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Institute of Water
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INSTITUTE OF WATER AND ENERGY SCIENCES (INCLUDING
CLIMATE CHANGE)

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Towards a Systemic Approach to Energy Transformation in Algeria

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PAN-AFRICAN UNIVERSITY
INSTITUTE OF WATER AND ENERGY SCIENCES
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Towards a Systemic Approach to Energy Transformation in Algeria

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STATEMENT OF THE AUTHOR

I, Khadidja SAKHRAOUI hereby declare that this thesis represents my original work and has not been submitted to another institution for the award of a degree, diploma, or certificate. I also declare that all words and ideas from other works presented in this thesis have been duly cited and referenced in accordance with the academic rules and regulations.

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DEDICATION

I dedicate my dissertation work to my wonderful family. A special feeling of gratitude to my loving parents, Louisa and Nacer whose words of encouragement and push for tenacity are in my ears. My sisters Asma and Hassna have never left my side. My brother Mohamed and my lovely nephew Lyne. I love you too much. I also dedicate this work to my friends and all my other family members who have supported me through the process. I will always appreciate all that you have done for me, especially, Asma, Bouchra, and Madhulika. Last but not least I give special thanks to myself for never give up.

BIOGRAPHICAL SKETCH

Khadidja SAKHRAOUI is of Algerian nationality. Holding a Bachelor Degree in Renewable Energy Engineering from Mohamed Khaider University, Biskra. Her vision was to mix both engineering and policy skills to strive to collaborate with different actors to enhance sustainable energy development. Conducting her M.Sc. thesis on the energy transformation in Algeria, she has acquired a mastery of the renewable energy transformation sector. While at PAUWES, Khadidja has acquired in-depth skills in Energy planning, policy analysis, energy access, and environmental impact assessment. She has been a participant in WASCAL training, and she was the general coordinator of the PAUWES Climate Change and Gender Club. Khadidja is a self-driven individual seeking to work in an international organization that has strong research culture in the energy sector, offers support for countries in their transformation to a sustainable future, and helps governments, industry, and citizens make good energy choices.

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ABBREVIATIONS

APRUE	The National Agency for Promotion and Rationalization of Energy
CDER	Renewable Energy Development Centre
CEREFE	The Renewable Energies and Energy Efficiency Commission
CREG	Electricity and Gas Regulation Commission
EE	Energy Efficiency
FNER	The National Energy Efficiency Fund
FNME	The National Fund for Energy Management
IAER	Algerian Institute for Renewable Energies and Energy Efficiency
IPP	Independent power producers
MDA's	Ministries Departments and Agencies
MEM	Ministry of Energy and Mines
METRE	The Ministry of Energy Transformation and Renewable Energies
NEAL	New Energy Algeria
NFEEREC	National Fund for Energy Efficiency, Renewable Energies, and Co-generation
NFEM	National Fund for Energy Management
NFRE	The National Fund for Renewable Energies
NFREC	The National Fund for Renewable Energies and Co-generation
NGO's	Non-Governmental Organization
RE	Renewable energy
RES	Renewable Energy Sources

RET	Renewable Energy Transformation
SGTE	Algerian Electricity Transport Network Management Company
SKTM	Sharikat Kahrabaa Wa Taqua'at Motajadida
SONALGAZ	National Society for Electricity and Gas
SONATRACH	National Society for Research, Production, Transport, Transform, and Commercialization of Hydrocarbon
SPE	Algerian Electricity Production Company

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ABSTRACT

Concerns over climate and sustainable natural resources management have stimulated calls for a transformation in global energy systems. The situation is even more interesting in countries with a high level of fossil recourse endowment that have built their economy upon the development and consumption of fossil resources such as Algeria. While there is significant evidence on the government's commitment towards facilitating a transformation to clean energy, the rate of adoption of these technologies is low due to insufficient evidence on the behavior of the country's energy system to inform policy. This study, therefore, seeks to contribute towards filling this lacuna by applying a systems theory in analyzing Algeria's renewable energy transformational landscape and proposing sustainable policy options to enhance a sustainable energy transformation. The study adopts a qualitative method design to understand how comprehensive the policy is in fostering the synergy between the major variables that will be identified in the study. Key-informant interviews and document reviews were the main methods of inquiry. A total of twenty energy stakeholders were interviewed and seven policy documents were purposelessly sampled. Data were analyzed using NVIVO software. Results show that Economic, social, Market and institutional drivers have been identified as very important key drivers in enhancing the energy transformations especially the deployment and development of renewable energy. Whereas Institutional, political and social barriers to energy transformation are contingent on these particular circumstances. Against these challenges, centralized planning and monopolistic power sector structure have been found as the most important barriers in dimensions of barriers to the energy transformation initiative, subsidized conventional electricity, and knowledge and coordination gap were highlighted as dominant barriers. whereas unstable policies/regulations and political skepticism were also rated as important barriers. The recent energy policy has discussed such barriers, yet the policy documents fail to explicitly outline strategies to face the over-mentioned challenges in an applicable way. The study recommends the integrating of systemic reasoning planning into the central planning level of the government to enhance the sustainable energy transformation pathway of Algeria and proposes an integrated framework based on the findings toward this initiative.

RÉSUMÉ

Les préoccupations relatives au changement climatique et à la gestion durable des ressources naturelles ont stimulé les appels à une transformation énergétique mondiale. La situation est encore plus intéressante dans les pays disposant d'un niveau élevé de ressources fossiles et qui ont construit leur économie sur le développement et la consommation de ces dernières, comme le cas érie de l'Alg. Bien qu'elles existent des preuves significatives de l'engagement du gouvernement pour faciliter la transformation vers les énergies propres, le taux d'adoption de ces technologies est faible en raison de l'insuffisance des preuves sur le comportement des énergies pour un indicateur de la politique. Cette étude, par conséquent, cherche à contribuer à combler cette lacune en appliquant une systématique approche dans l'analyse du passage transitoire des énergies renouvelables durables en transformation Algérie tout pour on proposant égé options L'étude adopte une méthode qualitative pour comprendre dans quelle mesure la politique favorise la synergie entre les principales variables qui seront définies dans l'étude. Des entretiens avec des informateurs clés et des examens de documents ont été la principale méthode d'enquête. Vingt parties prenantes du secteur de l'énergie ont été interrogées et sept documents de politique ont été échantillonnés à dessein. Les données ont été analysées à l'aide du logiciel NVIVO. Les résultats déterminés que les facteurs économiques, sociaux, commerciaux et institutionnels ont été identifiés comme des facteurs clés très importants pour améliorer les transformations énergétiques, en particulier le déploiement et le développement des énergies renouvelables. Les obstacles institutionnels, politiques et sociaux à la transformation énergétique dépendent de ces circonstances particulières. Face à ces défis, la planification centralisée et la structure monopolistique du secteur de l'électricité ce sont avérées être les barrières les plus importantes dans les dimensions des obstacles à l'initiative de transformation énergétique, l'électricité conventionnelle subventionnée et le manque de connaissances et de coordination ont été soulignés comme des barrières dominantes. La récente politique énergétique a discuté de ces barrières, mais les documents politiques ne décrivent pas explicitement les stratégies pour faire face aux défis sus-mentionnés de manière applicable. L'étude recommande l'intégration d'une planification systématique du raisonnement au niveau de la planification centrale du gouvernement pour améliorer la voie de la transformation énergétique durable de l'Algérie et propose un cadre intégré basé sur les résultats de cette initiative.

1. INTRODUCTION

This chapter provides an overview of the study. specifically, it contains information that generally sets the scope for the research. It will present the research problem, the objectives, the significance of the study, the scope of the study, and an outline of the tentative chapters that the study entails.

1.1. Background of the study

Globally the current need for new electricity generation capacity and the decreasing costs of renewable energy technologies have opened up a window of opportunity for sustainable energy pathways (GIZ, 2019). This situation provides significant opportunities for advancing the global energy transformation in the developing world especially fossil-based economies. Energy efficiency and renewable energy are the two key solutions to enable global energy transformation. Despite the plurality of evidence on the relevance of RET adoption, improvement rates are slow, with only an estimated 1% in 2020, less than anticipated before the Covid-19 crisis, however. A faster recovery would have a minimal impact on renewable energy production, though it would enable more new renewables-based projects to be completed (IEA, 2020).

The North African context is characterized by a high dependence on oil and gas either for exports (Algeria, Libya, and Egypt) or for imports (Morocco) (Khennas, 2012). Indeed, Algeria plays a very important role in world energy markets, both as a significant hydrocarbon producer and as an exporter, as well as a key participant in the renewable energy market (Boudghene Stambouli, 2011). Due to its geographical location, the country holds one of the highest solar potentials in the world in addition to other renewable energy resources.

Over the years, the development of these fossils has been the major bedrock of Algeria's economy. The country has a wide coverage of grid-connected electricity at subsidized prices, making it for households and other consumers to shift from fossil-based electricity to renewable sources despite recent commitment on the part of the government to enhance renewable energy technology adoption. With policy playing a significant role in shaping production and consumption behavior, it becomes important to understand the dynamics of Algeria's energy sector and the behavior of the key sectors to ensure that national energy

policies can effectively manage such dynamics to enhance renewable energy technology adoption. The transformation to a renewable-energy economy, as part of the energy transformation, is a collective, complex and long-term process comprising multiple actors for social changes (or innovations) (Anderson, T.; Curtis, A.; Wittig, C., 2015), which involves far-reaching societal, technological, organizational, political, economic and sociocultural changes (Markard et al., 2012). It is against this background that this study seeks to adopt a systemic perspective to examine Algeria's renewable energy transformation and to facilitate the transformation to cleaner and modern energy sources and the adoption of renewables using. This will therefore establish a framework for actor engagement and behavioral reinforcement which are necessary if Algeria is to transit from a fossil-based economy to an energy-mix economy, and therefore contributes towards meeting global goals of sustainable development, particularly Sustainable Development Goal 7 (SDG 7) and other SDG's. This research aims to find out (i) the key factors and barriers towards the energy transformation initiative in the energy sector of the country,(ii) how comprehensive are the existing energy policy and regulatory provisions in addressing these challenges, (iii) and to develop a framework for the sustainable renewable energy transformation in Algeria based on the system theory.

1.2. Research Problem:

Despite evidence on the significant renewable energy potentials of Algeria, adoption rates for renewable energy in the country is very low. This is attributable to the fact that there is insufficient evidence on the behavior of the main variables that will inform policy and shape production and consumption attitudes. The country's vast solar potential is largely underutilized, with most of its energy consumers dwelling on the perceived low-cost energy which is produced from fossil sources. Across all of its major sectors (transport, industry, and households), the over-reliance on fossil-based energy leads to an increased generation of carbon emissions. Consequently, the effects of the current production and consumption patterns of energy in Algeria on the environment are dire, especially in the long run.

While efforts are being made by the government in recent agreements, policy initiatives, and interventions to promote renewable energy transformation, the rate of uptake of the technology is still slow. Several behaviorist theorists have affirmed that people's attitudes are influenced by their perception, and the extent to which their behavior is understood contributes significantly towards leverage in altering them. Again, the complex nature of the society

manifested in the diverse energy needs of the populace implies that there will be cross-cutting synergies across the major sectors, and understanding these dynamics will go a long way towards influencing policy and practice to promote sustainable renewable energy technology adoption.

Recent energy discourse has sought to investigate the most feasible and sustainable ways of promoting a transformation in the energy systems of the world. Within the context of Algeria, evidence in research on renewable energy potential has significantly been established. Bouraiou et al., (Bouraiou et al., 2020a) extensively demonstrated the renewable energy potential of Algeria, highlighting the consumption behavior of the country. They demonstrated the over-reliance on fossils, as well as the plurality of renewable resources that can be harnessed to transform the energy landscape of the country. In a similar context, Himri, Malik, Boudghene Stambouli, Himri, & Draoui (Himri et al., 2009a) provided further evidence on the possibility of renewable energy transformation when they investigated the potential of Algeria's renewable energy resource endowment for sustainable energy production. Other authors such as (Bélaïd & Youssef, 2017a; Boudghene Stambouli, 2011; Stambouli, 2011a) fully established evidence on the energy behavior of the country and how recent cleaner technologies can be adopted to transform the system.

A review of the aforementioned studies suggests that even though significant evidence on the resource potential has been investigated, inquiries into the overall behavior of the energy landscape, including how to manage the synergies across the sectors are limited. The closest studies to this effect (Saiah & Stambouli, 2017; Seetharaman, Moorthy, K., Patwa, N., Saravanan, & Gupta, 2019) established preliminary pieces of evidence that can be adopted as a basis for sustainable renewable energy transformation planning. However, the gap regarding the behavior of the underlying determinants of the renewable energy transformation in Algeria and how these can be managed within a systemic approach, collectivism is evident. This study, therefore, seeks to contribute towards filling this lacuna by applying a systemic perspective in viewing and proposing sustainable policy options to enhance renewable energy transformation in Algeria. In doing so, the study will seek to answer the following research questions.

1.3. Research Question:

1.3.1. Main research question

How can energy transformation in Algeria be managed from the perspective of systemic reasoning?

1.3.2. Specific research question

1. What are the key factors that drive renewable energy transformation in Algeria?
2. What are the cross-cutting issues surrounding renewable energy technology adoption in the energy sector of Algeria?
3. How comprehensive are the existing energy policy and regulatory provisions in addressing these cross-cutting issues?

1.4. Research Objectives:

1.4.1. Main research objective

The study is being implemented to find out how the Algerian energy transformation can be improved through the adoption of a systemic perspective.

