

# Master Thesis

## ASSESSMENT OF THE RENEWABLE ENERGY TRANSITION AND SUSTAINABLE DEVELOPMENT SITUATION IN EGYPT

Hussein Abouyoussef

Student number: 1935224

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*Figure 1 Source: (Arab news, 2021)*

Supervisors: Dr. Florence Metz and Dr. Gül Özerol

## Abstract

In recent years, decreasing the carbon footprint and mitigating the effects of global warming has been one of the main concerns for states all over the world. One of the main areas that must be altered in order to achieve this is the energy sector. This study aims to evaluate the current situation of the energy sector in Egypt along with the different energy sources available in the country. Furthermore, the different targets set by Egypt both on the National and International level are assessed. Next, through research and different interviews with respectable representatives from the sector and with the use of the Actors, objectives, and context (AOC Framework) a study is done to identify the different actors in the Egyptian energy sector along with their objectives and the context in which the specified objectives matter to the relevant actors. From the results, the various actors involved in the Egyptian energy sector are identified along with the influence of each one on the energy sector. Also, the context in which the specified objectives matter to the different actors is deduced. Moreover, the results show that the AOC framework applies to the case of the Egyptian energy sector in which the most powerful actors have the highest influence on the sector in terms of fulfilling their objectives. Last but not least, various proposed improvements are stated based on the analysis of various documents and the different interviews conducted.

# Contents

1- Introduction: .....	6
1.1 Problem Statement .....	6
1.2 Background .....	7
1.3 Research Objective .....	7
1.4 Research Question .....	8
1.5 RELEVANCE .....	8
2- Context .....	9
2.1 Fossil fuels .....	9
2.2 Renewable Energy sources .....	10
2.2.1 Hydropower .....	10
2.2.2 Wind energy .....	11
2.2.3 Solar energy .....	11
2.3 Nuclear Energy .....	12
3- Research Framework .....	13
4- Methods .....	15
4.1 Research object, Research Unit, and Research Boundary .....	15
4.2 Data collection & analysis .....	15
4.2.1 What are the energy and environmental targets set by Egypt and when should they be fulfilled ? .....	16
4.2.2 How far is Egypt in completing the set targets ? .....	17
4.2.3 How is the Egyptian energy sector organized ? .....	17
4.2.4 What are the viable organizational improvements to achieve the set goals ? .....	18
4.3 Data Validation .....	20
4.4 Ethics Statement.....	20
5- Results .....	21
5.1Energy Targets Set by Egypt .....	21
5.1.1 NDCs.....	21
5.1.2 .....	22
Egypt Vision 2030 & Integrated sustainable energy strategy (ISES 2035) .....	22
5.2Progress done to achieve set targets.....	24
5.2.1 Policy Formation in Egypt .....	24
5.3 Organization of the Egyptian Energy Sector .....	26
Relevant actors.....	26
Objectives .....	30
Context:.....	35

Review of AOC framework in relation to the energy sector in Egypt.....	39
Actors.....	39
Objectives .....	39
Context.....	40
6. Conclusion: .....	41
References.....	44
Appendix:.....	48
1.Different mitigation measures of NDCs in various energy consuming sectors: .....	48
2.Adaptation Measures suggested in NDCs.....	48
3.Interview Questions:.....	49
4.Different scenarios to achieve the required electricity demand.....	49
5.Informed Consent form For MEEM Thesis.....	52

## List of tables:

Table 1 Recently discovered natural gas fields.....	10
Table 2 Hydropower stations and their generation capacities.....	10
Table 3. Interviewees .....	16
Table 4 Research process.....	19
Table 5 Different energy sources and their generation capacity .....	21
Table 6 SDS goals in 2016, 2020, and 2030.....	23
Table 7. FIT prices for solar power.....	25
Table 8. FIT prices wind energy .....	25
Table 9. Electricity production in Egypt in 2020 .....	26

## List of figures:

Figure 1 Source: (Arabnews, 2021) .....	1
Figure 2 Egypt's wind Atlas. (IRENA, 2018) .....	11
Figure 3 Egypt's Solar Atlas. (IRENA, 2018) .....	12
Figure 4. organizational arrangement of the different actors in the Egyptian energy sector.....	27
Figure 5. generation, transmission, and distribution in the Egyptian electricity sector.....	29
Figure 6. Power-interest matrix of the relevant actors .....	29
Figure 7. hierarchical arrangement of Egyptian energy sector.....	30
Figure 8. Electricity production in 2022 (source:NREA).....	31
Figure 9. Electricity production in 2035 (source:NREA) .....	31
Figure 10. SEC objectives .....	32
Figure 11. MOERE objectives .....	32
Figure 12. EgyptERA objectives.....	33
Figure 13. NREA objectives .....	34
Figure 14. Private sector objectives .....	34
Figure 15. SEC context .....	35
Figure 16. MOERE context.....	36
Figure 17. EgyptERA context .....	37
Figure 18. NREA Context.....	38
Figure 19. Private Sector context .....	38
Figure 20. average of objectives.....	39

## List of Abbreviations

NDC: Nationally Determined Contributions

AOC Framework: Actors, Objectives, and context framework

PV: photo-volvic

UNFCC:

SEC: Supreme Energy Council

MOERE: Ministry of Electricity and Renewable Energy

MOP: Ministry of Petroleum

NREA: New and Renewable Energy Agency

EEHC: Egypt electricity holding Company

EETC: Egypt Electricity Transmission Company

NPPA: Nuclear Powerplant Authority

MW: Mega-Watt

GWh: Giga-Watt-hour

## 1- Introduction:

### 1.1 Problem Statement

In 2015, 197 parties agreed to sign the Paris agreement in the 21<sup>st</sup> conference of parties (COP21). In this agreement, the participating parties agreed to hold the increase in global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C (UN, 2015). To satisfy this agreement, each country was required to submit Intended Nationally Determined Contributions (INDCs) which are transformed to NDCs once a country officially ratifies the agreement that have come to force in 2020 and are to be updated every five years to ensure the success of the set target (Levin, Rich, Tirpak, McGray, Waskow & Bonduki, 2015). This method is known as the pledge and review system, under which all participating states will offer nationally determined contributions (NDCs) to reduce emissions that cause climate change (Keohane & Oppenheimer, 2016). This method was chosen after the Kyoto regime failed which consisted of targets and timetables, so a different plan of action had to be considered. NDCs are the contributions stated by the countries that participated in the Paris agreement in order to reduce national emissions and mitigate the effects of climate change (Levin et al., 2015). The main component of the NDCs is mitigation which are the actions conducted to reduce GHG concentration in the atmosphere. Additionally, NDCs may include adaptation measures to react to the already existing impacts of climate change. Committing to the Paris Agreement does not ensure that a country accomplishes the set target, since every country chooses its own pathway in fulfilling the final target at the set time. Although all parties that signed the agreement aim to drastically decrease their GHG emissions, they also aim to maintain their economic development. However, many countries are dependant on fossil fuels. Therefore, the renewable energy transition is not an overnight process and will definitely take some time for the countries to reach the agreed upon targets without affecting their economic growth.

Egypt is among the countries that took part in the Paris Agreement in which the state have submitted its NDCs which will be discussed in further chapters. In recent years, Egypt has witnessed multiple revolutions and regime changes that affected the stability of the country last of which was in 2013 (Egypt today, 2020). Consequently, the renewable energy transition and the steps taken for the country to become more sustainable have been hindered. As a result, the Egyptian economy has been largely built and reliant on fossil fuels in which 90% of the country's energy supply comes from fossil fuels (IRENA, 2018). This would have not been the case if not for the political disruptions. So, after the country reaching political stability and participating in the Paris Agreement, there should be a huge interest in becoming more dependant on renewables than on fossil fuels (IRENA, 2018) . Nevertheless, Egypt has a huge potential for renewable specifically solar energy and wind energy since more than 95% of the country consists of desert lands (Khalifa & Abdelall, 2019). Given that, after the Paris agreement in 2015 which Egypt took part in the country set specific targets -all of which have been publicly announced- to be reached in order to comply with the agreed terms. To satisfy the required targets, Egypt must work on decreasing GHG emissions by increasing renewable energy production, along with other required steps to be followed in different domains (*Sustainable Development Strategy: Egypt Vision 2030*, 2021). Other domains include: Industry, Commercial and residential use, agriculture, land use and forestry (Sources of Greenhouse Gas Emissions, 2021). However, the organization of the Egyptian energy

sector will be the main focus of this research given that it has the most prominent effect on the environment.

## 1.2 Background

Over the last few decades, there has been a global concern regarding global warming which is the rise earth's temperature. Global warming has various detrimental effects that most of which will affect all living organisms. To begin with, extreme weather events such as heat waves, droughts, blizzards, rainstorms, and more intense weather events such as hurricanes (Bradford, 2017). Furthermore, there has been a rise in global sea levels due to the melting of polar ice from the arctic and Antarctic regions. Another phenomenon caused by global warming is ocean acidification, since the levels of CO<sub>2</sub> increase the ocean absorbs the gas which has an acidic nature that leads to the increased acidity in seas and oceans. Another disastrous effect of global warming is harm to plants and animals. Numerous ecosystems have been affected by the phenomenon causing many animal and plants species to move their habitat to higher altitudes due to the warming temperatures. Apart from the aforementioned natural effect of global warming there are also multiple social effects like loss of food security, loss of valuable land and an increase in chronic diseases and mosquito-borne diseases like malaria and dengue fever (Bradford, 2017).

Global warming is mainly caused due to various human activities that cause greenhouse gas (GHG) emissions (Deziel, 2019). Industrial activity is one of the major causes of global warming, due to the burning of fossil fuels to provide energy for heat, electricity, industrial processes, and transportation (Deziel, 2019). Other human activities that cause global warming are agricultural activities and deforestation (youmatter, 2020).

In this thesis, the main focus is on decreasing GHG emissions through the analysis of the Egyptian energy sector and the renewable energy transition in Egypt. For countries seeking a renewable energy transition, the main challenges are: to utilize the countries' resources and renewable energy potential to generate sustainable energy in a quantity that fulfills its needs. Moreover, every state must determine the most suitable energy mix that will perform most efficiently depending on the country's resources. Another challenge is to alter the operating conditions of various industries that emit reasonable amounts of GHG. Furthermore, increase the awareness about sustainable energy use to mitigate the effects of global warming. Last but not least, Egypt must enhance its energy saving and energy efficiency measures. All of which are incorporated in a country by policy formations and altering the governing infrastructure.

## 1.3 Research Objective

In this research, various energy goals are mentioned; specifically: NDCs, Egypt vision 2030 and the Integrated Sustainable Energy Strategy (ISES 2035). Furthermore, the current progress of the energy transition in the country will be analysed. In addition to this, various theories like the Actors, Objectives, And context theory (AOC framework) and the energy triangle which are discussed in the next chapters are applied to provide an appropriate method for assessing different aspects affecting the energy sector in Egypt. Using this assessment, deductions will be provided on how well the Egyptian energy sector is governed to reach the required goals. This step will take into consideration any misalignment in the set targets. Regardless of whether Egypt are on track or not in fulfilling their set targets, recommendations will be provided either to put Egypt on the right track to accomplish their

targets or increase the effectiveness of the process to reach the targets in a faster and more efficient manner. To further clarify the research objective of this paper, the main objective is divided into the following objectives:

- Assess the energy targets set by Egypt and the progress made to reach them.
- Assess the current situation of the Egyptian energy sector
- Evaluate the structure of the Egyptian energy sector.
- Provide possible improvements to reach the set targets in a more efficient and faster manner.

#### 1.4 Research Question

In the previous section, the research objectives have been specified. To accomplish these objectives, the following research questions must be answered:

##### **Main research questions:**

How adequate is the current state of the Egyptian energy sector to fulfil the set energy related targets ?

##### **Research Sub-questions:**

- What are the energy targets set by Egypt and when should they be fulfilled ?
- How far is Egypt in achieving the set targets ?
- How is the Egyptian energy sector organized ?
- What are the viable organizational improvements to achieve the set goals ?

#### 1.5 RELEVANCE

By answering the research sub-questions mentioned in the previous section, Egypt's place in its renewable energy transition process will become more clear. Additionally, the main factors affecting the fulfilment of the country's specified NDCs will be identified. This will help understand what needs to be altered in order successfully comply to the targets set in the Paris agreement. Accordingly, this will shed light on the Egyptian energy sector's current situation and it will clarify all the relevant entities that have a say or control over the sector.

Another vital aspect about this research is the status of Egypt as a developing country. Since most researches in this field are done on developed countries, this research can help further researches initiate or develop on other developing countries. The reason behind this is the various common social and economic similarities between developing countries. All these countries want to increase development and increase the share of renewable energy in their energy mix however, they all face more hindrances than developed countries given their economic state and current energy situations.



