KWh) of the 1,000 MWh program should be produced "by the end of the year or early next year at the latest." (Algerie Presse Service, 2019).

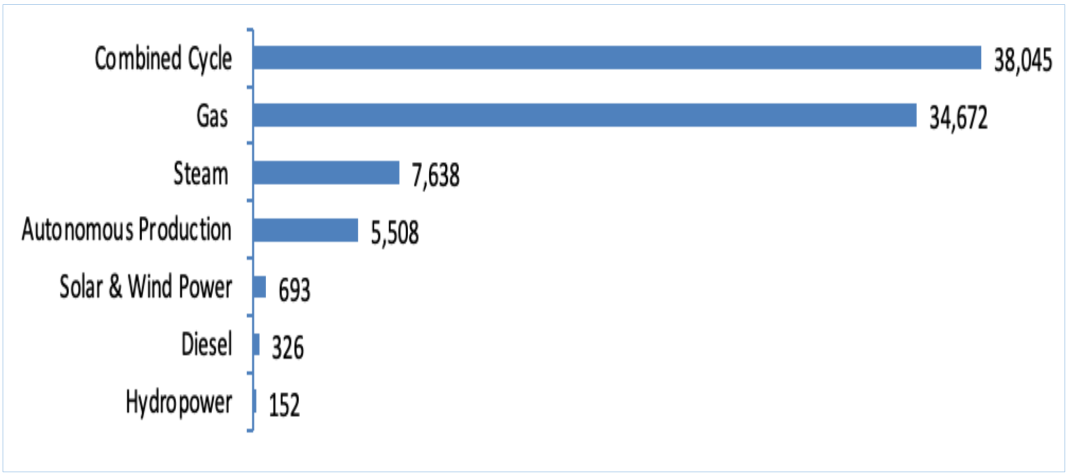


Figure 14: Annual Electricity Generation by Source in Algeria in 2019 (GWh)

Renewable energies are little exploited representing 1% of the energy produced which covers the needs of the population. Yet the country has potential sources of renewable energy (Ourworldindata, 2020).

III.2.3 Electricity consumption

Algeria is one of the energy intensive countries in terms of energy consumption. The energy sector is based mainly on natural gas as an energy source (Ouki, 2019). The national energy report on the country's energy sector shows that national consumption increased from 76,572 GWh in 2018 to 81,384 GWh in 2019 for a final consumption of 62,184 GWh. This consumption is distributed among the different sectors as shown in the figure 15 (Ministry of Energy, 2020). Above all from the point of view of the allocation of this energy consumption, most of which is used by residential 26,533 GWh, industry 21,941 GWh with no return of surplus value or any wealth, while the transport, agriculture and tertiary sector consume about 13,710 GWh of the final electricity consumption. The growth in electricity consumption (2.7%) is due to the increase in demand from Sonelgaz customers, particularly households. In addition, if the rate of internal energy consumption continues at the same trend, it risks doubling by 2030, or even tripling by 2040 (Salami, 2020). The main energy increases have been especially related to changes in the way of life.., Furthermore, electricity consumption is estimated to increase more than double by 2030 (Bouznit, Pablo-Romero, and Sánchez-Braza, 2018). Total energy production risk of being equal to internal energy consumption by 2030. This will affect the export sector of naturel gas and then dropping the GDP. According to the (Ministry of Energy, 2020) , the National energy consumption (including losses) reached 66.9 Toe in 2019, reflecting an increase of 3.0% compared to 2018, driven by that of final consumption.

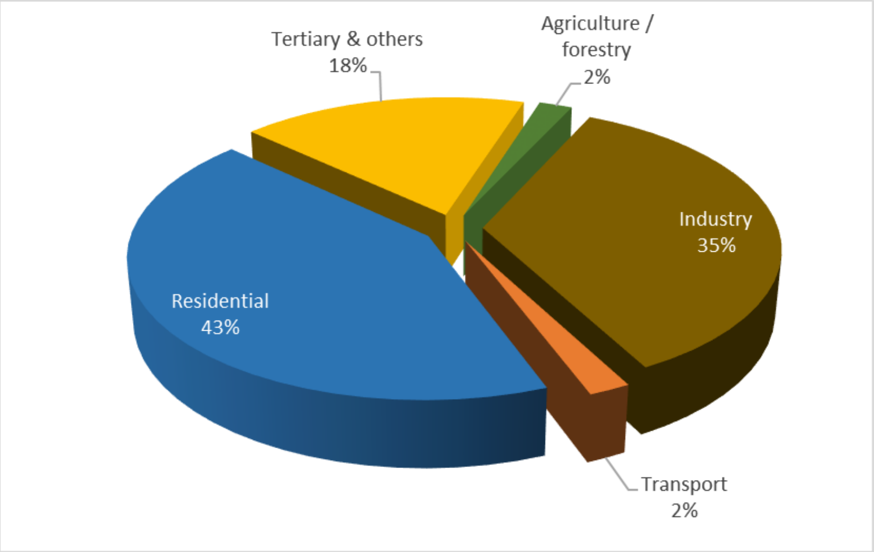


Figure 15: Electricity Consumption by Sector

Source : (Ministry of Energy, 2020)

III.2.4 Access to electricity

Access to electricity is the percentage of population with access to electricity. according to the World Bank Access to electricity (% of population) in Algeria was reported at 99.5 % in 2019 (Figure 16). Algeria's problem is not access to electricity, but rather the sources of electricity production (figure 15), which are gradually drying up with the high demand of the population and at the same time destroying the environment. However, there is a concern for farmers who need electricity to irrigate their fields. The electricity tariff is expensive for farmers whose fields are located far from the electricity grid.

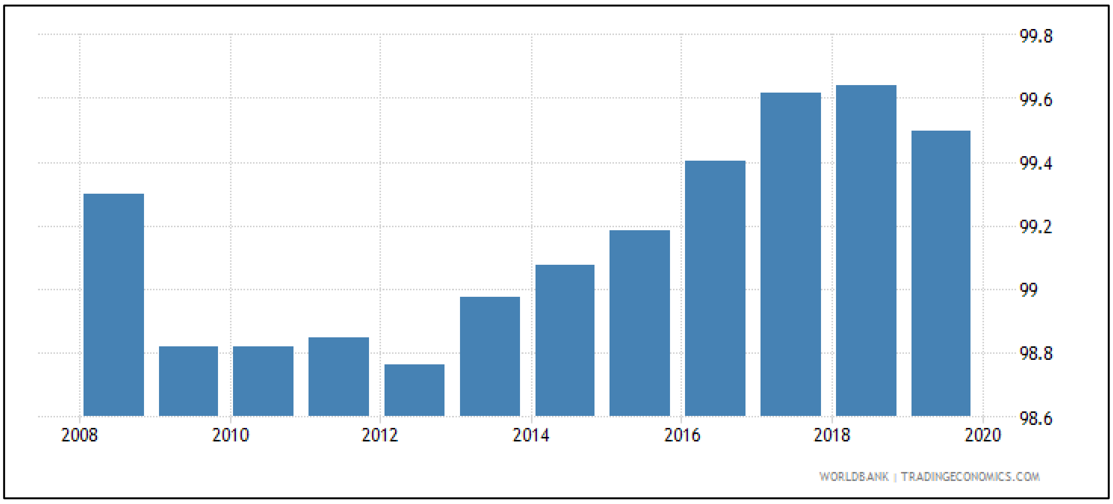


Figure 16: access to electricity

Source: (Knoema, 2021)

IV.1.3 CO2 emissions

Algeria is one of the most important emitters of CO_2 among developing countries and the third largest among African countries; emitted a total of 147 Mt CO_2 in 2014 and thus occupied 34th place in the world ranking list of countries for fossil fuel emissions and 6th place for CO_2 emissions from gas flaring (Sahnoune et al., 2013). In addition, Algeria is particularly vulnerable to the multiple effects of climate change, with average annual rainfall falling by more than 30% over the past few decades. In addition, the land's characteristics, mainly desert areas, reduce the likelihood of carbon sequestration (INDCs, 2015).The demand for energy continues to increase every year with population growth, industrial development, agricultural activities and other public welfare activities resulting in the consumption of primary energy sources such as gas and oil. The exploitation of these primary sources and the consumption of the final products (transport and industries) cause huge greenhouse gas emissions, the main source of climate change.

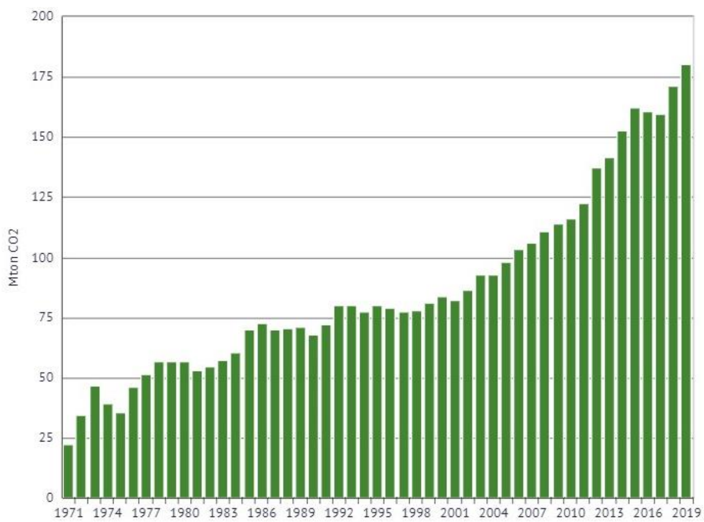


Figure 17: CO2 emissions

Source: (Knoema, 2021)

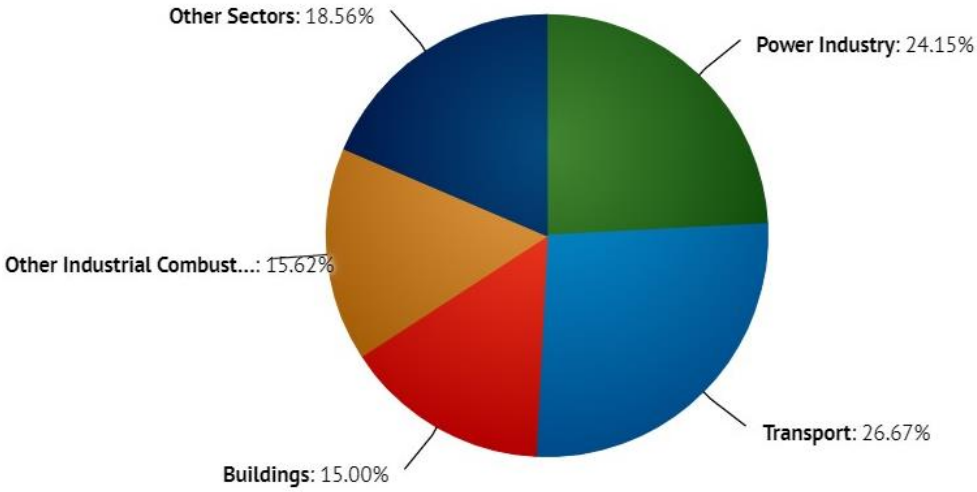


Figure 18: CO_2 emissions by sector

Source:(Knoema, 2021)

In 2019, CO_2 emissions for Algeria was 180.6 million tons. It increased from 18.9 million tons in 1970 to 180.6 million tons in 2019 growing at an average annual rate of 5.20% (Figure 18). The Algerian government, in its program to combat climate change, aims to increase the capacity of renewable energies in the energy mix in order to reduce these emissions. Thus, a reduction from 7% to 22% by 2030 is foreseen (Bouznit et al., 2020).

V. Key Actors in the Energy Sector

V.1 Governmental Bodies

The Energy Policy Evolution in Algeria: before speaking about the nature of energy policy, it is worth mentioning some apparatus responsible for elaborating energy policy in Algeria:

Ministry of Energy (ME): M.E. is one of the most important players in the Algerian energy sector. Its mandate has given by decree no. 07-266 of 2010, assuring the ministry's responsibility of elaboration and implementation of policies and strategies in the context of research, exploitation, production and usage of energy sources. M.E. is assuring control of the energy sector. Public institutions and organizations are subordinated to it.

The National Energy Council (NEC): established by presidential decree N°95- 102, the NEC is charged with supervising and controlling Algeria long-term national energy policy. The NEC is presided over by head of state in addition to other members such as Ministers of energy, defence, finance and the governor of Algerian central bank.

SONATRACH: National Company for Research, Production, Transport, Transformation, and Commercialization of Hydrocarbons. Is a state-owned company formed to exploit the hydrocarbon resources of the country, it was mandate by Decree 63-491 of 31 December 1963 and by law 86-14 of 10 August 1986. Under which it was mandated to act both as a commercial entity handling government participation in petroleum contracts and as the regulatory agency for the entire hydrocarbon sector, including the upstream and downstream components (Luce et.al,2014, p. 213).

SONELGAZ: The National Society of Electricity and Gas is a state-owned company dedicated to the construction, distribution, generation and transportation of electricity and the distribution and transportation of natural gas in Algeria. The Sonelgaz group of companies consisted of 36 subsidiaries, including Sonelgaz Holding, which is the sole owner of the company in 2010; Sonelgaz Holding has issued the guideline for the development of the national renewable energy program of Algeria (Mowafa, 2010, p.2.1). Sonelgaz is recently intervening in other segments of activities presenting an interest for the company in particular in the field of the marketing of electricity and gas abroad.

The Renewable Energies Development Centre (CDER): is a research centre, established on 22 March 1988. Its main responsibility is conducting research and development programs, scientific and technological, of energetic systems using solar, geothermal and biomass energy.