1.4.2. Specific research objectives

Specifically, this study intends to achieve the following objectives:

1. To unravel the key drivers and barriers facing renewable energy transformation in Algeria
2. To assess the comprehensiveness of Algeria's Energy Policy in addressing the cross-cutting sectoral linkages in the energy transformation
3. To develop a framework for the sustainable renewable energy transformation in Algeria based on the system theory

1.5. Significance of the study:

Owing to the increasing global and local calls for sustainable energy production and consumption behavior, a study of this nature, therefore, contributes towards generating empirical evidence on the Algerian energy sector and therefore contributes towards meeting global goals of sustainable development, particularly in the field of energy. It will establish a framework for actor engagement and behavioral reinforcement which are necessary if Algeria is to transit from a fossil-based economy to an energy-mix economy. Again, studies on the renewable energy adoption potential of Algeria, as well as empirical-based feasible policy

options that can be adopted to transform the system are limited. This creates a gap in scholarship which this study seeks to fill. The evidence gathered will, therefore, be useful for the academic discourse, not only within Algeria but also across the entire North African region. It is therefore further justified by its contribution to knowledge in this regard. Further, the research's attempt to view Algeria's energy landscape from a systemic perspective generates evidence on methodology.

Its attempt to identify the behavioral linkages across the major actors and sectors has a great potential of demonstrating how a multiplicity of tools and techniques can be used to abstract an entire energy economy. This establishes preliminary evidence which can be subsequently applied to study the dynamics and behavior of other energy sectors in fossil-based economies. Finally, knowledge generated from this study will contribute significantly to improving the policy environment of the energy sector of Algeria. It will ensure that adequate measures are taken based on how the complex relationships between the fundamental variables that influence the energy systems in Algeria can be coordinated to enhance sustainable energy production and consumption.

1.6. Scope of the study:

The study focuses on assessing the role of central governments in sustainable energy transformations in Algeria and how these roles can be enhanced to facilitate the energy transformation process. This assessment entails how can energy transformation in Algeria be organized from the perspective of systemic reasoning and examines the key factors that drive the renewable energy transformation in Algeria. The content of the study is organized into five main chapters. The first chapter presents an overview of the study, and the second chapter reviews relevant literature while the third chapter deals with the methodology adopted in implementing the study. The fourth focuses on results and discussion while the fifth chapter presents a summary of the major findings as well as the recommendations and conclusions.

2. LITERATURE REVIEW

This chapter presents scholarly works that are relevant to systemic energy transformation within the Central level of governance. It commences with a review of the theoretical underpinnings of the study, under which the tenets of systemic reasoning. The empirical literature on sustainable energy transformations, the politics of sustainability transformations in Africa and Europe, renewable energy policy and planning in Algeria, the Energy sector in Algeria, and an overview of sustainable energy development in Algeria were also reviewed.

The chapter further discusses the conceptual framework adopted for the study. The framework was modeled to give an overview of the key linkages between the various essential parts of the work. A summary of the literature review was then presented.

2.1. Theoretical underpinnings of the Study

According to Kerlinger (1979), a theory is a set of interrelated constructs, definitions, and propositions, or hypotheses, that specify the relationship among variables. Simply defined, a theory is a collection of ideas that attempt to explain or forecast realistic phenomena by making links between the elements that comprise the phenomenon. Although theory should ideally guide research, the contribution of research findings to the evolution of theories implies that the relationship can be described as reversed-reinforcing (Daniel Udo-Akang, 2012). Nonetheless, theories are essential because they provide a framework for analysis and are required for practical real-world application (Gay, B., & Weaver, S, 2011), also they provide a road map for studying problems and developing appropriate interventions. In essence, research without theory has no foundation; likewise, theory depends on research to provide proof of the theory's correctness (Daniel Udo-Akang, 2012). The ensuing sub-sections discuss theoretical perspectives that have thus been adopted based on the consistency of their tenets with the objectives and assumptions underlying this study.

2.1.1. Systemic theory and energy transformation

Energy system transformation processes are not driven by technological innovation and policy change alone but also depend on changes in values, norms, and behavior (Kollmorgen et al., 2015; van de Kerkhof & Wieczorek, 2005). Thus, changes and adjustments to informal institutions, cultural systems, and individual mindsets are relevant to such transformation

(Schürmann et al., 2019). According to Scoones, ‘systemic approaches’, connotes intentional changes targeted at the inter-dependencies of specific institutions, technologies, and constellations of actors to steer complex systems towards normative goals (Scoones et al., 2020). The theory emerged as a social paradigm of viewing entities not as isolated variables, but as ones that have relationships and interactions with other elements within their environment. Consequently, being able to understand the nature and behavior of the components will enable appropriate manipulation of the energy landscape towards desired goals, which is a sustainable renewable energy transformation.

Patterson in an attempt to further shed light on the ideologies underlying the theory averred that it concerns itself with “fundamental changes in the structural, functional, relational, and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes”(Patterson et al., 2017). It is interesting to note that there is consistency in the literature on the structural organizations of systems. However, there is the recognition of limits on the range of variables that specify the limit of the system. Other work on transformation underscores how system limits are characterized, which capacities and construction are perceived as deciding system states, and what elements are viewed as fundamental for a system's industriousness (Leach et al., 2010; Stirling, 2011).

Despite its wide application across diverse classes of theories, systemic reasoning is often closely related to other behavioral theories. Again, even though its application in absolute is not dominant in the renewable energy discourse, some of its tenets have been applied in previous energy studies (Du & Pan, 2021; Liobikienė et al., 2021; Navidi et al., 2021). The application of the theory is much visible in its provision of a spectrum of ideas on the nature of the interrelationships and linkages across the diverse structural units of any energy system. This will therefore guide the modeling of the behavior of the Algerian energy environment to facilitate the renewable energy transformation.

In applying the tenets of the general systems theory to this study, the Algerian energy landscape is conceptualized as “a system”, which is made up of several sub-components whose interactions determine the overall performance of the energy sector. Consequently, being able to understand the nature and behavior of the components will enable appropriate manipulation of the energy landscape towards desired goals. The goals in perspective for this

study are the country's transformational goals from a fossil-based economy to one which is renewable energy-based, which are well articulated in this study as a fundamental basis for assessing the nature of the interaction between the various components of the energy sector.

2.2. The Energy Transformation Debate:

The global energy demand has been growing from 2011 to 2018 by approximately 30 % and is expected to be doubled by 2022 (Paris: REN21 Secretariat, 2020). Available evidence suggests that many countries are moving toward RE to reduce dependency on fossil fuels and mitigate CO₂ emissions (Zahraoui, Basir Khan, et al., 2021). Renewable energy and energy efficiency measures can potentially contribute towards achieving 90% of the required carbon reductions, which then becomes consistent with the environmental sustainability objectives of almost every country.

While the drive is intense among governments, the research community has had its fair share of increased attention to renewable energy technology development. Recent evidence in the trend of energy studies suggests that attention has shifted from the phase-in of renewables and support for so-called niches to the complementary analysis of how incumbents influence policy outcomes and how they can be destabilized (Arne Heyen et al., 2017; Hess, 2014; Kivimaa & Kern, 2016; Kungl & Geels, 2018; Lockwood et al., 2019; Stirling, 2019; Turnheim & Geels, 2012).

What is interesting to note is that the energy transformation policy and activities are often multifaceted, cross-sectional strategies. Its impacts affect a variety of important policy areas, including the economy, society, and technical infrastructure. Because of the great level of sophistication of the energy transformation, there are often perceived trade-offs or conflicts among targets inside and within policy domains. To this point, (Fischer et al., 2016) gave an example of, the assumption that a growing share of "residential" renewable energy will lead to higher geostrategic security, but on the downside, may result in lower technical security (i.e., grid stability, blackouts) due to intermittent renewable supply, or the need for steadily increasing efforts to preserve grid stability.

Elsewhere, it has been extensively debated that high electricity prices may inspire innovation, but they may also put substantial pressure on energy-intensive sectors or impose a financial burden on low-income populations. At the same time, it is assumed that rising employment in

renewable industries would be mitigated by a shrinking labor market in fossil electricity generating and allied sectors. Once these common worries are combined, they lead to the widely held belief that the electricity structures and systems impacted by the policy-driven pace of the Energy transformation require more time to adjust to shifting political and economic circumstances.

Overall, A transformation cannot be planned and then implemented by decision-makers (Brauers et al., 2020). It is rather a “product of competition and interaction between several pathways, supported by diverse social actors with highly uneven political power”(Scoones et al., 2015). Other important elements influencing energy transformation include, among others, the economic development and technological innovation of a country or region (Cherp et al., 2018).

Within the North African Context, Algeria is one of the countries making headway in developing its pathway toward a sustainable energy transformation, yet challenges remain. These include financial barriers, technical barriers, and market barriers such as inconsistent pricing structures; institutional, political, and regulatory barriers; and social and environmental barriers. Himri et al (2009) cited many difficulties that might slow the progress of RE projects, including Weak inter-sector coordination and communication, a complex procedure for applying regulatory decrees, human resource challenges, and a lack of knowledge network (Himri et al., 2009b). Stamboli approached the issue from the perspective of sustainability. The study identifies challenges that confront the sustainable development of such renewable energy resources. Importantly, technical inadequacies, as well as limited localization of the manufacturing of energy equipment, dominated the author’s views on the major challenges to sustainable transformation to renewable energy in Algeria (Stambouli, 2011a).

Elsewhere, Haddad (Haddad et al., 2017a) used analytic hierarchy process (AHP) and experts feedback to perform different RES according to 13 sub-criteria reflecting social, environmental, economic, and technical concerns, and The results highlighted the importance of social and 19 environmental criteria as the main drivers for the obtained final ranking. another study from Haddoum (Haddoum et al., 2018) analyzed the reasons for the failure of deployment of RE as well as other issues linked with the energy-water–food trilemma. Given Algeria’s location at the crossroads of Europe, the MENA region, and sub-Saharan Africa, the

nation could conceivably become a manufacturing supply hub for the renewables industry (Michael Hochberg, 2020). Taking into consideration the RES potential (in particular solar) of the country, Algeria can become a major energy player as a supplier of electricity from RES to north African countries and even to Europe as already discussed in recent studies (Boie et al., 2016; Haddad et al., 2017b).

The possibility of combining solar, wind, and biomass seems then to be a well-accepted and sustainable strategy allowing one to ponder technical, social, economic, and environmental concerns. It is therefore important to put in place an energy transformation that will allow it to reduce its dependence on fuels by reserving oil only for noble uses, to save energy, to launch without delay the energy plan Renewable energy sources, for example, a 1000 MW solar power plant would save 1.5 billion m³ of natural gas (Abada & Bouharkat, 2018). It is also necessary to establish a mechanism to ensure a progressive contribution of renewable resources in the energy economy and the energy mix. So that it can achieve higher levels of economic development. This would allow all of its inhabitants access to a quality energy supply, irrespective of their place of residence (Stambouli, 2011b).

Indeed, the diversity of the RES mix will provide a significant advantage in terms of supply security, allowing to benefit from both resources complementary and high solar power output during peak hours (Haddad et al., 2017a). Finally, this transformation creates opportunities for research and development and the development of a local renewables industry that increases wealth and employment.

2.2.1. Politics and Energy Governance:

Energy governance in most parts of the world is often embedded in the overall political governance frameworks of countries. For rational allocation of resources and efficiency, dedicated ministries are often set aside to plan for the development, and implements projects, monitor, and evaluate the progress of the energy sector (Hughes, 1993). Regardless, there have been contestations surrounding the nature of governance that has the highest propensity of generating the most efficient and effective results. In capitalist societies such as the United States, the market is competitive, with free entry and free exit. However, the government maintains the oversight responsibility of regulating the sector (Meus et al., 2021).

However, in countries more organized after socialist ideas such as Algeria, the greater spectrum of the energy management activities from production to management of consumer behavior (energy demand and supply) are largely under the auspices of the governments. Literature suggests that countries such as Algeria even with such management systems are among the top-performing countries in the Middle East and North African region in terms of energy access and affordability (Stambouli, 2011b). While debates have been inconclusive regarding whether it is the management system that has the highest influence on the high rates of access, or the natural presence of vast fossils that have resulted in such large access rates, renewable energy market development rates have been slow.

One stem of the arguments suggests that private governance drives, like corporate renewable energy investment, are the most effective approaches to propel electricity de-carbonization targets by adding a significant market pull to the public administrative move (Meus et al., 2021). Such interventions are often in the form of energy efficiency and sustainable electricity guidelines, cap and exchange programs, establishing pricing limits on carbon emissions, and taxes on fossils. Further, a key argument underlying the argument that the private sector should spearhead the transformational drive is the purchaser-driven governance for electricity de-carbonization- developing cultural assumptions for ecologically dependable business conduct joined with mechanical advances that make renewables cost cut-throat and financially alluring (Jager et al., 2011). The traditional efficiency argument also contributes a strong footing to the holders of such ideology.

Then again, the opposing school of thought argues that putting the private sector at the forefront of climate and energy governance might rather attempt to hinder the transformation to renewables (Matthews, 2014). They maintain that such actions could slow down or obstruct such transformations disintegrating public help for government natural guidelines, by expanding business ability to drive policy while subverting the affinity and limit of government to manage in the public interest (Woo et al., 2003). Consequently, the government-led interventions have been seen as more directed towards overall policy objectives of various countries, particularly in the global south (Krupa & Burch, 2011).

The transformations and private governance literary works consequently offer some conflicting assumptions about the nature and components of private governance. Particularly,

areas of consternation relate to the investment direction, time of interest for recovery of investment costs, and legislative issues of managing the externalities surrounding such investments (Woo et al., 2003). Notably, current transformation grants and some private governance research interventions propose a potential for private energy and electricity governance to progress, even speed up electricity de-carbonization and sustainable transformations (Moner-Girona et al., 2019; Newell & Phillips, 2016). Such investment and research outcomes extensively shed light on the opportunities for private governance to eventually sabotage and slow down such transformations if not managed properly by instruments of public interest. Consequently, this study sheds light on the nature of actor engagement that has the tendency of contribution higher to advancing transformational targets in Algeria.

