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Presented by

Kouame David ZAUCYN

**Impacts of Regulations on the diffusion of renewable energy in Africa:
The case study of the Republic of Benin**

Defended on 03/09/2019 Before the Following Committee:

Chair	Bensmaine SOUHILA	Doctor	University of Tlemcen
Supervisor	Raphael HEFFRON	Professor	University of Dundee, UK
External Examiner	Nana Sarfo A. DERKYI	Professor	University of Natural Resources/ Ghana
Internal Examiner	Dib AMAZIGH	Doctor	PAUWES/ University of Tlemcen

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DECLARATION

I, **Kouame David ZAUCYN**, hereby declare that this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

Kouame David ZAUCYN

29/09/2019

(Student)

A handwritten signature in black ink, appearing to read 'Kouame David ZAUCYN', enclosed in a light gray rectangular box.

Certified by:

Prof Raphael HEFFRON

29/09/2019

(Supervisor)

A handwritten signature in black ink, appearing to read 'Raphael J Heffron', written in a cursive style.

ABSTRACT

Energy transition is one of the key challenges the world in general and Africa especially is facing in order to reach sustainable development. As a vulnerable continent to the effects of climate change, it is in the interest of African countries to go for renewable energy which is indispensable in the process of reducing greenhouse gas emissions and help in the achievement of total access to clean energy. This study elucidates that mainstreaming renewable energy in Republic of Benin appears to be essential to achieve total access to energy and foster economic growth, social well-being in a friendly environment. Currently, Republic of Benin relies on neighbouring countries such as Nigeria, Ghana and Ivory coast for nearly 76% of its electricity supply as well as for most of the petroleum products despite its huge renewable energy potential. However, it is difficult to have an appropriate development of renewable energy without the existence of suitable environment, this involves the establishment and implementation of a precise and clear legal, policy and regulatory frameworks. Thus, investment in the sector will be encouraged and guaranteed while making energy accessible and affordable for the populations. An in-depth examination of the overall renewable energy situation in the Republic of Benin has been conducted through interviews and examination of relevant materials in order to evaluate the deficiencies and the needs within the renewable energy sector. The study was focused on the regulatory framework for the diffusion of renewable energy in the country. The findings confirmed clearly that the mainstreaming of renewable energy in Republic of Benin is tremendously lacking favourable regulatory support, this is evident in the current non satisfactory energy situation within the country. The existing policy documents that could lead to the diffusion of RE also have serious gaps. One of these gaps is the unclear PPP law, this creates hesitance from the side of potential investors in the sector due to time and money lost in procedures. Also, the finance law that removes VAT on rural electrification equipment is complex to understand. In addition to this is the fact that the Beninese code of electricity does not prioritise renewable energy; more, there is an obvious lack of adapted funding and Feed-In-Tariff measures. The establishment of a smart energy law based on the energy law theory in Republic of Benin that gives priority to RE is the right step in achieving Energy transition and by extension Energy security in the country. For the implementation of such law to go well both the public and private sectors, national and international cooperation must work in synchronization and ensure gender equality in every step of the decision-making process.

Keywords: *energy transition, sustainable development, climate change, greenhouse gas emissions, regulations, diffusion, energy access, energy potential*

RESUMÉ

La transition énergétique est l'un des principaux défis actuels de développement durable du monde en général, et de l'Afrique en particulier. Face à la vulnérabilité de l'Afrique aux effets du changement climatique, les pays africains ont intérêt à opter pour les énergies renouvelables. Elles sont indispensables au processus de réduction des émissions de gaz à effet de serre et à la réalisation de l'accès total à l'énergie propre. Cette étude précise que l'intégration des énergies renouvelables en République du Bénin apparaît essentielle en vue d'assurer un total accès à l'énergie. Cela aura également pour objectif de favoriser la croissance économique et le bien-être social dans un environnement sain. En dépit des fortes ressources en énergies renouvelables du Bénin, près de 76% de son approvisionnement en électricité est importé des pays voisins tels que le Nigeria, le Ghana et la Côte d'Ivoire. C'est également le cas pour son approvisionnement pour la plupart des produits pétroliers. Un développement adapté des énergies renouvelables serait difficile sans l'existence d'un environnement approprié impliquant la mise en place et en œuvre d'un cadre légal, politique et réglementaire précis et clair. Par ailleurs, les investissements dans le secteur pourront être encouragés et garantis tout en rendant l'énergie accessible et abordable aux populations. Une étude de la situation générale des énergies renouvelables en République du Bénin a été faite à travers des interviews et des recherches documentaires. L'objectif était d'évaluer les carences et les besoins du secteur. L'étude était axée sur le cadre réglementaire régissant la diffusion des énergies renouvelables dans le pays. Les résultats ont clairement confirmé que le développement des énergies renouvelables en République du Bénin souffre d'une quasi-inexistence de réglementations appropriées. C'est la conséquence directe de la situation énergétique non satisfaisante du pays. Les textes existants susceptibles de conduire à la diffusion des énergies renouvelables présentent également de graves lacunes. L'une de ces lacunes est l'absence de clarté de la loi sur les PPP. Cela a pour effet de créer une réticence chez les potentiels investisseurs du secteur en raison du temps et de l'argent perdus au cours des procédures. Par exemple, la loi de finances qui supprime la TVA sur les équipements d'électrification rurale est complexe à comprendre. A cela s'ajoute le fait que le code béninois de l'électricité ne donne pas la priorité aux énergies renouvelables. De plus, il y a un manque évident de financement adapté et de mesures de tarif de rachat garantis. L'instauration d'un Droit de l'énergie intelligent fondé sur la théorie du droit de l'énergie en République du Bénin, qui donne la priorité à l'énergie renouvelable peut être une solution et une avancée vers la transition énergétique et, par extension, la sécurité

énergétique. Pour une parfaite mise en œuvre de ce Droit, les secteurs public et privé, la coopération nationale et internationale doivent travailler de manière synchronisée et aussi assurer l'égalité des sexes à chaque étape du processus de prise de décision.

Mots-clés : *transition énergétique, développement durable, changement climatique, émissions de gaz à effet de serre, droit de l'énergie, diffusion, accès à l'énergie, potentiel énergétique*

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<< Au début, l'étude est pénible ; plus tard elle devient une source abondante de jouissances. >>

Citation de Jean-Louis Moré ; Le petit livre pour le premier âge (1840).

<< At first, study is painful; later it becomes an abundant source of enjoyment. >>

Quote from Jean-Louis More; The little book for the first age (1840)

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ABBREVIATIONS AND ACRONYMS

ABERME	Beninese Agency for Rural Electrification and Energy Control
AFD	French Development Agency
AfDB	African Development Bank
AISER	Interprofessional Association of Renewable Energy Specialists
ARE	Authority of Electricity Regulation
AU	African Union
CEB	Electrical Community of Benin
CIF	Climate Investment Funds
COP	Conference of the Parties
DGE	Directorate General for Energy
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EnDev	Energising Development
EREP	ECOWAS Renewable Energy Policy
EU	European Union
FER	Rural Electrification Fund
FIT	Feed-In-Tariffs
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIZ	DeutscheGesellschaft für Internationale Zusammenarbeit
IRED	Regional Initiative for Sustainable Energy
Ktoe	Kiloton of oil equivalent
MCA Benin II	Millennium Challenge Account Benin II
NDCs	Nationally Determined Contributions
PAG	Government Action Programme
PANER/ PANEE	Action Plans for Renewable Energy Development and Energy Efficiency
PIDA	Programme for Infrastructure Development in Africa
PONAME	National Energy Management Policy
PPP	Public-Private Partnership
PRODERE	Regional Program of Renewable Energy Development and Energy Efficiency
PV	Photovoltaic

RE	Renewable Energy
SBEE	Benin Electric Power Corporation
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SMEs	Small and Medium-sized Enterprises
SREP	Scaling-up Renewable Energy Program
UAC	University of Abomey-Calavi
UC / PDER	Unit Responsible for Renewable Energy Development Policy
UDHR	Universal Declaration of Human Rights
UNDP	United Nations Development Programme
VAT	Value-Added Tax
WAEMU/	
UEMOA	West African Economic and Monetary Union
WAPP	West African Power Pool

CHAPTER I: INTRODUCTION

1.1 Background

Energy is vital for a society, in such a way that we cannot talk about development without energy. The economic development of a state is strongly linked to its energy consumption because the more the consumption of energy is observed, the more the development is significant. This importance of energy can be indicated by its influence on many factors characterizing development such as economic, education, health, social welfare and infrastructure (Lloyd, 2017). The perfect illustration is that the industrial revolution without energy would have not been possible in the realization of many industrialized states. Thus, energy represents the centre of life and almost all the needs of human existence (Carbonnier & Grinevald, 2011).

Africa is a rich continent and has enough energy resources both renewable and non-renewable to meet its development but is an energy poor continent; this poverty is a result of lacking access to energy. In Sub-Saharan Africa, over 130 million households are relying to kerosene, charcoal, fossil fuels, lantern; also, more than 620 million people do not have access to reliable electricity and are facing a serious energy poverty, and lack of energy services which is an obstacle to the economic growth. The Energy mix in Africa shows that Oil contributes to 23%, coal 14%, Gas 14%, Bioenergy 48% and the other such as nuclear, hydro, renewable have only 1% (Ispy publishing's Industry Survey, 2018).

Energy transition from non-renewable energy to renewable energy is needed to achieve a more sustainable development and at least three reasons can be raised up:

- Many countries are not energy auto-dependent and then, are depending for their energy supply to energy importation,
- Non-renewable energies are depleting and are facing high prices and,
- Climate Change actions to prevent its effects (Tupy, 2009)

Talking about climate change, even though energy is the sine-qua-none condition of development, energy taken from fossil fuel can be a danger for the humanity. It is shown that the supply and use of energy from fossil fuels are nearly two-thirds of global greenhouse gas emissions demonstrated by the fact that nearly 1°C of global warming has already been experienced by the world. At the Paris agreement, it has been agreed that without any concrete action in reducing these emissions by limiting the rise in temperature to below 2°C with an limit objective of 1°C, the whole globe, in the 30 to 40 years coming will experience the effects of a

2°C temperature rise. (IRENA, CLIMATE POLICY DRIVES SHIFT TO RENEWABLE ENERGY, 2017)

Going to a more sustainable development and a better reduction of CO₂ emissions, an energy transition into renewable energy and energy efficiency measures should be observed and can help achieving around 90 % of the requested reductions of carbon with only renewable energy as two-thirds of contribution. (IRENA, CLIMATE POLICY DRIVES SHIFT TO RENEWABLE ENERGY, 2017)

1.2 Problem statement and justification

Energy is strongly linked to development, but this development should be sustainable and should not affect negatively the socio-economic and environmental factors. The world in general is facing a serious issue which is climate change due to the extreme use of Fossil Fuels releasing abundant greenhouse gas emissions. Africa, in addition to an inadequate access to energy, is the most vulnerable to climate change effects despite the fact that the continent is the least contributor to greenhouse gas emissions (Nkiruka, Carvallo, Shaw, & Kammen, 2017).

These issues, despite their complexities, give a large advantage to Africa to develop a more sustainable system using its important basket of renewable energy sources to tackle climate change and supply a cleaner energy. It is shown that Sub-Saharan Africa has as technical potential for generation capacity about 10,000 GW of solar power, 350 GW of hydroelectricity, and 400 GW of natural gas, a total of more than 11 000 GW and Renewable technologies are more inclusive economic and social development while protecting environment than fossil fuel-based options (Nkiruka, Carvallo, Shaw, & Kammen, 2017).

Many African governments such as the Republic of Benin, aware of these challenges, demonstrated their commitment to face the different issues through their national Action plan based on the Agenda 2063 of the African Union(AU) adopted in January 2015, in the renewable energy sector (The University of Abomey-Calavi Foundation, 2018) and this Agenda 2063 calls for: “Harnessing all African energy resources to ensure modern, efficient, reliable, cost-effective, renewable and environmentally friendly energy to all African households, businesses, industries and institutions, through building the national and regional energy pools and grids, and Programme for Infrastructure Development in Africa (PIDA) energy projects” (African Union, 2015).

Also, the commitment of many African States to faster and better Renewable Energy development through national vision based on the 2030 Agenda for Sustainable Development Goals mainly the SDG 7 which is about ensure access to affordable, reliable, sustainable and modern energy, and the SDG 13 about combatting climate change in order to minimize its effects as well as adopted the Paris Agreement on climate change in 2015 (McCollum, Echeverri, Riahi, & Parkinson, 2017).

Benin had 41.4% of access to electricity in 2016 (World Bank) and has an important potential in renewable energy but remains under-exploited. (The University of Abomey-Calavi Foundation, 2018).

A better management of this renewable energy potential requires the establishment of favourable legal and regulatory framework to its growth.

For a well-done renewable energy market creation, renewable energy industry development and encouraging the energy transition, favourable legal and regulatory framework must be developed in order to create an environment more adapted to investment in the sector. (Tupy, 2009).

For a vision of a secure energy future for all people, countries environment of policies, regulations and institutions should be enough solid. RISE is a tool helping countries in achieving their objectives and provide reference to policymakers supporting best environment for sustainable energy (RISE, 2016).

	Policies and Regulations			Administrative Procedures*
Energy Access	<ul style="list-style-type: none"> ● Existence and monitoring of officially approved electrification plan ● Scope of officially approved electrification plan 	<ul style="list-style-type: none"> ● Framework for grid electrification ● Framework for minigrids ● Framework for stand-alone systems 	<ul style="list-style-type: none"> ● Consumer affordability of electricity ● Utility transparency and monitoring ● Utility creditworthiness 	<ul style="list-style-type: none"> ● Establishing a new household grid connection ● Permitting a new minigrid
Energy Efficiency	<ul style="list-style-type: none"> ● National energy efficiency planning ● Energy efficiency entities ● Information provided to electricity consumers ● Incentives from electricity rate structures 	<ul style="list-style-type: none"> ● Mandates & incentives: large consumers ● Mandates & incentives: public sector ● Mandates & incentives: utilities ● Financing mechanisms for energy efficiency 	<ul style="list-style-type: none"> ● Minimum energy performance standards ● Energy labeling systems ● Building energy codes ● Carbon pricing and monitoring 	<ul style="list-style-type: none"> ● Securing energy efficiency appliance standards certification
Renewable Energy	<ul style="list-style-type: none"> ● Legal framework for renewable energy ● Planning for renewable energy expansion 	<ul style="list-style-type: none"> ● Incentives & regulatory support for renewable energy ● Attributes of financial and regulatory incentives 	<ul style="list-style-type: none"> ● Network connection and access ● Counterparty risk ● Carbon pricing and monitoring 	<ul style="list-style-type: none"> ● Permitting a new renewable energy project

Figure 1: Capturing the quality of the policy environment (Source: RISE executive summary, 2016)

As a product of the Sustainable Energy for All (SE4LL) initiative Knowledge Hub, RISE aligns its actions on the Sustainable Development Goal 7 and the SE4ALL in order to show through its indicators the necessity of policy and regulatory framework in the achievement of a sustainable energy transition (RISE, 2016).