The Algerian National Agency for Promotion and Rationalization of Energy Use: created in 1985, this institution has been restructured by law N° 99-09 dating to 1999. According to this law the main tasks include the implementation of the National Plan of control of energy and sectorial projects involving partnerships with other sectors (e.g. industry, transportation) (Energypedia, Algeria Energy Situation)

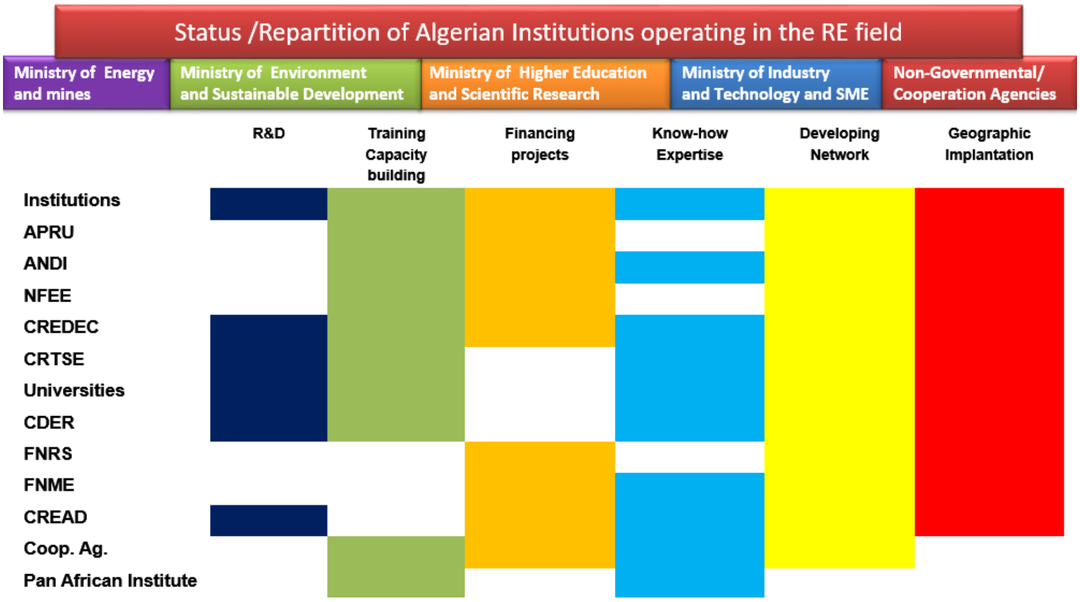
New Energy Algeria (NEAL): NEAL is a company which was founded in 2002 as a subsidiary of Algerian energy incumbent Sonatrach (45%) and Sonelgaz (45%) with 10% extra capital from privet investor, its function mainly involves the production and development of renewable energies. (Kumetat, 2015, p.p.164-165)

AEC (public company): Algerian Energy Company was created of an association between Sonatrach and Sonelgaz, in May, 2001, so that Algeria can seize the opportunities of investments in the energy markets. In addition, AEC has as its first objective the valuation of Algerian natural gas.

IAER (public institution): Algerian Renewable Energy Institute, the result of a collaboration between the Scientific Ministry for Higher Education and Scientific Research (MESRS) and the Renewable Energies Development Centre (CDER). The institute aims at improving access to the scientific and technical information, facilitating the exchange and the sharing of the knowledge in the field of renewable energies.

V.2 Institutions and agencies

In order to accelerate the implementation of the national renewable energy and energy efficiency development program. Agencies and other institutions have been created by the state to complement the existing ones.



VI. Energy programs

Algeria is an OPEC member and a major producer of hydrocarbons in the region and an exporter of natural gas to Europe. Algeria's economy is heavily dependent on the fossil fuel sector, whose income accounts for around 50% of the country's gross domestic product. Gas and oil account for almost all of Algeria's primary energy consumption and so far only 1% of installed energy capacity comes from renewable energy sources; Water and solar. Between the pollution generated by fossil energies, and the imports dependency of gas reserves (El Ghazi et al., 2021), Algeria have drawn up a new energy strategy, the main objective is to introduce renewable energies into the energy mix.

In 2011, Algeria adopted the Algerian Renewable Energy and Energy Efficiency Development Plan. The main objective of this national plan was to expand the usage of REs and to diversify the energy sources in the country.

VI.1 Renewable Energy National Renewable Energy Program

The government wants to diversify the energy mix and increase the share of electricity generated from renewable energy sources to 27% by 2030 (*Algeria | RCREEE*, 2008). Algeria aims to reduce its energy consumption by 5% by 2020 and by 20% by 2030. The development of the renewable electricity generation program (12,000 MW) for the national market should also take place in three stages. Several pilot projects should be carried out in 2011-2013 to test different technologies (Bouznit et al., 2020). However, in 2015 the Algerian government updated the 2011-2020 program, which provides for the installation of 22,000 MW of renewable energy by 2030 energy efficiency, with the RES targets set to be achieved in two time periods (2015-20 and 2021-30), thereby encouraging investment in all RE sources (photovoltaics, concentrated solar energy (CSP), geothermal energy, wind, biomass and combined heat and power) are clearly promoted 3 shows the most important renewable energy targets for electricity generation in both periods. By 2030, a total of 22,000 MW are to be produced through the use of RE, of which 12,000 MW for the domestic market and 10,000 MW for export (Bouznit et al., 2020).

Table 5:. RE targets for the electricity production of the Algerian national program of RE and energy

Electric Power						
	1st Period (2015–20)		2nd Period (2021–30)			
Energy Source	**MW**	**%**	**MW**	**%**	**Total (MW)**	**%**
Photovoltaic	3000	66.3	10,575	60.52	13,575	61.70
Wind power	1010	22.32	4000	22.89	5010	22.77
Concentrated solar power			2000	11.44	2000	9.09
Biomass	360	7.95	640	3.66	1000	4.55
Cogeneration	150	3.31	250	1.43	400	1.82
Geothermal	5	0.11	10	0.06	15	0.07
Total	4525		17,475		22,000	

The main objective of the Renewable Energy and Energy Efficiency Development Plan is to expand usage of renewable energies and to diversify energy sources in the country. The Plan's renewable energy goals are:

- ✓ To install 22,000MW of power generating capacity from renewable sources between 2011 and 2030 (of which 12,000MW for internal usage and 10,000MW for export);
- ✓ To meet 20% of electricity generation from renewables by 2030;
- ✓ For renewable energy development to drive sustainable economic development, Climate Change Legislation Algeria to increase energy security supply, and to create jobs (Grantham Research Institute, 2011).

This RES program is estimated to generate around 300,000 direct and indirect job, develop the local industry, transfer of technology and expertise via the realization of the first RES projects and saving hundreds of billions of cubic meters of natural gas and significant reduction of CO_2 emissions (Chahar, 2018). According to IRENA, jobs in the renewable energy field are divided between solar module manufacturing companies (ALPV, Miltech, Condor, ENIE and Autre Solaire) and renewable energy production plants. The following figure 19 and table 6 show the distribution of jobs according to the different technologies and the capacity of each manufacturing company.

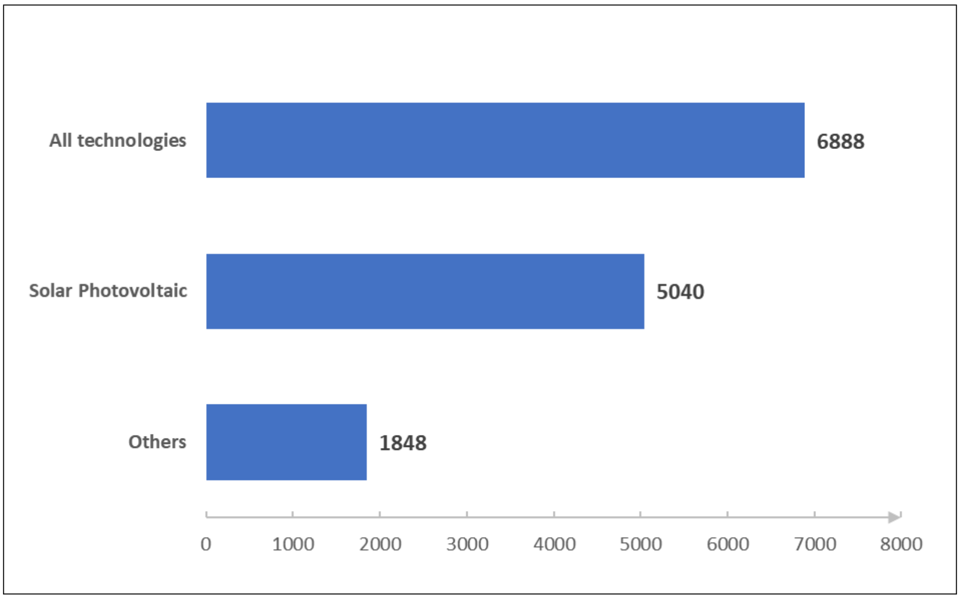


Figure 19: RE employment

Table 6 : PV module factory locations in Algeria

Company	Capacity (MW)	Location	In Operation Since
Condor	130	Bordj Bou Arreridj, Northern Algeria	2013
ALPV	12	Batna, Eastern Algeria	2010
Aures solaire	50	Sidi Bel Abbes, Western Algeria	2016
Aures solaire	30	Batna, Eastern Algeria	2017
ENIE	25	Sidi Bel Abbes, Western Algeria	2016
Milltech	100	Chelghoum El Aid, Northeast Algeria	2020 (under development)

VI.2 Energy efficiency program

Energy efficiency is one of the most important strategies that can lead a country to energy security. The International Energy Agency (IEA) and its member countries have identified, energy efficiency as the fastest and the least expensive option for addressing energy security and at the same time contribute to economic growth while solving environmental challenges. The decoupling of energy growth and economic growth is an important factor for the future: it shows that the nation can improve energy efficiency and increase economic productivity (Barkan, 2007). Energy efficiency and conservation have also been described as the cheapest and fasted form of generation of energy and one of the main drivers of sustainable development in many economies in the world. The efficient use of energy will enhance the sustainable use of environmental resources and in turn contribute to national growth and sustainable development (Godoi et al., 2021). Moving to a greener economy requires action in the various dimensions of sustainability that can mitigate further environmental degradation and restore its ability to support human life. The most important global challenges the world is facing, such as poverty reduction, climate change, and global food and environmental security. 189 of the

197 parties ratified the United Nations Framework Convention on Climate Change during the Paris agreement (UNESCO-UNEVOC, 2020).

Thus the energy efficiency programs are aimed at three sectors: buildings (both residential and commercial); industry (manufacturing and nonmanufacturing); and transportation (Barkan, 2007).In the national energy program of Algeria, energy efficiency is the second very important component in the new Algerian energy strategy. In Algeria, energy efficiency, alongside the development of REs, is a major priority in the national energy strategy. The energy efficiency program obeys Algeria's desire to promote a more responsible use of energy and to explore all ways to preserve resources and systematize useful and optimal consumption. The objective of EE is to produce the same goods or services, but using as less energy as possible. This program includes actions that favour recourse to the forms of energy best suited to different uses and requiring modification of behaviour and improvement of equipment. This program is to provide also the introduction of EE measures in the three sectors of transport, building and industry, the main sectors that consumed more energy et release a huge amount of CO_2. also to promote the creation of a local industry for the manufacture of high-performance lamps, for solar water heaters and thermal insulators by encouragement of local or foreign investment. Algeria is ranked among the largest energy consumers in Africa with a consumption of 1727 kWh per capita in 2019. One of the responsibilities of the government is to support through standards, measures and programs the evolution of the economy towards a more efficient and conscious use of energy. This would lead to long-term cost effectiveness and security of supply for users (Comission sur les enjeux énergétiques de Québec, 2014). (Amine Boudghen Stambouli, 2021). The program mainly consists of carrying out the following actions.

The Plan aims to increase energy efficiency through a number of avenues:

- improvement of heat insulation of buildings
- development of solar water heating; promotion of co-generation
- promotion of LPG and natural gas fuels
- developing solar cooling systems
- converting simply cycle power plants to combined cycle power plants, where possible
- desalinating brackish water using renewable energy
- substituting all mercury lamps with sodium lamps and promoting the use of low-energy lamps.(Nachmany et al., 2015)

This chapter is dedicated to the presentation of the methodology used to complete this work as well as an overview of the country covered by the study.

I. Country profile

I.1 Location of the country

Algeria's geographical location offers several advantages for the extensive use of most renewable energy sources. Algeria is located in the centre of North Africa, with an area of 2,381,741 km^2, of which the Sahara occupies 80%. It lies on the coast of the Mediterranean Sea in the north. The length of the coastline is 2400 km. In the west, Algeria borders Morocco, Mauritania and the Western Sahara, in the south-west with Mali, in the east with Tunisia and Libya, and in the south-east with Niger.

The climate is transitional between maritime (north) and semi-arid to arid (middle and south). The mean annual precipitation varies from 500 mm (in the north) to 150 mm (in the south). The average annual temperature is about 18ºC (Himri et al., 2009).The country is predominantly arid and semi-arid. Moreover, due to climate change, rainfall has decreased by more than 30% in recent decades (INDCs, 2015).

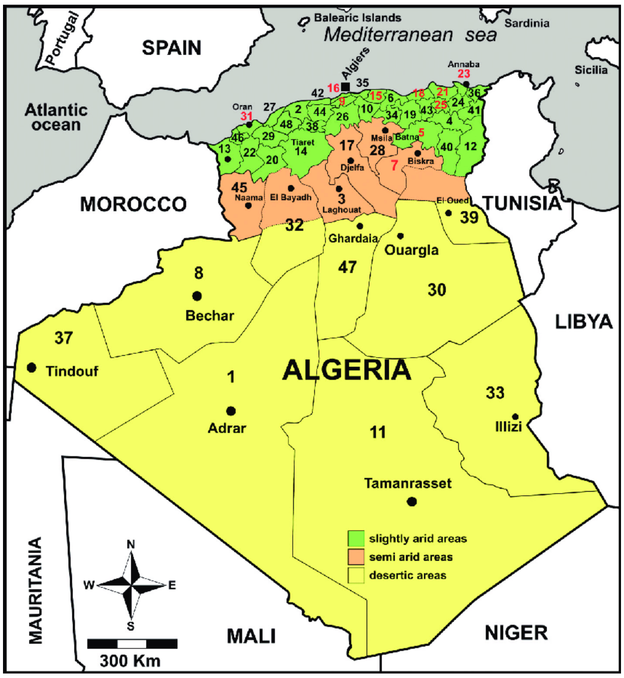


Figure 20 :Geographic location of Algeria

Source:(Amrani et al., 2015)

I.2 Background of the country

Algeria is at a critical stage in the development of its energy sector. The country has both the potential and the incentives to maximize its natural resources and become a leader in renewable energy. In addition to being the second most populous country in North Africa, Algeria is also

notable for its relative size, wealth, location, gas reserves, renewable energy potential and greenhouse gas emissions - just 240 kilometers from Spain and Italy, which borders the Mediterranean Sea, Algeria in the south with Mauritania, Niger and Mali, in the northeast with Morocco and in the west with Libya and Tunisia and connects the MENA region with southern Europe and sub-Saharan Africa (Hochberg, 2020). Algeria is the richest country in the region by GDP per capita, the highest being 5,592.22 in 2012 and falling to 3,310,387 (currently US $) in 2020 and the largest nation on the continent by area (WorldBank, 2020). Algeria also receives over 3,000 hours of Sunlight per year, which gives it significant solar potential but ranks third in Africa in terms of carbon dioxide (CO2) emissions, a powerful greenhouse gas.
Algeria has been a member of OPEC since 1967 and one of the largest hydrocarbon producers in Africa, whose oil and gas revenues historically account for around half of the national budget and 90 percent of export revenues (Hochberg, 2020). The demand for electricity is causing Algeria to prioritize investments in clean energy. Stagnating hydrocarbon production and the increasing urgency to tackle climate change are providing Algeria with additional incentives to diversify its power generation mix.