2.3. Algeria Energy Landscape:

Algeria, a country severely affected by desertification, is particularly vulnerable to the multiform effects of climate change risking undermining its economic and social development, like other countries in Africa and on the Southern shore of the Mediterranean¹. The country is considered an upper-middle-income country (World Bank, 2021). However, it remains plagued by a weak fiscal due to the high dependency on hydrocarbons revenues and lack of economic reforms (Bélaïd & Youssef, 2017b).

In terms of energy potential, Algeria has the tenth-largest proven reserves of natural gas in the world, and it is the sixth-largest gas exporter and has the third-largest proven reserves of shale gas in the world; it also ranks sixteenth in the proven oil reserves, which is estimated at 12.2 billion barrels (International Trade Administration, 2020). It is also one of the biggest countries in Africa and is one major player in the oil and natural gas market (Brahim et al., 2019).

Available evidence on scholarly and policy reports suggests that the country has a diverse potential for energy resources. Such resources range from conventional energy sources such as oil or natural gas to renewable energy sources such as solar, wind, and biomass (Bouraiou et al., 2020b). However, the most developed source of energy in the country as suggested by available literature are the exhaustible sources that have been substantiated to have severe

¹ République Algérienne Démocratique et Populaire (République & Algérienne Démocratique et Populaire, 2015)

negative impacts on the environment. Consequently, the government of the country has in recent times approved a program for energy transformation² aimed at promoting the use of renewable energies (Hatem & Ahmed, 2020). The established RE targets are programmed to be achieved in two periods (2015–20 and 2021–30), by significantly promoting investment in all RE sources (photovoltaic, concentrated solar power (CSP), geothermal, wind, biomass, and co-generation) (Bouznit et al., 2020a).

According to the RE Plan (**Table 2.1**), the generation amount is expected to be around 4,500 MW in 2020, meaning that less than 10% of the plan was met over the lifetime. It seems clear that achieving 22000 megawatts by 2020 is a distance goal (Hatem & Ahmed, 2020). Therefore, a report done by the International Renewable Energy Agency (IRENA, 2020) suggested that Algeria has experience only one building RES power plant (354 MW: 344 in PV and 10 MW in wind). The foregoing suggests that the total renewable energy resource generation capacity of the country stands at 400 MW of RE as of 2020. The progress of PV and wind are far from the target capacity with 13.33% and 5%, respectively. Meanwhile, there is no development for other RE generations, such as bio-power and geothermal (Zahraoui, Khan, et al., 2021).

Table 2:1: Algerian National RE program target installation and achievements

Source	Target in 2020 (MW)	Installed by 2020 (MW)	Achievement (%)
PV	3,000	400	13.33
Wind	1,010	50	5
Bio-power	360	0	0
Geothermal	5	0	0
CSP	-	25	-
TOTAL	4,375	475	10

Source: (Zahraoui, Khan, et al., 2021)

The country’s reliance on the development and trade of hydrocarbons for about 95% of its foreign income earnings, as well as for about 40% of the gross domestic product has been cited as the main reason for the over-development of the exhaustible energy resources over the renewable sources (Saleh, 2019). However, estimates to affirm the potential for a significant renewable energy transformation suggest that if developed properly, about 60% of the

² Renewable Energy and Energy Efficiency Program, (Algeria, March 2011)

country's energy consumption can be accounted for by renewable sources (Abada & Bouharkat, 2018).

In response to both national and global calls for environmental sustainability in the development of energy resources, the Algerian government aims to reduce the reliance of the electricity sector on fossil by changing the energy policy towards enhanced power production from Renewable Energy Sources (RES) (Guezgouz et al., 2021). Indeed, the government added new features in 2020 to the energy transformation plan, with an action plan until 2035 aimed at increasing the development of RE. As a result, it is expected to create employment opportunities, grow local manufacturing, move technologies and skills through the implementation of RES programs, and save hundreds of billions of cubic meters of natural gas and significantly reduce CO₂ emissions, and recently, the government added new features to the energy transformation plan in its 2020 agenda, with an action plan until 2035 aimed at increasing the development of RE.

2.3.1. Institutional Structure of the Algerian Energy Sector:

The Algerian energy sector is managed by a series of interrelated institutions and agencies, which are mostly dominated by the government. The Ministry of Energy and Mines (MEM) oversees energy policy in the country, including concerns such as energy generation, transmission, distribution, and consumption. Meanwhile, on November 22, 2020, Executive Decree No. 20-322 establishes the powers of the Ministry of Energy Transformation and Renewable Energies, including the commitment to secure the implementation of national policies and strategies in the fields of energy transformation and renewable energies, as well as to define the necessary legal, human, financial, and material resources.

Regulation of all developmental activities however is under the auspices of the Electricity and Gas Regulation Commission (CREG). At the same time, other energy players include utility and service businesses, as well as other organizations that offer finance, services, and research and development works. **Table 2.2** summarizes the country's energy stakeholders.

2.4. Conceptual Framework

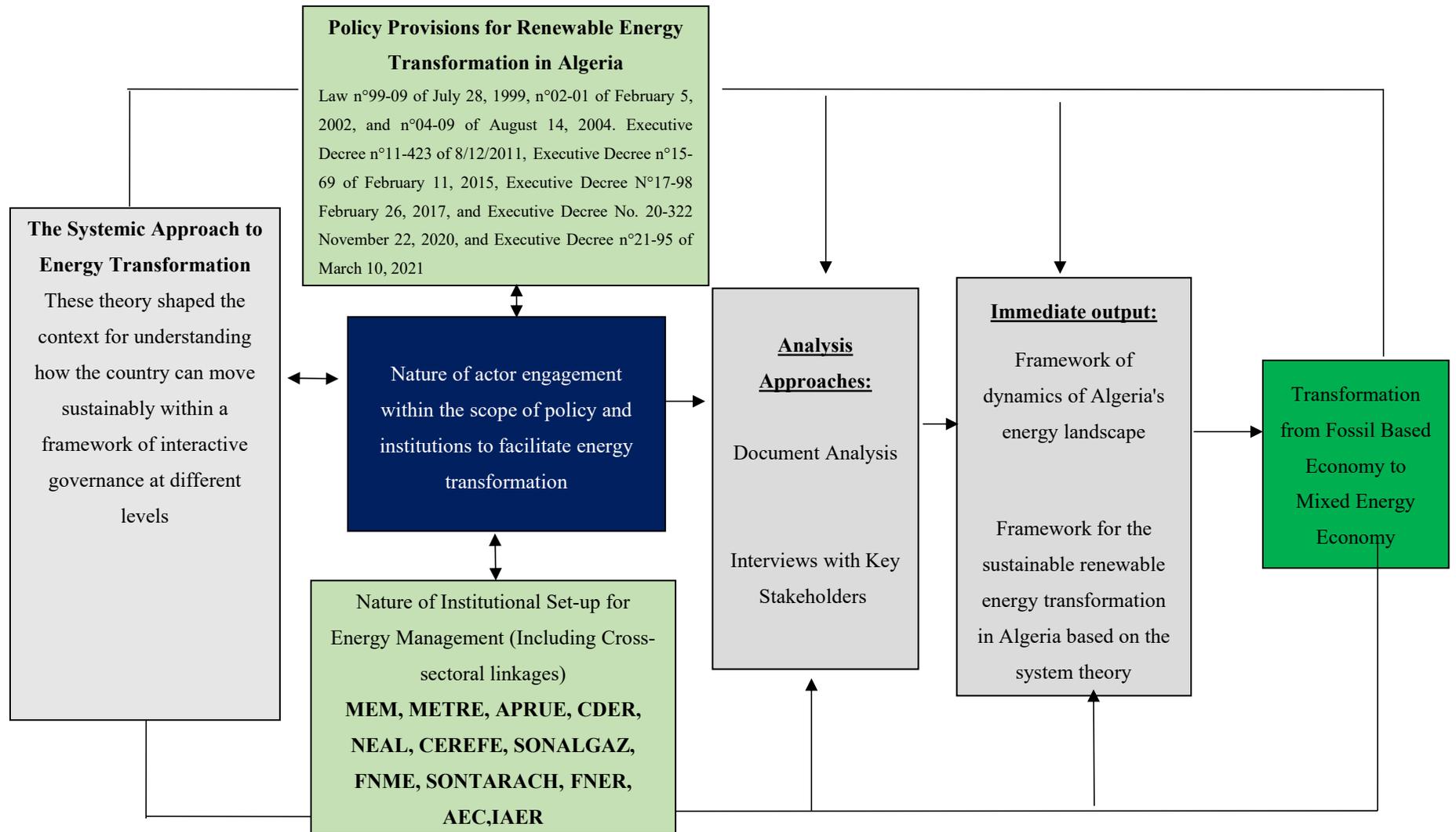


Figure 2-1 Conceptual Framework for the Study

A conceptual framework is often seen as the roadmap for a study. It details the major study concepts and variables, as well as the underlying theoretical propositions, methods, and relationship between these essential components. In simple terms, the conceptual framework of research summarizes the major details of the study, showing its fundamental units and the relationship that exists between them. Contextualized within the framework of promoting energy transformation in Algeria within the framework of systemic reasoning, this study was modeled upon the tenets of the systemic approach.

Its hypothesis and objectives were driven largely by an extensive examination of the country's policy and regulatory provisions for the management of its energy sector. These documents facilitated an understanding of the political economy of Algeria's energy sector and provided the basis for defining essential variables employed in the study. Upon examining the available empirical, conceptual, and theoretical literature on the phenomenon in the second chapter. Based on the review of available initial evidence, the study was advanced upon the proposition that the policy provisions for Renewable Energy Transformation in Algeria, as well as the nature of institutional set-up for energy management (including cross-sectoral linkages), will altogether define the nature of actor engagement within the scope of policy and institutions to facilitate the energy transformation.

This provides the basis for the application for further document analysis and analysis of primary data collected through direct interviews with relevant stakeholders to understand the most realistic frameworks that can be applied with sensitivity to the systemic relationship between the various components of the energy sector. The framework is consistent with major conclusions drawn from previous studies that attempted to describe the political landscape of other countries that were previously dependent on fossils but has made significant strides in the transformation of their economies to renewable-based economies (IEA, & IRENA, 2017, p. 201; Karatayev et al., 2016; Prasad, 2008; York & Bell, 2019)

2.5. Summary

With the management of every system being integral to understanding the output of the system, the study conceptualizes Algeria's energy landscape as a system that is made up of diverse players. With diversity comes the need for a common direction in the pursuit of growth objectives. Consequently, the tenets of systemic reasoning examined in this review suggested that for every system that is made up of underlying structural variables, the nature of interactions significantly alters the outcome. Further, the multi-level governance framework emanated from ideologies of systemic reasoning, and further buttresses the proposition that organizing the political landscape into series of interconnected management levels, across diverse sectors have a high propensity to contribute towards sustainable energy transformation.

Evidence on the Algerian energy resource endowment further affirms the claim that appropriate management frameworks can be applied to alter the behavior of the market to ensure a shift from a fossil-based economy to one whose major energy consumption will be accounted for by renewables. Evidence on vast resources such as solar, wind, and biomass have been substantiated from the various scholarly sources examined. It is upon this premise therefore that the specified approaches of analysis were further developed in the advancing chapter to collect and analyze data that will be useful for modeling a management framework that will enhance a sustainable transformation of Algeria to a mixed energy economy.

3. METHODOLOGY

Research methodology is a process of how research is being conducted. It encompasses tools and techniques to conduct particular research or finding. According to Walliman, the research method is a range of tools that are used for different types of inquiry (Walliman, 2010). Therefore, it is important to select an accurate method that suits the research objective. This chapter proceeds with a description of the study setting and then focuses on the methodology that is adopted for the research. Primarily, it discusses the research approach, selection of study participants, sampling techniques, methods of data collection, and data analysis.

3.1. Study Setting (Algeria in Context)

3.1.1. Locations and size

Algeria – officially called the People’s Democratic Republic of Algeria – lies in the Maghreb region of North Africa. With an area of 2,381,741 square kilometers, where Sahara occupies 86 % of the total land. The capital is Algiers and the largest city in Algeria in the north. The country lies within latitudes 28° 00' N and longitudes 3° 00' E and share boundaries with Tunisia to the north-east, Libya to the east, to the west by Morocco, to the south-west by the Western Saharan territory, Mauritania and Mali, to the south-east by Niger and the north by the Mediterranean Sea with a 998 km coastline. Fig 3.1 depicts the map of the country.

There are three main climate zones in Algeria, the Mediterranean in the north, semi-arid in High Plateaus, and arid in the south of the country (Boudghene Stambouli, 2011). The climate ranges from arid to semiarid, with warm, rainy winters and scorching, dry summers by the coast; drier, with cold winters and hot summers on the high plateau; and summers marked by the heavy storm, a hot, dust/sand-laden wind. However, enormous temperature variations are observed regularly. Rainfall is generally plentiful throughout the Tell Atlas coast, ranging from 400-670 mm yearly with temperature ranges from 25°C to 11°C (Zahraoui, Basir Khan, et al., 2021); precipitation increases from west to east, and it is higher in the northern portion of Eastern part of the country, reaching up to 1,000 mm in some years.