1.3 Research Objectives

General objective

The aim of this study is to identify and evaluate the impacts of law on the penetration of renewable energy in Africa, the precise case of Benin in order to better the energy transition and sustainable development.

Specific objectives

The specific objectives of this study were to:

- a) To review the existing laws promoting the exploitation, management and development of renewable energy in Benin;
- b) To assess the threats and opportunities of the existing laws on the development of renewable energy in Benin
- c) To propose an adapted renewable energy regulatory and institutional framework to reinforce the necessary approaches for renewable energy development.

1.4 Research questions

In order to better the assessment of the specific objectives specified above, the particular research examines the following questions:

- What are the existing regulations governing the exploitation, management and development of renewable energy in Benin?
- What are the threats and opportunities of the existing laws on the penetration of renewable energy in Benin?
- Which adapted regulatory and institutional framework can be proposed for a better penetration of renewable energy in Benin?

1.5 Methodology

This study will employ the qualitative research method. Qualitative interviews will be used to help the researcher to be closer to the participants and conduct a face-to-face interview which is very important to understand the historical approaches of the study in details through open-ended questions. Qualitative documents such as official reports, newspapers, public documents or even private documents will also be used to conduct the research (Creswell, 2009).

For that, data will be collected from both primary and secondary sources. Firstly, from the governmental institutions related to energy, experts in energy policy and regulations, professors and professionals, the primary data will be collected through interviews. Secondly, from specific national and international reports, laws, published books and documents related to energy regulations and policy, the secondary data will be collected.

This research will follow a purposive sampling design. Because of their expertise and their knowledge, the participants are purposively selected for this research to get adapted data to the research.

The availability of key participants and key documents for this research have been the main obstacle of this research. Key participants were sometimes not available due to their busy occupations. Many times, appointments have been rescheduled in order to meet them.

Limitation were found in data gathering during interviews with some institution keyboards who seen some information needed too confidential. Difficulties were also found in getting data and information from ongoing regulations, policies and programs regarding renewable energy.

1.6 Significance of the study

Despite some demonstration from our governments to tackle the issues of energy transition and climate change through some projects, programs and action plans, it is seen as insufficient and sometimes not adapted to carry out the reality of the situation. Then, this research is a strong opportunity for our governments to reinforce their policies and regulations in the perfect achievement of the Sustainable Development Goals (SDGs) especially the SDG 7 about ensuring sustainable, clean and affordable energy for all by 2030 and the SDG 13 related to Climate Change.

The significance of this study is shown by the following abilities:

-This study will help to assess in a precise, concise and clear way the existing regulations dealing with the exploitation, management and development of Renewable energy in Benin.

-It will identify the threats and opportunities of the existing laws on the penetration of renewable energy in Benin.

-It will propose an adapted regulatory and institutional framework in order to strengthen the development of renewable energy in Benin.

1.7 Scope and limitations of the study

This research is conducted for the accomplishment of a master's degree in energy policy. The main aspect looked in this research were the understanding, assessment and analysis of the possibilities of energy transition in a more sustainable source by the diffusion of renewable energy through regulations impacts in Africa, a case study of the Republic of Benin and proposed solutions to the problems. In another way how can adapted regulations influence and favor energy transition, the penetration of renewable energy in Africa, precisely in Benin.

The targets are government, institutions in renewable energy or related to renewable energy, experts, professors, public and private sectors directly or indirectly linked to renewable energy growth in Benin. The whole country is the beneficiary as it is common environmental, social and economic added profits.

The research mention Africa as geographical region but the research will be focused on Benin specifically to be realistic due to time constraint, also because of the high hostility of the country to energy transition even if some important actors and investors see a big opportunity and attractivity in developing renewable energy in the country and due to the sensitivity of the study which require more attention on details.

Benin is almost facing the same situation to many African countries in terms of adapted regulations in order to fostering energy transition to a more sustainable source and favorable policies and institutional framework.

Africa Union, as a motor of the development of the continent, with specific initiatives in general legal and policy framework while considering this large network can motivate better many

countries in this common vision of the Africa we want. Also, regional organization such as ECOWAS can create more specific framework to develop opportunities of renewable energy.

Therefore, this research does not explore the control and the application approaches of the regulatory, legal and policy framework impacts in renewable energy development. However, the findings obtained from this research can serve as a basis and eventually a source for implementation of regulatory, legal and policy framework control and application measures in Republic of Benin

1.8 Structure of the research

This research is arranged in chapters as followed:

Chapter one is the Introduction; This part is to contextualize the topic and to give the direction of the research.

Chapter two is dedicated to the literature review; Here, the researcher gives a contextual explanation of the different key terms to better the understanding of the transitional theory, energy law theory while showing how sustainability should be determinant in renewable energy growth and demonstrate the importance and impacts of regulations in renewable energy deployment.

Chapter three assesses the renewable energy practice and instruments in Republic of Benin; This part is necessary in understanding the situation of renewable energy in Benin, and the instruments driving the sector.

Chapter four covers the results and discussion; It shows the advantages and disadvantages of current instruments relating to renewable energy, the progress and challenges facing renewable energy development and the need of energy transition in Benin.

Chapter five is about the conclusion and provides our contribution to a suitable development of the sector. This chapter reinforce the needs of developing adapted environment in the development of renewable energy in Benin and for that, we recommend specific regulations and policies as solutions to better the renewable energy sector in order to reinforce socio-economic growth in a safe environment.

CHAPTER II: LITERATURE REVIEW

Few researches have been developed on the impacts of regulations on the diffusion of renewable energy in Africa and in Benin. This research is taking its inspiration from strategic documents, articles that have highly contributed in clarifying the key words of the topic and providing better understanding of the probable suggestions that could help in the appropriate regulations of the renewable energy growth in the Republic of Benin.

This research will be proposing specific evaluations of the policies and in Benin in order to enhance awareness at the high-level decision making and attract adapted factors to the development of renewable energy.

2.1 Regulations and Renewable Energy

According to the Latin maxim “ubi societas, ibi jus” meaning wherever there is society, there is law, each society and the activities, sectors related to this society must be regulated by law for a sustainable organization and functioning of this sector.

What is regulation?

Oxford dictionary defines regulation as: “rule, in accordance with rules or conventions, by law, commandment, decree, dictate, directive, edict, law order, requirement, restriction, rule, and statute”.

For Dudley & Brito (2012), regulations or administrative rules or laws can be seen as the “primary vehicles” governments use to implement laws and agency objectives. They are instructions that authorize and limit businesses; individual and organisation actions (Dudley & Brito, 2012).

Another point is that Regulation seeks to adopt necessary approaches in protecting economy, society and environment.

What is Renewable Energy

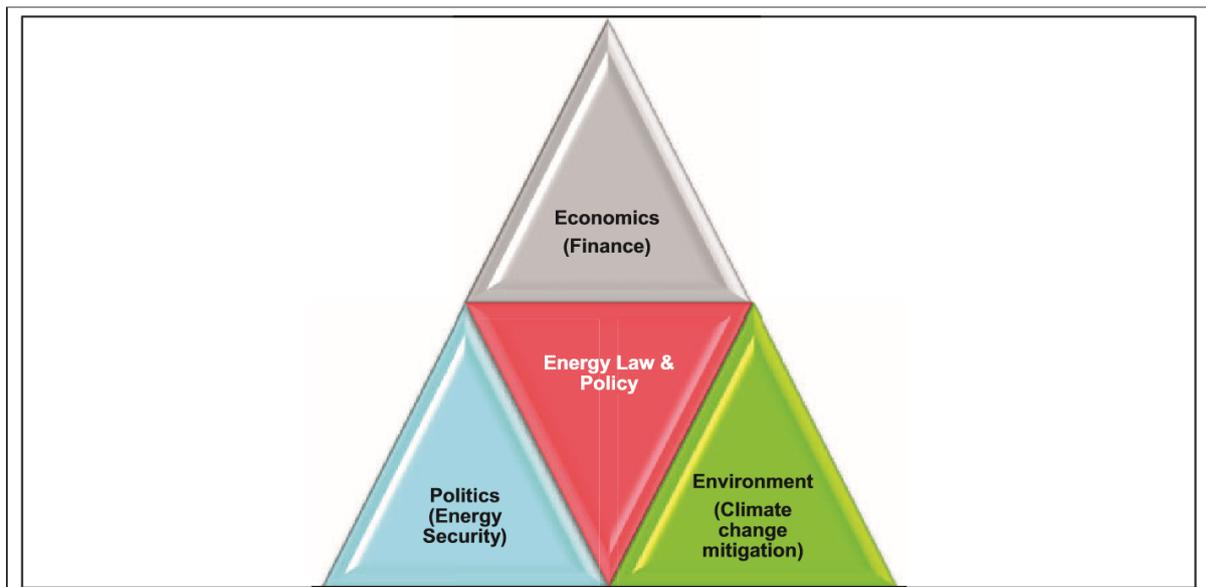
The article III of the statute of the International Renewable Energy Agency defines renewable Energy as: “the term "renewable energy" means all forms of energy produced from renewable sources in a sustainable manner, which includes, inter alia: 1. bioenergy; 2. geothermal energy; 3. hydropower; 4. ocean energy, including inter alia tidal, wave and ocean thermal energy; 5. solar energy; 6. wind energy” (IRENA, Statute of the International Renewable Energy Agency (IRENA), 2009).

Also, Art. 2(a) of the Directive 2009/28/EC on the promotion of the use of energy from renewable sources sees renewable energy as: “the energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases” (THE EUROPEAN UNION, 2009).

The International Energy Agency (IEA), in its definition sees renewable energy as resource “derived from natural processes that are replenished constantly” (IEA, 2002).

As a basic Human Right recognizes by the Universal Declaration of Human Rights (UDHR) of 1948, access to energy is one of the most important factors of development and by the way, energy as the key element connecting societies, economies and politics to the environment. This Human Right is not only about access to energy but mostly insisting in access to clean, modern and affordable energy for sustainable development and to guarantee the welfare of the population and drive a sustainable economy in a healthy and safe environment. (Apurvaa, 2018)

According to Heffron & Talus (2016), “Energy Law concerns the management of energy resources”. For the authors, energy law is one of the important solutions to mitigate climate change and encourage sustainable development while using a low-carbon energy source. In addition, this is a unique attempt in handling the energy business environment which is increasingly blossoming. The number of companies and industries in the energy business environment is getting considerable, escaping the traditional legal system and making room for a new legal environment favouring the development of renewable energy and low carbon sources. A gap that seems to be appropriately filled by the development of energy law. In the same line, the authors showed how inadequate it is to separate energy law to energy policy as they are strongly linked and are the centre in the realization of energy law and policy triangle (Heffron & Talus, 2016).



Explanation: Energy law and policy is in the centre of the triangle and on the three points of the triangle are economics (finance), politics (energy security) and environment (climate change mitigation). These three issues are each trying to pull energy law and policy in their direction. In essence, effective and efficient energy law and policy will balance these three aims to deliver the best outcome to society. However, if one examines energy law and policy in more detail, often it is just one of these issues that dominates the energy agenda.

Figure 2: The Energy Law and Policy Triangle- 'the Energy Trilemma'. Source: RJ Heffron, Energy Law: An Introduction (Springer 2015)

Following this figure, there is a triple objective (economic- political- environmental) that is influenced by Energy Law and Policy.

In the achievement of this vision of developing and ensuring reliable access to clean energy for all or better energy transition, precise and clear regulations should be the centre of its promotion. The above documents provide an accurate understanding of the term's "regulations" and "renewable energy", giving us therefore the ground to specify the form of energy we are dealing with and the need of linking it to regulations for the purpose of this study.

2.2 Energy transition theory: definition, features and critics

According to (Rotmans, 1994), Talking about transition is shifting from a stable situation or system following a process to reach another system or situation which is relatively stable (Loorbach, Van der Brugge, & Taanman, xxxx).Transitions is the process of fundamental system transformations in the society or a structure. Illustration of demographic transition, industrial to service economies transition (Geels, 2002).

As one of the key proponents of the transition theory, Rotmans et al., in “More evolution than revolution: transition management in public policy” give these features to transitions:

- ✓ Transitions concern large scale technological, economical, ecological, socio-cultural and institutional developments that influence and reinforce each other
- ✓ Transitions are long term processes that takes at least one generation;
- ✓ Transitions are interactions between different scale levels (niche, regime, landscape) (Rotmans, Kemp, & Van Asselt, 2001).

To better organize our modern society with its complexities and enforcing sustainability, new ways of governance are needed in order to be adapted to this complex society. In this line, many authors see transition management as this new way of governance that can be applied in complex society. (Loorbach, 2007), exposes a framework that showcases the different steps of governance that deal with societal innovation. This framework makes a difference between types of activities that take strategic, tactical and operational and phases that consider envisioning, agenda-building, experimentation and evaluation. This framework as generic is a good approach to deal with specific context and apply transition management in a successful manner. The two authors have even worked together as leaders on project called “Sustainable Living and Housing in Flanders” showing their common vision’s share in terms of transition management (Loorbach D. A., 2007).

This theory knew strong debates and criticism that enriched and created relevant foundation to its evolution. The debates were mostly focused on two different critics from Meadowcroft (2007) and Shove and Walker (2008).

According to Shove and Walker (2008), the idea stating that transition management should be a way for transition being done through managerial task should be rejected. For the authors, many influences outside of the transition management zone such as culture, belief systems, political interests exist and forbid even the practices of management in their transition management.

Meadowcroft (2007) argue that politics play an important role in transitions and that sustainable transitions are strongly linked to political aspect at a way that sustainable development was seen a political project because the social aspect does not immediately create a path to sustainable development due to the fact that the social aspect is somehow under the intervention of politics.

It can therefore help in the domain of regulations to adapt laws to its current environment in order to reinforce the diffusion of renewable energy. This kind of change from inadequate laws that were only favourable to fossil fuels to adequate laws that take into consideration both renewable and non-renewable energy management.

The transition theory fits the best the study in the sense that the latter intervenes in a context of unavoidable transition in the use of energy, a process that is global and requires quite relevant regulations in order to be effective and efficient in the environment and economy of the society.

2.3 Energy and Sustainable Development

In the Brundtland report “Our Common Future”, Sustainable development is defined as the development that takes into account the objective to meet what the current generation is needed without making an obstacle in meeting the needs of the future generations (World Commission on Environment and Development, 1987).

For the International Atomic Energy Agency, in its report “Energy Indicators for Sustainable Development: Guidelines and Methodologies, Energy is the center of social wellbeing by its abilities of eradicating poverty, economic growth, thus the indispensable tool for development and also that the main objectives at the end of energy utilization is good health, high living standards, clean environment and adequate economy growth so no form of energy from any source it can come from should be neglected and rejected as far as it reaches the main objectives (International Atomic Energy Agency, 2005).