I.3 Growth population and energy nexus

Algeria's growing population is helping to drive increased electricity generation capacity. Growing at an average pace of 2% per year for the last 10 years, the nation's population increased from 35 million in 2009 to 43 million in 2019. Actually, the population is about 43,851.04 million of inhabitants according to the (World Bank, 2020) in 2020. Maintaining this growth rate would result in a total population of 53 million by 2030 and nearly 65 million by 2040 (Hochberg, 2020). This demographic development represents an upward pressure on energy demand in general and electricity demand in particular. From 2015 to 2019, electricity generation in Algeria increased from 64,663 GWh to 76,229 GWh to meet the increasing demand for electricity, which corresponds to an average annual growth rate of. corresponds to more than 5%.

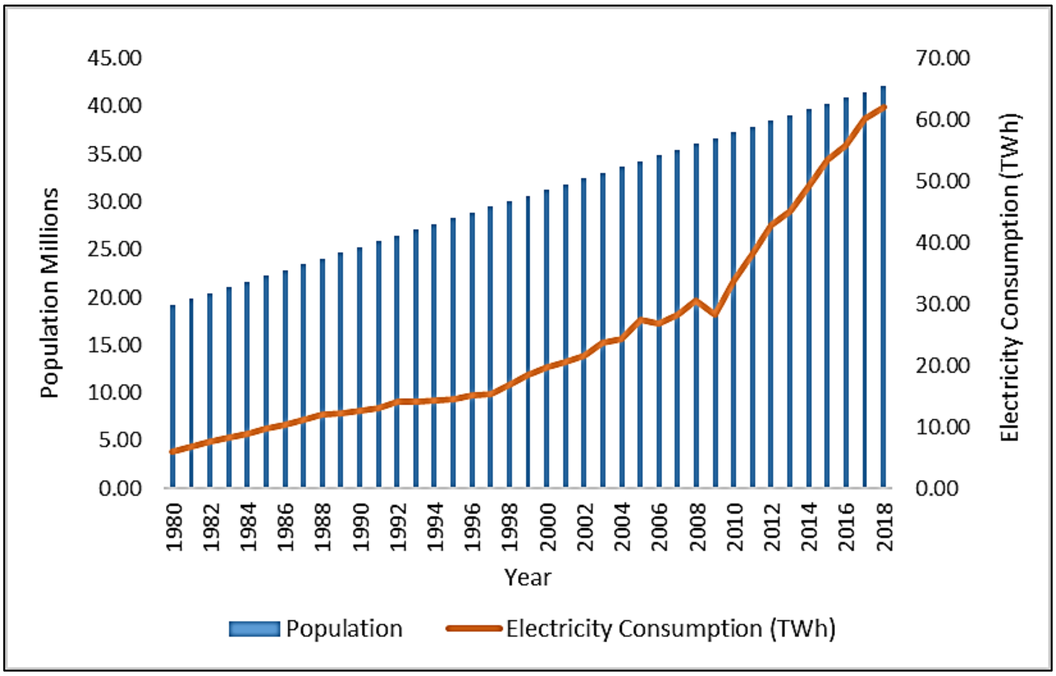


Figure 21: Annual growth of the population and Electricity Consumption

II. Method and Data Collection

The different methods used to gather the data included, the questionnaires; direct interview; and literature of the different books, programs related to Sahara solar breeder and the energy sector of Algeria.

II.1 Method

The methodology used in this work is the collection of secondary data from previous research on the energy sector. These data are much more quantitative and qualitative that have been in the previous research. In this study, there is first data collection and analysis (literature review) on the actual energy sector situation and the issues facing it; on renewable energy sources and their potential use; on policy and program in the energy sector with emphasis on their weaknesses, strengths and gaps; and finally on the actors and stakeholders with emphasis on the role they can play in the success of the national energy program and the SSB project in the energy paradigm shift.

The analysis of the results is based on what has been done for energy management by financiers, measures, technology and laws in the framework of the energy transition. then the actions to be undertaken to achieve the objectives set and finally the impact of the SSB project bringing a sustainable energy solution for Algeria and other countries. the analysis allowed to address the questions asked in the introduction of the work.

II.2 Data collection

This study adopts the secondary data collection approach for the literature review. It relied on secondary data elicited from reputable journal publications, articles, books and also from reliable internationals institutions web site such as IRENA, IEA, World Bank and other national institutions such as CDER, SONATRACH, SONALGAZ, Ministry of Energy etc. The selected sources of data were obtained following the approach for scientific writing (Pati & Lorusso, 2018). These articles have been referenced with Mendeley tool and obtained through a search engine on sciencedirect.com, Google Scholar…The search was done by combining key words relative to the energy sector and the SSB project in the study in the search engine.

The data was analysed using a content analysis of the relevant information obtained from the selected articles (Elo & Kyngäs, 2008). Tables and graphs that were relevant for the study were reproduced and appropriately referenced. These assumptions were based on the most recent accessible data.

The aim is to know their current policy and the challenge they face in the energy paradigm shift. other important purpose is to provide the effectives solutions from the SSB project for sustainable energy, energy security and paradigm shift. Also to show the benefits of SSB project.

CHAPTER IV: THE SSB PROJECT

1. Background of the project

The Algerian economy highly depended on the energy sector such as oil and natural gas, which accounted for approximately 98% of export, 50% of GDP and 75% of revenue of the country. However, employment absorption rate of this sector was subdued around 2% of the total employment. The country's unemployment rate in 2007 was 11.8%, and employment creation, fostering of new industries as well as human resource development responsible for the industries became important policy issues. Under those circumstances, there was an increasing expectation for possibility of solar power generation in Algeria as the country had a large land area on the African continent, and the volume of solar radiation in the southern region was 6kWh/m^2 /day, which was about twice as much as that of Tokyo. On the other hand, about 90% of the country’s land was covered by Sahara Desert, and 3.5% of the land area was used only for the agricultural land (Project Sahara Solar Breeder Research Center, 2021).

2. History of the SSB project

The story between Algeria and Japan began years ago when Algeria began to take an interest in Japanese science, technology and industry. Japan's rapid technological and economic growth was triggered and facilitated by the energy paradigm shift from coal to cheap oil. Japan, in the midst of its economic growth, was very interested in the oil-exporting countries of the Middle East, but not so much in Algeria, despite Japan's early approval and diplomatic relations.

It was during a visit in 2009 to USTO that the partnership between the two countries on the SSB was born. This cooperation is supported by JICA and JST under the SATREPS program. As an ultimate solution to the global energy and environment problem, the SSB plan was originally presented to the SCJ by K. Kitazawa and H. Koinuma in 2007.

With the Algerian government's ambition to promote renewable energy, its vast territory and good location between continents gives it an advantage to play an important strategic role in the implementation of renewable energy technology in the north of Africa, providing sufficient energy for its own needs and even exporting it to African countries as far as Europe and other (SATREPS, n.d.).

3. Potential solar energy of the desert

Solar energy is created by nuclear fusion that takes place in the sun. Fusion occurs when protons of hydrogen atoms violently collide in the sun’s core and fuse to create a helium atom. This process emits an enormous amount of energy (National Geographic, 2012). In its core, the sun fuses about 620 million metric tons of hydrogen every second. 30% of the energy coming from the sun is reflected in the space and the rest is absorbed by the earth. According to (Energies, 2019), 5% of the surface area of deserts could produce all the electricity of the world needs.

Solar energy is the most promising source of clean, renewable energy and it has the greatest potential of any power source to solve the world's energy problems. Today, Solar energy is the most promising source of clean, renewable energy, and it has the greatest potential of any power source to solve the world's energy problems (Chowdhury, 2014). All the other renewable energy resources derive their energy from the sun being an abundant energy resource except geothermal and tidal.

Although solar power generating devices have been around for more than 50 years, solar power devices, often referred to as PV, are still considered cutting-edge technology. Theoretically, around 1700 TW of solar energy is available on land for photovoltaics worldwide. even 1% of this energy would cover more of the world's energy needs. Algeria has the potential to be a major supplier of solar energy and become a role model for other countries in the world, as shown in Figure 22 (A. Boudghene Stambouli et al., 2012). The implementation of various policies and programs by the Algerian government has raised awareness of the importance of renewable energies in a sustainable energy system.

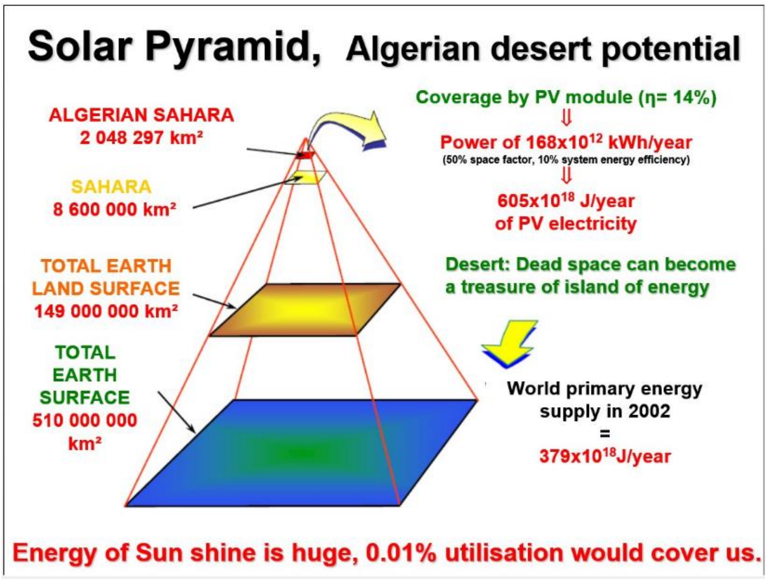


Figure 22: Solar pyramid, the Algerian desert, dead space can be a treasure island of energy used by humanity

Source: (A. Boudghene Stambouli et al., 2012)

4. Overview of Sahara solar breeder

Sahara Solar Breeder is a project that proposes an international partnership plan in the areas of basic research, research and development, industrial production, trade, financing, etc. to gradually build a "Global Clean Energy Superhighway" out of the Sahara desert over the next few decades North Africa: SSB will help shift from the currently unsustainable global energy paradigm that is overly fossil fuel based to a more sustainable one (A. Boudghene Stambouli

& Koinuma, 2012). It will also help address global energy challenges and mitigate climate change and other environmental problems.
SSB consists of two key technologies:

- The production of Si feedstock (solar grade Si of six-nine purity with B and P impurities less than 1 ppm) from desert sands and the subsequent manufacture of Si solar cells;
- The transmission of solar electricity through a high temperature superconductor cable.

The solar Si and solar cells are manufactured in a replication mode, i.e. doubling production whenever the energy recovery time (currently about two years) can provide the PV electricity needed to manufacture the SOG-Si and solar cells. By building 100 GW of PV power plants on about 1,000 km^2 of desert area each year to accumulate 2 TW of PV power plants in 20 years, which is the lifetime of solar cells, it is possible to meet not only the current energy needs of about 2 TW, but also the growing energy demands to improve life in developing countries. Another important problem of photovoltaic electricity, the lack of energy production at night, has been proposed to be solved by a high-temperature superconducting DC transmission network. Deserts like the Sahara, the largest in the world, cover huge stretches of land, have a lot of sunlight and are a treasure trove for sand, which contains large amounts of silica, the raw material for silicon. Factory and photovoltaic power plant in the desert and the generated energy is used to build further solar generators. Then, high temperature superconducting power transmission systems with low power transmission loss are used to send power to different parts of the world. The project is an attempt to finally solve the world's energy problem by converting arid deserts into a new source of energy. The project is an attempt to finally solve the world's energy problem by converting arid deserts into a new source of energy.

5. Objectives of the project

The most important objectives of SSB’s energy policy and its portfolio include five basic strategies that are:

- Basic, applied, practical research and development, in Japan, North Africa, the Middle East, Africa, and other regions of the world;
- Industrial production of silicon from sand;
- Industrial production of cells, modules, panels, and other PV devices,
- Building, operating, networking and monitoring Very Large Scale Photovoltaic Power Stations (VLS-PVPS);
- Environment monitoring and gradual implementation of SSB.

One of the strengths of PV is to be found in its decentralized applications. This is particularly true for supplying isolated consumers in areas of low population density, where the demand consists essentially in satisfying basic energy requirements. Other notable characteristics of PV are:

- Modular design enabling it to be extended according to need;
- The possibility of developing small businesses in areas of low economic development;
- Protection of the environment;
- Limited capital assets, capable of being used flexibly and in a decentralized way, and of being moved about over longer periods of time.

The SSB project's development strategy is designed to encourage the diffusion of RE in places where it is profitable compared to classical energies and to guide scientific research efforts to enable the generalization of RE through mass production (Himri et al., 2009). They consist in contributing to a conservative hydrocarbon policy by both increasing the participation of renewable energies in the international energy balance and improving the living conditions of isolated communities. and on the other hand to collect information about:

- Equipment behaviour in Saharan environment;
- Technical -economic system optimization
- Maintenance of organization and management;
- Matching the systems with the electricity supply;

6. SSB Project plan

The idea of the Sahara Solar Breeder (SSB) project consists of constructing industrial plants in the Sahara Desert that would extract silica from the sand and use it to produce photovoltaic panels. The first solar panels are going to be used to construct photovoltaic power plants. On the other hand, the principal object of this project is to construct sufficient plants until the breeding plan can deliver 100 GW of electricity to supply 50% of the world's electrical demand by 2050. This energy will be delivered via a High Temperature Superconductor (HTSC) cable to transport the produced DC current electricity over 500 km (Mostefai et al., 2019). This is will turn the world's biggest desert into the world's biggest power station taking advantage of two resources that are found in abundance in the Sahara namely silica and sunlight (Boudghene Stambouli et al., 2014). The development and implementation of the SSB project in the Algerian Sahara, which covers a total area of 2,048,297 km^2, or about 86% of the country's total area, will address the main challenges and problems in the field of photovoltaics, which is the material of the current R&D view and promotes innovative processes for solar silicon with a focus on the use of Saharan sands. Three elements should drive Algeria's national energy policy: sun, sand and space (Boudghene Stambouli et al., 2014).