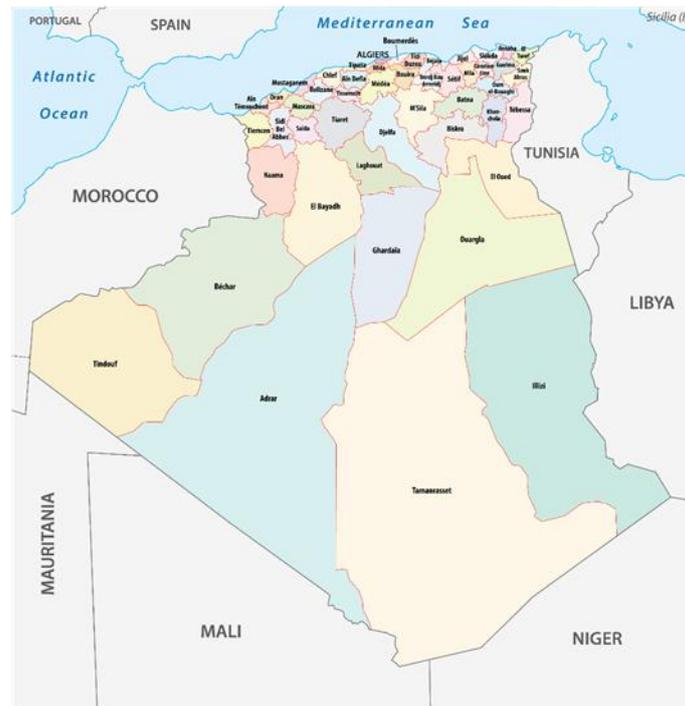


Figure 3:1: Algeria location in Africa

3.1.2. Political landscape

The country is a semi-presidential republic consisting of 58 provinces and 1,541 communes (municipalities). The legislative power is held by a bicameral Parliament, consisting of the Council of Nation (upper house with 144 seats; one-third of members appointed by the president, two-thirds indirectly elected by simple majority vote by an electoral college composed of local council members; members serve 6-year terms with one-half of the membership renewed every 3 years) and the National People's Assembly (lower house with 462 seats including 8 seats for Algerians living abroad; members directly elected in multi-seat constituencies by proportional representation vote to serve 5-year terms) (indexmundi, 2020). The executive power is in the hands of the chief of State or President, directly elected by absolute majority popular vote in two rounds if needed for a 5-year term. The President appoints also the Cabinet of Ministers and nominates the Prime minister after consultation with the party that holds the majority in the Parliament (indexmundi, 2020).

3.1.3. Demography of Algeria

The total population of the country is 43,851,043 inhabitants with growth rates of 1.8% (World Bank, 2021). A large part of the population is young, 90% of which live in the northern coastal area because of climate conditions and economic development. Most of the

population lives in the urban area (72.9 %) (Worldometer, 2020). With regards to energy, over than 99% national coverage rate for electricity (Bouraiou et al., 2020).

3.1.4. Overview of the energy landscape

Algeria has the tenth-largest proven reserves of natural gas in the world, and it is the sixth-largest gas exporter and has the third-largest proven reserves of shale gas in the world; it also ranks sixteenth in the proven oil reserves, which is estimated at 12.2 billion barrels (International Trade Administration, 2020). Moreover, Algeria is considered an upper-middle-income country (World Bank, 2021). However, it remains plagued by a weak fiscal due to the high dependency on hydrocarbons revenues and lack of economic reforms (Bélaïd & Youssef, 2017b). **Table 3.1** provides some economic indicators for the period 2015- 2019 (World Bank, 2021), inspired by (Bouraiou et al., 2020).

Table 3:1: Economic indicators for the period 2015-2019

Indicators	2015	2016	2017	2018	2019
Populations (Million)	39.9	40.6	41.5	42	43.4
GDP per capita (USD)	4063	3867	4104	3595	3973
GDP growth (%)	3.7	3.2	1.3	1.2	0.8

Source: inspired by (Bouraiou et al., 2020c)

On the other hand, the country has enormous renewable energy (RE) potential. Solar power was shown to be especially well suited for Algeria, outperforming most other renewable options in a wide array of highly weighted parameters. Wind power was rated second, followed by biomass, geothermal, and hydro-power (Haddad et al., 2017b). Available evidence suggests that the country has one of the largest solar fields in the world (Ghezloun et al., 2012). As shown in **Fig.3.2**, the global horizontal solar radiance received per day on a horizontal surface of one square meter ranges from 5.1 KWh in the North to 6.6 KWh in the Deep South, notably around the Tamanrasset region. Overall, the solar energy potential is in an annual average sum of 2.10 MWh/m²/ year (Guezgouz et al., 2021). This figure is significantly high and meets the minimum requirement for the installation of solar technology to produce electricity.

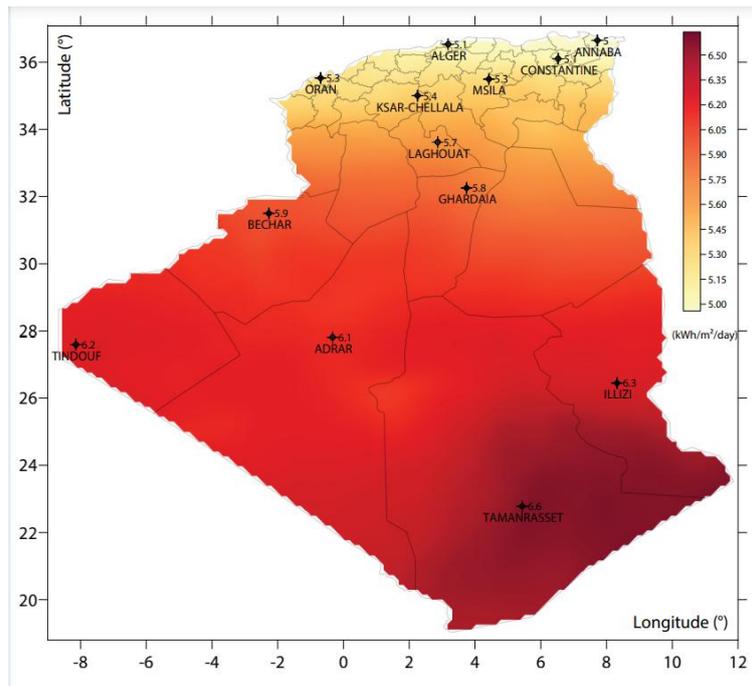


Figure 3:2: Global Horizontal Radiance received per day on an area of one square meter

Source: (METER, 2020)

Similarly, the distribution of estimated wind energy potential on the territory at 80 m high is measured and illustrated in **Fig 3.3**. This figure is estimated to have the potential of rising to as high as 7 to 8 m/s in some parts of the South, including Tindouf, Adrar, and Ain Salah. Moreover, another important wind potential is observed in the highlands of Algeria as well as in the northwest regions (Oran province) (Guezgouz et al., 2021). Despite its significant potential, the total installed capacity from both sources is measured at 693 GWh per year according to the Ministry of Energy and Mines (Ministère de L'Energie, 2020).

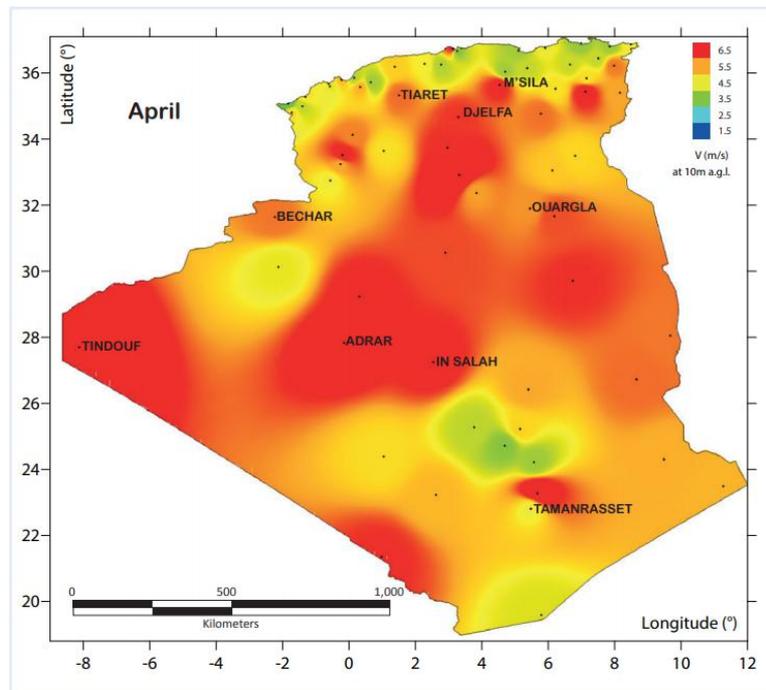


Figure 3:3: Power density of wind on the territory at 80 m high
 Source: (METER, 2020)

In addition to the above resources, the country has significant biomass resource potential. An estimated 3.7 MTOE of bio-energy is accounted for by resources from forests and 1.33 MTOE per year being accounted for by agricultural and urban wastes (Saiah & Stambouli, 2017b). Elsewhere, the compilation of geological, geochemical, and geophysical data has enabled the identification of more than two hundred (200) hot springs in the country's northern region (Bouraiou et al., 2020b). The highest temperatures registered are 98 °C in Guelma province at Hammam El Maskhoutin and 118 °C in Biskra province (Bouraiou et al., 2020b), both situated in the country's eastern part. While the potential of geothermal energy is significant, investment in the sector is low. According to (Saibi, 2009) the total installed capacity from producing wells and thermal springs is around 900 MW (Haddad et al., 2017b). Regarding hydro-power, the global rainfall quantity which rains on Algeria territory is important and estimated to be 65 billion m³, but it has a low benefit to the country for hydroelectric power generation due to the lack of exploitation of all existing sites (103 dam sites) (Stambouli, 2011b). The hydro-power potential was increased by rainfalls in 2019, where total electricity generation was measured at 152 GWh compared to 117 GWh in 2018 according to the Ministry of Energy and Mines (Ministère de L'Énergie, 2020).

A review of the available statistics on the country’s renewable energy potential suggests high viability for the development, installation, and operation of diverse forms of renewable energy technology. The commonest technologies suitable for the region are severally identified to include CSP, solar thermal, hydro-power, wind, co-generation, and waste to energy and hybrid plants (Bouznit et al., 2020a). However, the country is indeed one of the countries that play a crucial role in energy markets, both significantly to meet domestic demand and export. With approximately 90% of the electricity in Algeria being produced from natural gas power plants (Khraief et al., 2018), renewable energy technology adoption will contribute towards a sustainable environment.

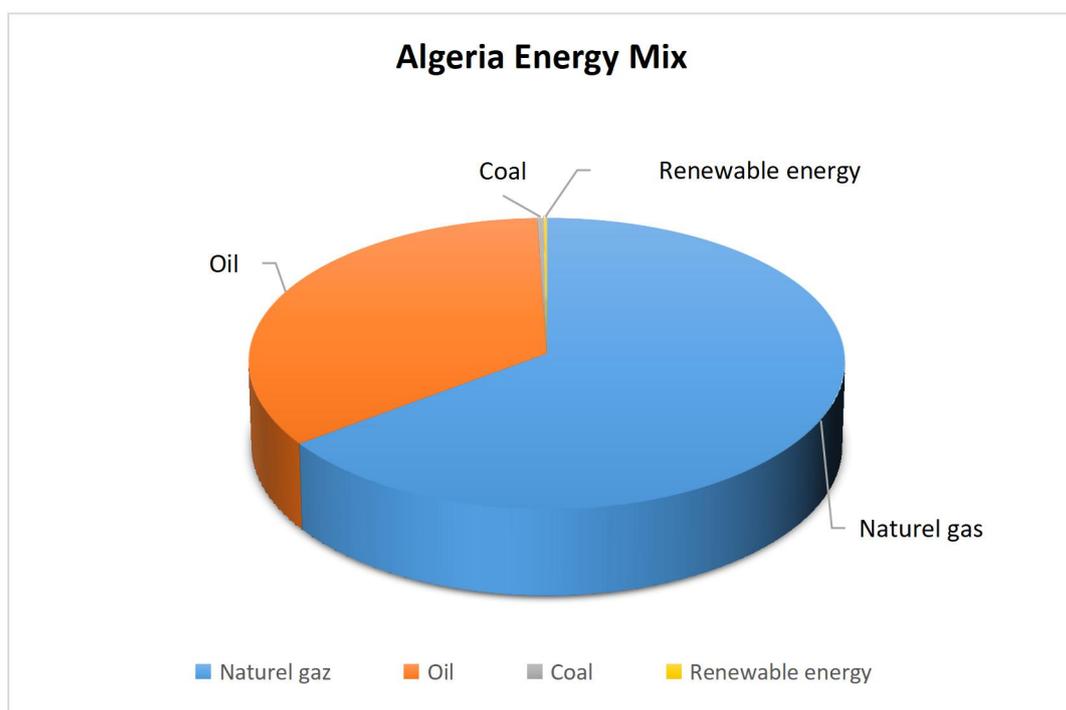


Figure 3:4: Algeria fossil fuel generation mix in 2019

Source : (Zahraoui, Basir Khan, et al., 2021)

The diversification of the national economy and the creation of new socioeconomic dynamics around renewable energies are becoming essential ambitions for the Algerian government (Bouraiou et al., 2020b). This motivates the current desire of the government to minimize its reliance on fossil fuel resources and implement a new policy strategy based on renewable energy resources. According to the Ministry of Energy and Mines report on 2019, the supply of electricity generated by renewable resources in Algeria is low and reported at 845 GWh from 81 526 GWh per year, including 152 GWh from hydro-power and 693 GWh from solar and wind energy (Ministère de L’Energie, 2020). This complicates the country’s ability to

reduce its carbon emissions. Otherwise, the key element to achieve this goal is by integrating more renewable resources into the existing grid.

3.2. Methods

This section presents the methods and techniques used for data collection, data analysis, and presentation of results.

3.2.1. Research approach and design

The research employed a qualitative method in gathering and analyzing data. Interviews have been collected from energy experts in the key energy sector in Algeria. These experts have been identified by an initial stakeholder mapping analysis based on the current structure of the Algerian energy economy. The response of the experts will then be used to draw a mapping between the key drivers and challenges of the renewable energy transformation in the country. Based on the behavior of the major drivers, a systemic framework will be done to show the behavior of the Algerian energy stakeholders, and the key game-changers that can be stimulated to improve the rate of renewable energy technology adoption in Algeria. It also entails a content analysis of The existing energy policy of Algeria to understand how comprehensive the policy is in fostering the synergy between the major variables that will be identified in the study.