## 2- Context

Before developing the research framework which is used to determine the main aspects to be researched in this thesis, an overview of the current energy situation in Egypt is provided. This overview provides the current energy mix relied upon in Egypt. Additionally, the most recent discoveries and advancements in Egypt's energy sector. Not only will this overview give an insight on the current state of the country, but it will help assess how viable the targets are and if there should be more optimistic targets. This will be discussed further in the results and discussion chapters.

Energy consumption in Egypt has dramatically increased since the beginning of the 21<sup>st</sup> century; rising from 60.5 terawatt hours (TWh) in 2000 to 164.2 TWh in 2017 (energy, 2018). To satisfy this immense demand, and amid the political and economic situation the country has been suffering from since 2011 which only started stabilizing by 2015, Egypt has been mostly reliant on fossil fuels to satisfy its energy demand. In 2018, Egypt's installed capacity of 42 Giga Watt (GW) consists of 90% fossil-fuel based technologies (IRENA, 2018). Accordingly, only 10% of the installed capacity is generated from renewable energy sources. Of this 5%, hydropower accounts for 77% of the renewable energy utilized and the rest is generated from wind turbines and solar panels (Energy, 2018). Due to the major reliance on fossil fuels to supply energy, Egypt ranks 27<sup>th</sup> worldwide in GHG emissions (BZ, 2018).

In Egypt's sustainable development strategy (SDS) published in 2016, it has been stated that the country emits 276 million tonnes of carbon dioxide equivalent (MtCO<sub>2</sub>eq) (MIC, 2016). The Third National Communication (TNC) of Egypt to the UNFCCC has shown that Carbon Dioxide accounts for 68% of the total GHG emitted meaning that it is the major contributor to climate change (EEAA, 2016). The main sectors accountable for CO<sub>2</sub> emissions in Egypt are: electricity sector (43%), transport sector (19%), industrial sector (15%), and the building sector (8%). (Egypt Today, 2018)

### 2.1 Fossil fuels

Outside the organization of the petroleum exporting countries (OPEC), Egypt is the largest oil producer in Africa and the third largest dry natural gas producer in the continent. Nevertheless, since it is one of the most populated countries in the region with 104 million citizens (*Egypt Population (2021) - Worldometer*, 2021) there is a huge energy demand that is not always fulfilled even with the recent offshore natural gas discoveries. The energy sector represents 13.1% of the overall gross domestic product (GDP) most of which consists of fossil fuels which accounted for 95% of the Egyptian energy mix in 2014 and currently accounts for 90% (IRENA, 2018; EEHC, 2021 ). Given that, Egypt currently imports oil to satisfy its needs since the consumption rate is much higher than the production rate.

In the case of natural gas, in 2015 Egypt became a net importer of natural gas with an estimated reserve of 77.2 trillion cubic feet (Tcf). However, in 2016 the huge natural gas discoveries occurred in Egypt which account for 68.5 Tcf which is close to the previous reserve of the country. Accordingly, the Egyptian government accelerated the development of multiple natural gas fields, namely: Zohr and Atoll fields and the West Nile Delta project, which is a five-field development project (bp global, 2019). The named fields are expected to make significant additions to the overall gas supply in the country. The contributions of the recently discovered fields to the total natural gas and condensates production of the country

are demonstrated in table 1 (International - U.S. Energy Information Administration (EIA), 2018). Most of which will be fed into Egypt's electricity grid to terminate any electricity shortages which were a huge issue in 2014.

<b>Name of field</b>	<b>Condensates production (barrels/day)</b>	<b>Natural Gas Production (billion cubic feet/day (Bcf/d))</b>
Zohr	-	2.7
Atoll	10,000	1.5
West Nile Delta (WND)	1000	1.5

*Table 1 Recently discovered natural gas fields*

## 2.2 Renewable Energy sources

As previously mentioned, the share of renewable energy resources in Egypt's total energy mix is below 10%. This is considered to be a drastically low fraction considering the increasing global demand to generate clean and sustainable energy whilst the need to ensure energy security. Thus, in 2014 the Egyptian government developed an energy diversification strategy known as the integrated sustainable energy strategy (ISES) set for completion in 2035. In the words of H.E Dr. Mohamed Shaker – Egypt's Minister of Electricity and Renewable Energy- The "ISES 2035" ensures continuous, diversified energy security and establishes the necessary conditions to enable the increased development of renewables through the engagement of all sectors (IRENA, 2018). The current situation of the most used renewable energy sources in Egypt will be further explicated.

### 2.2.1 Hydropower

Hydropower is regarded to be the most mature and reliable renewable energy source in Egypt, accounting for 77% of the total renewable energy capacity in Egypt. The main hydropower resource in Egypt is the Nile river, where a series of power stations are located in Aswan south of Egypt with a capacity totalling 2800 MW corresponding to an annual electricity generation capacity of 13,545 GWh. Table 2, depicts the current hydroelectric power stations and their capacity (IRENA,2018).

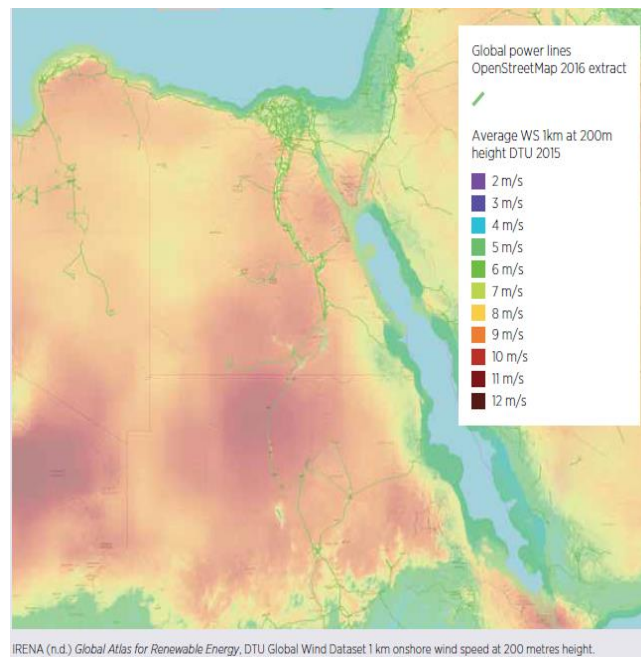
<b>station</b>	<b>Capacity (MW)</b>	<b>Annual generated electricity (GWh)</b>
High dam	2100	9,484
Aswan 1	280	1,578
Aswan 2	270	1,523
Esna	86	507
Naga Hamady	64	453
Assiut	32	-

*Table 2 Hydropower stations and their generation capacities*

Apart from the currently operating and developed hydroelectric powerplants, another powerplant with a capacity 2,400 MW is set to be completed in 2022 (Irena, 2018).

### 2.2.2 Wind energy

According to Egypt's wind atlas demonstrated in figure 2, the country is abundant in wind energy resources. The gulf of Suez is considered to be one of the best locations to harness wind for generating energy not only in Egypt but globally; with wind speeds reaching 10 m/s at the height of 100 meters (IRENA, 2018). By 2016, the total capacity of the installed windfarms in Egypt has reached 2,058 GWh which is a monumental increase compared to the 260 GWh capacity in 2002 (IRENA, 2018). Given that it is a clean source of energy, the installed windfarms have hindered the emission of 1.131 million tonnes of carbon dioxide (CO<sup>2</sup>) that were to be released if the same amount of energy was generated from conventional fossil fuel sources (EEHC, 2016a).

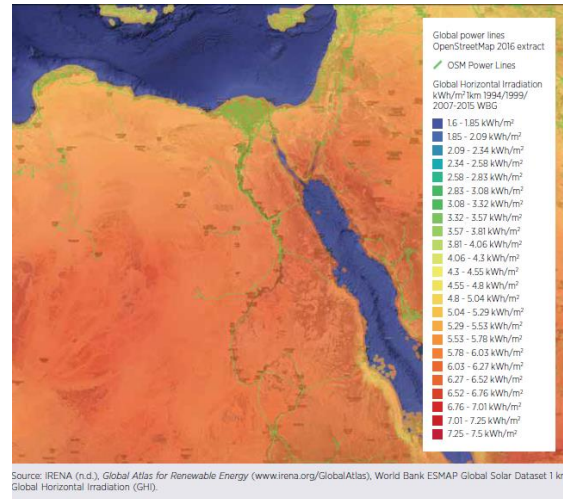


*Figure 2 Egypt's wind Atlas. (IRENA, 2018)*

A plan to build four more wind power plants to be operational by the year 2023 with an estimated capacity of 2,610 MW. In addition, Another wind energy project with a 2000 MW capacity are currently being progressed that has been signed between the New and Renewable Energy Authority (NREA) and German company siemens in 2015 (IRENA, 2018).

### 2.2.3 Solar energy

Egypt is considered to have a strategic geographic location when it comes to solar energy potential, the country often exhibits as much as 32,000 hours of sunshine yearly. The annual direct normal intensity ranges from 1970-3200 kWh/m<sup>2</sup> and the total radiation intensity varies in between 2000-32000 kWh/m<sup>2</sup> per year; making Egypt one of the most adequate countries for the exploitation of solar energy (IRENA, 2018). To further clarify the solar potential of Egypt, the solar atlas of the country which represents the solar intensity across the country is presented in figure 3 (IRENA, 2018).



*Figure 3 Egypt's Solar Atlas. (IRENA, 2018)*

In 2013, the total installed capacity of PV systems in Egypt had a capacity of only 6 MW. However, by the end of 2016, various off-grid power plants have been installed with a cumulative total capacity of 30 MW. Since then, the Ministry of Electricity and Renewable Energy (MOERE) set various planned grid-connected projects due to be complete by the year 2023, namely: Kom Ombo, West Nile, Hurghada, and Zaafarana. The aforementioned projects are set to have a combine capacity of 3,211 MW. Additionally, a solar thermal integrated combined cycle power plant has been built in Al Kuraymat area with a total capacity of 140 MW (IRENA, 2018). The power generation is divided into 20 MW from the solar component of the powerplant and the other 120 MW from the gas-fired combined cycle plant; which uses a heat recovery steam generator to convert the thermal energy from the exhaust to additional electrical energy (Roddy, 2010 ; IRENA, 2018).

### 2.3 Nuclear Energy

Though not a renewable energy source, nuclear energy is included in this section since it is a clean energy source which serves as an advantage to mitigate the effects of climate change since no GHG are emitted from the utilization of nuclear energy. It is worth mentioning that Egypt does not currently generate any electricity from nuclear power. However, in 2015 Egypt started arrangements with Russian Nuclear Organization (ROSATOM) for the first ever Egyptian nuclear powerplant located at El Dabaa; situated west of Alexandria. In December of 2017, Russian President Vladimir Putin met Egyptian President Abdel Fattah El-Sisi to officially launch the project which is set to begin commercial operations in 2026 (Shay, 2018). This powerplant consists of four nuclear power units, each with the capacity of producing 1,200 MW of energy. One will start operating in 2026, and the other three will be expected to operate by 2028. Accordingly, the total capacity of El Dabaa nuclear powerplant is estimated to be 4800 MW upon completion in 2028 (Shay, 2018). Furthermore, the powerplant's reactor will have new technologies with advanced safety measures which enabled Egypt to have an agreement with neighbour country Saudi Arabia regarding cooperation regarding safe use of nuclear power and nuclear security (Shay, 2018).

### 3- Research Framework

Achieving the Paris agreement targets is only possible through the vast decarbonization of the economy, particularly in the energy sector since it is the major contributor to anthropogenic GHG emissions (Williams et al., 2012). To decarbonize the energy sector, more use of renewable energy sources is required; from which GHG emitting technologies are replaced by low or non-emitting technologies; renewables in particular (Schmidt et al., 2019). In this framework, the dependant variable is policies Egypt's energy sector. On the other hand, the independent variable (cause) is the organizational structure which is translated into the actors, their objectives and the context in which the objectives matter to them which determines the utilization of renewables in Egypt's energy mix.

To enact the renewable energy transition and substantiate the NDCs set in the Paris agreement, countries should design and implement low-carbon energy policies (Schmidt & Huenteler, 2016; Schmidt & Sewerin, 2017; Trancik, Brown, Jean, Kavlak, & Klemun, 2015). For the policies to be put into practice various policy instruments can be used; for example: direct investment, feed-in tariffs, grants and subsidies, loans, taxes, green certificates, information and education, strategic planning, codes and standards, research, development and deployment and voluntary approaches (Romanov et al., 2018). For the policymakers to determine their preferred policy instruments and their designs, a balance between three main policy goals; namely: limit energy costs, have a secure energy supply, and reduce environmental burden from energy supply and use (Cashore & Howlett, 2007; Howlett & Cashore, 2009). All three mentioned energy goals are important and must be considered, hence a balance between them must be utilised depending on the current state of the region and the aspired goals.