Despite this importance of energy in development, the National Association of Regulatory Utility Commissioners (NARUC) with the Support of the United Nations Agency for International Development in 2011 from its publication “Encouraging Renewable Energy Development: A Handbook for International Energy Regulators” is focusing itself on the importance and priority of sustainability. The authors present sustainable energy as the smarter way of meeting present and future energy needs and the possibility of this vision is the use of energy coming from sources that can be replenished, affordable and environmentally friendly (Bjork, Connors, Welch, Shaw, & Hewitt, 2011).

For “An African Energy Industry Report: 2019” by ISPY publishing limited, Despite the rich energy resources, “Africa is an energy poor continent” where more than 130 million household are still in the constant use of charcoal, kerosene, lantern, candles, fossil fuels and also about

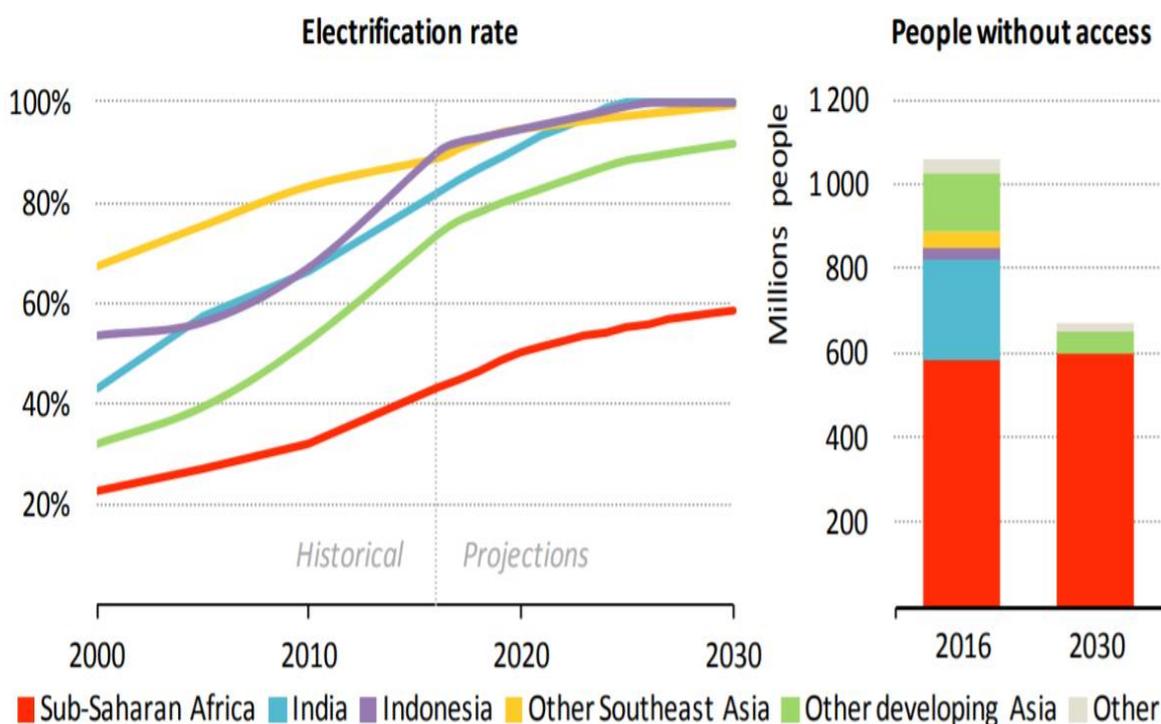
620 million lacking electricity (Ipsy publishing's Industry Survey, 2018). James Morrissey in part 2: Addressing energy poverty” from “The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers” showed that energy poverty should be understood as lacking access to electricity to meet basic needs and another aspect is about the low consumption of energy and the utilization of inappropriate cooking facilities by poor households due to their low incomes (Morrissey, 2017).

The reports of the Brundtland, of the International Atomic Energy Agency, and the publications of the NARUC and the IPSY have allowed to establish the unbreakable link that exist between sustainable development and quality energy in permanence.

Access to electricity and to clean cooking could be considered as indicators of the level of energy's penetration which relevant to evaluate the situation for the purpose of the study. Interesting documents have contributed in providing us with the information below.

➤ **Access to Electricity**

According to IEA (2017), access rate to electricity in sub-Saharan Africa when projecting is supposed to grow from 43% in 2016 to 59% in 2030. Despite this growth of access rate, Populations in sub-Saharan Africa without access to electricity will be growing from 588 million in 2016 to 602 million in 2030 which make the region accounting for about 90% of people without electricity (Figure 2). This worldwide growth of electricity access by 2030 will be possible in majority through renewable energy accounting for over 60% of new access (International Energy Agency, 2017).



By 2030, nine-out-of-ten people without access are in sub-Saharan Africa

Figure 3: Electricity access rate and population without electricity. (source: Energy Access Outlook 2017: IEA)

Table 1: Population without access to electricity. Source: Energy Access Outlook 2017: IEA)

	2000		2016		New Policies Scenario 2030	
	million	%	million	%	million	%
Africa	532	66%	588	48%	602	36%
North Africa	14	10%	0	0%	0	0%
Central Africa	73	90%	98	75%	122	63%
East Africa	164	90%	172	61%	135	34%
South Africa	15	34%	8	14%	1	1%
Other Southern Africa	108	86%	135	69%	156	55%
West Africa	158	67%	175	48%	188	36%
Developing Asia	1 059	33%	439	11%	54	1%
China	18	1%	0	0%	0	0%
India	600	57%	239	18%	0	0%
Indonesia	99	47%	23	9%	0	0%
Other Southeast Asia	100	33%	42	11%	2	<1%
Other developing Asia	242	68%	135	27%	52	9%
Central and South America	56	13%	17	3%	4	1%
Middle East	15	9%	17	7%	14	5%
World	1 672	27%	1 060	14%	674	8%

➤ **Access to clean cooking**

Access to clean cooking facilities in sub-Saharan Africa will be growing in 2030 to around 38% but population without access to clean cooking will increase from approximately 846 million in 2016 to around 908 million in 2030 (Figure 3) (International Energy Agency, 2017).

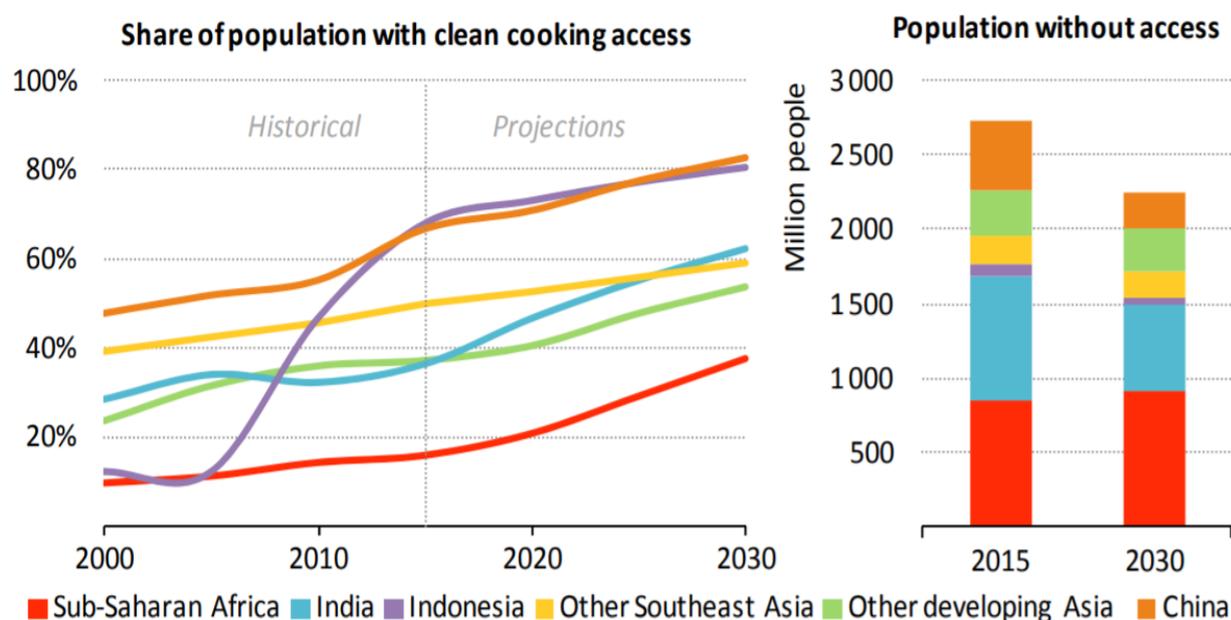


Figure 4: Population with and without access to clean cooking. (Source: Energy Access Outlook 2017: IEA)

Table 2: Population without access to clean cooking. Source: Energy Access Outlook 2017: IEA

	2000		2015		New Policies Scenario 2030	
	million	%	million	%	million	%
Africa	619	76%	848	71%	910	54%
North Africa	13	9%	2	1%	2	1%
South Africa	21	48%	10	17%	8	13%
Other sub-Saharan Africa	585	94%	836	88%	900	65%
Developing Asia	2 083	65%	1 874	49%	1 338	31%
China	658	52%	457	33%	247	18%
India	753	71%	834	64%	580	38%
Indonesia	186	88%	83	32%	58	20%
Other Southeast Asia	190	61%	188	50%	175	41%
Other developing Asia	296	76%	312	63%	279	46%
Central and South America	78	19%	59	12%	45	8%
Middle East	14	9%	12	5%	14	5%
World	2 794	46%	2 793	38%	2 307	27%

Both access to electricity and access to clean cooking projections are the results of new policies scenario that makes assessment on how existing and future policies will lead the energy sector while taking into consideration for the projection many approaches such as economic growth, population growth, price and availability of fuels.

Even if more actions are needed, Africa, as a continent in need of tackling energy poverty and providing sustainable energy is making one step more in advance for achieving their vision through the submission at the Paris agreement of their Nationally Determined Contributions (NDCs) where renewable energy advancement is showed as priority (International Energy Agency, 2017).

In the “ECOWAS NDC SPOTLIGHT, Towards the implementation of sustainable energy goals” from ECREEE, the country has a real vision in renewable energy diffusion and many strategic documents exist and are yet to come in order to better sustainable energy in Republic of Benin. Some important sustainable energy frameworks with ECREEE are also on development to support the state vision (ECREEE, 2017).

2.4 Status of the Sustainable Development Goal 7(SDG 7) in Republic of Benin

Several documents have allowed the study to figure out the situation of SDG 7 in Republic of Benin and the potential impacts SDG 7 can assure on the other SDGs such as the Government Action Plan, the International Energy Agency (IEA) report of 2017, the High-Level Political forum on sustainable development national report of July 2017, the quarterly newsletter of UNDP Benin N° 37 January – March 2018, the UN Forum on Sustainable Development in 2018, the Energy and the Sustainable Development Goals from energypedia.

➤ General Overview of the SDGs in Republic of Benin

Known as the 2030 Agenda for Sustainable Development, many countries in the world adopted the Sustainable Development Goals in September 2015. This agenda is made of 17 SDGs has an objective to tackle many challenges the world is facing today such as poverty, health, inequalities, climate change, and many other issues (International Energy Agency, 2017) (Figure below).



Figure 5: Sustainable Development Goals. Source: energypedia

As part of this global Agenda for Sustainable Development Goals, Benin has a strong stand in the vision of developing and implementing public policies with the objective of achieving by 2030 the Sustainable Development Goals. The country adopted a National Agenda for SDGs Appropriation led to the development of the national priority report of the SDG targets. Always in the same vision, Benin shows its desire to contribute to the realization of the SDGs through the voluntary national review on the implementation of the SDGs at the High-Level Political forum on sustainable development that took place in July 2017 in New York (Republic of Benin, 2017)



Figure 6: SDGs in Benin Map. Source: Benin's National report on SDGs showing Benin appropriation of the SDGs

The strong commitment of the Beninese government can be showed according to the Government Action Programme, by the integration of the SDGs in the “Revealing Benin” programme and has even being devised based on 2030 Agenda for Sustainable Development Goals and the Paris agreement on Climate Change (COP21).

In the quarterly newsletter of UNDP Benin N° 37 January – March 2018, regarding the realities of each country’s development, it is for each country to find the suitable way at the national level to implement the SDGs while respecting the international standard. In regard of this, the Republic of Benin took the step of prioritizing the SDGs targets in its context. In line with what

said above, the Minister of State in charge of Planning and Development, Mr. Abdoulaye Bio Tchane, declared: "The prioritization of the SDG targets becomes for us the Government a benchmark for all public action. The proof is that the Government Action Programme has suffered unceremoniously an alignment check on the SDGs. [...] The monitoring of target progress indicators seems to us, beyond the development policies themselves, the key the success of Benin's march towards the SDGs ". For that, between the 169 SDG targets, 49 targets of them have been selected in Benin (UNDP, bulletin trimestriel d'information du pnud benin , 2018).

➤ **SDG 7**

According to the SDG Agenda 2030, Sustainable Development Goal 7 aims to “ensure access to affordable, reliable, sustainable modern energy for all”, and is composed of three targets:

SDG7

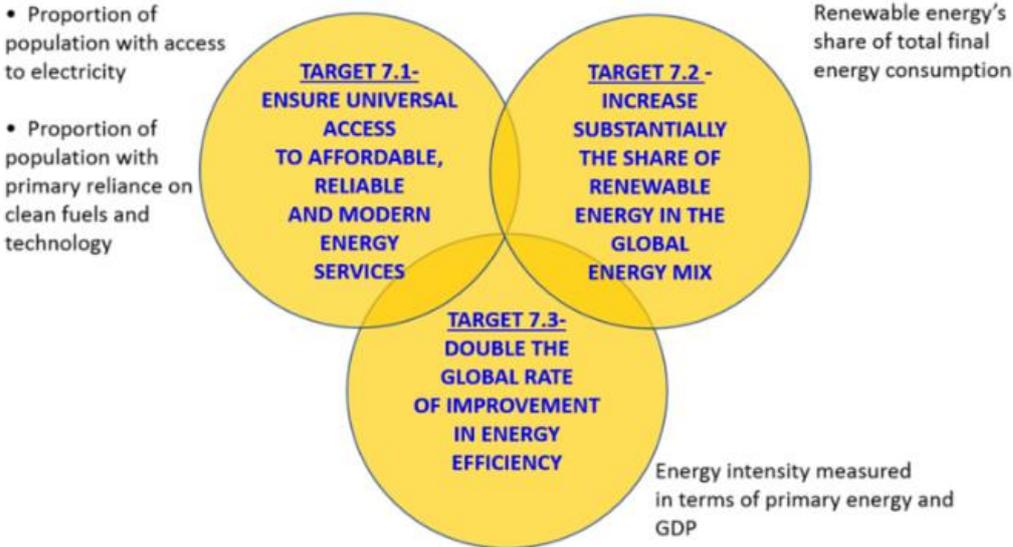


Figure 7: SDG 7 and targets. Source: United Nations ESCAP

- 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

Among the 49 targets from the SDGs that have been selected in Benin, the target 7.1 is the one that have been prioritized in the SDG 7 targets. According to IEA 2017, around 8 million people were lacking access to electricity in 2016.