3.2.2. Study population

The study population comprised all of the elements that the researcher wants to investigate. It includes items, locations, a certain group of individuals, or events that are chosen because they are related to the study aims. The population of interest in this study comprises major government ministries, stakeholders, and experts in Algeria's energy sector. The research is concentrated on assessing the central government's engagement and involvement in the country's sustainable energy transformation initiatives, and then addressing how these roles can be enhanced to facilitate the energy transformation process. Since they are primarily concerned with sustainable/renewable energy concerns, these key stakeholders (central government agencies, government units/departments, NGOs, and private sector players) are critical for acquiring the information needed to answer the research questions.

3.2.3. Sample selection

In this study, the purposive sampling method was used for the selection of the participants. Purposive sampling refers to intentionally chosen a sample according to the needs of the study. This technique is ideal for the study because the information is required from only

participants who are engaged in the sustainable energy transformation initiative of the country. The selecting of participants was done through a preliminary literature search on the key actors involved in renewable/sustainable energy transformation initiatives in Algeria. This search focused on institutional arrangements in key policy documents as well as a review of the main department that is currently working on the energy transformation plan. Next, communication with the first list of stakeholders obtained from literature by email, and Linked-in to book an appointment with them. After confirming the date and time, a visit was made to Algiers (Algeria's capital) to collect my data. Starting by The Ministry of Energy Transformation, which coordinate and responsible for all RE project at the central level of the government. A list of all actors and agencies working on RE projects was requested from the METRE. This list was reconciled with the first list mentioned above. Simultaneously, the respondents were asked to mention other actors at the end of the interview that they can contribute to the study. In another hand, online interviews were conducted in parallel with field visits because of covid-19 restrictions. The METRE, MEM, SONATRACH, NEAL, SONALGAZ, CDER, APRUE, CEREFÉ, among-st others were identified as the key actors with regards to the energy transformation development in Algeria. These key stakeholders play important roles in the proper functioning of the energy sector of the country. Hence, to enhance the transformation to energy-mix based, an assessment of their involvement is essential

3.3. Data Collection, Analyses, and Reporting

3.3.1. Type and Source of Data

Data for the study were obtained from both primary and secondary sources. Primary data were obtained through interviews. The data were collected from all the stakeholders mentioned above. Key stakeholders were interviewed to obtain primary data on their engagement in sustainable energy initiatives, the main barriers towards energy transformation in Algeria, and asking them for a recommendation for the new policy strategy and what are the future opportunities according to their experience in the field. Secondary data, on the other hand, were obtained from both published and unpublished sources. These sources include institutional reports (government action plan, reports) and other studies related to the subject matter and the [the ministry of the energy transformation and renewable energies (METER), Friedrich-Ebert-Stiftung Algeria 100% Renewable Energy Report, and CEREFÉ report on renewable energies and energy effectiveness on the energy transformation in Algeria were sources for relevant secondary data and information on the procedures and

processes involved in the RE transformation plan and implementation at the central level. The METER action plan was analyzed to establish the current state of the energy transformation plan and implementation at the central level while the Friedrich-Ebert-Stiftung report was reviewed to identify possible missing opportunities and highlighting obstacles for the national strategy of the energy transformation.

3.3.2. Methods and instruments of Data Collection

The researcher applied two methods of data collection techniques. This was done in order to collect adequate and relevant data to address the research objectives of this study. The methods and instruments used are primarily based on the qualitative nature of the research. Interviews were the main method used to gather data from all the actors involved in the study. Key stakeholders and experts of the energy sector were the points of contact and face-to-face, and online interviews were conducted with them to obtain needed data information. The researcher, with prepared written questions to the interviewees, used the structured interview. In this context, the structured interview protocols ask specific objective questions in an arranged order. In addition, the questions were well structured, planned, and organized in line with the objective of the study. This process encouraged the participants to respond to the questions as accurately as possible. The interview questions were designed in English Language but to ensure proper responses from the participants, the interview process was also conducted using the mother tongue language (Arabic) and the second common language used in Algeria (French). The responses were later carefully transcribed and translated to English. The use of the other two languages was used for those individuals who are not familiar with English thus enabling them to contribute relevant information in relation to the topic under study.

The second method of data collection used is documents review. The review is an iterative process that entails skimming, reading, and interpretation, and it combines elements of both content and thematic analysis (Bowen, 2009). This method was used to extract relevant data from energy transformation policies and strategies of the country. A data extraction sheet was the instrument used in gathering data from the different reviewed documents. **Table 3.2** summarizes the two methods used in collecting the needed data for the research

Table 3:2 Methods of data collection

Methods	Applied Instrument	Key Features	Outcomes
Interview	Interview guide	Face-to-face and online interviews with focal individuals from the several institutions chosen for the study were performed.	-Data on key stakeholders engagement in sustainable energy transformation initiatives -Data on major barriers surrounding RE technology adoption from the central level - Data on human resources and capacities in the energy sector.
Documents analysis	Data extraction sheet	Documentary analysis	-Archival data (previous and current energy policy) -Current state of the country’s energy transformation pathway. -Data on RE projects in the MDA’s (Ministries Departments and Agencies) -Data on Energy transformation plan from the government

3.3.3. Methods of Data analysis

Content analysis is a general term for a number of different strategies used to analyze text (Powers & Knapp, 2010). It is a systemic coding and categorizing approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication (Grbich, 2012; Mayring, 2000; Pope, A., et al., 2006). The purpose of content analysis is to describe the characteristics of the document's content by examining who says what, to whom, and with what effect (Bloor & Wood, 2006). Thematic analysis, on the other hand, is frequently seen as a poorly branded methodology since it does not appear to exist as a designated method of analysis in the same way that content analysis does. Thematic analysis as an independent qualitative descriptive approach is mainly described as “a method for identifying, analyzing and reporting patterns (themes) within data”(Braun & Clarke, 2006, p. 79). It has also been presented as a qualitative descriptive approach that provides researchers with the fundamentals of doing many different types of qualitative analysis. In this regard, qualitative researchers should get more associated with thematic analysis as an independent and dependable qualitative method of analysis.

The process of data analysis in the content analysis according to Elo and Kyngäs (2008), and in the thematic analysis according to Braun and Clarke (2006) is described in **Table 3.3**. The researcher is required to transcribe the interview and gain a sense of the entire by reviewing the transcripts numerous times during both phases. In this study, interviews were conducted with key stakeholders in the energy sector. Actors were asked to indicate their involvement in

the energy transformation development. They were asked to provide a brief description of the nature of their engagement in sustainable energy initiatives in the government, and the main barriers facing the country to shift away to an energy mix-based economy.

In another hand document analysis was conducted for reviewing the country reports, regulations, and previous similar studies within the same content. According to Bowen (2009) document analysis is a systemic procedure for reviewing or evaluating documents both printed and electronic (computer-based and Internet-transmitted) material. It entails an examination and interpretation of data to provide meaning, to understand, and to generate empirical knowledge (Corbin & Strauss, 2008). The major reason for using this approach is triangulation. Hence, the study aimed to rely on various sources of evidence in order to validate findings by using various data sources and methods.

Based on this data and the next step of data analysis, known as the organizing phase in content analysis, consists of open coding, collecting codes under potential subcategories/sub-themes or categories/themes, and comparing the emerged coding clusters together and in connection to the whole data set. The thematic analysis employs the same set of analytical interventions employed in the content analysis under the categories of creating initial codes, defining and identifying themes, evaluating themes, and searching for themes. In this study, Nvivo software was used for coding all this data based on the findings. The final stage of data analysis in both approaches is related to presenting the result of the previous stages. In this study, the findings will be presented in terms of a framework for the sustainable renewable energy transformation in Algeria using systemic theory.

Table 3:3: Processes of data analysis in thematic analysis and qualitative content analysis

Thematic analysis	Content analysis
<i>Familiarizing with data</i>	<i>Preparation</i>
Transcribing data, reviewing and rereading data, and jotting down initial observations	Immersion in the data and gaining a concept of the entire, picking the unit of analysis, and deciding whether to analyze manifest or latent content.
<i>Generating initial codes</i>	<i>Organizing</i>
Coding important data characteristics systemically over the full data collection, collecting data relevant to each code	Abstracting is the process of open coding and establishing categories, arranging codes under higher-order headings, and developing a broad description of the study issue by generating categories and subcategories.
<i>Searching for themes</i>	
Organizing codes into prospective topics and collecting all data pertinent to each potential theme.	/
<i>Reviewing themes</i>	
Creating a thematic map to see if the themes function in connection to the coded extracts and the whole data set.	/
<i>Defining and naming themes</i>	
Ongoing evaluation to fine-tune the specifics of each theme and the key topics that the analysis provides, as well as to generate precise descriptions and labels for each theme.	/
<i>reporting the result</i>	
The last step of the analysis. Selection of vivid, captivating extract examples, the final analysis of selected extracts, linking back to the research questions and literature, and development of an analysis report	conceptual framework, conceptual maps or categories, are used to report on the analysis process and outcomes.

Adapted from ((Braun & Clarke, 2006; Elo & Kyngäs, 2008; Vaismoradi et al., 2013)

3.4. Presentation of results

Qualitative data obtained from key informant interviews were transcribed and imported into the Nvivo software where codes were assigned to specific themes in each interview data. Outputs of the codes with their corresponding quotations were generated, and the patterns were used for analysis. Results were discussed and where necessary quotations were presented verbatim to support the findings.

3.5. Ethical considerations

For ethical reasons, the researcher acquired an introduction letter from the university, which granted her permission to gather information from different institutions and participants of this study. All data collection instruments excluded all personally identifiable information, such as identities or contact information. Each data collecting instrument has a preamble that

describes the main purpose of the research and includes a statement of assurance that the data obtained is for academic purposes only and that respondents were guaranteed confidentiality and anonymity. Interviews procedures and issues to be discussed were clearly explained to the interviews beforehand. This ensured that respondents know the subjects of discussion and also be comfortable discussing them. Also, in presenting quotations made by respondents, no identifying information such as names, or position titles of the respondents was mentioned as the source.

4. RESULTS AND DISCUSSIONS

4.1. Introduction

This Chapter presents the results based on the analysis of interviews and documents analysis. Results obtained are discussed in line with the research objectives. Hence, the chapter begins with a summary of the profile of the key interviewers, and an analysis and discussion of the key factors that drive the RET in Algeria. It examines the cross-cutting issues surrounding renewable energy technology adoption in the energy sectors of Algeria and assesses how the current energy policy is addressing those challenges toward the energy transformation. Qualitative results obtained from primary and secondary sources are mixed in the discussions to enable a systemic view of the results.

4.2. Summary of The Respondent Characteristics

The study sampled key informants from the Algerian energy management landscape who has diverse knowledge and experience in diverse actions geared towards the transformation of Algeria's energy landscape. The qualitative nature of this study was consistent with the selection of only people with relevant information towards the implementation of the project objectives. In this regard, a total of 20 key informants were interviewed. It was realized after interviewing about 14 key informants in the Algerian energy management landscape that the responses being obtained for the various study objectives were similar. A point of saturation was then pegged at 17 respondents. However, three additional experts were included to ensure consistency in the results that were being obtained.

The survey ensured that adequate opportunities were given to representatives across various sectors to contribute. However, since the interviews were based on convenience (willingness to participate, knowledge and experience in the subject area of the energy transformation, and the availability for the various interview sessions, the participants leaned towards male domination as opposed to females). This, however, was not perceived to have significantly created biases in the responses since all information being given was geared towards facilitating transformation in management, and were less sensitive therefore to such incongruence. The validity and reliability of the responses for policy planning were ascertained based on the years of experience of the participant in managing the energy transformation process. It was thus observed that more than 80% of the study participants had at least, five (5) years of working experience, affirming their familiarity with the context and aptness of suggestions. Further, the study participants were found to be dominantly employed in the

government sector, with summaries of the various backgrounds and socioeconomic characteristics being given in Table 4.1.

Table 4:1 Socioeconomic characteristics of respondents

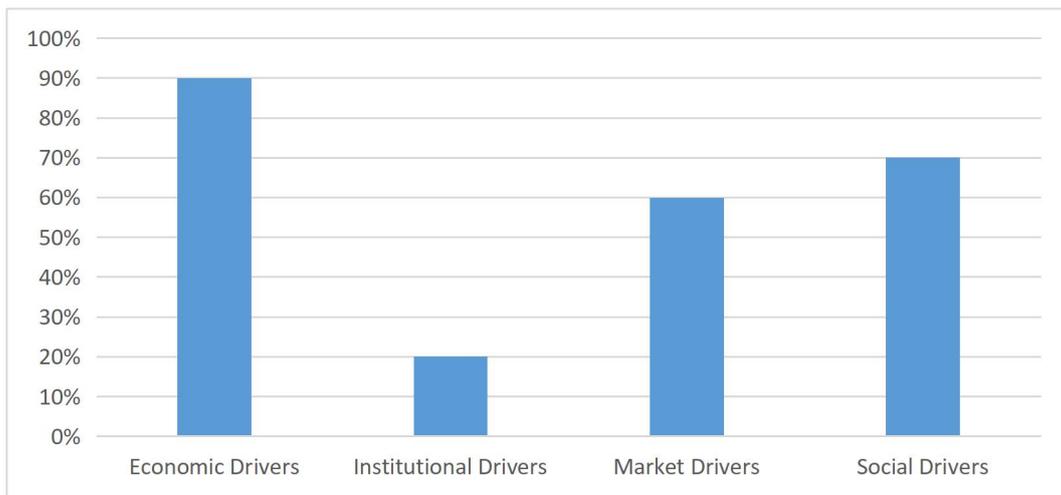
Sector	Entity /Description	Number of Participants	Gender		Educational Level			Years of Experiences	
			Male	Female	Diploma/ Bachelor	Masters	Doctorate	Max	Min
International Experts	IRENA, UN, EU, Vestas, Micro Energy	5	3	2		4	1	30	12
Government Body	MEM, METER, CEREFÉ, APRUE	4	1	3		3	1	20	4
Utilities	Sonalgaz, Sonatrach	4	3	1	1	3		15	5
Research Institute	CDER, UDES, CRTSE	3	3				3	25	15
Public Sector	NEAL, SKTM	2	2			2		26	12
Enterprise Private sector	Shems al djazair	1	1		1			4	
Civil Society	Solar Gluster	1				1		26	
Total		20	14	6	2	13	5		

The vast majority of respondents hold master. In parallel, years of experience in this study were indicated as an important factor in relation to their response. This shows the wealth of experience they have acquired in the energy sector and also goes to show credibility in using them as primary data sources.