After specifying the main energy policy instruments in which the policies will be enacted along with the policy goals used to define them, the political economy of energy and climate change policy formulation is assessed further. Based on research formulated by Jakob et al. (2020), regarding the framework of the political economy of energy and climate policy which demonstrates how political institutions, the political environment and economic structure of each country shape the different policy outcomes is analysed. The formulated framework of policy formulation builds on three different aspects; namely: the relevant actors, the actor's objectives, and context of how much each of the objectives matter to its corresponding actor. This framework is known as the AOC framework. Each aspect of this framework is clarified further since all aspects are country specific and not generalized. (Jakob et al., 2020)

First, the relevant actors which are considered to be the driving forces of policy formulation. Actors are divided into two groups, societal actors and political actors. Societal actors are the combination of civil society organizations, unions, industry associations, and NGOs. On the other hand, the parliament, key ministries, regulatory agencies, and the president are considered political actors. Needless to say, not all actors share the same interests -objectives- nor influence when it comes to energy and climate policy formulation. The analysed framework is based on the core concept that policies reflect the goals of actors with the highest influence. (Jakob et al., 2020)

The next aspect to be considered based on the AOC framework is the actors' objectives. The framework calls for establishing the list of objectives for all specified actors. This viewpoint recognizes that energy and climate policies are frequently enacted with various policy objectives in mind, and that these objectives and their prioritization vary by actor group. Numerous trade-offs and synergies between energy and climate policies and other policy



objectives are present, for example: economic costs and distribution, industrial development, job creation, energy security concerns, and air quality. As a result, it is assumed that each actor's perspective on energy and climate policy is influenced by the relative weighting of several of these policy objectives. Objectives often matter directly to societal actors (societal objectives), and political actors are concerned about the interests of the societal actors they represent, but may also have other objectives, such as being re-elected or increasing their standing or power (political objectives). It is also worth mentioning that while assessing the policies in a country it is important to distinguish between objectives that are directly influenced by energy and climate policy, such as low energy prices or supply security, and objectives that are influenced indirectly, such as employment and structural economic change. (Jakob et al., 2020)

The final aspect of the analysed framework is the general context in which the policymaking takes place. The context referred to includes: economic, environmental, and institutional factors. Economic factors include the level of development of a country and its economic structure (e.g. how reliant is its economy on fossil fuels) (Price, 2021). Institutional factors include: how policy related decisions are being made and how societal groups act with different actors. Environmental factors include how much a country or region is affected by environmental problems (e.g. air pollution and climate change). All these factors affect the policymaking procedure and how a state directs its interests during the policymaking process. To clarify, the importance of the context is elaborated further. To begin with, it shows why and how the objectives matter for the different actors; e.g. the ways in which profit matters for utilities depends on if the electricity generation companies are private or governmental (Oye et al., 1994). Moreover, it shows the degree of influence societal actors have on political actors; e.g. influence of organized lobby groups on policy making (Ostrom, 2005). Also, it shows how the political objectives are important for the individual political actors. Additionally, it demonstrates how political actors can influence the policymaking process

In this framework, it has been deduced that all countries that took part in the 2015 Paris Agreement should design and implement low-carbon energy policies which are implemented using a number of policy instruments to fulfil their pledges. The policy instruments are constructed by weighing different energy policy goals and finding the most suitable trade-offs for the region of interest. Moreover, it became clear that the political environment and economic structure of every country is independent yet in all countries, energy policy formulation depends on the relevant actors, their objectives and the context of how and to what extent do objectives matter to their corresponding actors. Furthermore, the context shows the degree of influence societal actors have on political actors and to what degree can the political actors influence the policymaking process. Therefore, when answering the research questions, the main focus will be on the different actors, their objectives, and the context relating the objectives to the relevant actors.

## 4- Methods

### 4.1 Research object, Research Unit, and Research Boundary

In this study, the research object is the different actors involved in the Egyptian energy sector. According to Jakob et al, and his AOC framework which was chosen in the previous section to analyse the Egyptian energy sector, there are two types of actors; political and societal. In this study, political actors are the actors with the highest legislative power in the Egyptian electricity sector. On the other hand, societal actors are the actors that influence the process directly or indirectly without any legislative power. Additionally, the research unit in this research is the Egyptian electricity sector.

Given the immense number of actors that are either effected or affect the Egyptian electricity sector, a research boundary had to be set to control the scope of the material and data required. For this research, the actors chosen to be analysed are the entities who have a direct role in policy making and electricity production. Furthermore, if there is more than one organization that do the same function (eg. electricity generation companies) they will be referred to as one.

### 4.2 Data collection & analysis

Previously, the research objectives have been specified along with the research questions required to answer them. The data and information needed to answer the research sub-questions will be collected via several methods that include the analysis of various documents and governmental reports from search engines and official websites of organizations, also semi-structured interviews are conducted to evaluate and validate the collected data.

#### Interviews

Three different interviews are conducted in this research aiming to gather relevant information regarding the organizational structure of the Egyptian energy sector along with the objectives of the various relevant actors, and the context in which the objectives matter to them. Accordingly, nine questions are asked; some of which are open questions others are closed questions (interview questions are presented in appendix 3). Furthermore, some of the gathered data was verified as part of the triangulation method used in data collection, which required data verification from several sources. In table 3, presented below are the names of the different interviewees who represent different entities in the Egyptian energy sector along with the entity they represent, their position and the date of interview.

While choosing the interviewees, different aspects were considered. First of all, it was a necessity that the interviewees are respectable employees at respectable organizations. The reason behind this is that their points of view are used in determining the results of this study; thus they need to be as reliable and relatable to the main entities involved in the Egyptian energy sector as possible. Another thing that is taken into account is that the interviewees must work in different organizations. The importance of this is to maintain accuracy of the results found since if all the interviewees are from the same entity for example this will only identify how this entity views the research topic. Last but not least, it is important to include an interviewee from a third party (NGO) to ensure that there is no bias towards the system, this will increase the accuracy and reliability of the results. It is also vital that all interviewees agree to the consent form presented in appendix 5.

Name	Entity	Position	Interview date
Eng.Ahmed Amer	Ministry of Electricity and Renewable Energy (MOERE)	Control Engineer	02/10/2021
Dr. Gihan Bayoumi	United Nations Industrial Development Organization (UNIDO)	Program Officer	08/10/2021
Eng. Ehab Ismail	New and Renewable Energy Agency (NREA)	Vice President	11/10/2021

*Table 3. Interviewees*

#### 4.2.1 What are the energy and environmental targets set by Egypt and when should they be fulfilled ?

The data required to answer this question is the NDCs set by Egypt according to the Paris Agreement along with the renewable energy strategies and policies introduced to achieve the main target which is fulfilling the pledged goals. Regarding the NDCs, all required information is accessible through the official Egypt's NDCs as published on the UNFCCC website. Moreover, Egypt's national energy targets are searched for. A mixed research method is used in the document analysis, since qualitative methods are used to assess the set targets as well as the quantitative methods to retrieve the numbers and dates associated with the set targets.

The search engine that is used to gather this information are google scholar and the results were refined to the documents released since 2016 to be on par with the energy plans following the 2015 Paris Agreement. The search term entered is "Egypt AND energy AND {renewable energy strategy} AND NDC AND targets OR goals AND climate AND {GHG emissions} AND governmental AND policy OR policies", 941 results are shown. From which the titles have been assessed to determine the most suitable documents. A document published in January 2020 with the title "Egypt's nationally determined contributions to Paris agreement: review and recommendations" by Dr. Lamia Abdullah (2020) was first analysed; from which it has become clear that apart from what is stated in the NDC report some of Egypt's renewable strategies are stated in the "Egypt 2030 vision report" which is an official policy document present on the website of the ministry of planning and economic development (MPED) (MPED, 2021).

Furthermore, the relation between Egypt's renewable energy strategy and the ministry of electricity and renewable energy (MOERE) was noticed. When visiting the official website of NREA, various points discussed and integrated sustainable energy strategy to be completed by 2035 (ISES 2035) which was also assessed further. Given that all documents are official documents released by the Egyptian government, to state the country's NDCs and renewable energy strategies, no further validation for the paper is needed.



#### 4.2.2 How far is Egypt in completing the set targets ?

The data required to answer this question is the current progress and state of the energy sector. A mixed research method is used in the document analysis since both qualitative data of the progress is needed along with the numbers and dates associated with the set targets.

Additionally, semi-structured interviews have been conducted with UNIDO program officer; Dr. Gihan Bayoumi, Eng. Ehab Ismail, Eng. Ahmed Amer to ensure the validity of the information retrieved from the documents as part of the aforementioned triangulation method and ask about any relevant information that requires further clarification.

The search engine that is used to gather this information are google scholar. The search term entered is “Egypt AND {Energy sector} AND {energy targets} AND NDC” , 621 results are shown. Additionally, the publication date was chosen to be since 2020 to ensure that the data is recent to elaborate on the current energy situation and not one from past years. Based on the title and abstract of the results, a chapter published in the book “ Energy transitions and the Future of the African Energy Sector ” which was published in 2020 by Nalule was chosen to be analysed further, namely: “Renewable energy development in Egypt and transitioning to a low-carbon economy ” which was written by Dr. Mostafa El-Shazly. Moreover, different ministry websites (mainly NREA) are also analysed to determine the steps taken by Egypt to achieve the set targets.

#### 4.2.3 How is the Egyptian energy sector organized ?

The data required to answer this question organizational factors and different institutions that are affecting the Egyptian energy sector. A qualitative research procedure is used to answer this sub-question.

In the research framework, it has been clarified that the AOC framework is adopted to assess the renewable energy policy formation process in Egypt. According to this framework, the factors influencing the process are the relevant actors, their objectives and the context of how relevant the objectives are to the actors and how the different actors affect the policy formation process in different ways. The search engine that is used to gather this information are google scholar. The search term entered is “Egypt AND {egypt vision 2030} AND {integrated renewable energy strategy} OR {ISES 2035} AND actors OR stakeholders AND {renewable energy targets} AND {policy formation} AND {societal actors} AND {political actors} AND {renewable energy transition}” and the results were refined to documents published since 2016 to be up to date, accordingly 779 results are shown. After assessing the relevance of the documents primarily based on the titles and then the abstract, a book published in 2019 by Alalouch et al. with the title “Advanced studies in energy efficiency and built environment for developing countries” was chosen to be investigated further. In this book a chapter with the title “governing the transition of RE electrification in Egypt” is used to gather data about the institutional barriers facing the Egyptian energy sector. Moreover, in the book “ Energy Transitions and the Future of the African Energy sector” which was previously analysed contained the relevant actors in the Egyptian energy sector. In addition, in all other governmental documents and research papers analysed all relevant actors will be used further and analysed in the rest of the research

Another factor in the mentioned framework is the objectives of the actor. To retrieve this information, the official websites of all governmental actors (Ministry of electricity & renewable energy & energy utilities) and non-governmental actors (mainly environmental

NGOs) are visited in which policy documents and press releases containing the goals and objectives of the each of the relevant entities are present.

As for the context, interviews are conducted with different members from the different organizations in the Egyptian energy sector and NGOs that work with the sector to assess how and in what way the different objectives matter to them. Given that the objectives from different organizations are very broad to assess explicitly, the assessment will be based on the energy triangle of the different policy goals. From literature, three main energy policy goals have been identified in the energy sector known as the energy triangle or trilemma; namely: limiting the cost of energy, securing energy supply, reducing environmental burden of energy supply and use (Edenhofer et al., 2011; Helm, 2002, 2005; Hughes & Lipsy, 2013). To clarify further, these policy goals are the main energy related goals which are translated to different objectives that policy instruments are used to implement Cashore & Howlett, 2007; Howlett & Cashore, 2009. Hence, during the conducted interviews, asking the different actor representatives about the importance of each policy goal to their organization gave an insight on the most important objectives to them.

Furthermore, in the aforementioned interview questions regarding other relevant actors and lobbying actions affecting the renewable energy transition were asked. This is to guarantee the accuracy of the results as some of the factors could be missing in current literature and only known by a person who is in direct contact with the energy sector like the interviewees. Furthermore, the retrieved results are verified with the interviewee as part of the triangular method of research.

#### 4.2.4 What are the viable organizational improvements to achieve the set goals ?

The data required to answer this question is the improved policy formulation structure that includes appropriate and equitable ways of actor inclusion and other factors of the AOC framework. Accordingly, this data will be compared to the previous findings and conclusions regarding the applicability of the AOC framework in Egypt will be devised. Hence a qualitative research procedure is used to answer this sub-question.

The search engine that is used to gather this information are google scholar. Since the chosen theory for analysis is the AOC framework, the search term used to answer this research question is the Author of the AOC framework Michael Jakob. After searching his name in google scholar, 149 results were obtained; two of which are extremely relevant documents. The first is “ political economy of climate and energy policy: a theoretical framework” and the second one is “unravelling the political economy of coal: insights from Vietnam” both of which are used to assess the viability and applicability of the chosen framework in Egypt.