Figure 8: Proportion of population with access to electricity in 2017. Source: IEA

In 2017, access to electricity in Benin was 30% while in 2016 in was around 31.3%.

In terms of access to clean fuel, around 10 million people were not able to have access to clean cooking facilities in 2015.



Figure 9: Proportion of population with primary reliance on clean cooking facilities in 2017. Source: IEA

In 2017, access to clean cooking facilities in Benin was around 4.2%.

Currently, the country is developing many specific strategies to better achieve this target and many projects are ongoing to reinforce the practical approach of the target.

- 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

Regarding the “facts about Benin” on Climate Investment Website, the Republic of Benin has an objective of achieving 25% of renewable energy in the national energy mix by 2025. For the 2016 status, the objective was very far.



Figure 10: Modern renewable share in total final energy consumption in 2016.

In 2016, modern renewable share in total final energy consumption was around 8.6%.

- 7.3 By 2030, double the global rate of improvement in energy efficiency.



Figure 11: Energy intensity measured in terms of primary energy and GDP in 2016. Source: IEA

In 2016, in Benin, Energy intensity measured in terms of primary energy and GDP in 2016 was about 0,208 toe/ 1000 USD (2010).

For the “Africa SDG Index and Dashboards Report 2018”, the trends of the SDGs show how difficult it is for Benin to tackle many challenges in order to contribute to the achievement of SDGs. The SDG 7 has the worse trend.



Figure 12: SDG trends in the Republic of Benin

Note: Green denotes SDG achievement, followed by yellow to orange which indicate an increasing distance from SDG achievement. Red highlights major challenges

2.4.1 The influential roles of SDG 7 on the other SDGs

During one of the key United Nations forum on Sustainable Development in July 2018, speakers demonstrated that energy, as the center of people lives is a source of realization of many objectives the whole world is trying to achieve today such as eradication of poverty, climate change, food production, education, gender equality, health, job creation then working on the achievement of the SDG 7 is also working on the achievement of many other SDGs as energy is strongly linked to them (UN Forum on Sustainable Development, 2018). For United Nations ESCAP; From a better understanding, actions of ensuring access to affordable, reliable, sustainable modern energy for all are the meaning and real determinant drivers of meeting energy transition from fossil fuel to renewable energy but also tackling the challenging facing the three dimensions of sustainable development: Economic, social and environment.

Energy and the Sustainable Development Goals (SDGs)



Figure 13: Impacts of SDG 7 on the other SDGs. Source: OFFGRIG Nigeria

From the (SDG1) perspective of ending poverty in all its form, the SDG 7 plays an important role. The 2030 Agenda for Sustainable Development stated in its Preamble that: ***"This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognise that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development"***. In order to fight against extreme poverty, new job creation through renewable energy access and activities like installing and services of PV, improved cookstove production can help households to better their purchase power and live decently. For Zero Hunger (SDG2), energy is needed in the cooking process and this energy should not provide negative impacts on people lives, so this energy should provide efficient technologies. Also, energy plays an important role in agricultural production through irrigation, drying and cooling. (SDG7) helps to better health systems and well-being (SDG3). Lighting, refrigerators for conserving medicines in hospitals need energy; According to the World Health Organization, 4.3 million people die each year because of pollution from traditional cooking technologies then clean energy for cooking provided by the SDG 7 is a solution to reduce mortality.

Quality education (SDG4) is impossible without energy and the teaching way is becoming more and more modern. Schools and students need more time and minimum lighting conditions to study and run. Collecting firewood at a long distance for cooking, heating and lighting reduce the quality of education. Through efficient cooking energy such as biogas can help gaining time to learn and domestic PV system can support the lighting system to improve education at night and make students adapt to technologies such as internet, computer access.

Gender equality (SDG5) needs energy to help girls and women to have time and access information, to communicate and access to clean energy will reduce their time of cooking, collecting firewood. SDG7 today has a strong influence on clean water and sanitation (SDG6) using solar and wind energy for desalination and purification. It is a good opportunity to tackle the issue of having access to clean drinking water because more than 660 million people lack it in the world. Decent work and economic growth (SDG 8) can be achieved through SDG 7. In 2015, in exclusion of large hydropower, 8.1 million people in the whole world have been employed in the renewable energy sector. Creation of all those businesses from renewable energy activities helps to structure an inclusive economic growth. Industry, innovation and infrastructure (SDG9) need for their sustainability energy to power communication and information technologies and those technologies from the SDG 7 emit no or less CO₂. SDG7 through clean, modern energy permit to achieve Sustainable cities and communities (SDG 11) in helping households to meet their basic needs while enhancing health standard and reducing pollution. It is important to be responsible in terms of consumption and production (SDG12). In fact, SDG 7 is a best road to sustain SDG 12 by reducing food losses through solar dryers or cold storage and reducing the use of firewood from the forest, thus saving forest using efficient cookstoves. All this contribute to a better management of natural resources. The use of renewable energy and energy efficiency is the key road to better energy transition from fossil fuel to renewable energy reducing greenhouse gas emissions in combating climate change (SDG 13). Life on land (SDG 15) is possible through saving forest using efficient technologies for cooking and heating and thus reduce pollution. Many projects on renewable energy especially efficient use of forest projects encourage reforestation. The use of SDG 7 through the connection of communication devices to energy is an important aspect to partnership for the SDGs (SDG 17) (energypedia, 2018).

2.5 The importance of regulatory framework in renewable energy development

Any society or sector related to this society or sector should have an appropriate environment in order to foster development. Renewable energy, as the center of great debates today in the world for its important impacts in all the domains and its ability to tackle many challenges such as climate change, energy security, the world is facing, needs favorable regulatory framework to create a harmonious sphere for the development of its market.

According to “The Importance of the Legal and Regulatory Framework for the Development of Renewable Energy” of Tatjana Tupy, talking about renewable energy deployment is also considering the existence and development of favorable markets supporting them to be strong enough in order to compete against conventional sources (Tupy, 2009). Supporting the idea of markets creation, Emem Onyejelam in “The Energy Crisis in Nigeria and the role of law in promoting renewable energy development”, shows that the relevance of renewable energy deployment depends on investment especially from private sector and for this investment to be effective, a structured and clear define legal framework should be at the center of every actions (EMEM, 2015). From a large point of view, the Global Reporting Initiative (GRI) precise that the establishment of regulations is not only for private sector investment but for both private and public sector because it is visible today that the public sector is acting as investor or investment manager. For the GRI, policies and regulations can drive an efficient renewable energy market progress and work in achieving the SDGs.

According to Trans Legal Dictionary (2019), Legal framework is “a broad system of rules that governs and regulates decision making, agreements, laws, etc. Talking about regulation, it is a “rule (usually issued by a government agency or established authority) that has the force of law”. For renewable energy to take an important position in energy supply, appropriate legal and regulatory framework need to exist. As favorable law enhances investment confidence, its absence can impact negatively many aspects suitable to renewable energy development such as technology transfer, National and international investors’ confidence (EMEM, 2015).

Tatjana Tupy cited many instruments related to renewable energy sources influenced by legal and regulatory frameworks like Feed-In-Tariffs which refer for Isabel Bjork & al to “the obligation of utilities to buy energy at fixed purchase prices (different depending on the type of renewable energy) for a fixed term. The authors show here that the renewable energy generation cost paired with social cost, investor requirement and political will are the base of FIT purchase

prices and so that the selling of energy under the terms of the tariff by any customer is normally allowed. Countries such as Philippines are an example of this instrument instituted in their regulations. Through this instrument, consumers can decide to choose a mandatory purchasing power from renewable energy while benefiting from many incentives, this is an approach to create a cost-effective RE tariffs (Bjork, Connors, Welch, Shaw, & Hewitt, 2011).

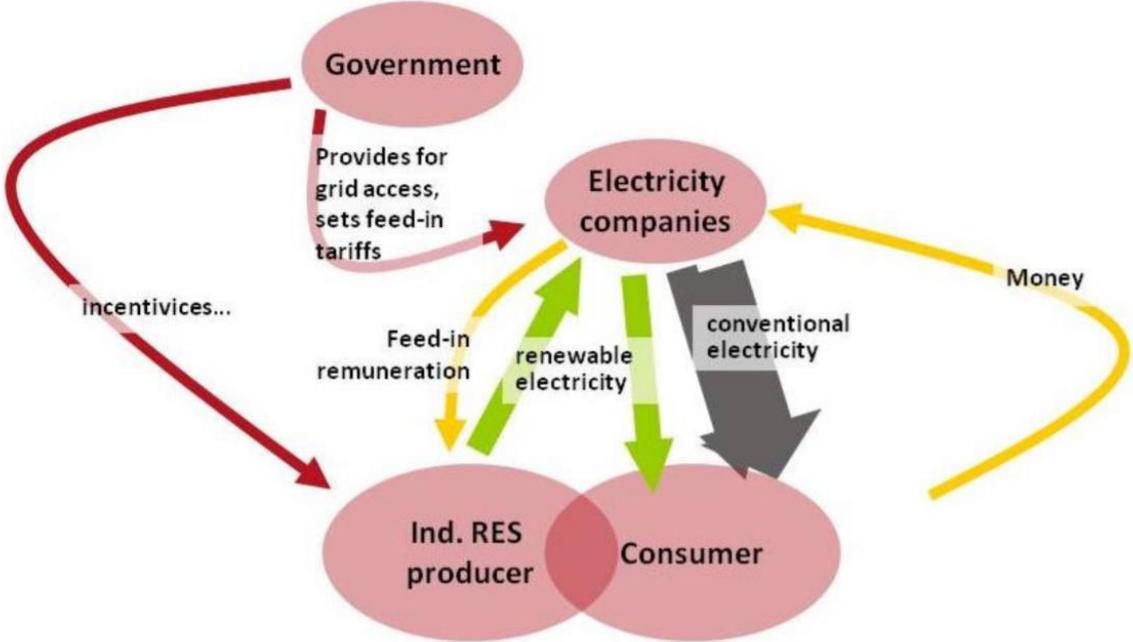


Figure 14: Scheme of a feed-in tariff system. Source: ILRFDRE

Another instrument are Subsidies and soft loans. Incentives are given by the government through resources allocated by the state budget to support parts of the initial investment costs of the system or through state banks in case of loans. Fiscal incentives are very important in order to reduce or delete taxes related to renewable energy producers, regulation can help promoting renewable energy through this fiscal incentive that help to tackle the excessive cost for investors to create their companies. Through regulations, subsidies in the budget can be removed and/ or reduced from fossil sources to profit to renewable energy sources, increase taxes for fossil fuel investment while taking in account the externalities (Tupy, 2009).

From this part we can have a better understanding of renewable energy regulations as a step ahead to energy transition that lead to sustainable development. This growth of renewable energy through favorable regulations will by the way empower the whole Sustainable Development Goals.

**CHAPTER III: DIAGNOSTIC OF THE RENEWABLE ENERGY PRACTICE
AND INSTRUMENTS IN THE REPUBLIC OF BENIN**

The understanding of the situation of renewable energy in the Republic of Benin is unavoidable in tackling the issue of the impacts of regulations on the diffusion of such an interesting type of energy. This involves an appraisal of the geography and the population of the country, the general energy situation with a clear view of its consumption, the effect of the climate change, the challenges, the international agreements, the institutional framework and the existing policies.

3.1 Geography and Population of Benin

The country is located in West Africa. It is a key-shaped land bordered in the west by Togo, in the east by Nigeria, in the north by Burkina Faso and Niger, with the bight of Benin in the south. A population of about 11,485,048 people in 2018 occupy its lands of about 114,763 km² where 53 % of its population is rural. It is important to not cloud its extension from the Niger River in the north to the Atlantic Ocean in the south, scientists argue on a distance of 700km. The country has a variation averaging 200 m in elevation according to a relief map. Attention must be drawn on the fact that the population is concentrated in the south where most of the main institutions (national, international, private) are found. This is not to shadow the relevance of the population of the rest of the country which faces critical challenges when it comes to access to energy, also stumbling block for the crowded south.

3.2 Energy situation in the Republic of Benin

The energy situation in the Republic of Benin appears to be not really satisfactory even though significant efforts have been made so far. This is definitely why more efforts are in the process to fully exploit the energy potential in order to increase access to energy and satisfy the demand in terms of consumption while meeting the needs of survival in this critical era of climate change. It is important to draw attention on the fact that the Government Action Plan (PAG 2016-2021) has taken seriously into consideration the renewable energy sector, with focus on developing the whole area of renewable energy in order to easily power remote areas of the country.

3.2.1 Energy potential in the Republic of Benin

The energy potential of the Republic of Benin should not be underestimated based on some relevant studies that have been conducted the university of Abomey-Calavi in collaboration with the MasterCard Foundation. The focus here is on renewable energy and the fact is that the country has an interesting potential in renewable energy sources which remains under-exploited, with the exception of the traditional form of biomass energy that constitutes firewood. Major renewable energy sectors that could constitute promising niches of projects for young graduates are identified. They are opportunities for job creation and the promotion of entrepreneurship. It appears that a high level of investment is not needed to develop these sectors, compared with other forms of renewable energy that require high or sometimes heavy investments such as hydroelectricity and gasification. The room for small and medium-sized enterprises (SMEs), which is a cross-cutting activity is more than a reality (The University of Abomey-Calavi Foundation, 2018).

The regions of Alibori, Borgou and Atacora have been revealed as being appropriate for construction and installation of biogas units, of photovoltaic biomass solar energy, including solar home systems. The Atlantique, the Donga, the Collines, the Mono, the Couffo, Ouémé, Plateau and Zou are equally considerable for biomass and solar energy. One should not cloud the probability of using wind energy in the coastal areas of the country such as Cotonou, Sèmè-Podji, Ouidah, Kpomassè, Grand-Popo, Comè and Abomey-Calavi (The University of Abomey-Calavi Foundation, 2018).

To provide the study with quantifiable data related to renewable energy potential in the Republic of Benin, a table showcasing renewable energy potential of each department or ecological zone and their classification is presented below.

