THE FUTURE SKILL NEEDS IN THE EGYPTIAN ENERGY SECTOR

Country report

Disclaimer

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Preface

Since 2020, the ETF has conducted multiple studies to examine how various drivers of change – both technological and non-technological – are affecting occupations and related skill needs in selected sectors and countries, and how education and training systems are adapting to these evolving needs. This has led to the identification of (emerging) future skill needs in the chosen sectors, through a combination of traditional research methods and innovative Big Data mining. These sectors include agritech in Israel, automotive in Turkey, agri-food in Morocco, energy in Albania and Tunisia, healthcare in Ukraine, construction in Armenia and platform work in the Eastern Partnership countries and Western Balkans.

The study on the future of skills in the energy sector in Egypt is part of the aforementioned series of studies that represent areas of innovation and potential for further development in the economic sectors in the ETF partner countries. The rationale behind this selection is twofold: in addition to the importance of the energy sector to the Egyptian economy, there is a need to understand the current and future skill needs in the energy sector, which can then be applied to reform employment policies in the energy sector as well as the energy-related skill supply.

Data analytics and AI are revolutionising the way we comprehend labour markets and skill demands. The other ETF project, “Big Data for Labour Market Information[1]," has been analysing and categorising online job vacancies in its partner countries, including Egypt, offering valuable insights into skill and occupational dynamics within the country. This project aligns with the ETF's work on future skill needs in Egypt's energy sector and provides complementary information, as it provides valuable, real-time insights into labour market trends and skills requirements, assisting in the development of strategies for workforce development and the future of the energy sector.

This study focuses on the evolving skills needs and occupations driven predominantly by technological innovations and non-technological developments. It does not evaluate potential shifts in the volume of employment and skills demand; however, it offers qualitative information on occupations, identifying the skills that individuals working in the energy sector will increasingly need to acquire. Additionally, the study provides insights into how companies are adapting to technological changes and developing the necessary skills. In this context, it demonstrates how the supply of skills is keeping pace with advancements in the energy sector. Ultimately, the study aims to raise awareness about the changing skill demands, identify drivers of change, and stimulate discussions among policy makers and practitioners in the field, enabling the findings to be further exploited and applied to adapt education and training provision.

The study employs a combination of traditional research methods (such as desk research, data analysis and interviews) and big data text-mining techniques. Despite certain limitations, text-mining of big data yields new insights and real-time information on recent trends. When integrated with other methods – including interviews with key stakeholders and companies, statistical analysis of skill trends, and more – it serves as a potential tool for identifying emerging skill needs and determining their implications for education and training provision, and reskilling workers within companies.

Fondazione Giacomo Brodolini srl SB and Erre Quadro have collaborated with the ETF to conduct studies on economic sectors across various countries. A team of international and national researchers from each respective country has been brought together to carry out these studies, in addition to the ETF’s team of experts. The study in Egypt was conducted between June 2022 and March 2023. This report was authored by Riccardo Apreda, Liga Baltina, Terence Hogarth, Panagiotis Ravanos with contributions from national experts Prof. Dr. Adel Abdou H. Ahmed and Prof. Dr. Ing Ahmed Hamza H Ali, as well as feedback from ETF experts Francesca Rosso, Ummuhan Bardak and Pasqualino Mare.

The report thoroughly documents the research process and presents the findings in a comprehensive manner. This is because ETF aims to raise awareness about changing skill needs in the energy sector

[1] https://solutions.lightcast.io/dashboard/overview

for all stakeholders in the partner countries, be they researchers, practitioners, or policymakers. The findings not only increase awareness but also offer valuable insights, particularly concerning the capacity of the education and training system to adapt to shifting skill demands and to prepare workers for the new jobs and occupations that are likely to emerge. Concise, targeted publications and further discussion papers will follow once all the case studies have been completed.

Lastly, the ETF would like to express its gratitude to all the relevant public and private institutions and individuals in Egypt (see the full list in Annex 2) for sharing information and their perspectives, as well as for actively participating in the ETF's online consultation workshop held in December 2022. Special thanks are extended to the United Nations Industrial Development Organisation (UNIDO), which has been partnering with ETF in the implementation of the research, as well as to the Ministry of International Cooperation of Egypt, CAPMAS and the EU Delegation in Egypt. This report would not have been possible without their support and contributions.

CONTENTS

Executive summary

The energy sector has always been strategically important, with countries seeking to achieve self-sufficiency in energy provision to meet their demand needs. Economic growth is closely tied to increases in energy demand, which creates a need to harness every available resource. Fossil fuels remain the largest source of energy provision globally, but renewable sources such as solar, wind, hydropower, nuclear, biowaste, and others are gaining ground due to climate change awareness and technological advancements that allow for their deployment. The energy sector encompasses more than just oil extraction plants and solar panels. It involves energy generation plants, transmission networks within and between countries, monitoring, and maintenance. It also includes investments at the industry or individual household level to secure energy efficiency, such as insulation and smart networks and grids.

Recent developments such as the Covid-19 pandemic and Russia's invasion of Ukraine have highlighted the importance of self-sufficiency in energy provision, accelerated the pace of transitioning to renewable sources, and brought forth new regional players in the global energy market. Egypt is an example of such a regional player, strategically located as an important transit route for oil and liquified natural gas. It operates various oil and natural gas extraction plants as well as hydropower plants, but the country's future focus is on solar and wind power generation due to its favourable conditions, increasing energy demand, and sustainability pledges.

Despite Egypt's growth trajectory being interrupted by various events in recent decades, energy consumption has more than doubled within the last 20 years. As such, the energy sector is considered one of Egypt's most promising sectors to drive future growth. Various strategies, plans, and investments rolled out in recent years, most of which focus on renewable energy generation, point towards even more investments in renewable technologies and energy efficiency in the future. Additional efforts are needed to improve the quality and sustainability of current municipal infrastructures to meet growing demand and withstand environmental pressures. A key factor for future growth in the sector is securing an adequate supply of skilled workers, but there is currently a shortage rather than an abundance of skilled workers.

The Egyptian energy sector definition in this report includes the NACE codes D35-Electricity, gas, steam, and air conditioning supply, B06-Extraction of crude petroleum and natural gas, B09-Mining support service activities, and C19-Manufacture of coke and refined petroleum products. This definition captures the generation of energy and the materials used to generate energy supply in Egypt, including conventional oil and gas extraction. However, the renewable energy sub-sector is undoubtedly the focal point for generating future employment.

Employment developments in the sector have been in contrast with future trends, with sectoral employment decreasing by 5.2% between 2010 and 2020. Employment in mining support activities and petroleum manufacturing increased while that in other parts of the sector, including renewables and electricity generation, declined. This trend may indicate a skill mismatch between the country's current level of expertise and that required for working in the renewables industry. The sector is also highly gender-segregated, with only 7% of workers being women in 2020, compared to 15% across all sectors. Segregation worsened compared to 2010, where women accounted for about 9% of workers.

Currently, the energy sector mainly employs medium-skilled workers. However, the distribution is expected to shift towards high-skilled workers if future developments in the renewable energy sector come to fruition. Employment across sub-sectors is expected to increase, and the greater uptake of renewable energy projects will drive skills demand towards more high-skilled professional, associate professional, and technician jobs. Technological advancements in renewables are also expected to increase demand for STEM professionals. It is important to identify more details about these future needs to drive the development and updating of curricula. However, skills anticipation studies are not conducted regularly or systematically in this or any other sector of the economy. As a result, field interviews and focus group discussions, as conducted by this study, are essential to gain insights into skills gaps and future demand. Discussions took place with companies operating in the fossil fuels and renewable energy sub-sectors, large energy-consuming firms, education providers (higher academic and technological education as well as TVET institutions), and stakeholders from the Ministry of Education and Technical Education (MOETE) and the Ministry of Higher Education and Scientific Research (MOHESR).

To date, the country has not developed a National Qualifications Framework (NQF), but temporary draft occupational standards have been created for occupations in the energy sector through partnerships between education providers and leading companies. The newly founded National Authority for Quality Assurance and Accreditation in Education (NAQAAE) currently supervises the development of a National Qualification Framework. Quality assurance and accreditation are the responsibility of the Authority for Quality Assurance (ETQAAN). ETQAAN accredits TVET and Technological Education programs. Additionally, the government has announced the founding a Teacher-Training Academy for TVET sector (TVETA) in 2019. This Academy will complement updating education curricula with adequate training for educators.

Drivers of change

A combination of extensive data analysis, desk research, and feedback from in-depth interviews and discussions was used to identify factors driving change in the Egyptian energy sector. These factors are ranked based on their perceived impact, measured via the overall occurrence of the topic in academic literature and its relative growth pace in recent years.

1. **Geographical position:** Egypt is rich in energy sources, including recent discoveries of large oil and natural gas reserves. However, this may delay the country's transition to 100% renewable energy, despite its potential for solar and wind solutions. Water shortages caused by climate change may also impact hydropower generation.
2. **Technological developments**: Digitisation and AI solutions drive the deployment of smart grids and better control systems, lower renewable energy costs, and facilitate the operation of large-scale renewable energy plants. However, there is an increased risk of cyber-attacks, and the shift towards more specialised and highly-skilled technical jobs require additional skills training.
3. **Climate change:** Urges a switch to renewable energies to reduce carbon emissions, but extreme weather events can increase household electricity consumption and disrupt energy generation.
4. **Increased needs for specialisation and lack of skilled workers**: The shift towards renewable energy and more significant energy management requires more highly-skilled and specialised professionals, but skills provision is adapting slowly.
5. **Policies and regulations:** National policies affect the sector, with current policies to liberalise the gas market and encourage external investments. Policies towards renewables include bids, feed-in-tariffs, and third-party access schemes, while removing subsidies to electricity and fossil fuels may have increased energy costs.
6. **Country development dynamics**: Rapid population growth, urbanisation, and increased living standards drive demand for electricity, which needs to be accommodated through future planning.
7. **Geopolitical dynamics:** Affect oil prices, energy demand, and the country's priorities. Egypt's ambition to become the main point of reference in Africa and the Middle East for energy drives investments and shapes labour demand.
8. **Availability of national/international investments:** Adequate investing shapes the future direction of development, with private and international investors actively investing in the country's energy sector. Recent reforms in investment legislation promise to create additional job positions.

Energy technologies

Inventive activity as in patents in Egypt has been sustained over the past years and was growing significantly since 1994, reaching its peak in 2009. However, only 5% of these patents were related to the energy sector. This is relatively low, considering the importance of the sector to the country's economy, indicating that the technologies needed have mainly been imported from abroad. Stakeholder interviews confirm this and attribute it to the absence of a regulatory framework to support the transfer of Egyptian innovations from the patent to the production stage and the private sector's reluctance to accept home-based technological innovations. The economic crisis and social unrest of the 2011 Arab Spring movements possibly caused a decline in patent filings after 2010, resulting in the country falling behind in its ability to keep up with technological advances in the energy sector worldwide. This is highlighted by the fact that the last of the 415 energy sector patents from 1977 to 2019 was filed in 2012.

Analysing how Egyptian energy sector patents are distributed across sub-sectors provides insights into the parts of the sector where research is more concentrated. The main sub-sectors of activity for energy-related patents in Egypt include solar, fossil fuel, oil and gas extraction, nuclear energy, wind, and hydro energy. Notably, innovation does not occur in the oil refinery sub-sector, indicating the country's reliance on imported technology. On the other hand, renewable sources of energy are actively researched, and innovative solutions invented by national companies and research centres can sustain more dynamic and autonomous growth in the future.

European trends in innovation determine, to a large extent, the parts of a sector that will be most affected by innovation activity within any given country. A complementary analysis of European patent filings in the energy sector revealed twelve technical sub-sectors that appear to be driving future innovation activity in the energy, indicating where future innovation activity should be pushed forward in the country to exploit positive synergies and initiate partnerships with the EU. These sub-sectors include Energy Transmission and Distribution, Fossil Fuel Energy, Solar Energy, Hydrogen Energy, Wind Energy, Energy Efficiency, Oil & Gas Extraction, Nuclear Energy, Biofuel Energy, Oil & Gas Transportation, Oil & Gas Refinery, and Hydro Energy.

Innovation in the fields of Energy Transmission and Distribution, Hydrogen Energy, and Wind Energy in Europe is growing at a fast pace, attributed to new and digital solutions driving innovation on smart grids, among others, and Europe's latest turn towards the use of hydrogen for energy production, storage, and transport. Some of these trends resonate with a research concentration in Egypt and indicate future needs in competencies and skills. A recent joint EU-Egypt agreement to promote hydrogen energy generation demonstrates the will for such collaboration.

Emerging skill needs

The input from various drivers of change has been correlated to the skills needed to properly use new technologies or manage new challenges and opportunities and the professional profiles involved in the process. Semantic software and the standard classification of skills, competencies, and occupations provided by the ESCO database were used in this process. The occupational profiles of the sector have been ranked according to their degree of correlation with the new or growing technologies whose adoption will impact the sector and the labour market the most. The resulting highest-ranking occupations will likely be in relatively high demand in the near future. The main findings from this analysis are as follows:

Firstly, emerging job profiles can be categorized into three broad groups: (i) high-skilled technical professionals and associate professionals (such as energy, mechanical, and electrical engineers and technicians), (ii) medium and low-skilled technical profiles (such as renewable energy plant operators and technicians and oil pipe welders), and (iii) business occupations related to the energy sector but not technology, including plant management jobs such as energy managers and operations managers, and market-oriented consultants, representatives, and salespeople. This indicates that future employment changes in the sector will not explicitly concern high-skilled professional profiles, but medium-skilled technical jobs will also be created, along with some softer managerial positions related to management.

Secondly, jobs likely to be most in demand in the future concern almost equally the emerging area of renewable energy generation and the traditional fossil fuel extraction and refining sub-sectors. This underlines the importance of the extraction industry and highlights that relevant training programs should not be neglected. However, it is evident that the ongoing transformation of the energy sector in Egypt will likely require upskilling and reskilling of the competencies in these jobs.

Thirdly, the highest-ranked job profiles in terms of likely future demand concern both highly specialized ones (such as Solar Power Plant Operators and Onshore Wind Farm Technicians) and jobs with a more horizontal skill set (such as Energy Engineers or Mechanical Engineers), which are in demand across energy sub-sectors.

Completely new job profiles are few in that most jobs in high demand have traditionally existed within the country's energy sector. New profiles concern managerial positions, especially energy managers and consultants. The emergence of these positions appears to be driven by climate change concerns, the need to minimise energy losses in the face of high future demand, and sustainability pledges.

Findings from in-depth interviews resonate with these results. Company representatives and sector stakeholders pointed out that emerging job profiles concern both technical and managerial jobs. They indicated that needs concern mostly high- and medium-skilled technical professions such as energy efficiency engineers and technicians, solar energy design engineers, and construction engineers with experience in renewable power infrastructure. However, they stressed the need for certain soft managerial positions (such as energy management system operators and energy managers) that have strong software competencies. Regarding skill gaps, interviewees noted that these are more pronounced for technical competencies and digital skills and that gaps mainly concern alternative energy sources sub-sectors than fossil fuel extraction and refining.

Limiting factors

In-depth discussions with stakeholders from the energy sector, large energy-consuming companies, and the education sector reveal various factors that limit the adoption of new technologies and a general change in the Egyptian energy sector. These factors include:

- Shortages of workers with sufficient skills, including both technical and managerial jobs. This is attributed to the lack of dedicated theoretical and technical programs in secondary and tertiary education, inadequate technical training of existing graduates, and the absence of coordination between education providers and companies in understanding emerging needs and acting jointly toward meeting them. Candidates lack both the technical "hands-on" experience required to work in the sector and general awareness of renewable energy, its uses, and potential. Incentives are also not given to the private sector to organize and promote skills development and facilitate workers' reskilling.
- Challenges related to work-based learning include the lack of general policies supporting academia-industry collaboration and scarce incentives for companies and employees to engage in work-based learning. Collaborations between companies and technical schools towards WBL exist up to date only on a 1-to-1 basis and cannot be scaled up without a central policy.
- There are weak links between industry and academia in terms of innovation diffusion and education and training. Communication between industry and academia appears to be scarce and hampered by industry perceptions against Egyptian innovations in the sector. This disincentivises investments in domestic technology creation in the energy sector. As for education and training, skills anticipation studies are not conducted, while partnerships to gain insights on skills gaps, update curricula, and create new training courses are conducted only on a 1-to-1 basis.
- Sectoral structure and authority inertia, with large state-owned companies dominating fossil fuel extraction and renewable energy generation sectors, which inhibits competition. However, this may be altered by emerging public-private partnerships to develop new renewable energy generation plants. Other obstacles include slow decision-making, bureaucracy, and the indecisiveness of authorities when adopting strategies for the future of the sector.
- The regulatory framework concerning both internal sector functioning and innovation diffusion. A unified platform that regulates and organizes the interaction between renewable energy developers and the national grid management is needed, as are more substantial incentives for rolling-out private-to-private collaborations in the energy sector. A regulatory framework for supporting the scaling-up of innovative technology from patented prototypes to production in universities has only recently been established but is not yet operational and needs further adjustments.