While answering this research question, the answers of all previous sub-questions will be used to identify the missing organizational aspects that in Egypt current path in the RET and compare them to Egypt’s current state. Consequently, either the required steps for Egypt to formulate renewable energy policies based on the AOC framework will be known or it will become clear that for following the AOC framework is not the most applicable option for Egypt in terms of renewable energy policy formulation and by this to answer to this research sub-question is developed.

To give a clearer overview regarding the research process table 4 presented below is provided:

Research Question	Documents evaluated	Author/s	Publication date	Main points	Data collection method
What are the energy and environmental targets set by Egypt and when should they be fulfilled ?	Egypt's nationally determined contributions to Paris agreement: review and recommendations	Dr. Lamia Abdallah	2020	Egypt's NDCs	Research
	ISES 2035	Arab Republic of Egypt	2016	Integrated sustainable energy strategy 2035	Research
How Far is Egypt in completing the set targets ?	Renewable energy development in Egypt and transitioning to a low-carbon economy	Dr. Mostafa El-Shazly	2020	Progress of renewable energy projects in Egypt	Research & Interviews
How is the Egyptian energy sector organized ?	Advanced studies in energy efficiency and built environment for developing countries	Alalouch et al.	2019	Organizational structure of Egyptian energy sector	Research & Interviews
	Renewable energy development in Egypt and transitioning to a low-carbon economy	Dr. Mostafa El-Shazly	2020		
What are the viable organizational improvements to achieve the set goals ?	Unravelling the political economy of coal: insights from Vietnam	Michael Jakob	2020	Energy sector Organization of different developing countries	Research & Interviews
	political economy of climate and energy policy: a theoretical		2020		

*Table 4 Research process*

#### 4.3 Data Validation

Throughout the research process, data will be validated through using multiple sources and through cross checking the information obtained to ensure the validity of the results. It is also essential to avoid research bias, hence triangulation technique will be used to ensure the validity of the qualitative data analysis (Carter, et al., 2014). In this technique, data is not only gathered by different sources but also by different methods. The data that will be used is mainly retrieved from literature and the semi-structured interview that will be conducted.

#### 4.4 Ethics Statement

This research followed and respected the guidelines of the academic ethical standards stated by University of Twente. The research also ensured that the analysis done will have a straightforward, truthful, and autonomous mindset in the writing process. In this thesis the interviews were made with an expert to find missing gaps in the research, and before conducting the interview an informed consent form has been used to safeguard the rights of the interviewees. Moreover, after the interviews were finished a detailed script was sent to the interviewee to check if any data is misused or misinterpreted and any data gathered from the interviews will be stored in a safe location to ensure privacy for both the responses and the respondents. Last but not least, APA referencing style is used throughout the writing process to give credit and to respect the intellectual property of the researchers.

## 5- Results

To present the results of this research, five sections will be utilised. The first four sections will answer the aforementioned research question and the last section will relate the Egyptian energy sector's organizational structure to the AOC framework. From that, an assessment if whether this structure is helping Egypt reach its energy goals or not will be devised.

### 5.1 Energy Targets Set by Egypt

Currently, Egypt's electricity generating capacity is 60GW (Abdallah & El-Shennawy, 2020). Most of which are generated from fossil fuels as demonstrated in table 3. However, to achieve the development goals set in Egypt vision 2030 the country should have an electricity generating capacity of 90 GW by 2030; meaning that by 2030, new powerplants must be established with an electricity generating capacity of 30GW.

Energy source	electrical generating capacity (GW)	Percentage of total generating capacity
Natural Gas	51	85
Mazout	3	5
Hydroelectric	3	5
Solar	1.5	2.5
Wind	1.5	2.5
Total	60	100

*Table 5 Different energy sources and their generation capacity*

(Source: Abdallah & El-Shennawy, 2020).

#### 5.1.1 NDCs

Egypt's INDC report includes the following three elements: National circumstances, National efforts in Adaptation and mitigation, and the required implementation mechanisms. In this section, the national efforts in adaptation and mitigation in regards to the energy sector will be further explicated. Mitigation Measures : As stated in the INDC report "they key for Egypt to mitigate GHGs emissions is to provide appropriate foundations for the development of low carbon energy systems" (Arab Republic of Egypt, 2015). The pathways to be followed in order to achieve high CO<sup>2</sup> mitigation levels must incorporate the following :

- Widespread adoption of regionally applicable low-carbon energy production technologies, resulting in significant energy intensity decreases (Arab Republic of Egypt, 2015).
- Mitigation efforts to decrease emissions from all major sources (Arab Republic of Egypt, 2015).
- Locally relevant technology transfer and financial flows from industrialized countries to promote carbon emission reductions in accordance with UNFCCC principles, which recognize that developed countries should provide the necessary help to developing countries (Arab Republic of Egypt, 2015).

Furthermore, policies targeting sustainable development must be incorporated and rely on the following five pillars as exactly stated in Egypt's INDC report:

1. Encourage end users to utilise energy in a more efficient manner. (Arab republic of Egypt, 2015)
2. Increase the use of renewable energy instead of non-renewable energy sources (Arab republic of Egypt, 2015).
3. Use more efficient and appropriate fossil fuels technology which are less emitting the currently used technologies. Also, utilize nuclear power for electricity (Arab republic of Egypt, 2015).
4. Energy efficiency is the basis to be targeted by policy makers to decouple demand on energy and economic growth (Arab republic of Egypt, 2015).
5. Reform energy subsidies. This policy is implemented using four pillars, namely: set different prices for petroleum products based on energy generation efficiency; increase the efficiency of energy use; provide support to certain sectors to promote switching from conventional energy sources to clean energy sources; and apply the fuel subsidy smartcard system to ensure that subsidies are received by target beneficiaries (a proposal which was cancelled by petroleum minister Tarek El-Molla due to unsolvable problems in the smartcard system) (Egypttoday, 2018).

Various mitigation measures in different energy sub-sectors are utilised in Egypt and are presented in appendix 1 along with the adaptation measures (appendix 2) both of which are ways to comply with the specified NDCs. In relation to this research, it is worth mentioning that the electricity generation sector the Egyptian government wants to introduce the following mitigation measures:

- Energy efficiency improvements (Arab Republic of Egypt, 2015).
- Nuclear energy use for power generation (Arab Republic of Egypt, 2015).
- Renewable energy use for power generation (Arab Republic of Egypt, 2015)

#### 5.1.2 Egypt Vision 2030 & Integrated sustainable energy strategy (ISES 2035)

Apart from the mitigation and adaptation steps provided in Egypt's INDC report, in February 2016 Egypt released its Sustainable Development Strategy (SDS) which is a roadmap for the country to achieve sustainable development. This SDS will focus to elevate Egypt in three dimensions: social, economic, and environmental. As stated in the Egypt Vision 2030 report "By 2030, the new Egypt will achieve a competitive, balanced, diversified and knowledge based economy, characterized by justice, social integration and participation, with a balanced and diversified ecosystem, benefiting from its strategic location and human capital to achieve sustainable development for a better life to all Egyptians" (Arab Republic of Egypt, 2016). In this section, the energy related targets (affecting the economic and environmental dimensions) set by Egypt that are due for completion by 2030 are provided. To demonstrate the energy targets set by Egypt in its SDS Egypt vision 2030 table 6 is provided with the indicator set to be altered, its value in 2016, the target set to be completed in 2020, and the final goal set for completion in 2030.

Indicator	Value in 2016	2020 target	2030 target
Ratio of primary energy supply to the total planned energy consumption	-	100%	100%
Average duration of outages	-	0	0
Percentage change in energy intensity	0.65	-1.3%	-14%
Share of energy sector to GDP	13.1%	20%	25%
Percentage decline in greenhouse gas emissions from the energy sector	-	5%	10%
Crude oil reserves (years)	15	15	15
Natural gas reserves (years)	33	33	33
Efficiency of electricity transmission and distribution	15%	12%	8%
Percentage of residential, commercial and industrial buildings connected to electricity	99%	100%	100%
Percentage of fuel mix for electricity production	Oil and Gas: 91% Hydroelectricity : 8% Solar and Wind: 1%	-	Oil and Gas: 27% Hydroelectricity: 5% Solar: 16% Wind: 14% Coal: 29% Nuclear: 9%
Value of fuel subsidy	126.2 Billion EGP	0	0

*Table 6 SDS goals in 2016, 2020, and 2030 (Arab Republic of Egypt, 2016)*



To achieve the targets presented in table 6, the following programs and projects were initiated for energy until 2030 (Arab Republic of Egypt, 2016):

- Developing an integrated energy strategy for medium and long-term.
- Energy sector restructuring.
- Reforming the current legislative framework.
- Improving the efficiency of energy subsidy.
- Developing the energy sectors infrastructure.
- Promoting innovation in energy sector.
- Applying environmental standards and accurate measurements.
- Improving skills development.
- Establishing the nuclear station in Dab'aa.

Aligning with Egypt vision 2030 the integrated sustainable energy strategy (ISES) was approved in 2016. This strategy aims to increase the share of renewables in the electricity generating energy mix. The strategy set a target that by the year 2022, 20% of Egypt electricity generation is to be provided by renewable energy sources a value that is set to account for 42% by 2035. Other targets mentioned in this strategy include: ensuring the financial sustainability of electricity companies, improving institutional and corporate governance, improving energy and resource efficiency, and strengthening competitive markets and regulations. (Shahid et al., 2020)

## 5.2 Progress done to achieve set targets

Needless to say, to achieve targets on a macro level (all across the country) various laws need to be enforced to ensure that the planned actions are on track. In this section, two important energy-related laws are introduced and the developments in various energy sub-sectors are explained.

### 5.2.1 Policy Formation in Egypt

The Egyptian government establishes renewable energy policy and incentives at the national level to achieve the set targets, usually through the Cabinet of Ministers (SEC). Two recent laws have been formulated in Egypt regarding the topic of increasing the utilization of renewable energy in Egypt and mitigating the effects of climate change; namely: the Renewable Energy Law 87/2015 and The Electricity Law 203/2014 which are clarified further in this section.

#### *Renewable Energy Law 203/2014*

On the 21<sup>st</sup> of December 2014, the Egyptian government published the renewable energy law (IRENA, 2018). This law demonstrates the following four steps that the government will do to reach the renewable energy targets set by Egypt.:

- 1- Formation of national projects with competitive bidding for engineering procurement and construction (EPC) contracts. (El-Mazghouny, 2021)
- 2- Bidding for build-own-operate (BOO) competitive contracts; where a private developer co-operates with the MOERE to design, implement, and operate RE projects for a specified time period. During that time period the developer charges power consumers



for the services they provide. After the agreed-upon time frame comes to an end, ownership of the project is transferred to the MOERE. (El-Mazghouny, 2021)

- 3- Introduction of Feed-in-tariffs (FIT). Feed-in-tariffs are schemes introduced to encourage private investors to start developing renewable energy projects in Egypt (wind & Solar) (IRENA, 2018). This is accomplished by providing long-term purchase agreements for renewable energy sources for a specified price per kWh of electricity produced. Tables 7 & 8 demonstrate the FIT prices for wind and solar projects respectively (El-Mazghouny, 2021).

PV project description	FIT prices
Residential	1.0288 (EGP/kWh)
Installed capacity < 500 kW	1.0858 (EGP/kWh)
500 kW ≤ Installed capacity < 20 MW	0.0788 (USD/kWh)
20 MW ≤ Installed capacity ≤ 50 MW	0.0840 (USD/kWh)

*Table 7. FIT prices for solar power*

(source IRENA, 2018)

Wind project description	Number of operating hours/year	FIT (USD/kWh)
Either 20 MW or 50 MW	2 500	0.0796
	3 000	0.0663
	3 500	0.0569
	4 000	0.0497
	5 000 and more	0.0400

**Table 8. FIT prices wind energy**

(source:IRENA, 2018)

Bilateral contracts for independent (non-governmental) power-producers to sell directly to the consumers using the national grid.

#### *Electricity Law 87/2015*

On the 8<sup>th</sup> of July 2015, the Egyptian government published the New Electricity law. The initiation of this law created two markets in which qualified high voltage (HV) consumers are free to choose their electricity supplier based on arrangements and the agreed upon prices (IRENA, 2018). On the other hand, medium and low-voltage consumers (unqualified) pay a regulated tariff to purchase electricity from distribution companies supplied by a public trader. Furthermore, the role of the Egyptian Electric Utility and Consumer Protection Regulatory Agency has been redefined to ensure sufficient organization, monitoring, controlling, and development of all power related activities.

By applying these laws, radicle changes are expected to take place in the Egyptian electricity sector. In this section, the progress in different energy sub-sectors will be explicated further. This will help assess the scale and necessity of the changes required in the Egyptian energy

sector. Presented below is table 9 that demonstrates electricity production in Egypt by all different generation companies that use different energy sources.