Table 3: Energy potential of renewable energy sources in Benin. source: Data collected in November 2017 UAC Foundation

Départements	Solar PV	Biogas	Harvest residues	Wind Power	Hydro Electricity useable
	Energy potential (kWh/m ² . j)	Biogas potential (m ³)	Available electricity potential	Productible energy (kWh)	Maximum Power (kW)
Alibori	6,1	2592360	7601133,9	11.471	1750
Atacora	6,0	1359288	4439887,9	11.471	380
Atlantique	4,0	203364	1282921,4	271.626	-
Borgou	6,0	2325600	3590171,4	11.471	-
Collines	5,6	478440	1743878,3	11471	-
Couffo	5,4	26928	1496657,3	94.703	-
Donga	5,8	342648	874577,36	11.471	-
Littoral	3,9	9000	-	285.666	-
Mono	4,0	54720	816325,89	162.561	-
Ouémé	4,0	171000	902601,86	271.626	706
Plateau	4,1	127800	2261520,3	94.703	-
Zou	5,4	106452	1285606,4	94.703	-

Apart from displaying an interesting potential of renewable energy, the country reveals a crucial opportunity for local employment and economic growth, generating direct or indirect jobs that have been estimated in either a realistic scenario (10%) or optimistic scenario (10%) of the potential demand in the table below

Table 4: Estimation of direct and indirect jobs by region. Source: UAC Foundation

Region	Estimated direct and indirect jobs (individuals)	
	Realistic scenario	Optimistic scenario
Alibori	141	703
Atacora	140	698
Atlantique	388	1938
Borgou	205	1026
Collines	168	838
Couffo	182	911
Donga	86	431
Littoral	216	1080
Mono	138	688
Ouémé	302	1509
Plateau	143	717
Zou	232	1159
Bénin	2339	11697

3.2.2 Access to Energy

Benin represents a very low access to energy despite the important renewable energy potential existing in the country. The hydroelectric potential is 624 MW and solar energy studies show that the daily irradiation averages are approximately 3.9 kWh/m² in the south for a sunshine duration of 4.5 h/day. The energy balance at the household level is dominated by biomass energy taken from natural forests (93%) for wood compared to 1% and 2% respectively for butane gas and electricity (The University of Abomey-Calavi Foundation, 2018) . Access to electricity, which seems to be the priority for the Government, is a real constraint. Benin is facing a serious problem of electrification. The electrification rate is estimated to be around 41.4%, 70.8% in urban areas and around 18% in rural areas. For the access to clean cooking solutions in both rural and urban, Benin presents an average of 6.4%. Firewood, charcoal and other forms of biomass represent the traditional form of energy most commonly used by predominantly rural and low-income populations (Sustainable Energy For All, Benin, 2019)



Figure 15: An example of traditional form of energy for cooking in Porto-Novo. Source: Objectif 2030.org

Almost all petroleum products are imported as well as nearly 76% of electricity. The country, despite all, shows positive progression in terms of energy access from 2010 to 2016 apart of the year 2016 where access to clean fuels and technologies for cooking declines showing in the table below.

Table 5: Energy statistics in Benin. Source: Sustainable Energy for All

Series	2010	2012	2014	2016
Access to electricity (% of population)	34.2%	38.4%	34.1%	41.4%
Urban (% of urban population)	65.4%	68.6%	57.6%	70.8%
Rural Population (% of rural population)	13.9%	14.5%	-	18%
Access to clean fuels and technologies for cooking (% of population)	5.3%	5.9%	6.6%	6.4

3.2.3 Energy consumption

With a total of 3344 ktoe, 0.392 toe/ capita in 2010, Energy consumption in Benin is relatively low dominated by the traditional uses of biomass energy. Firewood and charcoal have 49.5% in the total energy consumption while petroleum products and electricity represent respectively 48.3% and 2.2%. With a very low industrial development, the industrial sector account for 2% of energy consumption, 9% for services sector, the transport sector account for 36% and the highest percentage is from the household's sector with 53% (Directorate General of Energy / Ministry of Energy, 2014)

3.2.4 Challenges

The access to energy is met with many challenges. Among them is the lack of bank investment loans for Small and Medium-Sized Enterprises (SMEs) which is a barrier to the creation or expansion of innovative enterprises. The point is that most financial institutions do not have financial mechanisms adapted to the specificities of these types of renewable energy opportunities or projects. This hampers the resolution of energy challenges. Apparatuses to support the creation of innovative businesses in the sector require support from third persons or organizations, particularly technical and financial partners, government institutions and incubators to act as a pedal for the emergence of renewable energy technologies in communities. Concerning the market for renewable energy technologies, it is severely constrained by the demand due to insufficient household financial resources and inadequate ability to pay the cost of acquiring renewable energy products and technologies, and a lack of consciousness of the comparative advantages of this form of energy. Several technologies, particularly those related to solar energy, are quite well known and are in full competition due to the involvement of several commercial operators. However, quality and durability problems remain unsolved on the market for these products.

3.3 Climate Change in Benin

Taking the position of 155th out of 181 countries in the ranking of country's vulnerability to climate change, Benin is the 19th most vulnerable and 45th least ready country to climate change and is really experiencing the effects of climate change in many vital sectors such as food, water, health, human habitat, ecosystem service and infrastructure despite the low contribution

of greenhouse gas emissions, around 0.03% of global emissions. This climate change is shown by the increase of the mean temperature, deregulation of rain period, soil erosion, acceleration of desertification, floods, rise of sea level, coastal erosion.

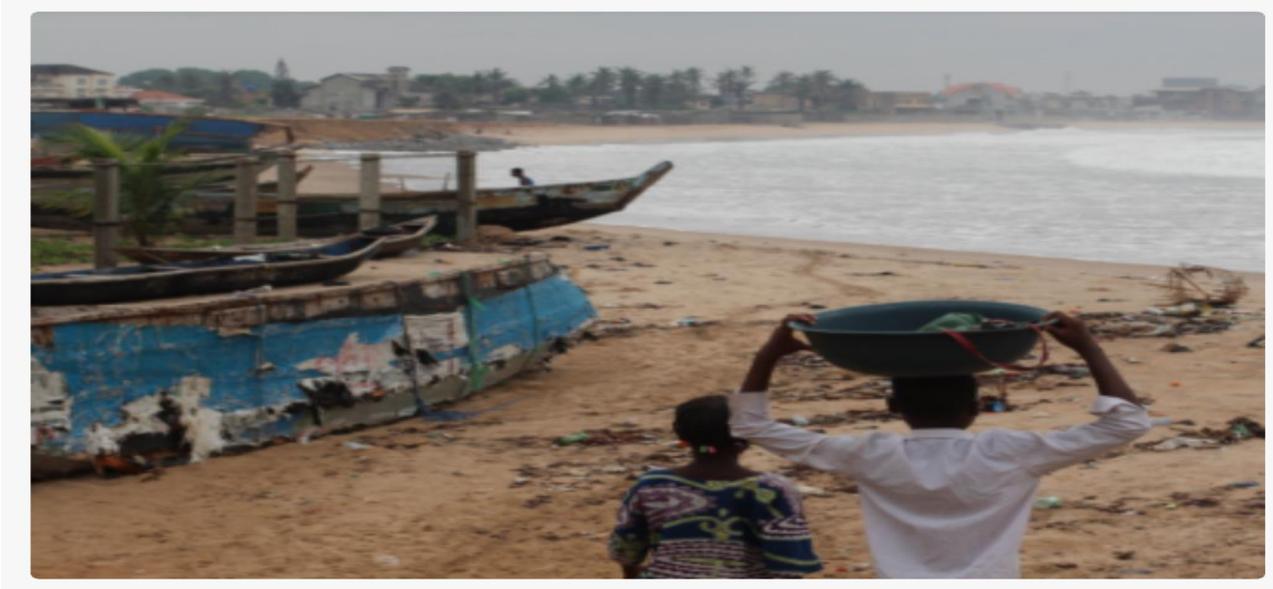


Figure 16: Coastal erosion in Benin. Source: UNDP Benin

Food production by 2025 might be reduced by 6% due to intensive floods and drought, the decline of precipitation could reduce in 40 to 60% the availability of water resources, the intensive use of charcoal in the country can reduce forests and damage the environment. With the important role that plays agriculture in the socio-economic sector of Benin with 36.3% of the GDP and 70% of the population employability, climate change is affecting the sector and making the sector vulnerable with an eventual decrease of production by 3 to 18% by 2025 enhancing poverty, creation of new conflicts due to migration, development of new diseases. The most vulnerable zones to climate change in Benin are the Coastal, the north-western, and far northern zones. Many actions have been taken by the country to fight against the effects of climate change such as the will, in the Nationally Determined Contributions, of reducing during the period 2021-2030 its emissions by 21.4% with 3.5% through national contribution and 17.9% requiring international finance. The total budget needed is about USD 30.13 billion, 12.13 billion for mitigation and 18 billion for adaptation. For the contribution of the energy sector in fighting against the effects of climate change, the country has objectives of developing the use of renewable energy such as hydro and solar. Many clean and climate-friendly projects have been set up through climate finance. International organizations donations like world bank, UNDP, GIZ, European Union which is the largest donor. Around USD 22,850,000 have been

received by Benin from climate funds between 2004 and 2014 (Ministry of Foreign Affairs of the Netherlands, 2018).

From the Nationally Determined Contribution, the energy sector has the power to really contribute to the reduction of greenhouse gas emissions with its potential of mitigation. The figure below shows the projection by 2030 of the reduction of GHG emissions through energy sector (ECREEE, 2017).

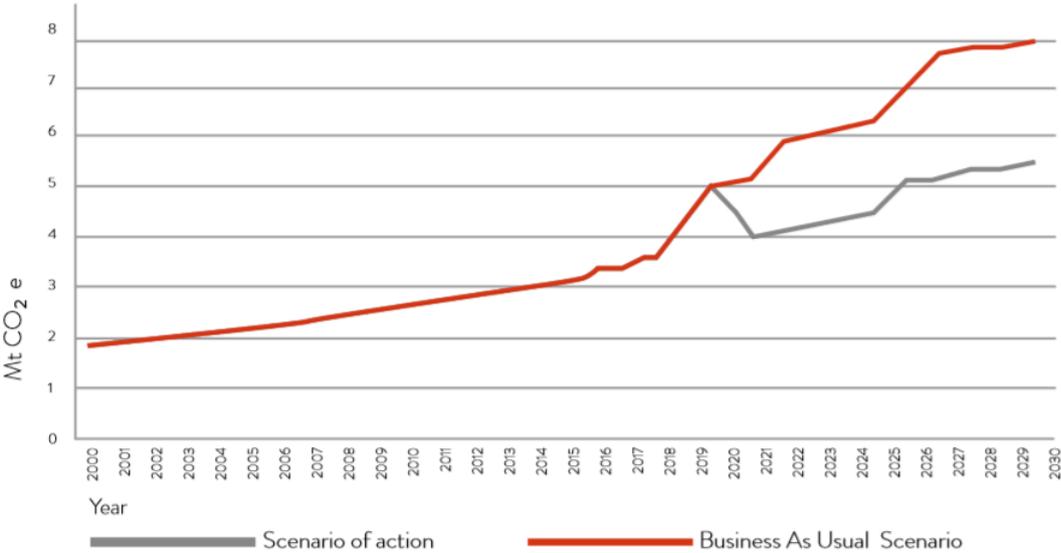


Figure 17: Estimation of the baseline emissions for the energy sector and the emission scenario with intervention. Source : Première Contribution Déterminée au Niveau National au Titre de l'Accord de Paris

To better the fight against the effects of climate change, on June 18, 2018, the country National Assembly adopted a Law No. 2018-18 to regulate climate change in the country making the country amongst the first country adopting national legislation on climate change in order to prevent, protect and manage the consequences of climate change (UNDP, Benin adopts national legislation on climate change, 2018).

3.4 Renewable energy in Benin

The huge and unexploited basket of renewable energy potentials Benin possesses can be an advantage to its development and its energy autonomy while creating better conditions to adapt and mitigate climate change. For this penetration of renewable energy, Benin has a clear vision and is on the development of strategic instruments to improve the power sector. Three main

documents including regulatory framework, policy and master energy plan have been drafted to encourage the diffusion of decentralized clean energy generation. Many supports from international organizations and partnerships exist to reinforce the instruments and better private investments in renewable energy. Many renewable energy projects are ongoing, and some are yet to come soon. The experience has shown that the private sector is vital to the expansion of renewable energy in Benin. One of the examples is that, in the 95 MW of the photovoltaic (PV) installed capacity, 40 MW have been the contribution of Independent Power Producers (IPPs) then, for Benin to reach better experiences, the development of adapted regulatory framework and instruments to guarantee private investments (ECREEE, 2017).

3.4.1 Renewable energy targets

From the scoping mission in the Scaling-up Renewable Energy Program (SREP), Benin aims for 25% by 2025 of renewable energy in the national energy mix (Scaling-up Renewable Energy Program in Benin SREP, 2015). According to the Expression of Interest of the Republic of Benin in the CIF/ SREP Program, through the renewable energy potential sources available in the country, a minimum of 25% of renewable energy in the energy mix is possible by 2025 developing the potential bioenergy, hydro, solar and wind energy (Directorate General of Energy / Ministry of Energy, 2014).

In the table that follows, Benin shows its energy vision by 2030.

Table 6: Energy targets of Benin by 2030. Source: Sustainable Energy for All

SEforAll Action Agenda Objectives	2030
Electricity Access, national	100%
Access to clean cooking, national	100%
Renewable Energy Output	35%

From the Scénario Bénin emergent, renewable energy production is estimated to be 1098 GWh for an installed capacity of 427 MW by 2020 and 2412 GWh for an installed capacity of 843 MW by 2030. Both rural and urban zones are expected to reach 100% of electricity access by

2030 and renewable energy will reach 35.14% of renewable energies share in the electricity mix by 2030 (Sustainable Energy For All, Agendas Energie Durable pour Tous au Bénin, 2015).

3.4.2 Institutional framework

In Benin, many national and international institutions with important support from some partners exist and can help in order to boost the development of renewable energy:

- **Ministry of Mines, Energy and Water (MMEE):** This institution is the main institution in the energy sector. The ministry has the role of ensuring the management of the energy sector, the ministry manages and intervenes also in the renewable energy subsector, define the energy policy and regulatory vision of energy sector and supervise all the other institutions directly linked to the energy sector (Presidency of the Republic of Benin, Les Décrets régissant l'électricité au Benin Décret N°2018-072 du 12 Mars 2018, 2018);
- **The Directorate General for Energy (DGE):** The DGE plays an important part in renewable energy diffusion and promotion and has the mission of proposition, in relation with relevant national institutions, adapted policies in energy, ensure the implementation, monitoring and evaluation of these policies.
- **Direction for new and renewable energies of the DGE:** This Direction is in charge of questions related to new and renewable energy and also the development of rural electrification. The direction work in managing the production, distribution and utilization of renewable energy and in updating the regulatory framework of the subsector.
- **The Beninese Agency for Rural Electrification and Energy Control (ABERME)** : ABERME is in charge of the implementation of the country's policy in the domain of rural electrification and control of energy. The article 5 of the decree on the statute of ABERME shows its role in the promotion of new and renewable energy in rural electrification while the article 6 of the same text works in the energy efficiency of energy or renewable energy equipment.
- **The Electrical Community of Benin (CEB):** The CEB is in charge of importation, production and distribution of electrical energy to Benin and Togo.
- **The Benin Electric Power Corporation (SBEE):** SBEE is in charge of electricity distribution in Benin. This corporation can be an important actor in the development

of renewable energy while reducing the high energy lost in electricity distribution by giving priority to renewable energy.

