الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي و البحث العلمي

Université Abou Bekr Belkaid جامعة أبي بكر بلقايد
Tlemcen Algérie تلمسان الجزائر

PEOPLE'S DEMONCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

ABOU BEKR BELKAID UNIVERISTY, TLEMCEN

FACULTY OF ECONOMICS SCIENCES, COMMERCIALS SCIENCES AND MANAGEMENT

The Impact of Renewable Energy on Sustainable Development Factors in Algeria

A Dissertation Submitted to the Department of Economics sciences in Candidacy for the Degree of DOCTOR in Applied Economics

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Date : February 13th, 2019

Academic Year: 2018 - 2019

DEDICATIONS

To my parents for their continuous encouragement and support.

To my brother Younes and my sister Hasna.

To my friends.

ACKNOWLEDGEMENTS

Before all, our thanks go to the world creator and the Merciful God.

It is after a great work and strong will that we have reached the end of this work and it is thanks to several people to whom I would like to express my gratitude.

All the thanks go to my teacher and supervisor Dr. Mekidiche Mohammed, who has guided me with great professionalism and whose guidance and suggestion have helped me a lot in the Fulfilment of this research work.

I welcome this opportunity to express my appreciation to the jury members, Pr. Bettahar Samir, Pr. Benbouziane Mohammed, Pr. Hassaine Amal, Dr. Chekouri Sidi Mohammed and Dr. Chibi Abderrahim for their time, valuable comments and precious remarks,

I also owe million thanks to all the teachers in the University of Tlemcen, University Center of Maghnia and University of Granada, from whom we have learnt a lot.

ABSTRACT

The present research work is an attempt to analyse the impact of renewable energy on sustainable development factors in Algeria over the period 1995-2016.

The main objective of this research work is to demonstrate the role and the importance of renewable energy in Algeria, and how it will influence the economic, environment and social situation. Also, we shall make a model to display the effect of energy policy and government on the introduction of renewable energy in Algeria.

This research paper consists of three chapters. The first one provides an overview about definition, role, advantage, inconvenient, and the market of renewable energy in the world and in Algeria. We shall also define the term of "Sustainable Development" and the importance of sustainable development goals in the world and how it can improve the current situation in Algeria. The second chapter draws an overall literature review about energy (renewable energy), economic growth (GDP and GDP growth), environment issue (carbon dioxide and greenhouse gas emissions), social aspect (Human Development Index), and the importance of government institutions and the energy policy in the introduction of renewable energy in Algeria. We will also review some econometric methods and empirical literature review. In the third chapter, we shall make four econometric models that will investigate the link between renewable energy and sustainable development factors in Algeria. The 1st model is about the relationship between economic growth and renewable energy. The 2nd model demonstrates if there's evidence of Environment Kuznets Curve hypothesis or not in Algeria and it will also study the impact of economic growth and renewable energy on the environment aspect. The 3rd model defines the relationship between renewable energy, economic growth, carbon dioxide emissions and Human Development Index. And, with the 4th model, we will study the role of government institutions and energy policy on renewable energy deployment. In doing so, we have collected data through using different statistics and mathematics methods. Quantitative and qualitative examination of outcomes, relieve us in understanding the importance of including renewable energy in Algerian system, and we have come up with the fact that the renewable energy will have a positive impact on increasing the economic growth and reducing the environment issue, but it will affect negatively the Human Development index. However, the outcomes from the 4th model indicate that the renewable energy policies applied right now are not suitable or perfect for the introduction of renewable energy in Algeria.

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Introduction and Context of the Study

The world is no longer the same as it used to be in the past. Today, more than 85% of the energy used in the world comes from fossil sources (coal, oil and natural gas) which were established in the course of ages and of geologic evolution. However, such sources are becoming scarce and limited, especially with the rise of the energy demand. Thus, such situation can lead inevitably to the drying out of these sources and it will affect negatively the socio-economic condition of any country.

In prevention of such crisis which will lead the global economy to the chaos. The world major power was obliged to make researches and studies that will push them to look after new sources as a supplier or as an alternative to fossil energy. Amongst of these sources, there's renewable energy which is considered as a cleaner and an unlimited source of energy. Despite the fact that this cleaner energy has a high cost of its technology and innovation machinery which it makes them almost uncompetitive with fossil fuel, such energy will remain a towering figure to avoid the dependence on fossil-fuel and support the economic growth.

During the recent period, researchers began to find new technologies which use the renewable energies with proficiency and efficiency such as the solar photovoltaic, wind power, and hydroelectric…etc. These inexhaustible resources exist worldwide in several forms (solar, wind, water, geothermal, and biomasses) and they can provide electricity, thermal (heat), mechanic and combustible energy.

Moreover, most of the developed countries have almost the necessary equipment and machinery that can use the renewable energy suitably, but the developing countries haven't enough financial assets that can allow them to support the renewable projects. Nevertheless, many nations are starting to recognize the renewable energy as a good alternative to other energy and they are beginning to make great investments to possess renewables like the installation of solar power plants and wind farms.

Furthermore, the sustainable development is a process of changes that makes the exploitation of the resources, the orientation of the investments, and the institutional government work together and reinforces their current and future situation to satisfy their needs. Thus, renewable energy represents one of the objectives that United Nation for Development Program to introduce with the term of "Sustainable Development", because, such energy offers a lot of advantages and opportunity for any country.

Algeria is a strategic geopolitical actor for the Mediterranean and Northern Africa area, and also a likely green energy exports leader in the near future, if policy pledges are to be fulfilled. The country identified the renewable energy as a potential supplier source for fossil energy, and started to make national programs and legislative law for the deployment of renewable energies and which are considered as a great addition that can aim to reach the energy efficiency and to reduce the environmental pollution. Also, if Algeria decides to swiftly change its energy mix and to become an international renewable energy provider, it will realize the sustainable development goals and it will make profitability, reduce costs, time and increase the energy supply. Therefore, Algeria needs to design training plans, and long-term strategy to reach the optimal use of these energies. Consequently, the problematic of this thesis can be formulated as follows:

- What is the role of renewable energy on sustainable development factors in Algeria?

Before answering this problematic, we shall define some research questions:

- What are the renewable energy and the term of sustainable development?
- Does renewable energy impact positively the economic growth?
- How will be the impact of renewables on the environment factor?
- Will the renewable energy improve the well-being and the life condition of Algerian population?
- Does the energy policy in Algeria encourage the introduction of renewable energy?

Therefore, to check the problematic and the research questions, we shall make 4 models to study the impact between renewable energy, economic growth (the economic factor of sustainable development), carbon dioxide emissions (the environmental factor of sustainable development), Human Development Index (social factor of sustainable development), and also studies the importance of government institutions and policy support on the renewable deployment in Algeria.

The objectives of this study are:

- ✓ Demonstrate the role and the importance of renewable energy;

- ✓ The influence of renewable energy on the economic, environment and social situation in Algeria;
- ✓ The contribution of Algerian energy policy and government institution on the introduction of renewable energy in Algeria.

The objectives from the introduction of renewable energy in Algerian system are:

- Increase the energy supply;
- Rise the level of economic growth;
- Decrease the level of CO_2 emissions in the atmosphere;
- Improve the well-being of the population;
- Avoid dependence on fossil fuel;
- Enhance the socio-economic situation in all aspects.

To answer the problematic and the research questions, we shall give the following hypotheses:

- ➢ The renewable energy may increase the level of economic growth, human development index and reduce the level of carbon dioxide emissions;
- ➢ The renewable energy will have a negative influence on sustainable development factors;
- ➢ The energy policy and the government institutional will support the introduction of renewable energy.

Therefore, the aim of the 1st hypothesis is to have a positive influence of renewable energy on economic growth and social indicator, while a negative effect on factor of environmental issue, so an increase in renewable energy consumption will increase the level of GDP and HDI, while it will decrease the level of CO_2 emissions;

The 2nd hypothesis aims at having a negative impact of renewable energy on economic growth and social indicator, while a positive effect on factor of environment issue, so an increase in renewable energy consumption will decrease the level of GDP and HDI, while it will increase the level of CO_2 emissions;

The purpose of the 3rd hypothesis is to ensure a positive and significant support of energy policy and government institutions toward renewable energy deployment.

Chapter 1:

Renewable Energy and Sustainable Development in Algeria

Chapter 1: Renewable Energy and Sustainable Development in Algeria:

Introduction:

Renewable energy is considered now as a great natural resource (wealth) which can provide us sustainable energy that can supply many countries for several centuries. In the light of this statement, many researchers stated that this energy will play a key role in the development of society in the future and it will shift the energy system in industrial, agricultural, and service sectors. Therefore, the renewable energy may have an important part in realising long-term objectives, and it can be brought into line with sustainable development goals.

Furthermore, the word “Sustainable Development” is an international term that aims at studying the relationship amongst economic, environment and social subjects. Despite the fact that the adoption of this term is extremely difficult, several countries were willing to recognise their long-term strategies and begun to respect several conditions that make them to attain the sustainable development goals in the future. Thus, nations decide to make some policies and international organisations such as (IEA[1], UNDP[2], and OECD[3]) to facilitate the sustainable development implementation in different states.

Moreover, Algeria is considering its position vis-à-vis sustainable development objectives, and agreed to make regulations and laws that can achieve the environment issues mitigation, increase the rate of economic growth, and improve the socio-economic situation by introducing renewables in its energy system. Consequently, the country is expected in the future that the deployment of renewable energy will satisfy the energy demand, reduce the environment and social problems by providing a less polluted atmosphere, and the development of economic growth.

In this chapter, we shall display different terminologies of renewable energy, sustainable development, and how it can influence the world system in the future. Also, a review of Algeria situation will be conducted and we will provide information about energy, environment, economics, social and political circumstances.

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[1] - International Energy Agency (https://www.iea.org/)
[2] - United Nations Development Programme (http://www.undp.org/content/undp/en/home.html)
[3] -They are almost 35 countries who share their experiences and find solutions to common problems, and their mission is to promote policies that will improve the economic and social well-being of people around the world (http://www.oecd.org/about/)

1. Renewable Energy:

1.1. Definition, technology and the potential of renewable energy:

1.1.1. Definition and application:

Renewable energy (clean energy or green energy) is unlimited or eternal source of energy which is originated from the environment and a repetitive phenomenon. It can be from the radiation of the sun, the power of wind, water of the ocean (tidal and tides or hydropower), trees and plants (biomass), volcanoes (geothermal), nuclear power…etc.

The renewable energy application[4] used different sources that can provide us a multitude of different energy flows like thermal, chemical, mechanical and electrical energy. Since previous times, these sources have existed on Earth and were directly or indirectly affected by many biological cycles (sun radiation, plantations, movement of sea and ocean). However, many researchers couldn't reach the real potential of such energy and are still working on how to get information that will permit them to improve the energy efficiency and the renewable energy production. This problem is mainly due to the renewables technology cost and the fossil fuel dependence. On the other hand, the investigation established the possibility to measure the magnitudes relating to the respective energy flow site, such as measuring the wind speed with an anemometer or the solar radiation with a radiation meter. Therefore, the renewable energy source can have several benefits[5] as following:

- contribute to reducing the greenhouse gas emission by making them a key segment of the energy structure;
- Substitute the fossil fuel;
- Rise the energy production;
- Enhance the economic growth and the rate of GDP in numerous importing nations and avoid the economic balance (import-export) deficit ;
- The solar photovoltaic and wind power can avoid thermal pollution and contamination that are caused by the discharge of cooling water for thermal power plants.

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[4] - Martin Kaltschmitt et al. (2007), «*Renewable Energy Technology, Economics and Environment* », Springer Berling Heidelberg New York, page 8.

[5] - S.Sumathi et al. (2015), « *Solar PV and Wind Energy Conversion Systems An Introduction to Theory, Modeling with MATLAB/SIMULINK, and the Role of Soft Comuting techniques* », Springer international publishing, Switzerland, from the page 18 to 30.

1.1.2. Types of technology:

They're a plentiful of renewable energy technologies[6] which are based on solar photovoltaic, wind power, hydropower, biomass and waste energy as following:

1.1.2.1. Biomass:

The biomass is made from the production of natural resources or organic substances that are resulting from ecological cycle. In this process, the environment habitat produces some organic matters from the dioxide of carbon, which is resulting from the atmosphere, water, and sunshine. This renewable source is directly or indirectly impacted the processes of energy and the emissions of greenhouse gas in the atmosphere by the use of woods, copses, waste…etc. Also, it can be used for the methane production with the decomposition and combustion of the plant waste and the substances that can contribute either in the greenhouse gas (GHG) emissions or in biogas (or biofuels) production process.

1.1.2.2. Wind energy:

The wind power[7] is originated from sunshine and it was used in ancient time to pump the water from rivers and lake. The principle is like the opposite of the ventilator which is composed of turbines and blades that will do a procedure of inhale the air and the wind (mechanical energy), and then convert this into energy (electricity) with the process of transformation (rotor). The quantity that's absorbed by the turbine and rotors differs from its nature and its colour, so there are some regions with high pressures of air (especially in the littoral) and other regions with low pressures of air. The average value of the atmospheric pressure is 1013 hectopascals[8] (hPa) in the sea and the coastal places.

1.1.2.3. Solar energy:

The solar energy is mainly from sun radiation and it provides two main forms of energy, the thermal solar energy, and the photovoltaic solar energy. The first form is used to produce, especially the heat energy, and it can be divided into two kinds according to its equipment:

- The low-temperature energy that is used for water stove;
- The high-temperature energy which is used to provide the heat energy to supply the cycle of thermodynamics and to offer an extra electricity production.

The second form is used to convert the solar radiation into electricity energy. The researchers used the physical phenomenon such as the photosynthesis which absorb the sun photon (photo or solar) by a material of transformation then convert it into electrical current

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[6] - Pr. Francis Meunier, (2005 and 2008), «*Domestiquer l'effet de serre Energies et changement climatique* », Edition Dunod, 2éme édition, Paris, from the page 55 until page 84.

[7] - Jean-Christian Lhomme, (2001 and 2004), « *Les énergies renouvelables* », Delachaux and Niestlé SA, Paris, page 77.

[8] - is a unit of measure of pressure which is equivalent of the millibar.

in a user's circuit (voltaic or electricity). However, the solar energy technology is still expensive, and the scare of their raw material makes their applications very limited in some countries.

1.1.2.4. Geothermal energy:

The geothermal energy is coming from a natural geyser which is formed at underground sites where it accumulates a hot water (by the magma of a volcano). After the rise of the temperature, this stored water will be ejected into the geological surfaces. Consequently, an artificial geyser will be creating which is containing a high-temperature of ground waters. We can distinguish generally three type of geothermal energy:

- The electricity energy;
- The heat energy production;
- The geothermal hot air pumps combines two last technics and can offer us the electricity and the heating energy.

1.1.2.5. Hydropower energy:

The hydropower or hydroelectric power[9] represents the most renewable energy used in the world and is an indirect form of the solar energy because it influences the level of the vapour of sea water and it makes the condensation of rain clouds. The hydropower energy transforms the water into electricity energy by a mechanical process, and it needs big dams to store a huge quantity of water in the stock and to allow a high level of electricity generator in anytime. However, this procedure requisite great amount of mechanical energy and there's always a great value of waste energy.

1.1.3. The potential of green energy:

The Earth's energy seems to have a huge potential[10] of renewable and natural sources which are associated with the sun radiation, the carbon dioxide and GHG emissions accumulation in the air. However, the human civilisation is just using only 0.02% of this natural resource, so this tiny statistic shows that the potential of renewable energy and natural resources are enormous and in 2017, it only reached only 25% of energy supply.

Both hydropower and biomass has an enormous potential and represent the main renewable energy used in the world. Followed by solar energy, and his passive warming, which is a key characteristic of building design all over the world, but it hasn't reached its maturity of development yet. Also, the wind energy has a both passive and active role,

[9] - Leon Freris and David Infield, (2009, 2013), «*Les énergies renouvelables pour la production d'électricité*», Edition Dunod, Paris, pages 28 and 29.
[10] - S.Sumathi et al. from the page 34 to 36.

inactive utilization of wind energy for ventilation of structures assumes a critical part, and active power generated by wind turbines is today a quickly developing energy innovation in some countries. However, their elevated penetration can reach at almost 20% of aggregate power produced which is found in Denmark “the nation of wind innovation and development”.

The investment in research and development[11] in clean energy was almost $8 billion in 2016 and the government spending on renewables research reached $5.5 billion in the same year. The solar and wind research and development investment was $3.6 billion and $1.2 billion, respectively. However, the biofuels investment was $1.7 billion in spite of low oil prices and a challenging regulatory environment. The investment in renewable energy research and development held up in 2016 in spite of some significant headwinds, including falling fossil fuel prices and some reduction in policy support.

Furthermore, the innovation in such area can develop the competitiveness between renewable energy and fossil fuel technologies either by cutting their capital cost, by reducing the energy and raw materials required to produce them, or by raising their efficiency, which is about increase the quantity of energy produced by each nominal mega-watt (MW) of capacity. Thus, such competition can reduce the cost level of electricity per mega-watt per hour (MWh) in the near future, especially in the renewable area, and it has already reduced the cost of solar modules by four fifths since 2008, with the promise of more to come.

1.2. Renewable energy efficiency and the sustainable energy for all initiatives:

1.2.1. The renewables investment:

The investment[12] in renewable energy projects has reached $187.1 billion in 2016, and it may attain the capacity of more than 1MW, especially with two principal sectors (solar and wind) accounted for $175.7 billion in the same year. However, the offshore wind was the main investment project in green energy with $30 billion and will reach 1.2 GW Hornsea array off the UK coast.

The market[13] of renewable energy sector has known a huge development in the world energy market. The main contributor to global renewable energy supply was bioenergy, and the total energy demand supplied from biomass was almost 62.5 exajoule (EJ) in 2016, while its usage in the energy sector has been rising by 2.5% per year since 2010. The geothermal

[11] - Frankfurt School, United Nation Environment Programme and Bloomberg New Energy Finance collaborating centre for climate & sustainable energy finance, (2017), «*Global Trends in Renewable Energy Investment 2017*», Frankfurt School of finance & management gGmbH, Germany, page 76 to 81.
[12] - Frankfurt School, page 50.
[13] - Renewable Energy Policy Network for the 21th century, (2017), « *Renewables 2017 Global Status Report*», REN21 Secretariat, Paris, France, pages 45, 52, 57, 63, 72, 75, and 82.

resource is providing energy, especially in the form of electricity and direct heating and cooling, which is estimated at 567 picojoule (PJ) or 157 Tera Watt per hour (TWh) in 2016. The hydropower energy has reached 1,096 Giga Watt (GW) of electricity energy capacity in 2016. The solar photovoltaic capacity has known great evolution in this market approximately an increase by 48% in 2015 which it means 75 GW added energy (equivalent to 185 million solar panels) during 2016, and the estimated energy of PV has reached 303 GW of electricity energy capacity. The concentrating solar thermal power (CSP) or solar thermal electricity (STE) was estimated more than 4.8 GW in 2016. The solar thermal heating and cooling has produced almost 456 GW of heating energy at the end of 2016. The wind power has reached 487 GW of generating electricity capacity in 2016 and it represents the second most energy bought and sold than any other renewable energy technology.

Several investors know that the green energies are representing the one of the most favourable energy sectors in the world. According to the report 2017 of Renewable Energy Policy Network for the 21st century (REN 21), they were at first sign of energy evolution from the fossil energy use to renewable energy use, and in the end of 2016, 19.3% of global final energy consumption were from renewable energy. In 2017, an around $333.5 billion were invested in the renewable energies (Blomberg New Energy Finance[14]). The solar was the main investment in the renewable energy sector and was estimated at $160.8 billion, followed by the wind, which was accounted for $107.2 billion, then the investment in energy-smart-technologies (equipment and battery storage) were valued at $48.8 billion, and the biomass investment was estimated at $4.7 billion. Such investment has provided more than 9.4 million of new jobs, particularly in solar photovoltaic, biofuels and hydropower energy.

Shell[15] has considered that 50% of our energy needs could be covered by the renewable energy before 2050, if we see the proportion that has taken this energy in previous years. We can confirm that it will be possible, but, the major problem of this new energy is their cost and their technologies immaturity.

1.2.2. Energy efficiency and energy intensity:

The energy efficiency[16] is used to measure the ratio of the energy consumption or various terms of plant and equipment, but it is extremely hard to estimate the qualitative data which are related to the skill, judgement, labour force…etc. Nevertheless, it is relatively easy to establish an upper limit for energy consumption by using:

14 - https://about.bnef.com/clean-energy-investment/

15 - is a multinational company that aims to meet the energy needs of society in ways that are economically, socially and environmentally viable. As it is called also the Royal Dutch Shell situated in the Netherland.

16 - S.Sumathi et al. page 6 and 7.

$$Annual\ Energy\ Consumption/Kwh = \frac{The\ plant\ power\ output/\ Kwh}{Efficiency\ of\ plant} * Number\ of\ operating\ hours/year$$

However, the energy efficiency can depend on how to use the energy appropriately, but it could be very limited use due the several conditions of laws, regulations, financials, and other factors that are related to the climate change. Therefore, in some countries, regulations and budgetary motivating are representing two only forces that can set up to empower of energy effectiveness as they are keeping rising their energy efficiency each year, because they found that the storing energy is more benefit than producing it. The energy efficiency can be improved by many solutions such as:

- Reduce the gas and electricity energy demand or the distribution that's wasted on networks, so then the energy efficiency can improve their security and resilience by reducing the imported fuels and the use of expensive energy;
- Decrease the energy bills and charge as the energy efficiency will give a support to enhance the businesses and make it more productive and competitive;
- Increase the use of domestic energy resources.

These strategies were constructed to supplement and improve the energy efficiency in the country that are desiring to boost their economic and environmental growth, as it can make a strong pillar of sustainable development and to mitigate the climate warm and other problems.

Furthermore, we can build a green economy that can encourage using the improved natural resources and attaining the goal of energy efficiency[17]. The inefficient use of natural resources can generate a high cost of production and this wasn't representing a big problem for human civilisation, because they always discovered a new natural wealth that can decrease the problem due to the resource overexploited, and then reach a business model that can adapt to this issue. Therefore, some recent studies were focussed on how to resolve the problems of resource scarcities and the externalized cost issues. Then they found that a good management of societies and the well-known use of natural resources can offer the resource efficiency and a prospering economic development with benefits.

The energy efficiency can be also on several changes of energy from a primary source to final output and may include large or small quantities of dioxide carbon emission. Moreover, the solar, wind or fossil fuel energy that can be transformed into electricity, heat or fuel energy is a process of conversion efficiency. For example, there are important restrictions on

[17] - United Nation Environment Programme, (2011), «*Towards a Green economy Pathways to Sustainable Development and poverty Eradication*», Copyright of UNEP, France, from page 23 to 27.

the efficiency of changes of heat to work in an automobile engine or a steam or gas turbine, and the reached conversion efficiency is always significantly less than these limits. The existing supercritical coal-fired steam turbines are rarely surpassing a 45% conversion of heat to electrical work and making a lot of waste energy.

On the other hand, the energy intensity[18] is the proportion of energy use to output. If the output is expressed in physical terms (tonnes of gold output), the energy intensity has the same purpose like energy productivity or energy efficiency. The production is calculated in terms of populations (per capita) or monetary units (economic factor) like the support to gross domestic product (GDP) or total value of shipments. At the national level, the energy intensity is the percentage of total domestic primary (or final) energy use to GDP, and it can be decomposed as a sum of intensities of specific actions divided by the actions of GDP. At an aggregate macro level, the energy intensity quantified in terms of energy per unit of GDP or in energy per capita, which is frequently used for transport, industry or building sectors, or to be related to economics study.

1.2.3. The sustainable energy initiatives and incentives:

Several nations made programmes and initiatives[19] to replace or to support the traditional energy, as it was the case for the USA by introducing the term of “development aid” in the wind sector, by means of the tax credit production in 1992, or to produce 20% of energy from renewable energy as the main target of European Union Programme in 2020.

The renewable energy was already heavier than the atom and nuclear, according to the “World Energy Outlook” realized by the Agency International of The Energy[20], nuclear power represents approximately 7% of the world energy production, but the renewable energy (with hydropower and bioenergy) is more than 19%. These rates show that the cleaner energies are taking a huge standing in the world due to their flexibility and their diversity, but require an important investment and a good location. However, compared to fossil energies, the cleaner energies are still behind, in terms of proportion the fossil energies are estimated at 74 % of energy produced.

The introduction of renewables in the energy supply system can participate to reduce the risk of high volatile prices for fossil fuels and may offer opportunities to diminish the carbon and greenhouse gas emissions, because the energy system is mainly constituted on the fossil fuel source and according to different studies, it represents the main reason for the climate

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[18] - William Moomaw and Francis Yamba, (2010), «*chapter1 of renewable energy and climate change*», Cambridge University Press, UK and New York (USA), page 25 and 26.

[19] - Julien Revillard, (2008), «*La croissance verte Comment le développement durable peut générer du profit*», Alban éditions, Paris, page 22, 26, 28 and 74.

[20] - https://www.iea.org/weo/

change. In contrast, the renewable energy can represent a major economic chances and initiatives[21] that can substitute the fossil fuel and by making an instant impact on carbon-intensity and improve the energy efficiency. Many opportunities for enhancing energy efficiency will pay for themselves, while investments in renewable energy technologies are already growing in today's market as they are becoming increasingly competitive. Consequently, the renewables will play an important role in the future and they will be taken into consideration. In this regard, many conferences are doing in this path and are encouraged to make a global agreement on carbon emissions, as they are focussed on creating a carbon market and a strong incentive for further business investment in renewable energy.

Furthermore, the government policy has an essential role to play in enhancing incentives about clean energy such as the application of feed-in-tariffs, direct subsidies and tax credits that will make a risk / revenue profile of renewable energy investment more attractive. Besides, such incentives can be improved with the implementation of the carbon market, which will help to capture the full social costs of fossil fuel use. Many studies from International Energy Agency (IEA) have demonstrated that the policy driven investments in renewable energy can increase the factor of economy growth by 1-2% of global GDP and can shift the global economy to a low-carbon growth path.

1.3. Energy access, renewable energy directive, and its policy:

1.3.1. Energy access and mechanism of assistance:

The energy access[22] is measured by the access to the electrical energy and the traditional fuels for the population all around the world. Almost 1.19 billion people around the world are living without electricity and almost 2.7 billion people are without clean cooking facilities in 2014. Such number of population needs support from institutions and government that can provide them with free access to the energy, especially with new renewable energy technologies, which will generate considerable electricity, or cooking devices that can ease their daily activities.

The people in rural and remote regions generally need an improved energy structure to satisfy their routine wants. Thus, the government can provide them with diverse solutions like the implementation of isolated devices and systems to empower generation at the household level as well as for heating, cooking and productive uses, or to use through several communities a mini grid system that can generate electricity energy or heating for cooking installation, or to use through grid based electrification, where the grid is extended beyond

[21] - United Nation Environment Programme, page 22 and 23.
[22] - Renewable Energy Policy Network for the 21th century, page 98 and 99.

urban and other areas. The advantage of these systems is to obtain more centralised models that can include generally lower costs per KW in different areas where we have a huge amount of population density. It offers also higher load diversity for industrial use, and for a more distributed model that can contribute to reduce the distribution and transmission losses in some communities and areas, the allowance for direct and local private investment, increase the local employment, and afford the energy security (secure the energy quantity). Besides, the distributed renewable energy system will benefit from trends of decreasing system sizes, improved system costs and enhanced the affordability linked to efficient appliances.

Furthermore, the renewable energy can be used as a mean of energy storage[23] that can facilitate the energy access each day, so it can offer a fast-responding balancing to the grid, with power generation from wind and solar energy, and it can be an option for the electrical energy, and for the consumers who can reduce their usage in return for payments.

The storage usage is interesting for several reasons, for its rapidly falling cost of batteries, and its electric vehicle market. Also, the local storage could enable wind and solar projects to provide electricity for a larger number of hours, with less in the way of fluctuation loss. This could offer a powerful combination at both utility-scale and in developing economy micro-grids. However, it can be confronted with the problem of batteries storage cost (length and living time of batteries) and their control.

On the other hand, the assistant and assessment[24] of the renewable energy programs have several issues and different mechanisms those are as following:

- The variability of renewable production efficiency and its production return (yield);
- The renewable energy technology costs, which it still doesn't reach its maturity;
- The external cost of the fossil and old energy from climate warms (the increase in the CO_2 and GHG emissions).

Moreover, some governments have already found solutions about how to promote the consumption of renewables by:

- ✓ Making regulations and laws that support the increase of renewable energy use and fix the price for every Kwh consumed and administrations in charge of this energy cycle will be enforced to accept the renewable energy consumption;

[23] - Frankfurt School, United Nation Environment Programme and Bloomberg New Energy Finance collaborating centre for climate & sustainable energy finance, (2016), «*Global Trends in Renewable Energy Investment 2016*», Frankfurt School of finance & management gGmbH, Germany, page 36.
[24] - Leon Freris and David Infield, from the page 241 until page 244.

- ✓ Introduce the quota systems that obligate companies to produce a certain quantity from renewables. However, for some organizations which are unable to follow such energy policy can buy obligations that make them pay for the missing proportion per renewable energy production, and this process can be facilitated by the elaboration of certain certificates as “Green Certificates” and “Renewable Obligation Certificates”;
- ✓ Make a carbon tax (climate change tax or eco-tax) on industries that use the thermal power plants to avoid the use of fossil source;
- ✓ Create a market of the carbon exchange, especially between the developing and developed countries;
- ✓ Offer a financial aid for the companies that want to deal with renewable energy project;
- ✓ Apply a new energy legislation which is based on determining the real price of renewable energy technology used by the different natural source like big turbine and rotor for wind power, huge mechanical tools for hydropower energy…etc.

1.3.2. Renewable energy directive:

Countries that are willing to shift its energy system and are eager to become renewable energy producer and consumer should follow and respect some instructions[25], such as making sets mandatory national targets for renewable energy shares of final energy consumption in 2020, (including a 10% renewables in transport target) as it was calculated on the basis of the 2005 portion of each country, this change will upsurge GDP by 5.5%. Also, a set interim targets which are focussed on the instruction groups of temporary targets per nations for 2011/12, 2013/14, 2015/16 and 2017/18 as a ratio share of their 2020 target.

Such objectives are vital for the improvement of renewable energy deployment in the world, but, unfortunately, they require national action plans from member states declaring how they can reach their aims. Nations shall apply national action plans that may focus on increasing the shares of energy supply from renewable sources in transport, electricity, heating and cooling in 2020 and suitable actions to attain these objectives. These strategies should give to each nation the flexibility to choose how they can reach their national targets, and how they can generate investor security and support to mobilize private capital by making specific objectives and use the best instruments on the national level. The national action plan should have also a detailed mandatory plan and objectives for different renewable energy

[25] - European Renewable Energy Council, (2010), «*Renewable Energy in Europe “Markets, Trends and Technologies”*», Earthscan in the UK and USA, page 22 and 23.

sectors to adapt it perfectly to the different energy situation. Besides, several countries, especially developing country need to decrease their administrative and regulatory barriers, enhance the information and training and facilitate the grid access to acquire the clean energy culture and to have a wide deployment of renewables.

There are also several of non-cost related choices to be included for any countries in its regulatory framework in order to push renewable energy introduction. The directive delivers significant supplies to eliminate further administrative and regulatory barriers which must be put in practice to cover the way for a quick and large-scale of renewable energy source deployment. In the same stream, infrastructure development and priority access for renewables to the grid can be a fundamental for a large-scale penetration of renewables, as it should be not only used for the production of electricity and support electricity grid, but also, for the production of heating energy and gas pipelines as well. Likewise, for the information and training, the directive needs from the nations to introduce a certification of installers by accredited training programmes, like the creation of sustainability regime for biofuels and the binding nature that has reached the 10% of the aim and has activated the main debate on sustainability standards and a long-established scheme. Furthermore, the industry is dedicated to strict, but practical sustainability standards that apply for domestic production as well as imports that will eventually be applied to all energy sources.

1.3.3. International policy about renewable energy and environment costs:

In March 2007, 27 European countries agreed an important objective[26] that aims at increasing the use of renewable energy from final energy consumption by 20% in 2020. This was the step ahead in the application of new energy policy which was also to increase the energy efficiency by 20% and decrease the effect of greenhouse gas emissions by 20% until 2020 (or respectively 30% in the case of a new international agreement). The European energy political wants to focus on having more sustainable energy for future generations (reach the sustainable development goal of UNDP). In January 2008, the European commission presented different laws and directives on the promotion of the use of energy from Renewable Energy Sources (RES) that comprises a sequence of basics to create the essential legislative framework for making 20% renewable energy become a reality. This commission also sets the legislative framework that should guarantee the rise by 8.5% in renewable energy's share of final energy consumption in 2005 to 20% in 2020.

[26] - European Renewable Energy Council, page 4 and 5.

The RES Directive (DIRECTIVE 2009/28/EC) (EC, 2009) was approved by the European Parliament in December 2008, by the Council at the end of March 2009, published in the Official Journal in June 2009 and will then need to be transposed into national law.

In June 2010, several nations required to make a national act plans on how they will reach their binding national target. Therefore, to reach this expected aim in the RES, they need to develop all existing renewable energy technology and create a balanced mix of the deployment in the sectors of heating, cooling, electricity and transport which are important for the development of agriculture, industry, service and other sectors. The purpose of the European Union was also to attain 21% of its electricity from renewables by the way of 2020, and this target has been formulated in the Directive 2001/77/EC on the promotion of renewable electricity. The Renewable Energy Framework Directive wants to maintain and strengthen the existing legislative frameworks for renewable electricity, and to make the minimum requirements for the exclusion of administrative walls, including efficient actions such as the one-step authorization.

Furthermore, problems of grid access and a more balanced sharing of the costs related to grid connection requisite equilibrium to be solved. As far as the heating and cooling sector is concerned, the directive finally ends the law gap which has been in this sector. However, Renewable Heating and Cooling (RES-H+C) has received little political attention and most of European countries haven’t yet the comprehensive approach to support RES-H+C. This is particularly striking in view of the fact that nearly half of the EU’s final energy consumption is used for generating heat, and making the RES-heating sector as a sleeping giant in the future. In 2010, the first biofuel directive was the main target of the European biofuels policy which was introduced in 2003, and the objective was to promote the use of renewable fuels in the transport sector, and to attain 5.75% of energy content. However, the experience with the current biofuels instruction demonstrates that the fuel distributors only use biofuels if there is a financial support. Therefore the renewable energy directive introduces a binding aim to reach 10% of renewable energy in transport by 2020, but, only sustainably produced biofuels are permitted to count towards the goal and the directive proposes a comprehensive sustainability scheme.

On the other hand, we displayed some energy policy[27] that may study the relationship between the factor of climate change and renewable energy, as coming:

- **Taxes on greenhouse gas emissions, and carbon taxes:**

The use of taxation is one of the policies which is consisting of putting a specific price on the release of CO_2 into the atmosphere such as 0.1 $ per carbon emitted. The main purpose of such tax is to reduce the combustion-related CO_2 emissions of fossil fuels (which represent the key source of CO_2 emissions). This tax is habitually calculated by measuring the carbon content of fossil fuels, which is directly proportional to the amount of CO_2 that is produced during their combustion and it can differ from each fossil fuels use as the oil and coal, which have a higher tax for the CO_2 emissions than the natural gas (because oil and coal released more CO_2 emissions than natural gas). Also, this tax may be imposed on the consumers or on the producers or for both of them, but its aim is still to switch the energy system of nations, companies or else from fossil fuel to renewable resource and especially to mitigate the effect of GHG and CO_2 emissions.

- **Emission trading schemes :**

Another policy application that can diminish the activities that have a negative impact on the environment by fixing a cap on total emissions, translate this cap into "allowed emissions", and create a market of CO_2 emissions (carbon market) in which these allowances can be permitted. This specific market should reflect the marginal cost of emissions drops and thus inspire emitters to reach a specified emissions reduction target and the price paid for the allowance is called carbon price.

Moreover, a provision for international emission trading for greenhouse gases was subsequently included in Article 17 of the 1997 Kyoto Protocol to the UNFCCC. It was intended to enable parties to Annex I of the Kyoto Protocol to reduce emissions through international emissions trading. Since the assumption of the Kyoto Protocol, the use of emissions trading at the domestic level has received an amplified attention as an efficient and effective instrument in complying with greenhouse gas emissions targets under the Kyoto Protocol.

[27] - United Nation Environment Programme and World Trade Organization, (2009), «*Trade and Climate Change*», report of UNEP and WTO production, Switzerland, from the page 90 to page 98.

Likewise, there are other types of domestic trading schemes and are as follows:

A. Scope:

This opportunity can be linked with two sorts of emission targets, an overall emission level (the cap-and-trade system) or an emission standard for each source (the rate-base system).

In a cap-and trade system, the government describes the general maximum quantity of GHG that can be emitted by each country. However, they need to achieve the emissions reduction goal, as the administration decides to create a number of "allowances" that can cover fully or partially emissions.

However, the rate-base system is based on carbon intensity that the government will regulate a standard according emissions source, usually expressed in either emissions allowed per unit of production, or emissions-intensity.

B. Allocation of emissions allowances:

The emissions trading system is mainly based on allowances that are permitted to emit some quantity of CO_2. Frequently, in some countries one allowance gives the holder the right to emit one tonne of CO_2, or the right to emit one tonne of CO_2- equivalent (CO_2-eq). The corporations that keep their emissions below the level of their allowances can sell their extra allowances on market of carbon emissions. In contrast, the firms that emit more than the level of their allowances permitted are generally offered two possibilities to regulate it. The first one is to take a measure to reduce their emissions with an investment in more climate-friendly technologies or to buy an additional allowance in the market.

C. Linkages with existing schemes including offsets:

The connection of several schemes can represent an immense challenge as it can offer crucial appearances about its size, environmental severity, reporting and monitoring mechanisms, or design CO_2 price. The linking emissions trading systems could fortunately lead to the formation of a greater market, which it can bring the reduction of GHG emissions cost, increase liquidity and reduce volatility of allowance prices. Therefore, they are two different links, the direct and indirect links. The first one can be installed on the emissions allowances that are traded across several different emissions trading schemes, but the second one can be recognized as emissions trading schemes when are linked to project-based offsets.

D. Other features:

Most emissions exchange schemes can be used in a banking mechanism that can stabilize the variations of allowance prices and limit the risk of non-compliance. The bank can also permit allowances which can be accepted from one phase to the other. Sometimes, we may find allowances that cannot be used during the trading period for which they were issued, but it can be used at a later trading period. Such method usually has an early impact on emissions reduction, while most of companies wish to reduce their emissions levels further than required, or buys more allowances than they needed, in order to be sure of avoiding non-compliance consequences and to have the necessary skills and flexibility to do it. However, the institutions can use it as the borrowing process, which is consisting of giving a flexible mechanism that allows the GHG emitting companies or countries to use the allowances from a future time period to cover their current emissions.

Consequently, these methods will have an important effect on the environment and energy situation, and they were essentially based on how to reduce the effect of GHG emissions, the application of energy-efficient measures, the substituting to low-carbon fuels and products, and changes in the economy’s production and consumption structures. Some energy policy may allow countries to determine the real price of carbon per energy used from fossil fuels or other sources. The government specific programs have also some instruments that support the production recycling and encourage the investment in more climate-friendly technologies (the development of renewable energy), or to enhance the emissions-reducing changes in investment and consumption patterns, especially for the companies that suffered from the carbon tax and emissions trading scheme.

- **Environmental effectiveness:**

The objectives from these methods is to encourage people and industries to decrease their use of high-carbon goods and services, increase the production of low-carbon emissions, promote the new production innovation (from renewables) that can meet the consumer demand and mitigate the pollution consequences.

2. Sustainable Development:

2.1. History, Objectives, Programmes and Initiatives of Sustainable Development:

2.1.1. History and definition:

2.1.1.1. History:

Many conferences were made for the "Sustainable Development" term and which many countries tried to give a precise definition, and defined several economics, environmental and social objectives. The following table summarise the main information about the history[28] of the sustainable development term:

Table 01: History of sustainable development and climate change:

Date	Information
1972	United Nation Summit for human and environment in Stockholm. The objective was to mitigate the negative and critical effect on world environment.
1980	The appearance of the term "Sustainable Development"
1987	Publication of the "Brundtland" report or "our future for all" by the United Nation committee for development and environment and its leader Gro Harlem Brundtland.
1989	Bale convention on control of international movement of toxic products.
1992	United Nation conference on environment and development at Rio de Janeiro.
1995	The implementation of the Carthage protocol on prevention of biotechnological risk and Berlin mandate.
1997	The Kyoto protocol on greenhouse gas mitigation (Kyoto 1).
2000	The United Nation has experienced an agreement on millennium development goal.
2002	Johannesburg summit or Rio +10 and its declaration on the necessity to modify the way of the production and consumption.
2005	The Kyoto protocol entered into force (Kyoto 2).
2012	Report of the United Nations Conferences on Sustainable Development or called the Rio +20 Summit[29], this meeting has known the adoption of new green economy policies and the continuation of the previous objectives.

[28] - Alain Journot, (2004), «*Le développement durable*», Afnor, Paris, page 11.
[29] - United Nations, (20-22 June 2012), «*Report of the United Nations Conference on Sustainable Development*», Rio De Janeiro, Brazil.

2014	The Third International Conference on Small Island Developing States[30]
2015	The launch of the United Nation Sustainable Development Goals[31] and Paris Conference on Climate Change

Source: done by the researchers with using references.

2.1.1.2. Definition:

From the early of 20th century, the environment destruction didn't stop growing and the ecologic situation becomes more and more negative, because of the industrial development, the urbanization, the scarcity of the natural resources, and the apparition of the climate change or climate warm. Such environmental problems might give birth to the pollution and may impact negatively the economics and social situation of any country.

Therefore, to avoid such issues some nations decided to make conference and meeting for a better environmental protection and preserving the stability of the economic growth. Consequently, the term of "Sustainable Development"[32] came to solve some of these problems and it was introduced into economics, social and environmental fields.

The definition of the World Committee on the Environment and the Development, Report of Brundtland (1987)[33] "The sustainable development[34] is a process of change that make the exploitation of the resources, the orientation of the investments, and the government institutions (institutional) work together and reinforce their current and future situation to satisfy their needs".

2.1.2. Objectives and criteria of sustainable development:

The sustainable development should be built on three main objectives[35] as following:

- The sustainable development of economic factors such as the development of economic growth or increasing per capita gross domestic product or GDP growth (%);
- The sustainable development on social factors that are mainly based on the satisfaction of human needs, equity and social cohesion (transparency, participation of the local, educational actors, improvement of the human development index);

[30] - United Nations for the Generaly Assembly (July/August 2014), «*The Third International Conference on Small Island Developing States*»,
[31] - United Nations, (2015), «*The Millennium Development Goals Report*».
[32] - Alain Journot, page 14.
[33] - Beat Bürgenmeier, (2008), «*Politiques économiques du développement durable*», De Boeck & Larcier s.a, Belgique, Page 34.
[34] - الطويل يونس زكي رواء ,(2009) , «*التنمية المستدامة و الامن الاقتصادي في ظل الديمقراطية و حقوق الانسان*» , دار زهران للنشر و التوزيع, عمان ,ص15.
[35] - Mahi Tabet-Aoul, (2011), «*Développement et environnement au Maghreb Contraintes et enjeux*», Edition impression Benmerabet, deuxième édition, page 15.