Type Co.	Cairo	East Delta	Middle Delta	West Delta	Upper Egypt	Hydro	EEHC Plants	Private Sector	Renewables	Total
Gas	1215	2130	336	24	350	--	--	--	--	4055
Steam	3320	4156	420	3431	3804	--	--	2048	--	17179
Combined Cycle	4834	4200	5107	907	3000	--	14400	--	--	32448
Hydro	--	--	--	--	--	2832	--	--	--	2832
Renewables	--	--	--	--	--	--	--	--	3016	3016
Total	9369	10486	5863	4362	7154	2832	14400	2048	3016	59530

*Table 9. Electricity production in Egypt in 2020*

*(source:EEHC, 2021)*

### 5.3 Organization of the Egyptian Energy Sector

In the previous section, the energy and environmental targets set by Egypt have been identified along with the laws introduced to achieve them. In this section , the different actors involved in the Egyptian energy sector are identified along with a brief description of their roles in the sector. Moreover, their objectives along with the context in which every objective matters to them is explicitly stated. This will determine whether or not the theory that the most powerful stakeholders have the highest influence in policy formation as stated in the AOC framework. Accordingly, it will be decided whether or not the theories stated in the AOC framework are coherent to the policy formation process in Egypt.

#### Relevant actors

In Egypt , the supreme energy court (SEC) sets the strategies and policies of the energy sector. However the execution of these policies and strategies is the responsibility of two ministries, namely: the ministry of petroleum and mineral resources (MOP) & ministry of electricity and renewable energy (MOERE). To have a better view of the institutional structure, the roles of the three mentioned entities is further explicated along with other actors involved in the Egyptian energy sector (IRENA, 2018).

To give a clearer insight of the Egyptian energy sector, figure 4 presented below demonstrates the different actors in the sector along with the organizational arrangement.

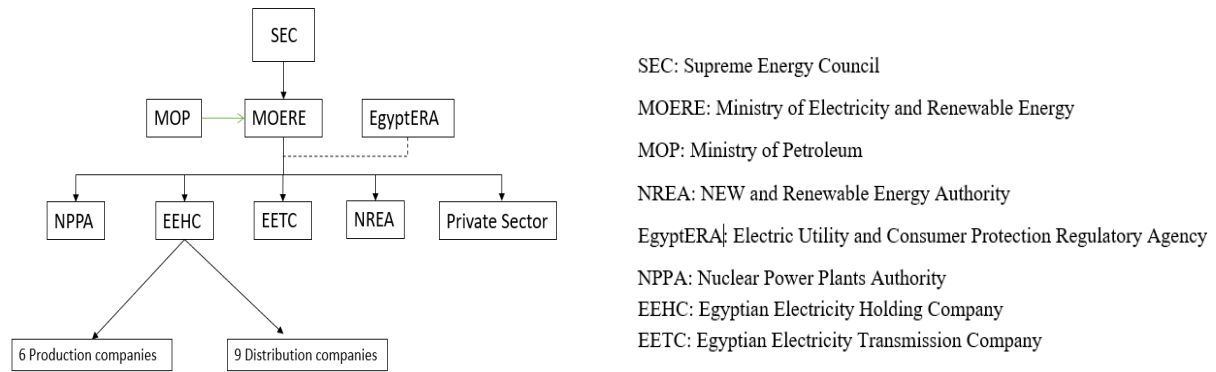


Figure 4. organizational arrangement of the different actors in the Egyptian energy sector

### *The Supreme Energy Council (SEC)*

Led by the Egyptian Prime Minister along with his team of ministers (of relevant ministries), the SEC is a governmental entity responsible for endorsing and reviewing the national energy strategies and policies and is considered the highest policymaking entity in the Egyptian energy sector. The Egyptian Prime Minister chairs the SEC; the council includes the Ministers of Defence, Finance, Petroleum, Electricity, Economic Development, Trade and Industry, Environment, Investment, Housing and Foreign Affairs as its members (UNDP, 2015). Furthermore, it evaluates the energy sector's performance along with the pricing policies. Additionally, policies, regulations, and incentives for energy pricing and energy sector investment must be approved by this entity making it the entity with the highest influence and significance in the Egyptian energy sector (Nalule, 2020).

### *Ministry of Electricity and Renewable Energy (MOERE)*

In Egypt, electricity generation transmission and distribution companies are mostly state owned with only 10% of the total generated capacity come from private companies (IRENA, 2018). The MOERE is entrusted with policy planning and overseeing the generation, transmission and distribution processes done by the Egyptian Electricity Holding Company (EEHC) and the Egyptian electricity transmission company (EETC). It is worth mentioning that this entity operates under the SEC and is considered to be the second most effective entity after the SEC in terms of policymaking in the Egyptian energy sector. The minister responsible of the MOERE is a member of the SEC.

### *Electric Utility and Consumer Protection Regulatory Agency (EgyptERA)*

This EgyptERA is a governmental independent entity that serves as a supervisor and regulator of all electricity sector activities in Egypt. Furthermore, it is responsible for issuing licences, approving tariffs, monitoring and establishing performance standards, and ensuring the regulatory process is fully functional in the electricity sector (Mills & Sim, 2021). The board of directors of this agency consists of four members who represent the consumers. Given that, this entity can be considered the consumer representative in the Egyptian energy sector.

*New and Renewable Energy Authority (NREA)*

The NREA works under the supervision of the MOERE in developing commercial renewable energy programs. This entity mainly focuses on wind and solar energy technologies. In addition, this entity has control over the land allocated for renewable energy development, in which permits for renewable energy development and land allocation are given by the NREA (Mills & Sim, 2021).

*Nuclear Power Plants Authority (NPPA)*

This entity is in charge of establishing and managing the nuclear energy sector in Egypt. Moreover, it is responsible for performing the necessary research for the development of nuclear power projects. This entity reports to the MOERE (Mills & Sim, 2021).

*Egyptian Electricity Holding Company (EEHC)*

Controlling the vast majority of electricity generation, distribution in Egypt, this entity controls 16 state-owned electric service companies (Mills & Sim, 2021). Additionally, all private investors act under the supervision of this entity.

*Egyptian Electricity Transmission Company (EETC)*

When investors are interested in initiating private generation projects, this entity issues the bids and tenders; in collaboration with the NREA for renewable energy schemes. Previously, this company sat within the EEHC, however, law 87/2015 will see it removed from EEHC and become Egypt's independent system operator to increase competition (Mills & Sim, 2021).

*Private sector*

Due to the different laws issued in recent years, the energy market monopoly in Egypt is set to come to an end. This will happen by involving private investors in the power generation and distribution processes. To guarantee involvement, various tariffs and schemes have been introduced to encourage renewable energy investment. As explicitly mentioned by Eng. Ehab Ismail the private sector is the future of the Egyptian power market.

Additionally, figure 5 illustrates all the different parties involved in the electricity generation, transmission, distribution, and consumption processes within the MOERE and EEHC.

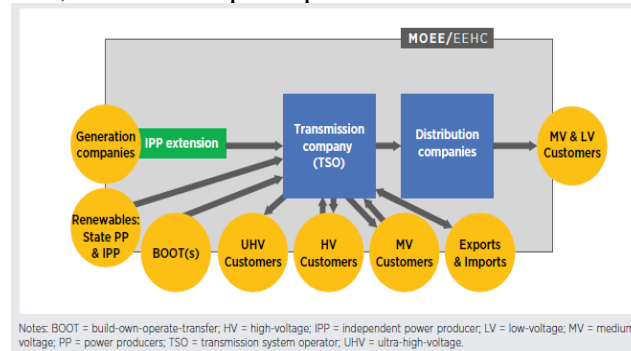


Figure 5. generation, transmission, and distribution in the Egyptian electricity sector

(source: IRENA, 2018)

Moreover, a power-interest matrix with the relevant actors is presented in figure 6 in which power is represented on the horizontal axis and interest on the vertical axis. To show who are the power and authority every actors has and the level of interest they have in the energy sector; specifically the renewable energy sector.

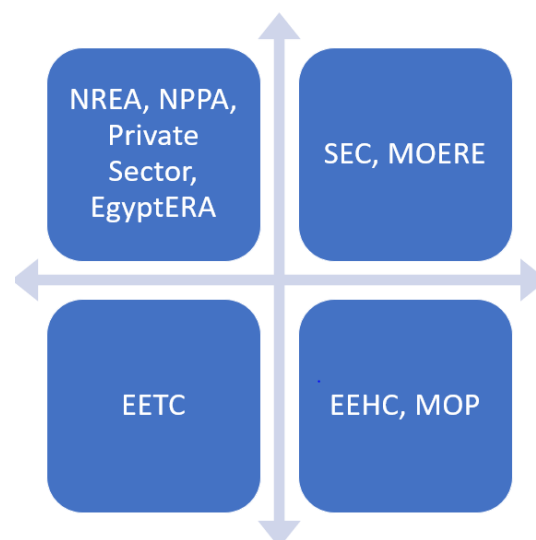
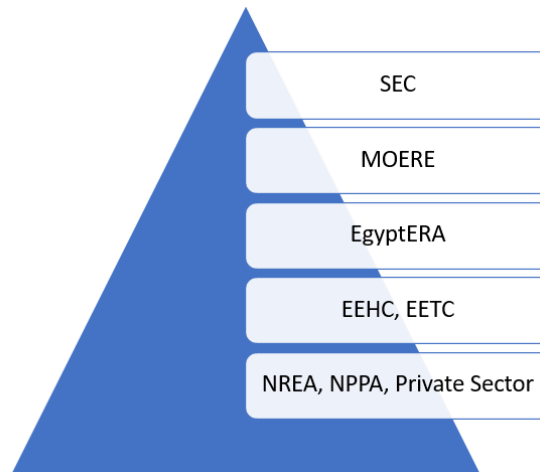


Figure 6. Power-interest matrix of the relevant actors

To give better insight on the actor situation in Egypt figure 7 below represents the hierarchical arrangement of the different actors in the Egyptian energy sector. This arrangement is not only based on research of the different roles of each actor but also based on the conducted interviews with Dr. Gihan Bayoumi, Eng. Ahmed Amer and Eng. Ehab Ismail.



*Figure 7. hierarchical arrangement of Egyptian energy sector*

### Actor's Objectives

The second aspect of the AOC framework is the different actor's objectives. Due to the numerous actors involved and the diversity of their objectives, for each actor, a spider-web diagram is created using the different energy goals literature from Schmidt et al. (2019).

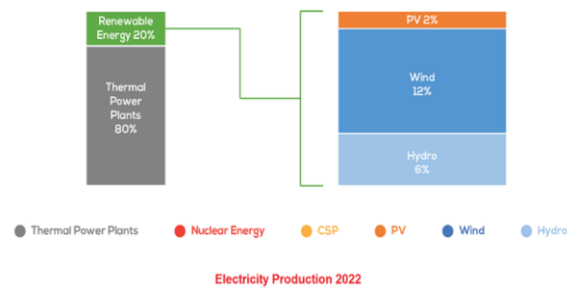
From literature, three main energy policy goals have been identified in the energy sector known as the energy trilemma; namely: limiting the cost of energy, securing energy supply, reducing environmental burden of energy supply and use (Edenhofer et al., 2011; Helm, 2002, 2005; Hughes & Lipsy, 2013). The main challenge facing the countries while forming new energy policies is to find the compromises between the three potentially contradicting goals (Bang, 2010; Costa-Campi, del Rio, & Trujillo-Baute, 2017; Winzer, 2012). In other words, often the best option in limiting the cost of energy is not the best option in having a secure energy supply or in reducing the environmental burden of energy supply and use and vice-versa.

Accordingly, interviews are conducted and in depth-research regarding the objectives of the different actors will be put under one of the three energy policy goals. From this, the main energy policy goal of Egypt is identified along with the objectives and main interests of the different actor groups.

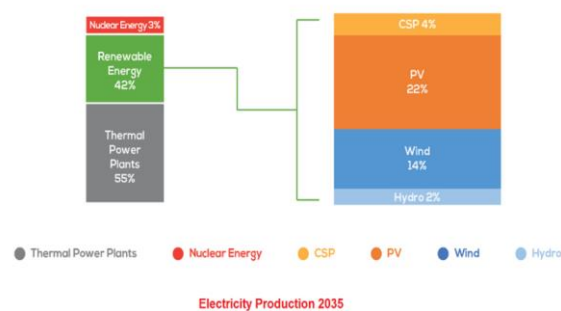
Following the research conducted regarding the Egyptian Energy sector, it became clear that of all mentioned actors only 3 of them have legislative power and can influence the sector. The entities referred to are: SEC, and MOERE. It is worth mentioning that although the MOP is considered one of the major ministries in Egypt, yet in the energy sector its is only considered the supplier of fuel as stated by Eng. Ehab Ismail. Other entities that are worth considering in the Egyptian energy sector are the EgyptERA since it represents the consumers in the Egyptian electricity market, NREA since they are the main entity concerned with increasing the share of renewable energy in the energy mix, and the private sector due to the immense role they are expected to play in the future of the Egyptian energy sector. Hence only these entities will be analysed further in this research.