- **The Agency for the Control of Internal Electrical Installations (CONTRELEC)** : This entity is controlling the electrical installation in buildings in order to respect the standard for household's security.
- **The Authority of Electricity Regulation (AER):** The AER is working on the respect of laws and regulations governing electricity, protect public interest and ensure continuity of service, quality services, the financial balance and harmonious development of the sub-sector. As renewable energy part of electrical energy, the AER is competent in regulating it.
- **West African Power Pool (WAPP):** the WAPP has for role the integration of national electrical network in the regional market, to facilitate electricity exchange among the countries to better the electrical energy supply at mid and long term. Its other vision is to fill the gap of lack of electricity with renewable energy alternatives while making it affordable for the population.
- **National private companies grouped within the Interprofessional Association of Renewable Energy Specialists in Benin (AISER Benin):** AISER is supporting the government in the vision of developing renewable energy in Benin, at the same time protecting the renewable energy actors (enterprises) and strengthening the technical capacity of its members.
- **ECOWAS Centre for Renewable Energies and Energy Efficiency (ECREEE):** The role of ECREEE is to promote renewable energies and energy efficiency markets in ECOWAS region. The vision of ECREEE is to ensure the utilization of renewable energy sources for electricity supply and energy access in rural areas. Another work of ECREEE is to help ECOWAS countries in the creation of adapted regulatory framework to facilitate renewable energy development.
- **The West African Economic and Monetary Union (WAEMU/ UEMOA) through its Regional Program of Renewable Energy Development and Energy Efficiency (PRODERE):** "WAEMU has a vision of developing the electrical energy sector in UEMOA zone by 2030. To achieve this vision, the institution has set up the Regional Initiative for Sustainable Energy (IREN) which has for strategies to:
 - Develop a diversified and competitive energy supply

- Establish a regional plan to control the electrical energy consumption
- Accelerate the emergence of West Africa's regional electricity exchange market
- Set up a mechanism dedicated to the financing of the electricity sector.

PRODERE has then been created in the frame of IRED and contributes to:

- Improve access to energy services for the population by building mini solar power plants and solar kits;
- Provide public lighting by autonomous photovoltaic solar systems in the main arteries of the capitals of WAEMU member states;
- Improve the regulatory and legal framework to promote the development of renewable energy in the WAEMU zone,
- Put in place mechanisms to facilitate the financing of renewable energy projects by private operators;
- Raise awareness on the part of the sector the challenges and opportunities offered by a wider use of renewable energy more specifically PRODERE supports the government Program for the Valorisation of Renewable Energy in the Republic of Benin.” (ACE-WA, 2016)

- **Unit Responsible for Renewable Energy Development Policy (UC / PDER):**
From the decree N° 2018-050 of February 15, 2018; ‘the unit responsible for the Renewable Energy Development Policy is responsible for providing technical assistance to the Government in the definition of renewable energy development policy and in the supervision of its implementation. In this capacity, she is responsible for:
 - carry out studies for the development and updating of the renewable energy development and energy efficiency policy;
 - monitor the implementation of the renewable energy development and energy efficiency policy;
 - provide technical advice or assistance in controlling the quality of operation of renewable energy production and distribution infrastructure;
 - provide project management assistance for any work, operation or project related to renewable energy development and energy efficiency policy.

The activities of the Unit will be carried out in synergy with the competent governmental structures, in particular the Ministry in charge of Energy’ (S cretariat G n ral du Gouvernement du Benin, 2018).

It is important to notice that many institutions as partners are also helping Benin in the renewable energy sector by developing projects, donations or bringing supports such as the World Bank, French Development Agency (AFD), the European Union, African Development Bank, DeutscheGesellschaft für Internationale Zusammenarbeit GIZ, Energising Development (EnDev), Millennium Challenge Account Benin II and many other partners... (Directorate General of Energy / Ministry of Energy, 2014)

Apart of the International funds and support, some national funds exist such as:

- **Rural Electrification Fund (FER):** This fund is providing to fund ABERME's activities in rural electrification, subsidies part of investment in renewable energy projects, giving loans, fund's project's study. It aims to support the development of renewable energy sources in rural electrification.
- **National Environment Fund of Benin (FNE) /National Fund for Environment and Climate (FNEC):** This fund is provided to support clean and environmentally friendly projects that better the living standard of population such as renewable energy projects, waste management projects.

This table shows a general organization of the institutions intervening in the energy

Table 7: Energy Institutions and their implications. Source : TAF-UE

	Bénin			Bénin - Togo	Sous-région
Politique	ARE Régulation du secteur électrique	DGE Politique du secteur de l'énergie	DGFRN Politique des forêts et des ressources naturelles (et du bois énergie)	HCIE Orientation de la politique – Contrôle de la CEB	
Agences d'exécution	ANADER Développement des énergies renouvelable et de l'Efficacité Energétique	SBEE Distribution de l'électricité sur réseau	ABERME Développement de l'électrification rurale	CEB Monopole du transport de l'électricité au Bénin et au Togo	WAPP Gestion des mouvements électriques dans la sous-région
Assistance	CONTRELEC Contrôle des installations électriques intérieures	ABENOR Normalisations Qualité des matériels	ABMCQ Métrologie des compteurs électriques	CENATEL Gestion des informations issues de la télédétection	IGN Cartographie, topographie et parcellaire du Bénin
				IGN Cartographie, topographie et parcellaire du Bénin	ECREEE Politique de soutien aux ENRs et à l'EE en Afrique de l'Ouest

3.5 Global instruments, regulatory and policy framework for renewable energy development

For the development of renewable energy, necessary approaches must be taken into consideration. Those approaches are the essence, the spirit of a favorable penetration. Reflective regulations and policies are needed to be the motor of this approaches. In Benin, there is no specific regulatory, legal framework driving the sector of renewable energy even if some texts try to contribute indirectly and slowly to the development of the sector. This constitute the source of not seeing an adapted growth of the renewable energy sector as wished and leaving the country living under the dependence of external supply which is mainly from non-renewable energy sources despite the favorable potential that could be used to improve the energy situation of the country. Some general policies exist but are insufficient and not well adapted to meet the objectives of the country. Important will also be to precise that despite the texts that exist to foster improvement in the renewable energy sector, Benin tends to develop more in his vision electricity than the other parameters of energy.

3.5.1 Legal and Regulatory framework

From the interview we had with the authorities working in the energy sector in Benin, no legal and regulatory framework exist but are in process to be implemented. Many documents taken as part of legal and regulatory framework for energy in general exist and some are favorable to renewable energy penetration but mainly for electricity:

The bilateral agreement between Benin and Togo called the Benin-Togo Code of Electricity since 1968. This international agreement has been ratified in Benin by the Law No. 2005-01 of January 12, 2005 published in the Official Journal of the republic of Benin No 14 bis of July 19, 2007 and in Togo by the Law No. 2006-005 of July 3, 2006 published in the official Journal of the Togolese Republic of July 5, 2006. This code, initially designed, was giving the monopoly of electrical energy production, transportation, importation and exportation to the Electrical Community of Benin in the two countries but in 2003, the agreement has been revised giving the possibility to Independent Power Producers (IPPs) to produce while making the CEB the single buyer. This revised agreement is an opportunity to the IPPs to generate their production through renewable energy sources but the article L8 of the

agreement requires price competitiveness compared with other sources of energy (Autorité de Régulation de l'Electricité, 1968)

Another law that complete the Benin-Togo Code of Electricity is the Act on the Code of Electricity in Benin adopted on March 27, 2007. (No.2006-16 of March 27, 2007). It liberalizes and gives the modalities for production, transportation and distribution of electrical energy by public and private sectors in the country, gives the legal regime for authorization to sign concession agreements with Independent Power Producers, sets the competition rules and present the different formalities companies should respect (LEGIBENIN, Codes en Vigueur, 2007).

Law No. 98-030 of February 12, 1999 in the Republic of Benin relating to the framework law on the environment. More specifically, the article 105 of this law is about fiscal incentive measures for companies that contribute in reducing pollution, nuisances and other degradation, also, to the companies that favour the use of ecotechnologies and develop sustainability in natural resources uses (Presidency of the Republic of Benin, Loi n°98 030 du 12 février 1999 portant loi cadre sur l'environnement en République du Bénin, 2012).

Code of Forest Regime in the Republic of Benin (Law No. 93-009 of July 2, 1993 on the Forest Regime). This code gives the definition of the components covered by Beninese forest. It set up the rules to better the management of the forest in order to use smartly and efficiently this renewable energy source (Biomass) for the protection of environment, ecosystems while promoting sustainability for present and future generations (LEGIBENIN, Bibliothèque de lois Béninoises, 1993).

The 2008 Finance Act. This Act abolishes VAT on the import or acquired equipment in the Republic of Benin for rural electrification projects if only the companies are approved through a document delivered by the authorities (Impôts BENIN, 2007)

Law No. 90-002 of May 9, 1990 on the Investment Code. This Law, in its article 13 guarantees fair competition. It elaborates the same rights and obligations for all companies. Even if it does not give specific incentives for renewable energy promotion, it opens the doors in its article 15 for any company that can contribute in the achievement of the National Economic and Social Development to be considered as eligible to benefit from one of the privileged schemes given by the law while the Title II of the law shows the privileged regimes (LEGIBENIN, Bibliothèque de lois Béninoises, 1990).

Decree n ° 2008-360 of June 13, 2008, on the creation, composition and attribution of the National Commission for the promotion of biofuels in the Republic of Benin

The Commission is responsible for the implementation, through its various components, of a national program on biofuels, which contributes to the eradication of rural poverty and the socio-economic development of localities of production. It is composed of a Coordination Unit, 3 Sectoral Committees and a Technical Committee as follows:

- Agricultural Promotion Committee for Biofuels;
- Marketing and Transformation Committee;
- Committee Accompaniment Measure;
- Technical Committee Study of Accreditation Files (ACE-WA, 2016).

Decree n ° 2008-361 of June 13, 2008, fixing the general conditions of installation of the companies of production and plant transformation to biofuels

It takes into consideration, research and cultivation of biofuel vegetable plants in the Republic of Benin, production and Biofuel processing and the establishment of companies in these sectors are subject to the general conditions laid down in this decree. Also, the biofuels covered by this Decree are those obtained from terrestrial plants and animals, resulting mainly from the following three sectors:

- Oil sector: jatropha, castor oil;
- Alcohol sector: sugar cane, sugar sorghum; cassava, cashew apple,
- Biogas sector: products resulting from the transformation of plants and animals (ACE-WA, 2016).

Any promoter of research, cultivation, production, processing and marketing of seeds, products of biofuel plants in the Republic of Benin must obtain an authorization granted by Decree taken by the Council of Ministers, on the proposal of the President of the National Commission for the Promotion of Biofuels.

Decree n ° 2018 - 415 of September 12, 2018 relating to Regulation in charge of off-grid electrification in the Republic of Benin.

This decree gives the rules relating to off-grid electrification in the Republic of Benin.

It applies to:

- The production, distribution and sale of electricity in localities not yet connected to the interconnected electricity grid or a distribution network dealer;
- supply of equipment for individual or community use and off-grid electrical installations.

The article 6 of the decree gives the possibility to use renewable energy plant or a hybrid system and photovoltaic system, solar lights for off-grid electrification

The management of network with renewable energy plants can be given, under a convention agreement, to private operators. The private sector, under this decree can benefit from incentives and subsidies for their will of providing access to off-grid systems for individual and communities through an appeal to competition. It is a good opportunity for this sector to invest in Benin.

The Authority of Electricity Regulation is in charge of regulating the activities relating to this decree (Présidence de la République, 2018)

3.5.2 Existing Policy

To facilitate the development of clean and renewable sources of energy, Benin shows its national and international political will based on regional and international agreement in order to develop and better the renewable energy sector. Despite the will, many specific actions must be considered to boost and help the sector while favouring social, economic and environmental sustainability.

Government Action Programme (PAG 2016-2021)

In the vision of playing an important role in renewable energy development, the Government of Benin, in its national programme decided to work in developing renewable energy. It plans to install a total capacity of 95 MW of solar farms (Government Action Programme, 2016).

Intended Nationally Determined Contributions (INDC) presented at CoP21 Paris 2015

From this document, Benin shows its will of reduction of greenhouse gas emissions using renewable energy in electricity production (Ministère de L'environnement, 2015).

ECOWAS Renewable Energy Policy (EREP), February 2015

This document from the ECREEE gives better understanding of the regional and local initiative that can be considered for Benin. It promotes the use of renewable energy such as solar, wind, hydropower and bioenergy plants and it determines the importance of using renewable energy for remotes rural areas far from the electrical networks (ECOWAS Renewable Energy Policy (EREP) , 2015)

National Energy Management Policy Document (PONAME) 2009 (ABERME)

This document promotes rural access to clean and modern energy services, it also works on renewable energy Public-Private-Partnerships, one of the important aspect of this document is defining fiscal regime for rural electrification projects through renewable energy, better consideration are given to potential micro hydropower sites, talking about funds, funding mechanisms are valorised through Rural Electrification funds and adapted training in the efficient use of energy by local and international training structures (ABERME, 2009).

Strategic Plan for the Development of the Energy Sector in Benin (October 2009)

This strategic plan works in the access to efficient and sustainable equipment such as improved cookstoves, the promotion of solar, wind, hydro plants and organizes the growth of efficient use of biomass energy and biofuels in Benin. It shows the necessity of private investment in the electricity sector but does not give adapted and clear political framework for private participation (Ministère de l'Energie et de l'Eau, 2009)

Policy and strategy document for the development of the electricity sector in Benin (September 2008)

This document promotes the development of Adjaralla's and Ketou's Hydro dams, the development of 15 mini/ Micro hydropower plants, the creation of 3 agricultural and agro-food residues plants, with municipalities, the creation household waste plants, production and development of biofuel, wind plants, it helps the development of renewable energy projects through funds (Ministère des Mines, de l'Energie et de l'Eau, 2008).

Energy Policy and Strategy of Benin (2003), MMEH

This policy has served as reference in the development of the strategic plan for the development of the energy sector in Benin. It consists in rural electrification development, mastering energy and bioenergy sector, identification, deep studies, exploration of potential, evaluation,

determines all the favourable condition for renewable energy development and facilitate customs disarmament of renewable energy equipment (MMEH, 2003)

Despite the existence of this strategic documents promoting renewable energy, the sector is poorly developed because of funding problems and lack of adapted coordination between the policies and institutions in charge of developing the sector. Also lack of feed-in-Tariff to stimulate important investors in the country.