- The sustainable development is mainly based on environmental factors and countries could not reach the sustainability in this area without reducing dioxide carbon emissions and greenhouse gas emissions.

Such objectives have several criteria[36], and we can describe them as following:

- Mitigate the greenhouse gas effect on the environment (reduce the intensity of GHG and CO_2 emissions from all sectors);
- Diminish the environment and ecology pollution (reduce the sulfur dioxide, the nitrogen oxides and particular materials);
- Reduce the water pollution which is caused by chemical products, nitrates, and phosphate;
- Increase the natural resources habitat, especially the water supply and renewables;
- Protect the fish and fish farming;
- Keep plantations and forests from deforestation and agricultural pollution (chemical products and pesticide);
- Decrease the industry and urban waste;
- Adopting a better manufacturing management with using an improved waste production treatment and minimizing the costs;
- Improve the living conditions, the parts of the total importations and annual average growth in developing countries;
- Develop the term of 'development public aid" which will help to cover the cost of future project of sustainable development like the renewables technologies;
- Guarantee an adequate pension for older workers who have more than 65 years and still practising activity.

2.1.3. Programmes, initiatives and institutions:

Several countries need to work to realise different sustainable development programmes and initiatives[37], especially the protection of the water resource and the energy security, providing a better social condition, keeping the environment healthy and safe from pollution.

The renewable energy is considered as a priority of the sustainable development programs, because they are approximately two billion people without several energies, except the biomass. Consequently, such energy can represent a good alternative, at least partially, to

[36] - OCDE, (2004), «*le développement durable dans les pays de l'OCDE mettre au point les politiques publiques*», éditions OCDE, page 205 to 220.
[37] - Mahi Tabet-Aoul, pages 21 and 22.

resolve the problem of economic growth and to mitigate the global warming according to many researchers in this domain.

On the other hand, the environment aspect has been the main topic of the United Nations General Assembly and which has suggested finding a necessary balance between the main features of the environment and other aspects. Thus, for the prevention of environmental, nations should:

- Support the sustainable development in the infrastructures and business sectors in the long term, taking care of industrial management (management of chemical industrial) and respecting the ethics that can lead to avoid the environmental issues;
- Take the environmental criteria into consideration when some nations take a decision of international financing of development aid, by following a coherent strategy of long term development;
- Contribute to the global environment protection by world convention and financing institutions.

In September 2011, the Sustainable Energy for All Initiative (SEFA)[38] has launched the mobilisation of global action to achieve three aims by the way of 2030 and which was to guarantee the universal access to modern energy services, enhance the global share of improvement in energy efficiency and increase the part of renewable energy in the global energy mix from 15% to 30%. Consequently, more than 50 nations (almost from developing countries) are planning new energy programs to raise their energy supply and production. Big companies and investors have dedicated over US $ 50 billion to attain and complete these objectives, stakeholders like multilateral development banks and civil society organizations have committed US $ 10 billion.

In January 2013, a report was done between the World Bank, IEA, and other agencies, which provide a result about the progression of these objectives, especially renewables projects. The SEFA's objectives were made because of the fact that 1.3 billion people are still without electricity and 2.6 billion people are without wood, coal, charcoal, and animal waste, which are used for cooking and heating. Such targets aim to decrease the proportion of poverty and inequality, especially in developing countries. Additionally, guaranteeing universal energy access through SEFA linking upwards of 2.6 billion people to electrical grids or supplying them with new forms of energy production, not to mention that at least 3 billion will enter the global middle class by 2030 and the demand will possible increase for more

[38] - Hany Besada et al., (May 2013), «Addressing the economic costs of sustainable energy in the global south, submitted to the high level panel on the post 2015 development agenda», *Background research paper*, page 16 to 26.

resource-intensive foods (meats) and in the same way it would upsurge the emissions levels and will significantly influence the global climate change. The third objective of SEFA was to embrace the renewable energy source by including new technologies and to decrease to use of fossil fuel.

However, these sustainable development goals are extremely difficult to attain for, because they represent a big challenge for every country and they are potential contradictions, especially with regard to subsidies and policies. They are also some problems with supply and demand chain in developing countries as they are suffering from supply-side shortages which is due to poor generation and distribution equipment, high levels of technical loss, low numbers of generation processes, technical constraints related to low levels of education, research and development, organizational issues, under-financed power companies, restricted or non-existent domestic financing, and consumer prices that are too low.

By the way, for the implementation of national and international programmes of such sustainable development targets, several countries should reach the technological transfer[39], which is composed of know-how process, experience and material, as it represent a huge aim for any country and it can progress them by:

- ❖ Strengthen the access to the technology of information, training and support the elaboration of industrial projects (improving the information and communication) ;
- ❖ Reinforce the scientific research and establishments of technical education with the necessary technology;
- ❖ Collect and evaluate the relevant data in the technical, commercial, financial and legal domains;
- ❖ Identify and elaborate solution for the technical, financial, statutory and legal obstacles with the aim of a wide use of the technology transfer;
- ❖ Estimate the needed technology for the promotion of new prototypes, and the implementation of demonstration projects;
- ❖ Implement the innovative mechanism of financing, as the partnership between public and private sectors.

They are also several societies, which work for the promotion of sustainable development goals such as the financing institutions[40] for sustainability objectives like the Global Environmental Facility (GEF) created in 1991. This institution has financed up to US $ 10.5 billion several sustainable programs, as well as a further US $ 51 billion in leveraged co-

[39] - Mahi Tabet-Aoul, page 215 and 216.
[40] - Alex Evans, (July 2012), «*The UN's Role on Sustainable Development, Center on International Cooperation*», New York University.

financing. The GEF is ruled by a governing Council of 32 countries from developed and developing countries, and funds agencies involving the World Bank, UNDP, and UNEP, as well as national governments and civil society organisations. The GEF works also as the financial instrument for many multilateral environmental arrangements. Also, we can display some important financing institutions on climate change as follow:

- ✓ The World Bank's Climate Investment Funds (CIFs) and the Clean Technology Fund (CTF) on low carbon production and technology progress as it's considered as the biggest funding climate organization, with almost US $ 5 billion pledged and US $ 1.9 billion already permitted. The smaller Strategic Climate Fund (SCF) with US $ 1.3 billion pledged, which in turn involves the Pilot Program for Climate Resilience (PPCR) with US $ 1.2 billion pledged, Forest Investment Program (FIP) with almost US $ 650 million pledged and Scaling up Renewable Energy Program (SREP) with approximately US $ 400 million pledged;
- ✓ GEF money reserved for climate change. The GEF Trust Fund's has already accepted US $ 1.1 billion under the GEF's fourth replacement round, with an extra US $ 1.1 billion pledged under GEF's fifth replacement round. Also, the GEF manages the Least Developed Countries Fund (LDCF) with US $ 400 million pledged and the Special Climate Change Fund on long-term adaptation measures (SCCF) with around US $ 200 million pledged.
- ✓ The Adaptation Fund (AF) is another financial instrument and is funded through a 2% share of emissions decreases qualified under the Kyoto Protocol's Clean Development Mechanism. Also, it has spent almost US $ 115 million on climate protection and it has its own leading board, the World Bank as Trustee, and is directed by the GEF;
- ✓ The Green Climate Fund (GCF), which was settled on at the Copenhagen Summit in 2009 as an "operating entity of the financial mechanism of the Climate Convention", and is expected to fund US $ 100 billion a year by 2020, from a mixture of public and private sources.

2.2. The environment of Sustainable Development:

2.2.1. The biodiversity and biochemical cycle:

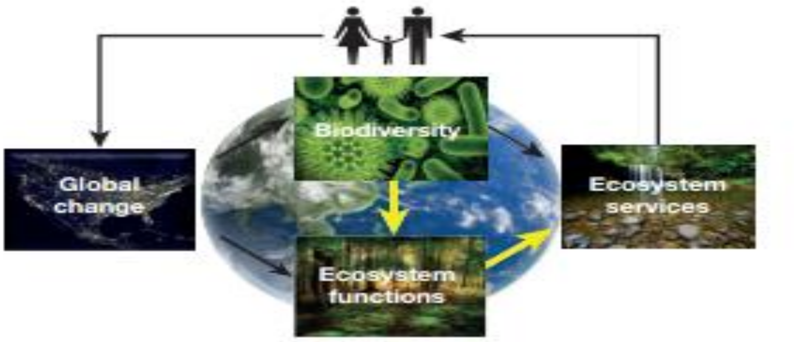
The biodiversity[41] damage was noticed at the level of ecosystems by the deforestation that has led to the loss of six million hectares per year of forest since 2000. This loss can provide a high cost for the human development and the environment. In the past, this deterioration was mostly caused by natural phenomena, but now they're caused by anthropogenic factors (the result of human action), as the destruction of the environment of the species by the overexploitation of the resources, such as oil, coal, gold and others. Despite the fact that the conventions have been signed by the United Nations for environmental protection and against poverty in the world, the ruin of natural biodiversity and ecosystems continues its degradation and that go worse and worse.

The idea of biodiversity can be examined in three diverse stages[42], ecosystem diversity, species diversity and genetic diversity. The 1st one represents the wealth and density of a biological habitat, involving tropical levels, ecological processes (which capture energy), agriculture (food) and material recycling. The 2nd one is defined as the amount of classes of organisms such as animals, plants and creature, within individual societies. The 3rd one is an estimation of different forms of the same gene within individual species. Consequently, the biodiversity can play a major role in the biosphere which is a life supporting system for all species. It is also the mixture of diverse beings that allows the biosphere to sustain life on the Earth. However, with the inconsistency stability in biodiversity, the biosphere will find difficulty to work properly and to give a good life condition, as it can have an important consequence in production, social, ethical and aesthetic factors.

Moreover, the ecosystem functions and services[43] are considered as the key factors of ecological process which they can control the fluidities of energy, nutrients and organic matter through an environment, as they are a set of advantage that ecosystem habitat may provide to human beings (the production of renewable resources and climate regulations).

[41] - Eloi Laurent and Jacques Le Cacheux, (2012), «*Economie de l'environnement et économie écologique*», Armand Colin, Paris, page 88.
[42] - http://www.idc-online.com/technical_references/pdfs/civil_engineering/Biodiversity_and_its_significance.pdf
[43] - http://snre.umich.edu/cardinale/wp-content/uploads/2012/04/Cardinale-et-al-Nature-2012.pdf

Figure 01: The relationship between biodiversity, ecosystem services and ecosystem functions.



Source: http://snre.umich.edu/cardinale/wp-content/uploads/2012/04/Cardinale-et-al-Nature-2012.pdf

We can see from this figure that the biodiversity has a close relationship with the ecosystem functions and services. If they are an impact on biodiversity, it will affect positively or negatively the ecosystem and the life condition of all species in the Earth.

Moreover, the biochemical cycle[44] is known as factors which impacted negatively the biological cycle and ecological systems, the definition is given by the official scientific committee of the White House for the environmental protection "The pollution is an unfavourable modification of the natural environment which appears altogether or partially from the results of human action, through direct or indirect changing effect of the distribution methods several aspects which are energy flows, levels of radiations, the physical and chemical constitution of the natural atmosphere. These modifications can affect living beings directly through the resources used in agricultural production, in water, and in other organic products".

The accumulative pollutions are caused by many sources such as the industrial and the agricultural production, the excessive use of energy activities. These sources of pollutions harm the environment and the population by their points of toxic matter rejections quickly in the air, the grounds or the waters, as their concentrations fall impulsively below the thresholds of harmfulness. The increase of the biodiversity erosion is due to the man action like the industrial revolution, which has indirectly damaged many animal species and plants, as well as reduction of their genetic variability. These deteriorations can also cause degradation on ecosystems, then in our global environment, and they are interpreted by the fall of the water resources, the general decrease in the fertility of grounds, the reduction in pollinators of some plants and the drop of the streams capacities to hold the floods.

[44] - Eloi Laurent and Jacques Le Cacheux, page 88.

On the other hand, the natural greenhouse gas plays a key role in the equilibrium of the temperature on Earth. The main contributions of various gases in the greenhouse effect are steam, dioxide carbon, the ozone, methane, the nitrous oxide, and other gases (the hydrofluorocarbons including CFC gas, the molecules of HCFC-22 and the hexafluoride of sulphur), but they are emitted in small quantity by industries. However, since the industrial time, the composition of the atmosphere of greenhouse gas, especially the dioxide carbon, the methane and the ozone were modified by biochemical cycle because the excessive use of the fossil sources and which have permitted to raise the CO_2 emissions and other gases in the atmosphere. Consequently, these factors (air pollution) are contributing to increase the average temperature of the surface of the Earth, as we are seeing now, the melt of ices on mountains in the north and south poles.

It has been said, that it's our relations with the ecosystem that are at the heart of the sustainable development and not the reduction of resources as it supposed to be. **Bertrand De Jouvenel** said that "Human being designed the natural environment as the discharge and not as the alive natural", it's a fact that the men since the age of the industrialization does not stop increasing its productions and ignored the environment circumstance, so that's why there's several environmental problems[45] that affect negatively the level of some environment factors such as:

- The acid rain, which is characterized by harmful levels of sulfuric dioxide or nitrogen oxide;
- The defoliants, which is a chemical products that is often used in agricultural practices for weed control, but make the plants lose their leaves artificially;
- The deforestation;
- The desertification;
- The effluents that are made from waste materials and are especially from industrial waste and pollution products;
- Endangered species caused by the poaching and illegal killing of animals;
- Increase in the greenhouse gas emissions, which is composed of the ultraviolet radiation in the lower atmosphere and it's responsible for surface warming; water vapour, carbon dioxide, nitrous oxide, methane, and hydrofluorocarbons;
- Decrease the level of ozone shield, which is the primary greenhouse gases in the Earth's atmosphere, and it protects all species and human being from sun radiation;

[45] - http://www.indexmundi.com/algeria/environment_current_issues.html

- Metallurgical plants, which are producing highly concentrated and toxic wastes that contribute to pollution of ground water and air when it is not properly disposed;
- Noxious substances;
- Overgrazing, which is the grazing of animals on plant material faster than it can naturally regrow leading to the permanent loss of plant cover;
- Siltation occurs when water channels and reservoirs become clotted with silt and mud, a side effect of deforestation and soil erosion;
- Slash-and-burn agriculture, which is a rotating cultivation technique in which trees are cut down and burned in order to clear land for temporary agriculture for the grow of the forest and plantations;
- Soil degradation, which is the damage to the land's productive capacity and is caused by the excessive use of pesticides or fertilizers, soil compaction from heavy equipment, or erosion of topsoil;
- Soil erosion, which is the removal of soil by the action of water or wind, compounded by poor agricultural practices, deforestation, overgrazing, and desertification.

2.2.2. Climate change:

The carbon cycle and greenhouse gas[46] have known several transformations since centuries. To date, our planet has known two transitory regimes of carbon, the first one was with the accumulation of carbon in the ground, the vegetation and the sea, but, the second regime begun with the age of industrialization, the overexploited energy resources and the use of the fossil combustibles have destocking the level of carbon. Consequently, it created a lot of carbon emissions in the atmosphere. According to International Panel Climate Change, they noticed that before 2100 the quantity of carbon would be increased by 10 times than now and it’s going to reach an unbelievable quantity of carbon that the atmosphere won’t be able to support it.

We can also distinguish that the natural greenhouse effect is now modified by human activities and it became more intense leading to climate warm. This natural greenhouse gas effect is extremely benefited for us and all species, because in the absence of its effect, the average temperature on the Earth would be only -18 C°, and with the existence of the GHG effect, the average temperature on the Earth is approximately 15 C° that’s what it made the life comfortable on Earth. Therefore, any effect on GHG emissions can lead to several environmental issues.

[46] - Pr. Francis Meunier, from the page 5 to page 14.

According to several studies, the greenhouse gas effect has a close relationship with the use of energy. The International Energy Agency has also confirmed this relation and made alternative plans[47] about how to mitigate the effect of GHG in different countries. Thus, they have used several scenarios based on model of energy consumption, CO_2 and GHG emissions, and in the same way they developed several strategies and policies that focussed on how to mitigate and reduce the air pollution in the world. However, they found that the energy need to be used carefully and countries require renewables plants and the nuclear infrastructures to supply and satisfy their energy situation. Therefore, if these strategies are applied perfectly, it will lead the world to reduce its CO_2 and GHG emissions by 15% in 2030.

2.2.3. The conferences about the sustainable development and climate change:

In 1992, the United Nations made the first convention on the climate change[48] in New York. The objective was the reduction of dioxide carbon and greenhouses gas emissions. Then in 1995, the first conference was known as the Berlin mandate, which have regrouped the parties who have begun discussions in order to agree on more complete obligation for industrialized countries.

Then and there in 1997, the United Nations decided to adopt the Kyoto protocol or the Kyoto accord, which was accepted only by 84 countries. The objective was also to restrict the emissions of the greenhouse gas and preserve the environment habitat. Besides, some members of this accord started to make groups of contact in Copenhagen to mark the progress about the worried questions. They tried to reach an international agreement about the climate change and sustainable development goals, but it was a failure. After, they made the "Agreement of Copenhagen", which were built on an international cooperation based on political recommendations, and they defined the terms of a needed agreement, including financing importing of developed countries towards developing countries to help them in their action against the climate change.

Later, the signatories of this agreement made a promise to maintain the rise of world temperature inferior to +2°C to mitigate the greenhouse gas emissions, but it was considered as a modest objective, and it was already suggested during the meeting of the G8[49] and the G20[50] countries who haven't any concern about the climate change. Besides, they assume also

[47] - Pr. Francis Meunier, page 22 and 23.
[48] - François Mancebo, (2010), «Le développement durable», Armand Colin, deuxième édition, Paris, pages 268,269 and 270.
[49] - composed of United Kingdom, Canada, France, Germany, Italy, Japan, Russia (suspended since 2014), United State of America, sometimes they can add European Union.
[50] - They're Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, Korea, Turkey, United Kingdom, United State of America and the European Union.

to reach their highest level of world emissions as fast as possible. The agreement marks a curve counting to the regard of the Kyoto protocol and which have planned a common objective declined by countries, but at the same time every country takes an individual commitment which will allow them to reach these aims of environmental protection.

Since then, the protocol Kyoto came into force with the conference of Kyoto 2 [51] in 2005, which was built on the flexibility of emissions exchange, the cooperative implementation and work for a clean development. At this meeting, they made objectives that should be done in the period 2008-2012 and it was obvious about the reduction of greenhouse gas emissions by at least 5% compared to their GHG emission rate in 1990. Therefore, not all countries reached this target which was produced by almost 38 industrialized countries.

In June 2012, The United Nation has adopted the summit of Rio (+20)[52], in Rio de Janeiro (Brazil). The signatory states decided to introduce a new development process that aims to realize the Sustainable Development Goals (SDGs), which is done upon the Millennium Development Goals (MDGs) and converge with the post 2015 development agenda. This meeting has known also the application of new green economy policies.

The member of this meeting recommended to the United Nations to create a Statistical Commission to measure the progress of sustainable development goals and try to find an appropriate variable for each area of economics, energy, food security, oceans, cities...etc.

The World Wildlife Fund (WWF)[53] has noted that for the prevention from dangerous global warming, countries need to reduce the vast majority of fossil fuels as they're representing the biggest sources of climate change. Fortunately, the introduction of renewable energy can help to protect the world from the climate warm, improve human health, increase our economies, and providing new jobs.

In December 2015, nearly 200 governments participated in the UN Paris climate conference (COP 21) and they recognized the risk of climate change, and they approved to work towards keeping warming to 1.5°C. This meeting was known as "climate-safe future meeting" and has seen the application of the aim of climate efforts in (2020). Moreover, they said that the man can still avoid such environmental issues, but action is needed urgently to cut emissions for a better world.

[51] - Jacques Fialaire, (2008), «les stratégies du développement durable», L'Harmattan, Paris, page 160.
[52] - United Nations, Report of the United Nations Conference on Sustainable Development.
[53] - http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/

Furthermore, the United Nations for Development Program (UNDP) made several Millennium Development Goals[54] (MDGs), which was on the Annual Ministerial (AMR), and they agreed some objectives in the economic, social and environmental aspect. These aims were based on a set of eleven thematic discussions, on conflict and fragility, education, environmental sustainability, governance, growth and employment, health, food and nutrition, inequalities, population dynamics; energy, and water.

In 2016, The UNDP introduced the Sustainable Development Goals (SDGs), which were displayed in the Report[55] of 2016 and 2017. The objectives were composed of 17 goals in the 1st year (2016) and 2nd year (2017) of implementation of the 2030 Agenda for Sustainable Development. These targets are:

1. End Poverty in all its forms everywhere;
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
3. Ensure health lives and promote well-being for all at all ages;
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
5. Achieve gender equality and empower all women and girls;
6. Ensure availability and sustainable management of water and sanitation for all;
7. Ensure access to affordable, reliable, sustainable and modern energy for all;
8. Promote sustained, inclusive and sustainable economic growth, full productive employment and decent work for all;
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
10. Reduce inequality within and among countries;
11. Make cities and human settlements inclusive, safe, resilient and sustainable;
12. Ensure sustainable consumption and production patterns;
13. Take urgent action to combat climate change and its impacts;
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development;
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;

[54] - United Nations, «The Millennium Development Goals Report».
[55] - United Nations, (2016), « The Sustainable Development Goals Report 2016 », New York and United Nations, (2017) «The Sustainable Development Goals Report 2017 », New York.

16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels;
17. Strengthen the means of implementations and revitalize and the global partnership for Sustainable Development.

2.3. The Sustainable Development on the economic and the social sectors:

2.3.1. Definition, economic growth and pollution:

2.3.1.1. Definition:

The economic factor of sustainable development[56] is based on the complementarity between several approaches like the main aggregate of economics only, or economics-environment relationship as they might study the relationship between GDP (Gross Domestic product) or per capita GDP and CO_2 emissions (especially emitted from fossil fuel) or the loss in the biodiversity. They can also use the social factor such as the investigation on the human activities and behaviour or explore the main factors of social inequalities.

Moreover, the economy of environment refers to an economy growth model, which is adjusted to the environmental challenges, and such model may give an importance to the natural resources and energy use. Yet, the economy of ecology is based on sustainable development goals and on the social aspect according to the “Agenda 21” who has recommended clearly the promotion of the social and the human condition level.

We can also find two positions from this definition:

- The economics isn’t having fundamental constraints with natural resource, while the sustainable development has a complementary with the natural resources theory.
- The economics can be developed by several constraints of natural resource and the sustainable development at the same time.

Consequently, these two situations made researchers confused about the definition of the sustainable economic development, because the economic growth and a constant of sustainable development can be developed and applied by several constraints of natural resource, social, energy or other factors and in another case it can develop without any constraint.

[56] - Beat Bürgenmeier, Page 224, 225 and 226.

Therefore, from this definition, we can specify some objectives[57] that can support to reach the sustainable economic development are:

- Improving the life condition of people all around the world;
- Protecting the environment habitat and reducing the pollution in all forms;
- Using prudently the natural resources and the energy structure of each sector;
- Enhancing markets to be more efficient and provide it with information about the needs and priorities of people;
- Upgrading technologies and innovations transfer inter-countries;
- Creating administrations for the ecological system.

2.3.1.2. Economic growth:

The economic growth[58] represents one of the most important goals of economic policy and it represents the total of economic activity production of each country. In several studies, the stability and increase in the economic growth is the main condition for development cycle, but this indicator is limited because it doesn't include different aspects of environmental and social.

Since previous time, many economists have studied many factors that can impact on economic growth[59] [60]and try to attain the balance between different aspects of economic theory. **Pareto**[61] is one of them who has done many analyse about the economic phenomena and studied the term of the "optimization" between the equilibrium of economic factors and utility or commodities value. He said that if we exceed the value of these things we can't reach the balance for the long-term. Besides, **Marx**[62] has said that the development is depending on income that comes from capital investment. However, **Schumpeter**[63] has demonstrated that when we have stabilization in the production factors we can manage to get a prosper development and increase the capital investment (increase the profit and income), but the economic growth can be affected by other aspects like open market and the execution

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57- محمد سمير مصطفى, (2006) ,« *استراتيجيات التنمية المستدامة: مقاربة نظرية و تطبيقية, الموسوعة العربية للمعرفة من أجل التنمية المستدامة*», المجلد الأول, الدار العربية للعلوم-ناشرون بموجب اتفاق مع منظمة اليونسكو و الأكاديمية للعربية للعلوم, الطبعة الأولى, بيروت, ص447 الى 453.

58-حفيظ فطيمة,(2010), «*واقع الاستثمار الاجنبي المباشر في دول المغرب العربي (تونس و المغرب و الجزائر) في ظل المتغيرات العالمية*» ,مجلة بحوث اقتصادية عربية, العدد 50, ص80

59- الامام محمد محمود ,(2006) ,« *السكان و الموارد و البيئة و التنمية, التطور التاريخي, الموسوعة العربية للمعرفة من أجل التنمية المستدامة*», المجلد الأول, الدار العربية للعلوم-ناشرون بموجب اتفاق مع منظمة اليونسكو و الأكاديمية العربية للعلوم, الطبعة الأولى, بيروت, ص347.

60- غنيم محمد عثمان, أبو زنط أحمد ماجدة,(2007), «*التنمية المستديمة : فلسفتها و أساليب تخطيطها و أدوات قياسها*», دار صفاء للنشر و للتوزيع, الطبعة الأولى, عمان, ص20.

61 - Vilfredo Pareto was an Italian socialist and economist who have studied several aspects of economics such the distribution of wealth and income.

62 - Karl Marx was a Germanic socialist, economist, and philosophe. He was against the capitalist system and has replaced man by the producers and consumers.

63 - Joseph Alois Schumpeter was an Austrian-born American economist and political scientist who has done many investigations about the financial and econometrics aspects

of new technics in production cycle. Moreover, **Rostow**[64] has applied a model that contain a new technique of economic growth stages and its definition, as he has divided the steps into five categories (the usual population step, before start step, start step, mature step, and consumption step) which from these aspects, he tried to explain the term of "economic growth operation".

The economic growth theory[65] was often known as an indicator of economic well-being. In the industrial revolution, this theory was only concerned with the agricultural production and aggregate. By the way, it indicated only the capacity if it's good or bad harvests of farming production.

The measure of the economic growth per capita has served as an indicator to compare between countries, in terms of standard of living or economic development. The human development aspect was used as a weighting means to measure the impact of the economic production. In several literature reviews, the indicator of per capita GDP design the economic factor of sustainable development and it represents the socio-economic variable. However, the concept of growth or development is not only limited in economic growth, but it contains the aspects of income distribution, the cultural aspect and other factors as well.

We can summarize different facets of the economic growth in the following table:

Table 02: The main factor of economic growth

Social aspect	Labour as the factor of production, skills and motivation of worker.
Capital formation	Investment and savings.
Technology	Savoir-faire and knowledge evolution, investment on research and development.
Natural resources	Climate, energy, water…etc.

Source: Book of Beat Bürgenmeier, page 13.

However, the Theory of the endogenous growth (TEG) [66] has provided the theoretical structure for the long term policy, and explains how and why the economic policy has the capacity to modify the rate of economic growth and improve the well-being of the societies in several periods.

TEG studies the growth as an economic phenomenon, and the growth rate variable is considered as an endogenous variable, because it results from choice, labour, capital and

[64] - Walt Whitman Rostow was an American economist and politician0. He has introduced the term of development theory, and the economic growth conditions.
[65] - Beat Bürgenmeier, page 11.
[66] - Philippe Darreau, (2003), «*Croissance et politique économique*», De Boeck & Larcier s.a, Bruxelles, page 25.

money, or other factors. It can be also considered as an exogenous variable in a model of capitalism (factor of marginal productivity).

Furthermore, some researchers investigated on how to have a sustainable growth[67] in different countries like **Aghion and Howitt (1997)** who showed that in the presence of non-renewable resources or pollution, the traditional growth model can't be enough to obtain the sustainable growth. Consequently, the lack of resources can have an inexorable decrease in the economic and social growth. It's necessary to deal with a real endogenous model of growth with accumulation of knowledgeable capital (because it provides a good management and a lesser consumption of non-renewable resources), and for that reason, it may be possible for the socio-economic growth to be longer and sustainable. This is what **Aghion and Howitt** have developed in their model (by referring to **Schumpeter** and the Schumpeterian model of economic growth).

2.3.1.3. Economic growth and pollution:

The originated model of **Kuznets**[68] studied several graphs of the economic inequality against per capita income over the economic development, but now several researchers used the Kuznets model to investigate the pollution control factor and other aspects. Therefore, they applied this model on the social inequalities with the use of statistics and mathematical model on the income distribution as it was the case for Kuznets model (1955) who investigated the impact of the industrial revolution on the rural migration.

However, the curve of Kuznets has known many interpretations, and it was transferred into the environmental model by substituting social inequalities by an indicator of pollution control. Consequently, many economists' recommended new model and new hypothesis called the Environmental Kuznets Curve (EKC) to investigate the relationship between the pollution[69] and the economic growth and they interpreted two results as following:

- ✓ In the 1st period, the economic growth can increase the rate of the pollution by the way of the industry and chemical production, especially for the nations, which rely on fossil fuel production, but in the 2nd period, when the countries depend on cleaner industry and green production, the economic factor can decrease the level of pollution;

[67] - Philippe Darreau, page 247.
[68] - Simon Kuznets (1901-1985) was an American economist and statistician who have received the Nobel Prize in economics in 1971 and he suggested this hypothesis which is used to explain the relationship between economic development and the environment deterioration.
[69] - Beat Bürgenmeier, Pages 14, 15 and 16.

- ✓ The continuation of the economic growth can only deteriorate the environment and ecosystem, because of the industrial advancement and the conception of new dangerous products, and then create demographic, social and ecological problems.

2.3.2. Economy of the environment:

The economy of the environment[70] studies several natural resources using the economic analysis and the social implications, so this field of study uses an interdisciplinary method to examine the social impact, the ecological study, the environmental situation and the economic theory. This domain explores also the energy and monetary models which are used to resolve different issues of the environmental model such as the mitigation of pollution, waste management and market of carbon. Furthermore, the right use of the sea resources and the improvement of natural sites can be used as illustrations to have an idea about the natural resource theory, and is also used to confirm the main result in the growth theory.

However, in the sustainable development theory, the stock of the natural capital, which is transmitted from generation to generation, cannot be decreased. But, the limits of the substitution between the various forms of natural resources become obvious when we will have several deteriorations in the environment habitats as it's the case for the deforestation, the reduction of the biodiversity, the acidification of lakes, climate change and the overexploit of energy.

On the other hand, the complex relationship between private sector and the environment case[71] was used in the economic theory as "theory of the tragedy of the common"[72], because now our natural resources are becoming overexploited due to their free access, whereby individuals behave against to the common good. The government is expected to create a set of laws and regulations to achieve a purpose to have free resources for all. However, they are several environmental challenges for the private sector and their suppliers conduct business that will face in the near future, such as the increasing in deforestation of some forest areas or the cumulative of GHG emissions. Thus, they need to focus more on the protection of the environment, because they necessitate many natural resources in their origin forms as the use of water for agricultural production or mineral extraction and processing, so if these activities are stopped or disturbed, it can expose companies to a variety of risks including market, regulatory, and reputational risks as well as the physical risks of climate-related threats. Consequently, an alliance has been made between 554 global firms and shareholders, with

[70] - Beat Bürgenmeier, Page 168 and 169.

[71] - United Nation Environment Programme, (2016), «*UNEP Frontiers 2016 report Emerging Issues of Environment Concern*», UNEP, Nairobi, Kenya, from the page 8 to page 17.

[72] - It's about theory that studies the management of the natural resource and habitat, how we can use well the fishing industry, animals, minerals or else.

shared revenue that can reach US $ 7.8 trillion. This practise is called “We Mean Business”, and their objectives were to decarbonize (reduce the carbon in the air) their businesses with the use of renewable energy production (electricity, heat or fuel), and invest more on low carbon production.

The Consumer Goods Forum which is an association composed of 400 large retailers, manufacturers, and service providers across 70 countries with combined sales of around US $ 3 trillion The aim of this association was to apply the strategy of “zero net deforestation” in their supply chains by 2020. Therefore, many private companies have made promises to “deforestation-free sourcing”, fundamentally decoupling production of vegetable oil, beef, or other commodities from forest damage. In 2014, the United Nations of Climate Summit known the participation of 130 governments, companies, civil society, and indigenous people’s organisations and they signed the New York Declaration on Forests. The members of this conference initiated to stop their deforestation by 50% in 2020 and to end the forest loss by 100% in 2030.

Moreover, the availability of global water and clean water use is another challenge that can impact the private corporation. The Water Stewardship initiative of the CEO Water Mandate[73] has attracted over 140 leading companies from a wide range of industries in 40 countries to accept the water sustainability practices. These diverse initiatives are significantly accelerating business commitments to develop a strategy about environmental sustainability, which can diminish the material risks in the present and improve the company’s financial stability and growth in the future.

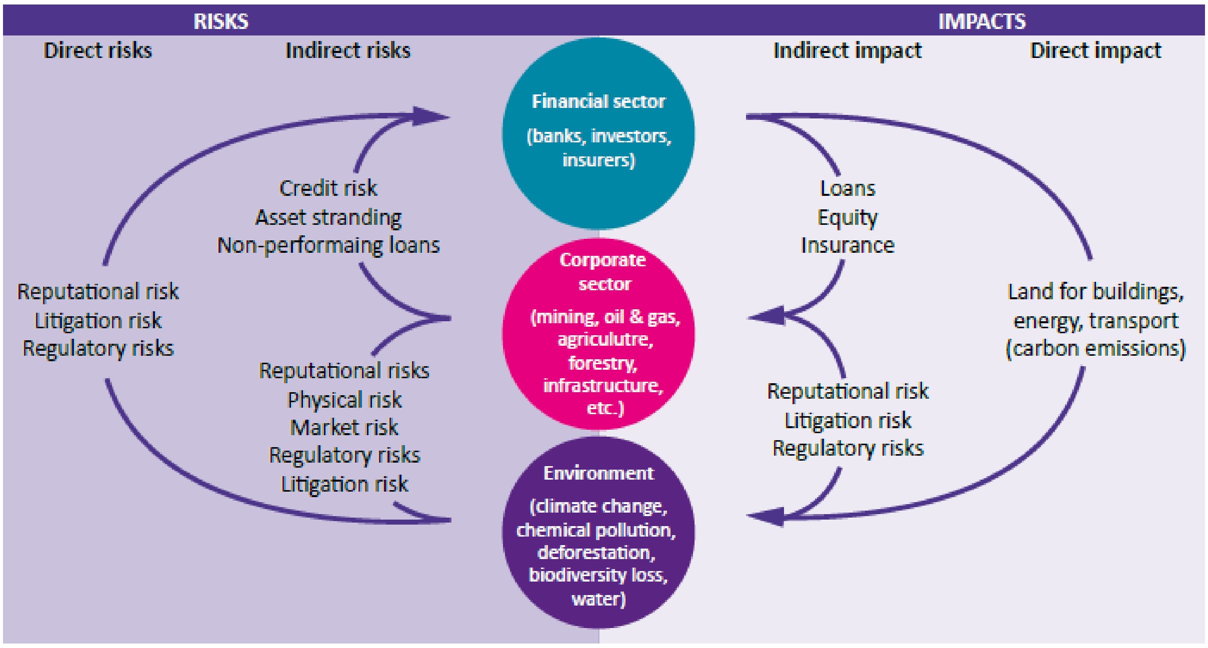
Therefore, to preserve the environment from deteriorations, institutions need financial support that will get them into environmental sustainability. Such financial segment can help the global economy mechanisms by the added-value and which are estimated at more than US $ 300 trillion and are from banks, pension funds…etc. Subsequently, such financial assets can start to change the investment that is on unsustainable corporations, plans and other properties which had a negative impact on the environment and the sustainable resources, but now it begins to operate with minimal environmental costs or even with environmental benefits. Besides, many companies have introduced an environmental strategies and policies on a voluntary foundation, but, at the present, the financial sector can’t afford any modification because of its design and its capital, and mainly to the change that can be about having more low-carbon production, and more resource-efficient economy, because this change can create

[73] - It’s about an organisation that aim the get a better management for a better use of water quality, water balance, water scarcity and pollution or else. (http://ceowatermandate.org/)

a lot of the significant drivers of instability in the economy system and in long term processes it will have a bad financial decision-making for the objective of sustainable development.

However, without changes in rules and in charges, it is unlikely that the financial business as a whole will convert into a responsible mode. Concerted public-private sector initiatives are required to boost financial societies to change their investments from high carbon production to low carbon production, resource efficient and environmentally sound assets. They can make an estimation on environment dangers (pricing environmental risk) and new application of long term strategies (reforming the regulatory regime) which are two vital devices to motivate banks, pension funds, and other actors in the financial system to accelerate towards environmental sustainability. Both supply and demand drivers need to be applied to enable a global transition to a low carbon production, resource efficient and equitable economy. They are also several standards like "Sustainability standards" that can measure the performance of the financial sector into the environment and we can summarise this relationship into following figure:

Figure 02: The relationship between financial sector, corporate sector and environment



Source: from UNEP Frontiers 2016 report Emerging Issues of Environment Concern page 13.

2.3.2.1. Pricing environmental risk:

Many plans and models are developed for the estimation of environmental dangers (water scarcity, loss of biodiversity…etc.), such as the Carbon Tracker and the Natural Capital Declaration. In the extractive industries, energy, agriculture, and other sectors, the environmental dangers can be comprised in the charge of capital to borrow money or in the market value of public and private companies. In December 2015, the Paris Agreement grants an immense challenge for the global community to change, systematically and rapidly, away from fossil fuels towards renewable energy. Besides, the members of the conference have to diminish their carbon emissions from deforestation, loss of biodiversity, and other sources of GHG.

2.3.2.2. Reforming the regulatory regime:

All countries that want to reach the sustainable development process and mitigate the risk of the environment loss are recommended to make a new redirection of investment flows towards serious priorities, and away from properties that reduce the natural capital. They need to apply new policies that can shift the monetary system which is based on fossil fuel source (high carbon production) into cleaner source and lower carbon emission. Climate change, water scarcity, and other forms of environmental danger are impacting the economy system in all his forms (organisation, finance, and other sectors). In 2015, the UNEP (United Nation Environment Program) reviewed several projects on Sustainable Financial System and policies to facilitate the financial system support of sustainable development. The Portfolio of Decarbonisation Coalition engaged 25 organizations in decarbonizing and they invested US $ 600 billion to shift from carbon-intensive to carbon-efficient companies. Therefore, such evolutions will develop swiftly the new asset class, and green bonds, which are on financing low-carbon properties in several sectors.

2.3.3. Economy and energy:

The energy[74] is a productive resource that is used in the economic activities and it can be considered as an economic activity which it's consumed and used in the industry, the transport and the heating sector. We can also describe the energy with the work that she allows to complete, as she transforms the physical, chemical nature, or the structure and the material into an output which is defined by the processes of production.

The energy potential is depending on several aspects, as the part of knowledge in the process of the transformation which is considered as the main factors that convert the stock into the flow, we can take an example of hydropower that used the water of the dam (input)

[74] - Beat Bürgenmeier, Page 169, 171, 172 and 173.

and with the process of transformation (gravitational forces and machinery), we can create the energy of electricity (output). Therefore, they are several hypotheses concerning the theory between the economy, the natural resources and the energy as following:

- ✓ The studies about the relation between energy and the economic growth is the most known in the environmental debate, as there are many investigations about how to evaluate the evolution of the energy in the transport sectors. If the technical progress can offer a form of constant in energy supply, we will have an assured economic growth for the long term (Energy-Economic growth nexus). However, we may find other factors that may impact the economic growth and the energy consumption, as the population growth and the technical advancement. The different factors of this relationship can differ from developed and developing countries;
- ✓ The relation between energy and the development has highlighted as the effect of exclusion by the prices. If we apply the rule of **Hotelling**[75] who showed that the prices of the non-renewable sources are supposed to increase highly (an exponential increase). The countries with low purchasing power parity will find themselves excluded from the world energy market, and the developing countries will overexploiting their resources, especially woods for their needs, so then it will result all forms of deforestation in the world and create an imbalance in the environment habitat;
- ✓ The substitution between renewable and non-renewable energy are established by the evolution of the relative prices, which is resulting from the economic model and it may find issues with the natural resource constraints;
- ✓ The nuclear energy represents a source of conflicting problems because many researchers found several ambiguities of the hypothesis known as “unlimited substituting hypotheses”. However, the nuclear waste remains extremely dangerous because of its radioactivity as we can see their effect for more than one thousand years.

[75] - Harold Hotelling is an American economist who has done a study on the field of non-renewable resources and he has studied the price of the resource and rate of interest in 1931.

2.3.4. The social sector:

2.3.4.1. Definition:

The social indicators[76] are very important for scheduling, making policy, strategy, and for guiding decisions and actions for human development, as they help to build awareness of current living conditions and trends over time. Governments and non-governmental organizations are progressively using social indicators to manage their trends in human development and to get the best result possible. Social indicators are defined as tool of measurements of the main phenomena in complex human systems or the development and allow us to estimate the direction or the rate of change, and thus performance in many areas, as well as progress toward specified goals. However, the human development and social indicators are extremely difficult to measure, because of the complexity to quantify several domains of the human indicators like education, health or poverty.

Consequently, a realistic approach is required to choose a small and representative group of indicators for main areas to estimate them over time and across space (Panel model). Such indicators summarize the real-life complexity into a manageable amount of meaningful information, as they can be also used as a proxy measure to deduce the condition over time or trends in the human system. Also, these indicators can be quantitative or qualitative measurements and often used in the statistic study as a simple measurement of what is happening in a system. Indicators should be clearly defined, reproducible, unambiguous, understandable and practical. Likewise, they should be relatively easy to measure in an accepted manner, stable, and suitable for use in longitudinal analyses. The social sector studies the indicators of human development[77] which are composed of HDI (Human development index) and HPI (Human poverty index). The first one is based on the life expectancy in the birth, the average level of wealth and the academic level. The second one focusses on the capacity to live longer and healthier, the academic level, the economic fund or revenue and the participation in the social life.