### *Supreme Energy Council (SEC)*

Since the main goal of the council is to review and endorse national energy strategies and policies, the main objective of this council is to apply Egypt's integrated sustainable energy strategy (ISES 2035). This strategy is mainly concerned with fulfilling Egypt's electricity needs while increasing the share of renewable energy sources. Figures 8 & 9 bellow demonstrate the required energy mix for electricity production both in 2022 and when the strategy is set to be complete in 2035 (Shahid et al., 2020)

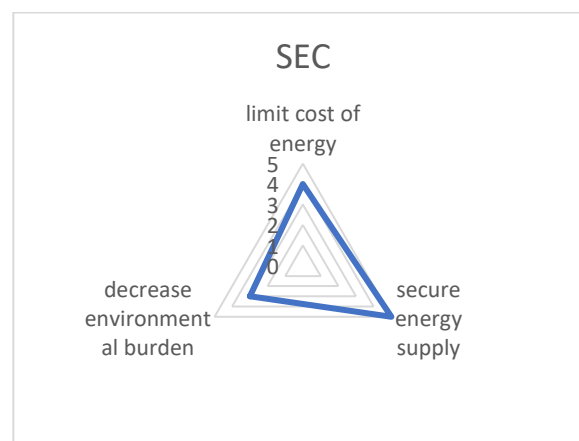


*Figure 8. Electricity production in 2022 (source:NREA)*



*Figure 9. Electricity production in 2035 (source:NREA)*

After analysing various documents, it became clear that although limiting the cost of energy is important for the SEC, this entity's main priorities are to ensure a secure supply and decrease the environmental burden of the generated power. This has also been verified by interviews with Dr. Gihan Bayoumi (UNIDO program Director) and Eng. Ahmed Amer (Control Engineer in MOERE). Given that, figure 10 presents a spider web diagram that demonstrates the current importance of every aspect of the energy triangle to the SEC.

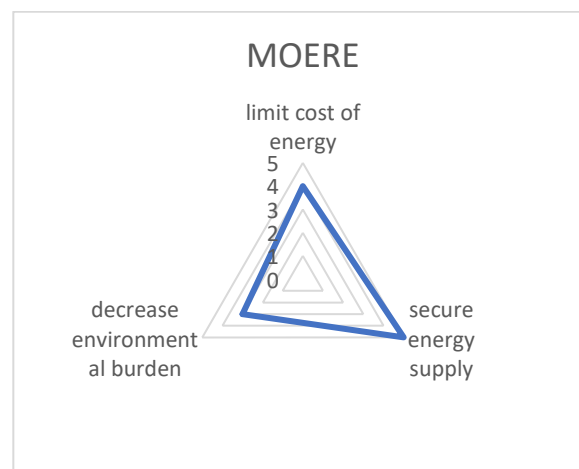


*Figure 10. SEC objectives**Ministry of Electricity and Renewable Energy (MOERE)*

Arguably, the entity with the most influence on the Egyptian energy sector due to their role in policy planning and overseeing the generation, transmission and distribution processes. On the ministry's website, their main objectives stated are as follows:

- Utilize available energy sources while taking into account the corresponding environmental implications (decrease environmental burden) (The Ministry of Electricity and Renewable Energy, 2021).
- Provide electricity to consumers with suitable prices and sufficient quality (secure energy supply/limit cost of energy) (The Ministry of Electricity and Renewable Energy, 2021).
- Increase usage of new and renewable energy sources (decrease environmental burden) (The Ministry of Electricity and Renewable Energy, 2021).
- Provide electricity in urban areas and low population communities (secure energy supply) (The Ministry of Electricity and Renewable Energy, 2021).
- Develop sufficient and safe nuclear power (secure energy supply/ decrease environmental burden) (The Ministry of Electricity and Renewable Energy, 2021).
- Use modern and developed technical systems in all electricity related activities and operations 9(The Ministry of Electricity and Renewable Energy, 2021).
- Develop skills of workforce in the Egyptian electricity sector (The Ministry of Electricity and Renewable Energy, 2021).

After looking at the objectives stated on the website, an interview was conducted with Eng. Ahmed Amer (a control engineer in the MEORE). In this interview he was asked on how much he believes his entity works towards achieving the three energy goals. This interview is used to verify the information present on the website. Although he agreed that work is being done in order to achieve the three energy goals, he also stated that securing and energy supply is the centre of focus in them MOERE. Furthermore, he confirmed that the targets set to be achieved by 2022 regarding renewable energy having an increased share of 20% in the Egyptian energy mix are on track. Given that, figure 11 below demonstrated how much the different energy goals are important for the MOERE.

*Figure 11. MOERE objectives*



### *EgyptERA*

After visiting their website, the agency's general objective has been retrieved which explicitly states: "The agency aims to organize, follow-up, monitor and develop everything related to electricity production, transmission, distribution and consumption, in a manner that ensures its availability, efficiency, quality and continuity in meeting the requirements of various aspects of use at the most appropriate prices, while preserving the environment, and to attract and encourage investment in this field in a framework of free and legitimate competition Taking into account the interests of consumers and the parties to the electricity utility, it also aims to provide information without discrimination and within a framework of equality and freedom of competition" (EgyptERA, 2020).

Apart from the mentioned objective, during the interview with Eng. Ehab Ismail he stated the following: the EgyptERA represent the consumer, so aim that the Egyptian energy sector reaches the optimal state which is not the case but they are the entity that works towards this direction in the Egyptian energy sector. Hence, it is clear that all three different aspects are of great interest for the agency. Furthermore, the agency is a public authority independent of all other electricity related entities with a supervisory role on the Egyptian energy sector, it is reasonable to consider all three different energy goals equally important for the agency as presented below in figure 12 .

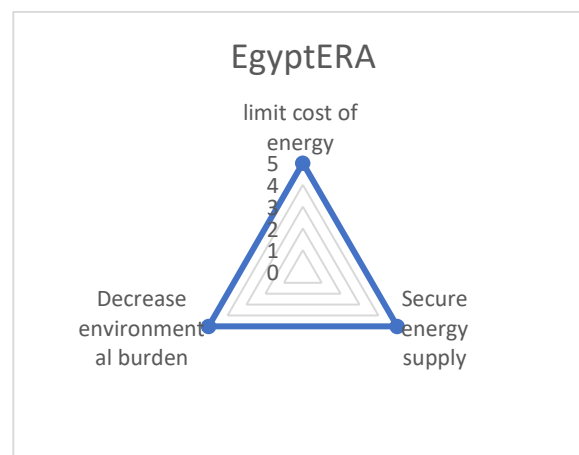


Figure 12. EgyptERA objectives

### *New and Renewable Energy Authority (NREA)*

As mentioned on their website, the main objective of this entity is to develop the use of renewable energy in Egypt. Moreover, it aims to introduce the manufacturing of renewable energy equipment locally to encourage the increased adoption of renewable energy in Egypt. During the Interview with vice president; Eng, Ehab Ismail, he mentioned that the main goal of NREA is to adequately implement ISES 2035. Furthermore, figure 13 shows the results Stated by Eng. Ehab Ismail when asked to rank the three energy goals in terms of importance to the NREA.

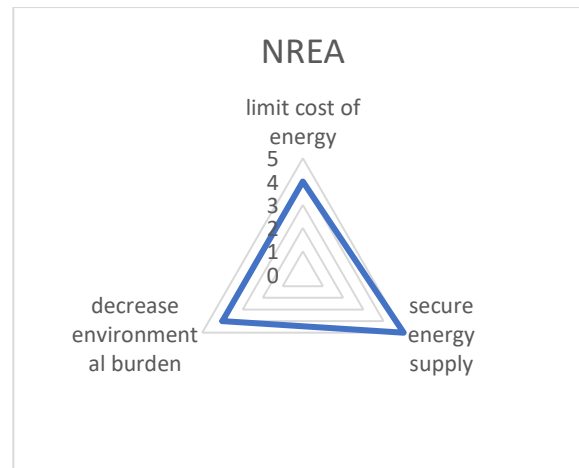


Figure 13. NREA objectives

### Private Sector

As previously stated, there has been various laws and incentives introduced to encourage private investment in the Egyptian electricity sector; which is described as the future of the sector by NREA vice president Dr. Ehab Ismail. When mentioning the private sector, private generation and distribution companies are referred to since these are the applications the Egyptian government is eager to privatise unlike transmission which is solely controlled by the Egyptian government (MOERE). Since electricity prices are fixed due to the value of the set Tariffs for generation, limiting the cost of energy production is important since the margin in difference represents the profit the private sector has. Needless to say, securing energy supply and decreasing the environmental burden are also vital objectives for the sector since both objectives are considered the main reason behind the sector's privatization. Furthermore, during the interviews the interviewees were asked to rank the importance of the three energy goals to the private sector organizations based on their experiences with them. In addition, the vast majority of the private sector generates electricity either by wind or solar power; both of which operate under the NREA guidelines; hence their objectives are expected to be similar which was the case after conducting the interviews. The results are presented below in figure 14.

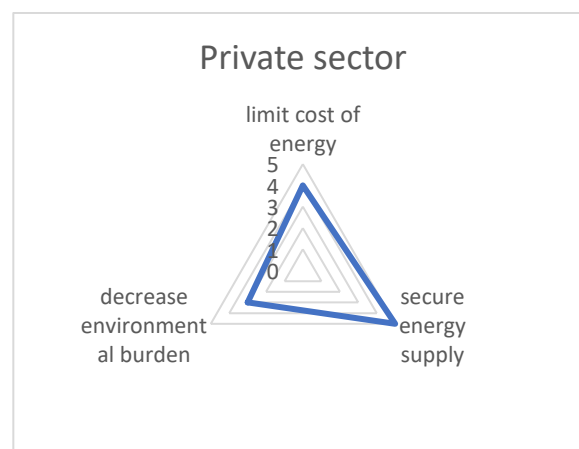


Figure 14. Private sector objectives

### Context:

After stating the different objectives for all relevant actors, the context of why these objectives matter to the specified actors is assessed in this section. During the Interviews, one of the open questions asked about why does the interviewee believe these objectives matter for the actors. From the conducted interviews, the context of behind the objectives of all actors are as follows:

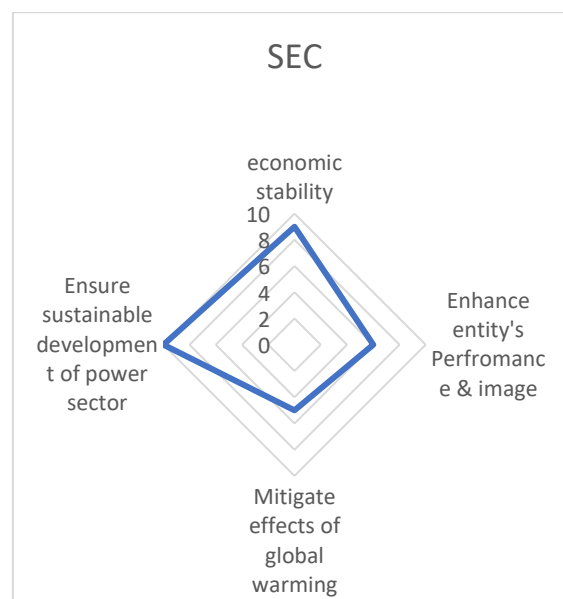
- Economic Stability
- Enhance Entity's Performance and Image
- Mitigate effects of global warming
- Ensure sustainable development of the Egyptian energy sector

Since it was not possible to interview members from all mentioned organizations; in the conducted interviews, the interviewees the context in which they believe is the reason behind the energy goals stated in the previous chapter. They were asked to give a rating from 1-10 for every possible context factor. To ensure reliability, the average answer from all conducted interview is selected only if there is not more than a difference of 2 in the given ratings. As for the MOERE and the NREA, the only the answers from the interviewees who are respective members of these entities were taken into account.

Provided below are the different actors with a radar graph that includes the magnitude of how much each context matters for them.

#### *Supreme energy council (SEC)*

As previously mentioned, the SEC consists of various ministers from all major ministries in Egypt and is headed by the Egyptian prime minister. Based on the conducted interviews, figure 15 demonstrates the ratings of how much each of the specified contexts matter to them; the results will be explained further below.