4.3. Drivers to penetration of higher share of renewables in the power sector

One of the primary objectives of this study was to identify the main drivers facilitating RE transformation. Based on the responses, we thematically scoped these drivers into four key categories as shown in Fig. 4.1. Further details could be traced in the subsequent section.

Figure 4:1: Key Drivers for the adoption of RE



4.3.1. Economic Drivers:

Several economic variables were identified by the various study participants as relevant to fast-tracking the uptake of renewable energy technology in Algeria. The drivers identified ranged from micro-level to macro-level variables. The first economic driver that was identified is the level of government investment into renewable energy technology in Algeria. Seventeen of the total 20 interviewed indicated that increasing investment in terms of financial and fiscal resources by the part of the government to specifically target the renewable energy sector will play a key role in advancing the uptake in Algeria. They cited interventions in the forms of subsidies on renewable energy technology products such as blades for the construction of windmills, panels for the construction of solar PV systems among other ways government can drive the transformation.

In his words, a participant affirmed: *“if we really want Algeria to enhance its uptake of renewable energy technology, we need to move beyond policy dialogue and discussions on to media to actually show how much it is important by allocating some significant amount of money from other sectors to help reduce the price of the renewable energy technologies. This is because we all know that these things are expensive, and the people are not often able to buy ten”* (Interview no.13 – Research Institute)

Following this, another 17 respondents affirmed that the general price levels of existing fossil products are a great determinant of the renewable energy transformation. Existing market evidence showed that as of 2021, The price of natural gas is 0.384 Algerian Dinars per KWh for households (0.003 U.S. Dollar) and 0.476 Algerian Dinar per KWh for businesses (0.003

U.S. Dollar). This has made it difficult for people to be identified to examine or even consider taking up new forms of energy.

In affirmation, a study participant revealed: *“A lot of people are stuck on the consumption of fossils, and you can see only one reason why: these are cheap. A little allowance and you can buy gas. If all of a sudden you start telling people that they should move, it will be very difficult”* (Interview no.4 – Private Sector).

To further buttress his assertion, another respondent affirmed, *“if we want to promote the uptake of renewables in its country, we have to first give the consumers a reason to look for alternative courses of energy. We have to ensure that price competition between natural gas and other renewable energy sources. The higher prices index is why even when introduce rebut policies, they do not work”*(Interview no.8 – Government Body).

Further, diversification of investments in the country emerged in about 11 discussions as relevant to the advancement of energy transformation goals in Algeria. The aim of economic diversification is therefore to develop an industry dedicated to energy and create long-term energy and economic provision for the country.

In an interview, a participant affirmed: *The diversification of the national economy and the creation of new socioeconomic dynamics around renewable energies are becoming essential ambitions for the Algerian government* (Interview no.7 – International Expert).

Among all participants who identified this as a major variable, there is a consensus that the government is on the right path towards such actions, and demonstrated optimism toward attaining transformational objectives in the next couple of years.

4.3.2. Social Drivers

A major social driver for the energy transformation in Algeria was identified as the extent of international pressure through international climate agreements. Almost all the surveyed respondents affirmed that the extent to which the government is committed to pursuing climate targets and ambition is a strong indicator of how far the country can go in its question to transform its energy economy. Importantly, Algeria is a signatory to the Paris COP 21 agreement, and with the government’s commitment to reducing its greenhouse gas emission levels, the energy transformation has become relevant.

In an interview with an international expert, she affirmed that *“The deployment of renewable energies is a basic condition for achieving the climate targets. If Algeria is to pursue and attain its objectives of increasing the share of renewable energy in the national energy mix, the government must show real commitment”*.(Interview no.3 – International Experts)

The energy management approach in the country was cited as a significant social determinant of energy transformation in Algeria. Evidence from 14 participants suggested that pushing forward the transformation agenda will require the wider involvement of energy consumers in the decision-making process.

Highlighting the need for a more decentralized system of energy decision-making, as one of the stakeholders affirm: *“When people are more involved in the energy decision-making process, the likelihood of attaining transformation objectives increases. We need more participation in decision-making at the municipal levels, and even the Wilaya levels if we are to really be able to drive forward our renewable energy agenda. People embrace change when they take part in the discussions, but resist change when it is forced on them in typical top-down approaches to governance”*.(Interview no.10 – Government Body)

Again, awareness levels of people about the relevance of renewable energy technology adoption and the market situation were also identified as a key driver of Energy transformation in Algeria. Most participants in the interviews revealed that the rationale behind the series of energy transformation dialogues being periodically organized around the country on diverse internet-based platforms is to increase awareness at all levels and enhance capacities towards the transformational objectives of the country. In further submissions, another participant averred:

“You cannot push forward an energy transformation drive in this country if you first do not change the minds of the people. If you ask me how many Algerians know why we should even transit to Renewable Energy, I honestly do not think it will be much. They feel the country has so much oil that they do not see why we should shift to renewables. Some will even tell you that the whole debate about the fossils getting depleted has been in existence for a long and still, we have abundant oil and gas...You cannot drive forward transformation without first changing their mindset”
(Interview no.12 – Utilities)

4.3.3. Market Drivers

The interplay of demand and supply significantly influences the behavior of both consumers, suppliers, and regulators on any market, including the energy market. The discussions revealed that all the 20 energy experts sampled consider the extent of private sector participation in the market as a key driver to energy transformation in Algeria. For a long, the country has been known to have the majority of its energy resources, if not all, under the ownership of the government. The debates over the efficiency of such public systems are endless, even though there is a recognition of the fact that energy resources are very volatile and if not managed by the central government can threaten the entire security of the country. Despite this, renewable energy technologies, particularly those on a smaller scale such as solar PV systems and mini wind turbine generators are consistently progressive when handled under free-market conditions.

A study participant specifically indicated: *“when it comes to renewable energy technology uptake, we can think of the successes of the private sector in many other countries, particularly among households and industries, particularly through rooftop solar PV systems. One way to meet this is to make sure that we create room for private sector players to invest in the Algerian energy market. If we want to be careful not to lose control over our fossil market, we can particularly participate in other mini markets such as those I have already mentioned. I do not think the downsides of this will outweigh the positives...”*.(Interview no.9 – Civil Society)

Again, the recent falling cost of renewables has positioned them as an increasing competitor to fossil fuels in most of the countries globally. The participating experts in the study revealed that owing to the significant potential of Algeria in RE resources mainly solar, the global market prices of fossils will have a high likelihood of shifting consumers unto exploring other cheaper alternatives, with solar energy being the currently cheaper option.

An expert affirmed: *“Thanks to its geographical location and its strategic position in the energy sector, all the conditions are met for Algeria to play a crucial role in the future in the supply of green electricity, in accordance with the Tarns-Mediterranean Plan. It is important therefore for the country to take advantage of the falling prices of renewable energy technologies such as solar energy. This could even transform the country into a renewable energy giant in the region”*.(Interview no.19– Government Body)

With all these drivers, renewable energy can potentially be an important key success in the country's energy transformation initiative.

4.3.4. Institutional Drivers

Technology is playing a dual role in the renewables and the oil and gas (O&G) industry. The advancements in battery technology have led to a significant drop in battery prices providing further bi-ability to RE (where batteries are used for storage). In this context, Algeria also aims to follow up those changes as one of the Research Institute affirm that:

“The country aims to develop educational institutions to support the needs of RE professionals, and the research institute and centers, alongside other RE entities in the country, has collaborated with local universities for short courses and training in order to share and develop knowledge”(Interview no.13 Research Institute).

Moreover, Prime Minister stated, on Thursday 14 November 2019 in Algiers, that the creation of the National Commissariat for renewable energies and energy efficiency CEREFÉ made up of representatives of 15 ministerial departments and 4 public institutions, besides an advisory council composed of recognized national competencies in the field, economic operators and representatives of civil society, in order to face obstacles and difficulties hampering the implementation on the ground of the national program.

Converting to renewables avoids these fuel security issues; however, cost-effective integration of a high share of utility-scale renewables depends on increasing transmission system capacity. Taking down one or two lines could disrupt the system's ability to balance, either on a regional or interconnection-wide basis, hampering reliability until the threats are addressed.

4.4. Cross-Cutting Issues in Algeria's energy transformation

Following a comprehensive analysis of the drivers of the energy transformation in Algeria, the study further investigated the cross-cutting issues surrounding the transformational drive. A dynamics of interrelated actions emanated from the key informant discussions. While the Energy Ministry takes care of the main responsibility of planning for the development of the energy sector, its activities have primarily been focused on fossil fuel development and management. Consequently, the previous Ministry of Environment and Renewable Energy has been split into two new independent ministries: The Ministry of Energy Transformation and Renewable Energy, and the Ministry of Environment, all geared towards accelerating Algeria's energy transformation and clean environment targets.

These ministries interact with other relevant ministries such as the Ministry of Finance that provides necessary support in financial resource management in the implementation of targets, and the Ministry of Higher Education and Research for necessary input in terms of evidence-based propositions and innovative ideas to advance the targets. In essence, the study revealed a systemic process in the transformational management approach. Each of the aforementioned ministries interacts with other relevant ministries to come out with a plan. Consequently, these plans are implemented and managed at different levels of the Algerian political structure. The national levels policies are coordinated at the regional or Wilaya levels. The municipalities focus more on the implementation of these policies and taking feedback from the various consumers.

It must be noted that the current nature of energy management assumes top-down system planning. This creates debates and contestants regarding the effectiveness of such systems. Again, it was revealed that the top-down nature of energy management is consistent with the country's overall governance structure, but creates room for participation, unlike traditional top-down management structures.

A participant averred: *“Well, most often, our structure is described as more consistent with centralized approaches than decentralized systems. However, even at the city levels, consumers are at liberty to always express their concerns, views, and even their displeasure to the utility companies, and then they address them. So I think we are a kind of system that looks centralized on paper, but in real life, we have important features of some form of decentralization”*.(Interview no.15 – Utilities)

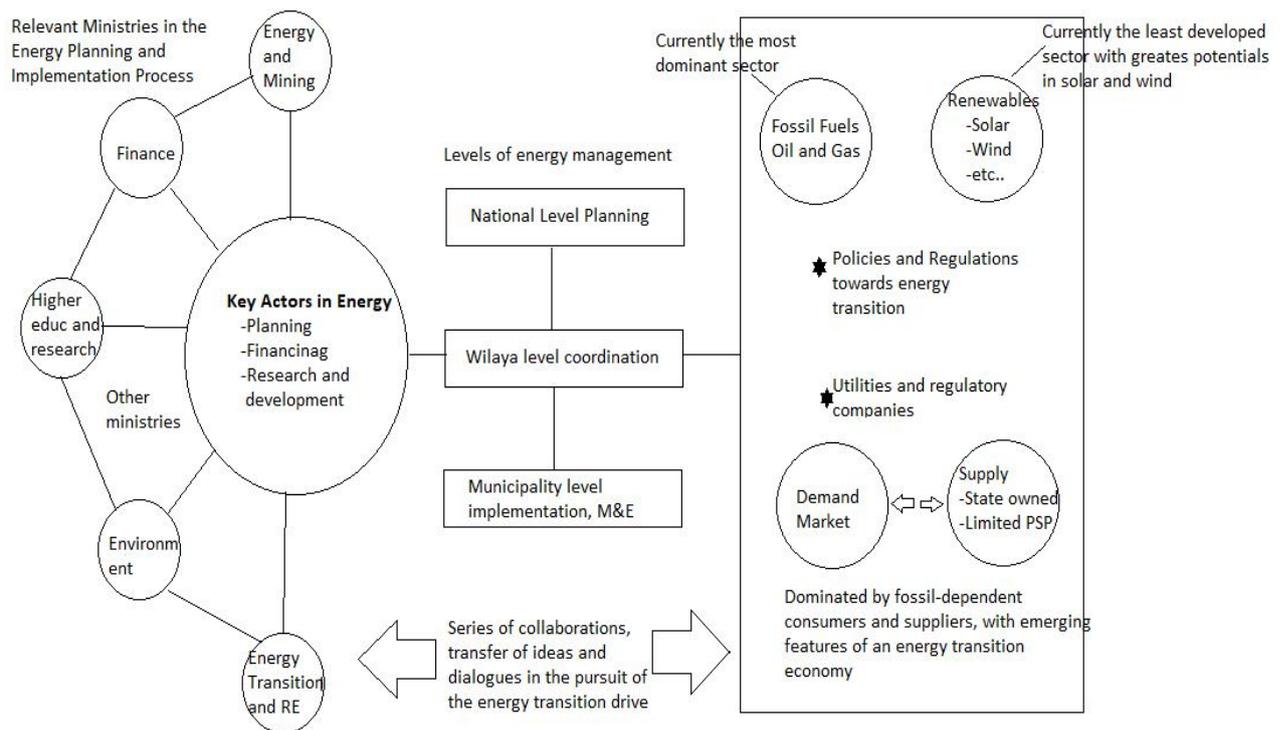


Figure 4-2 Dynamics of Algeria's energy landscape

Despite the significant number of interactions in the energy market, it was observed that the dynamics of energy resource development have been dominated previously by oil and gas development. It was not until recent times that the government's priorities have changed in the sector to focus more on the development of renewables in pursuit of sustainable energy and sustainable environment targets.