Moreover, The Millennium Development Goals (MDG) and Sustainable Development Goals (SDG) made a set of aims that rely on approving the human development and well-beings of the population. For the population indicator, the global population is projected to reach 9.6 billion by 2050, with 6.4 billion people living in urban areas, so a rise by 61% of the population is predicted from 2015. Significant problems can cause the decrease of population,

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[76] - Joan Nyman Larsen et al. (2014), «*Arctic Social Indicators ASI 2: implementation*», Nordic Council of Ministers, Denmark, page 34 and 35.
[77] - Mahi Tabet-Aoul, page 151 and 152.

as related by many governments around the world in 2007 and it includes the HIV/AIDS, infant and child mortality, maternal mortality, adolescent fertility, and life expectancy at birth.

2.3.4.2. Human development:

The human development is defined as an increasing of liberties so that all human beings can follow choices that they worth. Such freedoms have two important aspects, the freedom of well-being which is represented by functions and abilities (capabilities) and freedom of agency which is represented by voice and autonomy.

According to the Sustainable Development Goals (SDG) report for 2016 and 2017, the improvement in the human development has been remarkable over the past of 25 years. People are living longer, having more children in school and have access to basic social services. The Millennium Declaration and the Millennium Development Goals made worldwide promises at the turn of the century to end basic human lacks within 15 years. However, the human development has known several difficulties as some countries struggle to accomplish only the fundamentals of human development and some others not even that. Now, a new development challenges have arisen and was changed from inequalities aims to climate change objectives, from epidemics to desperate migration, from conflicts to violent extremism. The report 2016 and 2017 of (SDG) is more focussing on how the human development can be guaranteed for everyone. Such reports were also based on how making a good plan for the natural habitat and try to find the issues of human development and its deprivations. Several features of the human development method and assessment perspectives have to be faced and it needs to be identified, especially the national policies and key strategies which can lead us to achieve basic human development and protecting the gains.

In 1990, the first report on Human Development defined it as a people-centred approach to development. The human development method changed the development dissertation from following physical wealth to improving human well-being, from maximizing gains to expanding abilities, from emerging growth to expanding freedoms. It was more focused on the richness of human lives rather than on simply the wealth of economies and in the same way, it shifted the lens for viewing development results.

According to the United Nations, the human development must be accomplished for everyone and it should be positively encouraged. By 2015 the world has achieved some of what appeared to be intimidating challenges 25 years ago. Even though the global population increased by more than 2 billion from 5.3 billion in 1990 to approximately 7.4 billion in 2017, more than 1 billion people escaped from extreme poverty, almost 2.1 billion had access to improved sanitation and more than 2.6 billion gained access to an improved source of drinking water. Also, the global under-five mortality rate was more than halved between 1990 and 2015 from 91 per 1,000 live births to 43. The incidence of HIV, malaria and tuberculosis declined between 2000 and 2015. Besides, the proportion of seats held by women in parliaments worldwide rose to reach 23 % in 2016, up 6 % points over the preceding decade. In addition, the global net loss of forested areas reduced from 7.3 million hectares a year in the 1990s to 3.3 million during 2010–2015.

Even with all this admirable advancement, the world still faces many hard development challenges. Some challenges are persistent (deprivations), some are deepening (inequalities) and some are emerging (violent extremism). Some others are worldwide (gender inequality), some are regional (water stress) and some are local (natural disasters). Most of them are mutually reinforcing as climate change, which it reduces the food security or rapid urbanization marginalizes the urban poor. Whatever their spread, these defies have an undesirable effect on people's well-being. In fact, some of the impressive accomplishments have been in regions or areas that once were covered. All over the world, people are progressively engaged in influencing the procedures that shape their lives. Human ingenuity and creativity introduced technological advancements and translated them into the way we work, think and behave. Gender equality (women's authorization) is now mainstream dimensions of any development discourse, as there is no rejecting that with an intention to overcome them usefully, space for discussions and dialogues on issues once taboo is slowly opening. Consequently, awareness of sustainability in all aspects has been growing. The Agenda of 2030 and the Paris Agreement on climate change are major examples. They displayed also that under the rumble of discussion and gridlock, a promising global agreement is emerging around several global defies and confirming a sustainable world for future generations.

Furthermore, the UNDP presented the Human Development Index (HDI) as probably the most widely recognized indicator of human development and now is most likely to compete with the indicator of per capita GDP. Since 1990, UNDP has publishes each country's HDI annually in its Human Development Report. The general method that estimates the HDI[78] experienced some changes since 1990, the last one occurring in 2010 (add some aspects). However, UNDP continues to apply the basic method because it is relatively simple, transparent and accepted, so it consists in applying the mathematical mean of three indices

[78] - Michael Goujon, François Hermet, (20 January 2012), «*l'indice de développement humain: Une évaluation pour Mayotte*», Colloque « Inégalités et pauvreté dans les pays riches », IUFM Auvergne, Chamalières, page 02 and 03.

which are composed of wealth, health and education. The (HDI) measures the average achievement in a country in three basic dimensions of human development:

$$HDI = \frac{W + H + E}{3}$$

Where:

W: index of monetary wealth, based on per capita GDP;

H: health index, based on life expectancy at birth;

E: Education index based on the average of a youth enrolment index and an adult literacy index.

(W) Indicates a decent standard of living, as measured by gross domestic product (GDP) per capita at PPP (purchasing power parity) in USD.

(H) Means a long and healthy life, as measured by life expectancy at birth;

(E) Signifies the knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weight).

2.3.4.3. Human Poverty Index:

The Human Poverty Index (HPI)[79] is also another indicator of human development and the UNDP established this index to complement the Human Development Index and was the first reported as part of the Human Development Report in 1997. It’s used as an extra measure of the standard of living in a country. In 2010, the HPI was replaced by the UN's Multidimensional Poverty Index (UNDP Report of 2013). However, before 2010, the HPI was calculated separately for developing countries (HPI-1) and developed countries (HPI-2) (United Nations report of 2008). The HPI-1 is presented as a composite index computing lacks in the three basic dimensions captured in the human development index such as a long and healthy life, knowledge (education) and a decent standard of living (United Nations report of 2008). The formulation for estimating HPI-1 is as follows:

$$HPI - 1 = [\frac{1}{3}(P_1^3 + P_2^3 + P_3^3]^{1/3}$$

Where:

P1: Probability at birth of not surviving to age 40;

P2: Adult illiteracy rate;

P3: Unweighted average of population without sustainable access to an improved water source and children who are underweight for their age.

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[79] - Dorota Weziak-Bialowolska and Lewis Dijkstra , (2014), « *Regional Human Poverty Index Poverty in the regions of the European*», European Commission, Luxembourg, page 9 and 10.

The HPI-2 is presented as a composite index calculating deficiencies in the four basic dimensions captured in the human development index like a long and healthy life, knowledge, a decent standard of living and capturing social exclusion (United Nations report of 2008). The formulation for estimation the HPI-2 is as follows:

$$HPI - 2 = [\frac{1}{4}(P_1^3 + P_2^3 + P_3^3 + P_4^3]^{1/3}$$

Where:

P1: Probability at birth of not surviving to age 60;

P2: Adults lacking functional literacy skills;

P3: Population below the income poverty line (50% of median adjusted household disposable income);

P4: Rate of long-term unemployment (lasting 12 months or more).

3. Algeria situation:

3.1. The current situation and energy review:

3.1.1. Natural resource and agricultural sector:

The potential of natural resources in Algeria exists in huge quantity and different forms in several places. According to the Global Economy[80], 17.41% of land in the country is used by the agricultural sector and represent more than 40,000,000ha (Hectare), arable land was 3.1%, and the cereal yield was 89 kg per hectare. The main crops[81] in Algeria are potatoes with 140,000ha, wheat with 1,900,000ha, barley 1,100,000ha, olives with 330,000ha, oats with 86,000ha, rapeseed with 17,000ha, broad beans, horse beans and dry with 37,000ha, chick peas with 31,000ha, peas and dry with 10,000ha, lentils with 3,600ha. However, such production is unacceptable for a country like Algeria who had and still have a large agricultural land in the world, they should focus on this important sector, and the growth more crops and arable lands.

The natural resources[82] are petroleum, natural gas, iron ore, phosphates, uranium, lead, and zinc. Algeria's chief crops, which are grown in the more fertile regions, are sorghum, barley, maize, wheat and oats. Vineyards as well as tobacco plantations in the country export their products. Other goods grown are dates, figs, fruits, olives and vegetables.

80 - https://www.theglobaleconomy.com/Algeria/
81 - http://algeria.opendataforafrica.org/ucmijn/algeria-agriculture-sheet
82 - http://www.algeria.com/geography/

3.1.2. Fossil based on energy resources:

Algeria is considered as one of the major exporters and producer of oil and natural gas[83] in Africa and in the World, it's the 14th largest world exporter of oil, and is the 6th largest gas producer, from Bp statistic January 2016, the oil reserves are estimated at 12.2 billion barrels (Bb) or 1.5 thousand million tonnes (Tmt), and the natural gas reserves are estimated about 159.1 trillion cubic feet (Tcf) or 4.5 trillion cubic metres (Tcm), also Algeria holds vast unexploited shale gas resources located in eastern Algeria in Ghadamas Basin.

A recent report by the International Energy Agency (IEA) showed that energy usage in Algeria is split between three sectors, industrial (24%), transport (33%), and residential and services (43%). The main energy sources are crude oil (49.5%) and natural gas (50.4%). In comparison, the numbers concerning the renewable energies are much smaller and close to zero. Other energy sources such as coal or nuclear power are not used.

3.1.3. Renewable energy:

Recent studies suggest that about 5% of the country's electricity comes from small hydropower plants while only 0.5% to 1% comes from wind and solar energy. This awful position of renewable energy[84] in Algeria exists despite a favourable geographical location which offers one of the highest solar potentials in the world. Algeria resides within the solar belt of the world where it is estimated that 6 hours of solar energy from the world deserts can meet the annual global energy demands, so we can resume their availability[85] as following:

- ❖ The solar is estimated at an average of 3000 sunshine hours/ year and 3600 sunshine hours/ year in the South;
- ❖ The country has more than 200 sources for the geothermal energy;
- ❖ The wind is estimated approximately 7 meters per second;
- ❖ The hydropower potential is estimated at 1500 Giga-watt per hours and it represents only 6% of the current electricity production in 2013;
- ❖ The biomasses exist in different places and it's hard to measure the exact estimation.

The potential of these renewable energies[86] can be more productive, if they're used well, such as wind energy which is in the southwestern region where the wind velocity is higher than 6 m/s, also the geothermal energy is only used for thermal springs, but they're planning

[83] - S.M. Chekouri and A. Chibi, (April 2016), Algeria and the Natural Resource Curse: Oil Abundance and Economic Growth, *Economic Research Forum*, Working paper series.

[84] - http://www.new.anasr.org/2013/08/16/feature-renewable-energy-development-in-algeria/

[85] - Bouchkima Bachir, (2013), «Energies Renouvelables & Efficacité Energétique dans le cadre du développement durable en Algérie – RSE à RGA», université Ouargla.

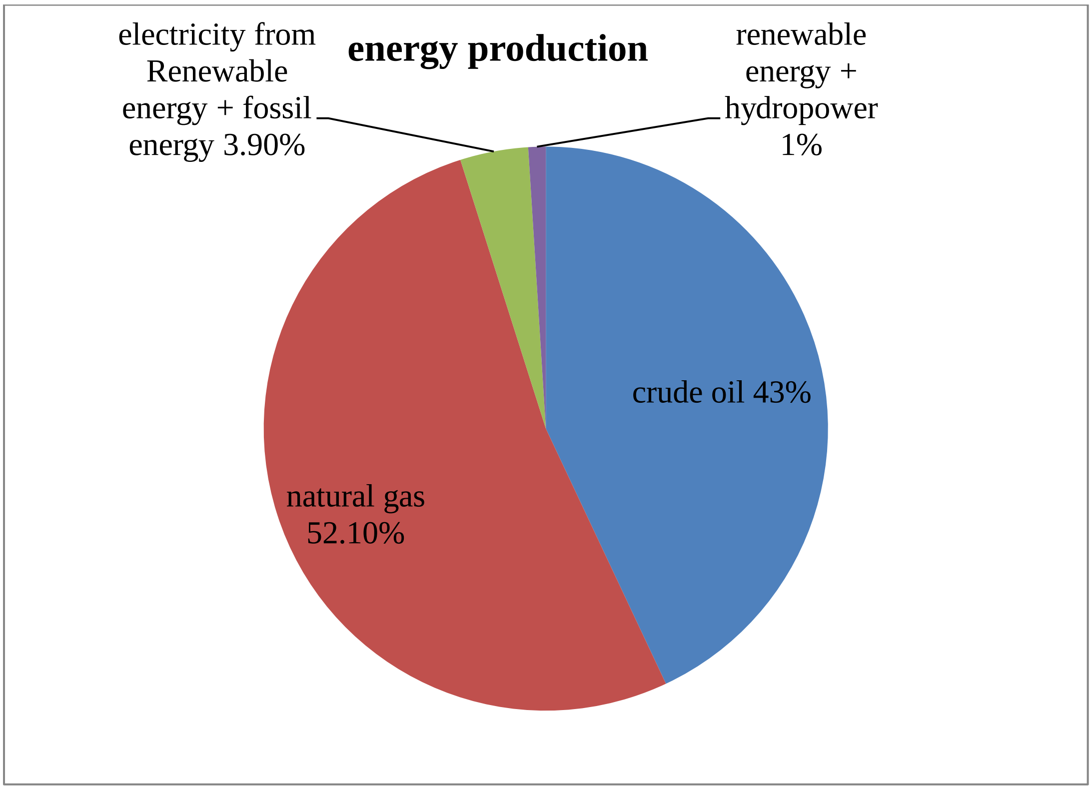
[86] - Y.Himri et al., (August 2009), Review and use of the Algerian renewable energy for sustainable development, *Renewable and Sustainable Development Reviews*, Vol 13, (Issue 6-7), pp 1584-1591.

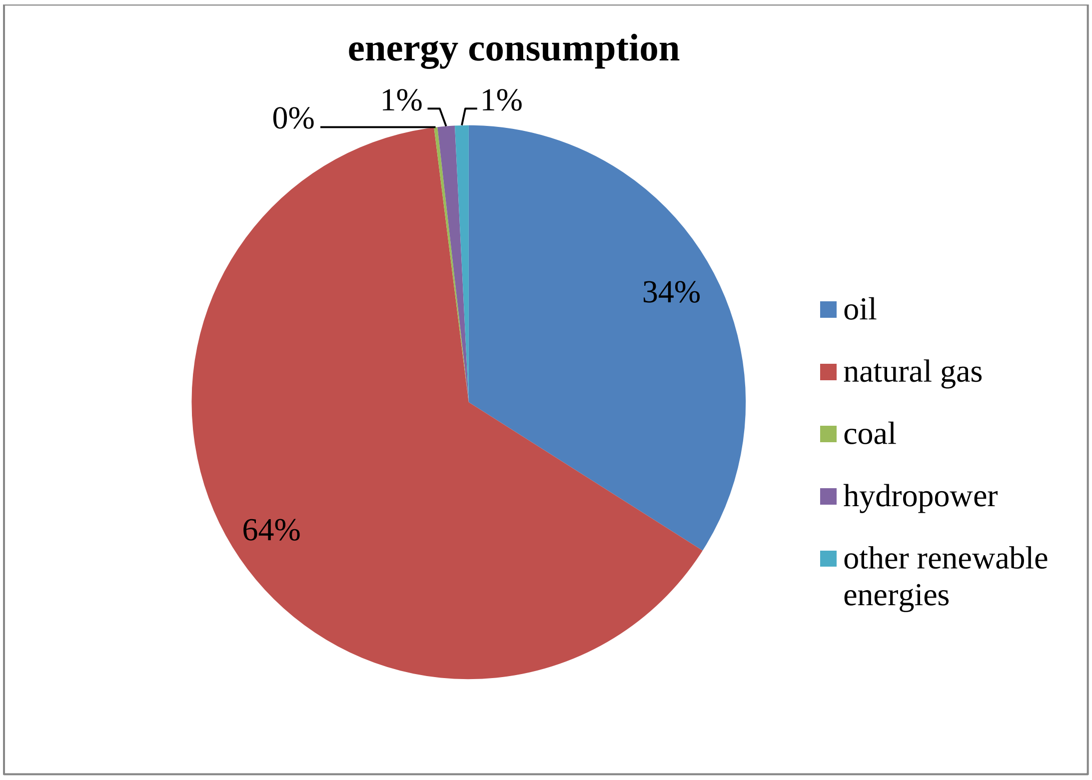
to use it as a small power plant to generate electricity, and some study said that the biomass could offer a 3.7 Mtoe from forest and 1.33 Mtoe per year coming from agricultural and urban wastes.

3.1.4. Energy supply and consumption pattern:

According to the Bp Statistical Review of World Energy of 2017, Algeria consumed 55.1 million tonnes oil equivalent (mtoe) of the primary energy. The energies in Algeria most consumed were oil and natural gas. The consumption of oil was 18.9 mtoe, the consumption of natural gas was 35.5 mtoe, the coal consumption was estimated approximately at 0.1 mtoe, the hydropower consumption was 0.016 and the consumption of other renewable energies was valued at 0.05. Also, the primary energy production was estimated at more than 156.14 mtoe, the oil production was 68.5 mtoe, the production of natural gas was 82.2 mtoe and the electricity production was estimated at 6.04 mtoe.

Figure 03: The energy production and consumption in Algeria in 2016





Source: made by the researchers with using database of OECD, IEA and BP.

3.1.5. Energy policy:

The revision of the national energy policy[87] concerns essentially the development of the photovoltaic, and wind energy on the large scale. The report of the thermal solar energy development for 2021 will focus on the introduction of the biomass, the cogeneration and the geothermal energy. Up to now, this program knew a first phase dedicated to the realization of the pilot projects and test several renewable energy technologies. According to the regulations, this program is open to the national public, private and foreign investors.

The consistency of the renewable energy program will realize 22,000 Mw (Mega-watt) for the needs of the national market over the period 2015-2030, and they will add more than 4,500 Mw in 2020. By the way, the renewables capacities will be settled according to different regions and its specification, and the complementary needs for other fields of application are integrated into the total capacity of the photovoltaic, as residential, agricultural, pumping, water, industry, street lighting and services.

Such program will produce at the end of 2030, 13,575 Mw from solar photovoltaic, 5,010 Mw for the wind, 2,000 Mw from solar thermal, 1,000 Mw from biomass, 400 Mw from cogeneration and 15 Mw from geothermal.

[87] - http://portail.cder.dz/spip.php?article4565

3.2. The environment and the social situation:

In 1999, the cost of environmental degradation[88] has been estimated at 3.6% of GDP and that means 97 billion annually Algerian Dinars (1.7 billion US dollars) was lost due to ecological issues, and the damage cost to the global environment was approximately 1.2% of GDP.

The impact of soil degradation was evaluated on the basis of losses in agricultural productivity resulting from water and wind erosion. Water erosion threatens 12 million hectares (ha) in northern and western Algeria. Wind erosion threatens more than 7 million ha of arid and semi-arid land.

The urban air pollution was caused by the transport sector in the large cities of Algiers, Oran and Constantine by burning municipal waste (Oued Smar in Algiers, Oran), and by the big industries in Annaba, Skikda, and Gazaouet. Such pollution has triggered on a yearly basis 353,000 cases of bronchitis, 544,000 asthma attacks and could be the cause of the 1,500 cases of lung cancer.

The lack of potable water and sanitation as well as poor water quality and hygienic practices causes mortality in children under the age of 5, because of acute diarrheal diseases. It is estimated that 205,500 DALYs (Disability Adjusted Life Years) to be lost per year. In addition to the health impacts, limited consideration was given to water resource degradation due to dam silting which is estimated at 0.09% of GDP.

Coastal degradation is due primarily to coastal erosion affecting 250-300 kilometres of beaches, sand extraction of 10 million cubic meters over the last 10 years, dredging a volume of 20 million cubic meters of soil from 18 ports, and over-exploitation of fisheries by increasing catches from 91,000 tons to 113,000 tons over the last decade. Estimates of coastal degradation were made on the basis of the loss of tourism revenues.

However, the country has made new national programs for renewable energy and energy efficiency, which focus on the reduction of the greenhouse gas emissions and environmental problems[89] by 7% to 22% in 2030, compared to a business as usual -BAU- scenario, conditional on external support in terms of finance, capacity building, technology development and transfer.

[88] - http://siteresources.worldbank.org/EXTMETAP/Resources/COED-AlgeriaCP.pdf

[89] - United Nations for Climate Change (UNFCCC), (September 3rd, 2015), « *Intended nationally determined contribution INDC-Algeria*».

According to the last report of the World Bank and BTI (2018)[90], the social situation has been improved in Algeria by achieving 20% poverty reduction in the past two decades, and the level of socioeconomic development revealed that the country's rating that the HDI (Human Development Index) while improving, remains relatively mediocre (with an index of 0.745, Algeria was ranked 83 out of 188 countries) and the life expectancy was 75.9 years.

Social exclusion has been caused by a significant increase in the urban population. Mass displacements during the 1990s due to insecurity in rural zones have led to increased problems in housing and access to jobs and public services in the cities. The country had an average on gender inequality (score of 0.429 Gender Equality Index).

Consequently, this social situation will make the Algerian government one of the countries that will reach one day the United Nations Sustainable Development Goals.

3.3. The factor of institutional policy, legal and economic:

Algeria is ranked 83th among 129 country of the status index, which is the composition of political transformation (application of law, strategy and commitment) and economic transformation (firms and private sectors), as the status index and other indexes which are measured on the scale of 0 to 10. According to the BTI-project (2018), Algeria had an average index of the status (4.98), for the political transformation (4.75), for the economic transformation (5.21), and for the governance index (4.55). Consequently, these institutional indexes demonstrate that the country suffered from bad management, submission of the laws and application of long-term strategy and policies that can enhance the economy sector, as a result of this, the country still depends only from the oil and natural gas revenues (Dutch Disease[91]).

3.4. The current economic situation:

The oil and natural gas sector have long been the backbone of the economy, accounting for roughly 60% of budget revenues, 30% of GDP, and over 95% of export earnings. Their exports have enabled Algeria to maintain macroeconomic stability and accumulate large foreign currency reserves and a large budget stabilization fund available. In addition, Algeria's external debt is extremely low at about 2% of GDP. However, the country is now struggling to develop non-hydrocarbon industries because of its regulations and policies.

According to the last report of the World Bank (2018), Algeria's economic growth decelerated in 2017 due to a slight decline in hydrocarbon production and continued modest non-hydrocarbon growth. Real GDP growth is estimated at 2.1% in 2017, a slowdown from

[90] - https://www.bti-project.org/en/reports/country-reports/detail/itc/dza/

[91] - is defining as an economic problem that lead the country depending only from one sector and neglect other sectors such as decrease the production from manufacture.

3.3% in 2016. The decline is attributable to a slowdown in hydrocarbon production, which is estimated to have decreased by 1.4% in 2017.

The reversal of the fiscal consolidation policy in the second half of 2017 led to a higher than expected fiscal deficit, depleting fiscal reserves and savings. Public spending decreased by less than expected due to difficulties in pursuing the 2017 budget target. The government, appointed in May 2017, put an end to fiscal consolidation and reverted to the previous, high levels of public spending, specifically in housing. The resulting fiscal deficit is estimated at 8.2% in 2017.

Also, the governments made considerable efforts to reduce high youth unemployment rates. A wave of economic protests in February and March 2011 encouraged the Algerian government to offer more than $ 23 billion in public grants and retroactive salary and benefit increases. In 2015, the Algerian government imposed further restrictions on imports to reduce withdrawals from its foreign exchange reserves, and also increased the value-added tax on electricity and fuel.

Moreover, in the energy sector, Algeria may add cleaner energy to consider the green economy[92] as a means of achieving the objectives of sustainable development, creating jobs, sustaining economic growth (diversifying the production base and increasing value-added), strengthening innovation and reducing poverty. The country wants to transition gradually to a green economy in keeping with its national priorities, particularly the crucial issue of energy transition. The new five-year growth plan (2015/2019) considers the green economy as a pivot for development and technological progress. It also enhances the investment in key sectors of the green economy (agriculture, water, waste recycling and recovery, industry and tourism) and the development of small and medium-sized enterprises. According to the study on youth and women's employability and entrepreneurship in the green economy, the job creation potential is huge but little known. The sector is reported to provide 1.4 million jobs by 2025, especially in five sectors: renewable energy, energy efficiency, water management, waste treatment and recycling, environment-related services and management of green zones, such as Boughezoul as a pilot scheme in energy saving and renewable energy development (solar, photovoltaic and wind) and the plans to develop green business areas, including agro-food processing and mostly agricultural waste recovery, in the province of Tipasa.

Consequently, such outlooks will have a serious impact on Algeria GDP and the growth is expected to improve suddenly in 2018 as fiscal expansion takes hold. As new public

[92] - The green economy in Algeria 'an opportunity to diversify and stimulate domestic production' united nation's economic commission for Africa.

investments announced in the 2018 budget are carried out, headline growth and inflation will increase. As a result, GDP growth is expected to rise by 3.5%, the inflation by 7.5%. However, the GDP growth will struggle to surpass the 2% threshold for 2019-2020, constituting weak growth for a middle-income country with a large youth bulge.

Conclusion of chapter:

This chapter described the renewable energy, which represents the main factor of sustainable development as it can contribute to mitigate the effect of environmental issues and improve the socio-economic factors, but such energy is hard to adapt in any country because now the developed and developing countries are mainly depending on fossil fuel source to develop their economic and industrial conditions, and also the high cost of renewable technologies may restrict the deployment of cleaner energy. Besides, the market failures, trade problem, and economic barriers are as well the main problems of renewables integration in the energy supply. We can also define some renewables inconvenient like the production efficiency, the chemical products used from bioenergy, and the exploitation of biomass.

On the other hand, we explored the term of “Sustainable Development”, which focuses on the realization of 17 objectives in three main sectors, economic, environment and social segments, and likewise we mentioned that the sustainable development can be a key factor to resolve the main issues and combating the climate change and mitigate the effect of carbon dioxide and greenhouse gas by introducing a new way of production such as the implementation of renewables in energy supply.

Therefore, the shift towards a more diversified economy, Algeria needs to move toward sustainable growth and create jobs. This does need to be done in a way that protects the most vulnerable by ensuring well defined and targeted compensation mechanisms. The Bank’s global perspective, analytical expertise, knowledge and resources are shared with the Algerian government to support the country in the implementation of the reforms.

Chapter 2:

Literature Reviews

Chapter 2: Literature Reviews

Introduction:

The world is no longer the same as it used to be in the past. Now several countries are not depending on agriculture sector only, but on other sectors as well. Despite the fact that the use of fossil fuel was the cot of the Industrial Revolution, especially in European countries, it remains a problem for the environment (climate change) and for the health of the population. Several studies focussed on how to shift the energy system from fossil to renewables and they did investigations on renewable energy, energy policy, economic growth, sustainable development, environment and social factors for the countries, which are mostly depending on fossil sources (80% of total energy used[93]) to produce their goods and services. However, many researchers appointed that the oil, natural gas and coal may create political tension, environment and social issues. Therefore, to reduce their use, several nations decided to focus on cleaner energy that can bring more electricity, heat and mechanical energy, but, the main problem in the renewable energy domain is their cost and several nations have not the necessary knowledge or required machinery that can develop and use this “clean” energy sources with competently and efficiently.

At the moment, countries are starting to make new energy policy that encourage the investment in the renewable energy sources because they believe that it can represent a good replacement to fossil energy or a decent addition to the energy sector and it may satisfy the major energy challenge today’s economies are confronted with. According to different investigates the renewable energy can secure the long-term availability, offer a political stability, satisfy the growing demand, reduce the environmental pollution, particularly the effect of greenhouse gases or the carbon emissions, and improve the life condition of the population.

In this chapter, we shall demonstrate different literature review about energy consumption (renewables, fossil and nuclear consumption), economic growth (GDP) or economic factor of sustainable development (per capita GDP), pollution factor (CO_2 emissions GHG emissions), social indicator (HDI) and reviews the impact of different energy policy (Feed-in Tariff, tax, market of carbon) on the introduction of renewable energy. Also, we will display the empirical literature review based on econometric and statistic model that are the most used in research papers on renewable energy.

[93] - EIA (U.S Energy Information Agency)

1. Investigating the Relationship between Energy, Economic Growth and Carbon Dioxide Emissions:

1.1. Studying the link amongst energy and economic growth:

Adams et al. (2018) analysed the impact of renewable and non-renewable energy consumption on economic growth for 30 Sub-Saharan African countries during the period of 1980-2012. They employed heterogeneous panel cointegration for the variables of real GDP, capital stock, labour force, renewable energy consumption, non-renewable energy consumption and regime type (Polity). They concluded with FMOLS and DOLS estimations that both renewable and non-renewable energy consumption had a positive and significant effect on economic growth in such countries, but the non-renewable energy consumption had a greater effect than renewable energy. They found also that there's no heterogeneous pairwise causality between renewable energy and economic growth or between non-renewable energy and economic growth.

Silva et al. (2018) made an empirical analysis to determine the factors that affect the growth of renewable energy for 17 Sub-Saharan countries during the period of 1990-2014. They used panel ARDL for the variables of the share of renewable energy in electricity production, coal prices, natural gas prices, crude oil prices, population growth, CO_2 emissions per capita, GDP per capita, energy use, share of electricity import for consumption, ratification of the Kyoto protocol. They found that the coal prices, oil prices, natural prices and CO_2 emissions per capita had a negative and significant impact on renewable energy. However, the sign of GDP per capita and energy use was a positive and significant effect on renewable energy.

Tugcu and Topcu (2018) studied the link between economic growth, renewable and non-renewable energy consumption in G7 countries during the period of 1980-2014. They employed the nonlinear autoregressive distributed lag (NARDL) for the variables of real GDP per capita, real gross fixed capital formation per capita, total labour force, total number of students enrolled in the public and private tertiary education institutions, the gross expenditure per capita on research and development, renewable energy consumption per capita, non-renewable energy consumption per capita and total primary energy consumption per capita. They found no causality between renewable energy consumption and economic growth in the UK and USA. They concluded that there's unidirectional causality running from renewable energy consumption to economic growth in Canada, France and Italy. They showed also unidirectional causality running from economic growth to renewable energy consumption for Germany.

Atems and Hotaling (2018) investigated the relationship between economic growth and electricity generation from renewable and non-renewable energy for 174 countries over the period of 1980-2012. They employed panel OLS, panel fixed effect and panel system of GMM for the variables of GDP per capita, total electricity, renewable electricity generation, non-renewable electricity generation, electricity loss, primary enrolment, life expectancy, foreign aid, trade, inflation, government, fertility rate, FDI and saving rate. They found with all methods that the renewable electricity generation and non-renewable electricity generation had a positive and significant effect on economic growth.

Amri (2017b) investigated the relationship between renewable, non-renewable energy and GDP in Algeria during the period of 1980-2012. He applied the ARDL model and Granger causality for the variables of GDP, GFCF (capital), the population, total renewable electricity consumption, total non-renewable electricity consumption. He concluded that in the long term, the per capita capital (1%) and the per capita non-renewable energy consumption (1%) impact positively GDP by an increase of 0.244% and 0.246%, respectively, but, the renewable category of energy consumption is unconnected to the GDP. The results confirm that Algeria has not (yet) reached the renewable energy threshold that allows it to make a positive contribution on output. This participation is equal to nearly 0.10% in the aggregate Algerian energy consumption in 2013. However, he found unidirectional causality running from renewable energy to economic growth.

Rafindadi and Ozturk (2017) investigated the relationship between renewable energy consumption and economic growth in Germany by using ARDL and VECM method from the period of 1970 Q1 (quarter one) to 2013 Q4 (quarter four). The variables were real GDP per capita, renewable energy consumption per capita, real capital per capita and labour force per capita. They used a structural break in unit root test and the cointegration test of Bayer and Hanck which is based on Fisher-statistics. They found in the long-run that the renewable energy consumption has positive and significant influence on economic growth, so a 1% increase in renewable energy consumption can develop the economic growth by 0.2194% with keeping other factors constant. The impact of capital on economic growth was positive and statistically accepted, so a 1% increase in physical capital will raise the economic growth by 1.1320%. The labour had also a positive and significant sign, so a 1% rise will upsurge the economic growth by 0.5125%.

Kahia et al. (2017) tried to make a panel vector error correction model for Mena Net Oil Importing Countries over the period of 1980-2012 and they worked with real GDP, total renewable energy and total no renewable use, real gross fixed capital formation and labour force. They found feedback causality between renewable energy use and economic growth and between non-renewable energy use and economic growth.

Amri (2017a) investigated the relationship between renewable energy consumption, trade and economic growth for 72 developing and developed countries during the period of 1990-2012. He employed two-step generalized method of moments for the variables of GDP, total factor of productivity, capital, labour, renewable energy consumption and trade, as a result, he concluded for bidirectional causality between income and renewable energy consumption and among trade and renewable energy consumption.

Armeanu et al. (2017) tested the hypothesis that the renewable energy can contribute to get a sustainable economic growth by using a panel cointegration method, fixed effect model and Granger causality in 28 European countries over the period of 2003-2014. They used the variables of GDP per capita, renewable energy production, and energy dependency. They found a long-term relationship between primary production of renewable energies, energy dependence, and gross domestic product per capita. They also showed that there's a positive influence of primary production of renewable energies on economic growth. In addition, the conservation hypothesis was acknowledged, and being identified for both short and long-run, and they found a relationship running from GDP to the primary production of renewable energies.

Koçak and Şarkgüneşi (2017) examined the renewable energy and economic growth nexus in 9 black sea and Balkan countries with panel cointegration and heterogeneous causality. They used the variables of GDP per capita, gross fixed capital formation as capital stock, labour force participation rate, and the share of renewable energy in total energy consumption over the period of 1990-2012. They found a positive and significant impact of exogenous variables on economic growth and the existence of long term relationship between renewable energy consumption and economic growth, confirming the unidirectional causality, which was running from renewable energy consumption to economic growth (growth hypothesis) in Bulgaria, Greece, Macedonia and Russia Federal, and two-way relationship between these two variables (feedback hypothesis) in Albania, Georgia, and Romania, and no relationship (neutrality hypothesis) for the case of Turkey and Ukraine.

Kahia et al. (2016) examined the influence of renewable and non-renewable energy on economic growth for two groups of MENA countries over the period of 1980-2012, the 1st set was composed of 13 countries and 2nd group was composed of 5 top countries that shared the renewable energy in their energy production system. They used the pairwise correlation, FMOLS method and Granger causality for the variables of real GDP, total renewable and non-renewable electricity consumption, GFCF and labour force, as a conclusion, they found in the long-run a strong evidence for a panel cointegration between real GDP, renewable energy, non-renewable energy, capital and labour force. They showed that the coefficient of non-renewable energy use was the main source for producing electricity, as it represents 0.241 for the 5 selected MENA countries, and 0.772 for 13 MENA countries, indicating that the most of the whole sample used non-renewable energy as input in the production process and in the water desalination. They also found also that the estimated coefficient associated with renewable energy for the whole MENA countries was 0.058 which is about half the estimated coefficient for the 5 selected MENA countries 0.11. This result is mainly explained by the higher share of renewable energy consumption in the total energy consumption for 5 selected MENA compared to the whole MENA sample, and which indicates that an increase by 1% in renewable energy consumption will increase the real GDP by 0.058% and 0.11% of the panel data. They likewise concluded that there was unidirectional causality running from renewable energy to economic growth.

Lotz (2016) used panel model to study the link between renewable energy consumption and economic growth in 34 OECD countries over the period of 1990-2010. The variables were GDP, GDP per capita, total renewable energy consumption, the share of renewable energy consumption to total energy consumption, the gross capital formation, the number of employees, and research and development expenditure. She found that there's a long-run equilibrium relationship between real GDP (GDP per capita), total renewable energy consumption or share of total renewable energy consumption, real gross fixed capital formation, employment, and the R&D expenditure. The estimations indicated that a 1 % increase in renewable energy consumption will increase GDP by 0.105% and GDP per capita by 0.100%, while a 1 % increase of the share of renewable energy in the energy mix of the countries will increase GDP by 0.089% and GDP per capita by 0.090%.

Chang et al. (2015) investigated the relationship between renewable energy and economic growth by using heterogeneous panel model and Granger causality in the G7 countries during the period of 1990 and 2013. The variables were GDP and renewable energy consumption, as a conclusion, they found that there's a unidirectional relationship running from renewable energy consumption to economic growth only in Japan, France and Canada.

Solarin and Ozturk (2015) studied the causal dynamics between hydroelectricity consumption and economic growth in 7 Latin America countries covering the period of 1970-2012. They used the panel VECM for the variables of GDP, hydroelectricity consumption, gross fixed capital formation and labour force. The evidence of feedback hypothesis was found between hydroelectricity consumption and economic growth in Argentina and Venezuela. However, for the rest of Latin American countries, there was unidirectional causality (growth hypothesis) running from hydroelectricity consumption to economic growth.

Bilgili and Ozturk (2015) studied the biomass energy and economic growth nexus in G7 countries during the period of 1980-2009. They employed panel cointegration, conventional OLS and Dynamic OLS for the variables of GDP, biomass used, total energy supply, biomass % of total energy supply, human capital index (based on years of schooling and returns to education), capital stock, population. They concluded that the biomass consumption, the human capital index and capital stock have a positive and significant impact on economic growth and it's confirmed by the homogenous OLS, homogenous adjusted OLS, homogenous DOLS and heterogeneous DOLS. They found also a one-way relationship running from biomass energy consumption to economic growth (growth hypothesis).

Omri et al. (2015) investigated the relationship between nuclear energy consumption, GDP and renewable energy consumption by using dynamic simultaneous-equation panel data model in 17 developed and developing countries over the period of 1990-2011, as a conclusion, they provided several results according to different countries, therefore they found the existence of the bidirectional relationship between GDP and renewable energy consumption in Belgium, Bulgaria, Canada, France, Pakistan and USA. However, they established for the global panel an evidence of a unidirectional relationship running from GDP to renewable energy consumption.

Ozturk and Bilgili (2015) examined the economic growth and biomass consumption nexus for 51 Sub-Sahara African countries. They employed panel cointegration, conventional OLS and Dynamic OLS for the variables of GDP, population, openness and biomass consumption over the period of 1980-2009. They found that the three exogenous variables have a positive and significant impact on economic growth as it's confirmed by the homogenous OLS, homogenous adjusted OLS, homogenous DOLS and heterogeneous DOLS.

Bildirici (2014) explored the link between biomass energy and economic growth in transition countries by using a panel ARDL model. He used the variables of per capita GDP and biomass energy consumption over the period of 1990-2011. He provided with FMOLS and ARDL model that the biomass energy consumption has a positive impact on the economic growth and there’s bidirectional causality between these variables in the long-run.

Pao et al. (2014) used a neo-classical one-sector aggregate production model by employing the variables of capital, labour, renewable/nuclear energy consumption and fossil fuel energy consumption to investigate the influence of each type of energy consumption on economic growth by using a panel cointegration procedure in 4 countries of MIST over the period of 1990-2010. They found in the long-run unidirectional causality running from renewable energy consumption to economic growth with positive bidirectional short-run causality. They said also that the renewables and nuclear energy are a viable solution for addressing energy security and climate change issues.

Aïssa et al. (2014) explored the relationship between renewable energy consumption, trade, and output in 11 African countries during the period of 1980-2008. They used the panel cointegration method for the variables of real GDP, renewable energy consumption defined as total renewable electricity consumption, export and import, the capital stock defined by the gross fixed capital formation and labour force. They showed that there’s bidirectional causality between output and trade in both short and long run, however, in the short run, they found no causality between renewable energy consumption and output and between trade and renewable energy consumption.

Ocal and Arslan (2013) used ARDL and Toda-Yamamoto causality to study the link between renewable energy consumption and economic growth in Turkey over the period of 1990-2010. The variables were GDP, gross fixed capital formation, total labour force and combustible renewables and waste % of total energy. They found that the renewable energy consumption has a negative impact on economic growth and the Toda-Yamamoto causality showed the existence of unidirectional causality running from economic growth to renewable energy consumption (conservative hypothesis).

Pao and Fu (2013) explored the link between renewable energy, non-renewable energy and economic growth in Brazil over the period of 1980-2010. They employed the VECM model for the variables of real GDP, real gross fixed capital formation, labour force, non-hydro renewable energy consumption, total renewable consumption, and total primary energy consumption. The result provided bidirectional causality between non-hydroelectric renewable energy consumption and GDP in the short-run. However, in the long-run, there’s unidirectional causality running from non-hydroelectric renewable energy consumption to GDP and there’s also bidirectional causality between total renewable consumption and GDP.

Al-mulali et al. (2013) examined the impact of renewable energy consumption on economic growth for high income, upper middle income and lower middle income countries covering the period of 1980-2009. They employed the FMOLS procedure for the variables of electricity consumption from renewable energy sources and GDP, as results, they showed that 79% of the countries have a positive bi-directional long run relationship between variables (feedback hypothesis). However, 19% of the countries showed that there's no long run relationship between renewable energy consumption and GDP (neutrality hypothesis). Otherwise, 2% of the countries showed a unidirectional relationship running from GDP growth to renewable energy consumption (conservation hypothesis).

Bildirici (2013) explored the link between biomass energy and economic growth in the selected 10 developing and emerging countries by using a panel ARDL model. He used the variables of real GDP and biomass energy consumption over the period of 1980-2009, but he employed the period of 1980-2005 for the case of Argentina only. He provided with Granger causality that there's unidirectional causality running from biomass energy consumption to GDP in nine selected countries, but there's bidirectional causality for El Salvador in the short-run. However, he found that there's a weak evidence of a causal relationship between biomass energy consumption and GDP in some countries.

Yildirim et al. (2012) examined with the method of Toda-Yamamoto and bootstrap-corrected causality the link between renewable energy consumption and gross domestic product for the period of 1949–2010 in USA. They used the variables of real gross fixed capital formation, real GDP, total of renewable energy consumption (biomass, hydropower and biomass-wood-derived, geothermal and biomass-wood-derived) energy consumption. They found the existence of one causal linkage from biomass-waste-derived energy consumption to real GDP, while there's no relationship with renewable energy consumption or its forms.

Tugcu et al. (2012) examined the existence of long-run causality between economic growth, non-renewable and renewable energy for the G7 countries during the period of 1980-2009. The data were real GDP, real gross fixed capital formation, labour force, total number of the full and part time student enrolled in public and private tertiary education, the sum of the number of patent application to a European patent office and patent application filled under patent co-operation treaty, renewable and non-renewable energy consumption. They employed panel cointegration, Granger causality and the modified Wald statistic test which accounts for the possibility of ARCH effect via a bootstrapping simulation. They found that there's no causal relationship between renewable energy consumption and economic growth in France, Italy, Canada and in the USA, but there was an evidence of feedback hypothesis for England and Japan, and also unidirectional causality running from GDP to renewable energy consumption in Germany. Moreover, they applied the modified Wald statistic test for classical production function, and they observed that there's bidirectional causality between renewable, non-renewable energy consumption and economic growth for the whole panel.