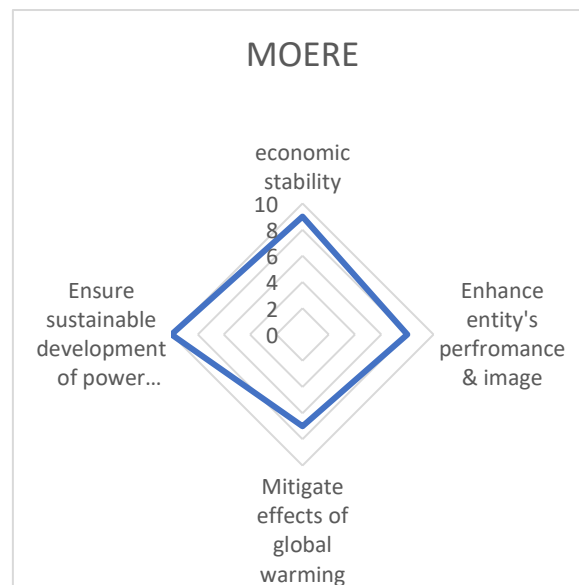


*Figure 15. SEC context*

The results demonstrated in figure 15 are explained as follows by the different interviewees: since the SEC is not an independent entity, the council is neither interested in making profit nor enhancing their image. However, they must guarantee that the plans and schemes they approve do not cause economic losses for Egypt. The priority of the council is to ensure sustainable development in Egypt since this is a direction all states must follow to thrive in the near future as exactly stated by Dr. Gihan Bayoumi. Mitigating effects of global warming is looked upon, however its not the main concern of the council but of some of the ministries inside it.

#### *Ministry of Electricity and Renewable Energy (MOERE)*

In the interview with Eng. Ahmed Amer, he was asked to give his viewpoint on the context in which the different energy objectives matter for the MOERE. He stated that since the MOERE is one of the major Egyptian ministries. Hence, their main interest is to make profit. Following the power outages in 2014, the ministry lost some of their credibility between the people. Ever since the ministry redeemed itself by generating sufficient power to satisfy the country's needs, maintain their credible image has been essential ever since. This explains that their most important objective mentioned in the previous section is securing a sufficient energy supply. However, mitigating the effects of global warming is not considered a driver for the ministry's activities. On the other hand, ensuring sustainable development is key given that they are one of the main ministry's that are required to take action in fulfilling Egypt's energy targets; whether the NDCs, Egypt vision 2030, or ISES 2035. These results are presented below in figure 16.

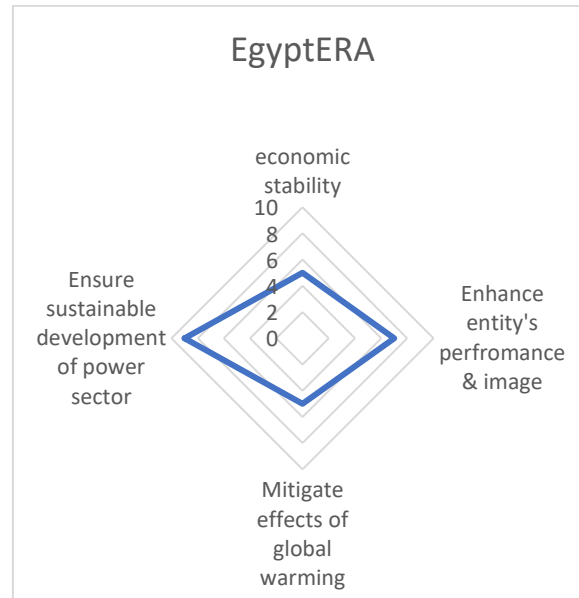


*Figure 16. MOERE context*

#### *EgyptERA*

The EgyptERA is an independent entity in charge of supervising all electricity related activities in Egypt. Furthermore, they set the values of the different tariffs according to the generated capacities in MW. From the interviews, all interviewees agreed that making profit is not considered a driver for their objectives whatsoever since there is no way in which they can make profit. Also, they agreed that this entity's main goal is to ensure sustainable

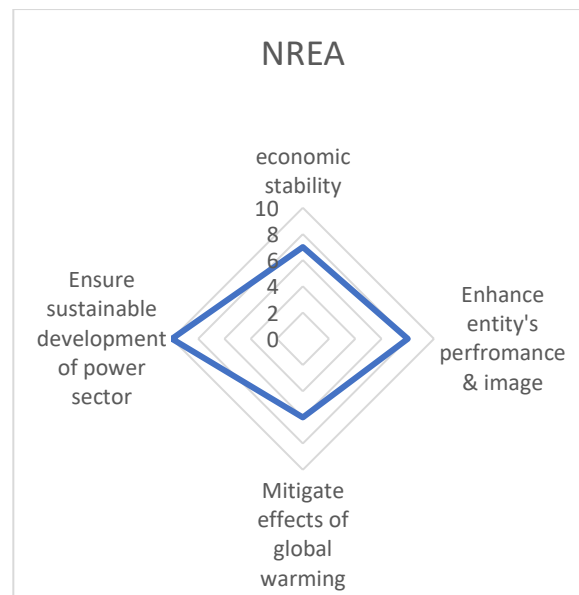
development in Egypt and to supervise that everything is going as planned in the country's strategies. However, mitigating effect of global warming is not considered relevant to the agency specially that it is a supervisory entity. Regarding the entity's image, since the agency represents the consumer they must maintain their credibility if not enhance it; thus enhancing their image is vital for them. Figure 17 demonstrates the different context factors and how they matter for the EgyptERA



*Figure 17. EgyptERA context*

#### *NREA*

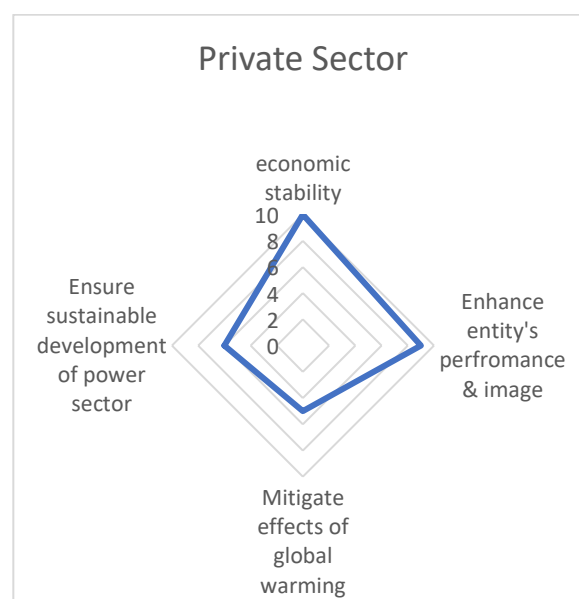
The NREA is the main entity responsible for the development of the Electricity generation by renewable energy sources. During the interview with vice president Eng. Ehab Ismail he stated the following about the context in which the entity acts. First he stated that the main goal of the entity and the direction in which they act is mainly to ensure the sustainable development of the Egyptian energy sector. What is meant by this is to diversify the Energy mix used to generate electricity. An issue which was considered vital after the power shortages that faced the country in 2013-2014. Furthermore, he elaborated that given Egypt's status as a developing country mitigating effects of global warming is not considered to be a driver for actions taken in the Egyptian energy sector. Nevertheless, the plan adopted in ISES 2035 (the green scenario) which is presented in the appendix along with other proposed scenarios is the least costly which turned out to be beneficial both for the sector's economic stability and in mitigating the effects of global warming. Last but not least, Eng. Ehab Ismail emphasized the importance of enhancing the sector's performance so that the country does not witness shortages again specially given the exponential increase in electricity demand. Accordingly, he ranked the different contexts as demonstrated below in figure 18.



*Figure 18. NREA Context*

#### *Private sector*

Unlike all other mentioned actors, the private sector is non-governmental. Consequently, ensuring their economic stability is essential for the owners. Furthermore, since this sector is relevantly new each company aims to enhance its performance and image to pioneer in the market as stated by Eng. Ahmed Amer. He also stated that ensuring sustainable development and mitigating the effects of global warming is not a relative context to them, in terms of what drives them to achieve their objectives. Nevertheless, the new market is organized in way that makes the private sector achieve the latter contexts in their operation. This information was also verified by the two other interviewees who shared the same opinion with only minor differences in the scale they ranked the different context attributes with. Figure 19 below demonstrates how the different context attributes matter for the private sector.



*Figure 19. Private Sector context*

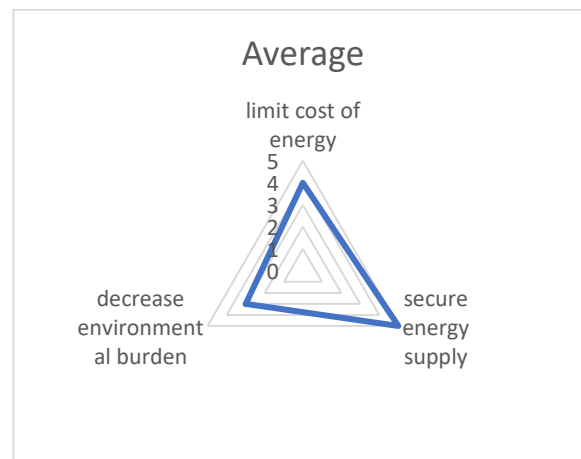
## Review of AOC framework in relation to the energy sector in Egypt

### Actors

In the previous sections, the different actors in the Egyptian electricity sector are stated, along with their objectives and the context of how these objectives matter to them. To begin with, various actors in the Egyptian energy sector have been specified; some political and some societal. It is clear that in the Egyptian energy sector, political actors have the upper hand in terms of planning and applying the set targets. However, it is predicted by all interviewees who are specialists in this field that societal actors that include private investors will have an increasing role in the market during the coming years.

### Objectives

In regards to the objectives of the mentioned actors, figure 20 below demonstrates the average rating from the objectives of all involved actors. This figure will be used to demonstrate whether or not an actor is more interested in a certain objective than the average.



*Figure 20. average of objectives*

In regards to the objectives of the relevant actors, having a secure energy supply is clearly the main objective for all actors involved in the Egyptian energy sector as demonstrated in figure 20 where the average score is 5. It is worth mentioning that this is the only objective that received the same rating for all actors. Given that, it is undeniably true that having a secure energy supply is the main generalized objective in the Egyptian energy sector.

On the other hand, limiting the cost of energy is considered the second most important objective. During the Interviews with Eng. Ehab Ismail and Eng. Ahmed Amer, they both stated that it is vital that the cost should be fair for both the suppliers and the consumers to maintain the structure set for the sector. Eng. Ahmed Amer elaborated further by stating that given its importance, electricity should be affordable for all citizens (consumers). Nevertheless, he stated that it is essential that the MOERE maintains its economic status which is reflected on the sector in terms of performing adequate maintenance and introducing new and efficient technologies. The actors who is mainly interested in this objective is the EgyptERA which is the entity that represents the consumer in the sector.

Furthermore, when discussing the last objective mentioned which is reducing the environmental burden, all interviewees mentioned that during planning this is the least objective considered from the three energy goals. Dr. Bayoumi stated that due to the country's developing status, having a secure energy supply and limiting the cost of energy are prioritized over reducing the environmental burden. Nonetheless, the strategy chosen to be implemented in ISES 2035 is the green scenario which is the most environmentally friendly strategy from the suggested (different proposed scenarios can be found in appendix 4). As previously stated, this eco-friendly scenario is the least costly of all mentioned scenarios which is the main reason for choosing it as stated by Eng. Ehab Ismail who also mentioned that being environmentally friendly was an additional reason for choosing it though not the main.

As argued by Michael Jakob in his paper: The political economy of climate and energy policy, he states that the policies implemented are the policies which best meet the objectives of the actors with the greatest influence. Looking at figures 10 & 20, it is devised that the average rating of the objectives of all different actors exactly matches the score of the entity with the highest hierarchy in the sector (the supreme energy council). Accordingly, in relation to the objectives of the various actors, the AOC framework applies in the case of the Egyptian energy sector.

### Context

In the AOC framework, context is defined as follows; the economic, institutional, and environmental factors that determine in what ways different actors' objectives matter to them. Moreover, it considered the degree of influence societal actors have on political actors. In the case of the Egyptian energy sector, all actors have different reasons to why their objectives matter to them. However, it is clear when analysing the different contexts of the various actors which are provided in figures 15-19, that ensuring the sustainable development of the Egyptian energy sector is the main driver behind all power related activities in Egypt. Another point that is worth mentioning about the Egyptian energy sector is that at this moment in time there is no influence by societal actors on political actors regarding any decisions making processes. During the interviews a question was asked relating to this matter, in all interviews the answer was no and the reason behind it was always the same which is: societal actors do not yet have the "strength" to influence actors due to their recent introduction to the market and vitality of the political actors' objectives.

### Improvement suggestions

During this research, numerous governmental documents and research papers have been reviewed and three interviews were conducted that asked the interviewees the following question in the end: What do you think are the main problems that should be tackled in the Egyptian energy sector and what improvements do you believe are required to solve them ? Based on this information, various possible improvements are stated below:

- Encourage Renewable Energy investment
- Enhance maintenance procedures in the sector.
- Strengthen the renewable energy technology industry in Egypt.
- Minimize investment in fossil fuel based technologies.
- Re-structure the hiring procedure in the MOERE and other relevant organizations.