- Low investment activity is driven by lack of investments, investment capital constraints, the cost of adopting new technologies, and the absence of incentivisation to reach larger electricity generation capacities from renewable sources. Investments are also low in innovations, with the lack of state funding for new laboratories, training courses, and facilities and scarce research opportunities. Recent policies to support company innovation via loans and funds to apply and use modern energy conservation and management technologies are considered relatively insufficient.
- Macroeconomic instability in the recent past has disincentivised potential investors and driven foreign capital away. Several crises have hampered Egypt's growth trajectory in the recent past, including the Arab Spring and the Covid-19 pandemic. A significant decline in foreign direct investment was documented during the post-Arab Spring period, while the low trustworthiness of state-owned energy companies affects investments in existing and new oil and natural gas projects. Moreover, instability affects exchange rates, which is a significant factor inhibiting the adoption of new technologies in the energy sector.

A final word on the findings

Energy is a key driver of economic growth in every country. With the green and digital transitions, energy generation is changing and greater emphasis is placed on the potential of alternative energy technologies. Innovation is also vibrant in the field of energy conservation, management, and efficiency. Digital technologies that facilitate energy management are now commercial, and this concerns both households and large facilities, including transmission networks.

Egypt is naturally well-endowed in terms of energy generation capacity, which has historically been concentrated in fossil fuel extraction. However, now various opportunities are seized to transform its energy sector from one dependent on fossil fuels under public ownership to one that can capitalize on its natural endowments of wind and sunlight through public-private investments to develop a sizeable renewable sector. Alternative sources of energy, especially hydrogen, are also a high priority. In the face of Russia's aggression in Ukraine, the proximity to regional energy markets and Egypt's potential as a regional energy hub for Europe appear to be paving the way for strong growth in the energy sector.

This ongoing transformation is potentially skill-intensive, with specific skill needs for the construction, operation, and maintenance of wind and solar farms, network grids, and pipelines, as well as the potential development of novel energy sources such as hydrogen. Increasing digitalisation in several solutions in grid management and energy plant operation highlights the need for a strong digital component in the future skill sets of many energy sector workers. The shift to a mixed economy involving the public and private sectors implies the implementation of new business models, with subsequent demand for new business skills.

Meeting these needs requires an education and training system that is aware of them and can plan accordingly, is flexible enough to adapt quickly to new needs that may arise due to technology innovation and diffusion and cater to continuous skills upgrading. The capacity of the education and training sector to meet skill needs may shape the strategic choices that employers in the energy sector make with respect to the activities in which they decide to invest and how they organize their workforce. Currently, several skill gaps are reported in terms of technical and managerial jobs, technical experience and training, awareness of alternative sources of energy, and digital competencies. The education and training system's responses were unstructured and have not filled these gaps adequately.

The following is a list of necessary actions that the energy sector stakeholders and education, higher education and training authorities need to undertake in order to meet the future skills requirements of Egypt's energy sector. These actions were identified through a combination of desk research, big data analysis of trends, and in-depth interviews with stakeholders:

- Develop a systematic approach to anticipate skill needs. Currently, this is done in a fragmented manner by various actors. In particular, the energy sector lacks a systematic approach, which requires cooperation between energy sector representatives, vocational education and training (VET) and higher education providers.

- Expand and formalize the existing fragmented cooperation between VET and higher education providers and the private energy sector for developing and updating curricula. A formal strategy is recommended to establish such collaborations.
- Develop stringent quality criteria that training providers must meet to deliver accredited training.
- Establish a system of formal National Occupational Standards (NOS) for occupations based on the existing "draft" occupational standards that have been developed through 1-to-1 partnerships between certain educational institutions and the private sector. This is especially important for the energy sector.
- Set up a strong system and relevant legal framework for training, including in-house training, apprenticeships, and work-based learning to strengthen the competences of recent graduates and reduce dependence on foreign labour and foreign training.
- Develop a dedicated framework and concrete actions to increase work-based learning in the energy sector. This will compensate for the current lack of "hands-on" technical competencies. Incentives are needed for companies to engage in such schemes and retain workers post-training, as well as incentives for students to follow this educational pathway into the labour market. Career progression opportunities and clear pathways to the labour market should be established for students. Learning from international best practices is crucial, such as those in South Korea and Germany.
- Ensure that training provision improvement does not neglect the traditional fossil fuels extraction and refinery sector, which will continue to be a vital part of Egypt's energy sector. The sector's skill needs are transforming due to sustainability concerns and digital technologies, and future training programs should consider the need to reskill workers in the oil extraction industry. Reskilling can also concern their potential transition to the renewable energy sector to accommodate shortages in the latter.
- Exploit the untapped potential of the female population as a source of the future workforce in the energy sector. Women currently exhibit relatively high levels of inactivity and unemployment, while young female NEET rates are relatively high and persistent.

1. Introduction

1.1 Country overview

Egypt is located in the North-Eastern part of Africa and borders with Western Asia through the natural land bridge of Sinai Peninsula. Its advantageous location facing both the Mediterranean and the Red Sea has historically established it as a major strategic hub. Nowadays, it still is a significant partner for both neighbouring countries and the rest of the World. However, over the course of recent history, the country has struggled to achieve and secure sustainable growth. Growth was interrupted various times during the last 30 years, most recently by the 2008 global economic crisis, the Arab Spring uprisings in 2011, and the Covid-19 pandemic.

The country is one of the most populous countries in Africa and the Middle East, and its population is rather young and growing at high rates. However, employment figures are rather dissatisfactory. Employment and participation rates are low, particularly for the female population. The country is also characterised by “educated unemployment”, in that the vast majority of unemployed people have at least an intermediate degree. The private sector is the major employer, dominated by SMEs and with a strong presence of informal economy.

The Covid-19 pandemic had a major impact on the country’s economy. Prior to the pandemic, the economic outlook was positive, and the country was one of the fastest growing emerging markets (IMF, 2020). Economic stabilisation was maintained via economic reforms supported by the IMF. The pandemic slowed down the economy’s growth, mainly through a sudden curtailment in tourism and associated activities (IMF, 2020). The country was forecast to gradually regain its growth momentum during the fiscal year 2022-2023 (World Bank, 2021), but recent disruptions in energy markets and supply chains have called this into question, partly due to the Russia-Ukraine conflict..

The energy sector is considered as Egypt’s most promising one to drive future growth. The country is strategically located and comprises an essential transit route for oil and liquified natural gas. It also operates multiple oil extraction sites and has a large and rather untapped natural gas liquefaction capacity (12 million tons of LNG per annum). Potential future developments have recently been focused on renewable energy generation, driven both by sustainability pledges and by increasing demand for energy. Egypt already operates hydropower plants, but the future focus is on solar and wind power generation, with several plants being constructed via public-private partnerships. The country’s determination towards harnessing the power of renewable energy resources is highlighted by various recently announced strategies such as the Egyptian Solar Plan, the 2035 Integrated Sustainable Energy Strategy, and the Egypt Vision 2030 strategy.

1.2 Methodology

The purpose of this study is to identify trends that provide insight into emerging or future skill requirements. Predicting the evolution of the labour market is a complex undertaking that cannot solely depend on assessing the present situation. To achieve this objective, a comprehensive methodology was created, incorporating traditional methods for skills anticipation with the potential of data science. The resulting methodology consists of a series of steps.

1. A background analysis, using well-established social science methodologies, such as a literature review and a secondary analysis of employment and skills data. The analysis builds on analysis of national and international data (mostly Eurostat, ILOSTAT, World Bank), in addition to a collection of national and international reports and papers regarding the economy and skills.

2. A data science (big data) analysis utilising text-mining techniques on a vast number of patents and scientific publications related to the sector. This analysis supports the identification of drivers of change as well as emerging technologies. Next, the identified societal and technical trends are correlated using semantic software with the standard ESCO classification of jobs and competences.

The outcome of this correlation helps to identify which occupations and skills will likely be in higher demand.

3. Fieldwork with employers and stakeholders to obtain direct information from the industry's actors, particularly on issues where data are limited. This phase involved 18 semi-structured interviews, which were conducted with employers (both companies operating in the energy sector and large energy-consuming manufacturing companies) and sector stakeholders (representatives from education institutions and the Egyptian Ministry of Education).

4. Validation of the preliminary findings, through a focus group with key stakeholders where feedback was obtained for the final report.

For further details on the approach adopted in the study, see ETF's methodological note for conducting studies on the future of work (ETF 2021c) and its update (ETF 2022h).

1.3 Structure

The structure of the report is as follows: following the introduction, Chapter 2 provides an overview of the Egyptian economy and labour market characteristics, while Chapter 3 focuses on the features of the country's energy sector, the main policies adopted over the years, and the major actors. This is based on literature review and a secondary analysis of employment statistics. Chapter 4 analyses the main drivers of change affecting the sector, accounting for both technological and non-technological trends. In chapter 5, the impact of technological trends on emerging skill needs is analysed by comparing and matching skill needs with occupational job profiles. Chapter 6 draws on in-depth discussions during interviews with sector stakeholders. It reviews bottlenecks that are currently preventing technological advance in the sector (with an emphasis on skill shortage), discusses sector initiatives and training strategies put in place as a response, and provides policy recommendations.

The report also includes a detailed analysis of patent clusters (Annex 1), a list of the key stakeholders and companies in Egypt that were consulted for the study (Annex 2), a glossary of terms relating to employment, skills and technology (Annex 3) and a bibliography.

2. Employment, skills and the labour market in Egypt

KEY INSIGHTS FROM THIS CHAPTER

- The Egyptian economy has faced several challenges, with significant interruptions in growth due to events in 1991, 2008-2012, and 2020, including the Covid-19 pandemic. Despite these challenges, Egypt has generally outperformed other countries in the MENA region in terms of economic growth.
- Egypt has a young population, with almost 60% below the age of 30. The country has improved in key educational indicators such as enrolment rates in primary, secondary, and tertiary education.
- Employment and activity rates in Egypt are lower compared to the EU, with women facing substantial barriers to finding and maintaining employment. About 74% of employed persons work in the private sector, which is dominated by small firms and informal work. Services and agriculture are the major employment sectors.
- Unemployment rates have decreased from 2010 to 2020, with educated unemployment being a significant issue. Youth unemployment and NEET rates have also seen a decline with a narrowing gender gap. Labour market challenges include increasing activity rates, reducing NEET rates, and increasing demand for high-skilled work.
- The labour force in Egypt is generally educated to a lower level than in the EU, with a higher percentage of employed people having basic or secondary education. The occupational distribution of employment in Egypt shows a larger share of skilled agricultural jobs and a smaller share of highly skilled jobs compared to the EU.
- Technical and Vocational Education and Training (TVET) is a central focus for addressing unemployment and enhancing competitiveness. The Technical Education 2.0 strategy aims to improve the quality and attractiveness of VET.
- Egypt's TVET system is currently undergoing numerous reforms, with support from various international partners and organizations. Public-private partnerships in training and upskilling programs are essential for meeting labour market needs.

This chapter presents an overview of the current state and latest developments in the Egyptian economy and labour market. The commentary starts with a general overview of Egypt's economic development over recent years, the effects of the Covid-19 crisis, and the main challenges facing the Egyptian economy. This is followed, in section 2.2, by a summary of the labour market and education system. It provides the background information and context for the following chapters which provide detailed information on the size, structure and development of the energy sector and its emerging skill needs.

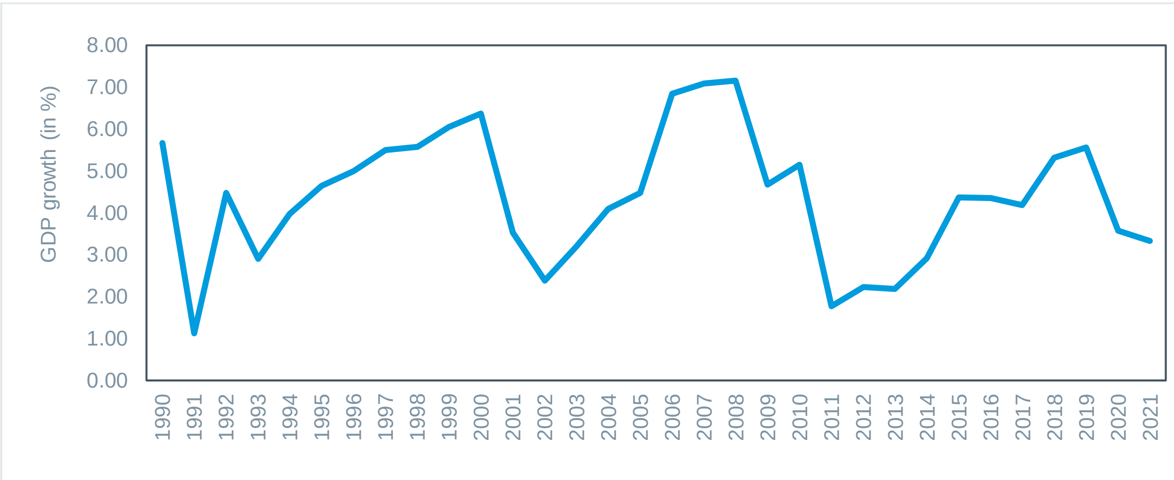
2.1 The Egyptian economy

Egypt is located in the North-Eastern part of Africa and borders with Western Asia through the natural land bridge of Sinai Peninsula. It stretches over an area of about 1,010,000 square kilometres from the Mediterranean Sea to the north, the Gaza Strip and Palestinian to the northeast, and the Red Sea to the east, while it has borders with Sudan to the south and Libya to the west (Elbaset, 2009). Along with Algeria, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia, Egypt is part of the European Neighbourhood Policy-South region (Eurostat, 2019), which consists of a group of countries surrounding the Mediterranean Sea. Egypt's advantageous location facing both the Mediterranean and the Red Sea has played an important part in its establishment as a major strategic hub throughout history. Being at the crossroads between Europe, the Middle East, Asia and Africa and home to one of the key transportation routes of the world (the Suez Canal), Egypt has long been recognised as a major partner for both neighbouring countries and the rest of the world.

The country has faced several challenges in the course of achieving and securing sustainable growth. As it can be seen from Figure 1.1 below, its growth trajectory has suffered at least three major interruptions over the last 30 years. The 1991 interruption can be partly attributed to terrorist attacks targeting key figures in Egyptian society, tourists and foreigners, resulting in serious damage to the tourism sector, one of the largest in the Egyptian economy. The two latest downturns (2008-2012 and 2020) can be attributed, respectively, to (a) the global economic crisis of 2008 and the Arab Spring uprisings of 2011, and (b) the Covid-19 pandemic which had a major impact on the Egyptian tourism sector. Despite these shocks, as Figure 2.1 demonstrates, throughout most of the latest 20 years, Egypt has economically outperformed other countries in the MENA region (ETF, 2021a), while its growth was less interrupted by the Covid-19 pandemic.

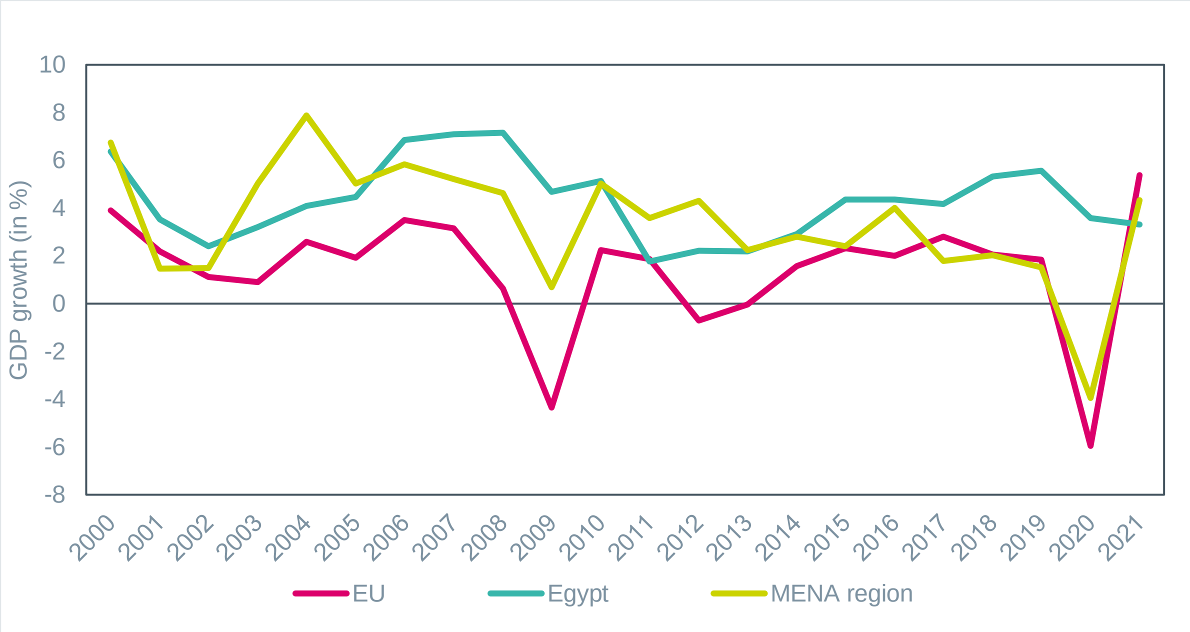
Regional inequalities in growth and opportunities persist, despite progress in reducing the urban/rural economic divide. Household income and expenditure have, in general, grown more in urban than rural areas. Egypt is categorised as a "high human development" country by UN's Human Development Report (2020), but it is positioned at the lower range category. Overall, it is ranked 116th out of 189 countries in 2020, but when adjusted for inequality, its Human Development Index decreases by almost 30% and the country drops nine positions compared with the conventional HDI (UNDP, 2020).