Apergis and Payne (2011b) did an investigation about the causality between renewable energy consumption and economic growth in the short and long-term for 16 emerging market economies over the period of 1990-2007. They used the panel cointegration procedure for the variables of real GDP, total renewable electricity consumption, total non-renewable electricity consumption, real gross fixed capital formation and labour force, as a conclusion, they found that the total non-renewable electricity consumption, real gross fixed capital formation and the labour force have a significant and positive impact on GDP, but the total renewable electricity consumption has an insignificant and positive effect on GDP. They also concluded that there's bidirectional causality between renewable electricity consumption and economic growth in the long term. However, in the short-term, there's unidirectional causality running from GDP to renewable electricity consumption.

Apergis and Payne (2011a) explored the relationship among renewable energy consumption and economic growth for six countries of Central America over the period of 1980-2006. They employed the panel cointegration procedure for the variables of real GDP, real gross fixed capital formation, labour force, and renewable energy consumption. They found with the FMOLS estimation that all exogenous variables have a positive and significant effect on GDP and there's bidirectional causality between renewable energy consumption and economic growth in short and long-run.

Apergis and Payne (2010b) studied the causality between renewable energy consumption and economic growth for 13 countries within Eurasia over the period of 1992-2007. They used the heterogeneous panel cointegration for the variables of real GDP, real gross fixed capital formation, labour force, and renewable energy consumption. They found with the FMOLS estimation that all variables have a positive and significant impact on GDP and there's bidirectional causality between renewable energy consumption and economic growth in the short and long-term.

Apergis and Payne (2010a) examined the link amongst renewable energy consumption and economic growth in the short and long-term for 20 OECD countries over the period of 1985-2005. They employed the procedure of panel cointegration for the variables of real GDP, real gross fixed capital formation, labour force, and renewable energy consumption; as a result, they found that all the coefficients are positive and statistically significant at the level of 1%. They also revealed in both short and long-run with the Granger-causality that there's a positive bidirectional between renewable energy consumption and economic growth.

Sadorsky (2009b) examined the relationship between renewable energy consumption and economic growth (income) over the period of 1994-2003 in 18 emerging countries. He used the procedure of panel cointegration for the variables of renewable energy consumption per capita and real GDP per capita (income per capita). He found that the increase in real per capita income has a positive and statistically significant impact on renewable energy consumption per capita. However, there's no panel causality between renewable energy per capita and income per capita for the full sample of countries.

Payne (2009) used the Toda-Yamamoto causality to test the relationship between real GDP, renewable and non-renewable energy consumption in the case of the USA over the period of 1949-2006. He found that there's no causality between renewable energy consumption and economic growth, supporting neutrality hypothesis.

1.2. Examining the link between energy, economic growth and carbon dioxide emissions:

Lotz and Dogan (2018) explored the link between trade openness, income (real GDP), GDP squared, CO_2 emissions, and electricity production from renewable and non-renewable sources. They employed panel cointegration procedure for ten biggest electricity generators in Sub-Saharan Africa during the period of 1980-2011. They concluded with the DOLS model that the GDP and electricity production from renewable source had a negative and significant impact on carbon dioxide emissions, but the GDP squared and electricity production from non-renewable source had a positive and significant impact on carbon dioxide emissions. This implied that the Environmental Kuznets Curve hypothesis is not supported in this study. They found with Emirmahmutoglu-Kose Granger causality that there's bidirectional causality between GDP and carbon dioxide emissions and unidirectional causality running from carbon dioxide emissions to renewable energy.

Apergis et al. (2018) examined the relationship between per capita carbon dioxide emissions, per capita GDP, renewable energy consumption, and health expenditure for 42 sub-Saharan Africa countries over the period of 1995-2011 by using the panel methodological approach. They found with FMOLS and DOLS that the GDP had a positive and significant impact on CO_2 emissions, while the renewable energy consumption had a negative and significant effect on CO_2 emissions. They concluded in the short-term that there's bidirectional causality between CO_2 emissions and renewable energy consumption and there's unidirectional causality running from GDP to CO_2 emissions.

Mbarek et al. (2018) analysed by using the VECM procedure the factors that may affect the environmental deterioration (per capita CO_2 emissions) and economic growth (per capita GDP). They employed the per capita renewable and non-renewable energy use for the case of Tunisia over the period of 1990-2015 and they found the existence of the long-run relationship between variables. They also showed that an increase by 1% in GDP can raise renewable energy consumption, energy use and CO_2 emissions by 1.33%, 0.36% and 1.12%, respectively, and they provided that a 1% increase in CO_2 decreases GDP by 0.28%, but a 1% increase in renewable upsurge GDP by 0.16%. Besides, the Granger causality revealed the existence of a unidirectional relationship running from GDP to the renewable energy consumption and from energy consumption to GDP, and there's also bidirectional causality between CO_2 emissions and GDP and between CO_2 emissions and energy consumption.

Solarin et al. (2017) investigated the EKC hypothesis for India and China during the period of 1965-2013. They employed ARDL methodology and structural breaks for the variables of CO_2 emissions per capita, real GDP per capita, real GDP squared per capita, hydroelectricity consumption per capita and urbanisation population ratio. They found in both countries that the GDP and urbanisation had a positive effect on CO_2 emissions, while real GDP squared and hydroelectricity consumption had a negative influence on CO_2 emissions, demonstrating an evidence of the EKC. They concluded also in the short-run that there's unidirectional causality running from GDP per capita to CO_2 emissions per capita and from hydroelectricity consumption to CO_2 emissions, but in the long-term, there's bidirectional causality between CO_2 emissions and hydroelectricity consumption and between GDP (and GDP squared) and hydroelectricity consumption.

Shahbaz et al. (2017) explored the short and long-run link amongst carbon emissions and their determinants in the presence of structural breaks and determine whether biomass energy consumption improves environmental quality by reducing carbon pollutants for USA. They employed ARDL, VECM and Granger causality for the variables (all per capita) of real GDP, real GDP squared, oil prices, real trade, real trade squared, CO_2 emissions and biomass energy consumption over the period of 1960-2016. They found that the biomass energy consumption has a negative impact on CO_2 emissions, but GDP and GDP squared have a positive and negative effect on CO_2 emissions, respectively, confirming the existence of the EKC hypothesis in the U.S.A. They concluded also that there's bidirectional causality between biomass energy consumption and CO_2 emissions, and unidirectional causality running from GDP to CO_2 emissions and from GDP to biomass energy consumption.

Ito (2017) conducted a work about renewable and non-renewable energy consumption, CO_2 emissions and factor of economic growth in the case of 42 developed countries over the period of 2002-2011. They employed the GMM procedure and ARDL method for the variables of CO_2 emissions per capita, consumption of fossil fuel energy, GDP per capita and renewable energy consumption. They showed that the renewable energy consumption can contribute to mitigate and reduce the effect of CO_2 emissions and it had a positive and significant effect on the economic growth development in the long run.

Dogan and Aslan (2017) did a work about the link between environment factor, economic growth, energy consumption and tourism for 25 European and candidate countries during the period of 1995-2011. They used the variables of CO_2 emissions, real GDP, the number of international tourist arrivals and energy use. They employed the LM bootstrap panel cointegration test, the homogenous test of Pesaran and Yamagata and Granger causality of Emirmah mutoglu-Kose procedure. They found that the elasticity of carbon emissions with respect to economic growth is negative and it will be from -0.10% to -0.20%, so this can lead to lower levels of emissions. The negative coefficient for real income is indirectly connected to the EKC hypothesis which claims that increases in real income lead to environmental improvements in a country after the nation passes the threshold level of income coefficient on economic growth. Also, they concluded for bidirectional causality between GDP and CO_2 emissions.

Santra (2017) studied the impact of technological advancement on production, which is based on energy and CO_2 emissions in emerging countries (Brazil, the Russian Federation, India, China and South Africa). He used the variables of GDP per unit of total primary energy source (TPES) and GDP per unit of energy related CO_2 emissions as dependent variables, while the independent variables were renewable energy supply as a percentage of TPES, per capita of total primary energy production, per capita innovation of environmental related technology (policy variable) and real GDP per capita. He employed the pooled regression modelling with least squares dummy variable regression on two models over the period 2005-2012 and he showed that the renewable energy supply as a percentage of TPES has a significant impact on energy productivity, but, the renewable energy supply coefficient wasn't statistically significant. He also said that ff the per capita innovation environment related technologies, before three years, increases by one unit, then CO_2 emissions per GDP would decrease or GDP per CO_2 emissions would increase.

Zoundi (2017) examined the EKC hypothesis by using a panel cointegration procedure in the case of 25 countries over the period of 1980-2012. He used the variables of CO_2 emission per capita, real GDP per capita, GDP² per capita, primary energy consumption per capita, total renewable electricity net consumption per capita and population growth. He estimated with DOLS model, GMM system, dynamic fixed effect, mean group and pooled mean group. In the short-term, he found with DOLS estimation that an increase by 1% in the consumption of renewable energy reduces CO_2 emissions by 0.13%, while an increase by 1 % in primary energy consumption can lead to increase CO_2 emissions by 0.85%, suggesting that the consumption of renewable energy along with primary energy reduces air quality by around 0.72% (0.85–0.13). They concluded from these results that there's evidence that the renewable energy will be a good replacement for the conventional fossil-fuelled energy, and they will allow to meet household needs for energy and it will contribute to the improvement of air quality, but more efforts should be done to spread renewable energy policies across Africa and efforts should be made by households to switch to this new technology. They also showed that there is no evidence of the EKC hypothesis, because both of GDP per capita and GDP² per capita do not significantly impacted CO_2 emissions. However, he found in the short-term, the existence of the EKC hypothesis for the pooled mean group estimation.

Attiaoui et al. (2017) examined the relationship between carbon dioxide, renewable energy and economic growth in the case of 22 African countries over the period of 1990-2011. The variables were GDP per capita, CO_2 emissions per capita, renewable energy consumption per capita and non-renewable energy consumption per capita. They showed a positive and significant relationship among CO_2 emissions, GDP, and non-renewable energy consumption in both short and long-term. Consequently, a 1% increase in GDP increases CO_2 emissions by 0.19 in the long-term and by 0.015% in the short-term, while an increase by 1% in non-renewable energy consumption increases CO_2 emissions by 0.23% in the long-term and by 0.35% in the short-term. However, the renewable energy consumption has a negative impact on CO_2 emissions in both short and long-term, so a 1% increase in renewable energy consumption decreases CO_2 emissions by 0.22% in the long-term and by 0.07% in the short-term. In the GDP model, they displayed in the long-term that the carbon dioxide had a negative and significant effect, but, the renewable and non-renewable energy consumption had a positive effect. Therefore, these results suggested that the most African countries are still not depending mainly on renewable energy in their energy production.

Paramati et al. (2017) analysed the relationship between renewable energy use, economic growth and environment condition over the period of 1990 - 2012 in the case of 11 countries that are considered as the fastest developing countries in the world (Next 11). They employed heterogeneous panel cointegration and causality test for the variables of CO_2 emissions from the consumption of energy, GDP, GDP per capita, non-renewable and renewable energy consumption, gross fixed capital formation, and labour force as the total working population who aged 15 and above. They confirmed that there's long-run equilibrium relationship between CO_2 emissions, labour force, per capita income, non-renewable and renewable energy consumption. They showed that the renewable energy consumption and income had a negative and significant impact on CO_2 emissions. They found also homogenous unidirectional causality running from non-renewable energy consumption to CO_2 emissions and from CO_2 emissions to renewable energy consumption.

Dogan and Ozturk (2017) studied the contribution of the economic growth, renewable and non-renewable energy on aspects of climate change in the USA over the period of 1980-2014. They used the variables of CO_2 emissions, GDP, GDP^2, renewable energy consumption and non-renewable energy consumption. They employed unit root tests with structural break of Zivot-Andrews and Clemente-Montanes-Reyes and applied the cointegration test with structural break of Gregory-Hansen then they estimate the model with ARDL procedure. They found that an increase in the use of renewable energy consumption by 1% will negatively affect the levels of CO_2 emissions by 0.09% and a rise in non-renewable energy consumption by 1% will increase the air pollution in the atmosphere by 1.04%. Consequently, an obvious action towards lower levels of emissions is to increase the use of energy from renewable sources and decrease the use of energy from non-renewable sources in the energy mix in the USA. The coefficient of GDP was negative by 4.66% and the sign of GDP^2 was positive by 0.08% on CO_2 emissions. Consequently, the EKC hypothesis is not validated, because the expansion in production level won't stop the USA growth and will create a collapse to the environment.

Sarkodie and Owusu (2017) explored the factors that may affect CO_2 emissions in Ghana over the period of 1971-2013. They employed the linear regression model of Kendall's and bootstrapping, and cointegration procedure for the variables of CO_2 emissions, GDP, population and energy use per capita. They found that an increase by 1% in energy use will increase carbon dioxide emissions by 0.58%, while a 1% increase in GDP will increase carbon dioxide emissions by 0.73%, and a 1% increase in the population will increase the carbon dioxide emissions by 1.30%. However, when the energy use, GDP and the population are zero, the carbon dioxide emissions will be reduced by 18.57%. They found also with the

Granger causality that there's a unidirectional causality running from energy use to carbon dioxide emissions and from the population to CO_2 emissions.

Jebli and Youssef (2017) investigated the importance of renewable energy and agriculture in CO_2 mitigation in the case of 5 North African countries over the period of 1980-2011. The panel cointegration and Granger causality were applied to the variables of per capita carbon dioxide emissions, per capita real GDP, per capita renewable energy consumption and per capita agricultural value added. They found with the FMOLS approach that a 1% increase in GDP increases the CO_2 emissions by 1.55%, while a 1% increase in renewable energy increases emissions by 0.19%, and a 1% increase in agriculture value added reduces emissions by 0.93%. They said therefore that the increasing in output increases CO_2 emissions in the long-run, indicating that the economic growth that still needs intensively fossil energy for producing goods and services. However, the coefficient of renewable energy consumption was positive and it increases the level of CO_2 emissions, meaning that the renewables used contains combustible renewables and waste, which are considered as non-clean energy resources, but, they pollute less than fossil energy.

Menegaki and Tiwari (2017) used the quantile regression, the fixed effects model and the panel vector error correction model in the case of 20 American countries over the period of 1990-2013. They employed the variables of per capita labour, per capita gross fixed capital formation, per capita carbon dioxide emissions, per capita energy use, per capita renewable energy supply, per capita rents and per capita trade. They concluded that the energy does not impact eight in GDP or Index of Sustainable Economic Welfare model (ISEW) and is only influenced by gross fixed capital formation under the ISEW equation, but by no other economic factor. They also found bidirectional Granger causality between renewable energy and ISEW and a unidirectional Granger causality from renewable to (GDP).

Chen et al. (2016) employed a panel cointegration and VECM method to study the link between economic growth, energy consumption and CO_2 emissions in the case of 188 countries during the period of 1993-2010. The variables were average of energy consumption per capita, CO_2 emissions per capita, real GDP and GDP^2. They found that the energy consumption per capita has significant influences on CO_2 emissions, so a 1% increase in energy consumption per capita increase the emission of CO_2 per capita by 7.6%, 26.1%, and 13.5% in developed countries, developing countries, and all 188 countries, respectively, suggesting a positive relationship between these two variables in the long-run. Moreover, they indicated that the energy consumption per capita in developing countries induced more CO_2

emissions per capita than in developed countries. However, they found that the increase in energy consumption will decrease the rate of (GDP) for the 188 countries in the long-run.

Mulali et al. (2016) explored the environmental Kuznets curve hypothesis in seven selected regions with DOLS and VECM Granger causality over the period of 1980-2010. The variables were CO_2 emissions, GDP, GDP squared, urbanization, trade openness, financial development and renewable energy consumption. They found that the GDP and GDP squared had a positive and negative impact, respectively on CO_2 emissions except for the Sub Saharan Africa, while the renewable energy consumption had a negative influence on CO_2 emissions except for the Sub Saharan Africa, indicating that the EKC was accepted for six regions except for the region of Sub Saharan Africa. They also showed a several causalities (bidirectional and unidirectional) between CO_2 emissions, renewable energy consumption and GDP.

Shahbaz et al. (2016) examined the EKC hypothesis in 19 African countries over the period of 1971-2012. They employed the ARDL procedure for the variables of CO_2 emissions, real GDP, real GDP squared, energy intensity and globalization. They found that the energy intensity and GDP had a positive impact on CO_2 emissions, while GDP squared had a negative effect on CO_2 emissions, validating the ECK hypothesis for these nations. However, in individual data, they were only 6 countries who follow the EKC hypothesis.

Dogan and Seker (2016) did a work about the role of some factors that impact the level of CO_2 emissions in the case of 23 countries during the period of 1985-2011. The variables were CO_2 emissions, GDP, GDP^2, electricity from renewable energy consumption, electricity from non-renewable energy consumption, trade openness (exports and imports of goods and services) and financial development (domestic credit to private sector). They used the cross-sectional independence test, panel unit root tests, and cointegration procedure, as results, they showed that the environmental effects of energy consumption by sources can allow an increase in renewable energy consumption by (1%) which will lead to mitigate the carbon emissions by (3% or 4%) and an increase in non-renewable energy consumption may raise the level of CO_2 emissions by (20% or 24%).

Bilgili et al. (2016) revisited the Environmental Kuznets Curve hypothesis with the FMOLS and DOLS estimations for 17 OECD countries over the period of 1977-2010. They employed the panel cointegration procedure for the variables of carbon monoxide emissions per capita, GDP per capita, GDP squared per capita and renewable energy consumption. They concluded from both FMOLS and DOLS that the GDP per capita was impacting positively the carbon monoxide emissions per capita, but the GDP squared per capita and renewable energy consumption was affecting negatively CO_2 emissions per capita, confirming the EKC hypothesis in the panel data. However, for the individual data (country), the EKC may occur in any country, no matter if she is low income or high income country.

Boluk and Mert (2015) conducted a work about renewable energy, climate change and economic growth in the case of Turkey over the period of 1961-2010. They employed the procedure of ARDL for the variables of CO_2 emissions per capita, GDP per capita, GDP^2 per capita and electricity production from renewable energy per capita. They found that the coefficient of GDP and GDP^2 are positive and negative, respectively, which it means that the EKC hypothesis is accepted, even if the relationship between CO_2 and GDP does not valid the existence of the EKC hypothesis, while the sign of renewable energy was negative, which it means that the country is not depending yet on renewable energy.

Lin and Moubarak (2014) used the ARDL method and Granger causality to study the link between renewable energy consumption and economic growth in China over the period of 1977-2011. They employed Granger causality for the variables of renewable energy consumption, GDP, carbon dioxide emissions, and labour. They concluded that GDP per capita, CO_2 emissions and labour force have a positive relationship with the consumption of renewable energy and there's bidirectional between renewable energy consumption and economic growth.

Sebri and Salha (2014) explored the causal dynamics between economic growth, renewable energy consumption, CO_2 emissions and trade openness over five BRICS Countries during the period of 1971-2010. They employed ARDL and VECM methodology to study the variables of GDP, renewable energy consumption, carbon dioxide emissions and trade openness, and they indicated that the renewable energy consumption has a positive effect on economic growth and vice versa. They also concluded for the existence of the bidirectional relationship between economic growth and renewable energy consumption in 4 countries except for India.

Shahbaz et al. (2014) analysed the EKC hypothesis and the causal relationship between CO_2 emissions per capita, GDP per capita, energy consumption and trade openness in the case of Tunisia by using ARDL procedure and innovative accounting approach over the period of 1971-2010. They found an evidence of the EKC hypothesis between economic growth and CO_2 emissions. Also, the causal analysis reveals that the overall results point out that economic growth causes CO) emissions and energy consumption.

Farhani (2013) investigated the relationship between renewable energy consumption, economic growth and CO_2 emissions in the case of 12 MENA countries during the period of

1975-2008. He used the panel cointegration model and the causality test for the variables of GDP per capita, CO_2 emissions per capita, renewable energy consumption and he found that GDP have a significant impact on the renewable energy consumption in most of the countries except for Algeria, Cyprus, Jordan and Morocco, under both FMLOS and DOLS models. However, for the countries like Iran, Saudi Arabia, and Turkey, the impact of GDP on renewable energy consumption was negative and statistically significant at the 5% level. Moreover, he showed in the case of Iran, Jordan, Morocco, Syria, and Turkey that CO_2 emissions have a positive and statistically significant impact on renewable energy, while, for Sudan the impact was negative and statistically significant at the 5% level, under FMOLS model only. But, in the panel data, he found from both models that only CO_2 emissions elasticity is negative and significant at the 5% level, which means that with an increase in CO_2 emissions, the demand for renewable energy decreases. In the long-run, the carbon dioxide emissions elasticities were -2,281% and -2,236%, for both models. Consequently, these outcomes indicated that the most of these countries don't use renewable energy yet because the costs of its technology investment, which is very expensive and such government does not encourage economies to adopt cleaner technologies using renewable energy.

Sulaiman et al. (2013) explored the relationship between the environmental pollutant factors (GHG and CO_2 emissions), real (GDP) per capita, trade openness, renewable and fossil energy consumption by using the ARDL approach over the period of 1980-2009 in Malaysia. They concluded that the elasticity of CO_2 emissions with respect to electricity production from renewable sources was negative and statistically significant in both short and long-run. The Granger causality showed that there's bidirectional causality between economic growth and carbon dioxide emissions in the short and long-run and between electricity production from renewables and carbon dioxide emissions in the long-run only, suggesting an inverted U-shaped relationship.

Menegaki (2011) did a study about economic growth and renewable energy in 27 European countries during the period of 1997-2007. She used a panel data with a random effect model for the variables of real GDP per capita, the rate of renewable energy sources in gross inland energy consumption, final energy consumption, and greenhouse gas emissions in CO_2 equivalent and employment rate. She found that an increase by 1% in the share of renewable energy to the total supply mix will increase GDP by 4.4%, while a 1% increase in greenhouse gas emissions causes a 6.0% increase in GDP and a 1% increase in employment rate rises 4.9% in GDP. However, the final energy consumption was not significant with a coefficient close to zero, but the renewable energy source, greenhouse gas emissions and the employment rate were significant at the level of 5%. She also concluded that there's no causality between renewable energy consumption and economic growth (evidence of neutrality hypothesis).

Marques et al. (2010) conducted a work about the factors that may impact the use of renewable energy in 24 European countries for the period of 1990-2006. The variables were the contribution of renewable energy (or share) to total energy supply, carbon dioxide emissions per capita, energy consumption per capita, the contribution of fossil sources (coal, oil and natural gas) for electricity generation, the contribution of nuclear energy for electricity generation, the use of nuclear power demotivates the use of renewable energy security, GDP per capita, and the price of oil, coal and natural gas. They employed a fixed effect panel model, dynamic estimators with GMM-dif, GMM-sys and LSDV estimator. They provided an indication on the influence of lobbying exercised by the fossil energy sources in restraining the deployment of renewables, and they accepted the hypothesis of a negative relationship between the weight of the fossil sources for electricity generation and the use of renewable with LSDV estimator. They have also accepted the hypothesis that the nuclear source technology needs a large-scale use to substitute the other sources, and they suggested that the additional energy must be included to stimulate production of energy supply, especially from renewable energy sources.

Menyah and Rufael (2010) studied the link between CO_2 emissions, economic growth, nuclear and renewable energy in the case of the USA. They employed Toda-Yamamoto test for the variables of CO_2 emissions, real GDP, renewable and nuclear energy consumption during the period of 1960-2007. They found with Toda-Yamamoto causality that there are two unidirectional causalities. The 1st relationship was running from CO_2 emissions to renewable energy consumption, while the 2nd relationship was running from GDP to renewable energy consumption. They also found the bidirectional causality between GDP and CO_2 emissions and they concluded with generalized forecast error variance decomposition that the renewable energy consumption explains more than 19% of the forecast error variance of CO_2 emissions and GDP explains not more than 7% of the forecast error variance of CO_2 emissions.

Sadorsky (2009a) examined the renewable energy consumption per capita, CO_2 emissions per capita, real GDP per capita and real oil prices in the countries of the G7 over the period of 1980-2005, as a conclusion, he found with panel cointegration that an increase in oil price has a small and negative impact on renewable energy consumption. In the long term, an increase in real GDP per capita and carbon dioxide emissions per capita are established to be the key drivers behind per capita renewable energy consumption.

2. The Relationship between Human Development, Economic Growth, Energy and Pollution Factor and the Role of Energy Policy and the Government Institution (Institutional) on Renewable Energy Deployment:

2.1. Investigating the relationship between human development, economic growth, pollution factor and energy:

Wang et al. (2018) studied the link between renewable energy consumption, economic growth and human development process in Pakistan during the period of 1990-2014. They employed the Two-stage least square model (due to the problem of multicollinearity in OLS method), GMM and VECM Granger causality for the variables of CO_2 emissions per capita, GDP per capita, Human Development Index (HDI), renewable energy consumption per capita, trade and urbanisation. They found with 2SLS and GMM models that the sign of CO_2 emissions per capita was positive and significant at the level of 5%, while the coefficient of GDP per capita and trade were negative and significant at the level of 10%. However the other variables had a negative and insignificant effect on HDI and they concluded in the short-term that there’s unidirectional causality running from CO_2 emissions to HDI and from CO_2 emissions to renewable energy consumption, while there’s bidirectional causality between CO_2 emissions and GDP.

Zang et al. (2017) used the evaluation index of human welfare, and indicator system of sustainable development pressures with the Delphi method in The South China Sea Neighbouring countries, which include China, Cambodia, Vietnam, Thailand, the Philippines, Malaysia, Indonesia, Singapore and Brunei Darussalam covering the period of 2003-2015. The variables were human development index (HDI), land area per capita, forest coverage rate, food production index, fresh water per capita, urbanisation rate, mortality of Children under age 5, education investment rate, GNI per capita, car penetration rate, chemical fertilizer utilisation rate, particle emissions intensity, Co_2 emissions intensity, GDP/national land area, the national saving rate, fixed asset investment rate, energy and mineral consumption rate. They concluded that the HDI increased steadily, with an average annual growth rate between 0.29% and 2.50%. Singapore, Brunei Darussalam, Malaysia and Thailand were the top 4 countries ranked in descending order, whereas Cambodia always ranked in last place and also he sustainable development pressure was very high in these countries.

Grubaugh (2015) studied the relationship between HDI, GDP and other variables for 83 countries over the period of 1980-2010 and using six five-year intervals. He employed the dynamic panel estimation of Arellano and Bond (1998) for the variables of GDP growth per capita, GDP per capita, the population, the average growth rate of the population, fraction of population living in urban areas, exports plus imports (% of GDP), investment (% of GDP), government consumption (% of GDP), average investment price level, life expectancy at birth, index of political right (scale 1 to 7), index of civil liberties (scale of 1 to 7) and minimum kilometre from New York, Rotterdam or Tokyo. He found that the initial level of GDP, population, average population growth over the five-year periods and life expectancy are found to be statistically significant for both models (GDP and HDI). In the HDI growth model, the sign of GDP per capita and population was positive. However, the coefficient of life expectancy and the initial GDP were negative.

Lonska and Boronenko (2015) employed Pearson Correlation analysis and cluster analysis for 102 countries during the period of 2006-2012. They studied the variables of HDI and global competitiveness index, which is measured on a scale from 1 to 7. They concluded that the countries that have a faster growth of competitiveness have a swift expansion of their human capital develop (Pearson correlation was 0.364 and statistically accepted). However, those are not so called “developed” countries that take higher places in the competitiveness rating, but they do not show their ability to grow, or it occurs in every year for the “developed” countries, which they suffered from the sustainable loss of their competitiveness, and the tendency is typical of their human capital development.

Frugoli et al. (2015) explored the link between ecological, economic, energy and social indicators with a scatter plots method and the Spearman correlation coefficient for 106 countries during the year of 2002. They used the variables of renewable quantities, non-renewable, purchased resources, ecological footprint, surplus biocapacity, wellbeing index, environmental sustainability index, energy yield ratio, GDP, GDP per capita, HDI, democracy index, happiness index and life expectancy. They concluded from correlation coefficient that the GDP is inadequate for monitoring sustainable societal development. Also, none of the indices studies encompass all perspectives needed to guide societies to sustainable development and the combinations of biophysical and socioeconomic indices improve the information provided.

Roy et al. (2015) investigated the role of energy consumption on the human development index in 60 countries during the period of 1985-2011. They used the procedure of pooled regression, panel cointegration and Granger causality for the variables of the HDI, energy consumption and new HDI (with recalculation and incorporating the energy index along with other original indexes such as education, health and income). They found bidirectional causality between HDI and energy consumption. They established for the new HDI that all countries scoring 0.80 are considered as “high human development” countries. However, all countries scoring below 0.50 are considered as “low human development” countries. They revealed also that the development in energy consumption will lead to increase the Human Development Index especially for poorer and developing nations.

Kazar and Kazar (2014) investigated the relationship amongst human development (HD) and the total renewable electricity net generation value with Granger causality in 154 countries, which were divided into 5 groups (all countries, countries with very high HD, countries with high HD, countries with middle HD, countries with low HD). They were two periods of study, the 1st period was from 1980 to 2010 with 5 years data to analyse the long term effects and 2nd period was from 2005 to 2010. They found that the variable of renewable electricity is significant for all datasets except for countries with high HD in the model with long-run test. For the Granger causality, they showed that there’s no long-run relationship between RE and HD for a group of very high HD and low HD. Meanwhile, there was unidirectional causality running from HD to RE for a group of all countries, and high HD. However, they found bidirectional causality for the countries with middle HD, while for the 2nd period, they found in the short-run that the group of all countries, middle HD and low HD had a significant coefficient for their RE, but the other groups were insignificant. The Granger causality revealed that there was bidirectional causality for all countries, while there’s unidirectional causality running from HD to RE in the group of high HD, but for the group of middle HD, they found a unidirectional relationship running from RE to HDI and no causality for the rest.

Ouedraogo (2013) used the variables of the HDI, energy consumption per capita, electricity consumption per capita and international oil price as proxy of energy price to investigate the link between the social factor and the energy sector. She employed the panel cointegration and Granger causality for 15 developing countries during the period of 1988-2008. She confirmed the existence of panel cointegration between the variables and she found in the long-run that a 1% increase in per capita energy consumption may reduce the HDI by 0.08%, while a 1% rise in the energy price elasticity can decrease the HDI by around 0.11% and an increase by 1% in electricity consumption could increase HDI by 0.22%. However, in the short-run, the energy consumption and energy prices had a statistically positive impact on the HDI, whereas electricity consumption is statistically insignificant. It appeared that only the energy prices can determine the level of energy consumption not the level of development. However, neither the level of development nor the energy prices have a statistically significant impact on electricity consumption. She also established with the joint causality test that the energy consumption has a neutral effect on the HDI, while the coefficients of energy consumption and the HDI are significant at the level of 10% in the long-term, but they have a negative effect. The Granger causality showed an evidence of unidirectional causality running from energy consumption to HDI, confirming that a growing economy needs to diminish the level of energy consumption as production shifts toward less energy intensive service sectors or an inefficient energy supply.

Hafner and M-Foulkes (2013) employed the procedure of Westerlund (panel cointegration model) to study the link amongst economic, social and energy aspects in 72 countries. They used the variables of GDP per capita, HDI, fertility, electricity and energy consumption per capita, domestic credit shares and trade during the period of 1980 - 2007. They confirmed the cointegration long-run in the case of electricity for fertility and for the HDI, then they found with DOLS method that there is no long-run relationship with GDP as the dependent variable. However, they found an evidence of cointegration when energy was used as a proxy for technology or as urbanization with a constant and a trend included in the HDI equation. Relating to DOLS estimation, the coefficients of GDP, domestic credit shares and trade were positive and significant at the 1% level, but they were no impact of energy consumption on human development.

Pîrlogea (2012) studied the link between human development, renewable energy and CO_2 emissions by using a panel data analysis in six European countries over the period of 1997-2008. The variables were renewable energy and fossil fuel consumption, total population; gross inland renewable energy consumption per capita, energy intensity, CO_2 intensity, and Human Development Index. The HDI was the dependent variable for two regression equations, but in the 1st equation, she took the renewable energy and fossil fuel energy consumption as independent variables, while in the 2nd equation, she took the energy intensity and CO_2 intensity as independent variables. She found that the fossil fuel consumption had a negative impact on the HDI in Romania and Bulgaria, but, she found a positive impact in the countries with very high HDI. The renewable consumption had a positive impact on human development in the case of Poland and Ireland. Besides, in individual data, and in the most cases, the energy consumption has a positive relationship with the HDI, but when she included the energy intensity variable, the contribution was negative. She also concluded in the 2nd equation that the energy intensity had a negative effect on the HDI in 6 countries.

However, the CO_2 intensity had a negative impact on the HDI in Romania, Bulgaria and Poland, but it had a positive influence on the HDI in Portugal, Ireland and Netherlands.

Abraham and Ahmed (2011) conducted a study about economic growth and Human Development Index in the case of Nigeria during the period of 1975-2008 and they employed the ECM for the variables of GDP and HDI. They found that there is a significant difference between the average growth of the economy and the HDI and they also showed that there is a negative and insignificant short-run relationship between GDP and HDI. In the long-run, the coefficient was statistically accepted, suggesting that the policies aimed at accelerating growth would have a negative impact on human development in the short-run, but in the long-run, it will be re-established by HDI adjusting upwards or downward to correct the equilibrium error.

Steinberger and Roberts (2010) used several regressions based on energy, economic growth, human development, and carbon emissions in 156 countries during the period of 1975-2005. The variables were HDI, GDP per capita, primary energy supply per capita, total carbon emissions from fossil energy, gas flaring, cement manufacturing and population. They showed that for some selected stages of energy consumption, the HDI will increase over time and when HDI is attaining a high level of development, it will decrease the level of energy usage (especially fossil fuel). They also demonstrated that the dropping in the energy and carbon thresholds for growth will not automatically resolve the problem of climate change, energy supply and human development losses, but, it is only possible if the industrialized nations, which have high use of energy per capita and dioxide carbon emissions per capita will significantly moderate or diminish their consumption and emissions.

Martinez and Ebenhack (2008) did a comprehensive examination on 120 countries by using correlation matrix and they divided their study into an energy advantage nations and energy export nations. They employed the variables of Human Development Index (HDI) and per capita energy consumption and they found a strong relationship between these two variables for almost all datasets. They also found the same result in the poor countries as it's for the industrialized countries, which indicated that a high value of HDI are corresponding to greater energy consumption patterns. They concluded that the relationship amongst the HDI and energy access becomes certain as they speculated that some reasons for better performance in an energy-poor nations comprise quantities and kind of foreign aid, relatively stable governments and a considerable decrease in the fire-wood (biomass) use of primary energy.

2.2. The role of energy policy and the government institution on renewable energy deployment:

Verdolini et al. (2018) explored the importance of modern fossil-based power generation technologies in supporting renewable energy investment in 26 OECD countries between 1990 and 2013 with OLS panel fixed effects method. The dependent variables were the net installed electrical capacity in renewable energy technologies per capita and investment in renewable energy per capita. The independent variables were the capacity in modern fossil (gas and coal) per capita, the capacity in traditional fossil (gas and coal) per capita, the capacity in modern fossil (gas turbines and combined cycle) per capita, the capacity in traditional fossil (gas turbines and combined cycle) per capita, feed-in tariff (FIT), certificates, limits, tax, the OECD index capturing the level of entry barriers in the electricity market, growth rate of electricity consumption, GDP per capita, the share of nuclear capacity, share of hydro capacity, share of energy imports, and the share of fossil fuel rents in GDP and stock of knowledge in renewable energy (patent). They concluded that lowering entry barriers promotes the deployment of renewable energy capacity, and the certificate had a positive impact on the diffusion of RE capacity. They found that the capacity in modern fossil (gas and coal) per capita, (FIT) certificates had a positive and significant impact on the renewable energy deployment. However, the lowering entry barriers had a negative and significant impact on the renewable energy deployment. They showed also that countries where the capacity in modern fossil was available were more likely, to invest in renewable energy generation.

Nicolli and Tavoni (2017) examined the role of policy support for renewable electricity in 5 European countries during the period of 2000-2010. They used pooled OLS, pooled fixed and random effect for the variables of energy imports, fossil sources prices, CO_2 emissions per capita, energy consumption per capita, the contribution of fossil fuels to electricity generation, electricity price, % of GDP attributable to petroleum and coal products, market deregulation, total customers/green residential customers, utilities public ownership, GDP, GDP per capita, tax incentives and subsidies, unemployment rate, area, renewable source technical potential, population growth, EU 2011 directive, government/parliament political orientation, employees in natural resources governmental position per capita, the share of renewable energy of total primary energy supply, % of renewable energy of total energy capacity, renewable energy % of electricity generation, renewable energy generation, added capacity, growth in capacity, and installed capacity. They found that the coefficient attached to the amount of incentive, GDP per capita and the share of electricity from fossil sources were positive and significant on the incentivized renewable energy sources (total production and installed capacity), so they concluded a positive correlation between the subsidies and the production of incentivized energy, as well as the installed capacity, so an increase by 1% in the incentive (tariff) will rise the renewable generation by 0.4 to 1% (18-26%). They showed also that the (FIT) was outperforming tradable green certificate in this model and such policies have been effective in promoting renewable energy both in the short and in the long-run.

Nicolli and Vona (2016) studied different renewable energy policies and the impact of market regulation on innovation activity in several renewable energy technologies in 19 European countries over the period of 1980-2007. They employed the panel fixed-effect model for the variables of patents filed at the European Patent Office (EPO) in the eight sub-fields (wind, marine, solar thermal, solar photovoltaic, biofuels, hydroelectric, fuel from waste and geothermal), the technology-specific public research and development expenditure in the eight sub-fields, technology-specific feed-in tariff in the eight sub-fields, patent stock in the eight sub-fields, patent of global stock (the global capacity to innovate) in the eight sub-fields, average of households and industrial energy end use price, average of households and industrial electricity consumption, GDP per capita, product market regulation, Kyoto protocol and share of electricity covered by a tradable permit. They concluded that the policy support, stock of past knowledge, level of entry barriers and electricity prices were the main drivers of patenting in renewable energy technologies and they noticed that the wind and solar thermal technologies had the strongest potential as they may be beneficial for countries with appropriate natural conditions. They found also that the (FIT) was statistically significant and is associated with a positive coefficient only in the case of solar photovoltaic.

Ata (2016) analysed assessments of renewable energy policies over 27 European countries and 50 states of US during the period of 1990-2008. She analysed with panel procedure regression and fixed effect model the variables based on a ratio of renewable electricity capacity in total electricity supply from non-hydro renewable sources, the renewable energy policy instruments in use (FIT, quota, tender and tax), GDP, energy security (energy import), thermal consumption, nuclear consumption, electricity consumption, gas price, coal price, electricity import and carbon dioxide emissions. The results showed that the most variables have a significant sign on determinants of (RE) deployment capacity, but the traditional energy sources hadn’t any effect on (RE) capacity, while nuclear participation in the total energy generation had negative and significant relationships with (RE) deployment. The renewable promotion policies are being enacted due to powerful lobbying activities in traditional industries and the fossil based energy industry has been funding political campaigns in the world because politicians are mainly related to the current levels of wealth and quality of life. Fossil-based fuels have also been used as a strong Geo-strategic force in the military industry, employment, capital markets and economy in general.

Polzin et al. (2015) investigated the community policy contribution on cleaner energy investments for OECD countries over the period of 2003 - 2011. The data were investments (additions in renewable energy capacity) which include 5840 solar investments, 9643 wind investments and 2889 biomass and waste investments and policy indicators (Policy and Measures) which include 957 distinct policy measures. The variables were aggregate newly installed capacity and proxy for the deployment of a technology, active instances of policies affecting the renewable energy sector, technological progress, (GDP), (CO_2) intensity, electricity consumption, interest rate and share prices. They employed panel data regression with random effects/pooled OLS, fixed effects and panel-corrected standard error. They concluded that the fiscal and financial incentives were highlighted as an efficient policy because it directly influences the renewable energy projects. The (FIT) policy concerning wind and solar sector exposed a highly significant positive coefficient, but, the effect varies across sectors. In the solar sector, the (FIT) has a stronger impact than in the wind sector. They also showed that the grants and subventions prove to be effective as short term measures to alleviate finance constraints and they established that the Market-based incentive, which is mainly found on the presence of (GHG) emissions and its allowances, was found to have a stronger impact on the capacity financed by institutional investors than (FIT).

Oteman et al. (2014) worked on the effect of the institutional space of community initiatives on renewable energy. They showed the main characteristics that influence the energy structure and the renewable energy sector. They demonstrated that such renewable energy projects need a better management of political institutional dimension (application of FIT, renewable portfolio standards and other energy policy), legal institutional dimension (the respect of law and regulation of increasing in the share of renewable energy in the total energy supply) and economic institutional dimension (cost of technology implementation and profit from renewable energy production). They concluded from their analysis that the Netherlands has had a market-oriented arrangement, Germany was strongly stated-oriented and Denmark has had societies with more leading position.

Aguirre and Ibikunle (2014) worked on aspects that may adjust the renewable energy growth for 38 countries over the period of 1990-2010. They used fixed effect vector decomposition and panel corrected standard error on the variables of the contribution of renewables to energy supply, the R&D programmes (7 policies variables), the institutional variable in ratification of the Kyoto protocol, energy security (which is relying on energy imported), CO_2 emissions, prices of oil, natural gas, coal and electricity, GDP per capita, contribution of traditional energy sources for electricity generation, energy needs, potential for renewable energy, deregulation of the electricity market, and commitment to renewable energy in countries. They concluded that the CO_2 emissions, the commitment for renewable energy, Kyoto protocol, biomass and solar, were positive and statistically accepted, as they impact positively to introduction of renewable energy. The signs of nuclear participation in electricity generation, the fossil fuel, energy use, wind, industry, fiscal and financial policy and voluntary policy were negative and significant, so they effect negatively the level of renewable energy contribution, but, the rest of the variables were almost positive and insignificant, indicating in this case that their inclusion will maybe help to increase the level of renewable energy deployment.

Flora et al. (2014) did an investigation about renewable energy policies and the wind power capacity by using a panel data model in 18 European countries during the period of 1998-2011. The variables were ratio of unused output to the maximum possible output over a year, the total accumulated rate of renewable energy policies and measures, and yearly growth rate of wind installed capacity. They concluded that the effect from an installed capacity of hydro plants, ration of electricity generated from waste, population density and the total of the accumulated number of RE policies and measures are positive and statistically significant. In its turn, the coefficient of the ratio of electricity generated from solar energy wasn't statistically significant in explaining the ratio of non-used output to the maximum possible output over a year. However, GDP per capita, ratio of electricity generated by coal and gas and installed capacity of nuclear power are negative and statistically significant, although at different significance levels. They also established as expected, the results of the growth rate of wind installed capacity confirm that more installed capacity can increase the ratio of non-used output to the maximum possible output over a year renewable energy sources.