## 6. Conclusion:

In this research, the organization Egyptian energy sector was investigated. The reason behind analysing this sector is that it is one of the most prominent GHG emitting sectors in Egypt. First, the targets set by Egypt in regards to the sector are stated. Additionally, the current state of the sector is also mentioned to provide insight on whether or not the set targets are reasonable or not. When analysing the sector's organization, the AOC framework is chosen since it analyses the different actors along with their objectives and the context of how the different objectives matter to them. This framework is chosen because it assesses the activities and motives of all relevant actors which in return affects the policymaking process that decides the direction in which the whole sector is heading to. To gather this information, numerous governmental documents, laws, and research documents were analysed along with conducting three interviews. All this information is used to assess the Egyptian energy sector by answering the following research questions:

- What are the energy targets set by Egypt and when should they be fulfilled ?
- How far is Egypt in completing the set targets ?
- How is the Egyptian energy sector organized ?
- What are the viable organizational improvements to achieve the set goals ?

To begin with, different energy targets related to the energy sector were stated; namely: NDCs, Egypt vision 2030, and ISES 2035. The NDCs set by Egypt are too general and lack quantity as exactly stated by Dr. Gihan Bayoumi. Nonetheless, this is not the case in regards to Egypt vision 2030 and its subsequent strategy ISES 2035; in which quantitative information is specified regarding the energy goals Egypt aspire to reach.

Next, The current situation of the energy sector is stated. Specifically, the description of the different sources used in the energy mix used for power generation. Furthermore, a description of the planned projects that are set to operate in coming years is provided. In this section it became clear that Fossil fuels will still be the main source in the energy mix used to generate electricity in Egypt. Yet, renewable are witnessing a huge rise in popularity that is yet to increase given the recent law enforced namely the Renewable energy law of 2014 and the Electricity law of 2015.

The next step in this research was to evaluate the organizational structure of the Egyptian energy sector in which the AOC framework was used. In this part of the research all the relevant actors have been determined along with their organizational and hierarchical arrangement. Furthermore, the different objectives of the actors have been retrieved and classified under the three energy goals which are : having a secure energy supply , reducing the environmental burden, and limiting the cost of energy. Additionally, the context of why and how these objectives matter to the actors has also been retrieved; the different contexts have been classified to the following:

- Economic Stability
- Enhance Entity's Performance and Image
- Mitigate effects of global warming
- Ensure sustainable development of the Egyptian energy sector

Both the objectives and context factors were demonstrated in radar graphs to present the differences between the relevant actors. This data was based on the information retrieved from the official websites of the different actors and the interviews conducted. It has been concluded that the main objective for all actors is to have a secure energy supply. The second most important is to limit the cost of energy and the last was to reduce the environmental burden. The reason behind this, is the state of Egypt as a developing country and that the entities with the highest hierarchy (SEC & MOERE) view this arrangement as the most suitable for Egypt at its current state. Hence all other actors that operate under these two entities operate under these guidelines. This also verifies that the AOC framework applies for the case of the Egyptian energy sector in which the actors with the highest hierarchical position have the greatest influence on the Egyptian energy sector.

Last but not least, the interviewees were asked about the possible improvements that in their respectable opinion will enhance Egypt performance in terms of reaching the set targets. Also, based on the analysed documents various improvements were attained in which they were verified by the interviewees as part of the triangulation technique used in this research to have more reliable results. The suggested improvements are as follows:

- Encourage Renewable Energy investment
- Enhance maintenance procedures in the sector.
- Strengthen the renewable energy technology industry in Egypt.
- Minimize investment in fossil fuel based technologies.
- Re-structure the hiring procedure in the MOERE and other relevant organizations.

Lastly, it is worth mentioning that this research has the following limitations which if eliminated the accuracy and reliability of the results would increase. The aspects include:

- Interviewing actors from all relevant organizations: Unfortunately, relevant actors in the Egyptian energy sector is challenging. Actors from all relevant entities have been contacted yet most of them did not respond or rejected to be interviewed.
- More information could have been gathered regarding the NPPA: Since it is currently not operating (expected to operate in 2022), it was not viable to contact workers from this agency. Furthermore, when the interviewees were asked about it they stated that they have little information about it since this project is considered confidential by Egyptian authorities.
- Interviewing more than one member of each actor organization will enhance the research: interviewing various actors from the relevant entities will elevate the research and will eliminate any chances of a bias opinion specially regarding the context of why the different objectives matter for the mentioned actors.
- Obtaining more recent data regarding the Egyptian energy sector: During the research procedure, a very limited number of data was published this year (2021) regarding the Egyptian energy sector. This data would elevate the research given the huge changes that are recently occurring after the formation of the electricity law.

Although there are limitations, this paper demonstrates how the different actors have different objectives and contexts of which these objectives matter to them in Egypt. This is unprecedented since the vast majority of the researches that utilize and apply this framework assess developed countries. Furthermore, this paper proves that the AOC framework is applicable for different

countries in different parts of the world. Additionally, the energy triangle theory used to assess the different actor's objectives proved its worth when assessing the different actors' objectives.

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## Appendix:

## 1. Different mitigation measures of NDCs in various energy consuming sectors:

Sector	Mitigation measure
Industry	Utilization of solar energy for water heating
	Energy efficiency improvements
Transportation	Energy efficiency improvements
Passengers	Increase Share of Railways, buses, Microbuses, and river passenger Transport
	Expand Cairo metro (Line 3 phase 3& 4 + Line 4)
Freight (goods or cargo transported)	Improve road transport efficiency
	Switch from road to river transport
	Switch from road to rail transport
Agriculture	Energy efficiency improvements
Res.& Comm.	Energy efficiency improvements
	Utilization of solar energy for water heating
Electricity	Energy efficiency improvements
	Nuclear energy use for power generation
	Renewable energy use for power generation
Petroleum	Energy efficiency improvements

## 2. Adaptation Measures suggested in NDCs :

As previously stated, NDCs may include adaptation measures to cope with the already existing harms of global warming. Before stating the required adaptation measures, a brief explanation regarding the existing harms caused by global warming to the energy sector is provided. Following this explanation, the adaptation procedures that are used to cope with them are specified.

First, the efficiency of power plants and photo-volvic cells decrease from the increased temperature. Moreover, the temperature rise causes glaciers to melt resulting in a rise in sea levels all over the world. Consequently, this threatens the electric power plants and networks located in costal areas since they become vulnerable to having significant harms. Furthermore, the rates and distribution of annual rain fall is altered due to climate change. The reason behind why this is considered to be a negative impact is because this affects generation rates in hydropower plants which are the most used renewable energy source in Egypt up to this date. Another, effect that global warming causes is the increased consumption of electricity due to the increased use of air conditioners.

Accordingly, Egypt have set various adaptation actions to cope with the harmful effects of global warming. The adaptation measures suggested in the INDC report are as follows :

Conduct extensive research to assess the effects of climate change on the energy sector, recommend appropriate adaptation measures, and evaluate the cost of the suggested adaptation measures. These studies should also indicate the safest areas for power plant building.

Build technical and institutional capacities of different units in the energy sector regarding climate change issues.

Promote technological and research developments that will enable the electricity sector to adequately deal with climate change.

### 3. Interview Questions:

Apart from the mentioned actors (SEC, MOERE, MOP, EEHC, EETC, NPPA, NREA, EgyptERA) do you believe there are any other actors involved in the Egyptian energy sector ? (yes/No) , if yes state who

Rate based on your experiences how much you believe each energy goal matters for the relevant actors ? (1-5)

Rate the actors in hierarchical order in terms of legislative power ?

Do you believe the Egyptian energy sector is advancing adequately to achieve the goals set for 2022, 2035, and the NDCs agenda ? (yes/no)

What are the objectives of your entity ?

Do you believe other energy goals are relevant other than the energy triangle ? (Yes/No)

For what reasons (context) do you believe the energy goals matter for the different relevant actors ?

Rate from 1-10 the context behind the objectives for all mentioned actors ?

What are the objectives of your entity ?

Do you believe the private sector (generation and distribution companies) have any power /influence in terms of policy making in the electricity sector ?(Yes/No)

What do you think are the main problems that should be tackled in the Egyptian energy sector and what improvements do you believe can solve them ?

### 4. Different scenarios to achieve the required electricity demand

Previously, the amount of CO<sup>2</sup> emitted by Egypt has been stated along with the targets set by the country to fulfil the Paris agreement and its sustainable development goals. However, when it comes to the electricity generating sector there are three scenarios that can be followed to fulfil the required electric capacity by 2030 (Abdallah & El-Shennawy, 2020). In the study performed by Abdullah & El shennawy, (2020) the three different scenarios have been analysed and the energy mix used to generate electricity have been deduced till the year 2030 and is further discussed. In this section the scenarios are identified to facilitate the selection of the most appropriate pathway for Egypt to achieve its goals.

Diversified energy mix scenario:

The first scenario, which was presented in Egypt vision 2030 report aims to use a diversified energy mix. However, the energy mix proposed will introduce coal for the first time in Egypt and it will be one of the main contributors in the energy mix for electricity generation as presented in table 5. The issue with coal is that it is the most polluting fossil fuel. Needless to

say, this is not something to look up to in terms of sustainable development and achieving the set goals. Another important addition in this energy mix scenario is the introduction of nuclear energy which is not considered a renewable energy source. Nevertheless, generating electricity from it does not emit GHG. If implemented, this energy mix will consist of 29% coal, 27% oil gas, 9% nuclear, and 35% renewables.

Year	2020	2024	2030
Power generating capacity (GW)			
Oil&Gas	54	42	24
Hydro	3	4.5	4.5
Renewables	3	10	27
Coal	0	13.5	26.5
Nuclear	0	2	8
Electricity generation associated factors			
Power (GW)	60	72	90
CO <sup>2</sup> emissions (Ktons)	100,877	203,654	307,043
CO <sup>2</sup> intensity (gCO <sup>2</sup> /kWh)	628	806	767

Fossil fuel based scenario:

As previously mentioned, in 2016 several natural gas fields have been discovered in Egypt. Hence, the country has the option to base its electricity generating vision to become more dependant on natural gas. In this scenario, gas and oil will generate an immense 60% of the total electricity by 2030. Additionally, coal will account for 22%, 9% from nuclear power, and 12 % from renewables. Needless to say, this scenario is highly polluting given that about 82% of the energy sources used are fossil fuels that will emit a significant amount of GHG as shown in table 6 below. However, it is worth mentioning that if this scenario is incorporated it will be almost impossible for Egypt to reach its target set in ISES 2035 of 42% of the total electricity to be generated by renewable sources in 2035; making this scenario almost unapplicable (Shahid et al., 2020).

Year	2020	2024	2030
Power generating capacity (GW)			
Oil&Gas	54	54	54
Hydro	3	5.5	5.5
Renewables	3	3.5	5.5
Coal	0	8	20
Nuclear	0	1	5
Electricity generation associated factors			
Power (GW)	60	72	90
CO <sup>2</sup> emissions (Ktons)	100,877	191,466	330,085
CO <sup>2</sup> intensity (gCO <sup>2</sup> /kWh)	628	759	825

Green scenario:

The third and final scenario will allow Egypt to generate 37% of its electricity by 2030, a ratio which is planned to increase to 42% in 2035. Given its high renewable energy potential, the Egyptian government announced a feed-in-tariff (FIT) to encourage investors and households to invest in renewable energy by paying them back per kilowatt generated- rates vary per amount of electricity generated. Table 7 demonstrates the expected electricity generated per source in 3 different years according to this scenario.

Year	2020	2024	2030
Power generating capacity (GW)			
Oil&Gas	54	53	52
Hydro	3	4.5	4.5
Renewables	3	13.3	28.7
Coal	0	0	0
Nuclear	0	1.2	4.8
Electricity generation associated factors			
Power (GW)	60	72	90
CO <sup>2</sup> emissions (Ktons)	100,877	203,654	128,863
CO <sup>2</sup> intensity (gCO <sup>2</sup> /kWh)	628	806	322

After looking at all three scenarios, it is clear that by 2030 the amount of CO<sup>2</sup> emissions will be greater than the current capacity regardless of the scenario chosen. Nevertheless, the green scenario is the most environment friendly in which the CO<sup>2</sup> intensity is almost half of the current figure. However, various hindrances and aspects will decide the most applicable scenario.

### 5. Informed Consent form For MEEM Thesis

For the semi-structured interviews used in this research: ASSESSEMENT OF THE RENEWABLE ENERGY TRANSITION AND SUSTAINABLE DEVELOPMENT SITUATION IN EGYPT; the following ethical considerations are followed and are to be reviewed and agreed upon by the interviewees before conducting the interview:

Interviewee is aware of the topic, research goals, and activities done during the research before starting the interview.

Interviewees are asked if it is possible to record the interview or not

Interviewees can stop/withdraw from the interview at any time without justification.

Interviewees agree that they are cited in this research.

Interviewees have the possibility to see the research when finished; if requested.

After the interview, the participants are asked if anything that was said in the interview should be confidential or not.

Signature:

I declare my responsibility to comply with all points mentioned in this consent form

Name: Hussein Abouyoussef