Figure 2.1: Annual growth in GDP volumes, 1990-2021



Source: World Bank

Figure 2.2: Annual growth in GDP volumes, EGYPT, THE MENA region and the EU, 2000-2021



Source: World Bank

Egypt is one of the most populous countries in Africa and the Middle East and ranks 14th globally. Its population is growing at an annual rate of about 2% in the last 20 years (see Table 1.1) and stood at around 102 million inhabitants in 2020. Most of the population lives along river Nile and is concentrated in urban centres. Recent projections estimate that, by 2052, the population is projected to reach 180 million, putting Egypt amongst the top nine largest populations in the world (draft Multi-Annual Indicative Programme European Union – Egypt 2021-2027 Version 5 July 2021).

Table 2.1: Economic fundamentals in Egypt, selected years 2000 to 2020

Key economic figure	2000	2005	2010	2015	2020
Population growth (annual %)	1.93	1.81	1.98	2.21	1.92
Exports of goods and services (% of GDP)	16.20	30.34	21.35	13.18	13.11
External balance on goods and services (% of GDP)	-6.62	-2.27	-5.24	-8.48	-7.55
Current account balance (% of GDP)	-0.97	2.35	-2.06	-5.24	-3.90
Foreign direct investment, net inflows (% of GDP)	1.24	6.00	2.92	2.10	1.60
Exchange rate against EUR/ECU	3.30	7.21	7.47	8.56	18.07
Agriculture, forestry, and fishing, value added (% of GDP)	15.54	13.98	13.34	11.39	11.57
Industry (including construction), value added (% of GDP)	30.75	34.15	35.78	36.63	32.01
Services, value added (% of GDP)	46.53	45.93	46.23	53.17	51.76

Source: Eurostat, World Bank (World Development Indicators)

Egypt's main exports include crude and refined petroleum, gold, chemicals, and metallurgical products such as nitrogenous fertilisers, aluminium powder, and citrus fruits. The main destination countries for exports are the United Arab Emirates, the United States, Saudi Arabia, Turkey, and Italy. Egypt is the world's largest importer of wheat (ERDB, 2022) and locomotives, while other top imports include crude and refined petroleum, and broadcasting equipment. Major import partners include China, the Russian Federation, the United States, Germany, and the United Arab Emirates.[2]

The Covid-19 pandemic inflicted a major shock on the country's economy. Prior to the pandemic, Egypt's economic outlook was favourable as one of the fastest growing emerging markets (IMF, 2020). The country had achieved macroeconomic stabilisation after a successful economic reform programme supported by the IMF Extended Fund Facility (EFF) during 2016-19. The Egyptian authorities addressed large external and domestic imbalances and expanded social safety nets while sharply reducing public debt. The economic impact of the pandemic was demonstrated by the sudden drop in tourism and associated activities (IMF, 2020). Despite Egypt imposing a relatively looser lockdown than other countries, airport closures severely affected the tourism sector (ETF, 2021a). This severe downturn resulted in the country seeking IMF aid, which in June 2020 led to the Executive Board of the International Monetary Fund (IMF) providing a 12-month stand-by arrangement for Egypt. This arrangement stipulated the advancement of structural reforms to support private-sector-led growth and job creation amongst other requirements (IMF, 2020).

The implementation of the programme, along with a slowdown of the Covid-19 pandemic resulted in a resumption of economic activity, employment and growth in the last quarter of 2020 and the first of 2021 (World Bank, 2021). This led to a slowdown of inflation and a primary fiscal surplus. This positive outlook helped attract portfolio flows and stabilise foreign exchange reserves (ERDB, 2022). The country was expected to gradually regain its growth momentum during the fiscal year 2022-2023 (World Bank, 2021), but recent domestic and global economic disruptions -most notably the Russia-Ukraine conflict- have called this into question. Egypt has undertaken exchange rate, monetary and fiscal measures in response to soaring prices, tightening financial conditions, and fading demand that were aggravated by the conflict. Such measures are also targeted towards several structural challenges that are on the path of full transformation of the Egyptian economy to a more sustainable and resilient one (World Bank, 2022). These include, among other things the following:

- Reform of the state's role in the economy, including developing a transparent state ownership policy and governance framework, and separating the state's role as regulator from that of operator. These reforms are intended to support competition and create a level playing field for private enterprises (ERDB, 2022).
- Targeting the sluggish non-oil private sector activity, under-performing exports and foreign investments, and improving competition in the economy (World Bank, 2021; ERDB, 2022). These are to be achieved through further trade liberalisation and integration of the country into the global value chains, and an upgrading the transport and logistics infrastructure. ERDB (2022) points to the need for a "master plan for logistics", as well as for upgrading the infrastructure to facilitate improved integration with other African economies, along with reforms to customs and ports, and a greater uptake of automation.
- Fiscal consolidation and a targeting of the elevated government debt-to-GDP ratio (World Bank, 2021).
- Raising spending on the key human development sectors (improving health conditions and facilitating a decent standard of living, investing more on education provision) and social protection (World Bank, 2022)

There has been progress towards meeting the challenges the country faces. Prior to the pandemic Egypt had already embarked on the "Egypt Takes Off" programme (stretching over fiscal years 2018 to 2022), while after the pandemic the country agreed with the IMF on support through a 12-month Stand-By Arrangement programme with access to US$5.2 Billion of funding to cope with the challenges posed by the COVID-19 pandemic (IMF, 2020) and launched its new National Structural Reform Programme (NSRP) for the years 2021-2024. In this programme, scheduled reforms focus on improving the

[2] OEC, Country Profile: Egypt. https://oec.world/en/profile/country/egy#:~:text=Overview%20In%202020%20Egypt%20was,Economic%20Complexity%20Index%20(ECI).

standards of living and service delivery to all Egyptians, strengthening, and better targeting social safety nets (World Bank, 2022), and supporting private-sector-led growth and job creation. (ERDB, 2022).

2.2 The Labour Market, Education and Skills

2.2.1 The Labour Market

The Egyptian population is relatively young: almost 60% are below the age of 30 according to the latest available national data (ETF, 2021). According to 2019 data available from the United Nations Educational, Scientific and Cultural Organisation (UNESCO, IUS), the country has improved its performance in terms of key educational indicators such as net enrolment rate in primary education (97%), gross enrolment in secondary (90%,) and upper secondary education (78%), while in the same year 43% of Egyptians were enrolled in the tertiary education system.

In contrast to these trends, employment and activity rates have been consistently lower by comparison with the EU. For instance, the activity rate for the general population aged 20-64 increased by 1.5 percentage points over the last decade (see Table 1.2). The activity rate for men decreased by 5.4 percentage points, while that for women, who face substantial barriers to finding work and remaining employed, especially after marriage (ETF, 2021a), increased rather sharply but still was less than half of the respective rate for men in 2020 (KIESE and ETF, 2021). The same pattern is apparent in employment rates. After a period of no improvement over the past 20 years they appear to have recently slowed down (see Table 1.2). Female employment rate appears to have increased markedly (by 10%) by 2020 but was still less than half of the respective rate for men. About 52% of working age Egyptians were employed in 2020 which reflects the relatively low female employment rates (ILO, 2019) that are amongst the lowest of surrounding ENP-South countries (Eurostat, 2019)..

Most of employed persons (about 74% according to the ERBD – see Morsy, 2017) are employed in the private sector. This sector is also the most active in new job creation. It is dominated by small firms and informal work. A total of 98% of Egypt's firms are micro enterprises, often limited to low-value-added activities (ETF, 2021a). Public employment is steadily decreasing (except for education). In 2020, the largest domain of employment was services (41.4%), with agriculture following closely (35.7%). Agricultural employment increased as a percentage of total employment in the past decade, despite it appearing to be responsible for most of job destruction in the country. On the other hand, sectors responsible for job creation were mostly Construction, Manufacturing, Wholesale and retail trade, Transport, and Accommodation services (ILO, 2022a).

Table 2.2: Statistics on employment in Egypt and the EU27 (20-64 age group)

	Egypt			EU-27		
	2010	2020	% Change	2010	2020	% Change
Population size (million and percentage change)	82.8	102.3	23.6	440.7	447.3	1.5
Population aged 15-24 years (%)	32.0	27.5	-4.5	11.8	10.6	-1.3
Activity rate (20-64) – Total	53.7	55.2	1.5	74.3	77.1	2.8
……Men	81.4	76.0	-5.4	81.3	82.8	1.5
……Women	25.4	33.3	7.9	67.3	71.4	4.1
Employment rate (20-64) – Total	49.2	51.8	2.6	67.0	71.7	4.7
……Men	77.7	71.7	-6.0	73.4	77.2	3.8

……Women	20.1	31.0	10.9	63.7	66.1	2.4
Employment in agriculture (% of total)	28.2	35.7	7.5	5.3	4.0	-1.3
Employment in industry (% of total)	25.3	22.9	-2.4	26.3	25.1	-1.2
Employment in services (% of total)	46.3	41.1	-5.2	67.9	70.1	2.2
Unemployment rate (15+) – Total	8.8	5.9	-2.8	10.1	7.2	-2.9
……Men	4.8	5.8	1.0	10.0	7.0	-3.0
……Women	22.1	6.2	-15.9	10.2	7.6	-2.6
Youth unemployment rate (15-24)	24.3	19.2	-5.1	22.4	17.6	-4.8
Youth not in employment, education, training (NEET % aged 15-24) – Total	33.1	28	-5.1	12.4	11.2	-1.2
……Men	15.8	16.4	0.6	6.2	5.7	-0.5
……Women	52	40.3	-11.7	6.2	5.5	-0.7

Sources: EU-28: Eurostat, EU LFS data. Egypt World Bank-World development Indicators, UN, ILOSTAT-LFS and ETF calculations based on ILOSTAT-LFS.

Note: NEET% for Egypt refers to 2019 instead of 2020

In 2010, the unemployment rate stood at 9% and had decreased to 6% by 2020. Youth unemployment appears to have decreased by about 5% over the same period. Women are more likely to be unemployed than men, notwithstanding their much lower activity rates. However, their unemployment rate appears to have dropped sharply (from 22.1 in 2010 to 6.2 in 2020) within the last decade, approaching that of men (5.8 in 2020). Large differences in unemployment by skill level are evident too. According to ETF calculations based on ILOSTAT-LFS data, unemployment rates in 2020 for high- and low-skilled workers were, respectively, 6.7% and 11.51%.

Among those workers formally listed as unemployed, the vast majority (89%) hold intermediate, above intermediate, or university qualifications. This points to a phenomenon referred to as 'educated unemployment'. In 2019, 42% of workers formally listed as unemployed held a medium / intermediate level qualification, while a 47% were university graduates (CAPMAS 2019). These figures are consistent with the loss of high-quality jobs in Egypt: the share of professional and technical jobs has declined lately, while jobs in the middle of the skills spectrum have increased, particularly in factory and construction work (ILO, 2019).

Young people not in employment, education or training (NEETs), as a percentage of all those aged 15—24 years of age, stood at 28% in 2019 (see Table 1.2).[3] Although young women constitute a large portion of this group, the evidence points to a decline in the NEET gender gap, that is, the NEET rate for young women being in decline (from 52.0% in 2010 to 40.3% in 2019), while that of men increases slightly.[4] This points towards important changes in the labour market in Egypt, with more young women being active (ETF, 2021c). However, the NEET rate for young men remains substantially below that of young women. The main reason for this is the dominant role of women as caretakers, according to a recent ETF (2021c) report. The educational attainment is another factor strongly influencing NEET rates. In particular, the probability of being a NEET increases for individuals with low and high education.

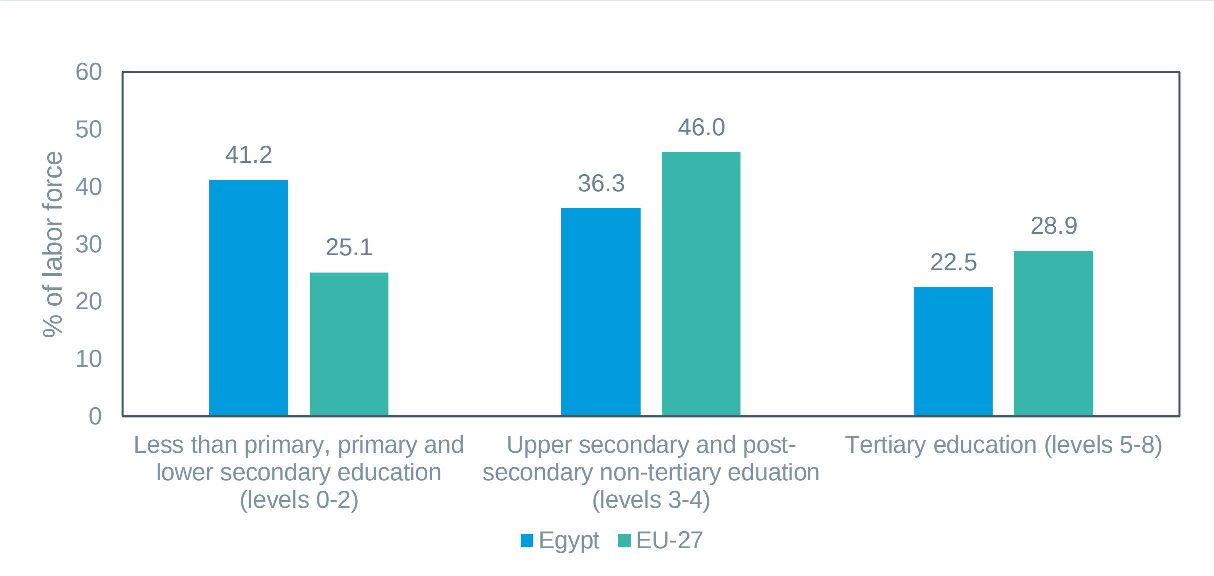
Detailed views of the levels of educational attainment in the labour force as a whole provide an overview of skills supply. Qualification provides a proxy measure of skills supply that is readily available in official statistics which can be compared across countries. Figure 1.3 reveals that the labour force is educated

[3] A more recent estimate by World Bank for 2020 is 30%.

[4] This points to a continuation of the trend reported in ETF (2021c) for 2010-2016.

to a lower level than in the EU. For example, 25% of the labour force in the EU had achieved a level of educational attainment equivalent to completing, at most, lower secondary education (ISCED levels 0-2) compared with 41% in Egypt. Similarly, a higher share of the labour force in the EU has on average educational attainment at intermediate and higher levels.

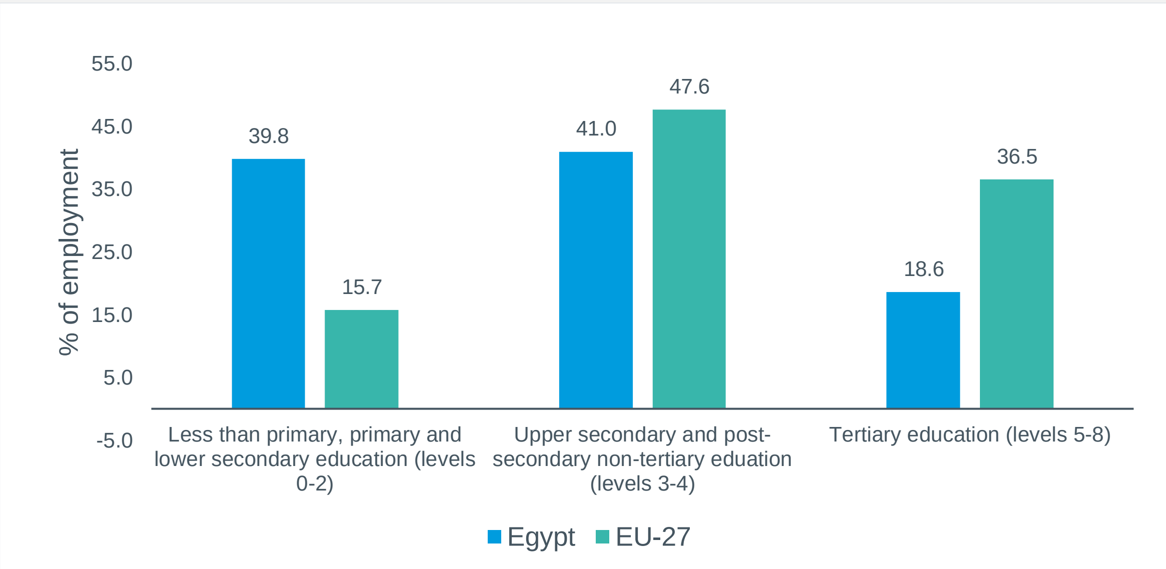
Figure 2.3: Educational attainment levels of the labour force in Egypt and the EU, 2020



Source: Eurostat; ETF (2020) (KIESE Database)

By looking at the educational attainment of those in employment we obtain an indication of skills demand since it reflects the types of job people with differing levels of attainment are actually undertaking. Figure 2.4 shows the distribution of people in employment by educational attainment for Egypt and the EU. From that we can see that the percentage of employed people with basic education is very high and almost equal to that of those with secondary education (40 versus 41%), while only a 18.6% of employed workers hold a tertiary education qualification. The employment composition of the EU-27 is relatively more evenly distributed across educational levels, with more employed workers having low and high education, and less workers having secondary education compared to Egypt.