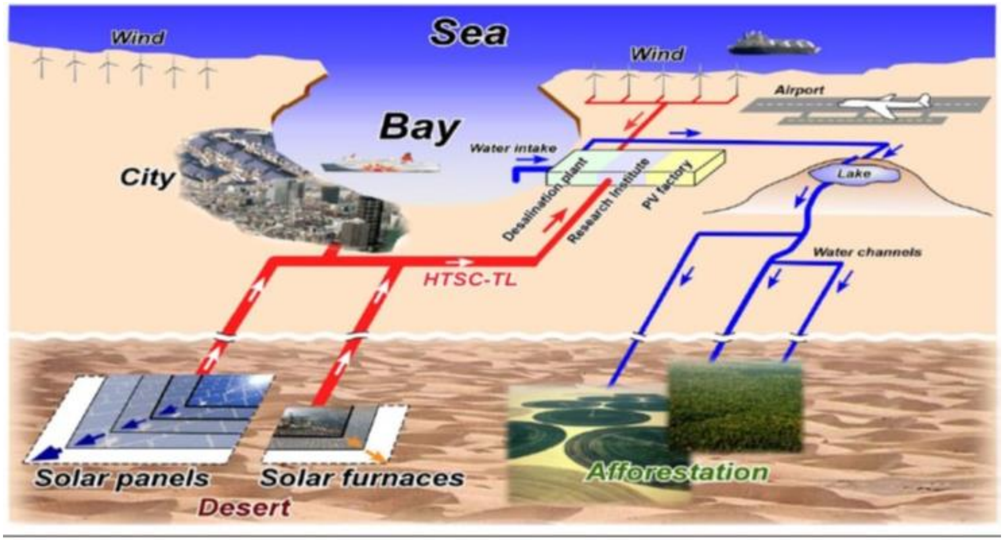


Figure 23: SSB model

7. Research Institutions involved in Sahara Solar Breeder (SSB) project

Particular attention is paid in this post to the joint event that the relevant parties, the University of Science and Technology of Oran, six Japanese universities, the Japanese Agency for International Business, the Japanese Agency for Science and Technology, Technology, Saida University and Adrar's Renewable Energy Center to develop a long-term vision and strategy to drive ideas for the realization and development of the SSB project proposed the SSB plan at the meeting of the G8 + 5 academies in Rome in 2009 and called for international cooperation to solve global energy and environmental problems (Boudghene Stambouli et al., 2013).

Japan established the Science and Technology Research Alliance for Sustainable Development in 2008, jointly managed by JICA and JSTA. SATREPS funds international collaborative research to address pressing global challenges such as climate change and infectious diseases. and natural disasters. SATREPS comprises alliances between researchers in Japan and researchers in developing countries who work together on projects lasting three to five years. The program aims to advance knowledge and technology to address critical global problems such as energy, which is at the heart of the global economy today. Problems and seeks to strengthen the human resources and research capacity of developing countries to use science and technology to address their development challenges. Countries through their technical assistance budget. An interesting example of a SATREPS project is the Sahara Solar Energy Research Center project in Algeria. Although the generation of electricity from solar cells has increased significantly in recent years, photovoltaic electricity still only accounts for one percent of the energy supply. To combat climate change effectively, however, a paradigm shift is required in the global energy generation and transport system, from the current fossil fuel/tanker base to nature-based renewable energies. Against this background, JICA and JST are working with their Algerian colleagues in collaboration with the University of Tokyo to set up a (SSERC) at the (USTO). It will serve as the basis for collaboration between North Africa and Japan for innovative research on photovoltaic solar systems and power transmission. The SSERC project has several ambitious goals, including research into technologies to use the Sahara as a new source of energy for silicon and solar energy; Research and development of innovative processes for cleaning solar silicon; Use of solar photovoltaic (PV) systems in Oran and Saida, in the far north of the Sahara, for PV application and durability tests; Feasibility studies for the transmission of photovoltaics through the desert; and education and training programs in new energy technology between Japanese and Algerian universities (Tachibana, 2011).

8. Sahara solar breeder plan as an accelerator of the transition to a sustainable energy solution

The SSB project is a project promoting energy technologies to address the major problems facing countries today and accelerate access to clean energy. The Science Council of Japan presents an international research and development collaboration to address global energy and environmental problems. It is a long-term plan ranging from basic research on photovoltaic materials and devices to the design and business plan for industrial production of solar cells for replication or scale-up in a large-scale solar power plant (SSB Foundation official, 2010). There are also plans to carry out research and development on high temperature superconductor direct current power transmission, a new technology for low-loss power transmission over long distances.

The SSB Research Institute is established in Africa as a key SSB station where the technical plan is designed and monitored so that the harmonious coupling of basic PV-HTSC research and industrial development can be achieved between the project partners. Our goal is to create a global clean energy superhighway connecting GW-scale PV plants in different desert areas to HTSC transmission lines.

The draft specifications and roadmap of the SSB plan are presented below. Figure 24 illustrates the Sahara Solar Breeder Project oriented towards a global clean energy superhighway (SSB Foundation official, 2010). The establishment of this photovoltaic cell production plant could also facilitate the rapid development of renewable energy in other African countries.

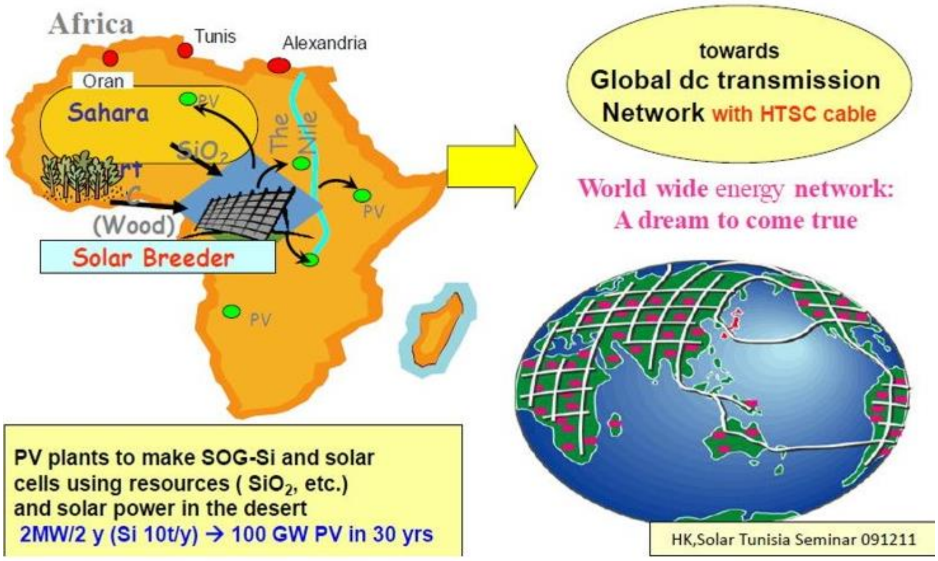


Figure 24: SSB plan directed toward global clean superhighway

Source: (SSB Foundation official, 2010)

9. Silicon technology opportunity in Algeria

Governments and industry invest in alternative energy sources such as solar-photovoltaics (PVs), wind, geothermal, hydroelectric, wave, tidal, nuclear, corn/cellulosic-ethanol, etc. to reduce dependence on non-renewable fossil energy sources which generate off gases that impact both the local and global environments (Ranjan et al., 2011). Fossil energy is also becoming more expensive to produce. Since the first real silicon p-n junction solar cell in the world was successfully developed in Bell Labs in 1941, silicon solar cells have always been on a steady uptrend. In the early stage, the cell efficiency was improved mainly due to classical semiconductor technology such as diffusion. Quartz is one of the most abundant compounds in the Earth’s crust. Generally, Silica is most found in nature as quartz, as well as in various living organisms. In many parts of the world, silica is the major constituent of sand and rocks. Silicate minerals are the name given to a group of minerals composed of silicon and oxygen, the two most abundant elements in the earth’s crust. It is composed of one atom of silicon and two atoms of oxygen resulting in the chemical formula SiO_2 (Anas Boussaa et al., 2016).

Occupying more than 80% of Algeria's total surface area, the Sahara Desert is a potential place where silica and solar radiation are abundant. The Sahara Desert and its surroundings are considered a suitable site for the construction of this solar breeder, as the desert is rich in silica, the raw material for silicon, and the sun, the source of solar energy. The SSB consists of two parts: the production of solar grade silicon which is expected to be initiated from basic research and the silicon solar cell manufacturing plant which will be built and operated by providing raw materials and machinery at start-up. Starting from a scale of 2 MW in 2012, the PV plant is expected to reach 1 GW in 20 years (SSB Foundation official, 2010). In parallel with the PV plant, a HTSC wires is being built to test the feasibility of long-distance transmission of the PV electricity produced by the solar breeder.

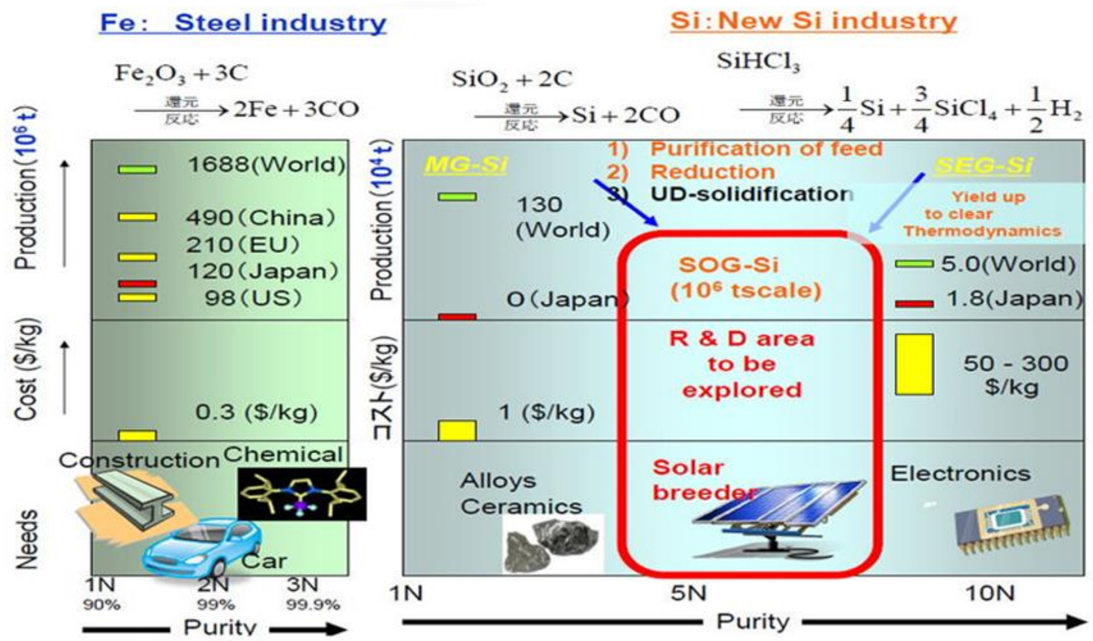


Figure 25: Si feed stock research area to be explored by innovative technology

10. High temperature superconductor cable

The economic demand objectives as well as obligations to reduce greenhouse gases made a strong push for renewable energy sources with power generation becoming increasingly distributed and a growing number of generation facilities located far away from load centres. The many applications of the high temperature superconductor had been developed for various fields, and one of the major fields is the power transmission line. This situation has stimulated research on direct current electric power transmission systems that are able to transport large amounts of electrical power, in contrast with the more common alternating current systems. Such as in the Chubu University, supported by the Japanese government and industries, has been promoting the development of superconducting DC transmission technologies for over 15 years for implementation in society. The demand for power keeps growing at a scale and speed never imagined in the past since the need for more and more electricity is exacerbated Several projects were focused to develop the AC power cable. however, long distance power transmission cables cause a huge amount of energy to be lost through heating. Long-distance power transmission generally poses environmental problems, both because of the large footprint of the lines and the heating of the ground due to energy dissipation. Superconducting technology minimizes environmental impact, has less losses and significantly reduces installation and operating costs. This DC superconducting line has been tested on a distance about 500 m to 1km. the results have been promising.

In order to accelerate the electric highway, the electricity generated by SSB, consisting of a network of VLSPVPS in the Sahara, has to be transmitted to North Africa, then to Europe, Africa and finally to the rest of the world via HTSC, which can be done in compact dimensions provide fixed capacities for base load, intermediate and peak power and thus effectively complement conventional power sources. Because HTSC are compact and can transmit a large amount of electrical energy (up to 10 times more than conventional electrical energy). Power transmission cables, you can make more effective use of the congested underground space, where there are already many pipelines and other units (Amine Boudghene Stambouli, n.d.).

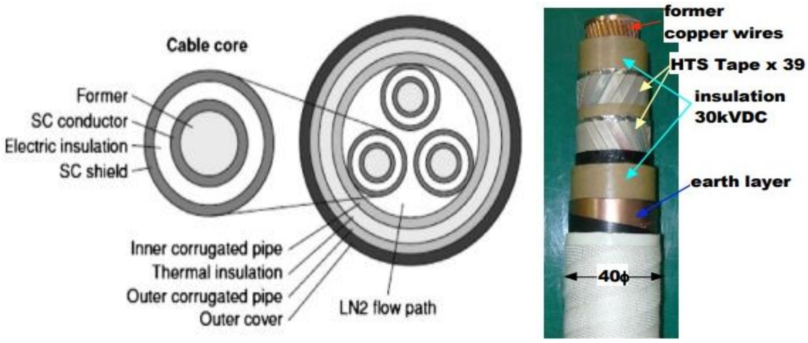


Figure 26: structure of HTSC cable

They are poised to help to reduce grid congestion as well as installation and operating costs. In addition, HTSC, using an N_2 cooling system (figure 26) are characterized by the following advantages:

- Compactness and high transmission capacity.
- Low transmission loss and environmental friendliness.
- No leakage of electro-magnetic field to the outside of the cable.
- Low impedance.
- Effectuate transportation of solar-generated power from the Sahara

The objectives of the SSB project are aimed at increasing photovoltaic production every 10 years in the sense of a global highway and significantly increasing and improving photovoltaic production from initially 2 MW to 100 GW in 30 years. Several semiconductors are available for photovoltaics, we can deduce that the annual production of 100 GW solar cells is the minimum requirement to cover more than 30% of the global energy demand and that only Si in infinite quantities can clearly cover this capacity. of Si-based photovoltaic solar power plants. This material is abundant. By adopting the two-year energy recovery time, the solar cell production can be duplicated every two years to increase 2 MW PV to 100 GW in 30 years, as shown in Table 7.