Bolkesjø et al. (2014) tested the effect of renewable energy support on renewable energy deployment with panel fixed-effect model. The variables were renewable energy capacity, share of return on an investment in renewable energy support scheme, incremental percentage requirement, binary tender, the share of nuclear, coal, gas, petroleum and renewable in the electricity, real (GDP) per capita, energy use per capita. The model was estimated during the period of 1990-2012 by using photovoltaic and wind technology, while over the period of 1990-2011 by using biomass technology. They found that the renewable portfolio standards

(RPS) have significantly positive result in the growth of bioenergy for power generation and the existence of tendering schemes has contributed to the expansion of onshore wind. The penetration of the different renewable energy technologies as well as the energy supply mix as a whole varies significantly in the different regions.

Jenner et al. (2013) employed two different dependent variables which were (RPS) Binary and incremental share indicator that represent the mandated increase in renewable generation. They used the method of maximum likelihood estimation and Tobit model for a panel data of 50 states in the USA during the period of 1998-2010. They found a statistically significant relationship between the contributions and the likelihood of a state to adopt a (RPS). However, in the short-term, the conventional energy interest groups contributions have a negative influence on the possibility of (RPS) adoption, whereas renewable energy interest group's contributions have a positive impact.

Zhang (2013) used OLS and GMM method to study the renewable energy policy in 35 European countries over the period 1991-2010. The variables were annual wind capacity additions, the total amount of wind electricity generation, (FIT) rate measured in euro cents/Kwh, (FIT) contract length, grid access and elasticity investment with respect to (FIT) incentives. He concluded that the coefficient associated with (FIT) rates is positive, but insignificant, implying that higher (FIT) rates do not necessarily lead to higher levels of wind installation. However, the countries with high remuneration levels may have a lack of the necessary institutional and regulatory environment to attract investment, and will fail to scale-up investment due to these non-economic barriers.

Marques and Fuinhas (2012) examined the renewable energy policy and the IEA nine polity-related variables which are education and outreach, financial, incentives/subsidies, policy processes, public investment, research and development (R&D), regulatory instruments, tradable permits and voluntary agreements. They employed the panel corrected standard errors in 24 European countries during the period of 1990-2007. They found that the CO_2 emissions per capita, import dependency of energy, importance of coal, oil, gas and nuclear to electricity had a negative and significant influence on renewable energy contribution, but the renewable energy policies and measures have a positive and statistically accepted impact on renewable energy deployment, indicating that such energy policy can encourage the introduction of renewable energy with a direct interventions from government and law, but it represents a risk of investment for the private firms and big companies.

Popp et al. (2011) tested the hypothesis that the technological progress can reduce the cost gap between renewable and traditional fossil fuel-based energy and making the former energy more attractive option in 26 OECD countries over the period of 1991 - 2004. They employed a descriptive statistic and regression method for the variables of renewable energy capacity, the Kyoto protocol, climate change policy, knowledge stocks, research and development cost, GDP per capita, purchasing power parity and the share of renewable energy in total energy production. They found that the knowledge stock, GDP per capita and Kyoto protocol had a positive and significant influence on investment per capita in energy capacity in the indicated renewable technology, but the signs of solar photovoltaic, geothermal technology and the growth in electricity were insignificant. However, the coefficient of % electricity production from nuclear and hydro were statistically accepted and negative.

Delmas and Sancho (2011) studied the policy effectiveness of renewable energy and climate change plans. They used two model, the renewable portfolio standard (RPS) over the period of 1997-2006 and the mandatory green power option (MGPO) over the period of 2001 - 2006 and they tested whatever the two hypotheses (RPS or MGPO are ineffective at increasing investments in renewable energy capacity or not). They employed two-stage modelling technique that allows determining simultaneously the adoption of (RPS) or (MGPO) in the binary logit model and they employed the predicted values of renewable policies to test the renewable capacity at the firm level. The variables used were disclosure, wind, solar and biomass resources, deregulation, and democratic governor. They concluded that the wind resources were positive and significant to predict (RPS) and (MGPO) at the level of 1% and 10%, respectively, while the sign of solar resources was positive and significant for (RPS) and negative for (MGPO), but, the coefficient of biomass resources was negative for both policies.

Johnston et al. (2010) examined the effect of policy variables on renewable energy technology using the number of patents as a proxy (public policy measures, electricity consumption, the cost of electricity production from renewable energy source, and electricity price). They applied the fixed-effect panel model over 25 OECD countries during the period of 1978-2003. The variables were patent application in each of the technological areas of renewable energy, policy application, research and development expenditures, electricity consumption and total EPO filings. They concluded with binominal fixed effects models with individual policy variables that the coefficients of electricity price (solar and biomass), specified R&D expenditure (except biomass), total EPO fillings (except ocean), investment incentive (solar and waste), tax measures (biomass and all renewables), tariff (biomass), voluntary programs (waste), obligations (wind and all renewables), and tradable certificates (wind and all renewables) were positive and significant on the patent count for successful and unsuccessful applications of renewable energy projects. They also showed with a binominal fixed effects model with clusters of policy variables that the coefficients had the same level of significance and were positive, the policy cluster 1 was positive and significant for solar, biomass, waste and all renewables, while the policy cluster 2 was positive and significant for waste only, and the policy cluster 3 was positive and significant for wind and all renewables. They likewise demonstrated with binominal fixed effects models with a composite policy variable that all coefficients had the same level of significant and were positive, but the composite policy variables were positive and significant for wind, solar, ocean, biomass, waste and all renewables.

Carley (2009) used the fixed effect vector decomposition (FEVD) model to study the application of energy policy (the adoption of the carbon mitigation and the renewable energy deployment) in 50 states of the USA over the period of 1998-2006. The variables were renewable portfolio standard (RPS), house LCV voting score, employees per capita on natural resources, % petrol/coal manufacturing, gross state product per capita, the growth rate of population, electricity use per capita, average retail electricity price, % regional (RPS), index of tax and subsidies, deregulated, wind, biomass and solar potential and share of renewable energy electrification in the electricity market. They concluded that the index of tax subsidies, deregulated, wind, biomass and solar potential had a negative and significant impact on the share of renewable energy electricity. She found also that the (RPS) operation is not considered as a good significant predictor for the proportion share of renewable energy generation out of the total generation mix. However, she said that the other nations who will apply this (RPS) policy in their system will have surely an increase in their share of renewable energy and may reduce their price of electricity produced by renewable energy.

Menz and Vachon (2006) studied the policy efficiency, which is designed to promote wind power generation in the USA by using the OLS method in 39 states during the period of 1998-2003. They used five different policies instruments, renewable portfolios standard (RPS), fuel generation disclosure requirement (FGS), mandatory green power option (MGPO), public benefit funding (PBF), and retail choice (RET). They found that the signs of (RPS), (MGPO) and policy implemented prior to 2003 were positive and significant, as they have a positive impact on policy implementation of wind power development. However, the public benefits funding was not a significant factor in the wind energy development which is responsible for the granting and loaning funds for these types of financial incentives on renewable energy projects.

3. The Causality amongst Renewable Energy, GDP and CO_2 Emissions and the Empirical Literature Reviews:

3.1. The link between renewable energy, GDP and CO_2 emissions:

The following table summarise different relationship and causality between several technologies of renewable energy consumption and production and economic growth or the economic factor of sustainable development (GDP and per capita GDP).

Table 03: Literature survey on renewable energy and economic growth

Study	Methodology	Causality results
Sadorsky (2009b)	Panel model	No causality between renewable energy consumption per capita and GDP per capita (income per capita).
Payne (2009)	Toda-Yamamoto causality	No causality (Neutrality hypothesis).
Apergis and Payne (2010b)	Panel model	Bidirectional causality (Feedback hypothesis).
Apergis and Payne (2010a)	Panel model	Bidirectional causality.
Apergis and Payne (2011a)	Panel model	Bidirectional causality.
Apergis and Payne (2011b)	Panel model	Unidirectional causality from (EG) to renewable electricity consumption; Bidirectional causality.
Tugcu et al. (2012)	Panel model The modified Wald test	Unidirectional causality running from (EG) to (RE); Bidirectional causality; No causality.
Bildirici (2013)	ARDL	Unidirectional causality (growth hypothesis) from biomass energy consumption to (EG); Bidirectional causality.
Mulali et al. (2013)	FMOLS	Bidirectional causality; Neutrality causality (no causality); Unidirectional causality from (EG) to (RE).
Koçak and Şarkgüneşi (2017)	Panel cointegration	Unidirectional causality running from (RE) to (EG), Bidirectional causality ; No causality.

Tugcu and Topcu (2018)	NARDL	Unidirectional causality from (EG) to (RE); Unidirectional causality from (RE) to (EG); No causality.
Adams et al. (2018)	FMOLS DOLS	No heterogeneous pairwise causality
Amri (2017b)	ARDL	Unidirectional causality from (RE) to (EG)
Armeanu et al. (2017)	Panel model	Unidirectional causality from (EG) to renewable energy production.
Kahia et al. (2017)	Panel VECM	Bidirectional causality
Amri (2017a)	two-step (GMM)	Bidirectional causality
Kahia et al. (2016)	FMOLS	Unidirectional causality from (RE) to (EG)
Chang et al. (2015)	Heterogeneous panel model	Unidirectional causality from (RE) to (EG).
Omri et al. (2015)	dynamic simultaneous-equation panel	Bidirectional causality Unidirectional causality from (RE) to (EG).
Bilgili and Ozturk (2015)	Panel model OLS DOLS	Unidirectional causality from biomass energy consumption (source of renewable energy) to (EG).
Solarin and Ozturk (2015)	panel VECM	Unidirectional causality running from hydroelectricity consumption to (EG); Bidirectional causality.
Bildirici (2014)	Panel ARDL FMOLS	Bidirectional causality between biomass energy consumption and (EG).
Pao et al. (2014)	Panel cointegration	Unidirectional causality running from (RE) to (EG); Bidirectional causality.
Aïssa et al. (2014)	Panel cointegration	No causality
Ocal and Arslan (2013)	ARDL Toda-Yamamoto	Unidirectional causality running from (EG) to (RE);
Pao and Fu	VECM	Bidirectional causality.

(2013)		
Yildirim et al. (2012)	Toda-Yamamoto and bootstrap-corrected causality	Unidirectional causality running from biomass-waste-derived to (EG) only; No causality for other (RE) forms.
Sebri and Ben-Salha (2014)	VECM ARDL	Bidirectional causality.

Source: done by the researchers

The 2nd table displays different causalities among environment, economy and energy factors and investigated if the Environment Kuznets Curve hypothesis was accepted or not.

Table 04: Summary of studies investigating association among economic growth, renewable energy and carbon dioxide emissions

Study	Method	EKC	Causal relationship
Menyah and Wolde-Rufael (2010)	Toda-Yamamoto causality	N/A	GDP $\leftrightarrow$ CO_2 GDP $\rightarrow$ RE CO_2 $\rightarrow$ RE
Menegaki (2011)	Panel model	N/A	No causality
Lotz and Dogan (2018)	Panel model Emirmahmutoglu-Kose causality	No	GDP $\leftrightarrow$ CO_2 CO_2 $\rightarrow$ REP (renewable energy production)
Apergis et al. (2018)	FMOLS DOLS	N/A	RE $\leftrightarrow$ CO_2 GDP $\rightarrow$ CO_2
Mbarek et al. (2018)	VECM	N/A	CO_2 $\leftrightarrow$ GDP GDP $\rightarrow$ RE
Solarin et al. (2017)	ARDL	Yes	GDP $\leftrightarrow$ CO_2 GDP $\leftrightarrow$ RE RE $\rightarrow$ CO_2
Shahbaz et al. (2017)	ARDL VECM	Yes	Biomass energy $\leftrightarrow$ CO_2 GDP $\rightarrow$ BE GDP $\rightarrow$ CO_2
Zoundi (2017)	Panel model	No	N/A
Paramati et al.	Panel	N/A	CO_2 $\rightarrow$ RE

(2017)	cointegration		
Dogan and Aslan (2017)	homogenous test of Pesaran and Yamagata	Yes	GDP ⟷ CO_2
Dogan and Ozturk (2017)	structural break of Gregory-Hansen ARDL	No	N/A
Mulali et al. (2016)	ARDL VECM	Yes	Several causalities between GDP, CO_2 and RE.
Shahbaz et al. (2016)	ARDL	Yes	N/A
Bilgili et al. (2016)	FMOLS DOLS	Yes	N/A
Boluk and Mert (2015)	ARDL	Yes	N/A
Shahbaz et al. (2014)	ARDL	Yes	N/A
Sulaiman et al. (2013)	ARDL	N/A	GDP ⟷ CO_2 REP ⟷ CO_2

Source: Done by the researchers.

3.2. The empirical literature reviews:

In our study, we shall use several econometrics and statistics tools to examine the relationship between the variables of economics, energy, social and environment factors. Therefore, we will start by transforming our exogenous variables into volatility series, after checking the long and the short memory process, and to see if they're affecting by an autoregressive fractional integrated moving average model (ARFIMA) or (ARMA) model, then investigating the existence of ARCH/GARCH effect or not, and to see if we will perform with the realized or the stochastic volatility.

3.2.1. Long memory process:

According to **Geweke and Porter-Hudak (1983)**, **Robinson and Henry (1998)** and **Write (2002)**, the long memory of time series is characterized by a slow rate of decay of the autocovariance function or long term persistence on their residual correlation. The autoregressive fractionally integrated moving average (ARFIMA) model is perfect to solve such time-series issues and which is composed of ARMA and a fractionally integrated of a coefficient (d). However, **Granger and Joyeux (1980)**, **Hosking (1981)**, and **Baillie (1996)** explored the conditions of time series variables which can be spuriously have a long memory when measured in terms of their fractional order of integration (ARFIMA model).

3.2.2. ARCH/GARCH effect:

Autoregressive Conditional Heteroscedasticity (ARCH) models are mainly designed to model and forecast conditional variances. The variance of the dependent variable is modelled as a function of past values of the dependent variable and independent or exogenous variables. The objective is to analyse the risk of holding an asset or the value of an option. Second, forecast confidence intervals may be time-varying, so that more accurate intervals can be obtained by modelling the variance of the errors. Third, more efficient estimators can be obtained if heteroscedasticity in the errors is handled properly.

This model was introduced by **Engle (1982)** who used the ARCH type models, then developed by **Bollerslev (1986)** who also worked on the GARCH models, and then **Ding et al. (1993)**, and **Baillie, Bollerslev and Mikkelsen (1996)** extended their investigation based on the ARCH family and FIGARCH model.

The ARCH/GARCH and the FIARCH/FIGARCH models are used to estimate the stochastic volatility series **Breidt et al. (1998)** and **Comte and Renault (1998)** proposed a long memory in stochastic volatility model. However, if there’s no ARCH effect in time-series, we will perform the realized volatility series, which was examined and used in the studies of **Anderson et al. (2003)** and **Koopman et al. (2005)**.

3.2.3. The causality model:

After transforming the exogenous variables into stochastic volatile series (variation) with ARCH/GARCH or FIARCH/FIGARCH effect or into realized volatile series, we shall perform different causality models of (k) variables (multivariate models). The most econometric model used in renewable energy are the causality and time-series model, which we shall study the impact in the short-run with vector autoregressive (VAR), and in the long-run effect with structured vector autoregressive model (SVAR) model. We also can perform the models that investigate the short and long-run with the error correction model (ECM) and the vector error correction model (VECM) when the variables have the same order of integration and are cointegrated or the autoregressive distributed lags (ARDL) model, when the variables have not the same order of integration and are cointegrated.

Before working with such models, we shall perform the unit root test to see if the variables are stationary or not with the Augmented Dickey-Fuller test **(ADF, 1981)** and Phillips-Perron test **(PP, 1988)** which can identify if the variables are accepted in time-series models or not.

The non-stationary variables can be affected by differency stationary, a deterministic trend or stochastic trend stationary. After checking the order of integration, we shall examine the number of lags that should be included in autoregressive model with Lag Length Criteria as Akaike information criterion **(Akaike, 1973)**, Schwarz Information criterion **(Schwarz, 1978)**, and Hannan-Quinn information criterion **(Hannan and Quinn, 1979)**.

The next step is to verify if there's a cointegration relationship between variables or not. **Granger (1981)** proposed for the 1st time the cointegration theory and it has been developed later by **Engle and Granger (1987)** who introduced the error correction model for 2 series (only) that have the same order of integration and are cointegrated, **Phillips and Hansen (1990)**, and **Johansen (1988, 1991)** proposed the vector error correction model (VECM) for more than 2 series, which are stationary with the same order I(p), but, if the variables haven't the same order of integration, especially in the case when we have a variable with I(0) and another one with I(1). We will use the ARDL procedure developed by **Pesaran and Shin (1995)** who spoke about the case where there are multiple cointegration relations among the variables on the level I(0), and which it presents an additional difficulty, as they developed the bound testing procedure to cointegration within an ARDL model. **Pesaran and Pesaran (1997)** worked with Microfit 4.0 and developed the autoregressive distributed lags, and **Pesaran et al. (2001)** introduced the bound testing approaches to the analysis of level relationship between the disaggregated energy data and industrial production, **Soytas and Sari (2003)**, **Rufael (2004)**, and **Sari et al. (2008)** highlighted the importance of ARDL method, as they utilized in disaggregated data and studying the relationship between the energy sector and the factors of production.

However, if the variables are integrated in the 2nd difference or haven't the cointegration relationship, we will make the (VAR) and (SVAR) model, which were developed for the 1st time by **Granger (1966)** and **Nelson and Plosser (1982)** who demonstrated that the financial and macroeconomic series can be almost non-stationary, and can be performed with autoregressive models. **Lippi and Reichlin (1993)** and **Cooley and Dwyer (1998)** found that the VAR model with weak lags can provide a bad interpretation on the dynamic coefficients. The structured vector autoregressive was also displayed by many researchers like **Shapiro and Watson (1988)**, and **Blanchard and Quah (1989)** who identified the structured chock and the long-term restrictions, **Gali (1999)** used the SVAR to investigate the impact of increasing technology on work hours, and adapt this model to measure the effect of technologies chocks on disaggregated variables, **Blanchard and Perotti (2002)**, and **Perotti**

(2002) employed the SVAR model on the efficiency of the budgetary policy, and the evaluation on the dynamic effect on macroeconomic variables (GDP).

The causality test was developed by **Granger (1969)** and **Toda-Yamamoto (1995)** who developed an alternative test (as an augmenter Granger causality) to study the long-run relationship amongst the variables, which haven't the same order of integration, irrespective of whether series are integer (0) or I(1) or I(2), non-cointegrated or cointegrated of an arbitrary order, and this procedure can provide the possibility of testing for causality between integrated variables.

3.2.4. The GMM model:

The simplest and the most common estimation method for the simultaneous equations model is the so-called two-stage least square method (2SLS). This method was introduced more or less independently by **Theil (1953a; 1953b; 1961)**, **Basmann (1957)** and **Sargan (1958)** who used in the case of data with small sample size and to resolve the problem of multicollinearity with various macroeconomic variables that are very high correlated. M. Arellano and S. Bond (1991) proposed the Generalized Method of Moments (GMM) estimator and it's paying particular attention to issues of weighting matrix estimation and coefficient covariance calculation.

Conclusion of Chapter:

In this chapter, we reviewed several studies about energy consumption (renewables, fossil and nuclear consumption), economic growth (GDP) or economic factor of sustainable development (per capita GDP), pollution factor (GHG and CO_2 emissions), social indicator (HDI) and examined the impact of different energy policy (Feed-in Tariff, tax, market of carbon) and the government institution (institutional) on the introduction of renewable energy.

The relationship between the energy sector and economic growth has been examined in many ways by using different methodologies to study the energy-economic growth nexus. The most econometric method was used is panel cointegration, vector error correction model and autoregressive distributed lags in the panel data and time series data (individual). The works of **Adams et al. (2018)**, **Silva et al. (2018)**, and **Ozturk and Bilgili (2015)** for example, they studied the datasets of Sub-Sahara countries and they found with their methods that there's a positive influence of renewable energy on economic growth, while, per capita GDP had also a positive effect on renewable energy. In relation, we reviewed different research papers and they employed almost the same control variables like the primary energy consumption, non-renewable energy consumption (especially fossil fuel), employment (labour force), gross fixed capital formation as a factor of capital, trade openness (Import and export), and R&D expenditure.

The link among environment factor and other sectors was highlighted by many researchers who tested mainly the (EKC) hypothesis, which it was confirmed by **Solarin et al. (2017)**, **Shahbaz et al. (2017)**, **Dogan and Aslan (2017)**, **Mulali et al. (2016)**, **Shahbaz et al. (2016)**, **Bilgili et al. (2016)**, and **Boluk and Mert (2015)**. Such papers found different causality and impact between the variables of CO_2 emissions or per capita CO_2 emissions, GDP or per capita GDP and renewable energy. However, they used practically the same control variables primary energy consumption and production, fossil energy consumption and production, nuclear energy consumption and production, GDP squared, population, the policy and institutional variables (Kyoto, Paris agreement, and the sustainable development goals).

Moreover, the sustainable development goals are mainly focused on economics, environment and social sectors. Consequently, we can't achieve the sustainable development without improving the life condition of population and the well-being of people around the world. **Frugoli et al. (2015)**, **Roy et al. (2015)**, **Grubaugh (2015)**, **Kazar and Kazar (2014)**, and **Pirlogea (2012)** demonstrated that an improvement in the economic and in the environment sectors and the increase of energy consumption (renewables and nonrenewables) can boost the human development. The researchers applied in their model several control variables such as the energy use, energy intensity, population, and CO_2 intensity.

Furthermore, we also examined the role of policy and government on the introduction of renewable energy. **Verdolini et al. (2018)**, **Nicolli and Tavoni (2017)**, **Nicolli and Vona (2016)**, **Ata (2016)** and **Polzin et al. (2015)** for example, we found that the support policy (FIT, certificate, the solar and wind technology facility, quota, tender, tax, grants, subvention, market based incentive, and financial and fiscal incentives) may have a positive influence on the renewable energy deployment. In relation, they involved nearly the same control variables GDP or per capita GDP, population, institutional index, energy use, CO_2 emissions, Kyoto protocol, and Paris agreement.

In a net of the shell, we defined the empirical literature reviews with some econometric and statistical method that are the most used in this domain and they will be involved in the next chapter. Therefore, we shall make 4 fields of study based on the investigation the relationship between economics, energy, environment, social sector, energy policy and the role of the government institution in Algeria during the period of 1995-2016.

Chapter 3:

The Effect of Renewable Energy on Sustainable Development Factors in Algeria

Chapter 3: The Effect of Renewable Energy on Sustainable Development Factors in Algeria

Introduction:

Algeria is considered as one of the major exporters and producer of oil and natural gas in Africa and in the World. This country is mainly depending on two main energy sources, which are oil and natural gas. However, such energies are limited, and it won't support the energy demand and the safety of the environment in the long-term. Therefore, it forces the country to look after renewable energy programs, especially with the difficulty to include shale gas in the energy system and the increase of greenhouse gas from fossil-fuel production.

Moreover, Algeria has applied several incentive programs to hasten the renewable energy deployment and to diversify its energy sector. The recent energy policy is made to support, especially the research and development of renewable technologies and the introduction of several plans that can offer lower risks for private shareholders that want to associate and introduce the renewable sources in the economy and energy system.

On the other hand, the definition of sustainability means that a system's social, economic, and natural capital should be preserved for the future generations. This assumes that the sustainable development will lead to the harmonious socio-economic development that does not place unacceptably high levels of pressure on the resources and the environment. According to the several researchers, the introduction of renewable energy in any country is required to reach the sustainable development goals defined by the UNDP.

In the light of this statement, we shall use several econometric and statistic tools to examine the renewable energy influence on sustainable development factors and to investigate the role of energy policy and the institutional on the deployment of renewables in Algeria. The aim is to adopt the term of "Sustainable Development" and introduce the renewable energy in the Algerian energy system.

1. Data and descriptive statistics:

1.1. Definition of the variables:

The following table displays all variables used in this study over the period 1995-2016 in Algeria:

Table 05: The variables description

Variables	Unites	Source of Data
FEC : Fossil energy consumption	Million tonne equivalent of petrol	Bp database (British Petroleum) and International Energy Agency (IEA)
FEP: Fossil energy production	Million tonne equivalent of petrol	Bp database and IEA
REC: Renewable energy consumption	Million tonne equivalent of petrol	Bp database
REP: Renewable energy production	Million tonne equivalent of petrol	OECD database
CREES: contribution of renewable energy to total energy supply	Percentage (%)	OECD database
CO_2 : Dioxide carbon emission	Million tonne carbon dioxide	Bp database
GDP: Gross domestic product	Current US $	World Bank database
GDP^2: Gross domestic product square	Current US $	Created with using World Bank database
GFCF: Gross fixed capital formation	Current US $	World Bank database
Population	Total of population	World Bank database
Trade: External balance on goods and services	Current US $	World Bank database
LF: Labour force	Total of employment	World Bank database
EU: Energy use	kg of oil equivalent per $1,000 GDP (constant 2011 PPP)	World Bank database
HDI: Human Development Index	Indices on the scale of 0 to 1	UNDP database (United Nation for Development program)
IV: Institutional overall score	Indices on the scale of 0	Heritage database

	to 100	(http://www.heritage.org/index/country/canada)
Kyoto: Kyoto protocol	Dummy variable	In 1997 and in 2005
Paris: Paris Agreement	Dummy variable	In 2015
REP: Renewable Energy Policies	accumulated number of renewable energy policies and measures	IEA
EI: Economic Instruments	accumulated number of economic instruments	IEA
PS: Policy Support	accumulated number of policy support	IEA
RI: Regulatory Instruments	accumulated number of regulatory instrument	IEA

Source: made by the researchers

The 2nd table reveals the accumulated number of renewable energy policies and measures in Algeria from International Energy Agency (IEA) Global RE Policies and Measures (http://www.iea.org/policiesandmeasures/renewableenergy/)

Table 06: The renewable energy policies and measures in Algeria

Title	Year	Policy Type	Policy Target
Renewable Energy and Energy Efficiency Development Plan 2015-2030	2015	Policy Support	Wind, Solar, Geothermal, Bioenergy
Feed-in tariff for solar PV installations	2014	Economic Instruments	Solar Photovoltaic
Renewable Energy and Energy Efficiency Development Plan 2011-2030	2011	Policy Support	Solar Photovoltaic, Solar Thermal
Renewable energy National Fund	2009	Policy Support	Multiple RE Sources
Law 04-92 on the Diversification of Power Generation Costs (REFIT)	2004	Economic Instruments	Multiple RE Sources
Law 04-90 on Renewable Energy	2004	Regulatory	Bioenergy, Biomass,

Promotion in the Framework of Sustainable Development		Instruments	Geothermal, Hydropower, Solar
Law 99-09 on the Management of Energy	1999	Policy Support	Multiple RE Sources

Source: International Energy Agency

1.2. Descriptive statistics:

In the following table, we shall define some statistical data of all variables used in this study, (LN) means natural logarithm and (RV) signifies realized volatility.

Table 07: Stats table

Variables	Mean	Median	Maximum	Minimum	Sum
LNGDP	7.970	8.094	8.624	7.275	175.341
Per capita GDP	3246.968	3282.366	5564.826	1444.908	71433.29
RVGDP	-0.0001	0.0001	0.0058	-0.0057	-0.004
LNREC	-20.464	-20.322	-19.394	-21.678	-450.224
Per capita REC	$1.50*10^{-9}$	$1.49*10^{-9}$	$3.77*10^{-9}$	$3.85*10^{-10}$	$3.31*10^{-8}$
RVREC	-0.0016	0.004	0.086	-0.087	-0.035
LNCO_2	-12.867	-12.911	-12.585	-13.065	-283.078
Per capita CO_2	$2.61*10^{-6}$	$2.47*10^{-6}$	$3.42*10^{-6}$	$2.12*10^{-6}$	$5.74*10^{-5}$
RVCO_2	$7.37*10^{-5}$	0.0002	0.001	-0.002	0.0016
HDI	0.684	0.688	0.747	0.600	15.063
LNHDI	-0.381	-0.373	-0.291	-0.510	-8.386
Per capita GDP^2	$4.12*10^{19}$	$2.71*10^{19}$	$1.17*10^{20}$	$6.03*10^{13}$	$9.05*10^{20}$
$RVGDP^2$	$3.36*10^{-14}$	64.356	64.538	-1337.660	$8.81*10^{-13}$
Per capita FEC	$1.05*10^{-6}$	$9.88*10^{-7}$	$1.38*10^{-6}$	$8.60*10^{-7}$	$2.30*10^{-5}$
RVFEC	$7.32*10^{-5}$	0.0003	0.0017	-0.0022	0.0016
Per capita FEP	$4.28*10^{-6}$	$4.25*10^{-6}$	$4.98*10^{-6}$	$3.60*10^{-6}$	$9.42*10^{-5}$
RVFEP	-0.0001	0.0002	0.0021	-0.002	-0.0023
Per capita REP	$2.02*10^{-9}$	$1.89*10^{-9}$	$3.58*10^{-9}$	$7.12*10^{-10}$	$4.45*10^{-8}$
RVREP	0.0002	0.0006	0.019	-0.022	0.004
Per capita GFCF	1004.342	748.053	2012.483	363.302	22095.53
RVGFCF	0.0001	$3.97*10^{-5}$	0.0040	-0.0037	0.0038
Per capita LF	0.297	0.302	0.314	0.268	6.543
RVLF	$-5.29*10^{-5}$	$-4.53*10^{-5}$	0.0004	-0.0003	-0.0011

Per capita Trade	257.341	214.718	944.858	-546.549	5661.502
RVTrade	$1.19*10^{-16}$	-0.303	5.107	-0.618	$3.22*10^{-15}$
Per capita EU	$2.58*10^{-6}$	$2.50*10^{-6}$	$3.12*10^{-6}$	$2.37*10^{-6}$	$5.68*10^{-5}$
RVEU	-0.0001	0.0001	0.0016	-0.0041	-0.0024
CREES	0.213	0.220	0.370	0.050	4.690
Kyoto	0.091	0	1	0	2
Paris	0.045	0	1	0	1
IV	54.695	55.55	61	48.900	1203.300
EI	0.091	0	1	0	2
PS	0.181	0	1	0	4
RI	0.045	0	1	0	1
REP	0.318	0	2	0	7

Source: Made on Eviews 9.

The above table aims at demonstrating the difference between realized volatility variables, which are considered as permanent exogenous variables and natural logarithm or per capita variables which are employed as permanent endogenous variables.

2. Models and methodology:

2.1. Models:

2.1.1. Economic growth-renewable energy consumption model:

The specific model is derived from several literatures as **Adams et al. (2018)**, **Silva et al. (2018)**, and **Tugcu and Topcu (2018)**…etc. The variables of GDP and REC variables are transformed into natural logarithm specification, because the coefficient on the natural-log scare is directly interpretable as approximate proportional differences and as elasticity. This transformation has provided us with the following benefits, problems related to dynamic qualifications of the data set are avoided log-linear specification and it gives more consistent and efficient empirical results. We can display the model as following:

$$LNGDP_t = \text{c} + \sum_{i=1}^{p} a_{1\text{i}} * LNGDP_{t-i} + b_1 LNREC_t + \sum_{i=1}^{p} c_{1\text{i}} * LNREC_{t-i} + d_1 RVFEC_t + e_1 RVGFCF_t + f_1 \text{RVLF}_t + g_1 \text{RVTrade}_t + \varepsilon_{t1} \quad \text{(1)}$$

$$LNREC_t = \text{c} + \sum_{i=1}^{p} a_{2\text{i}} * LNREC_{t-i} + b_2 LNGDP_t + \sum_{i=1}^{p} c_{2\text{i}} * LNGDP_{t-i} + d_2 RVFEC_t + e_2 RVGFCF_t + f_2 \text{RVLF}_t + g_2 \text{RVTrade}_t + \varepsilon_{t2} \quad \text{(2)}$$

LNGDP: represents the economic variable in Algeria that designs the economic growth or the economic factor of sustainable development, because it takes into consideration the population over time (t).

C: is the constant variable that represents all variables, which are not defined, and it can replace the variables of government expenditure, the cost of the implementation of renewable energy, or the level of technology introduced…etc.

LNREC: designs the variable of renewable energy consumption in Algeria, especially the consumption of solar photovoltaic, hydropower and geothermal over time (t).

RVFEC: is the 1st control variable and it characterizes the realized volatility of fossil energy consumption in Algeria over time (t). We can also find in many studies that there's a close relationship between this variable and GDP, as it represents the main energy for the industrial development and technological advancement.

RVGFCF: is the 2nd control variable and it symbolizes the realized volatility of gross fixed capital formation in Algeria over time (t). It measures the value of acquisitions of new or existing fixed assets by the business sector, governments and households. It also shows how much of the new value added in the economy is invested rather than consumed.

RVLF: is the 3rd control variable and it describes the realized volatility of labour force in Algeria over time (t). It comprises people ages 15 and older who supply labour for the production of goods and services.

RVTrade: is the 4th control variable and it represents the realized volatility of the external balance on goods and services (imported and exported) in Algeria over time (t). It equals exports of goods and services minus imports of goods and services.

$\boldsymbol{\varepsilon_t}$: defines the error term (the specification error), and it's used to test whatever the model is well specified (statistically accepted) or not.

2.1.2. Carbon dioxide emissions-economic growth-renewable energy consumption model:

The defined model is derived from several literatures like **Lotz and Dogan (2018)**, **Apergis et al. (2018)** and **Mbarek et al. (2018)**…etc. We shall use the variables of per capita CO_2 emissions, per capita GDP and per capita REC in linear form, because it gives us consistent and efficient empirical results.

Also, the majority of the researchers and literatures in this domain follow a quadratic model with the inclusion of GDP^2 variable to verify the validity of the Environment Kuznets Curve hypothesis. The model can be written as follow:

$$GDP_t = a_1 + \sum_{i=1}^{p} b_{1i}\, GDP_{t-1} + \sum_{i=1}^{p} c_{1i}\, CO2_{t-1} + \sum_{i=1}^{p} d_{1i}\, REC_{t-1} + e_1 RVGDP^2{}_t + f_1 RVREP_t + g_1 RVFEP_t + h_1 RVFEC_t + j_1 \text{Kyoto}_t + k_1 \text{Paris}_t + \varepsilon_{t1} \quad (3)$$

$$CO2_t = a_2 + \sum_{i=1}^{p} b_{2i}\, GDP_{t-1} + \sum_{i=1}^{p} c_{2i}\, CO2_{t-1} + \sum_{i=1}^{p} d_{2i}\, REC_{t-1} + e_2 RVGDP^2{}_t + f_2 RVREP_t + g_2 RVFEP_t + h_2 RVFEC_t + j_2 \text{Kyoto}_t + k_2 \text{Paris}_t + \varepsilon_{t2} \quad (4)$$

$$REC_t = a_3 + \sum_{i=1}^{p} b_{3i}\, GDP_{t-1} + \sum_{i=1}^{p} c_{3i}\, CO2_{t-1} + \sum_{i=1}^{p} d_{3i}\, REC_{t-1} + e_3 RVGDP^2{}_t + f_3 RVREP_t + g_3 RVFEP_t + h_3 RVFEC_t + j_3 \text{Kyoto}_t + k_3 \text{Paris}_t + \varepsilon_{t3} \quad (5)$$

$\mathbf{a_1}$, $\mathbf{a_2}$ and $\mathbf{a_3}$: are the intercept of each equation and they define the variables that are not included in the equation system like the number of cars, fuel consumption and the level of technology introduced, which can have an influence on dioxide carbon…etc.

GDP: represents the economic variable in Algeria that designs the economic growth.

$\mathbf{CO_2}$: indicates the level of dioxide carbon emissions and it represents the factors of pollution, which is emitted by from the industrial sector and fossil fuel energy.

REC: designs the variable of renewable energy consumption in Algeria.

$\mathbf{RVGDP^2}$: is the gross domestic production square or the income square. This variable is used to show the difference in the partial effect of real production on carbon emissions and to verify the validity of the Environment Kuznets Curve hypothesis.

RVREP and **RVFEP**: are the realized volatility of the fossil and the renewable energy production. Both variables have a close relationship with the increase or the decrease of the dioxide carbon emissions.

RVFEC: characterizes the realized volatility of fossil energy consumption in Algeria over time (t).

Kyoto and **Paris**: are the dummy variables that represent the Summit of Kyoto in 1997and in 2005, while the Paris climate conference was in 2015.

$\boldsymbol{\varepsilon_{t1}}, \boldsymbol{\varepsilon_{t2}},$ and $\boldsymbol{\varepsilon_{t3}}$: define the error term in the equation system and they also represent the innovation or the shock term that can be used to study the impulse responses.

2.1.3. Human Development Index-carbon dioxide emissions-economic growth-renewable energy consumption model:

The particular model is imitated from several literatures as **Wang et al. (2018)**, **Frugoli et al. (2015)**, and **Pîrlogea (2012)** …etc. The variables of HDI, GDP, REC and CO_2 are transformed into natural logarithm specification. However, in this model, we shall develop system VAR and study only the HDI variable as endogenous in the short-run, and then we shall make the GMM system to study the model in the long-run. The VAR model is described as follow:

$$LNHDI_t = a_1 + \sum_{i=1}^{p} b_{1i}\, LNHDI_{t-1} + \sum_{i=1}^{p} c_{1i}\, LNGDP_{t-1} + \sum_{i=1}^{p} d_{1i}\, LNREC_{t-1} + \sum_{i=1}^{p} e_{1i}\, LNCO2_{t-1} + v_{t1} \quad (6)$$

The (**LNHDI**) measures the average achievement in Algeria in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth;
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weight);
- A decent standard of living, as measured by gross domestic product (GDP) per capita at PPP (purchasing power parity) in USD.

a_1: is the intercept that represents all variables, which are not introduced in this model such as the ecological footprint, the fertility rate…etc.

The rest of the variables are determined in the previous models.

Due to the high level of endogeneity of GDP, CO_2 and REC, we shall develop the non-linear GMM specification with estimating weighting matrix of two-stage least squares and to estimate the long-run coefficient between LNHDI and the rest of the variables. The GMM equation can be written as following:

$$LNHDI_t = \beta_1 + \beta_2 LNGDP_t + \beta_3 LNCO2_t + \beta_4 LNREC_t + v_{t2} \quad (7)$$

v_{t1} and v_{t2} are the error term of each equation in the short and long-term, respectively.

2.1.4. The renewable energy deployment model:

The actual model is derived from several studies of **Verdolini et al. (2018)**, **Nicolli and Tavoni (2017)**, **Ata (2016)**…etc. All variables involved in this model are taken as a dummy and index variable, except the RVGDP, $RVCO_2$ and RVEU, which are transforming into realized volatility variables. However, in such specification, we can't study the causality model because it gives us a bias coefficient and an instability relationship between such variables, so we shall estimate 3 equations with a classical OLS model as following:

$$CREES_t = c + a_1 IV_t + a_2 \mathrm{EI}_t + a_3 PS_t + a_4 RI_t + a_5 \mathrm{Kyoto}_t + a_6 \mathrm{Paris}_t + a_7 RVGDP_t + a_8 \mathrm{RVCO2}_t + a_9 RVEU_t + \varepsilon_{t1} \quad (8)$$

$$CREES_t = c + a_1 \mathrm{EI}_t + a_2 PS_t + a_3 RI_t + a_4 \mathrm{Kyoto}_t + a_5 \mathrm{Paris}_t + a_6 RVGDP_t + a_7 \mathrm{RVCO2}_t + a_8 RVEU_t + \varepsilon_{t2} \quad (9)$$

$$CREES_t = c + a_1 IV_t + a_2 REP_t + a_3 \mathrm{Kyoto}_t + a_4 \mathrm{Paris}_t + a_5 RVGDP_t + a_6 \mathrm{RVCO2}_t + a_7 RVEU_t + \varepsilon_{t3} \quad (10)$$

CREES: designs the contribution of renewable energy by percentage to energy supply as it can be considered as the renewable energy deployment or the level of renewable energy introduction in Algeria.

IV: represents the index of political, law and economic score. Also, it can measure the level of corruption, the application of law, such as decision making procedures, control mechanism, a division of materiel resource and availability of investors and long-term strategy like subventions, flexibility, priority for sustainability areas, development support, formal rules. (This variable is derived from the study of **Oteman et al., 2014**).

C: is the intercept term that represents all variables, which are not included, such as the research and development expenditure, level of renewable energy technology included and expected profitability or investor…etc.

Kyoto and **Paris**: are defined previously.

EI: defined the accumulated number of economic instruments used for renewable energy deployment and it represents the Feed-in tariff, financial and fiscal support…etc.

PS: is the accumulated number of policy support used for renewable energy deployment and it represents the long-term strategy for energy diversification, creation of institutional and firms based on renewable energy…etc.

RI: represents the accumulated number of regulatory instruments used for renewable energy deployment and it represents the application of laws and objectives of sustainable development and renewable energy…etc.

RVGDP: defined the realized volatility of gross domestic product and the level of income in Algeria.

RVCO_2: represents the realized volatility of carbon dioxide emissions and the factor of pollution.

RVEU: is the realized volatility of energy use and it defines to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus export and fuels supplied to ships and aircraft engaged in international transport. (**World Bank**).

REP: groups the accumulated number of economic instruments, policy support and regulatory instruments used for renewable energy deployment in one variable.

2.2. Methodology:

2.2.1. Economic growth-renewable energy consumption model:

We started our procedure by transforming the control variables into volatile series as they can be interpreted as variation change or rated coefficients. Then, in the time-series models, we usually employ the unit root procedure and cointegration test, to verify if such series can be estimated with Vector Autoregressive model (VAR), Vector Error Correction model (VECM), or Autoregressive Distributed Lags model (ARDL). Subsequently, we shall select the perfect model according to unit root and cointegration tests.

Therefore, we tested the unit root with Phillips-Perron and Augmented Dickey-Fuller, by making two hypotheses as following:

H_0 (null hypothesis): the series has a unit root;

H_1 (alternative hypothesis): the series has not a unit root;

The unit root test will be done on 3 models:

$$\Delta x_t = \partial x_{t-1} - \sum_{j=2}^{p} \omega_j \, \Delta x_{t-j+1} + \varepsilon_t \quad (11)$$

$$\Delta x_t = \partial x_{t-1} - \sum_{j=2}^{p} \omega_j \, \Delta x_{t-j+1} + c + \varepsilon_t \quad (12)$$

$$\Delta x_t = \partial x_{t-1} - \sum_{j=2}^{p} \omega_j \, \Delta x_{t-j+1} + c + b * trend + \varepsilon_t \quad (13)$$

In this study, we selected four lag (p=4) for the Schwarz Info Criterion, Bartlett Kernel as the spectral estimation method and the Newey-West Bandwidth.