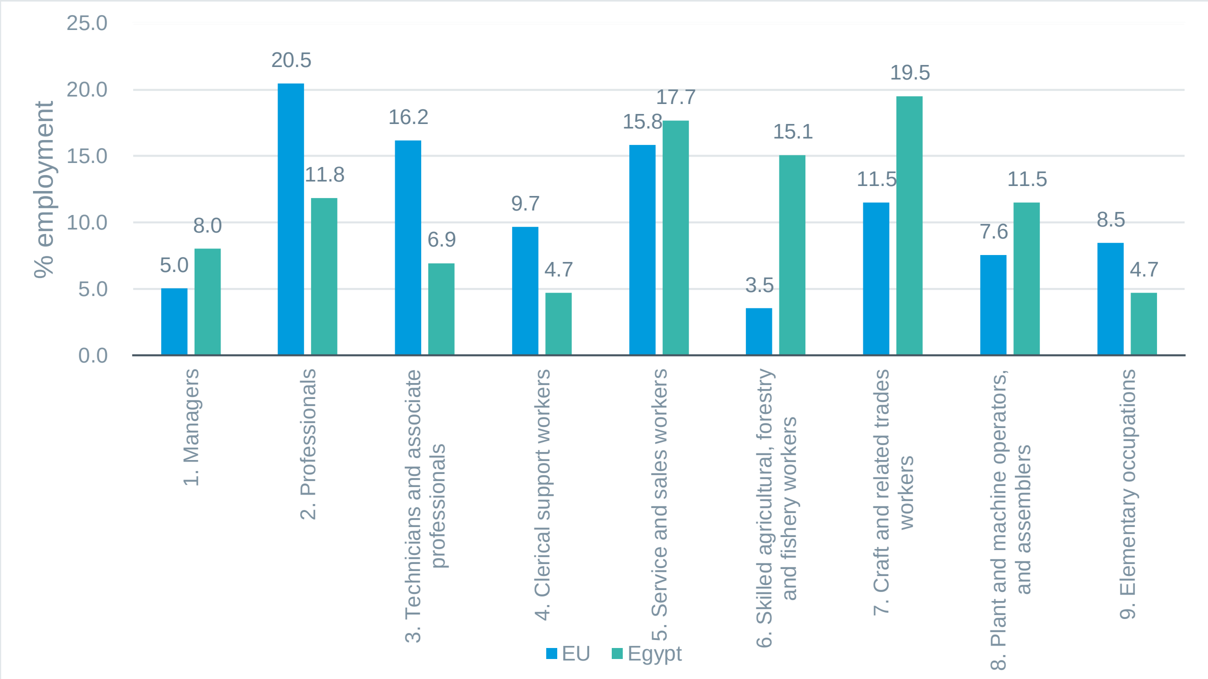
Figure 2.4: Educational attainment levels of people in employment in Egypt and the EU-27, 2020



Source: ILOSTAT, Eurostat

An indication of skill demand can also be obtained by looking at the occupations in which people work. Like educational attainment it is an imperfect measure of skill but nevertheless provides an indication in the extent to which people are employed in more or less skilled jobs. Figure 2.5 shows the occupational distribution of employment in Egypt compared with the EU. It reveals that a much larger share of employment in the EU is accounted for relatively highly skilled jobs (managers, professionals, and associate professionals) than in Egypt. In the EU, 42% of employment is accounted for by these occupations compared to 29% in Egypt, that said a larger share of employment is accounted for by managers than in the EU. It is apparent that a much larger share of employment is accounted for by skilled agricultural jobs in Egypt (15%) compared to the EU (3.5%) reflecting the relative importance of agriculture to Egypt's economy. In Egypt a higher percentage of people work as (a) craft and related trades, (b) service and sales workers, and (c) plant and machine operators than in the EU.

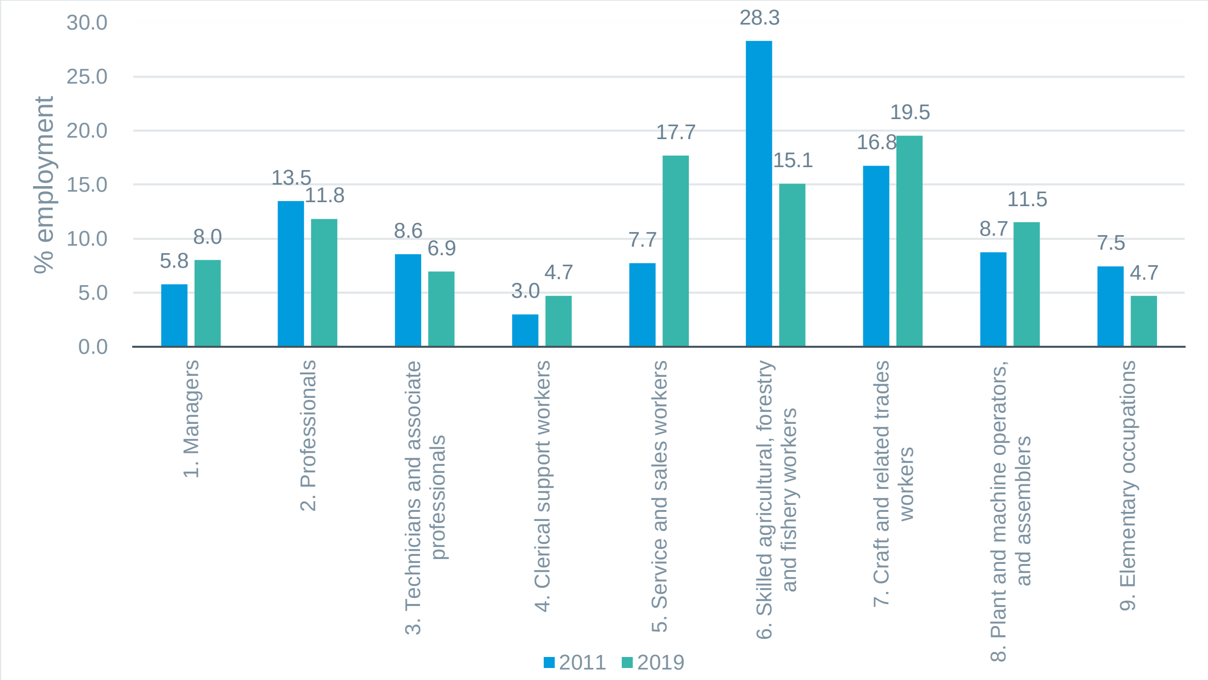
Figure 2.5: Occupational distribution of employment in Egypt and the EU, 2020



Source: ILOSTAT, Eurostat

Over time, there has been relatively modest change in the occupational structure of employment. Between 2011 and 2020 the only major change is the observed decline in the share of employment accounted for by skilled agricultural employment. There does not appear to be a convergence towards the occupational structure of employment found in the EU where over time increasing shares of employment have been accounted for by those working in managerial, professional, and associate professional occupations. In fact, the share of employment accounted for by professional and associate professionals appears to have fallen overtime in Egypt.

Figure 2.6: Occupational distribution of employment in Egypt, 2011-2020.



Note: Occupational data prior to 2011 are not comparable to those after 2011 due to a change in the ISCO classification.
Source: ILOSTAT

The commentary provided above points to the challenges facing the labour market in Egypt. These include the need to increase activity rates (especially for women), further reduce NEET rates (especially for young women), and increase the demand for relatively high skilled work. Solving these problems will largely rely on stimulating economic growth allied to labour market policies which increase employment opportunities, notably for women. Skills supply also has a role, as is discussed in the next section.

2.2.2 VET providers, labour market stakeholders and relevant policies

Technical and Vocational Education and Training (TVET) is widely recognised as a focal point in the country's efforts to reduce unemployment, create social equality, and enhance competitiveness (El-Ashmawi, 2019). By 2019, almost half (47%) of the total number of students in upper secondary education in Egypt were in VET (KIESE ETF, 2021). This secondary education pathway - including agricultural, industrial, commercial, hospitality and dual system streams (three- and five-year programmes) - represents the larger part of the Egyptian education system at this level (El-Ashmawi, 2019). Upon completion of secondary education, the possible pathways for VET graduates are either: (i) university admission; or (ii) enrolment into mid-level technical colleges. Most graduates opt for the latter (KIESE ETF, 2021).

The TVET sector in Egypt comprises several stakeholders, each of which is engaged in efforts to reform the sector to better meet the skill needs of the Egyptian economy. It is something which is difficult to centrally coordinate around a common vision (ETF, 2021a). Stakeholders include the country's educational authorities (Ministries) along with the associated institutions and councils.

The **Ministry of Education and Technical Education** (MoETE) is the main VET authority in the country, responsible for more than 1,300 industrial, commercial, agricultural, and dual system Technical Secondary Schools (TSSs), in which more than 1.8 million students were enrolled in 2018, either in three-year technical diploma or five-year advanced technical diploma tracks (El-Ashmawi, 2019). Currently, the Ministry is working on the implementation of the 'Technical Education 2.0' strategy (launched in 2019), which aims to increase the attractiveness and quality of VET, train teachers, review the governance model, and establish new models of public-private partnerships (ETF, 2021a).

The **Ministry of Higher Education** (MOHE) is the main authority for higher education. It supervises the various public and private higher education institutions in the country,[5] middle technical institutes, as well as four Faculties of Technology and TVET Teacher Education. The latter offer four-year-long programmes to train technical teachers for technical secondary schools as well as technologists (EQF level 5), leading to the award of a Bachelor of Technology qualification (El-Ashmawi, 2019). The MOHE is cooperating with the MoETE for modernising the higher education sector (ETF, 2021a). Towards this end, new legislation was approved in 2018 for establishing New Technological Universities (TUs). These are planned to offer two- and four-year programmes covering multiple specialties such as agriculture, industry, technology, and commerce (ETF, 2021a). The main aim of establishing the TUs is to respond to VET labour market requirements corresponding to EQF level 5 and higher and make secondary VET more attractive for those who wish to continue to higher levels of education. The courses will be open to students with general secondary school certificates, as well as those who have attended a technical school. A total of 10 TUs have already been established and the Ministry aims for a total of 27 TUs, one in each governorate that will offer programmes tailored to each governorates' needs.[6]

Quality, rather than quantity and inclusion, is recognised as the main deficiency in the Egyptian TVET system (El-Ashmawi, 2019). Up until recently, the main quality assurance authority was the **National Authority for Quality Assurance and Accreditation in Education** (NAQAAE). Established in 2005, it is an independent quality assurance and accreditation body with administrative and financial autonomy. Its evaluation framework is aligned with international standards and its focus covers both technical and general education schools (El-Ashmawi, 2019). Several actions have recently been taken towards the goal of further improving quality in education provision through a unified approach to the quality assurance of technical education and vocational training across various providers in Egypt. More specifically, in late 2022 amendments were approved to the law related to NAQAAE. Part of this legislative reform process is the approval of the development of the Egyptian National Qualification Framework (NQF), authorising NAQAAE to launch and govern the National Qualifications Framework (NQF). Within this framework, the following will be developed: National Qualifications Framework level descriptors (specified in terms of three domains of learning: knowledge, skills and competencies), articulation pathways, a National Register of Qualifications, a credit system (following an outcomes-based approach) and credit transfer system, as well as a system for recognising prior learning (both formal and informal) (ETF, 2023).

In addition, The Teacher Training Academy for VET (TVETA) was recently (2019) established (ETF, 2021a), while laws were approved on the institutions that will ensure the quality of technical education (ETQAAN and CEQAT). More than 40 Applied Technology Schools (ATS), in which the curricula were designed in partnership with the private sector, have been established. Another pilot project concerns Centres of competence (CoCs). These are state-of-the-art technical institutes that operate through a network of technical schools. Two SSCs have been established, which involve the private sector throughout the entire cycle from the identification of skills and occupational standards to competence assessments. Course upgrading is proceeding fast as well: more than 70% of technical education curricula have been transformed into competence-based curricula, with more than 60,000 teachers and staff receiving associated training (ETF, 2023).

Developments discussed above have started to stimulate demand for technical education in Egypt. The MoETE has been the main driver of this progress, supported by a cohesive development partners group including the EU, GIZ, the German Kreditanstalt fuer Wiederaufbau (KfW), AICS and USAID as main donors, UNICEF, World Food Programme (WFP) and ILO from the UN side (ETF, 2023). The European Training Foundation (ETF) has also established itself as key technical cooperation support. It regularly conducts a Torino Process on the state of the Egyptian technical education system and has provided

[5] For a detailed list, please refer to the MOHE's website: http://mohesr.gov.eg/en-us/Pages/home.aspx

[6] El-Shinawi, M. (2022). Presentation in Egypt-EU Union Stability and Social Development cluster

support to the EU Delegation for the identification of the action (EU Delegation, draft Action Document 2023)

As regards new training methods and the connection between education and training and market needs, the Education Development Fund (EDF), established in 2004, serves as an innovation incubator. EDF in cooperation with the Ministry of Education and Ministry of Higher Education pursues these goals by establishing a network of Integrated Technological Education Cluster's (ITECs). These aim to provide distinguished technical education, establish pilot centres to meet labour market needs, while also integrating the vision of policymakers involved in the process of education, training, and professional and industrial services. Each ITEC comprises of a 3-year technical secondary school, a 2-year intermediate technical college, and a 2-year advanced technical college. An example is Assiut-ITEC (established on 2013), which aims to provide modern and up-to-date vocational training in several stages and to support the regional enterprises by providing highly qualified skilled workers in the medium term (Ahmed and Sayed, 2020; 2021).

In terms of the labour market policy and regulation, the main entity responsible for managing and monitoring labour supply and demand and acting on improving the employability of the workforce is the **Ministry of Manpower** (MoMM). It administers a network of 300 employment offices. Many of these were, at least until recently, not well-resourced and their main activities included mostly the issuing of work permits and registrations (Amer, 2012). Governmental efforts to increase the employability of the labour force include the creation of several school-to-work transition and career-guidance units within the relevant ministries. These were originally planned only for the MoETE but have been also established in the MoMM and the Ministry of Trade and Industry (see below) in 2018.

Other efforts involve the cooperation of the public and private sectors in the training and up- / re-skilling. These include policies such as the "dual system" and are examined separately below. Governmental acts to aid this public-private cooperation involve the establishment of the **National Human Resource Development Council (**NHRDC), which recently replaced an older similar entity (ETF, 2021a). NCHRD is the recognised entity for the 30 Regional Units for the Dual System (see below) in technical and vocational education which currently supervise more than 28.000 apprentices in 176 schools across 42 different trades/professions (UNESCO, 2021). Its main activities include cooperating with the investors associations, standardising rules and procedures in managing and assuring the quality of the dual system, monitoring the provision of information regarding labour market needs from the Investors Associations, while at the same time raising awareness in society and amongst Egyptian youth regarding the value of work. It also supports other entities in developing their services to meet skill needs (e.g., in developing curricula, training of trainers, career counselling, etc.) (UNESCO, 2021). It has two executive councils under its jurisdiction, namely the **Executive TVET Council** and the **Executive Workforce Skills Development Council.**

From the labour demand side, the main actor is the **Ministry of Trade and Industry** (MoTI), which plays an indirect role in several policies, and sectoral federations and chambers. The MoTI acts through (a) the **Egyptian Accreditation Council** (EGAC), which provides accreditation (based on ISO standards) for bodies that certify training workshops and personnel (El-Ashmawi, 2019) and (b), through the **Enterprise-TVET Partnerships** (ETPs). These private sector stakeholders have a mainly consultative role in VET governance (UNESCO, 2021), such as providing analysis aiding the development of occupational profiles (El-Ashmawi, 2019). Another actor is the Ministry of Planning and Economic Development (MoPED), which in November 2021 began coordinating actions to establish new Sector Skills Councils (SSCs) and their umbrella organization. MoPED's mandate is to draft legislative acts that will govern the establishment of the umbrella entity and subsequently the SSCs and ensure initial funding for a period of 10 years (ETF, 2023).