Table 7: Roadmap of SSB road and global energy superhighway

Year 2009	2010	2020	2030	2040–2050
Planning	Master plan First	Second	Third	Global energy highway Final
SSB construction	First term $2 \rightarrow 16$ MW PV station Si and cell factory HT_cSC transmission line test station	Second term32 → 512 MW	Third term1 GW → 16 GWExtension of SSB to continents	Fourth term $32 \rightarrow 512$ GW Extension of SSB to the world
Management and finance	International cooperation Sahara clean energy consortium		Continental clean energy consortium	Global clean energy consortium

CHAPTER V: RESEARCH FINDINGS

1.0 Introduction

This chapter presents the main findings in this research. These findings have been reported in relation to their response to the research questions.

2.0 Key drivers of energy policy

2.1 Renewable energy status

On 24 February 2015, the Minister of Energy announced the adoption of Algeria's updated renewal energy development program. The program aims to increase the targeted installed capacity from renewable sources by 22 GW by 2030, of which 12 GW for domestic consumption and 10 GW for export, with the aim of diversifying Algeria's electricity production by increasing production from sustainable sources and preserving fossil fuel resources (Group, 2015). These new targets represent an increase of almost 400% in the targeted installed capacity for solar photovoltaic and wind power, compared to the initial targets of the development program in 2011. The table summarizes the distribution of the different renewable energy sources

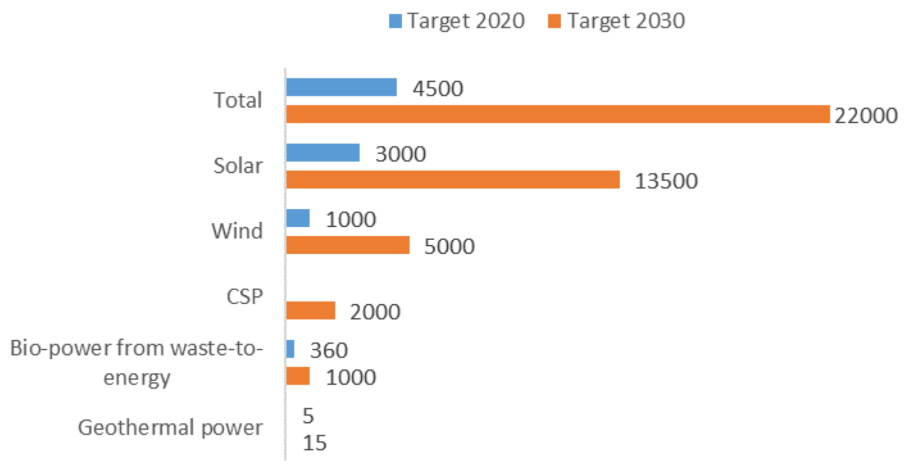


Figure 27: target of RE capacity by 2030

Since the adoption of the program, many projects have been launched to meet the targets by 2030. In June 2018, the Algerian government approved a tender for a hybrid plant and another for 150 MW (Group, 2015). Algerian Electricity and Gas Regulatory Commission launched in mid-November 2018 a tender for the construction of 15 solar power plants in south-western Algeria, namely in the wilayas of Biskra and Ghardaia (Bellini, 2019) . These plants are grouped into four lots, two of which are of 50 MW each and the other two of 30 and 20 MW located in the wilayas of Ouargla and El Oued respectively (CEREFE, 2020). However, the current situation does not reflect the progress of the renewable energy promotion program. The figure shows that the targets set for increasing the capacity of renewable energy in the energy mix are lagging behind.

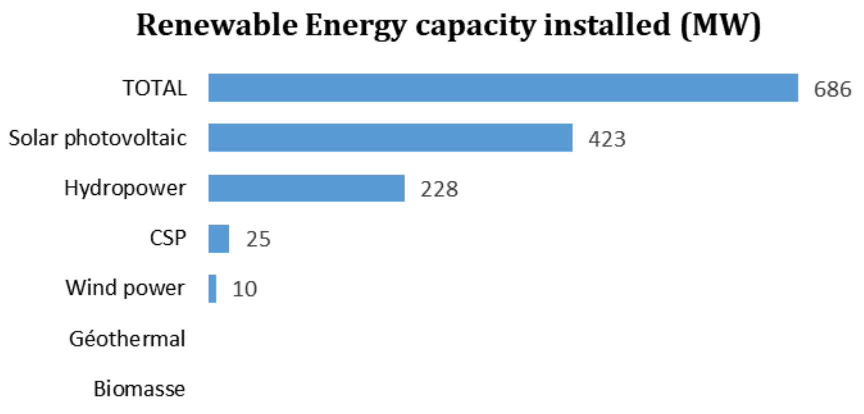


Figure 28: Share of RE

2.2 Regulatory energy policies

For the control and regulation of the energy sector, the Algerian government has established laws for the promotion of renewable energies. The main laws and ordinances related to the promotion and production of RE in Algeria are presented in the table 3. In order to accelerate the introduction of renewable energies, Law No. 09-09 was established in 2009 to define practical measures, such as the creation of the National Fund for Renewable Energies and the allocation of 0.5% of oil royalties to the RE fund. Furthermore, in 2011 Law 11-11 established the National Fund for Renewable Energy and Cogeneration, where the NFRE was extended to include cogeneration activities along with the 1% increase in oil royalties for the RE fund (Zahraoui et al., 2021). Later, incentives for increased RE production were identified in Executive Decree No. 13-218 of 2013. Thus, to show its commitment, the government provided for premiums for the production of electricity from renewable energies, and also premiums dedicated to consumption by public and private entities. Finally, Executive Decree No. 17-98 and Executive Decree No. 17-204 were introduced in 2017, where RE generation projects must be distributed through tenders and auctions. Current and future RE production plan in Algeria. The different laws and decrees for the regulation are summarised in the table 8.

Table 8: Laws and decree for Energy regulatory

Law References	In Force	Main Objectives
Law No. 99-09 (28-6-1999)	Yes	Define the contours of energy management policy, namely: • Rationalizing the endogenous use of energy • Developing RE (solar energy, geothermal, biomass, hydroelectricity and wind energy) • Reducing the impact of the energy system on the environment (reduction of greenhouse gas and urban exhaust gas)
Law No. 99-11 (2000 Finance Bill)	No	• Creating the National Fund for Energy Management (NFEM) and determining its functions (finance actions and projects included in the energy management and energy efficiency program)
Executive Decree No. 2000-116 (29-5-2000)	No	• Official implementation of the National Fund for Energy Management (NFEM)
Law No. 02-01 (5-2-2002)	Yes	• Provides the legal basis which organizes electricity activities and gas by pipeline (production, transport, distribution and marketing)
Law No. 04-09 (14-8-2004)	Yes	Defines the regulatory framework to: • Promote RE and generalize its uses • Protect the environment • Fight against climate warming by limiting greenhouse gas emissions • Preserve and conserve fossil fuels
Law No. 09-09 on the Finance Bill 2010	No	• Provides the regulatory basis to create the National Fund for Renewable Energy and its functions • Determines financial resources (0.5% of oil royalties)
Law No. 11-11 on the complementary Finance Bill 2011	Yes	• Provides the regulatory basis to create the National Fund for Renewable Energies and Cogeneration and its functions. • Determines financial resources (1% of oil royalties)
Executive Decree No. 11-423 –12 December 2011)	Yes	• implementation of establishing the operational modalities related to the National Fund for Renewable Energies and Cogeneration

Executive Decree No. 13-218 (18-6-2013) & Executive Decree No. 17-166 2-5-2017)	Yes	• Determine the incentive measures to promote investment in RE (premiums for the costs of diversification of electricity production from RE)
Law No. 14-10 2015 Finance Bill	Yes	• Closing the National Fund for Energy Management and transferring of its operations to the National Fund for Renewable Energies and Cogeneration
Ministerial decision (2-2-2014)	Yes	• Define the legal procedures for tendering to produce RE and cogeneration, and their integration into the national electricity system.

2.3 Financial Aid

The Algerian government is helping to build up new capacities through the NFREC. With the abolition of the National Fund for Energy Management (special account no. 302101), the Finance Act of 2015 created the NFREC, defined as special account now. Financed by public funds and approved by the Ministry of Energy (Zahraoui et al., 2021). This fund offers greater financial capacity, mainly through a 1% levy on oil revenues and energy consumption taxes paid by energy consumers, and is used not only to finance the food tariff under Power Purchase Agreements (PPAs) but also specifically designed to support various costs of renewable energy projects. State aid, therefore, takes different forms and should be used, be it to carry out power plant projects, to purchase production facilities, to finance additional production costs and to maintain production facilities, or to finance training and research (Nachmany et al., 2015). Executive Decree No. 17168 (May 22, 2017), which amends and complements Executive Decree No. 15319 (December 13, 2015), sets out the funds allocated to NFREC and how they are used to finance RE activities, summarized in Table 13 are (Appendix).

2.4 Feed-in tariff

Feed-in tariff is a good strategy to encourage diversification of energy sources. In 2004, the Algerian government introduced a feed-in tariff mechanism to accelerate the development of RE, in order to diversify its national energy mix and achieve its RE targets. This mechanism was created based on the establishment of a legal framework for a feed-in tariff system, incorporating high tariffs for renewable energy production, to promote solar electricity production in integrated solar combined cycles. Executive Decree No. 13-218 of 2013 explained the feed-in tariff process and also established the technologies eligible for these benefits: photovoltaic, CSP, solar thermal, hydro, wind, cogeneration and waste-to-energy and hybrid plants. The feed-in premiums vary according to the technologies as a percentage of 100%, 200% and 300% of the price of the kWh consumed or produced from hydro, biomass, waste and wind and 300% of the price of the kWh produced from solar radiant or thermal energy (Zahraoui et al., 2021). However, the government incentives for RE generated from solar thermal energy with the hybrid solar-gas system are shown below in the table 4. Thus the preferential feed-in tariffs will be guaranteed for the duration of 20 years. The basic tariffs will vary from 0.12 USD/kWh to 0.15 USD/kWh based on exchange rates for solar photovoltaic projects. For wind projects, the basic tariff will be between 0.10 USD/kWh to 0.12 USD/kWh based on exchange rates depending on whether the installed capacity of the production facility is greater than 5 MW or between 1 MW and 5 MW (Group, 2015).

After an initial five-year phase during which the base rates will apply based on the potential operating hours of the plant, the applicable feed-in tariff will be reviewed for each project to adjust it, based on its actual operating hours during the initial five-year phase. The feed-in tariff for facilities with low production time will be increased by up to 15%, while the feed-in tariff for facilities with high production time will be reduced by up to 15%, in accordance with the regulatory revaluation rates (official journal of Algerian Republic No 23, 2014).

The subsidized feed-in tariffs will be financed by a National Fund for Renewable Energy and Cogeneration, established by a 1% tax levy on state oil revenues, and by other resources or contributions, including a premium paid by end users.

Table 9 : Feed-in tariffs for RE in Algeria

Source	Contribution	FiT (DZD/kWh)		FiT (USD/kWh)	
		First 5 Years	5 to 15 Years	First 5 Years	5 to 15 Years
PV	<5 MW	15.94	11.80–20.08	0.12	0.089–0.15
	>5 MW	12.75	9.44–16.06	0.096	0.071–0.12
Wind	<5 MW	13.10	9.55–16.66	0.098	0.072–0.13
	>5 MW	10.48	7.64–13.33	0.079	0.057–0.10

Source : (Zahraoui et al., 2021)

2.5 Tax Inventives

In terms of support incentives, it should be noted that the Algerian Investment Code is based on three pillars: freedom of investment, equity and protection of existing rights so that Algerians and foreigners can invest freely and benefit from equal treatment in any area. In fact, like several other countries in the world, Algeria has introduced specific subsidy measures to encourage electricity generation from renewable sources (Zahraoui et al., 2021). According to Ordinance N°. 01-03 of 20-8-2001 (modified and completed by Ordinance N°. 06-08 of 15-7-2006), the main incentive supports to promote national and foreign investment in renewable electricity generation are defined below:

- Exemption from all fees due for the registration and transfer of real estate property necessary to achieve the investment project.
- Exemption from tax on company profits (IBS) and the tax on turnover (TAP).
- For 10 years, the investors are exempt from the land tax related to the real estate used in the production process.
- Goods and equipment included in the production process are exempt from customs tax and VAT.
- Investment exploitation phase (the incentive supports are granted for 10 years):
- Investment projects at the achievement phase (incentive supports are granted for 5 years at most):
- The equipment, machinery, materials and services imported, or purchased from the local market, are exempt from customs duties and Value Added Tax (VAT).
- The investors benefit from a reduction of 50% on the annual rental fee set by the state property department.
- The investors could benefit from other sets of advantages granted by the National Investment Council (CNI).
- The investors do not pay any fees on the registration of the Articles of Incorporation and the increase of capital.

2.6 Tendering

Algeria has developed a reverse bidding program to stimulate investments in renewable energy, in which long-term contracts, so-called Power Purchase Agreements (PPAs), are given to companies that sell energy at the lowest price. Sonelgaz, a government utility company, acts as a counterpart to the PPAs. The implementation of the solar program was clarified by Executive Decree No. 1798 of February 26, 2017, this executive decree lays the legal basis for the tendering of renewable energies and cogeneration and their integration into the national electricity system (Jones, 2017). Although, the recently adopted tendering procedure is to become the standard procedure for the start of renewable energy projects in Algeria in the coming years (Bouznit et al., 2020). The Decree sets out two types of requests for proposals for the development of renewable photovoltaic energy projects: requests for proposals to investors and requests for proposals by auction. The first, calls for proposals to investors (RPI), should be carried out at the initiative of the energy minister (although the process can be delegated to a public body or state company) and would only apply to large projects. The locations of the projects are also determined beforehand by the energy minister on the proposal of the regulatory commission for gas and electricity. The RPI should cover two components:

the energy component and the industrial component. The energy component includes the planning, delivery of the equipment, the construction and operation of electricity generation plants from renewable energy sources and the commercialization of the electricity generated. This component is divided into three lots of 1350 MW, each developed and financed via a vehicle property held by private investors (49%) and public companies and/or private Algerian companies (51%). The industrial component (also called industrial project) is defined as "an investment project to manufacture equipment that is used to generate electricity from renewable sources and/or to provide services". In this case, the bidder must submit an offer for the development an industrial project that includes the establishment of one or more Algerian companies. The Algerian company (or company) is responsible for the construction, operation and maintenance of the production facilities (photovoltaic cell, modules and inverters) including marketing and sales of these industrial products.