We found that both LNGDP and LNREC were stationary with differency stationary, so they have the same order of integration I (1), and we found for the control variables that they're obvious stationary on level (because they're realized volatility).

According to this outcome, we can perform the cointegration test of Johansen and the bound test of Pesaran, after checking the lag length criteria with VAR estimation. Therefore, we concluded that the optimal model is defined with two lag (p=2), so we shall take (p=1) for Johansen cointegration test in Eviews 9 and it works by exclusion of alternative hypothesis as following:

H_0: r = 0; then H_0: r = 1; then H_0: r = 2; then H_0: r = k-1.

H_1: r > 0; then H_1: r > 1; then H_1: r > 2; then H_1: r = k.

According to the Johansen test, we found that there's a cointegration relationship between LNGDP and LNREC in the 3rd cointegration test specification (with intercept in the short and long-run).

However, the sign of long-run equilibrium was not significant and the VECM model was not statistically accepted. Consequently, we can't accept this model specification. Thus, we need to check again with the bound test of Pesaran to confirm if there's the long-run relationship with ARDL model or not.

We shall develop the bound test with the unrestricted intercept and no trend model, after taking two lag as the optimal model from VAR estimation. We can write the hypotheses of the bound test as following:

H_0: no long-run relationships exist between variables;

H_1: The existence of long-run relationships exists between variables.

We concluded from the test for the existence of long-run relationships between LNGDP and LNREC, and we confirmed this relationship with the long-run equilibrium (et_{-1}), which was negative and significant at the level of 1%, so we can accept the ARDL specification for both models.

The last step is to verify the Granger causality between LNGDP and LNREC. The existence of the long-run relationship doesn't mean that there's a real causality between variables, so we need to check if there's a two-way causality or one-way causality or no causality between such variables.

H_0: LNGDP does not Granger cause LNREC or the opposite;

H_1: LNGDP does Granger cause LNREC or the opposite.

2.2.2. Carbon dioxide emissions-economic growth-renewable energy consumption model:

We applied the same procedure of the previous study and we found that the three variables were stationary at 1st difference, so they have the same order of integration I (1). Then, we need to check the optimal lag with the lag length criteria with VAR estimation. Therefore, we concluded that the optimal model is with three lag (p=3), so we take (p=2) for Johansen cointegration test in Eviews 9.

Therefore, we concluded for the VECM (2) model in 3 cointegration specifications (the model without intercept, the model with intercept in the long-run and the model with intercept in the short and long-run). However, we selected only the 2nd model with only intercept in the long-run, because it has the less value of Akaike and Schwarz criteria. **Granger (1988)** posited that the VECM is more suitable to investigate the causality between series that are integrated at I (1). So the model is based on the assumption that all the variables are not exogenous and also premised on the fact that the depend variables is explained by the past values of the independent variables and the past values of the dependent variables.

However, the sign of long-run relationship was accepted, but not for all the coefficients, so we need to check again the validity of the coefficient with the exogeneity test and to make some restriction in VECM.

H_0: the restricted coefficients equal to 0;

H_1: the restricted coefficients are unequal to 0.

We struggled to find the perfect restriction for this VECM, but we selected the restriction A (2, 2) = 0, A (3, 1) = 0 and we accepted in this case the null hypothesis, so the 2nd coefficient of per capita GDP and the 1st coefficient of per capita REC have a low power of exogeneity in this model.

We shall also study the impulse response and the variance decomposition between the innovation or shock (residual series) of each variable and to verify the Granger causality between per capita GDP, per capita REC and per capita CO_2.

2.2.3. Human Development Index-carbon dioxide emissions-economic growth-renewable energy consumption model:

In this model, we won't take into consideration the realized volatility or the control variable, so we shall perform the same analysis on the unit root test between LNHDI, LNGDP, $LNCO_2$ and LNREC. We found that all variables were stationary at the 1^{st} difference except the LNHDI variable, which was stationary with the 2^{nd} difference, so the variables aren't integrated with the same order. Therefore, we proceed with VAR estimation rather than cointegration model. Then, we selected the number of lags that should be included in the Vector Autoregressive model, and we found 3 lag (p=3) that can be used in the optimal VAR model. Next, we will check several tests of residual and autoregressive root to see if the VAR model is stationary or not, and then we shall estimate the structural VAR and structural impulse response.

The structural VAR (SVAR) works with extra identifying restrictions and estimation of structural matrices to convert them into uncorrelated structural impacts which can trace four effects (LNHDI, LNGDP, $LNCO_2$ and LNREC residuals) of a one-time shock to one of the innovations on current and future values. Therefore, we shall estimate a general VAR model, then a structured VAR (structural factorization with identifying restrictions) and then structural decomposition of innovations.

However, we have the variables with different order of integration, so we need to check the causality with the Augmented Granger causality called **Toda-Yamamoto causality (1995)**.

We shall also perform the long-run estimation with the OLS, but, this regression is unreliable and biased due to the presence of multicollinearity, so we will estimate the relationship between LNHDI and other variables with the GMM estimation, and check the level of exogeneity with **Hausman (1978)**. This test permits to detect the correlation between the error terms and the exogenous variables, so in this case we can't afford to accept the OLS estimation, because it gives non-convergent results and the estimators are blue, so we need to estimate such variables and models with Generalized Method of Moment (GMM).

2.2.4. The renewable energy deployment model:

We made a classical OLS model to estimate only the long-run coefficients amongst 3 equations. However, we avoided a deterministic trend that was on RVEU, because the coefficients of all equations were not well specified, so we used the RVEU without its trend and then estimated the 3 equations with this variable.

In the 1st equation, we defined the model with the 3 renewable energy policies, measures and with the institutional index score to see their influence on the contribution of renewable energy in energy supply;

In the 2nd equation, we redefined the model with 3 renewable energy policies, measures and without the institutional index score to show if the 3 renewable policies impact significantly the endogenous variable or not;

In the 3rd equation, we estimated the model with the policy cluster that groups the 3 renewable energy policies and measures on one variable (REP) and we included the institutional index score.

Therefore, we made only 3 equations, which contain different variables, and we didn't include the 4th equation, which include REP and without the institutional index score, because it adds nothing to our findings. Consequently, to confirm the validity of these 3 equations, we made several coefficients, residual and stability diagnostic to see if the renewable energy deployment model is statically acceptable or not.

3. Results and discussion:

3.1. Economic growth-renewable energy consumption model:

- The ARDL (2,1) equation for (LNGDP):

$$LNGDP = 6.126 + 0.252 * LNGDP_{t-1} + 0.598 * LNGDP_{t-2} + 0.104 * LNREC_t + 0.135 * LNREC_{t-1} + 124.594 * RVFEC_t + 22.910 * RVGFCF_t - 272.653 * RVLF_t - 0.005 * RVTrade_t + et \quad \ldots\ldots (14)$$

- The cointegrating equation for (LNGDP):

$$DLNGDP = 110.485 * DLNGDP_{t-1} + 9.742 * DLNREC_t + 0.010 * DRVFEC_t + 0.088 * DRVGFCF_t + 6.694 * RVLF_t - 10.616 * DRVTrade_t - 112.565[LNGDP_t - (0.087 * LNREC_{t-1} + 0.00009 * RVFEC_{t-1} + 0.0007 * RVGFCF_{t-1} + 0.059 * RVLF_{t-1} - 0.094 * RVTrade_{t-1} + 0.16)] \quad \ldots\ldots (15)$$

- The ARDL (1,2) equation for (LNREC):

$LNREC = -35.289 - 0.422 * LNREC_{t-1} + 3.223 * LNGDP_t + 0.684 * LNGDP_{t-1} - 3.155 * LNGDP_{t-2} - 443.613 * RVFEC_t - 108.475 * RVGFCF_t + 784.881 * RVLF_t + 0.048 * RVTrade_t + et$……………………………………………………….….. (16)

- The cointegrating equation for (LNREC):

$DLNREC = 3.223 * DLNGDP_t + 3.155 * DLNGDP_{t-1} - 443.613 * DRVFEC_t - 108.475 * DRVGFCF_t + 784.881 * DRVLF_t + 0.048 * DRVTrade_t - 1.422[LNREC_t - (0.529 * LNGDP_{t-1} - 311.792 * RVFEC_{t-1} - 76.241 * RVGFCF_{t-1} + 551.652 * RVLF_{t-1} + 0.034 * RVTrade_{t-1} - 24.803)]$ ……………………………………………….….. (17)

- The Granger causality:

Table 08: Granger causality between LNGDP and LNREC

Lag 1		
Null hypothesis	**Fisher-statistic**	**Probability**
LNGDP does not Granger cause LNREC	2.477	0.132
LNREC does not Granger cause LNGDP	0.802	0.382
Lag 2		
Null hypothesis	**Fisher-statistic**	**Probability**
LNGDP does not Granger cause LNREC	2.242	0.140
LNREC does not Granger cause LNGDP	0.643	0.539

Source: Done on EViews 9.

- **The coefficient and stability diagnostic:**

Both models were statistically acceptable, the ARDL (2,1) model have the R^2 equal to 0.975, indicating that 97.5% of exogenous variables explain the endogenous variable and 2.5% were explicated by other factors that are not determining in the model such as the technology factor, while the ARDL (1,2) model have the regression coefficient equal to 0.56, indicating that 56% of exogenous variables explain the endogenous variable and 44% were explicated by other factors that are not defining in the model.

In the 1st model, the Fisher-statistic (estimated) = 55.44 was superior the fisher-statistic (table) at level of 5% = 4.35 and the fisher-statistic (table) at level of 1% = 8.10, indicating that we can't reject the alternative hypothesis and we can say that the model was globally significant and it can be used in the forecasting study. However, in the 2nd model the Fisher-statistic was not significant.

The variation inflation factors indicated that all exogenous variables have a coefficient inferior to 10, indicating that we can reject the null hypothesis and accept the alternative hypothesis, so we can say that there’s no multicollinearity in both models. However, the variable of GDP is superior to 10, because it has several lag variables included in both models.

The intercept coefficient was significant, so we can apply the Ramsey Reset test to see if they’re some omitted variables or not. Therefore, we made 3 statistics test and we found that all of them are superior to the level of 1%, 5% and 10%, demonstrating that there are no omitted variables and the models are well specified.

- **The residual diagnostic:**

We develop several residual diagnostic tests to see if the models are affected by the error or residual term or not, because the econometrics theory works to reach the optimal model and to seek for a model with a minimum errors.

The 1st test was introduced by **Box-Pierce (1970)** and **Ljung-Box (1978)**, which permit to identify the processes without memory. Therefore, both tests indicated that the probability estimated is superior to the level of 1%, 5% and 10%, showing that we can’t reject the null hypothesis and we can say that the residual in both models follow white noise process.

The 2nd test was developed by **Jarque and Bera (1984)**, which allows verifying if the errors are normally distributed or not. The test showed that the probability estimated is superior to the level of 1%, 5% and 10%, demonstrating that we can reject the alternative hypothesis and we may accept the null hypothesis, so the residuals follow normality distribution.

Breusch-Godfrey (1978) represents the 3rd residual test, which is based on the detection of autocorrelation between residuals from lag 1 (p=1) to lag four lag (p=4). We found with this test that the probability estimated is superior to the level of 1%, 5% and 10% from p=1 to p=4, so we can’t afford to accept the alternative hypothesis, and we can say that there’s no autocorrelation between residuals.

The last test is the detection of heteroscedasticity with the Breusch-Pagan-Godfrey, Harvey and Glejser tests. We found that the estimated probability in three tests was superior to the level of 1%, 5% and 10%, indicating that we can accept the null hypothesis and reject the alternative hypothesis, meaning that the residual variances are homoscedasticity.

- **Discussion:**

From the cointegration form of (LNGDP), the sign of long-run equilibrium was negative and significant, suggesting that the speed of the adjustment coefficients among which the negative and the statistical significant validated the error-correction model. The negative sign of the speed considered of the coefficient of adjustment indicates the convergence towards the long-term balance. Therefore, the coefficient was (-112.565), meaning that the variable responses are strong and it will return quickly to the equilibrium. The sign and the significance of each coefficient are the same for both equations in the short and long run estimation.

For the 2nd model, the coefficient was estimated at (-1.422), meaning that the variable responses are good, but they will not return quickly to the equilibrium. The sign and the significance of each coefficient are the same for both equations in the short and long run estimation.

In the 1st model, the sign of intercept is significant at the level of 1% and positive, so an increase by 1 unit in intercept will raise LNGDP by 6.126 units, meaning that the other factor such as the technological advancement or the investment in new projects will develop the economic growth and it will encourage the sustainable development.

The signs of $LNGDP_{t-1}$ and $LNGDP_{t-2}$ were positive, non-significant and significant at the level of 5%, respectively, so an increase by 1 unit in $LNGDP_{t-1}$ will surge the elasticity of economic growth by 0.252 and a rise by 1 unit in $LNGDP_{t-2}$ will upsurge the elasticity of economic growth by 0.598, indicating that the industry and the economic development of the country is lesser than what it was in previous period due to the decrease the level of oil prices.

The coefficient of LNREC and $LNREC_{t-1}$ were positive and statistically accepted at the level of 5%, respectively, so an increase by 1 unit in LNREC and in $LNREC_{t-1}$ will affect positively the elasticity of GDP by 0.104 and by 0.135, respectively. This sign appears to be very strange, because the economic growth of Algeria isn't yet depending on renewable energy source to produce and develop its goods and services (the opposite what find **Amri, 2017**). However, the introduction of such energy can be beneficial for the country and it can enhance the economic level. It will also provide more sustainable energy and it may satisfy the energy demand for the future generation in several sectors. This result is in line with the main literatures of **Adams et al. (2018)**, **Atems and Hotaling (2018)**, **Koçak and Şarkgüneşi (2017)**, **Armeanu et al. (2017)**, **Rafindadi and Ozturk (2017)**, **Kahia et al. (2016)**, **Lotz (2016)**, **Bilgili and Ozturk (2015)**, **Ozturk and Bilgili (2015)**, **Bildirici (2014)**, **Apergis and Payne (2011b and 2011a)** and **Apergis and Payne (2010b and 2010a)**. Also, the IEA U.S Administration report 2017 states that the renewable energy can contribute to increase the economic factor of sustainable development by 1 to 2% per year.

The sign of RVFEC was positive and significant at the level of 5%, so an increase by 1 variation in fossil energy consumption will raise the level of GDP by 124.594. This statistic is logical, because, up till now almost all countries (also Algeria) are depending mainly on fossil fuel to develop its industry and economic sectors. This result is supported by **Adams et al. (2018)**, **Atems and Hotaling (2018)**, **Koçak and Şarkgüneşi (2017)** and **Amri (2017)**.

However, the coefficients of RVGFCF, RVTrade and RVLF are not significant, meaning that the new assets included by the government and the investment in production cycle won't support the economic growth and the national production. We can say also that the employment in Algeria has not the necessary skill and competence to upsurge the level of GDP growth.

In the 2nd model, there's only the variable of LNGDP, which was significant and it had a positive impact on LNREC, so an increase by 1 unit in the income will raise the elasticity of renewable energy consumption by 3.223, validating that the income can play a major role in integrating the renewable energy in the Algerian energy system by investing in new technologies and making policies that encourage the deployment of renewables. The same result was found in the studies of **Silva et al. (2018)**, **Lin and Moubarak (2014)**, **Sadorsky (2009)**.

These outcomes demonstrate that Algeria is going to the adoption of the renewable energy in its process of energy production and it will stabilize its socio-economic situation in the long-term. Moreover to reach the goal of the sustainable development, protecting the energy resources and preserving natural resources (especially the fossil fuel), sustainable consumption, production, and sustainable transport, it will be necessary for Algeria to focus on renewables, because according to the last balance sheets, the energy consumption is attaining a critical threshold and it will push countries to look after alternative energy. Besides, according to the Renewable Energy Development Center (report of June 2018) Algeria is one of the African country that possess the most installed capacity in renewable energy, approximately 0.4 Gw (2017), and the country can still reach a higher statistic of renewables with the cost reduction of photovoltaic and wind energy, so as they become more competitive with fossil fuel energy.

The Granger causality demonstrates that there's no causality between economic growth and renewable energy consumption, so an evidence of neutrality hypothesis. The same suppositions were found in the study of **Tugcu and Topcu (2018)**, **Koçak and Şarkgüneşi (2017)**, **Aïssa et al. (2014)**, **Mulali et al. (2013)**, **Yildirim et al. (2012)**, **Tugcu et al. (2012)**, **Sadorsky (2009)** and **Payne (2009)**. This result is consistent with the Algerian energy situation because the consumption and the production of renewable energy won't exceed 6% of total energy and there are some barriers that limit the renewable energy introduction such as the market, economic, informational and awareness, socio-cultural, institutional and policy and also the cost of the production efficiency and the technology machinery. However to attain the energy efficiency with cheaper energy and less cost of energy production, Algeria needs to implement the renewables into its system, because it provided opportunities for work, increase foreign investment and reduce the trade problem.

3.2. Carbon dioxide emissions-economic growth-renewable energy consumption model:

- The VECM equation:

$$DGDP_t = 0.007 * (GDP_{t-1} - 4.223 * 10^{12} REC_{t-1} + 2452.787) - 636735627.516 * (CO2_{t-1} - 931.420 * REC_{t-1} - 1.292 * 10^{-6}) - 1.392 * DGDP_{t-1} - 0.756 * DGDP_{t-2} + 5266938986.17 * DCO2_{t-1} - 1518481388.51 * DCO2_{t-2} - 261549920393 * DREC_{t-1} - 16343983499 * DREC_{t-2} - 305048.683 * RVFEP_t + 754209.079 * RVFEC_t + 10665.553 * RVREP_t + 0.399 * RVGDP^2{}_t + 391.348 * Kyoto_t - 1249.705 * Paris_t \quad (18)$$

$$DCO2_t = -5.834 * 10^{-13} * (GDP_{t-1} - 4.223 * 10^{12} REC_{t-1} + 2452.787) + 0.265 * (CO2_{t-1} - 931.420 * REC_{t-1} - 1.292 * 10^{-6}) + 1.986 * 10^{-10} * DGDP_{t-1} + 4.053 * 10^{-11} * DGDP_{t-2} + 0.150 * DCO2_{t-1} + 0.258 * DCO2_{t-2} - 5.321 * DREC_{t-1} - 18.500 * DREC_{t-2} + 3.351 * 10^{-5} * RVFEP_t + 4.403 * 10^{-5} * RVFEC_t + 3.460 * 10^{-7} * RVREP_t - 1.935 * 10^{-11} * RVGDP^2{}_t - 3.109 * 10^{-8} * Kyoto_t + 3.628 * 10^{-8} * Paris_t \quad (19)$$

$$DREC_t = -2.025 * 10^{-13} * (GDP_{t-1} - 4.223 * 10^{12} REC_{t-1} + 2452.787) + 0.002 * (CO2_{t-1} - 931.420 * REC_{t-1} - 1.292 * 10^{-6}) + 3.949 * 10^{-13} * DGDP_{t-1} - 7.617 * 10^{-14} * DGDP_{t-2} + 0.0001 * DCO2_{t-1} - 0.0005 * DCO2_{t-2} + 0.140 * DREC_{t-1} - 0.018 * DREC_{t-2} - 2.003 * 10^{-7} * RVFEP_t + 2.711 * 10^{-7} * RVFEC_t + 3.145 * 10^{-8} * RVREP_t + 3.145 * 10^{-8} * RVGDP^2{}_t + 6.771 * 10^{-9} * Kyoto_t - 1.645 * 10^{-9} * Paris_t \quad (20)$$

- The VECM (r) equation:

$DGDP_t = -26.271 * (0.003 * GDP_{t-1} - 16830620.898 * CO2_{t-1} + 32970740.193 * REC_{t-1} + 30.835) - 97.467 * (-0.001 * GDP_{t-1} + 11069512.034 * CO2_{t-1} - 5.75 * 109 * REC_{t-1} - 16.952) - 1.392 * DGDP_{t-1} - 0.756 * DGDP_{t-2} + 5266938986.17 * DCO2_{t-1} - 1518481388.51 * DCO2_{t-2} - 261549920393 * DREC_{t-1} - 16343983499 * DREC_{t-2} - 305048.683 * RVFEP_t + 754209.079 * RVFEC_t + 10665.553 * RVREP_t + 0.399 * RVGDP^2{}_t + 391.348 * Kyoto_t - 1249.705 * Paris_t$……………………..….. (21)

$DCO2_t = -1.58 * 10^{-8} * (0.003 * GDP_{t-1} - 16830620.898 * CO2_{t-1} + 32970740.193 * REC_{t-1} + 30.835) + (0) + 1.986 * 10^{-10} * DGDP_{t-1} + 4.053 * 10^{-11} * DGDP_{t-2} + 0.150 * DCO2_{t-1} + 0.258 * DCO2_{t-2} - 5.321 * DREC_{t-1} - 18.500 * DREC_{t-2} + 3.351 * 10^{-5} * RVFEP_t + 4.403 * 10^{-5} * RVFEC_t + 3.460 * 10^{-7} * RVREP_t - 1.935 * 10^{-11} * RVGDP^2{}_t - 3.109 * 10^{-8} * Kyoto_t + 3.628 * 10^{-8} * Paris_t$………………….…….….. (22)

$DREC_t = (0) + 1.88 * 10^{-10} * (-0.001 * GDP_{t-1} + 11069512.034 * CO2_{t-1} - 5.75 * 109 * REC_{t-1} - 16.952) + 3.949 * 10^{-13} * DGDP_{t-1} - 7.617 * 10^{-14} * DGDP_{t-2} + 0.0001 * DCO2_{t-1} - 0.0005 * DCO2_{t-2} + 0.140 * DREC_{t-1} - 0.018 * DREC_{t-2} - 2.003 * 10^{-7} * RVFEP_t + 2.711 * 10^{-7} * RVFEC_t + 3.145 * 10^{-8} * RVREP_t + 3.145 * 10^{-8} * RVGDP^2{}_t + 6.771 * 10^{-9} * Kyoto_t - 1.645 * 10^{-9} * Paris_t$…..…………………….….. (23)

- The Granger causality:

Table 09: VEC Granger causality/Block exogeneity Wald tests Between DGDP, DCO_2 and DREC

DGDP		
Excluded	**Chi-square**	**Probability**
DCO_{2t}	9.302*	0.009
$DREC_t$	3.170	0.204
DCO_2		
Excluded	**Chi-square**	**Probability**
$DGDP_t$	100.401*	0
$DREC_t$	12.705*	0.001
DREC		
Excluded	**Chi-square**	**Probability**
$DGDP_t$	0.308	0.857
DCO_{2t}	0.031	0.984

Source: Done on EViews 9.

Table 10: Granger causality between per capita CO_2, GDP and REC

Lag 2		
Null hypothesis	**Fisher-statistic**	**Probability**
CO_2 does not Granger cause GDP	1.180	0.334
GDP does not Granger cause CO_2	12.149*	0
REC does not Granger cause GDP	1.636	0.227
GDP does not Granger cause REC	1.525	0.249
CO_2 does not Granger cause REC	0.008	0.991
REC does not Granger cause CO_2	0.111	0.894

Source: Done on EViews 9.

- **The coefficient diagnostic:**

The system VECM equation have significant coefficients, the $DGDP_t$ model have the regression coefficient equal to 0.94, indicating that 94% of exogenous variables explain the endogenous variable and 6% were explicated by other factors that are not determining in the model, while the DCO_{2t} model have the regression coefficient equal to 0.99, indicating that 99% of exogenous variables explain the endogenous variable and 1% were explicated by other factors that are not defining in the model, and the $DREC_t$ have the regression coefficient equal to 0.892, indicating that 89.2% of exogenous variables explain the endogenous variable and 10.8% were explicated by other factors that are not determined in the model.

We can say also that the model was globally significant due to the high value of Fisher statistic, which were superior the tabulated statistic.

- **The residual diagnostic:**

We initiated our investigations with the graph of the inverse roots of the characteristic AR polynomial (**Lütkepohl, 1991**). The autoregressive root graph showed that the model VAR is more or less stationary or stable, because we have only two from nine roots lie outside the unit circle, so this result can have a serious impact on impulse response function and it may make the VECM model not stationary.

We also tested with multivariate normality, if the residuals are normally distributed or not. Our outcomes showed that the VAR residuals are normally distributed and we concluded for the acceptation of the null hypothesis (normality distribution) and the rejection of alternative hypothesis.

- **Discussion:**

The model has 4 long-run coefficients; three of them have the negative sign and were statistically accepted, so we can accept the specification of VECM (2) restricted system equation.

In the 1st equation when per capita GDP was considered as an endogenous variable. The signs of $DGDP_{t-1}$ and $DGDP_{t-2}$ were negative and significant at the level of 5%, respectively, so an increase by 1% in $DGDP_{t-1}$ and $DGDP_{t-2}$ will decrease the economic growth by 1.392% and 0.756%, respectively, confirming the result of previous model (economic growth-renewable energy consumption model), so we can say that the industry and the economic development of the country are lesser than what it was in the previous period.

The sign of DCO_{2t-1} was positive and significant at the level of 5%, and DCO_{2t-2} was negative and insignificant, demonstrating that a rise by 1% in carbon dioxide emission in 2015 had a positive impact on GDP by $5.27*10^{9}$%, so this result indicates that the country is depending a lot on goods and services that emitted the polluted air to develop its economic growth.

The coefficients of $DREC_{t-1}$ and $DREC_{t-2}$ were negative and insignificant, so this result is in line with the main hypothesis of Growth, indicating that Algeria was not depending on renewable energy to improve its socio-economic situation.

Both variables of realized volatility of the fossil energy production and consumption have a statistically accepted coefficient, but the production has a negative influence, while the consumption has a positive influence on GDP, so an increase by 1 unit in RVFEP and RVFEC will decrease and increase the variation level of GDP by -305048.6 and by 754208.4, respectively. Therefore, we found an unexpected result, because Algeria is considered as one of the country that rely on fossil energy production, so this might reveal the existence of inefficiency in energy production and it may contribute negatively to the economic growth, while the sign of fossil energy consumption was good and have a positive effect on per capita GDP.

The signs of RVREP, $RVGDP^2$ and Kyoto were both positive and insignificant, so they haven't any effect on GDP, while the coefficient of Paris was negative and statistically accepted, indicating that this conference had a negative effect on GDP of Algeria. In this circumstance, when the country tries to change, systematically and rapidly its energy policy, it will impact negatively its economic growth (the change from fossil fuel dependence towards renewable energy dependence and then diminish the deforestation, loss of biodiversity, the carbon emissions and other sources of greenhouse gas that was the aim of Paris Summit).

In the 2nd equation when per capita CO_2 was considered as an endogenous variable. The signs of $DGDP_{t-1}$ and $DGDP_{t-2}$ were positive, and significant at the level of 1% and 5%, respectively, so an increase by 1% in $DGDP_{t-1}$ and $DGDP_{t-2}$ will upsurge the rate of the carbon dioxide emissions by $2*10^{-10}$% and $4.05*10^{-11}$%, indicating that the industry and the economic development of the country is depending a lot of polluted goods and services, so confirming again the relationship between GDP, CO_2 and fossil energy. This result is supported by the studies of **Mbarek et al. (2018)**, **Apergis et al. (2018)** and **Attiaoui et al. (2017)**.

The sign of DCO_{2t-1} was positive and insignificant, while the coefficient of DCO_{2t-2} was statistically positive, demonstrating that a rise by 1% in carbon dioxide emissions in 2014 had a positive impact on itself by 0.258%, approving the last result.

The coefficients of $DREC_{t-1}$ and $DREC_{t-2}$ were negative, insignificant and significant, respectively, so an increase by 1% in renewable energy consumption in 2014 would diminish the level of carbon dioxide emissions by 18.50%. Consequently, the renewable energy can reduce the pollution factor that causes the climate warm. Also, Algeria is going to apply some energy policies that focus on photovoltaic and wind energy, as they represent the alternative of hydropower and biomass energy, which emit a lot of negative gazes from their chemical product that contaminate the ocean and increase the deforestation and the loss of biodiversity. This result is in line with the main literature of **Lotz and Dogan (2018)**, **Zoundi (2017)**, **Paramati et al. (2017)**, **Dogan and Seker (2016)** and **Sulaiman et al. (2013)**.

The variables of RVFEP and RVFEC have a positive and significant coefficient, respectively, so an increase by 1 unit in RVFEP and RVFEP will surge the variation level of carbon dioxide emissions by $3.35*10^{-5}$ and by $4.40*10^{-5}$, respectively. This outcome is in line with the hypothesis that the country is depending on fossil energy which represent the main source of energy that emit a lot of pollution in the atmosphere, and especially the carbon dioxide. This result indicates also that the country in this period was using unclean technology that use the waste and combustible energy that emits a high level of pollution in ecosystem. Consequently, the energy policy of Algeria for now appears to be more focused on supporting the development of its economic growth than encouraging the decline of the air pollution. The same result found in studies of **Lotz and Dogan (2018)**, **Attiaoui et al. (2017)**, and **Chen et al. (2016)**.

For the rest of the variables in this equation, they had an insignificant coefficient, meaning that Algeria was not concerned by the objectives of such conferences such as the protection of the fish stocks, the introduction of sustainable development term to the private sector and in the global companies.

Also, we could not accept the Environment Kuznets Curves Hypothesis where the level of ecological pollution initially rises with income until it attains its equilibrium points, because the $RVGDP^2$ was not significant, so the EKC hypothesis is not valid, in this situation and we can say that the country is considered as developing country that needs a lot of polluted manufactures and productions to keep its economic growth expansion then to develop its economic structure. This result is supported by studies of **Lotz and Dogan (2018)**, **Zoundi (2017)** and **Dogan and Ozturk (2017)**.

In the 3rd equation when per capita REC was considered as an endogenous variable. All the variables seem to be not significant at any level, except the Kyoto variable, so an increase by 1 unit in the dummy variable of Kyoto will surge the elasticity of renewable energy consumption by $1.93*10^{-9}$, showing that the country is starting to concern with the environmental issues and Algeria is aware of the ratification of the Kyoto protocol, which it will have a good consequence on renewables.

After analysing the impact of each coefficient on VECM system, we shall study the Granger causality between variables. We found in the short-run that there's bidirectional causality between per capita DCO_2 and per capita DGDP at the level of 1% and we found also that there's a unidirectional causality running from per capita DREC to per capita DCO_2 at the level of 1%. Therefore, we can say that the carbon dioxide emissions and the economic growth are interrelated to each other, so when there's a variation on GDP, it will impact directly the level of CO_2, confirming that Algeria is depending a lot on combustible and fuel energy that emit a lot of polluted gases. The same result was found in the studies of **Lotz and Dogan (2018)**, **Mbarek et al. (2018)**, **Solarin et al. (2017)**, **Dogan and Aslan (2017)**, **Sulaiman et al. (2013)** and **Menyah and Rufael (2010)**. Besides, the consumption of the renewable energy, especially the photovoltaic and wind energy can decrease the level of the carbon dioxide emissions, as is known, the renewable energy is considered as a clean energy power and since renewables induce far fewer pollutant gas emissions when they are compared to fossil energy sources, such as petrol, coal and natural gas. This result is supported by the main literature of **Solarin et al. (2017)** and **Mulali et al. (2016)**. However, the Granger causality in the long-run indicated that there's a one-way causality running from per capita GDP to per capita CO_2 and it confirms the previous findings. This result is in line with the investigations of **Apergis et al. (2018)**, and **Shahbaz et al. (2017)**.

After analysing the impact of each coefficient on VECM system and the Granger causality, we shall display the impulse response to indicate the variation between the endogenous variables and their residual series. In the 1st period, a shock on per capita CO_2 has not a contemporary effect on per capita GDP or on per capita REC, confirming the result of causality, while a shock on GDP has a contemporary effect CO_2 only. The shock or innovation amplitude of GDP was 233.657 and will immediately be reflected on the CO_2 shock by $4.11*10^{-9}$, confirming the relationship in the long-run between these variables, so in the first period, Algeria increases its economic and industrial production, with a sudden increase in the emission of carbon dioxide, so we can say that the country is using and producing goods and service that release a lot of polluting air, also a shock on REC has a contemporary effect CO_2 and GDP, so the shock amplitude of REC was $6.69*10^{-10}$ and will directly be reflecting on GDP innovation by 128.77 and on CO_2 shock by $1.39*10^{-8}$, confirming that the renewable energy has a positive effect on economic growth, but the shock on CO_2 appears to be very strange, because we found a negative relationship between the REC and CO_2, so we can that in the 1st period Algeria was using combustible renewables that release some carbon dioxide in the air. In the 2nd period, a shock on CO_2 by $2.44*10^{-9}$ has a contemporary effect on innovation of GDP by 7.979 and on the innovation of REC by $3.86*10^{-12}$.

A shock on GDP by -70.809 [9] has a current impact on shock of CO_2 by $3.86*10^{-8}$ and on the innovation of REC by $5.41*10^{-11}$, while an innovation on REC by $9.68*10^{-11}$ will influence the innovation of CO_2 by $3.38*10^{-8}$ and the shock of GDP by 214.073. From this outcome, we can say that Algeria is focusing on the development of economic growth rather than reducing the environmental issues, so the country has no concern with the international conferences on climate warm.

The variance decomposition indicate in the 3rd period, that the forecast errors of per capita CO_2 is due 0.581% of its innovation, 29.069% of per capita GDP innovation, and 70.35% of per capita REC shock, while the forecast errors of GDP is due to 67.078% of its shock, 0.026% to per capita CO_2 innovation and 32.896% to per capita REC innovation. And, the forecast errors of REC is due to 99.062% to its shock, while 0.927% to CO_2 innovation and 0.011% of GDP innovation. Consequently, this result confirms the Granger causality test.

In sum, this model reveals that a rise in Algeria economic and industrial production will reduce the emission of carbon dioxide for short-term, while if the country diminishes its economic growth, it will affect positively the emission of carbon dioxide, so in this case Algeria needs some controlling strategies that should be applied to fight the environmental pollution, such as buildings, institutions, firms, factories, and electricity power companies which should be forced by regulations to meet some portion of their energy needs from renewable sources, and to gradually increase its portion in the future.

3.3. Human Development Index-carbon dioxide emissions-economic growth-renewable energy consumption model:

- The VAR estimation:

$$DLNHDI_t = 1.254 * LNHDI_{t-1} - 1.028 * LNHDI_{t-2} + 0.669 * LNHDI_{t-3} + 0.004 * LNGDP_{t-1} + 0.031 * LNGDP_{t-2} + 0.002 * LNGDP_{t-3} - 0.0006 * LNREC_{t-1} - 0.002 * LNREC_{t-2} - 0.005 * LNREC_{t-3} - 0.142 * LNCO2_{t-1} + 0.030 * LNCO2_{t-2} - 0.022 * LNCO2_{t-3} - 1.652 + v_t \quad (24)$$

- The Augmented-Granger causality:

Table 11: Toda-Yamamoto causality between LNHDI, $LNCO_2$, LNGDP and LNREC

LNHDI		
Excluded	**Chi-square**	**Probability**
LNGDP	458.924***	0
LNREC	82.858***	0
$LNCO_2$	179.596***	0
$LNCO_2$		
Excluded	**Chi-square**	**Probability**
LNGDP	95.575***	0
LNREC	1394.105***	0
LNHDI	183.922***	0
LNGDP		
Excluded	**Chi-square**	**Probability**
LNHDI	5.760	0.123
LNREC	24.926***	0
$LNCO_2$	11.902***	0.007
LNREC		
Excluded	**Chi-square**	**Probability**
LNGDP	0.545	0.908
LNHDI	1.917	0.589
$LNCO_2$	0.753	0.860

Source: Done on Eviews 9.

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficient is significant at 10%, 5% or 1%.

- The structured VAR model:

LNREC depend on $V_{t1} = 0.650*u_1$………………………………………………….. (25)

LNGDP depend on $V_{t2} = 0.118\ V_{t1} +0.099*\ u_2$…………………………………….. (26)

$LNCO_2$ depend on $V_{t3} = 0.085\ V_{t2}\ -0.0005\ Vt_1+0.010*\ u_3$……………………..…….. (27)

LNHDI depend on $V_{t4} = -0.100\ Vt_3+0.010\ V_{t2}\ +1.03*10^{-5}Vt_1+0.0005*\ u_4$………... (28)

Where, $V_{t1,}$ $V_{t2,}$ V_{t3} and V_{t4} are LNREC, LNGDP, $LNCO_2$ and LNHDI residuals, u_1, $u_{2,}$ u_3 and u_4 represent the innovation function or shocks.

- GMM estimation:

$$LNHDI_t = 0.091 * LNGDP_t + 0.0091 * LNREC_t + 0.071 * LNCO2_t + e_t \ldots\ldots\ldots\ldots (29)$$

- **The coefficient diagnostic:**

The system of VAR equation has significant coefficients, but we shall study only the LNHDI equation, so the regression coefficient was equal to 0.999, indicating that 99.9% of the exogenous variables explain the endogenous variable and 0.1% were explicated by other factors that are not determined in the model and the model was globally significant at the level of 1% due to the high value of Fisher statistic, which were superior the tabulated statistic.

The long-run estimation with the OLS indicates that the model contains a good statistic coefficient, but the correlation coefficient between variables was too high, so there's a problem of multicollinearity, and we verified it with the test of variance inflation factors, which showed that the value of the regressors are greater than 10. Therefore, these variables cannot be used in the OLS estimation, so we need to re-estimate the model with GMM equation.

The GMM model showed that the regression coefficient was equal to 0.861, indicating that 86.1% of exogenous variables explain the endogenous variable and 13.9% were explicated by other factors that are not defined in the model. Also, the probability of J-statistic is superior to 1%, indicating that the GMM specification is well identified and the endogeneity test specifies that its probability test is inferior to 5%, so we can't reject the alternative hypothesis, and we can say that LNGDP, LNREC, $LNCO_2$ are endogenous.

- **The residual diagnostic:**

We initiated our investigations with the system VAR equation. The autoregressive root graph showed that the model VAR is stable and stationary because all roots lie inside the unit circle, so we can make the structural impulse response function without any problem.

We also tested with multivariate normality, if the residuals are normally distributed or not. Our outcomes showed that we can't accept the alternative hypothesis rather than we accept the null hypothesis, so the VAR residuals are normally distributed.

Concerning the GMM equation, we made only the test of **Ljung-Box (1978)**, which it showed that we can't reject the null hypothesis at the level of 1%, so the residual follows a white noise process. Also, the normality test showed that the probability estimated is superior to the level of 1%, 5% and 10%, demonstrating that we reject the alternative hypothesis rather than we accept the null hypothesis, so the residuals are normally distributed.

- **Discussion:**

In the VAR model, we used only the LNHDI as an endogenous variable, because the other variables are defined in previous models. The $LNHDI_{t-1}$ and $LNHDI_{t-3}$ were positive and significant, so a rise by 1 unit in these variables will increase the elasticity of Human Development Index by 1.25 and 0.66, respectively, indicating that the level of well-being improved in the 2015 and in 2013. However the $LNHDI_{t-2}$ had a negative and significant influence on LNHDI, so an increase by 1 unit in this variable will decrease the elasticity of HDI by 1.02, showing that the level of well-being declined in the 2014.

The $LNCO_{2t-2}$ and $LNCO_{2t-3}$ were insignificant, but the $LNCO_{2t-1}$ was negative and significant, so a rise by 1 unit in this variable will reduce the elasticity of Human Development Index by 0.142. This result is consistent with the theory, because an increase in the level of the pollution may affect negatively the well-being of the population, by increasing the health problems, and it may cause respiratory diseases, cancer, tuberculosis, as well as weight loss and eye diseases among newborns. This problem may hurt the health of the living beings, especially women and children and it may reduce the expectancy at birth. Also, the inefficient use of these traditional fuels in open fires could lead to the instability of the environment situation. If such problem persists for Algeria, the country won't be able to achieve the economic and the social stability for the future generation, and therefore they cannot reach the sustainable development in economic, environment and social sectors. This finding is consistent with the study of **Pîrlogea (2012)**.

The $LNGDP_{t-1}$ and $LNGDP_{t-3}$ were insignificant, but the $LNGDP_{t-2}$ had a positive and statistically accepted coefficient on LNHDI, therefore, an upsurge by 1 unit in this variable can lead to surge the elasticity of Human Development Index by 0.031, showing that in this period, the economic growth supported the development of the HDI, by improving the level of education and facilitate the access to energy and offering a health security and higher life expectancy. Also, we can say that the policies aimed at accelerating growth would have a positive impact on the HDI in the short-run. This result is in line with the main literature of **Grubaugh (2015)**, and **Hafner and Foulkes (2013)**.

The $LNREC_{t-1}$ was insignificant, but the $LNREC_{t-2}$ and $LNREC_{t-3}$ had statistically accepted coefficient and they affect negatively the level of Human Development Index, so a rise by 1 unit in $LNREC_{t-2}$ and $LNREC_{t-3}$ may diminish the elasticity of HDI by 0.002 and by 0.005, respectively, demonstrating that the country is using the renewable combustible and fuel that hurt the well-being of the population and the renewables does not display any effect on development levels. This outcome is inconsistent with the investigations of **Kazar and Kazar**

(2014) and **Pîrlogea (2012)** who found that the renewable energy has significant and positive influences on human development index.

After analysing the impact of each coefficient on VAR system, we shall study the Augmented-Granger causality between variables. We found with the Toda-Yamamoto test that there's bidirectional causality between $LNCO_2$ and LNHDI and between LNGDP and $LNCO_2$ at the level of 1%, confirming the result in the previous models, and we can say that the carbon dioxide emissions affects negatively the level of the human development process in Algeria, conversely low human development in this country causes the environmental pollution. This finding is supported in the main literature of **Wang et al. (2018)**.

We found also that there's unidirectional causality running from LNGDP to LNHDI, one-way relationship running from LNREC to LNHDI, growth hypothesis running from LNREC to LNGDP, and another one from LNREC to CO_2, approving the outcomes in the prior models, so we can say that the renewable energy consumption can have a serious impact on the level of economic, environment and social factors (the main elements of Sustainable Development), however, it depends on how the country use renewables. Therefore, this result indicates that the resources from national income allocated to activities contributing to the Human Development Index and this latest can support the socio-economic factor and help to increase the national income and production. Also, a well-educated and healthy human capital is a significant factor of state competitive advantage formation. It also influences the labour efficiency, which in its turn attracts foreign direct investment into Algeria. The same conclusions were found in the studies of **Zang et al. (2017)**, **Kazar and Kazar (2014)** and **Martinez and Ebenhack (2008)**.