The **EU** supports the development of the education sector. EU actions place an emphasis on increasing access to, and the quality of, education, especially for the most vulnerable parts of the population. In the area of VET, the EU is providing support through the TVET Egypt programme (2013-2022). This programme, which is the result of cooperation among both national and other international stakeholders, should improve the structure and performance of the TVET system to better respond to Egypt's rapidly changing socio-economic needs. It places a focus on enhancing the employability of the young people and improving national competitiveness (ETF, 2021a).

Public-Private Partnerships improving the skills of workers constitute an important source of training, to provide the skills that are increasingly in demand in the labour market. These include training through industry attachments or cooperative education, in-service training, and re-training of both employed and unemployed workers. Most of these schemes are developed under the supervision of the MoETE, sometimes with international support (e.g., Germany and the EU) (ETF, 2021a). Examples of such partnership schemes include the following.

- The **Dual system**: formally known as the Mubarak Kohl Initiative, it was introduced to Egyptian technical secondary schools in 1994, supported by the German Federal Ministry for Economic Cooperation and Development. This three -year-long scheme combines two days of formal schooling with four days of in-company training. Nowadays the scheme is fully integrated within the Egyptian education system, with 21 dedicated schools and 198 classes within traditional technical secondary schools. More than 15% of the registered companies in Egypt participate in it. (El-Ashmawi, 2019)
- **Productivity and Vocational Training Departments** under the supervision of MTI. It is based on enterprise-based work and training within the industrial sector, with students typically entering around the age of 15. This three-year programme offers training for around 40 industrial occupations and combines two years of formal education in a vocational training centre and one year of enterprise work (apprenticeship) (El-Ashmawi, 2019). Short courses for up- and re-skilling of employees and job seekers are also offered. A slightly different version of this programme was introduced in 1982 under the name “Training Station”. It differs from the conventional one in that the students spend 100% of their time within the enterprises which are responsible for the provision of both theoretical and practical knowledge (El-Ashmawi, 2019).
- A more recent example includes the joint occupational training centre ‘**EGT Academy’**, a partnership between Siemens, GIZ, and the Egyptian government. It was inaugurated in 2020 and is expected to provide training to more than 5 000 young Egyptians over the coming years to develop successive cohorts of skilled technicians to ensure the maintenance and repair of, among other things, power plants and wind farms (ETF, 2021a). This is seen as a necessary part of the country’s transition from fossil fuel to renewable energy generation.
- In 2018 the MoETE established “a new brand of schools” called Applied Technology Schools (ATS), as complementary to the dual system supported by the GIZ. These operate under public- private partnership schemes, where private companies have three agreement options depending on the level of responsibility they want or can undertake.[7] Up to date, 46 ATS have been established to date, while International Applied Technology Schools (IATS) were set up with support from USAID (El-Shinawi, 2022).

[7] This includes Full Partnership Agreement, Consortium Partnership, and Associate Partnership. Full Partnership is suitable for large and labour-intensive companies as well as with mega national projects. Consortium Partnership is suitable for medium-size enterprises, while Associate Partnership allows small and micro enterprises to participate in the apprenticeship programmes.

3. The Energy Sector in Egypt

KEY INSIGHTS FROM THIS CHAPTER

- Egypt's strategic location makes it a significant player in the international energy market, being the largest non-OPEC oil producer in Africa and the third-largest natural gas producer in the continent. The country is an important transit route for oil and LNG, mainly through the Suez Canal and the Suez-Mediterranean (SUMED) Pipeline.
- Egypt's Investment Map features numerous energy-related megaprojects, involving both fossil fuels extraction and renewable energy production. Fossil fuels remain the dominant source of electricity in Egypt (90%).
- Despite its vast potential, Egypt has been slow to adopt renewable energy sources, accounting for only 10% of the country's total installed power generation capacity. Recent policy shifts suggest an increased focus on harnessing renewable energy resources, with investments in solar and wind power generation systems.
- Major challenges of Egypt's energy sector include diversifying energy production towards renewables, addressing fuel subsidies and poorly implemented energy efficiency regulations, encouraging private sector participation in power generation projects, and improving the quality and sustainability of municipal infrastructures.
- The renewable energy sub-sector is important for Egypt's future employment trajectory with potential to increase employment and participation rates, engage youth, and improve female activity rates. From 2010 to 2020, overall energy sector employment decreased by 5.2%, with the largest declines in extraction of crude petroleum and natural gas (21%) and electricity, gas, and air-conditioning supply activities (13.7%).
- Employment in the energy sector is mostly concentrated in electricity, gas, and air-conditioning supply, although its share in total employment has decreased over time. Female employment in the energy sector is low and has been decreasing, with only 6.8% of energy sector jobs held by women in 2020. The renewable energy sector provides an opportunity to increase the share of employment taken by women, as it appears to have a better gender balance than conventional energy industries.
- Egypt's energy mix is not expected to change dramatically by 2030, but employment demand in renewable sectors is likely to increase, creating new skill demands in the economy.
- An increase in employment in both fossil fuel and renewable sectors is expected, with a shift in skills demand towards high-skilled professional, associate professional, and technical occupations, as well as skilled technicians for renewable energy projects.

3.1. Energy in Egypt at a glance: Resources and recent developments

Egypt has a significant role to play in the international energy (Hegazy, 2015) as it is in North Africa with approximately 3,000 km of coastlines on the Mediterranean, Red Sea and the Gulf of Suez, and Aqaba, and at the crossroads between the Europe, the Middle East, Asia and Africa. It is the largest non-OPEC oil producer in Africa and one of the leading dry natural gas producers in the region (the third-largest natural gas producer in Africa, following Algeria and Nigeria, EIA, 2022). According to the latest available data, crude oil production accounts for around 30 million tons and natural gas production for 35 million tons (CAPMAS, 2021).

Egypt’s location pinpoints its strategic position in the international energy market (Salah et al., 2022). The country is an important transit route for oil and liquified natural gas (LNG), mainly through the Suez Canal (CAPMAS, 2021) but also through the Suez-Mediterranean (SUMED) Pipeline. The Suez Canal is a transit route for oil and liquefied natural gas (LNG) shipments travelling from the Persian Gulf to Europe and North America. Shipments travelling from North Africa and other Mediterranean countries to Asia also move through the Suez Canal (EIA, 2022). Other than being an important partner in monitoring global energy resource transportation, Egypt is also the home of several other networks where all forms of energy resources are transported from Egypt towards neighbouring countries. These include, among others, the Arab Gas Pipeline (AGP), the subsea Eastern Mediterranean Gas (EMG) pipeline, as well as the Eight Countries Electric Interconnection Project, which transfers electricity across a broad part of the Northern Africa and Arab region.

The country's vision of arising as a major player in the global energy market is highlighted in its recent investment plans. The country's Investment Map includes several megaprojects related to energy, which are financed both by the government and by international donors and joints ventures of private and/or public agencies. These projects involve investments both in fossil fuels (natural gas and oil) extraction as well as in renewable energy (ILO, 2022b).

The latest developments in the production and consumption of the Egyptian energy sector are reviewed below in more detail for (i) fossil fuels extraction and transportation, (ii) electricity and hydroelectricity generation and transportation, and (iii) renewable energy production.

Fossil fuels

Egypt plays an important role as provider of oil and natural gas for neighbouring countries, and an equally important role in the transport and storage of fossil fuels for the rest of the world. Regarding production, eight petroleum refineries with a total nameplate capacity of approximately 762,000 b/d exist in Egypt.[8] Also, the country's natural gas production increased considerably after recent natural gas discoveries in the mid-2010s (which include the Zohr, Atoll, and West Nile Delta projects). Natural gas consumption, meanwhile, has remained relatively flat, allowing Egypt to export some of its surplus natural gas via pipelines and as LNG.

The country's untapped natural gas liquefaction capacity, which amounts to about 12 million tons of LNG annually, along with its strategic position (surrounded by smaller exporters), gives the country a future competitive advantage over other producers (e.g., Russia and Algeria), especially with regard to the EU.[9] Egypt currently has two LNG export facilities, the Spanish-Egyptian Gas Company (SEGAS) LNG facility and the Egyptian LNG facility (ELNG), as well as one floating storage and regasification unit. The country's LNG exports are primarily directed to the Asia Pacific region.

Regarding transportation, Egypt is home to two natural gas pipelines, namely the Arab Gas Pipeline (AGP) originating in Egypt, and running through Israel, Jordan, Syria, and Lebanon, and the subsea Eastern Mediterranean Gas (EMG) Pipeline connecting Israel and Egypt. These allow both the transfer of natural gas for consumption as well as exporting gas (mainly from Israel and Cyprus as a result of recent agreements) to Egypt for liquefaction and export to the EU. Similar negotiations are taking place between Egyptian and Greek officials. In addition, Egypt monitors the Suez Canal and the Suez-Mediterranean (SUMED) Pipeline, two major routes and transit chokepoints for crude oil and LNG shipments.[10] The country has strategically positioned its two crude oil storage facilities at the beginning and the end of the SUMED pipeline.

Sub-sectors with high potential for added value creation in the Egyptian fossil fuel industry include: (i) the compressed natural gas technology and peripherals; (ii) liquefied natural gas related technology; (iii) drilling rigs and related equipment; and (iv) state-of-the-art testing and measuring equipment.[11]

Electricity and hydroelectricity generation

A large share of the country's oil and natural gas consumption is used in electricity generation. The vast majority of Egypt's total electricity generation (about 90%) is produced through fossil fuel-derived

[8] "Refineries," Egyptian General Petroleum Corporation, accessed May 19, 2022. http://www.egpc.com.eg/Refinaries.aspx

[9] "Egypt's future in the LNG market", Middle East Institute https://www.mei.edu/publications/egypts-future-lng-market

[10] "World Oil Transit Chokepoints," U.S. Energy Information Administration, October 15, 2019, https://www.eia.gov/international/analysis/special-topics/World_Oil_Transit_Chokepoints

[11] Egypt Oil and Gas, Energy Resource Guide 2021, https://www.trade.gov/energy-resource-guide-egypt-oil-and-gas

sources (EIA, 2022).[12] The country's electricity grid connects to those of Libya, Jordan, and Syria under the Eight Countries Electric Interconnection Project. This project, which also involves the grids of Iraq, Lebanon, Palestine, and Turkey is currently under development.[13]

Egypt is the fourth highest country in Africa by the installed hydropower with a total capacity of 2800 MW (Salah et al. 2022). The main resource is the river Nile, with the highest potential for generation capacity being in Aswan (IRENA, 2018). Presently, there are five main hydropower plants (Aswan I, Esna, Aswan II, Naga Hamadi, Assiut and High Dam) with installed capacity of 280 MW,86 MW, 270 MW, 64, 32 MW and 2100 MW respectively (IRENA, 2018). Although hydroelectricity represented almost 50% of the Egypt's total generated electricity in the 1960s and 1970s, an increase in demand has mandated the use of fossil fuels for generating additional electricity. Hydropower is nowadays Egypt's third-largest energy source after fossil fuels. Nevertheless, concerns about potential water shortages in Egypt, and associated shortages in hydroelectricity generation, have emerged due to the plans of the Ethiopian government to build the Grand Ethiopian Renaissance Dam on the Blue Nile River, a dam with total capacity of 5.2 GW which can hold up to 2.6 trillion cubic feet of water (IRENA, 2018).

Egypt also plans to exploit **waste-to-energy** technologies to partially cope with increasing amount of waste and produce energy. The potential of sustainable waste-to-energy technologies, for the country is supported by recent studies[14]. Waste-to-energy projects relying on energy generation from municipal solid waste through pyrolysis and gasification are currently under development (Hemidat *et al.,* 2022).[15]

One such project is founded and run by a newly established Egyptian company Green Tech Egypt through an international consortium and involves the development of three Waste-to-energy projects in Egypt. The project's target is to process about 1.8 million tons of waste per year.[16] At present, the project is constructing the first waste-to-energy plant at the Giza governorate.[17]

Renewable energy sources

It is widely recognised that renewable energy sources such as power from sun (photovoltaic and solar thermal), hydro, wind and biomass-derived fuel have contributed to the sustainability in several countries with several environmental and socioeconomic benefits, and reliable and affordable power supply is an essential prerequisite for technological and economic growth (Aliyu et al., 2018). Egypt's uptake of renewable sources of energy has been slow in previous decades, owing to several barriers and constraints, such as political ones (lack of financial motives, information and access to adequate financial instruments supporting investments in renewables), and economic and technical ones (related to the absence of storage technology) (Patlitzianas, 2011). These resulted into a strong dependence on fossil energy supplies, which was exacerbated by the strong subsidies on fossil energy utilities (Ismail, 2014; Rady et al., 2018).

Only 10% of Egypt's total installed power generation capacity (around 54.5 GW in 2018) is from renewable energy technology (IRENA, 2018b), demonstrating that the level of utilised renewable resources sources in Egypt is still below its potential (Salah et al., 2022). Recent actions taken by the Egyptian authorities highlight a shift in the country's policies towards harnessing the power of renewable resources of energy, such as solar and wind power generation systems. Regarding the former, the government launched, in 2015, the 1.460 MW Benban solar power facility in Aswan Governorate, which today is Africa's largest solar park. The choice of location was based on studies and reports of NASA

[12] U.S. Energy Information Administration, International Energy Statistics database. https://www.eia.gov/international/data/world

[13] International Renewable Energy Agency, Renewable Energy Outlook: Egypt, October 2018.

[14] Salem *et al.* (2022). Potential of Waste to Energy Conversion in Egypt. Journal of Electrical and Computer Engineering, 7265553. https://doi.org/10.1155/2022/7265553

[15] Hemidat *et al.* (2022). Solid Waste Management in the Context of a Circular Economy in the MENA Region. Sustainability, 14, 480. https://doi.org/10.3390/su14010480

[16] Green Tech Egypt. Renewable Waste to Energy. Accessed 23 February 2023.

[17] Egypt Today. Egypt to establish waste-to-energy plant in Giza. 01 December 2022.

and international scientific institutions which confirmed that the site is one of the sunniest areas in the world. The investment cost of the project is about 3.4 billion euros, equivalent to EGP 40 billion. The project includes four main transmission stations and 40 solar sub-stations. Solar panels used in the station total 200,000 producing 50 megawatts of clean energy, which can illuminate 70,000 homes. Constructing and maintaining the site currently provides about 6 000 permanent job opportunities in the companies associated with the project (ECES, 2021). Other smaller scale projects are being planned, including the installation of solar panels on house and company rooftops allowing them to cover their electricity consumption and sell the surplus back to the electricity grid.

Egypt proves to be one of the best locations in the world for power generation from wind due to its high stable wind speeds and its large and uninhabited desert areas. The country currently has about 500 MW of wind power plants in operation. There are also three privately owned independent power producers (IPPs) with total generation capacity of about 2.5 GW. These operate under 20-year agreements with the state-owned electricity company (ITA, 2020). Several other wind farms are under development, with total generating capacity of 1340 MW.[18] . Sectors with high potential to benefit from these investments are wind turbines and towers construction and maintenance, photovoltaic panels and related technologies, and concentrated solar power equipment and related technologies.[19]

Egypt's recent interventions in the renewable energy sector include reforms to open the market to the private sector, which have resulted in boosting electricity supply (World Bank, 2021), as well as an agreement with the EU to reinforce their cooperation regarding energy trade, including renewable energy-produced green hydrogen supplies.

The above discussion points to the fact that, whereas the renewable energy sector (solar and wind power generation systems) is expected to be the key focal point in generating future employment, one should not neglect the conventional oil and gas extraction sector. For these reasons, the energy sector for this study is defined with reference to the following NACE sectors:

D 35 Electricity, gas, steam and air conditioning supply

B 06 Extraction of crude petroleum and natural gas

B 09 Mining support service activities

C 19 Manufacture of coke and refined petroleum products

The collection of the above sectors captures the generation of energy (NACE D35), and the materials used to generate energy supply (NACE B06, B09, C19).[20]

3.2. Key energy indicators in Egypt

A detailed breakdown of key indicators for the Egyptian energy sector is provided in Table 3.1. It reveals that Egypt has substantial oil and gas reserves. Concerning gas, in 2019 the proven reserves amounted to about 1.63% of the world's total reserves. In 2019 the country was a net exporter of both oil and gas as production exceeded consumption. Although coal has played a part in the country's energy power generation, it is 100% imported (mainly from Russia). Hydroelectricity amounted to about 16.2% of the country's total electricity generation (13.2 out of 81.5 TWh), while electricity from renewables was mainly though wind generation equipment. Power capacity generation from renewables amounted to about 0.25% of the world's generating capacity in 2019, but the introduction of new projects (see the discussion below) is expected to increase this. Notably, in 2019, the country's per capita primary energy consumption was about 51% of the world average per capita consumption. This figure is expected to

[18] An indicative list of these projects can be found in IRENA (2018, p. 26).