In this context, the Algerian government launched the first solar competition in 2019, with the goal of an electrical output of 150 MW, for this purpose all private investors were invited to present their projects in which the output expected per project should not be exceeded 10 to 50 MW and choose one of the proposed regions in the center and north of Algeria (Ghardaïa, Biskra, Ouargla, El Oued, Tendala and Nakhla). Proposals with a combined output of 90 MW were received. The selected projects are awarded a 20-year PPA (Bouznit et al., 2020). The planned 4,000 MW Tafouk 1 solar project is also picking up speed to meet Algeria's renewable target. Five tenders for 800 MW each are expected to be carried out for the project. Given its size and the local needs of Algeria, Tafouk1 could significantly increase its solar component manufacturing capacity in the country, including modules, racks, cables and other equipment. It should also lay the foundation for moving the country towards a more competitive electricity market that allows for a more efficient sector and greater penetration of renewable energies (Hochberg, 2020).

3.0 Energy management for a sustainable solution

3.1 Energy efficiency measures

The energy efficiency program is driven by Algeria's objective to promote a more efficient way of using energy and to explore all means to protect its energy resources through efficient and optimal consumption (A. Boudghene Stambouli et al., 2012). To achieve this objective, the MEM's current energy efficiency program is based on the following elements:

- **Improving the thermal insulation of buildings**: The construction sector uses more than 42% of global energy consumption. The measures proposed to achieve energy efficiency in this sector include the introduction of thermal insulation of buildings, which will reduce the energy consumption related to heating and cooling of houses by about 40%. To this end, the head of the APRUE department pointed to a programme to insulate 2,500 homes per year. Another programme of thermal insulation of buildings concerns 1000 dwellings per year (algerie prseese service, 2019).

- **Developing solar water heaters**: The penetration of solar water heaters in Algeria is still underdeveloped but the potential is significant. There are plans to develop the solar water heating system to gradually replace the conventional system as the Minister of Energy Transition and Renewable Energies has announced the launch of 3000 locally manufactured solar water heaters. These plans are included in the portfolio of the Ministry and supported by National Education Environmental Foundation (algerie prseese service, 2019).
- **Dissemination of the use of low-energy lamps**: The objective of the action strategy is to progressively ban the marketing of incandescent lamps (conventional lamps commonly used by households) on the national market to achieve a total ban in 2020. At the same time, it is planned to put several million low-energy light bulbs on the market. The same APRUE official mentioned a total of 10 million energy-saving lamps such as LEDs (algerie prseese service, 2019). In addition, local production of low-energy lamps will be encouraged, particularly through partnerships between local and foreign producers.
- **Introducing energy efficiency in street lighting**: Street lighting is the most energy-intensive sector in municipalities. Municipal staff are often not well informed about the possibilities to improve or even reduce energy consumption in street lighting. The energy efficiency program in municipalities consists of replacing all mercury lamps (energy guzzlers) with sodium lamps (low consumption).
- **Promoting energy efficiency in the industrial sector:** The industrial sector accounts for about a quarter of the country's overall energy consumption. It has an energy saving potential of 30% according to an APRUE framework. To increase energy efficiency, it is planned to: co-finance energy audits and feasibility studies that will enable companies to define precisely the technical and economic solutions best suited to reducing energy consumption. In particular, it is planned to introduce heat recovery systems in industries to recycle waste heat (A. Boudghene Stambouli et al., 2012). Co-financing of the additional costs of introducing energy efficiency in technically and economically viable projects.
- **Promoting liquefied petroleum gas (LPG) and Natural Gas fuels**: It is planned to increase the market share of LPG fuel in the vehicle fleet by 20% in 2020, with direct financial support for individuals wishing to convert their vehicles to LPG fuel (A. Boudghene Stambouli et al., 2012). Since the early 1990s, a research program was initiated to convert vehicles using diesel to natural gas fuel, more than one million private vehicles and 20,000 buses. Stations have been developed by Sonelgaz to distribute this fuel to an

experimental fleet. By 2013, it is planned to convert several dozen buses in the city of Algiers to NG fuel and to extend the operation to other major Algerian cities, such as Oran and Constantine, before 2020 (INDC, 2015).

- **Develop solar air-conditioning systems**: Solar energy for air-conditioning is a technology to be promoted especially in the south of the country, as cooling needs most often coincide with the availability of solar radiation (conversion of sunlight into energy). In addition, solar collectors can also be used for hot water production and room heating during the cold season. The overall performance of a solar cooling system is therefore of great interest. Two pilot projects on air cooling by absorption and adsorption will be launched for the cooling of buildings in the south of the country. In order to accompany the national program by 2030, CDER has set a target to introduce solar energy in cold production (Refrigeration, Air Conditioning and Cooling) through the development and implementation of cold production prototypes.
- **Promote cogeneration**: this is the simultaneous production of two different forms of energy in the same plant. The most common case is the simultaneous production of electricity and useful heat by thermal engines or gas turbines. Most restaurants use electricity and gas and release energy in the form of heat. This heat can be used for space heating or water heating. Convert simple cycle power plants to combined cycle power plants, where possible. Desalinate brackish water using renewable energy (SERVICE, 2019).

3.2 Mitigation measures of CO_2 emissions

When analyzing the national inventory of greenhouse gas emissions, the most emitting sectors are: the energy industry, transport and housing. These sectors are an important source of mitigation (Sahnoune et al., 2013).

The main mitigation measures implemented or being implemented to reduce pollutant and greenhouse gas emissions are:

- Recovery of associated gas from the wastewater treatment plant:
- Recovery of associated gas from oil wells (95% by 2020).
- The generalization of the use of gas in oil refineries
- The generalization of the use of natural gas for domestic needs
- Renewal of power plants by introducing combined cycle.
- The development of hybrid power plants (natural gas-solar)
- The development of LPG and CNG use as fuel for vehicles,
- Reduction of gas flaring in the energy industries,
- Introduction of energy efficiency in buildings,

- Development of solar energy

4.0 A path to sustainable energy development from SSB project

4.1 Current status of SSB project

Through development of silicon reduction process by designing new thermodynamics for silicon production and establishment of bases for energy engineering education in the Africa, the project aimed at verifying the feasibility of sustainable scaling up of the solar breeder concept and establishing basic research and education for new global energy supply system. The results of the different objectives are summarized as following:

- ❖ The generation of a high-purity silica and silicon reduction, which was the core of the technology in the project, were carried out in both Japan and Algeria. The silicon reduction from sand was achieved.
- ❖ The cost and energy balance of silicon reduction with the technology, which was more efficient than that of the current silicon manufacturing, was established. The silicon reduction from diatom was successful in USTO-MB.
- ❖ The silicon reduction from the sand had been carried out continuously in Algeria as planned after installation of a test plant in June 2015.
- ❖ The five (5) types of solar cells were installed, their operational records were obtained at least for 2 years, and quantitative data about cell performance such as efficiency and reliability were accumulated as planned.
- ❖ The key research outputs produced by the Project such as the silicon reduction process using silica stone, the silicon production test plant and the solar cell have been utilized at the Research Centre in Semiconductors Technology for Energy (CRTSE) in Algiers. For example, CRTSE conducts diverse research for instance in processing and enrichment of the raw material and crystal growth of silicon. It also developed knowhow of putting crystal growth technology into industrial use in photovoltaic and silicon electronics
- ❖ The human resource had been developed steadily based on Project's research results through the dispatch of students and researchers to Japan.
- ❖ USTO-MB established a PhD and master's degree courses related to solar cells and superconductivity for platform of technology introduced from Japan. Several master and PhD theses were submitted under the framework of the Project. Thus, the institutional capacity of research institutes also had been strengthened through the project.
- ❖ The researchers and students in Algeria had continued their research activities by utilizing the project equipment and technologies introduced from Japan.

- The remote education system utilizing WebELS was established, and USTO-MB signed memorandum of understanding (MOU) with Japanese universities for joint studies.
- The experimental sites in Saida University were of great help for USTO-MB and Saida University to continue research. Other universities were also concerned such as Pan African University Institute of Water and Energy Sciences (PAUWES) which was a centre of excellence at the University of Tlemcen in Algeria. (Ex-post Evaluation)
- The cooperation between Japanese universities/research institutes and USTO-MB has been maintained and a collaborative research on silicon production from sand and diatom has been undertaken. A Japanese professor and an Algerian researcher jointly attended to the International Conference on Renewable Energy and Energy Conversion organized in November 2019 at USTO-MB.

4.2 Effectives solution for sustainable energy from SSB project in Algeria

Algeria is one of the largest exporters of fossil energy sources, notably gas and oil. These sources are drying up over time and are largely responsible for global warming, which remains the main cause of global warming in all countries of the world. Face to this challenge, the Algerian government has been aiming for some years to develop a new model of energy use based on renewable energies and thus fight against climate change and ensure energy security. Overall, countries are implementing renewable energy programs to meet the energy needs of their economies while reducing GHG emissions. The growth of low-carbon economies can make a significant contribution to the global effort to mitigate climate change and preserve environmental integrity, while economies operate at optimal levels with electricity supplied by renewable energy Technologies. Electricity is essential to the development of any society, and to the transition to a low-carbon energy economy. As observed in the cases highlighted in this paper, large-scale distributed energy resources play an important role in achieving national energy transitions from non-clean energy sources to renewable electricity. On the other hand, if that contribute to the achievement of a country's energy mix diversification goals, increasing the available generation capacity to ensure Algeria's energy security and GHG emission reduction in the long term. However, the energy transition should not be limited to renewable energy projects made from imported materials to ensure sustainable energy security, but also and above all through education, information and the transfer of technology. Thus through the partnership between Japan and Algeria on the SSB project will provide effective solutions for the energy paradigm.

4.2.1 Basic research and development

Public energy research and development (R&D) is recognized as a key policy tool for transforming the world's energy system in a cost-effective way (Anadón et al., 2017). Technological progress plays a central role in the modern economy: It is an important contributor to economic growth and a crucial factor in determining the competitiveness of firms in the marketplace, nationally and internationally. R&D is widely recognized to be the technological pivot advance, and levels and rates of growth of R&D expenditures are viewed as reliable indicators of innovative capacity (Holdren, 1997). R&D led energy innovation plays an important role in balancing CO_2 reduction and economic growth. On the one hand, R&D investment promotes technological progress and ensures sustained economic growth. On the other hand, R&D improves energy efficiency and reduces the cost of renewable sources, both of which contribute to reduction of CO_2 emissions (Zhu et al., 2021).

Moreover, the SSB allowed the Ministry of Energy Transition and Renewable Energies to establish the Strategic Energy Research and Innovation Plan for Transition and Security in Algeria (2020-2030. It aims at establishing a scientific research database in the field of energy security in order to consolidate the research outputs and outcomes to achieve a transition to renewable energy and enhance energy efficiency. The research output and outcomes acquired by the project are expected to be integrated in this database and used for the implementation of the national strategic plan.

4.2.2 Education and training for science and technology of African people

To keep pace with the faster growth of science and technologies, it is necessary to have equally flexible system of education to meet the changing energy demand patterns well in time. A scientific and technological knowledge base with competent pool of human resources available in any country is necessary to improve economy and generate wealth. Today's economic growth and related industrial developments reveals that better functional qualities of a product such as the production of photovoltaic modules at lower cost per function is only possible by using right kind of scientific and technological knowledge base with creativity and innovative approach asking for further improving the efficiency of solar product. It has been a common practice in past to offer a number of pure and applied science programs at under and postgraduate levels in the Universities (Ahmad, 2009). Applied science disciplines primarily grew to support engineering and technology programs specially meant for industrial applications of energy systems. For local and global competition in the energy sector, the availability of appropriate and adaptable engineering education and research technologies, supported by the requisite institutions, is essential in any renewable energy project such as SSB's. African countries must have their own human resources to facilitate energy development and thus accelerate the adoption of the energy paradigm (Ahmad, 2009). The education system of African states must first be adapted to produce skilled human resources that can be deployed on a variety of tasks in a time-bound manner. It is necessary to offer the workforce the kind of training to meet specific requirements. The project can be the starting point for Africans to build up their solar cell manufacturing industry. For this, application-specific training modules for silicon production and solar products should complement the general programs introduced in the first part of schooling and at university level exhibitions.

Universities have a critical role to play in meeting the new energy paradigm shift and are key energy stakeholders. Universities build capacity through the development of new knowledge, new understanding and new insights, thereby providing effective solutions to complex problems. They also enable a regular supply of highly educated and skilled people who develop and implement energy and climate solutions. In the case of the SSB project, USTO-MB, Saida University, CDER Adrar, and CRTSE have been responsible to utilize the research outputs by the Project. USTO-MB and Saida University have undertaken operation and maintenance of the equipment provided by the Project. Approximately 100 students and researchers in Algeria have been continuously involved in research activities related to the Project (Project Sahara Solar Breeder Research Center, 2021). The cooperation between Algerian and Japanese universities has been maintained for promoting joint studies. Also, the collaborative mechanisms between government authorities and researchers. such as an advisory board with experts in energy and climate change, were established for reinforcing the government-academic policy dialogue to promote renewable energy and enhance energy efficiency. The researchers have been sustained and improved their research capacity by exchange of knowledge among them and other personnel, under the continuous support of USTO-MB and Saida University. They often start new research projects based on the research outputs of the Project. Also, many master and PhD research related to the research areas of the Project have been carried out in several Algerian universities. For instance, they studied, in a PhD project in October 2017, the installation of a large photovoltaic system at USTO-MB in order to provide enough energy for the university. They also studied the possibility of connecting this system to the Sonelgaz (national power utility)'s power grid. So through education, mentalities and habits will integrate the energy transition towards renewable energies.

4.2.2.1 Installation of WebEl system at USTO and Saida universities

The growth in online education and training resources available and being developed in the field of energy at many universities will therefore play an increasingly important role in training future engineers, technical experts, policy makers, social leaders, economists and other key professions (European University Association, 2017). Regarding to this, WebELS system and user manual have been used. By using WebELS system, national and international universities and research organizations benefit from distance education, online meeting, and international conference distribution without difficulty even in areas with low-speed Internet. The skills and knowledge to operate and maintain the research facilities in USTO-MB and Saida University have been sustained and improved with the support of specialized and qualified persons (Project Sahara Solar Breeder Research Center, 2021).