After examining the Toda-Yamamoto causality, we shall display the structural impulse response and the structural variance decomposition to indicate the variation between the endogenous variables and their residual series. In the 1^{st} period, a shock on LNHDI by 0.0005 has not a contemporary effect on $LNCO_2$, LNGDP, LNREC, confirming the result of causality, while a shock on $LNCO_2$ has a contemporary effect on LNHDI only. The shock or innovation amplitude of $LNCO_2$ was 0.010 and will immediately be reflected on the LNHDI shock by -0.0010, confirming the relationship in the long-run between these two variables, so in the first period, the rise in the emissions of carbon dioxide may influence the level of Human Development Index and by the way creating a health issue due to polluting air, also a shock on LNGDP has a contemporary effect on $LNCO_2$ and LNHDI only, so the shock amplitude of LNGDP was 0.099 and will directly be reflected on $LNCO_2$ innovation by 0.008 and on the LNHDI shock by 0.0001, confirming that the economic growth has a positive effect on the level of CO_2 and improving the well-being of the population, so we can say that Algeria depends a lot on fossil fuel and combustible energy that release a huge quantity of polluted air, and at the same time it enhances the HDI by improving the salary and wages of workers from fossil energy sales. The innovation on LNREC was 0.650 and will immediately influence the shock of LNGDP by 0.077, the innovation of LNCO2 by 0.0063 and the shock of LNHDI by 0.0001, indicating that the renewables support the economic growth, the socio-economic factor and the increase of carbon emissions. In the 2^{nd} period, a shock on LNHDI by 0.0007 has a contemporary effect on innovation of $LNCO_2$ by -0.0018, on the shock of LNGDP by0.0295 and on innovation of LNREC by 0.135. A shock on $LNCO_2$ by 0.0098 has a current impact on shock of LNHDI by -0.0026, on shock of LNGDP by -0.0287 and on innovation of LNREC by -0.255, while an innovation on LNGDP by 0.0678 will influence the innovation of $LNCO_2$ by 0.023, the shock of LNHDI by -0.0005 and the shock of LNREC by 0.462, also a shock on LNREC by 0.272 will impact the innovation of LNHDI by-0.0007, the shock of $LNCO_2$ by 0.007 and the innovation of LNGDP by 0.0655. From this outcome, we can say that Algeria is focusing on the development of economic growth rather than improving the level of Human Development Index, so the country has no concern with the well-being of the population.

The structural variance decomposition indicates in the 2^{rd} period that the forecast errors of LNHDI are due 8.928% of its innovation, 82.031% of LNGDP innovation, 3.158 of $LNCO_2$ shock and 5.883% of LNREC innovation, while the forecast errors of $LNCO_2$ is due to 21.564% of its shock, 0.3778% to LNHDI innovation, 10.063% to LNREC shock and 67.995% to LNGDO innovation, also the forecast errors of LNGDP are due to 54.890% to its shock, while 3.105% to $LNCO_2$ innovation, 3.292% of LNHDI shock and 38.713% to LNREC innovation. And the forecast errors of LNREC innovation are due to 62.578% of its shock, 26.935% to LNGDP innovation, 8.192% to $LNCO_2$ innovation and 2.295% to LNHDI shock. These results came to confirm our outcomes of the Toda-Yamamoto causality test.

In the GMM equation, we used 10 instrument rank (especially the realized volatility variables) to estimate the relationship between LNHDI and other endogenous variables. The coefficient of LNGDP was positive and significant at the level of 1%, so a rise by 1 unit in this variable will increase the elasticity of HDI by 0.091, confirming the result in the VAR equation and it also indicates that the improvement in the economic factor will enhance the level of the education, and guaranty health and security.

The coefficient of LNREC was positive and insignificant, meaning that the renewable energy consumption has not a significant impact on improving the Human Development Index or the REC is inelastic to HDI. The same result was found in the studies of **Wang et al. (2018)** and **Ouedraogo (2013)**. Consequently, the energy cannot contribute to the human development process, which may be due to the reason that the use of renewable energy is inefficient for socio-economic purpose and it won't affect considerably the level of human health, education and generation of income. Also, Algeria is relying on energy consumption to expanse its socio-economic situation and to attain the sustainable development in the future. Indeed, the energy in all forms is important for modern technologies and for the economic growth as well, but, it is also vital for certain basic activities in daily life of the population such as lighting, refrigeration and the running of household appliances.

The sign of $LNCO_2$ was positive and significant, so an increase by 1 unit in this variable may upsurge the elasticity of HDI by 0.071, this finding appears very strange, because logically the pollution gas affect negatively the well-being of the population, so we can say in this case that the environmental factor is helpful to improve the human development in Algeria, which may occur due to the reason that growing carbon dioxide emissions imposed policy makers to focus on clean energy. It may also be the reason of the positive role of the carbon dioxide emissions in the Human Development Index, so more production of clean energy will improve the level of the HDI. This result can be justified as it may be possible that green energy initiative by taken up and this has been taken due to the growing amount of carbon emissions in Algeria, which imposed the policymakers to introduce green energy initiatives, to get healthier Human Development Index results. This result is in line with the main literature of **Wang et al. (2018).**

3.4. The renewable energy deployment model:

- The 1st equation:

$$CREES_t = -0.345 + 0.012 * IV_t - 0.094 * \mathrm{EI}_t - 0.026 * PS_t + 0.109 * RI_t + 0.088 * \mathrm{Kyoto}_t - 0.027 * \mathrm{Paris}_t + 6.694 * RVGDP_t - 10.616 * \mathrm{RVCO2}_t + 18.813 * RVEU_t + e_{t1} \quad (30)$$

- The 2nd equation:

$$CREES_t = 0.213 - 0.127 * \mathrm{EI}_t - 0.014 * PS_t + 0.165 * RI_t + 0.084 * \mathrm{Kyoto}_t - 0.087 * \mathrm{Paris}_t + 8.708 * RVGDP_t - 0.377 * \mathrm{RVCO2}_t + 14.691 * RVEU_t + e_{t2} \quad (31)$$

- The 3rd equation:

$$CREES_t = -0.452 + 0.012 * IV_t - 0.014 * REP_t + 0.097 * \text{Kyoto}_t - 0.007 * \text{Paris}_t + 9.426 * RVGDP_t - 10.028 * \text{RVCO2}_t + 19.044 * RVEU_t + e_{t3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (32)$$

- **The coefficient and stability diagnostic:**

The 3 models have an acceptable statistic coefficient, the 1st equation have the R^2 equal to 0.774, indicating that 77.4% of exogenous variables explain the endogenous variable and 22.6% were explicated by other factors that are not determined in the model such as the technology factor, while the 2nd equation have the regression coefficient equal to 0.662, indicating that 66.2% of exogenous variables explain the endogenous variable and 43.8% were explicated by other factors that are not determined in the model. The 3rd equation has the R^2 equal to 0.723, showing that 72.3% of exogenous variables describe the CREES variable and 27.7% were explained by the extra variable that are not defined in this equation.

We showed also that the Fisher-statistic (estimated) was superior the fisher-statistic (table) at the level of 1%, indicating that we can't reject the alternative hypothesis and we can say that the model was globally significant and it can be used in the forecasting study.

The variation inflation factors indicated that all exogenous variables have a coefficient inferior to 10, indicating that we can reject the null hypothesis and we can accept the alternative hypothesis, so we can say that there's no multicollinearity in 3 equations.

The intercept coefficient is significant for the 2nd equation, so we applied the Ramsey Reset test to see if they're some omitted variables or not. We made 3 statistics test and we found that all of them are superior to the level of 1%, 5% and 10%, demonstrating that there are no omitted variables and the 2nd equation is well specified.

- **The residual diagnostic:**

We developed several residual diagnostic tests to see if the models have a lot of error or residual or not, because we are looking for the optimal model that contain a minimum of the errors.

We started with Box-Pierce and Ljung-Box tests to identify the processes without memory. Therefore, both tests indicate that the probability estimated in the 3 equations were superior to the level of 1%, 5% and 10%, showing that we can't reject the null hypothesis and we can say that the residual in both models follow a white noise process.

Then, we employed the Jarque and Bera test of normality, and we found that the probability estimated in the 3 equations were superior to the level of 1%, 5% and 10%, demonstrating that we can reject the alternative hypothesis, and we may accept the null hypothesis, so the residuals follow normality distribution.

After, we investigated if the 3 equations have a residual autocorrelation or not with the Breusch-Godfrey test. We established with the test that the probability estimated in both models were superior to the level of 1%, 5% and 10% from (e_{t-1}) to (e_{t-4}), so we excluded the alternative hypothesis, and we can say that there's no autocorrelation between residuals.

The last test is the detection of the heteroscedasticity in the 3 equations with Breusch-Pagan-Godfrey, Harvey and Glejser tests. Therefore, we accepted the null hypothesis in 3 equations for the Breusch-Pagan-Godfrey and Glejser test, but the Harvey test showed that there's heteroscedasticity and the variance are not constant in the time-series. However, in econometrics, we can't always reach the optimal model or the best model without any error, so in this case we accept the result of Breusch-Pagan-Godfrey and Glejser test, meaning that the residual variances are homoscedasticity.

- **Discussion:**

In the 1st equation, we found only two variables that are significant at the level of 5% and the rest of variables have no effect on the model. Therefore, the Institutional overall score has a positive and significant coefficient on CREES in the 1st and in the 3rd equation, so a rise by 1% in this variable can increase the level of CREES by 0.012% in both equations, meaning that the government institutions can participate to increase the level of renewable energy deployment and encourage the introduction of renewable energy in the Algerian energy system. Consequently, the control mechanism, division of material resource, subventions and development support applied by the government will support the introduction of renewable energy, and it may also encourage the investment incentives and innovations in this sector. However, the coefficient has a lower percentage on renewable energy introduction, because the conventional fossil fuel energy sources are still on average relatively less expensive. This result is in line with the studies of **Jenner et al. (2013)**, **Johnston et al. (2010)** and **Carley (2009)**.

The Kyoto was considered as the only variable in 3 equations that is significant at the level of 5% and 10%, so in the 1st equation, it can participate to increase the level of renewable energy contribution by 0.088%, in the 2nd equation by 0.084% and in the 3rd equation by 0.097%, demonstrating that the multilateral partnership, not only inside Algeria, but also between nations can be more valuable for promoting renewables deployment than policies at the national level because technology transfer and the pressure among the nobles to achieve the expected results, and the ratification of such protocol can push the country to look after high-quality renewables resources. The same findings have been found in the main literature of **Aguirre and Ibikunle (2014)** and **Popp et al. (2011)**. However, the Paris was not significant in 3 equations, meaning that Algeria is not concerned with the Paris agreement.

In the 2nd equation, the intercept term was positive and significant, meaning that the level of technology advancement or other factors that are not defined in the model may play a major role in the introduction of renewable energy in Algeria.

The sign of economic instruments was negative and significant at the level of 10%, so an increase by 1% in this variable can decrease the level of renewable energy introduction by 0.127%. This result appears very strange, because the Feed-in tariff, financial and fiscal support has usually a positive impact on the introduction of renewables in several countries, but in Algeria, it has a negative influence on the variable of CREES, so we can say that the diversification of Power Generation Costs (REFIT) in 2004 and the FIT on solar photovoltaic in 2014 were not good enough to develop the renewable energy deployment. This result is supported by **Nicolli and Vona (2016)**, **Aguirre and Ibikunle (2014)**, and **Popp et al. (2011)**.

The coefficient of regulatory instruments was positive and significant at the level of 10%, so this variable represents the institutionalization of markets in the form of codes and standards (especially RPS), it also attracts institutional investors, thus increase by 1% in this variable will upsurge the deployment of renewables by 0.165%, meaning that the plan of renewable energy promotion in the framework of sustainable development in 2004 was important for the introduction of renewable energy in Algeria, this proves that the solar photovoltaic and hydropower are becoming elements of a developed market based on mature technologies and it can compete with the fossil-fuel based electricity generation in certain areas. This outcome is in line with the studies of **Polzin et al. (2015)**, **Bolkesjø et al. (2014)**, **Jenner et al. (2013)** and **Menz and Vachon (2006)**.

In the 3rd equation, the realized volatility of gross domestic product has a positive and significant coefficient at the level of 10%, so a surge by 1% in RVGDP may raise the level of CREES by 9.426%, meaning that Algeria can produce more incentivized energy and it may lead to the development of renewables, so when the country has a large financial resource (it's not the case of Algeria), it will allow funding for research and development, which could be used in more efficient technologies and make the renewables more competitive. The same findings have been found in the main literature of **Nicolli and Tavoni (2017)**, **Bolkesjø et al. (2014)** and **Popp et al. (2011)**.

We also found that there's no relationship between CO_2 emissions and the promotion of renewable energy in Algeria. In line with **Ata (2016)** who found that the carbon emissions don't support the introduction of renewable energy. Also, the realized volatility of energy use was not significant, indicating that there's inefficiency in energy consumption.

The policy cluster (REP) was insignificant, demonstrating that the Algerian energy policy as whole, which are applied right now are inadequacy to surge the contribution share of renewable energy in the total energy supply, due to the high cost of renewable energy technology, such as the large-scale solar photovoltaic installations, solar thermal and onshore wind. But, according to several researchers, the energy policy can play a key role in the introduction of renewable capacity and they cannot compete with the traditional energy technologies without having a support from such policies.

Therefore, the renewable energy technologies, which are very expensive, cannot compete with the fossil fuel technologies and its prices at the moment, because there's an absence of supporting policies and limited portfolio, especially in Algeria. Also, the economic instruments were negatively linked with the renewables contribution. This is an astonishing outcome since the primary objective of FIT, financial and fiscal support is to financially improve renewables.

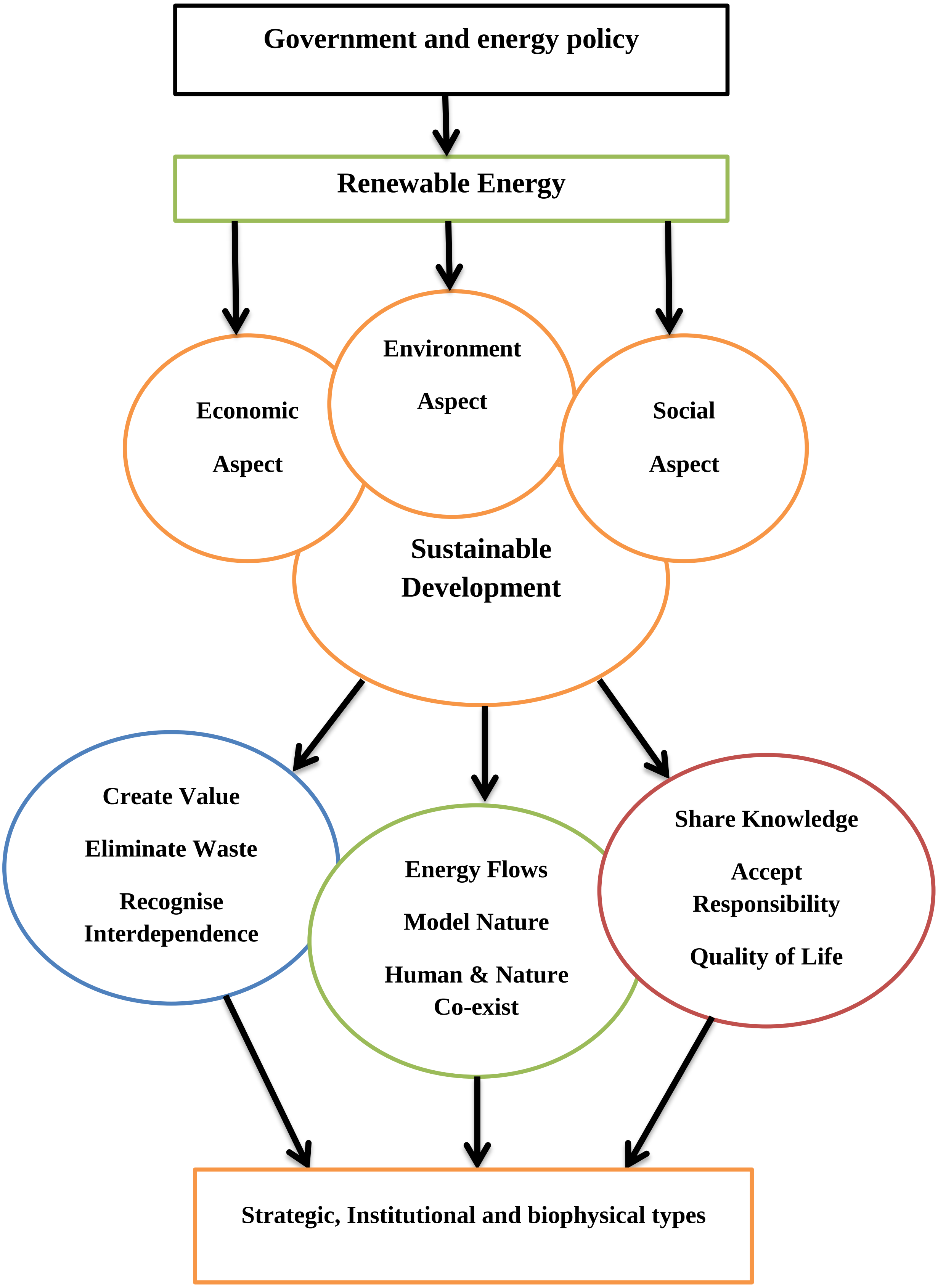
The analysis proved that the variable of government institutions are supporting the deployment of renewable energy, but, some public policy have not a significant impact on the introduction of renewable energy in the energy system of Algeria.

We also showed that the Algerian energy policy needs to shift some of its current policy and economic support, because some of renewable energy policies were affecting negatively the variable of the contribution of renewable energy to total energy supply and others were insignificant, indicating that the renewable energy situation in Algeria won't improve with the application of such energy policy (Feed-In Tariff policy, institutional creation and research & development). However, the sign of the government institutions was positive, indicating that with the introduction of renewable energy, the socio-economic situation will be stabilized and improved.

Also, such outcome can support the country in the climate policy modelling literature that the technological change may play a lesser role than policy-induced substitution. Their evidence, therefore suggests that the countries should adopt a stricter policies to promote their investment in renewable energy technology.

All in all, the results from 4 models can be summarised in the following figure:

Figure 04: Sustainable development structure



Source: Done by the researchers

This display demonstrates that the government institution (institutional) and the energy policy have a direct effect on the renewable energy introduction and the realisation of goal number 7 of sustainable development (Ensure access to affordable, reliable, sustainable and modern energy for all). Also, such energy can have a major impact on the economic, environment and social aspect, as it can be the pillar of sustainable development term. With the implementation of renewables, the country can reach the economic objectives like the goals number 1, 2 8, 9 and 12 (End Poverty in all its forms everywhere, end hunger, achieve food security and improved nutrition and promote sustainable agriculture, promote sustained, inclusive and sustainable economic growth, full productive employment and decent work for all, build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation and ensure sustainable consumption and production patterns), the environment objectives such as goals number 6, 13, 14 and 15 (Ensure availability and sustainable management of water and sanitation for all, take urgent action to combat climate change and its impacts, conserve and sustainably use the oceans, seas and marine resources for sustainable development and protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss), and the social objectives as goals number 3, 4, 5, 10, and 11 (Ensure health lives and promote well-being for all at all ages, ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, achieve gender equality and empower all women and girls, reduce inequality within and among countries and Make cities and human settlements inclusive, safe, resilient and sustainable). Therefore, such objectives can strengthen and reinforce the cultural, organisational, personal, political, legal, economic and socio-cultural dimensions of Algerian system.

Conclusion of Chapter

We made several models and analysis with different variables, including the natural logarithmic variables, the volatility variables and per capita variables to study the role and the importance of renewable energy on sustainable development factors.

In the first model, we investigated the relationship between renewable energy consumption and gross domestic product, and we found that the economic factor of sustainable development and the renewable energy consumption have a close relationship, so an increase in one variable will rise the level of the other variable, but this link was not confirmed by the Granger causality, indicating a neutrality hypothesis between these two variables and confirming that Algeria is still relying on fossil fuel energy to expanse its economic growth and improve its industrial production.

In the 2nd model, we established that the variable of economic growth will increase the level of carbon dioxide emissions, indicating that Algeria is still depending on combustible and fossil fuel that release a lot of carbon in the atmosphere and it approves the neutrality hypothesis between REC and GDP. However, we found that the use of renewable energy in Algeria can decrease the level of carbon dioxide emissions, and this result indicates the importance to include this source of energy in Algeria and its importance to mitigate the environmental issue. We also found that there's no evidence of Environment Kuznets Curve hypothesis, because the country is still depending on source that emit a high quantity of pollution.

In the 3rd model, we recognized that the level of carbon dioxide and the renewable energy consumption can decrease the level of Human Development Index, because such contamination and combustible renewables (especially biomass) can create health problems like skin cancer, respiratory issue…etc. Also, per capita gross domestic product had a positive sign on the Human Development Index, indicating that Algeria is going to shift its economic growth development and its energy dependence to focus more on socio-economic development. Therefore, Algeria needs to improve the access of adequate energy, health and education service to reach the sustainable development, which is crucial for the economic growth, human development and for the fight against climate change.

In the 4th model, we studied the role of energy policy and the government institutions (institutional) on the introduction of renewable energy in Algeria and we found that the deployment of renewables has everything to be successful, both in the reducing the global warming, and mitigating the use of classical energy dependence. However, they suggested that the opportunity cost of supporting renewables has been too high and it's maybe due to the high cost of renewable energy technology and the implementation of new deployment policy. Also, it is likely that the high costs of promoting renewable sources are being placed excessively upon the economy, namely by increasing tariffs for electricity, and this induces an economically counterproductive effect and a deceleration in economic activity since renewable sources increase production costs.

General Conclusion

The renewable energies are taking a central interest in the World Economy, and they are playing a key role in the recognition of sustainable development goals, so they can give added-value to the economic sector by satisfying the increasing energy demand, mitigating the effect of pollution and the surplus release of greenhouse gases and also improve the level of well-being of the population.

However, such energies are facing big challenges and difficulties, such as the market failures, trade problem, and economic barriers, which are considered as the main problems of renewables integration in the energy supply. They are also several inconvenient of adapting the renewables in any energy system, like the production efficiency and the cost of the technological innovation, which are representing the main issues of such energies.

Several studies examined the relationship between renewable energy (consumption and production), the economic factor of sustainable development defined as per capita gross domestic product, the environmental factor of sustainable development determined by CO_2 emissions or GHG emissions, the social factor of sustainable development in the Human Development Index, and the role of energy policy (RPS, tender, carbon tax) and the government on the renewable energy introduction. Also, such investigations displayed the importance to include the renewable energies in the energy system and their role to reach the sustainable development goals.

The renewable energy-economic growth nexus has been examined in many ways by using different methodologies to investigate the positive or the negative effect of renewable energy in reaching the goals of economic aspect. In this study, we found that an increase in renewable energy consumption will raise the level of the economic factor, and at the same time, we established that the per capita GDP has a positive impact on renewable energy consumption, however, this relationship was not approved by the Granger causality, indicating a neutrality hypothesis in Algeria.

The relationship between the pollution factor, economic growth and the renewables was emphasized by many researchers who tested mainly the (EKC) hypothesis. In this paper, we found that there’s no evidence of Environment Kuznets Curve hypothesis, because the country is still depending on source that emit a high quantity of pollution. Also, in the short-term, we established that there’s bidirectional causality between carbon emissions and GDP, and there’s a one-way causality running from renewable energy consumption to carbon emissions, but in the long-run, we found only that there's a one-way causality running from per capita GDP to per capita CO_2.

Furthermore, we studied the link amongst renewable energy, economic growth, CO_2 and Human Development Index, and to demonstrate the importance of including renewables on the social aspect. Several investigators found that an increase in renewable energy and in GDP, while a decrease in CO_2 emissions can enhance the level of human development by improving the sector of education and the well-being of the population. However, in our findings, we established that the renewable energy will decrease the level of the HDI, indicating that Algerian population is still depending on combustible and traditional renewables, especially biomass for certain basic activities in daily life such as lighting, refrigeration and the running of household appliances.

We also reviewed the importance of the government institutions and the energy policy on renewable energy deployment. Therefore, according to many studies, we found that the policy support may improve to increase the share of renewable energy in energy supply in any country. However, in this study, we recognized that some of energy policies have an insignificant influence on renewable energy deployment, but the government index indicated that a small and positive impact on the renewable energy introduction.

We couldn't confirm our 1st or 2nd hypothesis, which stated that the renewable energy has a positive impact on sustainable development factors. From our outcomes, we established that the renewable energy had a positive effect on economic growth and a negative influence on the level of pollution (CO_2), but also on the level of HDI, so the renewable energy in Algeria can realize 2 out of 3 objectives of sustainable development. Besides, some energy policies applied until now to support the introduction of renewable energy were insignificant, but the institutional overall score had a positive impact on the introduction of renewable energy, therefore, we couldn't also confirm our 3rd hypothesis. Consequently, this study aimed at reducing the dependence towards the fossil fuel, and the level of CO_2 emissions or pollution air, and increase the total of primary energy to satisfy the future energy demand.

According to paper of **Stambouli (2011)**, Algeria is facing big challenges to ensure the sustainable development and renewable energy source, which require immediate attention, are to be taken into consideration, public awareness and acceptance, research and development, infrastructure development, education and outreach, government participation, technology-transfer and financial incentives.

Currently, Algeria is working on new projects that may secure its economies stability and the development of its industries, but, it can't realise it without consuming goods, services, and energies. Nowadays, any country that wants to become a world economic power can't reach it without consuming a huge quantity of energy, but some of this energy source is damaging the environment and the ecological habitat.

Moreover, the environment and the social stability represent the main topic of sustainable development and the challenge to create a new energy policy that will adapt to this term is very hard, especially, the energy security due to the decrease of some energy sources in the world. Nevertheless, the rise of renewable energy will lessen the emissions of greenhouse gas and carbon dioxide reliable with the Kyoto protocol and Paris conference demands. Since Algeria is very depended on conventional oil and gas resources, the renewable energy sources (now) seem to be the key supplier for the energy security supply and the sustainable economic growth.

On the other hand, the shift towards a more diversified economy, Algeria needs to move toward sustainable growth and create jobs. This does need to be done in a way that protects the most vulnerable by ensuring well defined and targeted compensation mechanisms. The Bank's global perspective, analytical expertise, knowledge and resources are shared with the Algerian government to support the country in the implementation of the reforms.

Algeria should also adopt the conservation energy policy, which will aim at the realization of sustainable development goals, respect the international agreements (Kyoto and Paris), and protect the non-renewable resources from shortage for the future generation. Therefore, the renewable energy is a good alternative for profitability and covering the deficit of the other energies. However, the country still cannot reach the objective of energy efficiency, because up till now, Algeria didn't applied a worthy energy policy, which it supposes to protect the exhaustible energy, especially the crude oil and improve the storage of energy.

Also, the Algerian energy policy needs to change its instruments supporting renewables that may increase the competition between different technologies to market creation policies. And the government should look after incentives and instruments, which support the promotion not only the cheapest and mature renewable energy technologies but also to create a market for renewables that will activate innovation effects and reduce the costs as well.

Consequently, to reach the sustainable development goals and the renewable energy introduction, Algeria needs to:

- Upsurge the part of renewable energy by 15% to 30% in 2030.
- Include the process of the technological transfer by introducing new energy concepts to allow the improvement of the Algerian industry;
- Launch projects for the production of electricity from renewable sources to increase the exportation and improve the trade balance, which is in critical situation;
- Diversify the energy resources and decrease the use of fossil-fuel energy;
- Build institutions and companies in the renewable energy domain to reduce the unemployment and inflation;
- Create national product based on renewable fuels;
- Reduce the dependence on fossil-fuel energy (Dutch Disease);
- Respect the long-term strategies and laws on renewable energy.

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Appendices

Appendix "A": The univariate study

i. Long memory test:

Table 12: Long memory test on per capita exogenous variables

Variables	"D" parameter of Robinson and Henry	"D" parameter of Geweke and Porter-Hudak	Method
CO_2	0.35*	0.47*	ARFIMA
LF	0.38*	0.501	ARFIMA/ARMA
EU	0.29*	0.46*	ARFIMA
FEC	0.34*	0.47*	ARFIMA
FEP	0.35*	0.526	ARFIMA/ARMA
GDP	0.32*	0.41*	ARFIMA
GDP^2	0.00007*	0.00006*	ARFIMA
GFCF	0.36*	0.519	ARFIMA/ARMA
REC	0.20*	0.26*	ARFIMA
REP	0.29*	0.40*	ARFIMA
Trade	-0.004	-0.005	ARMA

Source: Done on the Ox-Metrics 6.0

*, indicate that we can reject the null hypothesis of short memory process rather we accept the alternative hypothesis of a long memory process, because the coefficient of "d" $\in (0, 0.5)$. We verified these tests with OLS estimation on Eviews 9, if the sign of "d" was significant or not. However, we found that per capita GDP^2 cannot be performed with ARFIMA method, but with ARMA method.

ii. ARCH test:

Table 13: ARCH/GARCH or FIARCH/FIGARCH test on per capita exogenous variables

Variables	Model	Fisher statistic	LR test ($N*R^2$)
CO_2	ARFIMA (2,d,2)	0.09	0.09
LF	ARFIMA (2,d,2)	0.18	0.18
EU	ARFIMA (1,d,2)	0.01	0.01
FEC	ARFIMA (2,d,2)	0.01	0.01
FEP	ARFIMA (0,d,0)	0.44	0.44
GDP	ARFIMA (2,d,2)	0.000004	0.000004
GDP^2	ARMA (0,0)	0.003	0.003
GFCF	ARFIMA (2,d,2)	0.04	0.04
REC	ARFIMA (3,d,2)	0.01	0.01
REP	ARFIMA (3,d,2)	0.01	0.01
Trade	ARMA (0,0)	0.005	0.005

Source: Done on the EViews 9.

*, demonstrate that we accept the alternative hypothesis of existence of ARCH effect, but in this case we accepted the null hypothesis, so there's no ARCH effect on exogenous variables and we shall estimate the realized volatility with this formula:

$$\sigma = \sqrt{\frac{1}{T}\sum_{i=1}^{T}(r_i - \bar{r})^2}$$

σ is the realized volatility of series and r_i is the rated or yield series.

iii. Unit root test:

Table 14: Unit root test of logarithm natural (LN) GDP

LNGDP						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-0.628	-3.631*	Model 3	-0.384	-3.631*	I(1)
Model 2	-1.288	-3.509**	Model 2	-1.295	-3.509**	I(1)
Model 1	1.383	-3.352***	Model 1	1.501	-3.352***	I(1)

Source: made on EViews 9.

Table 15: Unit root test of per capita GDP

Per capita GDP						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-0.984	-3.952**	Model 3	-0.984	-3.953**	I(1)
Model 2	-1.193	-3.909**	Model 2	-1.193	-3.907***	I(1)
Model 1	0.355	-3.872***	Model 1	0.355	-3.872***	I(1)

Source: made on EViews 9.

Table 16: Unit root test of realized volatility (RV) of GDP

RVGDP						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-3.501*	…	Model 3	-3.809**	…	I(0)
Model 2	-3.778**	…	Model 2	-3.848***	…	I(0)
Model 1	-3.864***	…	Model 1	-3.925***	…	I(0)

Source: made on EViews 9.

Table 17: Unit root test of LNREC

LNREC						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-3.545*	-8.087***	Model 3	-3.545*	-5.937***	I(1)
Model 2	-3.184**	-8.455***	Model 2	-3.184**	-6.108***	I(1)
Model 1	-0.085	-8.651***	Model 1	-0.101	-6.275***	I(1)

Source: made on EViews 9.

Table 18: Unit root test of per capita REC

per capita REC						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-3.803**	-11.480***	Model 3	-3.803**	-6.474***	I(1)
Model 2	-3.597**	-11.233***	Model 2	-3.597**	-6.655***	I(1)
Model 1	-1.120	-10.725***	Model 1	-1.362***	-6.837***	I(1)

Source: made on EViews 9.

Table 19: Unit root test of RVREC

RVREC						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-4.214**	…	Model 3	-4.214**	…	I(0)
Model 2	-4.313***	…	Model 2	-4.315***	…	I(0)
Model 1	-4.430***	…	Model 1	-4.431***	…	I(0)

Source: made on EViews 9.

Table 20: Unit root test of $LNCO_2$

$LNCO_2$						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-6.112***	-3.344*	Model 3	-3.266*	-3.488*	I(1)
Model 2	0.945	-3.183**	Model 2	…	-3.263**	I(1)
Model 1	-1.907*	-2.678**	Model 1	…	-2.733***	I(1)

Source: made on EViews 9.

Table 21: Unit root test of per capita CO_2

per capita CO_2						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-5.021***	-3.297*	Model 3	-2.854	-3.609*	I(1)
Model 2	1.149	-3.118**	Model 2	…	-3.201**	I(1)
Model 1	2.262	-2.590**	Model 1	…	-2.641**	I(1)

Source: made on EViews 9.

Table 22: Unit root test of $RVCO_2$

$RVCO_2$						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-1.331	…	Model 3	-2.930	…	I(0)
Model 2	-1.995	…	Model 2	-2.513	…	I(0)
Model 1	-2.302**	…	Model 1	-2.598**	…	I(0)

Source: made on EViews 9.

Table 23: Unit root test of LNHDI

LNHDI								
Phillips-Perron				Augmented Dickey-Fuller				
Models	lvl	1st dif	2nd dif	Models	Lvl	1st dif	2nd dif	Decision
M 3	0.567	-2.103	-3.741**	M 3	-0.222	-3.082	-3.719**	I(2)
M 2	…	-0.880	-3.704**	M 2	-2.606	…	-3.704**	I(2)
M 1	…	-1.329	-3.654***	M 1	-1.680	…	-3.654***	I(2)

Source: made on EViews 9.

Table 24: Unit root test of RVFEC

RVFEC						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-1.456	…	Model 3	-1.559	…	I(0)
Model 2	-2.031	…	Model 2	-2.014	…	I(0)
Model 1	-2.298**	…	Model 1	-2.755***	…	I(0)

Source: made on EViews 9.

Table 25: Unit root test of RVGFCF

RVGFCF						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-3.232	…	Model 3	-2.21	…	I(0)
Model 2	-2.766*	…	Model 2	-2.772*	…	I(0)
Model 1	-2.825***	…	Model 1	-2.814***	…	I(0)

Source: made on EViews 9.

Table 26: Unit root test of RVLF

RVLF						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-7.292***	…	Model 3	-2.519	…	I(0)
Model 2	-7.454***	…	Model 2	-1.890	…	I(0)
Model 1	-5.026***	…	Model 1	-5.170***	…	I(0)

Source: made on EViews 9.

Table 27: Unit root test of RVTrade

RVTrade						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-4.964***	…	Model 3	-4.849***	…	I(0)
Model 2	-4.907***	…	Model 2	-4.882***	…	I(0)
Model 1	-5.036***	…	Model 1	-5.006***	…	I(0)

Source: made on EViews 9.

Table 28: Unit root test of RVEU

RVEU						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-12.491(/)	…	Model 3	-4.968(/)	…	I(0)
Model 2	…	…	Model 2	…	…	I(0)
Model 1	…	…	Model 1	…	…	I(0)

Source: made on EViews 9.

Table 29: Unit root test of RVFEP

RVFEP						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-2.508	…	Model 3	-2.600	…	I(0)
Model 2	-2.748*	…	Model 2	-2.812*	…	I(0)
Model 1	-2.847***	…	Model 1	-2.882***	…	I(0)

Source: made on EViews 9.

Table 30: Unit root test of RVREP

RVREP						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-3.560*	…	Model 3	-3.697**	…	I(0)
Model 2	-3.645**	…	Model 2	-3.712**	…	I(0)
Model 1	-3.750***	…	Model 1	-3.810***	…	I(0)

Source: made on EViews 9.

Table 31: Unit root test of $RVGDP^2$

$RVGDP^2$						
Phillips-Perron			Augmented Dickey-Fuller			
Models	On level	1st difference	Models	On level	1st difference	Decision
Model 3	-4.640***	…	Model 3	-4.628***	…	I(0)
Model 2	-4.588***	…	Model 2	-4.587***	…	I(0)
Model 1	-4.706***	…	Model 1	-4.706***	…	I(0)

Source: made on EViews 9.

(***), (**), (*) Show that the null hypothesis would be rejected respectively at 1%, 5% or 10%, so there's no existence of unit root. However, the variables of HDI and CO_2 have an insignificant trend, so we made the stationary series with differency stationary. But, the

RVEU had a significant trend, so we avoided this deterministic trend and created RVEU without trend.

Appendix "B": The renewable energy-economic growth model

Table 32: VAR lag order selection criteria

Lag	AIC	SC	HQ
0	-19.193	-18.797	-19.139
1	-22.814	-22.220	-22.732
2	-23.032*	-22.241*	-22.923*
3	-22.866	-21.877	-22.730
4	-22.823	-21.636	-22.659

Source: made on EViews 9.

*, indicate the optimal lag length according to Akaike, Schwarz and Hannan-Quinn criterion.

Table 33: Johansen cointegration test

Unrestricted cointegration rank test (Trace)			
Eigenvalue	**λ_{trace} statistic**	**5% critical value**	**Probability**
0.571*	18.487*	15.494	0.017
0.074	1.556	3.841	0.212
Unrestricted cointegration rank test (Maximum Eigenvalue)			
Eigenvalue	**Max-Eigen statistic**	**5% critical value**	**Probability**
0.571*	16.931*	14.264	0.018
0.074	1.556	3.841	0.212

Source: made on EViews 9.

*, indicate that we can't reject the alternative hypothesis.

Table 34: ARDL bounds test for (LNGDP)

F-statistic	6.001**	
The bonds critical value		
10% (*)	4.04	4.78
5% (**)	4.94	5.73
2,5% (***)	5.77	6.68
1% (****)	6.84	7.84

Source: made on EViews 9.

Table 35: ARDL bounds test for (LNREC)

F-statistic	8.838****	
The bonds critical value		
10% (*)	4.04	4.78
5% (**)	4.94	5.73
2,5% (***)	5.77	6.68
1% (****)	6.84	7.84

Source: made on EViews 9.

*, **, ***, ****, demonstrate that we can reject the null hypothesis at level of 10%, 5%, 2.5% and 1%.

Table 36: ARDL (2, 1) estimation for (LNGDP)

Variables	**Coefficient**	**t-statistic**	**Probability**
$LNGDP_{t-1}$	0.252	0.874	0.400
$LNGDP_{t-2}$	0.598**	2.352	0.038
LNREC	0.104**	2.362	0.037
$LNREC_{t-1}$	0.135**	2.502	0.029
RVFEC	124.594**	3.031	0.011
RVGFCF	22.910	1.382	0.193
RVLF	-272.653	-1.217	0.248
RVTrade	-0.005	-0.267	0.793
Intercept	6.121**	3.288	0.007

Source: made on EViews 9.

Table 37: Cointegrating form for (LNGDP)

Variables	Coefficient	t-statistic	Probability
$DLNGDP_{t-1}$	110.485***	434.427	0
DLNREC	9.742***	220.435	0
DRVFEC	0.0102	0.0002	0.999
DRVGFCF	0.088	0.005	0.995
DRVLF	-10.616***	-477.787	0
DRVTrade	6.694	0.029	0.976
et_{-1}	-112.565***	-1434.420	0

Source: made on EViews 9.

Table 38: Long run coefficients for (LNGDP)

Variables	Coefficient	t-statistic	Probability
LNREC	0.087***	150.667	0
RVFEC	0.00009	0.0002	0.999
RVGFCF	0.0007	0.005	0.995
RVLF	-0.094***	-549.301	0
RVTrade	0.059	0.029	0.976
Intercept	0.167***	10.154	0

Source: made on EViews 9.

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Table 39: ARDL (1, 2) estimation for (LNREC)

Variables	Coefficient	t-statistic	Probability
$LNREC_{t-1}$	-0.422	-1.195	0.256
LNGDP	3.223**	2.362	0.037
$LNGDP_{t-1}$	0.684	0.415	0.685
$LNGDP_{t-2}$	-3.155*	-2.179	0.051
RVFEC	-444.613	-1.590	0.140
RVGFCF	-108.475	-1.153	0.273
RVLF	784.881	0.601	0.559

RVTrade	0.048	0.396	0.699
Intercept	-35.289	-3.541	0.004

Source: made on EViews 9.

Table 40: Cointegrating form for (LNREC)

Variables	**Coefficient**	**t-statistic**	**Probability**
$DLNGDP_t$	3.223**	2.362	0.037
$DLNGDP_{t-1}$	3.155*	2.179	0.051
DRVFEC	-444.613	-1.590	0.140
DRVGFCF	-108.475	-1.153	0.273
DRVLF	784.881	0.601	0.559
DRVTrade	0.048	0.396	0.699
et_{-1}	-1.422**	-4.024	0.002

Source: made on EViews 9.

Table 41: Long run coefficients for (LNREC)

Variables	**Coefficient**	**t-statistic**	**Probability**
LNGDP	0.529*	2.109	0.058
RVFEC	-311.792*	-2.037	0.066
RVGFCF	-76.241	-1.074	0.305
RVLF	551.652	0.629	0.541
RVTrade	0.034	0.404	0.693
Intercept	-24.803***	-12.349	0

Source: made on EViews 9.

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

1) **Coefficient and stability diagnostic:**

Table 42: Variance inflation factors for (LNGDP)

Variables	**Centered VIF**
$LNGDP_{t-1}$	40.898
$LNGDP_{t-2}$	34.039
$LNREC_{t}$	1.510*
$LNREC_{t-1}$	2.247*
$RVFEC_{t}$	2.499*
$RVGFCF_{t}$	2.481*
$RVLF_{t}$	1.629*
$RVTrade_{t}$	1.181*
C	N/A

Source: made on EViews 9

*, means that the coefficient is inferior to 10.

Table 43: Ramsey Reset test for (LNGDP)

Test	**Value**	**df**	**probability**
t-statistic	0.243	10	0.812
F-statistic	0.059	(1, 10)	0.812
F-statistic	0.026	(2, 9)	0.973

Source: made on EViews 9

Table 44: Variance inflation factors for (LNREC)

Variables	**Centered VIF**
$LNREC_{t-1}$	3.121*
$LNGDP_{t}$	27.414
$LNGDP_{t-1}$	43.064
$LNGDP_{t-2}$	35.736
$RVFEC_{t}$	3.729*
$RVGFCF_{t}$	2.600*
$RVLF_{t}$	1.297*

$RVTrade_t$	1.616*
C	N/A

Source: made on EViews 9

*, means that the coefficient is inferior to 10.