[19] International Trade Administration, "Egypt Country Commercial Guide: Renewable Energy," September 15, 2020. https://www.trade.gov/country-commercial-guides/egypt-renewable-energy

[20] It was opted to not consider the "Transport via pipeline" sector (NACE Code 49.5) due to unavailability of data. Relevant research cited in this report notes that the sector has some significance for the broad energy sector (as the country Is home to some major oil pipeline transport infrastructure). Quantitative information will be added in the background report if available via national sources.

increase in the future due to the population growth in Egypt which will pose challenges for the continuous and uninterrupted supply of energy in the country (Morsy, 2017).

Table 3.1: Detailed breakdown of the Egyptian Energy Sector, 2019

Indicator	Value	Details
CO_2 emissions	222.06 m. tones	growth p.a. 2009-2019: 2.34%
Oil: proven reserves	422.84 m. tones	0.18% of World reserves
Oil production	31.8 m. tones	0.71% of World production
Oil consumption	34.1 m. tones	0.77% of World consumption
Oil refining capacity	108.44 th. tones daily	0.78% of World capacity
Natural gas: proven reserves	2100 bn. m^3	1.63% of World reserves
Gas production	64.9 bn. m^3	1.63% of World production
Gas consumption	58.9 bn. m^3	1.51% of World consumption
Gas: LNG exports	4.5 bn. m^3	0.94% of World LNG exports
Coal: proven reserves	0	(Egypt has no coal reserves)
Coal production	0	
Coal consumption	0.08 exajoules	0.05% of World consumption
Hydroelectricity consumption	0.12 exajoules	0.31% of World consumption
Electricity generation (total)	200.6 TWh	0.01% of World generation
(by fuel) Oil	27.4 TWh	13.7% of Egypt’s total electricity generation
(by fuel) Natural gas	153.5 TWh	76.5% of Egypt’s total electricity generation
(by fuel) Hydropower	13.2 TWh	6.6% of Egypt’s total electricity generation
(by fuel) Renewables	6.5 TWh	3.3% of Egypt’s total electricity generation
(of which Wind)	4.6 TWh	70.8% of Egypt’s renewable power generation
(of which Solar)	1.9 TWh	29.2% of Egypt's renewable power generation
Renewable capacity (Solar)	1641 MW	0.28% of World capacity
Renewable capacity (Wind)	1375 MW	0.22% of World capacity
Primary energy consumption	3.86 exajoules	0.66% of World consumption
Primary energy consumption per capita	38.5 gigajoules	51% of World average

Source: BP (2021). Statistical Review of World Energy[21]

A comparison of Egypt’s energy production by type of fuel between 2000 and 2015 (see Table 3.2) shows that the apparent shift in renewable sources of energy has been rather slow over the first decade

[21] http://www.bp.com/statisticalreview

of the 21st century. Oil and natural gas remained the country's main energy production sources, while the increase in energy demand prompted an increase in electricity production form fossil fuels by about a factor of two between 2000 and 2015. The share of hydroelectric power generation has remained relatively stable across years, while the recent (after 2012) increase in the share of renewables points towards the increasing interest and potential in the use of renewable sources of energy production in Egypt.

Table 3.2: Primary energy production in Egypt, 2000-2015(% of total)

	2000	2005	2012	2015
coal	0.0%	0.0%	0.0%	0.0%
crude oil & oil products	69.3%	56.5%	45.4%	53.9%
natural gas	22.7%	34.5%	43.8%	31.8%
nuclear energy	0.0%	0.0%	0.0%	0.0%
electricity from fossil fuels	6.5%	7.9%	9.8%	13.1%
hydroelectricity	1.5%	1.0%	0.9%	1.1%
other renewable	0.0%	0.0%	0.1%	0.1%

Source: African Energy Commission (AFREC). (2017). Africa Energy Database.

Final energy consumption in Egypt has almost doubled between 2000 and 2015, reflecting the increasing demand for energy in the country in the 21st century. Most of this consumption is attributed to the industry and transport sectors, as well as residential homes (see Table 3.3). Over the years, the industry sector's share in energy consumption has gradually increased, while the transport's share has decreased. Energy consumption in the agricultural sector saw an increase between 2000 and 2005, but experienced a slight decline through 2020.

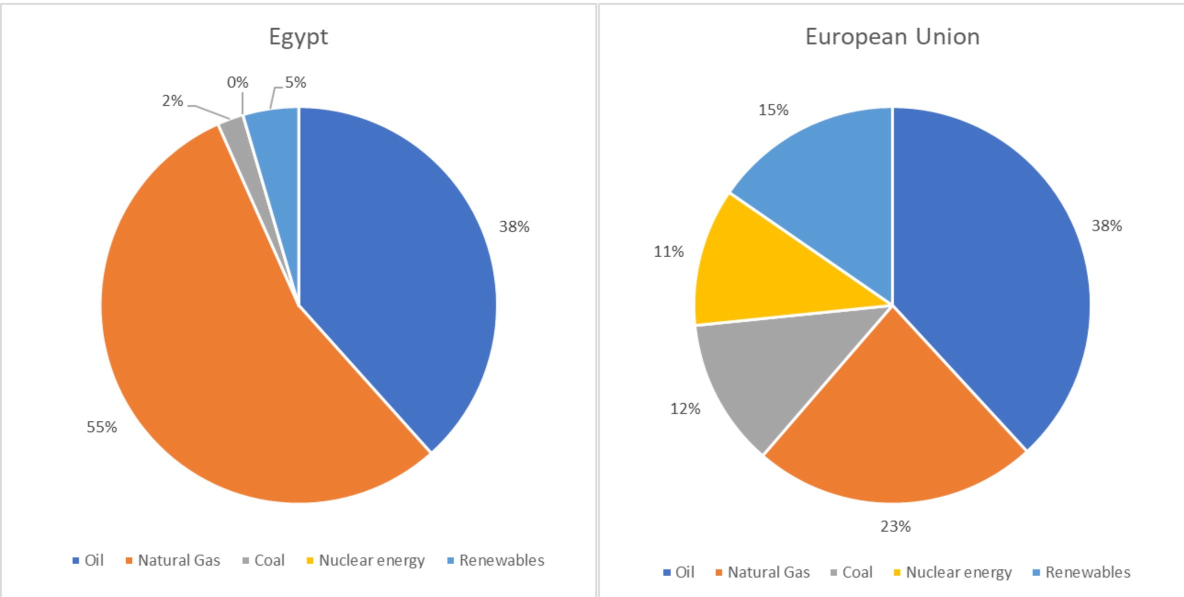
Table 3.3. Final energy consumption by sector in Egypt, 2000-2020 (% of total)

	2000	2005	2010	2015	2019	2020
industry sector	31.3%	32.9%	27.4%	35.3%	39.8%	37.7%
transport sector	30.3%	24.2%	28.1%	28.5%	26.0%	27.3%
agriculture sector	0.9%	4.9%	5.1%	3.2%	3.1%	3.2%
residential	23.5%	21.2%	22.3%	26.7%	25.5%	25.7%
services and other sectors	11.1%	17.3%	17.6%	6.3%	5.8%	6.2%

Source: Own calculations based on data from International Environmental Agency (years 2000, 2005, and 2010) and CAPMAS (years 2015, 2019, 2020)

Comparing energy consumption by source (see Figure 2.1.) between Egypt and the EU, we see that Egypt's economy is relatively more reliant on fossil fuels, while renewables account only for one third of the respective EU share. In addition, the EU harnesses a fair share of its power consumption from nuclear power plants (11%), while Egypt does not have such capacity yet.

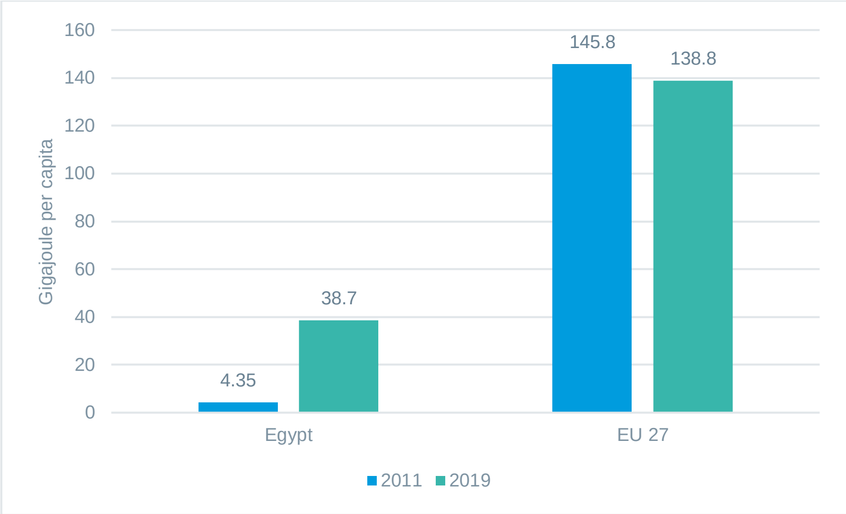
Figure 3.1: Egypt and EU energy consumption mix, 2019



Source: BP Statistical Review of World Energy, 2022.

Another indication of the increasing demand for energy in Egypt can be gauged by viewing the country's energy consumption per capita. From figure 3.2 we see that it increased by almost ten times between 2011 and 2019 (from 4 to almost 39 GJ/capita). In the EU-27, this appears to have slightly declined in the last decade.

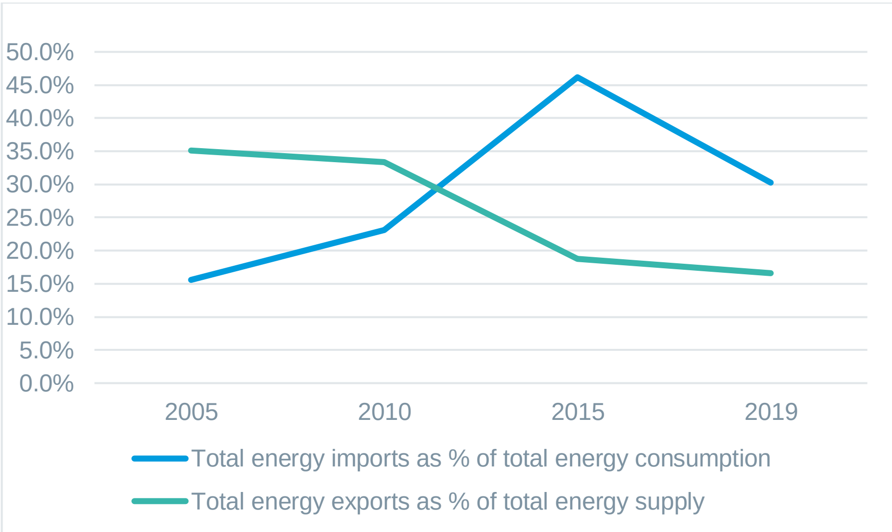
Figure 3.2: Energy consumption per capita, Egypt and EU-27, 2011 and 2019



Source: BP Statistical Review of World Energy, 2022.

Despite being a major producer and net exporter of oil, especially in the 1990s, the increasing demand for energy has resulted in Egypt turning to a net oil importer within the last decade. The country's self-sufficiency in terms of energy appears to have deteriorated in the last 15 years. Energy imports as a share of total energy consumption almost doubled by 15% to 30% in 2019. The reverse appears to have occurred for exports of energy (as a share of total energy supply).

Figure 3.3: Energy imports and exports in Egypt, 2005-2019



Source: Own calculations based on data from International Environmental Agency.

The data presented in this section point towards (a) an increasing energy demand in the country, which cannot be covered by domestic supply and deteriorates the country's dependency on imports, while at the same time reducing exports of energy to other countries and (b) a large dependency on fossil fuels, both for the production and consumption of energy. The use of renewables for energy production and consumption appears to be rather sluggish in the past two decades. However, recent investments in solar and wind power generation facilities may shift these figures in favour of renewables in the years to come. In view of climate change and Egypt's pursuit of a greener economy, this appears to be a necessity.

Several major challenges to Egypt's energy sector can be identified. First, energy (in particular, electricity) production needs to be further diversified towards renewables (ERDB, 2022). Second, the existence (as of lately) of fuel subsidies and poorly implemented regulations relating to energy efficiency (such as minimum energy performance standards) has resulted in the concentration of production in energy intensive sectors and discouraged efficient energy usage (Morsy, 2017). Third, there is a significant potential for the participation of private sector in power generation projects (Morsy, 2017). Fourth, the quality and sustainability of current municipal infrastructures is insufficient to meet growing demand and environmental pressures (ERDB, 2022). The main actors responsible to respond to these challenges are described in detail in the next section, along with several recent policies developments.

3.3. Sector governance and policies

The overall governance of the Egyptian energy sector at strategy and policy levels is guided by regulations and directions issued by the **Supreme Energy Council (SEC)** and is managed at the execution level by the **Ministry of Petroleum and Mineral Resources** and the **Ministry of Electricity and Renewable Energy (MOERE)**. The Supreme Energy Council reviews national energy strategies and policies, monitors the sector's performance, approves policies and regulations on energy pricing and is also responsible for incentivising actors to invest in the country's energy sector. The latter includes also investments targeting energy efficiency and renewable energy generation (IRENA, 2018).

The Ministry of Petroleum and Mineral Resources is responsible for the overall management of every activity related to petroleum and natural gas in the country's energy sector. These include the exploration, production and distribution of oil, oil products and gas, as well as all related services. (EIA, 2022). According to the Ministry, the management of the petroleum and gas sector is mainly conducted by five state-owned enterprises:[22]

- The **Egyptian Natural Gas Holding Company** (EGAS), which oversees the development, production, and marketing of natural gas, along with the issuance of gas exploitation licences.
- The **Egyptian Petrochemicals Holding Company** (ECHEM), managing the petrochemical sector (refinement of crude oil and related activities).
- The **Egyptian Mineral Resources Authority** (EMRA), which is responsible with the geological mapping of the country.
- the **Egyptian General Petroleum Corporation** (EGPC), and **Ganoub El-Wadi Holding Company** (Ganope). These two manage upstream oil activities and issue upstream licences.

The overall management of the electricity generation and transmission sector (which also includes renewable energy power generation) is conducted by the **Ministry of Electricity and Renewable Energy**. It oversees the generation, transmission, and distribution segments through several state-owned companies. The **Egyptian Electricity Holding Company** (EEHC) is responsible for power generation, which is conducted through its five subsidiaries,[23] while it also manages the transmission of electricity along with the **Egyptian Electricity Transmission Company** (EETC) (EEHC, 2012; IRENA, 2018; EIA, 2022).[24] The main responsibilities of the EEHC include, apart from the electricity production, transmission and distribution, the assessment of electrical energy resources, the estimation of sectoral electricity requirements, and future planning to meet future energy demands (Elbaset, 2009). The main roles of the EETC include electricity transmission and operation of the related networks, managing the

[22] "Organizational Structure of the Petroleum Sector," Arab Republic of Egypt, Ministry of Petroleum https://www.petroleum.gov.eg/ar-eg/about-ministry/Pages/petroleum-organization.aspx

[23] These are the Cairo Electricity Production Company, East Delta Electricity Production Company, Middle Delta Electricity Production Company, West Delta Electricity Production Company, and Upper Egypt Electricity Production Company

[24] The electricity transmission is conducted through nine other subsidiaries of the EEHC, namely the North Cairo, South Cairo, Alexandria, Canal, North Delta, South Delta, El-Behera, Middle Egypt and Upper Egypt Electricity Distribution Company.

use of the grid from third parties and protecting the interests of electricity producers and consumers (Fahmy and Hussein, 2020).[25]

The most important energy market regulator in Egypt is the **Egyptian Electricity Utility and Consumer Protection Regulatory Agency (EGYPTERA).** It is an independent authority with jurisdiction to supervise all key players in the electricity sector. It regulates and supervises all activities related to the production, transmission, distribution and consumption of electricity, such as monitoring the availability and quality of electricity, managing prices for the various types of electricity, and promoting environmental preservation and being a voice for the electricity consumers. Other authorities include the **New and Renewable Energy Authority**, which is responsible for forwarding and monitoring the implementation of the government's renewable energy plans, as well as the **Atomic Energy Authority** and the **Hydropower Plant Executive Authority**. These are supervised by the MOEE. (EIA, 2022)

The Egyptian government has pursued energy diversification and liberalisation by facilitating a market for private renewable energy development over recent years. Due to steady drops in its price, electricity produced by renewable sources has become more competitive than conventional fossil fuel sources. The phasing out of energy subsidies has also contributed to this (ETF, 2021a). As a result, strong demand has emerged lately from commercial and industrial heavy electricity consumers for access to electricity from private renewable energy producers in Egypt (ERBD, 2020).[26]

With the aim of modernising the country's energy sector, regulating the fossil fuels sector better, and shifting the focus on to renewables, the Egyptian government has established several laws and policy plans and strategies. Some of the most important pieces of legislation include the **Renewable Energy Law** (also known as the FiT Law), which aims to encourage the private sector to produce electricity from renewable energy sources by providing several options for support to renewable energy projects, and the **2015 Electricity Law**, which aims at encouraging transparency in the power market and attracting private sector participation. This is to be achieved by shifting the power sector from state-directed management to regulatory management, which could potentially increase private-sector investment. (Fahmy and Hussein, 2020). Another recent Law, the **Investment Law No. 72** was issued in 2017 to ensure investment guarantees and amendments as of May 2017, to establish a new arbitration centre for settling disputes, codifying social responsibility, and encouraging foreign investment in Egypt (IRENA, 2018)

Major strategies targeting alterative, sustainable, and renewable sources of energy production include the **Egyptian Solar Plan**, the **2035 Integrated Sustainable Energy Strategy**, and the **Egypt Vision 2030** strategy. The **Egyptian Solar Plan** was approved in 2012 and is currently under implementation. Its aim is to deliver an additional 3.5 GW of power via solar power systems by 2027. The **2035 Integrated Sustainable Energy Strategy** builds on previous strategies and sets further long-term goals for electricity generation from renewables, namely, to increase the supply of electricity generated from renewable sources to 20% by 2022 and 42% by 2035, with wind providing 14%, hydropower 2%, photovoltaic (PV) 25%, and concentrated solar power (CSP) 3% (EIA, 2022). Most of this capacity is expected to be delivered by the private sector through several public-private collaborations, some of which were mentioned above. Through its **Vision 2030** strategy, Egypt aims to achieve a diversified, competitive, and balanced economy within the framework of sustainable development. The strategy confirms Egypt's ambition to become an energy hub between Europe, Asia and Africa by expanding grid interconnections across the Arab region and beyond. The renewable energy plan up to 2023 includes government projects which aim to increase power generation capacity by 3.2. GW (ITA, 2020).