CHAPTER IV: RESULTS AND DISCUSSION

The energy situation in the Republic of Benin is definitely not satisfactory currently when you take into consideration the potential of the country. In terms of renewable energy, no clear regulations exist and very few has been done so far even though the ongoing Government actions plan, and some texts have made interesting room for its development. Eleven regions upon twelve have revealed great capability in renewable energy based on studies conducted by experts at the university of Abomey-Calavi. The total solar energy potential is estimated to 60.3 kwh/m² alongside with interesting biogas, harvest residues, wind power, and hydroelectricity useable potentials.

4.1 Results

This section is more about the findings obtained from gathered data. It is presenting and analyzing the energy access, the energy transition dynamism and the capital instruments that promote and develop renewable energy in the Republic of Benin.

4.1.1 Energy access

The most important aspect of energy that is taking into consideration in Benin is electricity. It is the priority of the country.

Benin faces serious electrification challenges, the access to electricity is merely above the average in urban areas and extremely low in rural areas (less than ten percent). When it comes to household energy, biomass is the most used with 93% taken from the forests, contributing therefore highly in the local global warmly. Meanwhile 76% of the electricity is imported as well as most of the petroleum products. In a recent past the little part of the population having access to electricity had to go through disturbing power shortage because the countries supplying Benin in electricity dealt with situations preventing them from supplying continuously the country.

4.1.2 Understanding the climate change and renewable energy

The country contributes only 0.03% of global emissions but stands among the most vulnerable countries to climate change. In other words, the Republic of Benin severely suffered from the effects of climate change. However, studies revealed that the country is not ready to efficiently cope with climate change. Segments such as food, water, ecosystem service, health, human habitat and infrastructure, are hampered by the lack of ability to pull investments to take actions that could enhance the economy and the governance for sustainable development. That is why the country is considered to not be ready to deal with the issue of climate change. Meanwhile, there is an increment of the aching average temperature by 1.1°C making the average number of “hot” days by 39 and “hot” nights by 73 within less than 55 years. The Northern part of the country is invading deserts and the agricultural capability is strongly compromised in the south by the extensive use of nutrients such as phosphorous, nitrogen and potassium combined with the climate change.

Regarding the energy transition, the country is quite aware and moving slowly with its vision of achieving 25% of renewable energy in the energy mix by 2025. It is therefore a good means for the government to better energy access. Concerning access to clean cooking facilities, Benin wants to achieve 100% by 2030 while access to electricity is expected to reach the 100% by 2030 where renewable energy output will account for approximately 35%. Despite this famous vision and the graduate progress, on the field; the public sector will be basically to achieve access to energy no matter if renewable or non-renewable sources are going to be used. For the private sector, it is somehow a very good business opportunity and at the same time a contribution to the achievement of government’s renewable energy vision. For the population, the question is not very known even if some of them are aware and are willing to go to renewable energy, access, availability, quality, durability and cost of technologies still constitute a blockage.

4.1.3 Analysis of determinant instruments vital for renewable energy development

Clear, precise and adapted legal and regulatory frameworks that could be a strength for raising awareness on climate change, better the energy transition while helping for a total access to clean energy are inexistent. Most of the existing texts trying to support renewable energy growth are also suffering from important gaps making obstacles to the creation of favorable

markets for investors. Regarding the policies, no precise and clear policies promoting renewable energy exist. Thus, creating no guarantees and absence of security for investors and producers.

4.1.3.1 Public-Private-Partnership law

The results given by this law is not really satisfactory because it is not determined for a specific activity, it extrapolates energy while other fields and also due to retrenchment on the part of the private sector for two basic reasons:

1/ During calls for tender, a reluctance is observed from the private sector. In fact, it appears uncertain to win the contract even when all required files are met. Then in case of rejection of the tender, time and money invested by the private sector are lost

2/ The private sector is more interested in direct agreements, but due to the high cost of procedures and project studies the interest is not expressed through actions.

4.1.3.2 The finance law on VAT abolishment

This law abolishes VAT on import or acquired equipment in the Republic of Benin for rural electrification but is not very clear and is very large in contents. Rural electrification equipment's are huge and some equipment such as pump and battery that are indirectly linked to rural electrification which are of capital importance are not mentioned in the law creating confusion in the understanding of what are considered as equipment.

4.1.3.3 The Beninese electricity code

From the data gathered, in the Beninese code of electricity, renewable energy is not considered as a priority and is even not developed in a more precise way. It appears that no specific law regarding renewable energy exist, a law and two implemented decrees were drafted with the support of ECREEE and many other partners but at the end have not been adopted till now. At the same time, the Beninese code of electricity in revision has also not yet seen the light, creating a delay in favoring the development of the sector.

As justification of delays in establishing these instruments, it was observed that the need for specific renewable energy law was not necessary as the electricity code is being revised, thus,

a new Beninese code of electricity will be a solution in order to incorporate both Renewable energy and electricity which is the priority of the energy actions in the country that takes mostly non-renewable sources from Nigeria, Ghana and Côte d'Ivoire for electrification. And establishing this new code is the responsibility of the AER in collaboration with the collaboration the ministry of energy, the ministry of justice, the legal unit of the presidency. So far, the new code will be an opportunity to understand the renewable energy implementation's conditions, the different conditions to invest in renewable energy in Benin. For this fact, three main levels will be considered in electricity production:

- 1) The first level is a self-electricity production for self-consumption,
- 2) The second production level concerns productions for production units, for company. This is considered as self-producer because it is only for the need of a specific company or production units,
- 3) The third level is about electricity production and sale: in this level, it opens the door for production in order to sell by injecting it in the grid for public service purposes.

4.1.3.4 Available instruments for renewable energy Programs and funding

From the data obtained, the country has serious issues in self-funding most of the important energy sector activities in general and more precisely the renewable energy activities. Despite this, the country has developed some national fund policies and objectives for projects to support renewable energy growth such as the Government Action Programme (2016-2021) that plans to install a total capacity of 95 MW of solar farms by 2020-2021. Solar energy is the priority in the Republic of Benin in terms of renewable energy. Some funds from the Rural Electrification Fund (FER), National Environment Fund of Benin (FNE) /National Fund for Environment and Climate (FNEC) also exist but are still not making great impacts.

It is also shown that the quasi-totality of the projects' funds come from partners and international organizations such as the following:

50 MW photovoltaic Off-grid for electrification: Four (04) Solar Photovoltaic Power Plants financed by Millennium Challenge Account II Benin, which is a support of the United States,

25 MW financed by the French Development Agency, called DEFISSOL project,

5MW funded by the private sector and,

The Direction in charge of renewable energy in the country receives as operating budgets 2 Million CFA (3395 USD Dollars/ year) which demonstrate impossibility in managing well the direction.

4.2 Discussion

From the results obtained, many points need to be discussed in order to create a clear vision of the development of renewable energy in the Republic of Benin. These aspects consider the energy transition view, Feed-In-Tariff environment, the exploitation, management and development of renewable energy, the guarantee of purchasing the energy produced by the private sector.

4.2.1 Practical view of energy transition

Energy transition to a low or no carbon source is in general defined in the Beninese context as a chance to achieve total access to electricity. In reality, the term energy in the country's actions regarding the legal, regulatory and policy instruments refer in most of the cases to electrification. Despite some texts promoting bioenergy and efficient use of the forest resources, the lack of important actions is observed and the reality shows that Firewood and charcoal have 49, 5% in the total energy consumption while petroleum products constitute 48.3% of the energy consumption. Consequently, progress in these important aspects that could highly contribute to reduction of greenhouse gas emission and reinforce the energy transition is not considerable.

Electrification is the center of the energy sector demonstrated by its strong occupation in the energy projects while contributing to only 2.2% of the energy consumption. With all this importance given to total electrification, the country does not have clear and specific instruments for renewable electricity growth. Most of the existing instruments promote only access to electricity and give the opportunity to generate electricity from any of the sources that could help to achieve this goal of total access to electricity.

Energy is not only electrification then taking the whole energy sector will enhance the action of reducing greenhouse gas emission in a more implicative way. Actions into energy transition are needed in the Republic of Benin while using the important renewable energy basket.

4.2.2 The Feed-In-Tariff environment

In the Republic of Benin, no Feed-In-Tariff environment exist to boost renewable energy deployment. This mechanism that could help to boost investment in technologies is inexistent in the country. In fact, FIT as part of the renewable energy regulatory and policy frameworks is a mean of stability for energy producers in the sense that it gives them an appropriate guarantee, support and environment to grow in their business for long-time. The case in Benin is very difficult because of policies that are not stable and not really supporting the producers because of political will that change from a government to another in the domain of energy. Even when sometimes nearest regulations exist, they are very difficult for investors. The example of public procurement code exists but is not specific to RE and is an obstacle to the diffusion of renewable energies due to the exceptionally long procedure.

4.2.3 Guarantee energy purchase

One of the attractive guarantees for producers is to be sure that the energy produced is going to be purchased. The tariff should be profitable for the producer and make him proud to invest better in the sector. The case of the Republic of Benin is very difficult to understand because it seems that some investors are not feeling the security in the purchase of the energy produced at a profitable tariff. The case of Innovent in Benin is an example. In fact, the company had a PV production of 1.25 MW and wanted to send it on the grid at 69 CFA the kwh while the CEB authorizes 58 CFA for the kwh then the energy produced by the PV plant of Innovent was more expensive than the one produced by the thermal plant. It creates a conflict and a case is pending at the Common Court of Justice and Arbitrage (CCJA).

4.2.4 Relevance of energy law, sustainable development and energy transition theories in tackling diagnostic and results

The tenets of the energy transition theory identified in the Chapter 2 (2.2) have allowed to understand during the diagnostic that the Republic of Benin, which is suffering highly of critical lack of energy, especially in terms of electricity is facing the challenges of climate change as well playing havoc with the whole planet. The few neighbouring countries providing the Republic of Benin with energy will have very soon to renegotiate the contracts or even stop supplying the Country for the simple reason that they are facing their own

challenges. Also, with the increasing price of fossil fuel, the transition will be an obligation instead of a negotiation. Due to the subsidies on fossil fuels that are reducing, and the externalities added to the use of fossil fuel, going to renewable energy will be an undebatable question. Thus, the only way to adapt is to swift from fossils energy to renewable one. But an appropriate period of transition is required where both types of energy will be used. The necessity to go to renewable energy is an unavoidable road to achieve sustainable development. This theory, as presented in the Chapter 2 (2.3), highlights that energy is the centre of development and it plays a big role in social well-being, economic growth and environmental sustainability; it is then the mean of achieving the present generation needs while also giving a chance to future generations to meet their needs and this could be an occasion for the country to solve many issues such as poverty, standard of living, environmental protection. Therefore, legal framework is needed to help achieve the purpose, only the energy law theory which has been highly developed and explained through the Energy Law and Policy Triangle by Heffron and Talus in the Chapter 2 (2.1), fits the best. It has allowed to realise the inexistence of the required legal framework and provided with insights pertaining to how to establish a relevant legal system to best support the transition from fossil energy to renewable energy in order to achieve sustainable development in the Republic of Benin. This energy law theory is an opportunity for the Republic of Benin with its adequate potential to boost economic growth and development in an environmentally friendly way while permitting to society to get security of access to energy. Moreover, the theories will help in shaping accurate suggestions that might significantly help the country in achieving its goals in the energy sector.

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The current study has rightly described the importance of renewable energy in Africa and particularly in the Republic of Benin. In the chapter 2, the focus was on energy transition theory and energy law theory as vital conditions for renewable energy growth. In the chapter 3, the most important aspects were the challenges in a total access to energy, energy security and the low progress in the renewable energy sector despite the abundant RE potential in the country, the chapter 3 also identified a serious lack of adapted regulations for RE growth in the Republic of Benin and the effects of this lack. The chapter 4 covers mostly the opportunities and threats of the existing RE instruments and shows the relevance of energy transition and energy law theories in RE mainstreaming in the Republic of Benin.

The continent has the necessary potential to be one of the key leaders in renewable energy deployment and thus, contribute to a total access to energy while mitigating climate change.

The study showed a huge deficit of access to energy in the Republic of Benin. From the statistics, even if access to electricity is growing progressively, the current situation is still not meeting the needs of the population and access to adequate cooking energy and facilities remains underdeveloped.

It is evident to see that the country is highly dependent on neighboring countries for electricity supply creating instability in constant electricity access characterized by untimely power outages by the suppliers and justified by the growing electricity demand from their local customers.

The important renewable energy basket is still unexploited in the Republic of Benin and efforts made in improving renewable energy development are mainly focused on electricity. Despite all these efforts made and the vision of the country, the renewable energy and “renewable electricity” sectors present slow progressions and are not really satisfactory due to numerous challenges such as the lack of favorable environment for renewable energy development.

It has been noticed in the data obtained from the face-to-face interviews and the qualitative documents that energy transition is not well developed in the country. The priority of the Beninese government is to improve access to energy and particularly improve access to electricity from both renewable and non-renewable sources.

The gradual process of going from fossil fuel to renewable energy as presented in the transition theory is needed to reinforce the value of sustainability while enhancing energy access and reduce energy dependency. This theory, if exploited efficiently, could reinforce the necessary approaches to mitigate climate change in Republic of Benin.

The inexistence of clear regulations related to renewable energy in Republic of Benin constitutes a strong obstacle to the health of the sector. While some renewable energy projects are ongoing, the existing laws and policy are largely unclear and do not favor the mainstreaming of renewable energy. Thus, leading to an insecure environment for the desired development of RE. At the center of appropriate renewable energy and clean energy diffusion is Energy Law, which is explained by the Energy Law Theory, has the power to create suitable environment for investment and governing the sector.

The institutional framework is also suffering from good management and impressive impacts. Productive researches, adapted training, innovation and favorable funds are missing in the advancement of the sector; the quasi-totality of the projects developed are possible thanks to external supports.

Regarding the exploitation, management and development of renewable energy, no clear and relevant procedures and institutions exist to explain how they should be, leading the sector in an uncertain route. This could be an opportunity for the private sector to manage in a successful way through the establishment of adequate energy law.

Through this study, achieving renewable energy diffusion without proper regulations and policies in the Republic of Benin is clearly difficult. This study suggests a secure environment that stimulate investment, promote access to clean and affordable energy, foster socio-economic growth in respect with environment through the establishment of clear energy law based on the energy law theory in order to achieve the Sustainable Development Goals and the Agenda 2063 of the African Union.

5.2 RECOMMENDATIONS

This research has been done following the existing documentations and interviews we could have. Availability of some data related to this study was a serious limitation for expanding the research. The study demonstrates and confirms one more time the importance of regulations in the diffusion of renewable energy.

Thus, further studies are needed in order to favour expansion, and development of such a study in the Beninese context.