Notably, each of the various units in the energy landscape model has its unique attributes but relies on at least one or more of the other units to attain its sectoral objectives, which altogether leads towards the overall national energy transformational objectives as showed in **Fig 4:2**. Such interactions are consistent with the fundamental tenets of systemic reasoning. The variations however occur when there are instances of unclear priorities of these sectors and entities.

A participant quizzed: *“can we entirely say the current management approach follows systemic reasoning? What about the objectives of the ministry of energy that has been predominantly focused on the development of fossils, while the new ministry for Energy Transformation and Renewable Energy will tell you that there are implementing renewable energy target? I am not sure what conclusions to make about the current nature, but probably you can tell me what you find at the end of your study”*. (Interview no.6 – Public sector Enterprises)

4.5. Challenges and Barriers

Barriers to the adoption of renewable energy technology in Algeria may share some similarities with other countries. However, the nature of the political landscape and Algeria's status as a fossil fuel energy exporter and fossil fuels-based economy means institutional, political, and social barriers to energy transformation are contingent on these particular circumstances. Against these challenges, centralized planning and monopolistic power sector structure have been found as the most important barriers in dimensions of barriers to the energy transformation initiative, subsidized conventional electricity, and knowledge and coordination gap were highlighted as dominant barriers. Whereas unstable policies/regulations and political skepticism were also rated as important barriers by the interviewees. In this regard, **Fig 4.3** shows the overall picture of barriers facing the transformation toward a mixed-energy economy in Algeria.

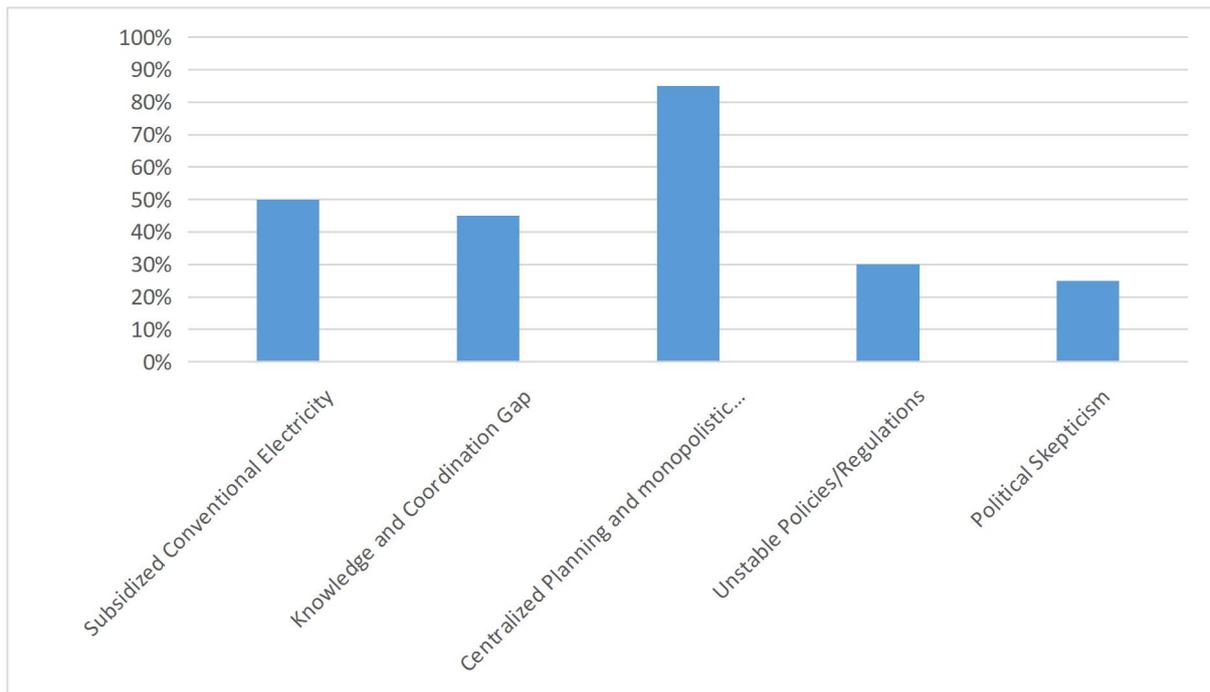


Figure 4:3 Challenges faced the energy transformation initiative

4.5.1. Centralized Planning and monopolistic power sector structure

From a governance point of view- the centralized planning and monopolistic power sector structure in Algeria continues to be a dominant barrier. The centralization of economic decision-making has crushed all local initiatives. When asked what is the major barrier facing the energy transformation in Algeria as shown in **Fig.4.3** vast majority (85%) of respondents have indicated that monopolistic system is one of the main barriers, an interviewee at the government state that:

“Monopolistic market, Sonalgaz is the only company controlling the electricity system in the country, and if we want to succeed in implementing this transformation we need to open up our electricity market”.(Interview no.19.Government body)

The country's centralized model of governance concentrates all significant powers in the capital. Thus, energy policy is being performed in a top-down mode at the national level. Also in the international level the law renewable energy investment still need improvements to attract inverters, as one of the respondents affirm that;

“Reviewing regulation to cancel the 51/49 rule, and allow foreign investors to contribute based on the lowest price of electricity”.(Interview no.14.International Expert)

The sale of electricity seems like a monopolistic market in Algeria and the practice scares independent power producers and international investors from investing in the sector.

“In terms of decentralized solar energy, citizens should be able in terms of regulations to install and sell electricity to SONELGAZ (The national Electricity company)”. (Interview no.02.Utilities)

Algeria as a country has a vast surface and difficult geography especially in the south part of the country, decentralized RE systems will enhance energy access in rural areas.

4.5.2. Subsidized Conventional Electricity

Algeria has been too slow in implementing its renewable energy program. Today, the share of renewable energy in electricity generation does not exceed 400 MW on an electricity generation capacity with gas that approaches 22,000 MW and tends to increase by 14,000 MW. This is due to the strong dependency on fossil energies to support the economy along with heavily subsidized energy products. As shown in Fig 4.1 half of the respondents highlighted such a barrier

“Until now, practical policies have focused on increasing subsidies for renewable energy rather than reducing subsidies for fossil fuels. In fact, the 2016 budget included an increase in the cost of direct subsidies, accounting for 23% of total public spending”.(Interview no.18 Research institute)

Looking at the above interviews, one can see that the first hinder for subsidizing electricity is purely political with an economic inclination. As one the Interviewers state;

“In 2009/10 Sonelgaz wanted to raise the general price of electricity – but the government intervened and made them retain this artificially low price”. (Interview no. 9 Utilities)

Similarly, Energy subsidize is related to Algeria’s economy, as referenced in the major barrier of containerized system, which make it a challenge to divert from the oil lobby, as a Government body said;

“Energy subsidies are intimately intertwined with the country’s economy, which makes any reform extremely complex. Algeria’s dual challenge is to divert the country’s economy away from oil and gas, while at the same time amortizing the social impact of energy reforms”. (Interview no.19 Government body)

In another hand, subsidies are certainly useful for stimulating specific economic sectors, reducing poverty, and increasing energy access, but they have also negative effects and encourage waste of energy which is the case in Algeria, and before going to such transformation energy efficiency is likely to play an important role and could result in considerable savings if sustained energy efficiency measures are implemented, as one of the stakeholders said;

“Algeria cannot and must not miss the turn of the energy transformation. The term energy security means that we must ensure energy independence for ourselves and future generations, but also through energy efficiency”.(Interview no.17International Expert)

Investing in RES and EE is a good step in the energy transformation initiative, and in order to strengthen these two elements, The recent plan of MTERE makes the EE one of the elements for the road of the energy transformation initiative and then enhancing the deployment of RE.

4.5.3. Knowledge and Coordination Gap

The energy transformation initiative in Algeria has so many actors involved. These multiple actors within the adoption of renewable energy would presuppose that the transformation would have been rolled out faster. This has however not been the case as shown in **Fig 4.3** many of the experts and stakeholders interviewed considered both insufficient coordination, due to the weak inter-sectoral coordination, and knowledge limitations (R&D, demonstration, and implementation) as an important challenge hindrance to the proliferation of renewable energy technologies in Algeria. A respondent puts it;

“There is lack of coordination. If coordination was good, we would do better. But since we have laws that we do not respect, coordination has become difficult”.(Interview no.10 Government body)

In a situation like this, lack of effective coordination, complicated bureaucratic procedures within and between various stakeholders involved. Situations like this make the entire policy process rigorous and complicated. In the words of staff from an international expert;

“Local and regional energy agencies are essential players in the sustainable energy field, with distinct competence and agility to support innovative decision-making and enable large-scale investments in their regions and cities, bridging the key actors of the energy transformation: citizens, public authorities, and private companies”.(Interview no.11 – International Expert)

Similarly, another interview with Utilities highlighted the importance of knowledge and R&D and bring experience from an international consultant.

“The most important target about renewables call for tenders is to bring down the cost of electricity, this cannot be possible unless we focus on terms of references according to international standards, thus for a first experience needs to rely on experienced advisory consulting services”.(Interview no.20 – International Expert)

4.5.4. Unstable Policies/Regulations

However, the failure of the promotions plan in the last 15 years has also shown that the immediate transfer-ability of government models is bound to fail due to a variety of reasons, such as conflicting intergovernmental interest groups and the not fully liberalized energy market. This made it difficult, if not impossible for the market-based incentive system to succeed, as one interviewee emphasized:

“Relative lack of continuity in the RE programs developed: The Renewable Energy Program adopted in 2011 and revised in 2015, had very limited implementation (343 MW in photovoltaic and 10 MW in wind power) at the end of 2020”.(Interview no.4 – Private Sector)

In the same context, civil society stakeholders affirm that; *“Frequent changes in regulations with discontinuities in announcements of projects to be launched”.*(Interview no.09 Civil Society)

These frequent changes in stakeholders and each one come up with a new strategy and plan will affect the development process.

4.5.5. Political Scepticism

Because out of the results of the interviews we can see the need of creating support among the consumers, although, as aforementioned above, the consumers are not aware of the importance of the energy transformation. Besides, they do not want to pay a lot of money for a sustainable solution for their houses/companies, as they already the government subsidize prices of conventional electricity, it becomes clear in **Fig 4.3**. On the contrary, affordability is not the most important concept, but sustainability is, a respondent had this to say;

The adoption of energy tariffs close to real costs is not a priority for the public authorities, in particular, because of the social implications. (Interview no.1 – Utilities)

However, the government has already an existing law for FIT since 2004 to boost the RE development and in 2014 the country launches a new tariff that is valid for 20 years for solar PV and Wind, but nothing has been implemented yet and consumers are not aware of such law. The entire policy process can fare better if policymakers are also expected to implement the policies. While acknowledging the importance of awareness and encouraging the transformation toward an energy-mix economy, it should however not be forgotten that the easiest way to face such challenge is by implementing popular approaches that directly promote renewables include feed-in-tariffs, renewable portfolio standards, subsidies, direct capital investment, public financing, renewable energy certificates, and production and investment credits, and implement them.

4.6. Algeria's energy transformation plan:

Since Algeria's, state-driven economy is based on oil and gas exports revenues, and writhing this last decade unstable prices and absence of significant oil discoveries have left the government with a stark choice to either push a bold to renewable energy agenda or consume its oil and gas export and keep on the same scenario. Recently, the government unveiled an energy transformation plan as part of its 2020 five-year development plan. This plan consists of three structural components- a new government ministry, a regulatory reform, and a new national renewable energy company.

- **Ministry of Energy Transformation and Renewable Energies (METRE)**

In June 2020, the government created METRE, the first new body to manage and carry out the transformation plan.

- **Regulatory Reform:** On January 25th, 2021, the Ministry of Energy declared that the 2002 law on electricity would soon be reformed to open the market to small and medium-sized enterprises working in RE, reduce natural gas consumption, and accelerate RE production.

It is important to note that the requirements for local content, local financing, and joint-venture partnerships may cause hesitation among some investors and could also increase the power prices resulting from the auctions. Yet such policies can encourage knowledge transfer to the local economy and stimulate economic development.

- **National Renewable Energy Company:** on April 19th, 2021, the government created a stand-alone renewable energy company, SHAEMS, under the authority of MTERE. It will serve as a one-stop shop for all prospective investors, service providers, and other renewable energy ecosystem players.

Furthermore, the plan includes three substantive pillars as follow:

National Energy Conservation and Efficiency Program: Energy conservation and efficiency efforts will improve energy efficiency by 10% annually in transportation, housing, and industry

National Renewable Energy Development Program: Renewable energy development will focus on developing extensive solar resources in the high plateaus and Sahel regions and substituting natural gas consumption with blue and green hydrogen

New National Energy Mix Model: the country's energy mix model aims to reach at least 30 percent power generation from renewables by 2030 and generate 25 gigawatts of power from green and blue hydrogen by 2050.

However, Algeria's renewable energy targets are ambitious relative to their time frame. With approximately 450 MW of installed solar capacity today, Algeria would need to deploy an additional 5,000 MW to meet the solar capacity target outlined in the regulator's 2028 generation capacity scenario. To meet the official 2030 targets, 22,000 MW total renewable capacity would need to be deployed. Following this, the government launched a program for the deployment of hydrogen: *"the country's energy mix model aims to reach at least 30 percent power generation from renewables by 2030 and generate 25 gigawatt of power from green and blue hydrogen by 2050"* Which is the horse of troy of the oil lobby, with regards to technology and situation is the country facing such an ambitious target would be better to develop the energy consumption that will determine the energy mix ensuring true energy security, and work on the current issues surrounding the transformation and give priority to the available RE source such as Solar PV.