Collaboration with neighbouring countries is actively pursued in the last years, both for energy exports as well as establishing interconnections. Egypt has lately signed an agreement with the European Union (EU) to reinforce their cooperation regarding both liquified natural gas (LNG) and renewable energy-

[25] Fahmy, M, Hussein N (2020), "Electricity Regulation in Egypt," Thomson Reuters Practical Law, November 1, 2020 https://uk.practicallaw.thomsonreuters.com/w-028-8626?transitionType=Default&contextData=(sc.Default)&firstPage=true

[26] https://www.ebrd.com/news/2020/ebrd-becomes-shareholder-in-egypts-infinity-energy.html

produced green hydrogen supplies between Europe and Africa.[27] In addition, the Egyptian government plans to increase its cross-border transmission interconnections to neighbouring countries' electricity grids, aiming to become a regional hub for electricity circulation. Egypt and Jordan signed an agreement to double the current interconnection capacity of 500 MW to enable Egypt to begin supplying electricity to Iraq through its connection with Jordan. Additionally, Egypt and Saudi Arabia are constructing a new 3 GW electricity cable interconnection between the two countries. The project is expected to be operational by 2024 and to reach full capacity by 2025.[28]

3.4. Non-state institutional actors

Other than the state-owned companies, several non-state agencies are active in Egypt's energy sector. This includes private investors cooperating with government agencies for fossil fuel extraction and renewable energy generation, as well as international agencies and donors, which mostly focus on promoting the transition to renewable energy. State-owned EGAS and EGPC companies collaborate with leading private companies in several joint ventures to develop and operate oil and natural gas fields. In the petroleum sector, the most important companies are **Eni** and **Apache Energy**, while Eni, **BP**, Apache, and **Shell** are the main partners and collaborators in the natural gas sector. In the most recent licensing round for exploration blocks in 2019 and 2022, several international companies such as **Chevron,** Shell, **Mubadala Petroleum**, Eni, BP, **Apex International Energy**, and **United Energy** received exploitation permits.

The country's determination to turn greener and its vast capacity for renewable power generation have attracted the interest of several actors who invest or support renewable energy generation in Egypt. The **European Bank for Reconstruction and Development** (ERDB) is a major supporter of the country's efforts to increase the share of renewables in its energy mix. In the Bank's latest report in February 2022, the further expansion of the private renewable energy market, support for low carbon pathways, and the implementation of climate change mitigation and adaptation measures across the economy is listed as one of the major reform areas in the bank's 2022-2027 Strategy for Egypt (ERDB, 2022).[29] Through its latest actions and policies, the Bank emerges as a major actor and stakeholder in Egypt's renewable energy market. Some of these include the following:

- Assisting in the development of a national low-carbon hydrogen strategy.[30] The Bank signed a memorandum of understanding with the two ministries responsible for the energy sector to establish a framework for assessing the potential of low-carbon hydrogen supply chains, thus promoting the sustainable development of hydrogen as a decarbonised fuel for climate change mitigation, while ensuring cost effectiveness and identifying potential areas for investment.
- Lending up to US$ 4.8 million to the companies **Intro Sustainable Resources** and **Intro Solar S.A.E** in Egypt.[31] The loan will finance Intro-SR's equity stake in a portfolio of energy efficiency, waste to energy, waste management and solar photovoltaic (PV) projects. The projects include one of the first private-to-private energy generation projects in Egypt, aimed at promoting resource consumption efficiency.

[27] Joint Statement European Union-Egypt (press release 11 April 2022, Directorate-General for Climate Action) https://ec.europa.eu/clima/news-your-voice/news/joint-statement-european-union-egypt-2022-04-11_en

[28] "Egypt and Jordan to double capacity of interconnection," Energy & Utilities, November 29, 2021. https://energy-utilities.com/egypt-and-jordan-to-double-capacity-of-news115489.html

[29] ERDB (2022) Egypt Country Strategy 2022-2027 https://www.ebrd.com/documents/strategy-and-policy-coordination/egypt-country-strategy.pdf

[30] EBRD assesses low-carbon hydrogen in Egypt https://www.ebrd.com/news/2022/ebrd-assesses-lowcarbon-hydrogen-in-egypt.html

[31] EBRD promotes green energy transition in Egypt https://www.ebrd.com/news/2022/ebrd-promotes-green-energy-transition-in-egypt-.html

- Investing up to US$ 100 million in a certified green bond issuance of US$ 334.5 million, backed by six solar power plants owned by **Scatec ASA** (see below).[32]
- Supporting one of the first green private-to-private projects in the country, with an initial US$ 4.2 million loan to **TAQA PV for Solar Energy** company. This company is the renewable energy subsidiary of TAQA Arabia company. The loan is part of a financing package of up to US$ 10 million to expand TAQA Arabia's private-to-private renewable energy business. The EBRD funds will finance the construction and operation of a 6 MWp solar photovoltaic power plant.[33]
- Investing US$ 60 million to become a shareholder in **Infinity Energy S.A.E.,** one of Egypt's leading private energy companies through the issuance of new shares.[34]
- A joint US$ 252 million investment by the EBRD, the International Finance Corporation (IFC) and the Overseas Private Investment Corporation (OPIC), which will finance a new 250MW wind farm in the Gulf of Suez.[35]

Other actions of the bank in aiding Egypt's efforts towards greater energy efficiency and sustainability include the following.

- Under the EBRD Green Cities framework, supporting the development of greener public transport in Egypt by financing the upgrade of an existing rail line between downtown Alexandria and the north-eastern town of Abou Qir.[36]
- In 2019 the Bank engaged in supporting the development of a more resilient and robust electricity grid across Egypt with a €182.9 million loan to the Egyptian Electricity Transmission Company (EETC). The EBRD funds aim to facilitate the integration of 1.3 GW of new renewable energy into the Egyptian electricity system by connecting new renewable energy plants into the grid with the help of new or refurbished high-voltage substations, while reducing electricity losses.[37]

Private actors engaged in Egypt's renewable energy sector include Egyptian companies such as **SolarizEgypt** and overseas firms such as **Scatec ASA**, and **Lekela**. **SolarizEgypt** has recently implemented the first rooftop photovoltaic (PV) system through a private-to-private power purchase agreement (PPA) in the country. The company is an independent power producer (IPP) based in Egypt, selling electricity to the private sector under the net metering scheme with a 25-year guarantee on the installed PV systems.[38] To date, it has implemented seven PV system projects support in different areas in the country, helping to save over 88,000 MWh of energy. **Scatec ASA** has been involved in renewable energy projects in Egypt since 2017, when it signed 25-year Power Purchase Agreements for delivery of electricity from six plants totalling 380 MW with the Government of Egypt. The Benban solar plant is Scatec's largest solar project and the first one using bifacial solar modules (producing energy from both sides of the solar panel, increasing the total clean energy generation). In 2022 Scatec and its partners refinanced the non-recourse project debt for six solar power plants in Egypt through the issuance of a 19-year USD 334.5 million non-recourse Green Project Bond.[39] **Lekela Power BV** is a renewable power generation company which was engaged in the West Bakr Wind project in the Gulf of Suez. The project

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32 EBRD invests in Scatec green bond https://www.ebrd.com/news/2022/ebrd-invests-in-scatec-green-bond-.html

33 EBRD and TAQA Arabia promote private-to-private renewable energy in Egypt https://www.ebrd.com/news/2020/ebrd-and-taqa-arabia-promote-privatetoprivate-renewable-energy-in-egypt-.html

34 EBRD becomes shareholder in Egypt's Infinity Energy https://www.ebrd.com/news/2020/ebrd-becomes-shareholder-in-egypts-infinity-energy.html

35 US$ 252 million loan for 250 MW wind farm in Gulf of Suez https://www.ebrd.com/news/2019/us-252-million-loan-for-250-mw-wind-farm-in-gulf-of-suez.html

36 EBRD promotes greener urban transport in Egypt https://www.ebrd.com/news/2022/ebrd-promotes-greener-urban-transport-in-egypt-.html

37 EBRD supporting access to renewable energy in Egypt https://www.ebrd.com/news/2019/ebrd-supporting-access-to-renewable-energy-in-egypt.html

38 EBRD and EU help SolarizEgypt promote rooftop solar panels in Egypt https://www.ebrd.com/news/2020/ebrd-and-eu-help-solarizegypt-promote-rooftop-solar-panels-in-egypt.html

39 https://scatec.com/2022/04/28/scatec-refinances-six-power-plants-in-egypt-with-a-green-project-bond/

started operating in 2021 and uses wind resource to produce 252MW of clean, reliable power at a highly competitive price.

3.3 Employment in the Egyptian energy sector

3.3.1 Overall employment trends and patterns

From the above discussion it is evident that the energy sector, and most importantly the sub-sector of renewables, arises as particularly important for the future employment trajectory of the country. The latest empirical evidence points to the further exploitation of the country's renewable and clean energy potential having positive effects on employment (Ibrahiem and Sameh, 2020) and may aid the employment and participation rates to increase and engage more youth in employment and training, and potentially improve female activity rates. The provision of adequate skills for harnessing the country's abundant clean energy opportunities is vital (Aliyu et al., 2018). A greater uptake of solar and wind energy power generation systems, along with the generation of the necessary transmission mechanisms will require a larger amount of some occupational positions and skill sets that are already utilized within the country but will also demand some newer that at this point are under-represented.

The aim of this section is to deliver a summary of the past and current composition of the labour market in Egypt specifically for the energy sector, as this was defined in the previous section. This will provide insights regarding the shifting skill needs in the sector. More specifically, we investigate the composition for the following NACE sectors:

D 35 Electricity, gas, steam, and air conditioning supply

B 06 Extraction of crude petroleum and natural gas

B 09 Mining support service activities

C 19 Manufacture of coke and refined petroleum products

Figure 3.4 shows employment trajectory for each of the selected energy sub-sectors from 2010 to 2020, while Figure 2.5. shows the change in employment in each sub-sector from 2010 to 2020. In aggregate terms, employment decreased from around 357 thousand workers in 2010 to 338 thousand workers in 2020, that is, by 5.2%. This is in contrast with the notable employment increase in total employment in the same period, which was almost 10%. Energy sector employment hit a low in 2016 (276 thousand workers) but recovered ever since. Employment was historically concentrated in *Electricity, gas, steam and air conditioning supply* (75% in 2010), followed by *Petroleum manufacturing* (22% in 2010). Within the last decade, this structure has not changed much.[40] As a share of total employment, employment in the energy subsectors considered decreased from 1.5% in 2010 to 1.3% in 2020 (see Table 2.4). The drop in overall energy-related employment is attributed to the large decline in employment in *Extraction of crude petroleum and natural gas* (21%) and *Electricity, gas and air-conditioning supply activities* (13.7%). However, employment in the *Mining support service activities* has increased by 29% between 2010 and 2020, while works in the petroleum manufacturing sector also increased by 24.5%. These developments could be partly attributed to the country's shift towards renewables, but it could also be attributed to the economic crisis and the Arab Spring turmoil, which brought the extraction industry to a standstill. The opposite courses in employment in extraction and manufacturing of oil might be "cyclical', i.e., related to the discoveries of new oil and natural gas reserves taking place in the 2000's, which might require more workers in that time to operate drilling facilities and more in the next decade to be employed to manufacturing facilities. The large increase in oil manufacturing employment may also be attributed to the surge in demand for energy in the country in the last 10 to 15 years and can be related to the increase in the share if energy consumed in the transport industry (see Table 2.3). New discoveries of reserves, collaborations with international companies, and the gradual economic recovery from the pandemic could boost employment again in the extraction industry in the future. The drop in employment

[40] In 2020, employment share of electricity, gas, steam and air conditioning supply reduced to 68% and that of petroleum manufacturing increased to 28%.

in the electricity sector despite the country's interest in renewables may hint towards a skill mismatch between the country's current level of expertise and that required for working in the renewables industry.

Figure 3.4: Employment in selected sectors, 2010-2020 (000s)

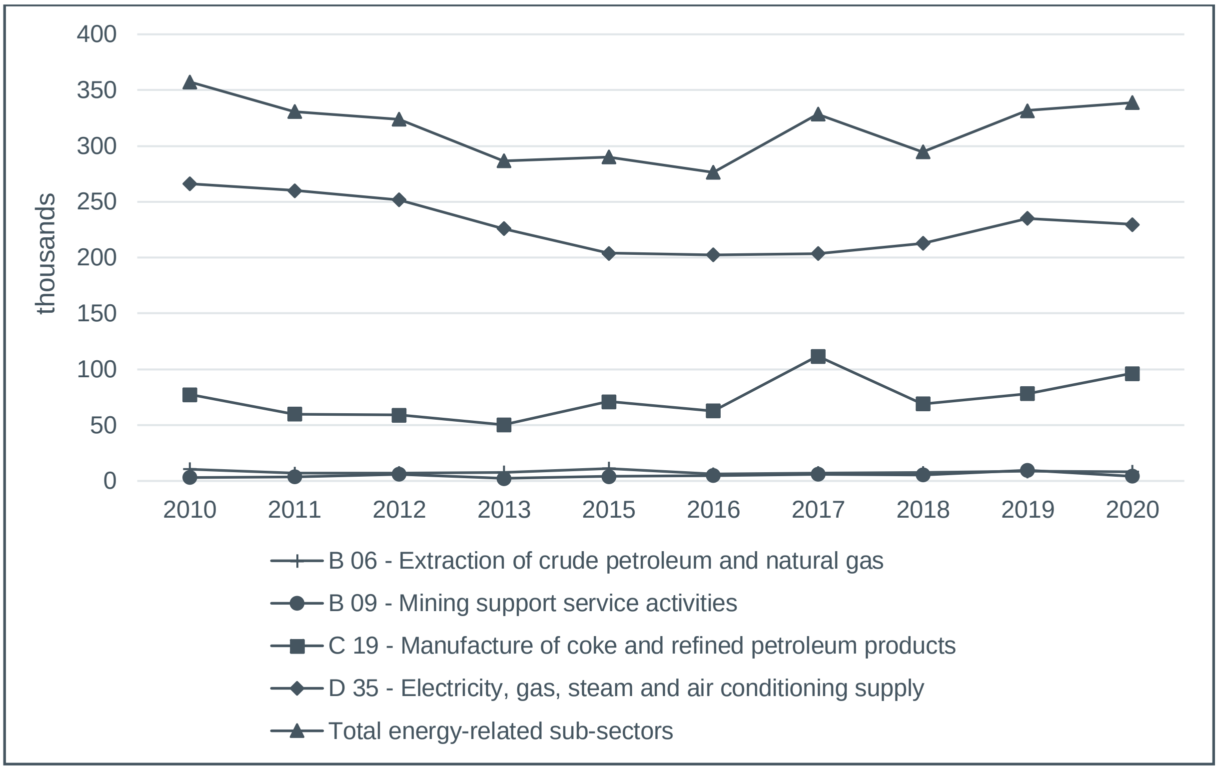
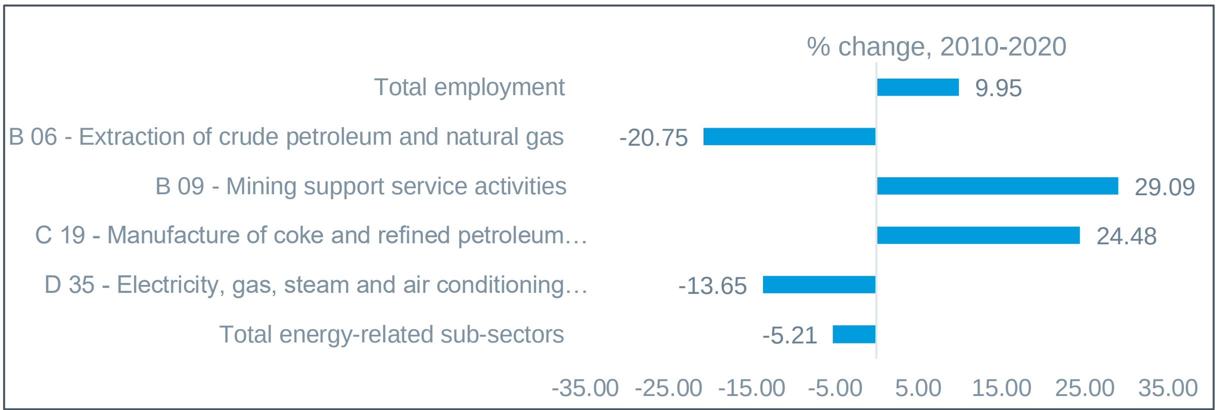


Figure 3.5: Employment change in selected sectors, 2010-2020 (%)



Source: ILOSTAT

The magnitude of employment in each of the energy-related sub-sectors, as a share of total Egyptian employment is shown in Table 3.4 below. Most employment is concentrated in the electricity, gas, and air-conditioning supply sector. Although employment in this sector as a share of total employment in Egypt has decreased over time (from 1.12% in 2010 to 0.88% in 2020), the share has remained by far the largest compared to the other two energy sub-sectors. Employment in mining and support service activities has increased (about 3.2 thousand workers in 2010 to 4.2 thousand in 2020), while the extraction of crude petroleum and natural gas sector appears to have lost more than two thousand jobs (from 10.5 thousand in 2010 to 8.3 thousand in 2020). In absolute terms, employment in the manufacturing of petroleum products (by almost 20 thousand workers) might compensate for the decline in extraction employment but cannot compensate for the one in the electricity sector (about 36 thousand workers).