4.2.3 Clean energy generation and energy saving transmission through HTSC

Reducing emissions associated with power generation and consumption is a fundamental part of the challenges to curb climate change. In the energy sector, the central strategy is to increase the share of renewable energies in the power generation mix of the countries and to guarantee access to clean energy, while making sure energy consumption is efficient (Green Climate Fund, 2018). Access to energy is essential, but the way we get energy from burning fossil fuels is one of the biggest contributors to climate change in the world. Our reliance on fossil fuels affects the energy security of nations around the world. Fossil fuels on human health and the environment are becoming increasingly evident. In relation to these issues, the SSB project was launched to address these issues. The SSB plan aims to build production facilities in the Sahara that will extract silica from sand and convert it into solar panels to generate renewable energy. It is then used to create more manufacturing equipment and, in turn, more solar panels to produce more and more solar energy. SSB will ensure energy and climate security with global justice and the development of civilization for the whole world, an intelligent global development strategy to solve energy and climate problems with the production of existing solar silicon from sand technology of the Sahara for a world in a sustainable way (A. Boudghene Stambouli & Koinuma, 2012). The ultimate goal is to build enough power plants until the replication strategy can deliver 100 GW of electricity to provide 50% of the world's electricity generating capacity by 2050 that would be delivered over a global superconducting power grid to transform the world's largest desert in the world. The largest power plant using two resources that are abundant in the Sahara, namely silica and sunlight. Once the electricity is produced, it must be transmitted for use. However, this transmission causes many energy losses. Electricity distribution over long distances increases the temperature within power lines and thus causes significant energy losses in the form of heat. In the end, these losses are paid for by everyday electricity consumers (Stompf, 2020). So transmitting energy for a long distance cause some challenges. New solution has been studied which is the high temperature superconducting cable. Superconductivity is a fascinating state of matter characterized by the absence of electrical resistivity that certain materials exhibit when cooled below a certain critical, cryogenic temperature using liquid nitrogen. Combined with other unique properties, such as the ability to carry huge currents and trap extremely large magnetic fields, they pave the way for accelerating the energy transition. High temperature superconducting (HTS) materials make possible more compact, efficient and even disruptive technologies that can be integrated into all links of the electrical energy chain, from generation to transmission and distribution, including energy use and storage, thus enabling its decarburization (MORANDI, 2021). Increasing distributed renewable generation, changing transportation paradigms, and improving energy efficiency are some of the foundations for the Energy Transition. A multitude of challenges requires a variety of solutions. HTS-based technologies can address all these major challenges, and thus have a role in the solutions (MORANDI, 2021). In particular, through desalination and adequate irrigation technologies, it will help mainstream marginal desert water resources and lands back into national, regional and international development processes as is showed in the figure 29.

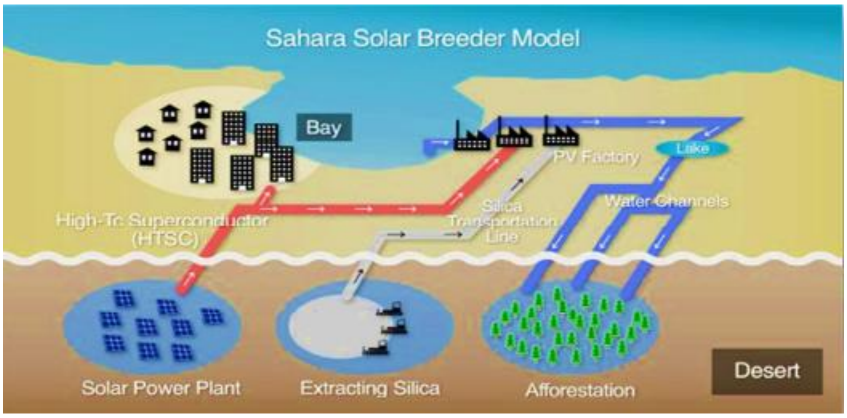


Figure 29: : SSB model, key to a sustainable civilization

Source:(Boudghene Stambouli et al., 2013)

4.2.4 Solving the global crisis through international cooperation and policy

Scientists, governments and industry recognize that the long-term consequences of energy consumption will be catastrophic if alternative methods of generating energy are not developed and used in our global economy (A. Boudghene Stambouli & Koinuma, 2012). The Science Council of Japan proposed the SSB plan at the G8+5 Academies' meeting[i] in Rome in 2009, and appealed for international cooperation to solve the global energy and ecological issues.

The development and realization of the SSB project, in the Sahara of Algeria which covers a total area of 2,048,297 km^2, approximately 86% of the total area of the country, will tackle the key challenges and issues related to the will tackle the key challenges and issues related to the field of PV putting forward the material Research and Development perspective and promoting innovative processes for solar silicon with a focus on the utilization of Sahara sands. the three elements Solar, Sand and Space that make up an advantage should be the national energy policy drivers of Algeria (Boudghene Stambouli et al., 2013). SSB proposes an international partnership plan in the areas of basic research and development, industrial production, trade, financing, etc. in order to gradually build a “Global Clean Energy Superhighway” over the next few decades starting in the Sahara Desert in northern Africa (starting with Algeria). SSB will help move from the current global energy paradigm, which is overly based on unsustainable fossil fuels, to a more sustainable one. It will also help address global energy challenges and mitigate climate change and other environmental problems as the whole world unanimously to maintain global temperature under 2 °C. SSB is more than an energy solution. It is an integrated community, socio-economic, industrial, agricultural, environmental, and science and technology development solution (A. Boudghene Stambouli & Koinuma, 2012). The SSB project is not an outmoded technology transfer or academic project. It permitted for USTO-MB and Saida University the acquisition of equipment for Training and Research in RE, this offered a unique opportunity of technological advancing in the energy field. The Japanese must learn many things from the Algerian to achieve a Win-Win strategy scenario between Japan, the Arab and African countries, and it is a destiny to uncover the energy solutions to the world’s environment problems with the cooperation and support of the Algerian, Arab and African cultural leaders, economists, finance specialists, politicians and government bureaucrats. countries such as Egypt and Tunisia have shown interest in the project. The figure 30 described the vision of the SSB.

4.3 Main benefits of SSB project

The SSB concept is globally orientated. Every country has an RE potential that can be developed and to fulfil its mission, Sahara Solar Breeder Foundation (A. Boudghene Stambouli M. T. Benmessaoud, 2017), International (SSBF) will engage in promoting and advancing SSB related initiatives such as:

SSBA: Academic and research initiatives

SSBB: Business and public policy initiatives

SSBC: Cultural and public relations initiatives

SSBA and SSBB will undertake academic, research and business relations initiatives in order to create:

1. Academia research which is the key in furthering the RE sector. Multidisciplinary research aspect of SSB is vital to this sector’s progress;
2. Newer metal industry (Silicon, etc.)
3. Cement industry;
4. Iron industry;
5. Carbon industry;
6. PV manufacturing Industry;

7. Water industry;
8. Local engineering company;
9. Local project management company;
10. Construction industry to realise above industries, etc.

SSBC will also undertake cultural and public relations initiatives in order to:

1. Promote solar energy technology that play a fundamental role in the fast-paced implementation of the SSB concept;
2. Promote the socioeconomic benefits associated with developing PV solar energy;
3. Award prizes to individuals, groups or institutions for undertaking pioneering projects or initiatives advancing the implementation of SSB vision and projects;
4. Create a supportive environment for RE investment and development by the SSB;
5. Find financing mean of RE projects which is critical in ensuring that projects such as SSB go from conceptualisation to implementation.
6. Help improve the image of desert life and regions, and build better awareness of their economic potential and cultural heritage;
7. Increase acceptance of PV electricity and raise awareness of PV PS potential, as well as RE and desert potential by informing, educating and outreaching the general public, the political, business and civil society establishments on the global, international, regional, national, local, corporate and civil society level;
8. Organise seminars, conference and round tables as well as other forms of public relations;
9. Uphold and defend social and ecological standards and environmental and desert regions development and protection;

The SSBB assumes that investment is a key factor for the diffusion of renewable energy technologies. In particular, for the use of economically viable renewable energies, they should be fully taken into account through state support and contributions from the private sector. Research shows that financial metrics that indicate the investment required and other ER usage costs (e.g., maintenance and operation), and the efficiency of each energy source (power) are two key criteria for ER funding. The reduction in solar PV installed costs has been driven by cost reductions in PV modules. Module prices fell by between 87% and 92% for crystalline silicon modules and this will lead to the reduction of electricity cost, depending on the type between 2009 and 2019 (International Renewable Energy Agency, 2019). SSB may then acts as a potentially significant new mean of jobs and rural growth in developing countries, and as a means of addressing environmental and energy security concerns. SSB is therefore a solution to provide social and environmental benefits. To succeed diffusion programs of SSB project development, different strategies such as technological improvements, increased economies of scale, and strong policy support should be contributed in both developed and developing countries. Above all the benefits, four major problems will be solved such as:

- ✓ Renewable and safe energy
- ✓ Water by desalination
- ✓ Creating new job in strong future market
- ✓ Peace keeping by development and economic cooperation

4.4 Discussion

The development of renewable energies, as a complement and alternative. Algeria has the largest potential solar energy reservoir in the world (estimated at around 3000 hours on average per year). This solar potential is equivalent to 37 billion m^3 of gas (i.e. 10 large natural gas deposits). The national program launched by the government for the development of renewable energies foresees a production of 4,500 MW in 2020 and which will increase to 22,000 MW in 2030, i.e. a contribution of 25 to 40% of the electricity production by 2030. Most of the current electricity is produced from natural gas (98%) (Cherif, 2016). According to (Bouznit et al., 2020), the production of this amount of RE implies that more than 300 billion m^3 of natural gas will be saved. Additionally, this implies that 348 $MtCO_2$ equivalents of CO_2 emission could be reduced.

In order to facilitate the integration of renewable energies into the national energy sector plan, the Algerian government has put in place mechanisms such as feed-in tariffs, laws, decrees, subsidies, inventive taxes, calls for tender for renewable projects etc. to encourage national and international investors as well as consumers, giving everyone the opportunity to take part in the development of renewable energies in order to achieve the set objectives. However, this development is far from the expected renewable energy targets, with a total capacity of 686 MW instead of 4500 MW in 2020.

Another important axis of this program is the promotion of energy saving and energy efficiency in the household and transport sector in Algeria, which should be a strategic goal to be achieved. Indeed, the energy-intensive sectors, namely transport, households and the tertiary sector, whose energy consumption represents 80% of the national energy balance. This model will make it possible to reduce internal energy demand by about 20% to 40% by 2030 (Cherif, 2016). The implementation of the national efficiency program would lead to an energy saving of 93 million toe by 2030 and thus 42 billion dollars will be saved on the reduction of 9% of the national consumption (INDC, 2015). The Union of Concerned Scientists (UCS) estimate that increased energy efficiency and a contribution of 20% from RE could eliminate the need for 975 of those prospective new power plants, as well as avoiding many miles of new gas and power lines (Goswami, 2004). Through this program, electricity from renewable energy sources will account for 40% of total electricity production in 2030. This programme will progressively contribute to the satisfaction of national electricity needs, but it is also designed to be an engine for industrial development, with national and global added value. Whatever the project, Algeria wants a real technology transfer. The "Energy Efficiency" initiative includes energy efficiency and rationalisation measures. The objective of energy efficiency is to produce the same goods or services using less energy (Sahnoune et al., 2013).

From the results, it can be said that the SSB project is an initiative that can offer Algeria and other African countries and the world a new energy paradigm. The development strategy has been designed to promote the spread of renewable energy at sites where it is cost-effective compared to conventional energy and to guide scientific research efforts to enable the widespread use of renewable energy in mass production (A. Boudghene Stambouli & Koinuma, 2012). Clean and secure energy is the key to sustainable civilisation, human security, reliable energy supply, climate stability and biodiversity, global and inter-generational justice, and a key to greater civilisation and wealth. It has an intelligent global development strategy to solve energy and climate problems with the existing technology of producing solar grade silicon from Sahara sand for a sustainable world. This will allow Algeria and Africa to have its own manufacturing plant for solar products that are until now imported from European countries. Algeria already has four solar cell assembly factories, whose production of silicon and solar cells will lead to the creation of jobs throughout the chain up to consumption. In addition, these products can be exported to African countries, starting with those closest to the country, and then to others. With the improved manufacturing and efficiency of solar modules, the cost will drop considerably and allow for affordable electricity production by off-grid mini solar power plants to populations in remote areas.

Through research, the SSB also seeks to identify the most important challenges facing the research and economic sectors and to propose new strategies that will identify the skills required to transform the research outlook, particularly that of the USTO-MB, based on the analysis and perspective of elementary processes and system design.

In order to accelerate the electricity highway, the electricity generated by the SSB, consisting of a VLS-PVPS network in the Sahara Desert, will have to be transferred to North Africa, then Europe, Africa, and finally the rest of the world, via HTcSC which can provide, in compact size, firm capacity for base load, intermediate and peak power, effectively complementing the conventional power source (A. Boudghene Stambouli & Koinuma, 2012). By analogy, this power transmission line is a pipeline that transports fossil fuels to other countries. So the collaboration like the one between Japan and Algeria is indispensable for the success of this project.

5.0 Challenges and Barriers of renewable energy programs

5.1 Challenges

Renewable energy is considered an important resource in many countries around the world. some challenges of renewable energy strategies for sustainable development can be identified.

- ✓ Integrating a high share of intermittent resources into the energy system, especially the electricity supply;
- ✓ Including the transportation sector in the strategies;
- ✓ Reducing the CO2 emissions by 2030 meanwhile the integration of renewable energy gets stack;
- ✓ Make electricity from renewables cheaper than electricity from natural gas;
- ✓ Limit fossil fuel subsidies, which are subsidized to the tune of 15 billion dollars per year in algeria (Hasni & Malek, 2021);

5.2 Barriers to investment in renewable energy project

The development of renewable energies is struggling to progress in Algeria due to certain barriers that make their integration into the energy sector difficult. The main barriers are summarized in the following table:

Table 10: Barriers to Investment in renewable energy Project

Economic and financial barriers	• lack of expertise in modelling the potential financial externalities when deciding to invest; • Long pay-back period of investments; • Difficulty in Power purchase agreement PPA negotiations; • Market design issues, hindering the integrations of renewable energies; • Difficulty in accessing financing; • High start-up cost; • Lack of subsidized loans for small scale facilities, • High market concentration • instability of the prices in the spot market
	• lack of a solid regulatory framework for land securement; • long processing time for the large number of permits; • grid connection constraints and lack of grid capacity;

Technological and infrastructural barriers to investments	• high risk of land specification due to mining concessions; • inadequate infrastructure to accommodate renewables;
Institutional and regulatory barriers	• lack of coordination between relevant institutions; • lack of a regulatory framework for competition • direct interest and participation of the state in the competitive sector; • lack of long term political strategy;
Public awareness and information barriers	• Lack of dissemination and public awareness; • Lack of necessary scientific and technical skills in the work force; • Local opposition to the development of projects.