Table 45: Ramsey Reset test for (LNREC)

Test	Value	df	probability
t-statistic	0.002	10	0.998
F-statistic	$4.98*10^{-6}$	(1, 10)	0.998
F-statistic	3.994	(2, 9)	0.057

Source: made on EViews 9

2) **Residual diagnostic:**

Table 46: Box-Pierce and Ljung-Box test for (LNGDP)

Lag	Q statistic	Probability
12	15.925	0.195
Lag	**Q statistic (residuals squared)**	**probability**
12	11.471	0.489

Source: made on EViews 9

Table 47: Box-Pierce and Ljung-Box test for (LNREC)

Lag	Q statistic	Probability
12	8.696	0.729
Lag	**Q statistic (residuals squared)**	**probability**
12	8.136	0.774

Source: made on EViews 9

Table 48: Normality test for (LNGDP)

Skewness Value	Kurtosis Value	Jarque-Bera Value	Prob. J-B
-0.333	3.995	1.197	0.549

Source: made on EViews 9

Table 49: Normality test for (LNREC)

Skewness Value	Kurtosis Value	Jarque-Bera Value	Prob. J-B
0.318	3.367	0.449	0.798

Source: made on EViews 9

Table 50: Autocorrelation test for (LNGDP)

Lag	F- statistic	Prob. F	LR-statistic	Prob. LR
1	0.019	0.893	0.037	0.845
2	0.781	0.486	2.959	0.227
3	0.489	0.699	3.102	0.376
4	0.433	0.781	3.971	0.409

Source: made on EViews 9

Table 51: Autocorrelation test for (LNREC)

Lag	F- statistic	Prob. F	LR-statistic	Prob. LR
1	0.105	0.756	0.201	0.653
2	0.219	0.807	0.930	0.628
3	0.578	0.645	3.566	0.312
4	0.567	0.694	4.899	0.297

Source: made on EViews 9

Table 52: Heteroscedasticity test for (LNGDP)

Tests	Fisher	Prob. F	LR	Prob. LR	Scaled explained	Prob. SS
Breusch-Pagan-Godfrey	0.515	0.822	5.449	0.708	2.469	0.963
Harvey	1.474	0.269	10.349	0.241	14.964	0.059
Glejser	0.709	0.680	6.808	0.557	4.910	0.767

Source: made on EViews 9

Table 53: Heteroscedasticity test for (LNREC)

Tests	Fisher	Prob. F	LR	Prob. LR	Scaled explained	Prob. SS
Breusch-Pagan-Godfrey	1.361	0.310	9.949	0.268	3.562	0.894
Harvey	1.290	0.339	9.683	0.288	7.841	0.449
Glejser	1.198	0.380	9.313	0.316	5.602	0.691

Source: made on EViews 9

Appendix "C": Carbon dioxide emissions-economic growth-renewable energy consumption model

Table 54: The selection lag criterion

Lag	AIC	SC	HQ
0	-50.913	-49.869	-50.736
1	-55.018	-53.527	-54.765
2	-56.456	-54.517	-56.128
3	-62.232*	-59.846*	-61.829*

Source: made on EViews 9

*, indicate the optimal lag for the VAR model.

Table 55: Johansen cointegration test

1st model specification			
Unrestricted cointegration rank test (Trace)			
Eigenvalue	**λ_{trace} statistic**	**5% critical value**	**Probability**
0.845	46.285*	24.275	0
0.433	10.825	12.320	0.087
0.001	0.023	4.129	0.900
Unrestricted cointegration rank test (Maximum Eigenvalue)			
Eigenvalue	**Max-Eigen statistic**	**5% critical value**	**Probability**
0.845	35.459*	17.797	0
0.433	10.802	11.224	0.059

0.001	0.023	4.129	0.900

2nd model specification			
Unrestricted cointegration rank test (Trace)			
Eigenvalue	**λ_{trace} statistic**	**5% critical value**	**Probability**
0.996	142.769*	35.192	0
0.822	34.618*	20.261	0
0.088	1.755	9.164	0.825
Unrestricted cointegration rank test (Maximum Eigenvalue)			
Eigenvalue	**Max-Eigen statistic**	**5% critical value**	**Probability**
0.996	108.150*	22.299	0
0.822	32.862*	15.892	0
0.088	1.755	9.164	0.825

3rd model specification			
Unrestricted cointegration rank test (Trace)			
Eigenvalue	**λ_{trace} statistic**	**5% critical value**	**Probability**
0.995	135.398*	29.797	0
0.822	33.554*	15.494	0
0.038	0.751	3.841	0.386
Unrestricted cointegration rank test (Maximum Eigenvalue)			
Eigenvalue	**Max-Eigen statistic**	**5% critical value**	**Probability**
0.995	101.843*	21.131	0
0.822	32.803*	14.264	0
0.038	0.751	3.84	0.386

Source: made on EViews 9.

*, indicate that we can’t reject the alternative hypothesis.

Table 56: The VECM optimal

VECM Models	Akaike criterion	Schwarz criterion
1st model	-55.216	-55.128
2nd model	-61.930	-59.444
3rd model	-61.877	-59.342

Source: made on EViews 9.

Table 57: The VECM restricted

Cointegration restriction	Chi-square (2)	Probability
A(1,1)=0	$1.89*10^{-8}$	1
A(1,2)=0	$1.70*10^{-8}$	1
A(2,1)=0	$3.58*10^{-8}$	1
A(2,2)=0	$3.55*10^{-8}$	1
A(3,1)=0	$3.49*10^{-8}$	1
A(3,2)=0	12.095	0.007
A(1,1)=0, A(1,2)=0	17.144	0.008
A(1,1)=0, A(2,1)=0	15.392	0.001
A(1,1)=0, A(2,2)=0	$3.75*10^{-8}$	1
A(1,1)=0, A(3,1)=0	0.177	0.981
A(1,2)=0, A(2,1)=0	$1.64*10^{-6}$	1
A(1,2)=0, A(2,2)=0	15.392	0.001
A(1,2)=0, A(3,1)=0	0.037	0.998
A(2,1)=0, A(2,2)=0	32.264	0
A(2,1)=0, A(3,1)=0	11.459	0.021
A(2,2)=0, A(3,1)=0	$3.88*10^{-8}$	1
A(1,1)=0, A(1,2)=0, A(2,1)=0	17.144	0.016
A(1,1)=0, A(2,2)=0, A(3,1)=0	0.177	0.996
A(1,2)=0, A(2,1)=0, A(2,2)=0	32.264	0

Source: Done on EViews 9.

Table 58: VECM estimation

Cointegrating equation	C.E. 1	C.E. 2	
GDP_{t-1}	1	0	
CO_{2t-1}	0	1	
REC_{t-1}	$-4.22*10^{12}$***	-931.420***	
t-statistic	-5.938	-5.728	
C	2452.788**	$-1.29*10^{-6}$***	
t-statistic	2.466	-5.684	
Error correction	**$DGDP_t$**	**$DCO2_t$**	**$DREC_t$**
C.E. 1	0.007	$-5.83*10^{-11}$***	$-2.03*10^{-13}$
t-statistic	0.034	-4.736	-0.358
C.E. 2	$-6.37*10^{8}$	0.265***	0.002
t-statistic	-0.605	4.618	0.788
$DGDP_{t-1}$	-1.392***	$1.99*10^{-10}$***	$3.95*10^{-13}$
t-statistic	-3.702	9.674	0.418
$DGDP_{t-2}$	-0.756**	$4.05*10^{-11}$**	$-7.62*10^{-14}$
t-statistic	-2.629	2.582	-0.105
DCO_{2t-1}	$5.27*10^{9}$***	0.150	0.0001
t-statistic	3.010	1.579	0.036
DCO_{2t-2}	$-1.52*10^{9}$	0.258***	-0.0005
t-statistic	-1.133	3.534	-0.167
$DREC_{t-1}$	$-2.62*10^{10}$*	-5.321	0.140
t-statistic	-1.745	-0.650	0.373
$DREC_{t-2}$	$-1.63*10^{11}$	-18.500***	-0.018
t-statistic	-1.448	-3.004	-0.065
$RVFEP_t$	-305048.683**	$3.35*10^{-5}$***	$-2.003*10^{-7}$
t-statistic	-2.510	5.053	-0.657
$RVFEC_t$	754209.079***	$4.40*10^{-5}$***	$2.71*10^{-7}$
t-statistic	5.018	5.367	0.720
$RVREP_t$	10665.55	$3.46*10^{-7}$	$3.15*10^{-8}$
t-statistic	0.950	0.565	1.118
$RVGDP^2_t$	0.399	$-1.94*10^{-11}$	$6.77*10^{-13}$

t-statistic	1.683	-1.495	1.139
$Kyoto_t$	391.348	$-3.11*10^{-8}$	$1.93*10^{-9}$**
t-statistic	1.126	-1.639	2.215
$Paris_t$	-1249.706***	$3.63*10^{-8}$	$-1.65*10^{-9}$
t-statistic	-3.066	1.630	-1.610

Source: Done on EViews 9.

Table 59: VECM (r) estimation

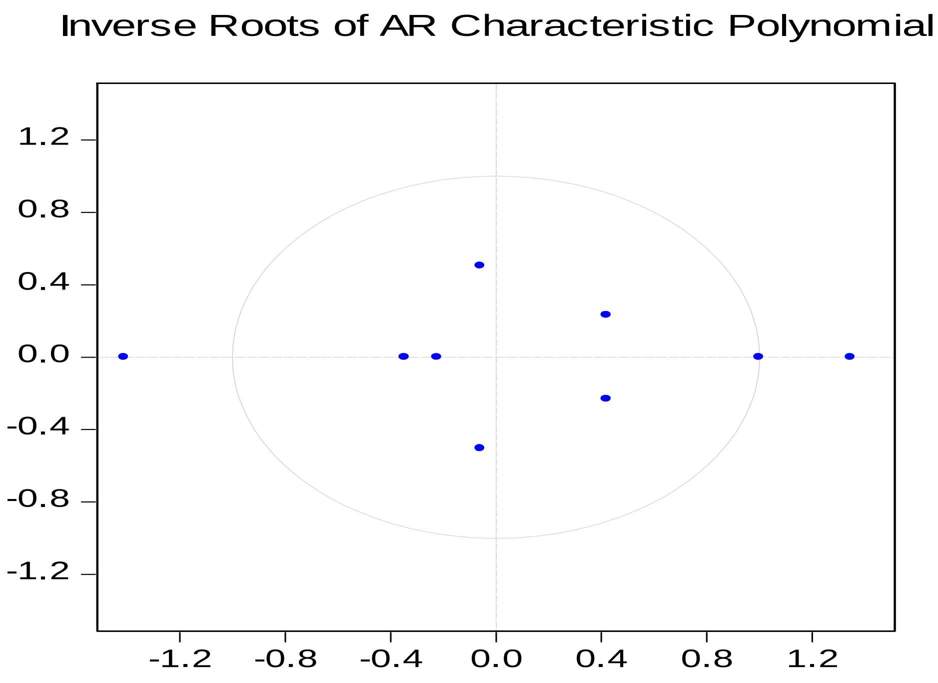
Cointegrating equation	**C.E. 1**	**C.E. 2**	
GDP_{t-1}	0.003	-0.001	
CO_{2t-1}	-16830620.898	11069512.034	
REC_{t-1}	32970740.193	$-5.75*10^{9}$	
C	30.835	-16.952	
Error correction	**$DGDP_t$**	**$DCO2_t$**	**$DREC_t$**
C.E. 1	-26.271	$-1.58*10^{-8}$***	N/A
t-statistic	-0.487	-15.321	N/A
C.E. 2	-97.467***	N/A	$1.88*10^{-10}$***
t-statistic	-3.927	N/A	6.976
$DGDP_{t-1}$	-1.392***	$1.99*10^{-10}$***	$3.95*10^{-13}$
t-statistic	-3.702	9.674	0.418
$DGDP_{t-2}$	-0.756**	$4.05*10^{-11}$**	$-7.62*10^{-14}$
t-statistic	-2.629	2.582	-0.105
DCO_{2t-1}	$5.27*10^{9}$***	0.150	0.0001
t-statistic	3.010	1.579	0.036
DCO_{2t-2}	$-1.52*10^{9}$	0.258***	-0.0005
t-statistic	-1.133	3.534	-0.167
$DREC_{t-1}$	$-2.62*10^{10}$*	-5.321	0.140
t-statistic	-1.745	-0.650	0.373
$DREC_{t-2}$	$-1.63*10^{11}$	-18.500***	-0.018
t-statistic	-1.448	-3.004	-0.065
$RVFEP_t$	-305048.683**	$3.35*10^{-5}$***	$-2.003*10^{-7}$
t-statistic	-2.510	5.053	-0.657
$RVFEC_t$	754209.079***	$4.40*10^{-5}$***	$2.71*10^{-7}$

t-statistic	5.018	5.367	0.720
$RVREP_t$	10665.55	$3.46*10^{-7}$	$3.15*10^{-8}$
t-statistic	0.950	0.565	1.118
$RVGDP^2_t$	0.399	$-1.94*10^{-11}$	$6.77*10^{-13}$
t-statistic	1.683	-1.495	1.139
$Kyoto_t$	391.348	$-3.11*10^{-8}$	$1.93*10^{-9}$**
t-statistic	1.126	-1.639	2.215
$Paris_t$	-1249.706***	$3.63*10^{-8}$	$-1.65*10^{-9}$
t-statistic	-3.066	1.630	-1.610

Source: Done on EViews 9.

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Figure 05: Autoregressive root graph



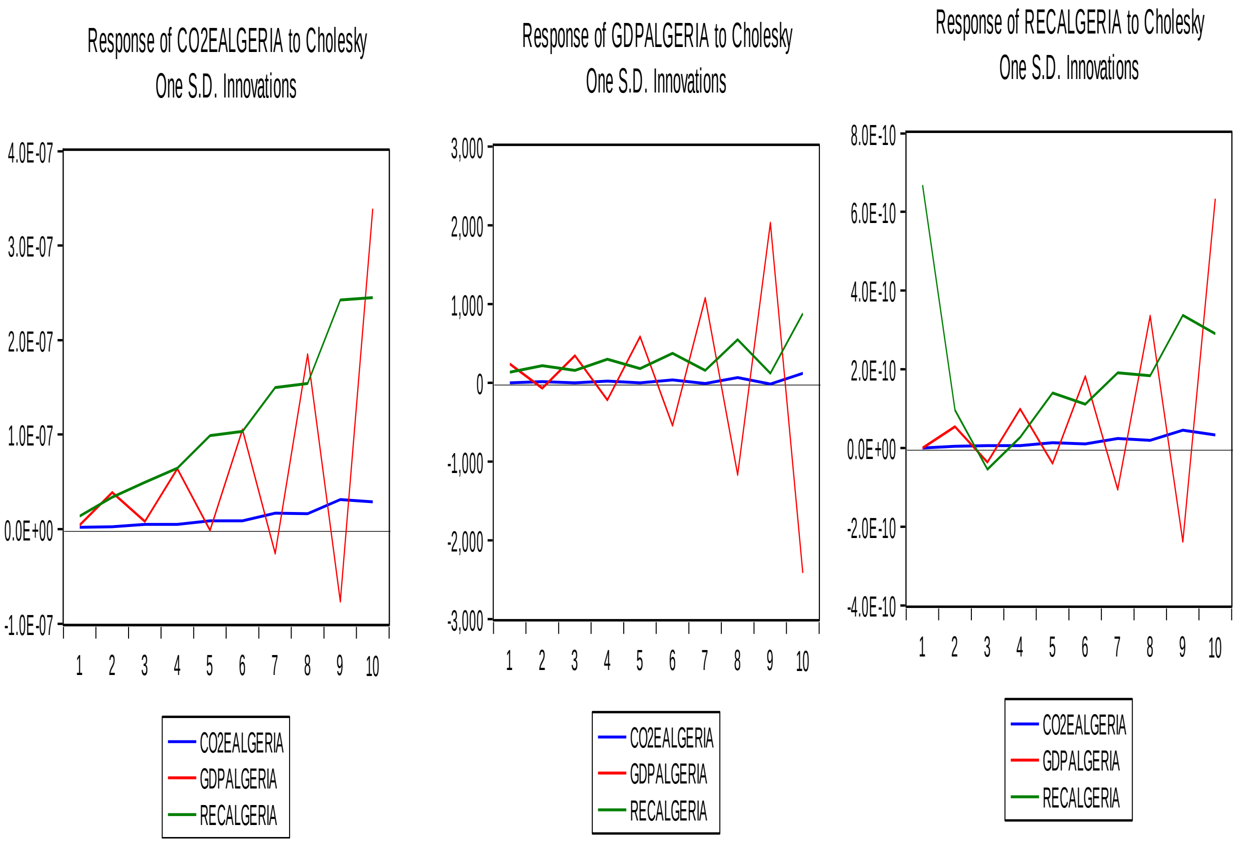
Source: done on EViews 9

Table 60: Multivariate normality tests

Component	Jarque-Bera	Prob
1	6.467	0.039
2	0.689	0.708
3	2.660	0.264
Joint	9.817	0.132

Source: Done on EViews 9

Figure 06: Impulse response with Cholesky decomposition



Source: Done on EViews 9.

Table 61: Impulse response to Cholesky of (CO_2)

Period	CO_2	GDP	REC
1	$1.72*10^{-9}$	$4.11*10^{-9}$	$1.39*10^{-8}$
2	$2.44*10^{-9}$	$3.86*10^{-8}$	$3.38*10^{-8}$
3	$4.74*10^{-9}$	$7.91*10^{-9}$	$4.96*10^{-8}$
4	$4.85*10^{-9}$	$6.36*10^{-8}$	$6.45*10^{-8}$
5	$9.02*10^{-9}$	$-1.04*10^{-9}$	$9.88*10^{-8}$

Source: Done on EViews 9

Table 62: Impulse response to Cholesky of (GDP)

Period	CO_2	GDP	REC
1	0	233.657	128.77
2	7.979	-70.809	214.073
3	-2.313	342.884	156.467
4	16.124	-225.012	297.622
5	-4.793	585.216	179.345

Source: Done on EViews 9

Table 63: Impulse response to Cholesky of (REC)

Period	CO_2	GDP	REC
1	0	0	$6.69*10^{-10}$
2	$3.86*10^{-12}$	$5.41*10^{-11}$	$9.68*10^{-11}$
3	$5.99*10^{-12}$	$-3.70*10^{-11}$	$-5.42*10^{-11}$
4	$5.35*10^{-12}$	$9.84*10^{-11}$	$2.71*10^{-11}$
5	$1.31*10^{-11}$	$-3.90*10^{-11}$	$1.40*10^{-10}$

Source: Done on EViews 9

Table 64: Variance decomposition (CO_2)

Period	GDP	CO_2	REC
1	7.965	1.400	90.635
2	52.872	0.313	46.815
3	29.069	0.581	70.35
4	41.154	0.403	58.443
5	23.911	0.58	75.509

Source: Done on EViews 9

Table 65: Variance decomposition (GDP)

Period	GDP	CO_2	REC
1	76.703	0	23.297
2	48.827	0.052	51.121
3	67.078	0.026	32.896
4	56.443	0.082	43.475
5	73.276	0.045	26.679

Source: Done on EViews 9

Table 66: Variance decomposition (REC)

Period	GDP	CO_2	REC
1	0	0	100
2	0.638	0.004	99.358
3	0.927	0.011	99.062
4	2.948	0.017	97.035
5	3.129	0.051	96.820

Source: Done on EViews 9

Appendix "D": Human Development Index-carbon dioxide emissions-economic growth-renewable energy consumption model

Table 67: The selection lag criterion for Human development model

Lag	AIC	SC	HQ
0	-4.997	-4.798	-4.963
1	-13.270	-12.276	-13.102
2	-15.317	-13.527	-15.014
3	-17.315*	-14.730*	-16.877*

Source: made on EViews 9

*, indicate the optimal lag for the VAR model.

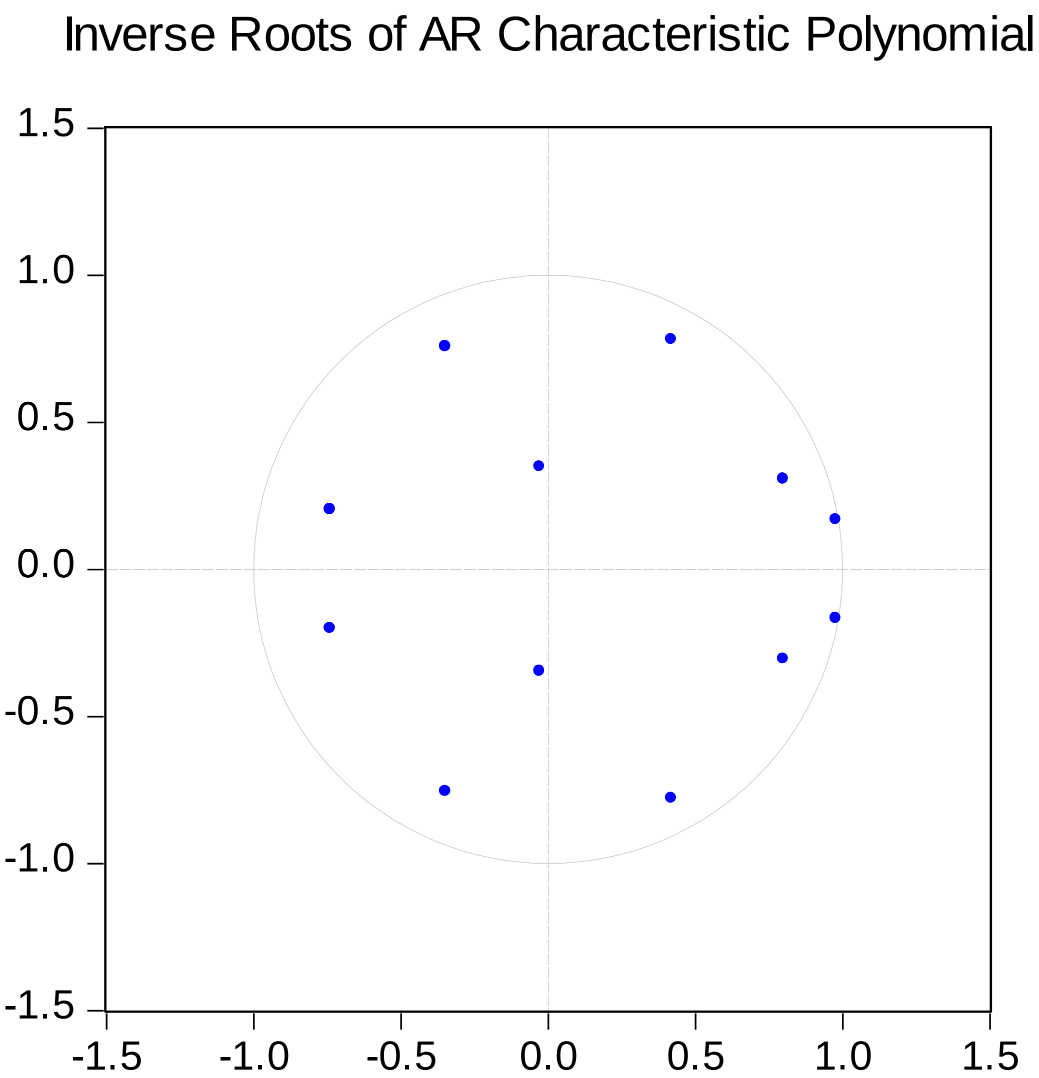
Table 68: VAR estimation

Variables	LNHDI	LNGDP	LNREC	$LNCO_2$
$LNHDI_{t-1}$	1.254	49.987	228.343	-3.147
t-statistic	4.423	1.668	1.479	-0.906
$LNHDI_{t-2}$	-1.028	-48.945	-431.807	3.334
t-statistic	-2.472	-1.112	-1.906	0.654
$LNHDI_{t-3}$	0.669	6.235	209.042	-0.073
t-statistic	2.832	0.249	1.626	-0.025
$LNGDP_{t-1}$	0.004	0.404	4.435	0.183
t-statistic	1.279	1.060	2.259	4.154
$LNGDP_{t-2}$	0.031	-0.376	-2.157	-0.091
t-statistic	4.921	-0.564	-0.628	-1.182
$LNGDP_{t-3}$	0.002	-0.446	-4.314	-0.008
t-statistic	0.416	-0.666	-1.250	-0.114
$LNREC_{t-1}$	-0.0006	0.017	-0.148	-0.016
t-statistic	-0.904	0.229	-0.369	-1.796
$LNREC_{t-2}$	-0.002	0.193	0.214	-0.021
t-statistic	-2.235	1.743	0.375	-1.680
$LNREC_{t-3}$	-0.005	0.155	-0.680	-0.001
t-statistic	-3.631	0.997	-0.847	-0.067

$LNCO_{2t-1}$	-0.142	2.150	-2.508	0.664
t-statistic	-3.757	0.537	-0.121	1.431
$LNCO_{2t-2}$	0.030	0.135	8.329	0.030
t-statistic	1.252	0.052	0.626	0.100
$LNCO_{2t-3}$	0.022	-1.027	5.172	0.098
t-statistic	1.450	-0.631	0.617	0.523
C	-1.652	37.356	126.647	-4.037
t-statistic	-4.105	0.877	0.578	-0.818

Source: Done on EViews 9.

Figure 07: Inverse root of AR characteristic polynomial



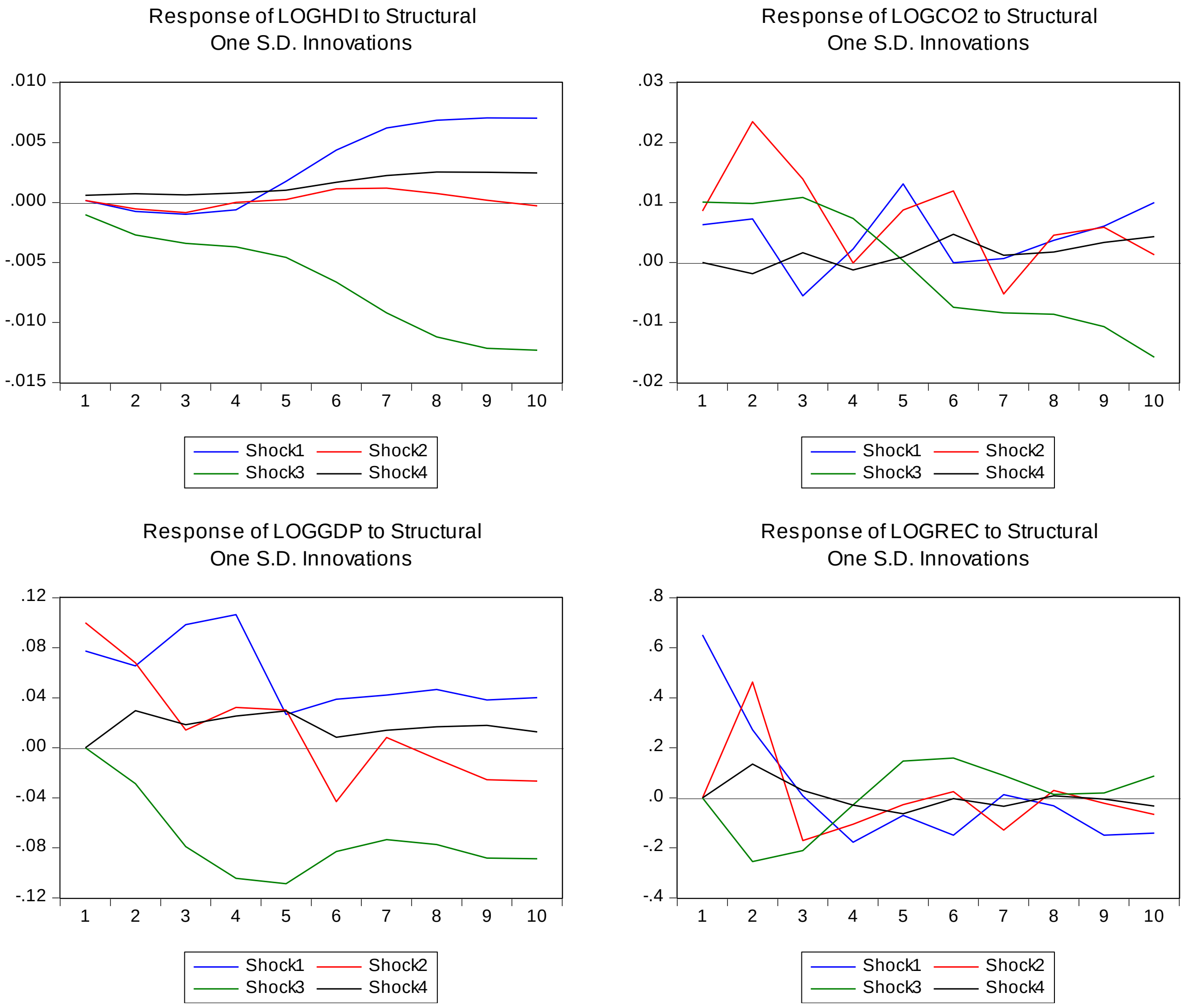
Source: Done on EViews 9.

Table 69: Multivariate normality tests

Component	Jarque-Bera	Prob
1	1.875	0.391
2	1.757	0.415
3	1.390	0.498
4	0.495	0.780
Joint	5.519	0.700

Source: Done on EViews 9.

Figure 08: Structural impulse response



Source: Made on EViews 9.

Table 70: Structural impulse response of LNHDI

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	0.0001	0.0001	-0.0010	0.0005
2	-0.0007	-0.0005	-0.0026	0.0007
3	-0.0009	0.0008	-0.0033	0.0006
4	-0.0006	$1.87*10^{-5}$	-0.0036	0.0008
5	0.0017	0.0002	-0.0045	0.0010

Source: Made on EViews 9.

Table 71: Structural impulse response of LNCO$_2$

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	0.0063	0.0085	0.0100	0
2	0.0072	0.0234	0.0098	-0.0018
3	-0.0055	0.0139	0.0108	0.0016
4	0.0022	$-8.67*10^{-5}$	0.0073	-0.0012
5	0.0130	0.0087	0.0003	0.0009

Source: Made on EViews 9.

Table 72: Structural impulse response of LNGDP

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	0.0774	0.0999	0	0
2	0.0655	0.0678	-0.0287	0.0295
3	0.0984	0.0142	-0.0790	0.0185
4	0.1064	0.0323	-0.1043	0.0253
5	0.0267	0.0301	-0.1087	0.0295

Source: Made on EViews 9.

Table 73: Structural impulse response of LNREC

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	0.6508	0	0	0
2	0.2720	0.4628	-0.2552	0.1351
3	0.0083	-0.1706	-0.2107	0.0297
4	-0.1775	-0.1056	-0.0284	-0.0289
5	-0.0703	-0.0273	0.1472	-0.0642

Source: Made on EViews 9.

Table 74: Structural variance decomposition of LNHDI

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	2.280	2.271	70.962	24.487
2	5.883	3.158	82.031	8.928
3	6.477	4.254	83.771	5.498
4	4.945	2.626	87.354	5.075
5	7.936	1.683	85.634	4.747

Source: Made on EViews 9.

Table 75: Structural impulse response of LNCO$_2$

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	18.544	34.337	41.119	0
2	10.063	67.995	21.564	0.3778
3	9.768	64.782	24.964	0.486
4	9.709	61.825	27.886	0.580
5	19.064	56.916	23.476	0.544

Source: Made on EViews 9.

Table 76: Structural impulse response of LNGDP

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	37.509	62.491	0	0
2	38.713	54.890	3.105	3.292
3	46.402	34.348	16.424	2.826
4	46.750	23.651	26.822	2.777
5	39.389	20.604	36.647	3.360

Source: Made on EViews 9.

Table 77: Structural impulse response of LNREC

Period	Shock 1	Shock 2	Shock 3	Shock 4
1	100	0	0	0
2	62.578	26.935	8.192	2.295
3	57.225	27.977	12.598	2.200
4	57.897	27.841	12.076	2.186
5	56.493	26.993	13.965	2.549

Source: Made on EViews 9.

Table 78: OLS estimation

Variables	Coefficient	t-statistic	probability	VIF
C	0.0124	0.0121	0.99	NA
LNGDP	0.1083***	5.185	0	1052.083
LNREC	-0.0100	-1.019	0.321	1533.112
$LNCO_2$	0.1136	1.715	0.103	27455.57

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: Made on EViews 9.

Table 79: Correlation matrix

Variables	LNCO2	LNGDP	LNHDI	LNREC
LNCO2	1	…	…	…
LNGDP	0.855	1	…	…
LNHDI	0.867	0.937	1	
LNREC	0.381	0.447	0.351	1

Source: Made on EViews 9.

Table 80: GMM estimation

Variables	**Coefficient**	**t-statistic**	**probability**
LNGDP	0.091***	6.550	0
LNREC	0.009	0.637	0.531
$LNCO_2$	0.071**	2.722	0.013

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: Made on EViews 9.

Table 81: Endogeneity test

Test	**Value**	**Probability**
Difference in J-stats	7.928**	0.0475

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: Made on EViews 9.

Table 82: Ljung-Box test

Lag	**Q statistic (residuals squared)**	**Probability**
12	12.288	0.423

Source: made on EViews 9

Table 83: Normality test for HDI model

Skewness Value	Kurtosis Value	Jarque-Bera Value	Prob. J-B
-0.622	3.107	1.433	0.488

Source: made on EViews 9

<u>Appendix "E":</u> The renewable energy deployment model

Table 84: The renewable energy deployment model

	1st equation			2nd equation			3rd equation		
Var	Coef	t-stat	Prob	Coef	t-stat	Prob	Coef	t-stat	Prob
C	-0.345	-1.506	0.157	0.213***	13.728	0	-0.452	-2.029	0.061
IV	0.012**	2.442	0.031	…	…	…	0.012**	2.967	0.010
EI	-0.094	-1.675	0.119	-0.127*	-1.998	0.067	…	…	…
PS	-0.026	-0.776	0.452	-0.014	-0.361	0.723	…	…	…
RI	0.109	1.406	0.185	0.165*	1.896	0.080	…	…	…
Kyoto	0.088**	2.314	0.039	0.084*	1.879	0.082	0.097**	2.518	0.0245
Paris	-0.027	-0.381	0.709	-0.087	-1.102	0.290	-0.007	-0.110	0.913
RVGDP	6.694	1.358	0.199	8.708	1.525	0.151	9.426*	1.987	0.066
$RVCO_2$	-10.616	-0.722	0.483	-0.377	-0.022	0.982	-10.028	-0.685	0.504
RVEU	18.813	1.413	0.182	14.691	0.946	0.361	19.044	1.515	0.151
REP	…	…	…	…	…	…	-0.014	-0.709	0.489
R^2	0.774	…	…	0.662	…	…	0.723	…	…
Log L	42.419	…	…	37.980	…	…	40.184	…	…
F-stat	4.582***	…	…	3.190**	…	…	5.241***	…	…
F-Prob	0.008	…	…	0.030	…	…	0.004	…	…
Akaike	-2.947	…	…	-2.634	…	…	-2.925	…	…
Schwarz	-2.451	…	…	-2.188	…	…	-2.529	…	…
HQ	-2.830	…	…	-2.529	…	…	-2.832	…	…

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: Done on EViews 9.

a) **Stability and coefficient diagnostic:**

Table 85: Variance inflation factors for RE deployment model

1st equation		2nd equation	3rd equation
Variables	**Centered VIF**	**Centered VIF**	**Centered VIF**
C	NA	NA	NA
IV	1.622	…	1.461
EI	2.523	2.370	…
PS	1.622	1.588	…
RI	2.534	2.312	…
Kyoto	1.182	1.180	1.135
Paris	2.154	1.901	1.641
RVGDP	2.153	2.093	1.901
$RVCO_2$	1.319	1.211	1.246
RVEU	1.950	1.919	1.655
REP	…	…	1.154

Source: Done on EViews 9.

Table 86: Ramsey Reset test for the 2nd equation

Test	Value	Df	Probability
t-statistic	1.239	12	0.238
F-statistic	1.536	(1, 12)	0.238
F-statistic	0.976	(2, 11)	0.165

Source: made on EViews 9

b) **Residual diagnostic:**

Table 87: Box-Pierce and Ljung-Box test for RE deployment model

1st equation			2nd equation			3rd equation		
Lag	**Q statistic**	**Prob**	**Lag**	**Q statistic**	**Prob**	**Lag**	**Q statistic**	**Prob**
12	3.983	0.984	12	15.575	0.212	12	2.737	0.997
Lag	**$Resid^2$**	**Prob**	**Lag**	**$Resid^2$**	**Prob**	**Lag**	**$Resid^2$**	**Prob**
12	11.795	0.462	12	10.482	0.574	12	11.471	0.277

Source: made on EViews 9

Table 88: Normality test for RE deployment model

1st equation		2nd equation		3rd equation	
J-B Value	Prob	J-B Value	Prob	J-B Value	Prob
0.058	0.971	1.018	0.600	0.236	0.888

Source: made on EViews 9

Table 89: Autocorrelation test for 1st equation

Lag	F- statistic	Prob. F	LR-statistic	Prob. LR
1	0.0008	0.977	0.0016	0.967
2	0.0056	0.994	0.0248	0.987
3	0.0043	0.999	0.0316	0.998
4	0.0612	0.991	0.653	0.957

Source: made on EViews 9

Table 90: Autocorrelation test for 2nd equation

Lag	F- statistic	Prob. F	LR-statistic	Prob. LR
1	2.032	0.179	3.185*	0.074
2	1.190	0.340	3.914	0.141
3	1.459	0.283	6.699*	0.082
4	1.226	0.365	7.762	0.100

Source: made on EViews 9.

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Table 91: Autocorrelation test for 3rd equation

Lag	F- statistic	Prob. F	LR-statistic	Prob. LR
1	0.108	0.746	0.182	0.669
2	0.116	0.891	0.418	0.811
3	0.089	0.964	0.521	0.914
4	0.067	0.990	0.575	0.965

Source: made on EViews 9.

Table 92: Heteroscedasticity test for 1st equation

Tests	Fisher	Prob. F	LR	Prob. LR	Scaled explained	Prob. SS
Breusch-Pagan-Godfrey	1.762	0.177	12.524	0.185	4.192	0.898
Harvey	NA	NA	NA	NA	NA	NA
Glejser	1.824	0.164	12.712	0.176	9.113	0.426

Source: made on EViews 9

Table 93: Heteroscedasticity test for 2nd equation

Tests	Fisher	Prob. F	LR	Prob. LR	Scaled explained	Prob. SS
Breusch-Pagan-Godfrey	0.602	0.760	5.951	0.652	1.464	0.993
Harvey	210.964***	0	21.831***	0.005	2675.537***	0
Glejser	1.291	0.327	9.740	0.283	6.286	0.615

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: made on EViews 9

Table 94: Heteroscedasticity test for 3rd equation

Tests	Fisher	Prob. F	LR	Prob. LR	Scaled explained	Prob. SS
Breusch-Pagan-Godfrey	1.133	0.396	7.958	0.336	3.256	0.860
Harvey	92.737***	0	21.535***	0.003	834.223***	0
Glejser	1.432	0.268	9.182	0.239	7.393	0.389

*,**,***, indicate that we can't reject the alternative hypothesis and the coefficients are significant at 10%, 5% or 1%.

Source: made on EViews 9

Abstract:

The aim of this research paper is to investigate the role of renewable energy on sustainable development factors and also the importance of energy policy and government institutional on renewable energy deployment in Algeria over the period 1995-2016. We made 4 econometrics models to study the relationship between renewable energy consumption (REC), economic growth (GDP), carbon dioxide emissions (CO_2), Human Development Index (HDI), energy policy and government institutional. We found that the (REC) had a positive impact on (GDP) only, while it had a negative influence on (CO_2) and (HDI). However, the energy policy had an insignificant effect on renewable energy deployment, while the institutional overall score had a positive influence. Also, we showed with Granger and Toda-Yamamoto causality that there's no causality between (REC) and (GDP), while there are three unidirectional causalities running from (REC) to (CO_2), one-way causality from (REC) to (HDI) and the other one from (GDP) to (HDI), we established that they are two bidirectional causalities between (CO_2) and (GDP), and among (CO_2) and (HDI).

Keyword: renewable energy, sustainable development factors, energy policy, government institutional, Algeria, Granger and Toda-Yamamoto causality.

الملخص :

الهدف من هذا البحث هو اختبار أثر الطاقة المتجددة على المعاملات التنمية المستدامة و دراسة أهمية السياسة الطاقوية و المؤسسة الحكومية على نشر و استعمال الطاقة المتجددة في الجزائر خلال الفترة 1995-2016. قمنا باستعمال 4 نماذج قياسية لدراسة العلاقة ما بين الطاقة المتجددة (REC), النمو الاقتصادي (GDP), انبعاث الغاز الثاني الأكسيد (CO_2), مؤشر التنمية الاجتماعية (HDI), السياسة الطاقوية و المؤسسة الحكومية . وجدنا بأن المتغير (REC) له أثر ايجابي على (GDP) بينما وجدنا بأن هناك تأثير سالب على (CO_2) و (HDI), ثم أظهر لنا بأن السياسة الطاقوية ليس لديها أي تأثير على نشر و استعمال الطاقة المتجددة, و لكن المتغير المؤسسة الحكومية له تأثير موجب على المتغير نشر و استعمال الطاقة المتجددة. ثم قمنا باستعمال السببية قرنجر و يودا-يماموتوا و أظهر لنا بأن ليس هناك علاقة سببية بين (REC) و (GDP), بينما هنا علاقة في اتجاه واحد من (REC) الى (CO_2) و من (REC) الى (HDI) و من (GDP) الى (HDI) و أيضا هناك علاقة السببية في اتجاهين بين (HDI) و (CO_2) و بين (CO_2) و (GDP).

الكلمات المفتاحية: الطاقة المتجددة, المعاملات التنمية المستدامة, السياسة الطاقوية, المؤسسة الحكومية, الجزائر, السببية قرنجر و تودا-يماموتوا.

Résumé :

L'objective de cette recherche est d'examiner l'impact d'énergie renouvelable sur les facteurs du développement durable, ainsi que démontrer l'importance de la politique énergétique et de l'institution gouvernementale dans le déploiement d'énergie renouvelable en Algérie pendant la période 1995-2016. On a fait 4 modèles économétriques pour étudier la relation entre la consommation d'énergie renouvelable (REC), la croissance économique (GDP), l'émission de dioxyde du carbone (CO_2), l'Indice du Développement Humain (HDI), la politique énergétique et l'institution gouvernementale. On a trouvé que la variable (REC) à un effet positif sur (GDP) seulement, par contre elle a un effet négatif sur (CO_2) et (HDI). En revanche, la politique énergétique a un effet insignifiant sur le déploiement d'énergie renouvelable, mais le score général des institutions à un effet positif. Aussi, on a montré avec la causalité au sens de Granger et au sens de Toda-Yamamoto, qu'il n'y avait pas une causalité entre (REC) et (GDP), tandis qu'il y avait trois relations unidirectionnelles allant de (REC) à (CO2), une causalité dans un sens de (REC) à (HDI) et une causalité allant de (GDP) à (HDI), et on a établi aussi qu' il y avait deux relations bidirectionnelles entre (CO2) et (GDP) et entre (CO2) et (HDI).

Les mots-clés : énergie renouvelable, les facteurs du développement durable, la politique énergétique, l'institution gouvernementale, Algérie, la causalité au sens de Granger et de Toda-Yamamoto.