Based on the literature reviewed and primary data collected on the deployment of energy transformation in Algeria, it can be seen clearly that the country is blessed with enormous racecourses and each of the mentioned drivers opens up a range of barriers towards a path of sustainable development depend on political, regulatory, economic and social factors, while the government of Algeria, through the establishments of new pathways toward the energy transformation, the mentioned challenges remains to be thoroughly discussed.

4.7. Summary

The industrial nature of the Algerian context has been used on the ever-expanding use of fossil fuels, so the changes required will inevitably be challenging. In particular, the economy and energy sector, at times involve all actors concerned without exclusion can be the key to buttress effective policy instruments in ways that subsequently would enhance the energy transformation in the country. The ensuing chapter presents a summary of major findings, recommendations, and conclusions based on the main objectives of this research. mentioned challenges remain to be discuss.

5. SUMMARY, CONCLUSION, AND RECOMMENDATION

The main aim of this study is to find out how the Algerian energy transformation can be improved through the adoption of a systemic perspective. Specifically, the study unravels the key factors that drive renewable energy transformation in Algeria, what are the cross-cutting issues surrounding renewable energy technology adoption in the energy sector of Algeria, and assesses the comprehensiveness of the Country's Energy Policy in addressing the cross-cutting sectoral linkages in the energy transformation. This chapter presents a summary of the major findings made under each objective, conclusion, and policy recommendation.

5.1. Summary

Overall, the research has shown that the country is blessed with enormous racecourses and each of the mentioned drivers opens up a range of barriers towards a path of sustainable development depend on political, regulatory, economic, and social factors, while the government of Algeria, through the establishments of new pathways toward the energy transformation, the mentioned challenges remain to discuss. The ensuring sub-sections present the major findings for each research objective.

5.1.1. Key drivers and barriers toward energy transformation in Algeria

Algeria is a market blessed with a high potential for renewables due to its geographic location, but challenges remain. The dominance of the oil and gas sector in both energy /economy sectors hinders the widespread deployment of renewables in different ways. Based on the findings, we thematically scoped the energy transformations drivers into four key categories: Economic, social, Market, and institutional drivers. However, the after-mentioned drivers open up a range of barriers to the adoption of renewable energy technology in the country. The nature of the political landscape and Algeria's status as a fossil fuel energy exporter and fossil fuels-based economy means institutional, political, and social barriers to energy transformation are contingent on these particular circumstances. Against these challenges, centralized planning and monopolistic power sector structure have been found as the most important barriers in dimensions of barriers to the energy transformation initiative with a majority of seventeen interviews, subsidized conventional electricity, and knowledge and coordination gap were highlighted as dominant barriers. Whereas unstable policies/regulations and political skepticism were also rated as important barriers by the interviewees.

Following a comprehensive analysis of the drivers of the energy transformation in Algeria in section 4.4, the study further investigated the cross-cutting issues surrounding the transformational drive. A dynamics of interrelated actions emanated based on the key informant discussions with experts. It has been noted that the current nature of energy management assumes top-down system planning. This creates debates and contestants regarding the effectiveness of such systems regarding the major challenges mentioned above especially when it comes to containerized planning. Again, it was revealed that the top-down nature of energy management is consistent with the country's overall governance structure, but creates room for participation, unlike traditional top-down management structures.

Despite the significant number of interactions in the energy market, it was observed that the dynamics of energy resource development have been dominated previously by oil and gas development. It was not until recent times that the government's priorities have changed in the sector to focus more on the development of renewables in pursuit of sustainable energy and sustainable environment targets.

5.1.2. The comprehensiveness of Algerian energy policy

The content analysis of the Energy policy documents of Algeria revealed that very little emphasis is placed on addressing the mentioned challenges. The term energy is often associated with electricity and fossil fuels and the economy in the country. Consequently, all energy-related projects found in the plans focused on increasing electricity access through the extension of the national grid and. Otherwise, The policy for the promotion and development of RE is governed by a series of laws and regulations as mentioned in detail in Table 2:3, in particular Law n°02-01 of February 5, 2002, on electricity and gas distribution by pipelines and Law n°04-09 of August 14, 2004, relating to the promotion of renewable energies within the framework of sustainable development, To overcome its dependence on hydrocarbons and implement its energy transformation, Algeria set up in 2011 a National Renewable Energy Development Program (PNER) and a National Energy Efficiency Program (PNEE). These two particularly ambitious programs were updated in February 2015, taking into account the relevant elements that appeared on the energy scene, both nationally and internationally, in particular in terms of a significant drop in the prices of the various technologies. Recently the governments established new institutions to enhance the transformation such as the Ministry of the energy transformation, Commissariat of energy efficiency, and renewable energy to accelerate this energy transformation in the country. To proceed with energy transformation in the energy system, efforts in the field of renewable

energy implementation must be increased, and the political will to act in this regard must be translated into concrete action.

5.1.3. Framework for the sustainable renewable energy transformation in Algeria based on the system theory

The third objective of this study is to establish a framework for enhancing the energy transformations in Algeria based on the systems theory. While Algeria's energy following a top-down approach in the energy sector planning, proposed interventions have been made based on major findings and expert recommendations. Based on **Fig 4.2**, a framework for enhancing sustainable energy transformation from the central level in Algeria's energy sector is proposed in **Fig 5.1**. The breaking lines mean planing guideline and straights ones means development plans. Development planning in Algeria generally follows a top-down approach. Proposed intervention follow up the same approach based on the major findings of the study and expert recommendation, starting from the governance and managerial reforms, and regulatory reforms for the market in order to open up the door for local/international investors, since the country centralized and monopolistic power sector structure, have been highlighted as a major barrier toward the energy transformation. In order to face the mentioned barriers mainly knowledge, unstable policies/regulations, and political skepticism, redefining policy priorities, capacity building, and awareness developments, it proposed as a key area of interventions to build a strong baseline in increasing level of planning and implementations towards the realization of the overall target.

According to Meadowcroft (2009), management refers to conscious efforts to guide such transformations along desirable pathways, and integrated assessment. Transformation management has roots in systems theory, evolutionary economics, and integrated assessment (Meadowcroft, 2009). Managing all the mentioned interventions above following a systems theory on Algeria's energy sector will need to coordinate on the three different levels of the country (National level, Wilaya level, and multiplicities) giving priority to en enhance local participation and close the coordination gap between all the mentioned levels.

Increasing level of planning and implementation towards realisation of overall target

Overall Target	Sustainable Renewable Energy Transition			
Priorities	Economic Sustainability	Improved market	Social and political development	Environmental Sustainability
Assessment Criteria	<ul style="list-style-type: none"> -Increased gov't investment -Competitive market prices between fossils and renewables -Generally affordable energy 	<ul style="list-style-type: none"> -Enhanced PSP -Diversification of energy market -Reduction in negative externalities 	<ul style="list-style-type: none"> -Equitable access to energy across income levels -Energy security in Algeria -Decentralised Planning 	<ul style="list-style-type: none"> -Reduced emission levels for greenhouse gases (CO2) -Natural resource conservation -Improvement in general environmental quality
Barriers to Interventior success	Centralized Planning and Monopolistic Structure	Over-subsidization of fossils against renewables	Knwoledge Gap and weak capacities	Unstable policies and political skepticism
Managemen Levels	State/National Level Wilaya level Municipal Level			
Proposed Interventions	Governance and managerial reforms	Regulatory reforms for the market	Redefining Policy priorities	Capacity and awareness development

Figure 5:1 Systemic framework for enhancing sustainable energy transformation from the central level in Algeria

Overall, to overcome the major barriers facing the pathways toward energy transformation in Algeria. Assessment criteria will be classified under priorities starting from economic sustainability by increasing government investment and create competitive market prices between fossil fossils and RE in order to provide affordable energy. The improved market will follow up the economic sustainability by enhancing private sector participation which leads the country to diversify the energy market and economy in general, also by reducing negative externalities. In practice, energy security is regarded as critical in the medium term (because of political instability in oil-producing regions or ‘peak oil’) (Meadowcroft, 2009). Diversify the energy sources and enhance the deployment of RE with facilitating regulations under social and political deployment developments will facilitate the pathway toward the overall goal. As a result, reducing CO2 emissions, meeting the global commitments, preserve natural energy resources, and improvement of environmental quality, in general, will come as results of all the mentioned interventions above.

Notably, to come up over all these challenges, economic, institutional, social, and environmental have been identified as key drivers for Algeria's energy transformation, and each of the various assessment criteria has its own unique attributions but relies on at least one or more of the other criteria to attain the overall objective. Such interactions are consistent with the fundamental tenets of system theory.

Such a framework is vital for government intervention and will also attract investors into the country since they will know where the need exists, how they will do it, and what potentials are available. These investments will facilitate the deployment and usage of RE and consequently facilitate the sustainable energy transformation.

5.2. Conclusion

The analysis has shown that interest in the energy transformation is growing in Algeria, and the government has set ambitious targets. Although the legal framework and plan for enhancing the energy transformation pathway are well developed, thus centralized/monopolistic planning, regulatory support for renewable energies, and financial incentive have so far been somewhat limited. Given that fossil fuels play a major role in the country’s energy sector, as well as in the economy as a whole, the pathway to a renewable energy-mix energy system needs strong government support at all levels to succeed in a systemic perspective manner.

Therefore, the Algerian government would be well advised to take measures to promote investment in RE and EE technologies. This requires holistic planning to facilitate system and infrastructure integration, taking socioeconomic structure into account.

In summary, at the central level, a number of factors currently limit Algeria's development in the energy transformations: the dependency on natural gas resources, centralized planning, subsidized electricity prices, energy market structures, hesitant support from institutional actors, and lack of social readiness to pay for renewables (political skepticism). All these barriers preventing Algeria from attaining its ambitious energy transformation goals.

5.3. Recommendation

In light of the major findings of the study, the following recommendations are made in order to enhance the energy transformation in the Algerian power sector.

- Making the future more clearly manifest in current decisions, by adopting longer time frames, exploring alternative trajectories, and opening avenues for system innovation.
- developing interactive processes where networks of actors implicated in a particular production/consumption nexus can come together, develop shared problem definitions, appreciate differing perspectives, and above all develop practical activities.
- linking technological and social innovation, because both sorts of change are necessary if society is to move on to a more sustainable pathway.
- the legal and investment framework conditions for implementing renewables projects must be revised to make them attractive. While Algeria has a clear regulatory framework in place for renewables, it is not effective. Tenders for the private sector have had only limited success, and the limitations imposed on foreign investments in Algeria is a definite major barrier
- Consumers in Algeria should also be incentivized to switch to renewables; for example, through guaranteed revenue from renewable energy generation. This could be in the form of tax allowances or exemptions for renewables, CO2 certifications, or energy auditing. Furthermore, by providing an adequate framework and

regulations to support businesses to adopt energy efficiency and GHG emissions reduction measures, companies could be encouraged to participate in efforts towards the energy transformation. The government is thus encouraged to establish such regulations in the market to enhance this transformation.

- The ministry of Energy Transformation is advised to strengthen cooperation with neighboring countries and the EU on technology transfer and capacity-building could also help to achieve the goal of a higher share of renewables in the electricity mix
- The Algerian government would be well advised to take measures to promote investment in low-carbon energy technologies. This requires holistic planning to facilitate system and infrastructure integration, taking socioeconomic structures into account. Building trust among decision-makers and other stakeholders is fundamental to realizing Algeria's renewable energy goals, and changes in policy, investment, and behavior will all be required.
- Furthermore, Algeria must create incentives for the introduction and integration of renewable energies and flexibility options. One important step would be to phase out energy subsidies for fossil fuels, which currently hinder the energy transformation.

Overall, progress will largely depend on political motivation to actively support the energy transformation. This not only entails state investment but also includes designing the necessary framework conditions to encourage participation and to attract investment from the private sector

5.4. Further Research

Further research could focus on involving other key sectors in order to enhance the energy transformations in Algeria.

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7. APPENDIX

7.1. Data Collection Instrument

Interviews Guide Energy Stakeholders in Algeria

Dear Respondent

I am SAKHRAOUI KHADIDJA, a student of the INSTITUTE OF WATER AND ENERGY SCIENCES of the PAN AFRICAN UNIVERSITY, TLEMCEM, ALGERIA carrying out research on: “A systemic approach of the energy transformation in Algeria” in partial fulfillment of the requirement for the award of a Master of Science (M.Sc.) Degree in ENERGY POLICY. The information you provide will be treated with confidentiality and will be solely for academic purposes.

SECTION A: IDENTIFICATION OF THE RESPONDENT

Sex: Female Male

Age range: 18-27 28– 37 38 – 47 48 – 57 58 and above

Educational Level: Bachelor's Master PhD Professor other

In Which Authority/ institute/ Department/organization:

Years in the energy sector: below 5 years 6-15 years 16-25 years Above 25

SECTION B: Interview main questions

RQ1. What are the key drivers’ factors that drive the renewable energy transformation in Algeria?

1. What are the key factors that drive the renewable energy transformation in Algeria?

RQ2. What are the cross-cutting issues surrounding renewable energy technology adoption in the energy sector of Algeria?

1. What factors hinder the improvement of the energy transformation in Algeria?
2. what are the major barriers to the energy transformation?
3. what issues are not negotiable?
4. How do you think these challenges can be addressed?

RQ3. How the existing energy policy and regulatory provisions could be improved from a central level toward energy transformation?

1. How can policy instrument support the deployment of the energy transformation?
2. In order to enable the deployment of RE, how would energy stakeholders contribute to accelerate such process?
3. Does the new policy address them?

According to you as an expert in the field, can you oriented me better by proposing, mechanisms, processes that can help me more in the field I have been interested in (my research study).

Thank you

7.2. Plagiarism Report



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