Source:(Switch & Energy, 2020)

RECOMMENDATION

The main barriers to investing in EE and RES depend on political, regulatory, economic and social factors. Algeria is facing an important transition on a path of sustainable development that has significant economic, social and political implications for a country heavily dependent on fossil fuel production. More than 95% of Algeria's revenue comes from its oil and gas exports. Algeria currently has enormous oil and gas revenues, so it is imperative that some of this capital be used to accelerate the development of renewable energy. but the country is faced with a reduction in its own resources in the face of a strongly fluctuating market, which is reducing its income compared to previous years. In addition, the domestic demand for energy is constantly growing with the demand for energy in line with the growth of the population, with the number of apartments, with the country's development projects and large-scale public works.

In the context of dwindling resources and incomes, this is a major challenge for the country. Even if economic considerations suggest an upward revision of energy prices that are too low in Algeria due to high government subsidies, the implementation of measures to revise energy prices is still a particularly sensitive issue due to their social implications and risks and gives the right to particularly complex political options. This strategy must not ignore the crucial role that public investment plans can play in this sector along with creating market conditions that encourage adequate levels of private investment by domestic and foreign companies. In the RE and RE sector you face numerous and complex barriers and obstacles.

The recommendations are much more related to financial, technical, institutional and social aspects.

The potential for the development of renewable energies in Algeria, particularly from solar and wind resources and to a lesser extent from geothermal and biomass, is great. These technologies offer a number of simple, feasible and economically viable applications that can be implemented in the short term. The ability to generate heat and electricity from renewable energy sources can significantly accelerate the paradigm shift in Algeria, create jobs, develop technical skills, reduce the country's reliance on oil and gas, while meeting commitments to reduce greenhouse effects and global warming. The generation of renewable energies will also enable better management of fuel-based reserves. Renewable energies offer opportunities in almost all areas. In addition to the chain of solar and wind parks, thousands of jobs can be created for Algerian scientists and engineers, as well as other supporting areas, which in turn would enrich the local economy and help promote national know-how to ensure long-term technical independence; Algeria cannot continue to rely on foreign experience in realizing its energy potential. In addition to the current vacancy in the field of renewable energies, public awareness of renewable energies can play a role here, starting with a program on energy saving, energy efficiency and renewable energies at schools and universities. Summer schools, specialist workshops, presentations and training centers.

The Ministry of Energy has developed a clear energy efficiency policy to establish a coherent government strategy aiming to address low energy costs. However, a strong coordination between the different sectors shall be achieved, as this would be desirable in order to enable Public Authorities to coordinate and harmonize their program in favour of a common energy efficiency strategy, in particular in key sectors such as construction, health, industry, tourism, transport and finance.

Renewable energy development will encourage international investment and collaboration, thereby securing funding for projects. But it is also important to encourage investment from Algeria's private sector and young entrepreneurs to help reduce reliance on state funding. Investment in renewable technology would give Algerian scientists and inventors the opportunity to develop patents for renewable systems.

To date, private sector intervention and investment in medium and long-term renewable energy projects is limited. With the publication of the above-mentioned decrees on the feed-in tariff for solar and wind power, projects financed by private sector investment should be able to come on stream, and local authorities will have a role to play in attracting these investors to their territory. Appropriate measures should be put in place to improve infrastructure, such as the national grid, to absorb all the energy generated by RES without affecting the quality of the electrical signal. Until now, most of the energy generated by renewables is not connected to the grids.

Higher Investment costs and length of pay-back times related to the implementation of RES and EE measures may be a financial constraint for investors, who may not understand the return on investment that will be generated by these costs. This is particularly true in the social housing sector, which is very sensitive to financial issues. In this case, the State, through the The Ministry of Housing is the only authority empowered to encourage investments in energy efficiency. When determining the property value, not only the construction costs but also the operating costs of these houses should be taken into account. Goods and projects. In addition, the lack of access to bank credit reduces the opportunities to start a project and excludes any possibility of funding.

The private sector could play a leading role in this area by investing in energy efficiency and renewable energy at the municipal level (mosques, schools, public buildings, public lighting, university halls of residence etc.) such as replacing fluorescent and incandescent lamps with energy saving lamps (LED). This is an area that not only contributes to improving the quality of energy supply, but also helps to create jobs and protect the environment by reducing greenhouse gas emissions and pollutants.

The lack of information about funding mechanisms and applicable regulations prevents small and medium-sized enterprises, suppliers and installers (such as architects, engineers, etc.) and policy makers, mainly at the local level, from taking advantage of efficiency energy, renewable energy and financing options, so most Operators and investors do not consider these energetic aspects in their projects and therefore do not develop projects that contribute to energy efficiency and the expansion of renewable energies.

The establishment of an information center and a database for all RE projects and a classification of RE and RE companies would be desirable. This classification should be based on feedback from customers of these companies. Only qualified and certified engineers and technicians. Additional awareness campaigns should start by organizing workshops at all levels through formal and informal means, social media, etc. It is necessary to prepare campaigns to disseminate and promote knowledge among citizens and in schools.

CONCLUSION

Renewable energies are a real and complementary alternative to fossil energy due to their characteristics. Although they are available in nature and are not polluting the environment, they require high costs and sophisticated technology to exploit them (Nouioua et al., 2019).

Algeria is endowed with large reserves of energy sources, mainly hydrocarbons and solar energy. Several studies have shown that the Algerian territory has considerable renewable energy potentials in the world, especially with regard to solar and wind energy. In the world energy markets Algeria plays a very important role, both as a significant hydrocarbon producer and as an exporter, as well as a key participant in the renewable energy market (Dib et al., 2012).

The Algerian energy sector is still heavily dependent on non-renewable fuels such as crude oil and natural gas as energy sources. In this context, energy transition and security must be the main axes of sustainable development of the energy sector. Moreover, domestic energy needs are constantly growing, with an annual increase. This rapid growth in the demand of energy is in line with the population growth, with the number of housing units, with the country's development projects and the major public works. The energy supply needed to meet this ever-growing demand, in a context of declining resources and revenues, is a major challenge for the country

With the problems caused by fossil fuels on the environment and drying up over time, the Algerian government has become aware of this situation and has adopted a national program for the promotion of energy and energy efficiency in order to integrate renewable energies into the energy mix and diversify its energy sources for energy security.

99% of the national electricity consumption comes from natural gas. The implementation of this national programme for the promotion of renewable energy and energy efficiency in buildings could lead to a saving of millions of cubic meters of natural gas and a reduction of millions of tons of CO_2 emissions. Rationalisation of energy consumption is more necessary than ever in the household and transport sectors. Its implementation requires the application of technical regulations and the upgrading of the equipment to international energy efficiency standards. But also, to put in place strong measures in order to orient the models of production and consumption of energy and development respectful of the environment and energy saving. There is a need for an action programme towards an energy transition to ensure sustainable development by 2030.

Despite the mechanisms and laws established by the Algerian government to encourage the production and consumption of energy from renewable sources, the share of renewable energy in the energy mix is still low (around 1%). This is due to certain challenges and barriers on the technical, financial and institutional levels that hinder the development of renewable energy.

Today the importance of access to clean solar energy is crucial for the sustainable development of the energy sector and the entire economy. Therefore, research, development and demonstration through numerous projects in all countries are the basis for progress and change towards sustainable energy systems and a paradigm shift is inevitable. The need for more electricity from renewables, especially solar, more investment and initiatives to make solar photovoltaic energy profitable and competitive, as suggested by the international Sahara Solar Breeder (SSB) project for today and a concept for the future (Amine Boudghen Stambouli, 2021). There are good examples of commercial initiatives to enhance the energy security of communities in energy-stressed regions, and the lessons of good practice from experienced countries, such as Japan, need to be more widely disseminated. Cooperation such as that between Algeria and the SSB project is crucial in leading the way towards the energy transition, an issue that concerns everyone. There is no lack of resources. The real challenges lie in our will, our organization and our societies. For renewable energy, as for energy efficiency measures, progress will not come simply from capital warnings. It will also depend on education and institutional frameworks to promote appropriate behaviour. Public institutions need to lead by example and the public will follow by providing information on their neighbour's energy consumption, people can be made to save energy (Boughali et al., 2017). For the new energy model to succeed. We need to change the energy culture and energy policy can no longer be seen in a vertical and technocratic way. It is now invited to be built collectively, by widely involving all the stakeholders and the different scales of the territory.

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Appendix

Table 11: Summary of Energy Security Dimensions and Parameters (Appendix)

Dimensions	Parameters
Availability	Existence of resources
	Existence of consumers
	Existence of means of transport (access)
Diversity	Diversity of sources
	Diversity of fuel (energy carriers)
	Diversity of means (technologies, transportation)
	Diversity of consumers
Cost	Energy price (consumers, producers, pricing system/subsidies, energy poverty, peak oil, and stability/volatility)
	Cost of disruption
	Cost of securing the system
Technology and efficiency	New technology advancement
	Energy system efficiency
	Energy intensity
	Energy conservation
Location	Energy systems boundaries
	Location of energy source
	Density factor (centralized/decentralized)
	Land use
	Globalization
	Population settlement and distribution
	Geography
	Industrial intensity
Timeframe	Timeline
	Length of the event
	Length of the effect (struggle or impact)
Resilience	Adaptive capacity
Environment	Exploration rate and resources' location
	Extraction and transportation methods
	Outcomes from energy use
	Impact resulting from environmental change
	Relationship to water
Health	Impact of people's health on the energy system
	Impact of the energy system on health of (energy sector workers, consumers, and international society)
Culture	Cultural effect on the energy system [production, connection, consumption, cultural acceptance (NIMBY, Not In My Back Yard)]
	Energy conditions shaping cultural aspects
Literacy	Information availability (quality, market information, public awareness, and structured educational program)
	Information presentation and provision
	Usage of energy information
Employment	Effect of energy security on unemployment rate
	Effect of employment rate on energy security
Policy	Political system, democracy/dictatorship (nature, stability, citizen's will, and internal and external relationship)
	Regulations (liberalized and controlled market, rules, and subsidies)

Table 12: Targets of Algeria's Intended Nationally Determined Contribution (INDC) and the main intended actions (2021–2030) (Appendix)

Targets	Main Intended Actions (2021–2030)
Unconditional goal: • With national efforts, the greenhouse gas (GHG) will be reduced by 7% by 2030. Conditional goal: • With international support in terms of financial aid, high technology transfer, and capacity building, the amount of GHG should be reduced from 7% to 22%, by 2030.	Energy sector: • Electricity generated from renewable sources reaching 27% by 2030. • Generalize high-performance lighting. • Thermal insulation of buildings between 2021 and 2030. • Increasing the share of liquefied petroleum and natural gas in the total energy consumption, between 2021 and 2030. • Reducing the volume of gas flaring to less than 1%, by 2030. Waste: • Waste valorization. • Organic and green waste. • Energy from landfill sites and waste water treatment plants. Forestry sector: • Forestation, reforestation and forest fires prevention. • Improving means and provide equipment to fight forest fires.

Table 13: The National Fund for Renewable Energy and Cogeneration (financial resources and aid) (Appendix)

	The National Fund for Renewable Energies and Cogeneration
Financial resources	• 1% of oil royalties each year. • The balance of the Account related to the National Fund for Energy Management. • Government subsidies. • Tax revenues from energy consumption. • Revenues from taxes on energy inefficient appliances. • The proceeds from fines provided in the Energy Efficiency Law. • The repayment proceeds related to unpaid interest-free credits. • Any other resources or contributions.

Kinds of aid to finance RE related activities 1st set of financial aid: REs and cogeneration	• Financing actions and projects included in the promotion of REs and cogeneration program:
	  ◦ Electricity generation projects from RE sources and/or cogeneration.
	  ◦ Purchase of equipment for electricity production from RE sources and/or cogeneration.
	  ◦ Over-costs compensation, arising from electricity generation from RE sources, and/or the cogeneration systems.
	  ◦ Pilot projects and demonstration operations relating to REs and/or cogeneration.
	  ◦ Actions to upgrade/maintain RE electricity installations generation.
	  ◦ Training actions related to REs and/or cogeneration systems.
	• The allocations for the pre-financing of actions related to the promotion of REs and cogeneration.

2nd set of financial aid: Energy management	• Financing actions and projects included in the energy management program. Actions included in the Energy management program: • Requirements conformity, norms and energy efficiency labels. • Awareness, communication, information, education, promotion, co-ordination and training in the field of energy management. • R&D in the field of energy management. • Accompaniment of industrialists in order to improve the energy efficiency of equipment. • Actions and works to evaluate energy efficiency potentials in the different activity sectors. • Animation and co-ordination of energy management. • Production and monitoring of the energy management program. • Management and monitoring of energy audits. • Instruction, monitoring and control of projects financed by the resources of the National Fund for Energy Efficiency. • Evaluating the impact of projects on energy consumption. • Production, publication and diffusion of the energy efficiency indicators. Projects included in the Energy management program: • Thermal insulation of buildings. • Use and diffusion of high-performance lamps. • Efficient public lighting. • Diffusion of individual and collective solar water heating. • Conversion of vehicles to Liquefied Petroleum Gas and Natural Gas. • Acquisition and conversion of buses to Natural Gas. • Introduction of efficient equipment in all activity sectors. Assistance for the decision on energy audits and project feasibility. • Pilot operations and demonstrations. • The Banks grant interest-free credits to investors in energy efficiency, which are not included in the energy management program. • The government is the guarantor of Bank credits.

Table 14: Plagiarism Check report (Appendix)

PREPOSTSEO

PLAGIARISM SCAN REPORT

Date	October 20, 2021
Exclude URL:	NO

Unique Content	91%
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Paraphrased Plagiarism	0

Word Count	23,643
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CONTENT CHECKED FOR PLAGIARISM:

- [i] The G8+5 Academies' Meeting 2009 is a meeting of the science academies of the G8 countries (France. Germany, Italy, Japan,United Kingdom,United States, Canada and Russia) and five others (Brazil, China, India, Mexico, South Africa) organized every year by the academy of the country hosting the G8 Summit. In 2009 Italy hosts the G8 Summit.