Taking into consideration the different factors constituting obstacles to the proper development of renewable energy in Republic of Benin, the research suggests to the government and the policy makers to ensure the following approaches:

First, Build a strong legal framework for Renewable Energy through the application of energy law theory. This legal framework should be precise and clear in order to create a better understanding of political, environmental, market, economic, social, local and international contexts required for harmonious diffusion of RE.

Second, Government must take smart measures in its action plans to improve access to energy through the application of energy transition theory and develop the renewable energy sector according to the different poles of economic development. With the existing potential in the country, developing renewable energy in each pole of economic development is an opportunity to improve access to energy and create economic growth through the implantation of industries that could produce their own renewable energy by using local resources while creating jobs. This will favour the social well-being of the population by giving them: the purchasing power to afford the energy used, access to clean energy facilities, reduce poverty and conflict, better education.

Third, Financial institutions. Through the government, national financial institutions must be established to provide funding for renewable energy development activities, research promotion in order to have a clear and accurate renewable energy database. Government must also take good profit from international financial institutions such as the World Bank, the African Development Bank that could help to achieve some targets.

Fourth, The necessity to partnership with international institutions such as the Ecowas Centre for Renewable Energy and Energy Efficiency (ECREEE), United Nations Department of

Economic and Social Affairs (UNDESA), the United Nations Development Programme (UNDP), the African Union Programme for Infrastructure Development in Africa (PIDA), the Action Plans for Renewable Energy Development and Energy Efficiency (PANER/ PANEE), and countries that have good expertise in renewable energy in order to get good strategies and assistance in transferring knowledge, skills and technology, strengthen training in the sector to improve technical know-how for the creation of local companies in the production of renewable energy equipment, also in establishing innovative and contextual renewable energy legislation in the Republic of Benin.

Fifth, establishing a strong Feed-In-Tariff regulation should be the priority of the government in order to create a secure environment for investors, government should encourage the producers, investors, beneficiaries in going to a low carbon energy source by furnishing adapted subventions, incentives, grants.

Sixth, more precise renewable energy Public-Private-Partnerships law should be adopted and help reducing time and money in procedures and project studies while bettering collaboration and enforce guarantee for both parties.

Seventh, integration of local community in the decision-making process and take into consideration traditions, cultures, to create inclusive decisions to avoid the destruction of installations. Also sensitize to promoting RE, especially for households and rural areas.

Eighth, establish a clear role and mission of institutions intervening in renewable energy for better coordination and information sharing among them and also with the populations and other stakeholders.

Ninth, the whole renewable energy sector should be considered in the policy, regulations, projects in order to cut significant greenhouse gas emissions and develop a more integrated green environment.

Tenth, the instruments should integrate Gender balance in the renewable energy actions and decision-making process.

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APPENDICES

Annex 1: interview guideline

Understanding of energy transition for public and private actors in Benin
Actions been done, what is being done and what is planned to be done in Benin
Current situation of renewable energy development in Benin
Vision of the Sustainable Development Goals 7 in Benin
Important projects developed by the country, the developers or in the context of PPPs
Existing regulations or policies favouring the development of renewable energies in Benin and their importance
Problems encountered (legal and political barriers) by potential investors
Will to create a legal and political framework adapted to the development of renewable energies in Benin (Investment): Public-Private Partnership
Organization of exploitation, management and development of renewable energies in Benin
Pertinence of the research

Annex 2: Energy Indicators for Sustainable Development

International Atomic Energy Agency (IAEA), 2005

Social				
Theme	Sub-theme	Energy Indicator		Components
Equity	Accessibility	SOC1	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	<ul style="list-style-type: none"> – Households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy – Total number of households or population
	Affordability	SOC2	Share of household income spent on fuel and electricity	<ul style="list-style-type: none"> – Household income spent on fuel and electricity – Household income (total and poorest 20% of population)
	Disparities	SOC3	Household energy use for each income group and corresponding fuel mix	<ul style="list-style-type: none"> – Energy use per household for each income group (quintiles) – Household income for each income group (quintiles) – Corresponding fuel mix for each income group (quintiles)
Health	Safety	SOC4	Accident fatalities per energy produced by fuel chain	<ul style="list-style-type: none"> – Annual fatalities by fuel chain – Annual energy produced

Annex 2 (Contd): Energy Indicators for Sustainable Development

Economic										
Theme	Sub-theme	Energy Indicator		Components						
Use and Production Patterns	Overall Use	ECO1	Energy use per capita	<ul style="list-style-type: none"> – Energy use (total primary energy supply, total final consumption and electricity use) – Total population 						
	Overall Productivity	ECO2	Energy use per unit of GDP	<ul style="list-style-type: none"> – Energy use (total primary energy supply, total final consumption and electricity use) – GDP 						
	Supply Efficiency	ECO3	Efficiency of energy conversion and distribution	<ul style="list-style-type: none"> – Losses in transformation systems including losses in electricity generation, transmission and distribution 						
	Production	ECO4	Reserves-to-production ratio	<ul style="list-style-type: none"> – Proven recoverable reserves – Total energy production 						
				ECO5	Resources-to-production ratio	<ul style="list-style-type: none"> – Total estimated resources – Total energy production 				
	End Use	ECO6	Industrial energy intensities	<ul style="list-style-type: none"> – Energy use in industrial sector and by manufacturing branch – Corresponding value added 						
				ECO7	Agricultural energy intensities	<ul style="list-style-type: none"> – Energy use in agricultural sector – Corresponding value added 				
						ECO8	Service/commercial energy intensities	<ul style="list-style-type: none"> – Energy use in service/commercial sector – Corresponding value added 		
								ECO9	Household energy intensities	<ul style="list-style-type: none"> – Energy use in households and by key end use – Number of households, floor area, persons per household, appliance ownership
										ECO10

Annex 2 (Contd): Energy Indicators for Sustainable Development

Economic				
Theme	Sub-theme	Energy Indicator		Components
	Diversification (Fuel Mix)	ECO11	Fuel shares in energy and electricity	<ul style="list-style-type: none"> – Primary energy supply and final consumption, electricity generation and generating capacity by fuel type – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
		ECO12	Non-carbon energy share in energy and electricity	<ul style="list-style-type: none"> – Primary supply, electricity generation and generating capacity by non-carbon energy – Total primary energy supply, total electricity generation and total generating capacity
		ECO13	Renewable energy share in energy and electricity	<ul style="list-style-type: none"> – Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
	Prices	ECO14	End-use energy prices by fuel and by sector	<ul style="list-style-type: none"> – Energy prices (with and without tax/subsidy)
Security	Imports	ECO15	Net energy import dependency	<ul style="list-style-type: none"> – Energy imports – Total primary energy supply
	Strategic Fuel Stocks	ECO16	Stocks of critical fuels per corresponding fuel consumption	<ul style="list-style-type: none"> – Stocks of critical fuel (e.g. oil, gas, etc.) – Critical fuel consumption

Annex 2 (Contd): Energy Indicators for Sustainable Development

Environmental				
Theme	Sub-theme	Energy Indicator		Components
Atmosphere	Climate Change	ENV1	GHG emissions from energy production and use per capita and per unit of GDP	<ul style="list-style-type: none"> – GHG emissions from energy production and use – Population and GDP
	Air Quality	ENV2	Ambient concentrations of air pollutants in urban areas	<ul style="list-style-type: none"> – Concentrations of pollutants in air
		ENV3	Air pollutant emissions from energy systems	<ul style="list-style-type: none"> – Air pollutant emissions
Water	Water Quality	ENV4	Contaminant discharges in liquid effluents from energy systems including oil discharges	<ul style="list-style-type: none"> – Contaminant discharges in liquid effluents
Land	Soil Quality	ENV5	Soil area where acidification exceeds critical load	<ul style="list-style-type: none"> – Affected soil area – Critical load
	Forest	ENV6	Rate of deforestation attributed to energy use	<ul style="list-style-type: none"> – Forest area at two different times – Biomass utilization
	Solid Waste Generation and Management	ENV7	Ratio of solid waste generation to units of energy produced	<ul style="list-style-type: none"> – Amount of solid waste – Energy produced
		ENV8	Ratio of solid waste properly disposed of to total generated solid waste	<ul style="list-style-type: none"> – Amount of solid waste properly disposed of – Total amount of solid waste
		ENV9	Ratio of solid radioactive waste to units of energy produced	<ul style="list-style-type: none"> – Amount of radioactive waste (cumulative for a selected period of time) – Energy produced

Annex 2 (Contd): Energy Indicators for Sustainable Development

Environmental				
Theme	Sub-theme	Energy Indicator		Components
		ENV10	Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	<ul style="list-style-type: none"> – Amount of radioactive waste awaiting disposal – Total volume of radioactive waste

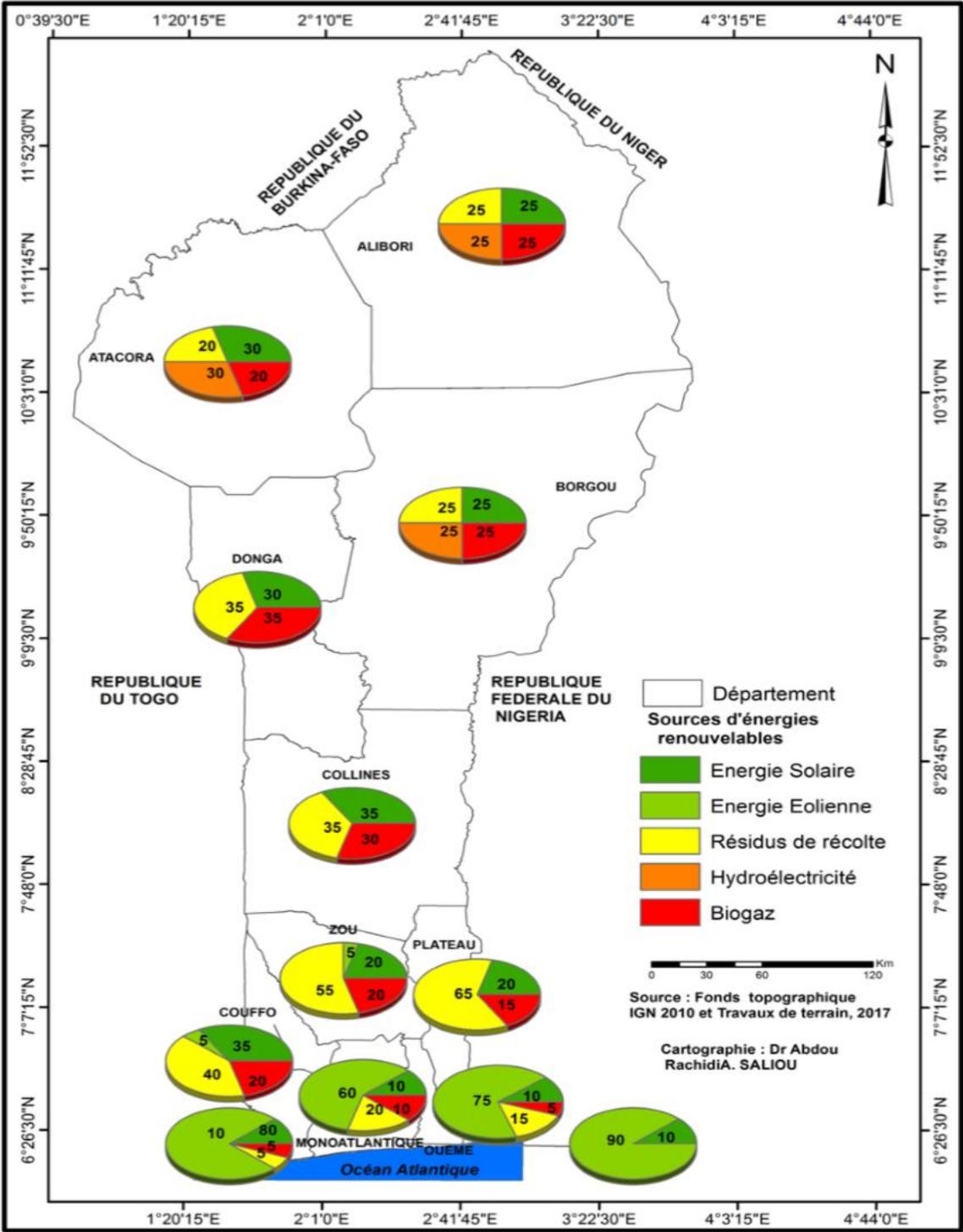
Annex 3: Renewable energy prioritization plan and poles of creation and development of renewable energy companies.

The University of Abomey-Calavi Foundation, 2018

Types of energy by department	Residues agricultural	Solar energy photovoltaic Energy	Win turbine	Microhydroelectric power plant (MCH)	Biogas	Biogas Biofuels
Alibori		1 st place			1 st place	2 nd place
Atacora	2 nd place	2 nd place		1 st place	2 nd place	
Atlantique	1 st place	2 nd place	1 st place		2 nd place	
Borgou	1 st place	1 st place		3 rd place	1 st place	2 nd place
Collines	1 st place	3 rd place		1 st place	2 nd place	2 nd place
Couffo	1 st place	3 rd place		1 st place	2 nd place	2 nd place
Donga	1 st place	3 rd place		1 st place	2 nd place	2 nd place
Littoral		4 th place	1 st place			
Mono		4 th place	1 st place	1 st place		
Ouémé	4 th place		1 st place			
Plateau	1 st place	3 rd place		3 rd place		2 nd place
Zou	1 st place	3 rd place		1 st place		4 th place

1st place
 2nd place
 3rd place
 4th place

Annex 3: Renewable energy prioritization plan and poles of creation and development of renewable energy companies.



Annex 4: Regulatory Indicators for Sustainable Energy (RISE)

2017 country Data – Benin

Clean Cooking

Indicator	Score
Planning	0
Scope of Planning	0
Standards of Labelling	0
Incentives and attributes	0
Total	0

Electricity Access

Indicator	Score
Existence and monitoring of officially approved electrification plan	69
Scope of officially approved electrification plan	50
Framework for grid electrification	33
Framework for minigrids	70
Framework for stand-alone systems	89
Consumer affordability of electricity	52
Utility Transparency and Monitoring	94
Utility Creditworthiness	50
Total	63.38

Annex 4: Regulatory Indicators for Sustainable Energy (RISE)

Energy Efficiency

Indicator	Score
National energy efficiency planning	77
Energy efficiency entities	61
Information provided to consumers about electricity usage	42
EE incentives from electricity rate structures	81

Renewable Energy

Indicator	Score
Legal framework for renewable energy	50
Planning for renewable energy expansion	70
Incentives and regulatory support for renewable energy	31
Attributes of financial and regulatory incentives	8
Network connection and use	13
Counterparty risk	48
Carbon Pricing and Monitoring	50
Total	38.57
Overall Score	32.95

Renewable Energy

Indicator	Score	50
Does a legal framework for renewable energy development exist?		No
Does the legal framework allow private sector ownership of renewable energy generation?		Yes