Table 3.4: Share of employment accounted for by energy and energy related sectors, 2010, 2015, 2020 (%)

	2010	2015	2020
B 06 - Extraction of crude petroleum and natural gas	0.04%	0.04%	0.03%
B 09 - Mining support service activities	0.01%	0.02%	0.02%
C 19 - Manufacture of coke and refined petroleum products	0.32%	0.29%	0.37%
D 35 - Electricity, gas, steam and air conditioning supply	1.12%	0.82%	0.88%
Total energy-related sub-sectors	1.50%	1.17%	1.29%

Source: ILOSTAT

While the country's current energy mix is not expected to change dramatically over the present decade (up to 2030) – with fossil fuel extraction probably remaining a major source of energy – it is expected that employment demand in sectors related to renewables will gain pace. This may be anticipated considering the multitude of large public-private and private-private partnerships that Egypt is currently engaged in linked to, for example, wind and solar power energy. It is also expected that this increase in demand will lead to new skill demands in the economy.[41]

3.3.2 Socio-demographic and educational characteristics of employment

In addition to looking at employers, there is also a need to look at the characteristics of the workforce with respect to, gender, age and educational attainment.

The limited participation of women in the labour market and their low employment rates was noted earlier as a major issue in Egypt's labour market. Female employment in the sector is very low compared with men (see Table 2.6). Moreover, the share of female employment in the sector has been getting smaller over the years– from 8.7% in 2010 to 6.8% in 2020. This under representation of women in the sector can be linked to a wider issue of participation of women in the national economy (in the economy as a whole, women accounted for 15% of overall employment in 2020). However, it also shows a particularly limited representation in the energy sector, which may be related to different elements, such as socio-cultural norms, sector segregation, limited participation of women in educational paths linked to energy. Whatever the reasons, an important source of labour and skills supply is clearly missed in the sector.

Table 2.6: Share of female employment in energy and energy related sectors (%)

	2010	2016	2019	2020
All employment, across all sectors	19.6	21.1	15.3	15.0
The energy sector:				
06 - Extraction of crude petroleum and natural gas	16.3	4.8	0 or n/a	0 or n/a
09 - Mining support service activities	0 or n/a	5.4	0 or n/a	0 or n/a
19- Manufacture of coke and refined petroleum products	8.9	5.8	6.4	5.7

[41] It was not possible to analyse occupational distribution of employment and other issues due to lack of access to data.

35 - Electricity, gas, steam and air conditioning supply	8.5	5.9	7.3	7.6
Total energy-related sub-sectors	8.8	5.9	6.7	6.8

Source: ILOSTAT

3.4 Conclusion

The analysis provides a detailed overview of current trends in energy-related sectors in Egypt, which can be summarised as follows.

- Employment in the Egyptian energy sector has decreased in the past decade.
- Employment in fossil fuel extraction and manufacturing industries, on the other hand, has increased, potentially indicating a greater focus on manufacturing fossil fuels than extracting crude ones.
- Most of the energy-related employment is still in traditional, fossil fuel related sub-sectors.
- Female participation in the sector remains very limited and has not improved thus far (on the contrary, it even decreased in the last decade).[42]

Combining these findings with the latest developments in the country's energy sector, namely the need for a balanced reliance on oil and gas reserves and renewables, several remarks may be made. First, an increase in employment in both the fossil fuel and renewable parts of the sector can be expected. Second, greater uptake of solar and wind energy projects is expected to shift skills demand towards high-skilled professional, associate professional, and technical occupations, heavily engaged in the construction of large-scale energy projects. This, however, relies heavily on public-private collaborations for the construction of new solar and wind farms develops as planned. Third, future needs for repairing and expanding the capacity of such projects will create increased demand for skilled technicians. Fourth, the renewable energy sector, which comprises state-of-the-art technology and potentially new technological advancements in fossil fuel extraction, may increase the demand for STEM professionals. This appears to have already acted as a signal for VET providers given the interest in updating curricula and developing new training programmes to facilitate the transfer of workers from other sectors to energy jobs through upskilling and reskilling. Fifth, these future developments in the energy sector provide an opportunity to increase the share of employment taken by women, as the renewables industry appears to have a rather better gender balance than conventional energy industries (IRENA and ILO, 2022).

[42] Additional insights to the background report will be supplied through the provision of missing data and through the discussions in the stakeholder meetings and company interviews.

4. KEY DRIVERS OF CHANGE IN THE SECTOR

KEY INSIGHTS FROM THIS CHAPTER

- The following factors are significant drivers of change in the energy sector in Egypt:
  - Geographical position, which affects the availability of energy sources and water shortage issues; and energy distribution routes.
  - Climate change, which necessitates a shift toward renewable energy and increased efficiency, while also impacting water resources and infrastructure.
  - Infrastructure development, which is expected to create new jobs and demand new competencies.
  - Industrial and population growth, which affect energy demands.
  - Investment availability, from both private and national/international institutions.
  - National and international policies and regulations as the energy sector is heavily influenced by both national and international policies and agreements.
  - Geopolitical factors.
  - Technological developments, which allow for new solutions and business models, such as decentralized energy production.
- These drivers are essential in shaping the future skill needs and understanding the evolution of the job market within the energy sector in Egypt.
- Over the last decade, patent activity in Egypt's energy sector experienced a decline, which indicates a lag in keeping pace with global technological advances. However, the country has great potential in renewable energy sources, such as solar and wind power, which could create new job opportunities in the sector. Despite the decline in patent activity, Egypt is likely to benefit from technologies in energy transmission and distribution, hydrogen energy, wind energy, and solar energy, as these areas demonstrate a growing trend of innovation and market growth.

To identify possible key drivers of change within the Egyptian energy sector, there are various possibilities in terms of data sources and methodologies that can be adopted. For the present study, multiple databases of open-access scientific literature and a set of documents from selected websites, all related to the energy sector in Egypt, have been used in the first part of the chapter to determine societal and economical drivers. In the second part, Egyptian and international patents have been studied instead to determine the technological innovation and their trends.

4.1 Analysis of scientific literature to extract drivers of change

Rapid technological development is a major factor influencing the demand for skills, but it does not account for everything. There are many other factors such as environmental concerns, economic and population growth, geographical position, etc., which all contribute to shape the future skill needs. Given that drivers of change are defined as those factors that influence or even guide the evolution of the job market, the present section is focused on the identification of the major non-technical drivers of change inside the energy sector.

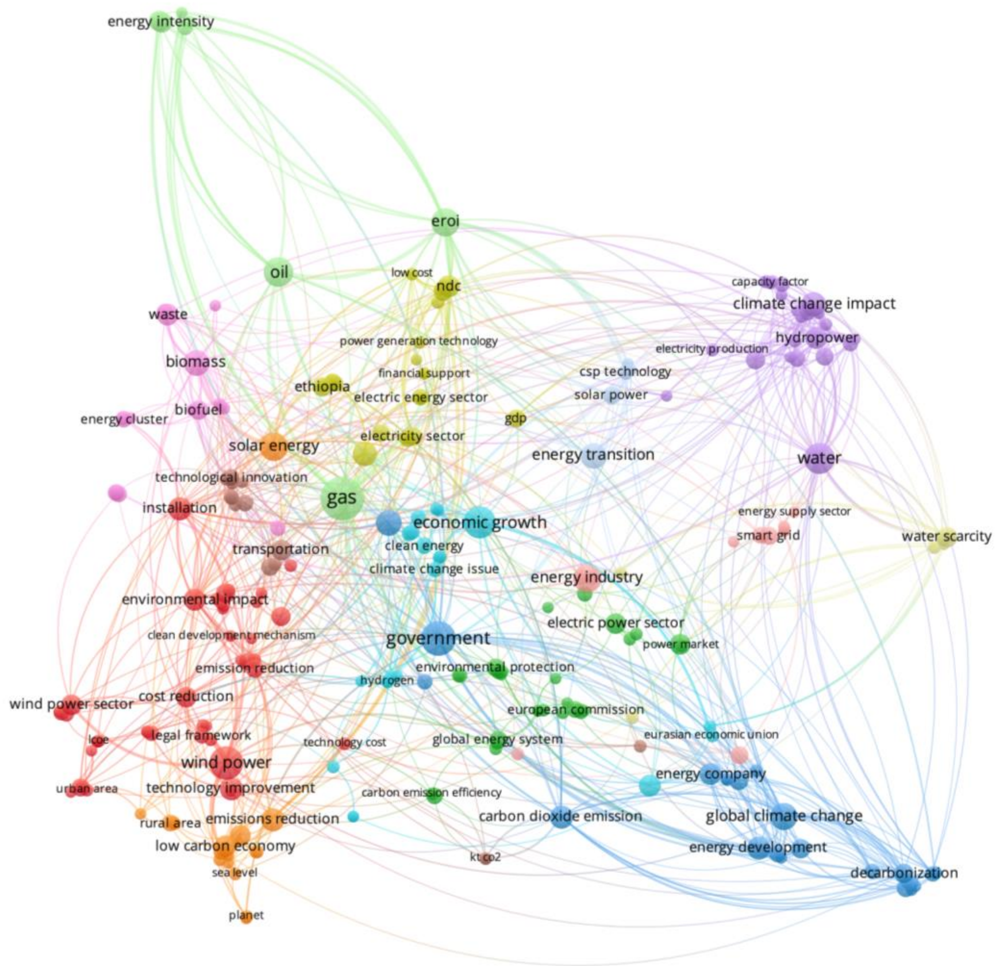
The first step is aimed at extracting the most relevant concepts present in the literature, highlighting thematic clusters and the relationships among them. In particular, the entire openAire[43] database has been scanned to find scientific papers related to the energy sector in Egypt; the data pool has been integrated with papers from Google Scholar[44] and ResearchGate[45]. Then the most recurrent keywords have been mapped using a network diagram.

An example of the output is shown below in Figure 4.1: the nodes represent the topics found in the papers and arcs are formed when at least two topics are mentioned within the same paper. The bigger the node, the higher is the frequency with which that concept appears in papers.

Figure 4.1 illustrates in an intuitive way the clustering and correlation approach adopted in the study. For example the concepts around the blue and violet clusters in the picture are related to the general topic of climate change, covering all aspects of the issue, from the consequent water scarcity problem to measures to reduce the damages such as decarbonisation; various specific concepts connects the climate change cluster to other clusters such as for example that of governmental policies (since of course institutional actions can affect, positively or negatively, the climate change issue).

Figure 4.1 however is not to be considered a complete representation; the picture shows, for sake of simplicity, just a part of the overall graph of relationships between the various relevant concepts.

Figure 4.1: Network graph of the keywords extracted from papers related to Energy in Egypt



[43] https://www.openaire.eu

[44] https://scholar.google.com

[45] https://www.researchgate.net

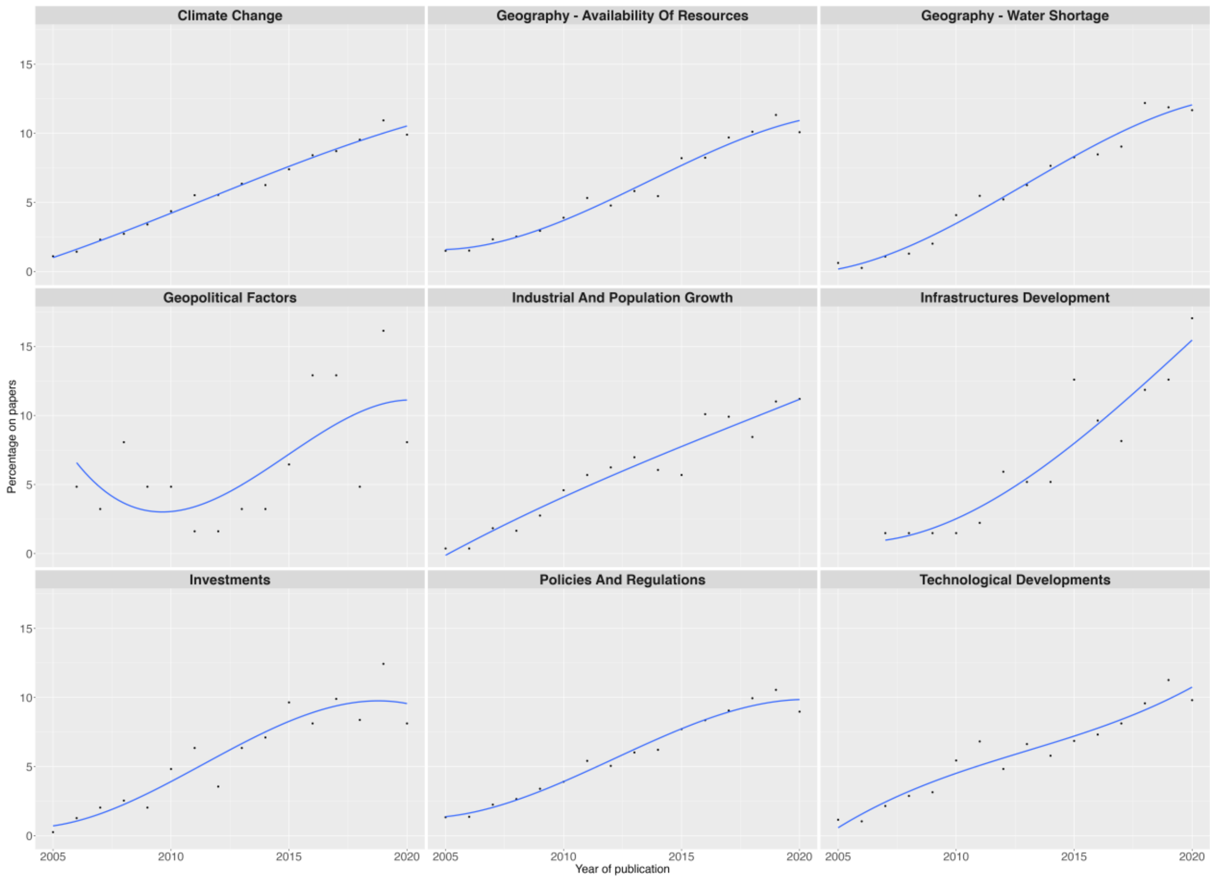
Once the entire network of concepts and relationships (of which the graph in Figure 4.1 is just a snapshot) has been determined, it is possible to study the temporal trends followed by each topic to identify which ones may affect the energy sector in Egypt in the coming years.

A driver of change is a factor that strongly influences the evolution of future scenarios, rather than present-day activities. Such factors can be identified by cross-checking the clusters of topics through the analysis of their evolutionary trends (in terms of number of occurrences in the literature).

In Figure 4.2, each plot represents the distribution of articles related to certain topics over the years. For the reasons discussed above, only topics that display growing trends are shown in the picture and can be considered relevant drivers of change.

For example, there is an ever-increasing attention in the literature to the topic of infrastructure development (last plot in the middle row), which passed from almost no mention in early 2000s, to being one of the most important topics (over 15% of total mentions) in 2020. This is a clear indication (as we will discuss more in detail shortly after) that upgrading the existing infrastructure will be actively pursued in the country, and thus will create new jobs and at the same time will increase the demand for new and specific sets of competencies, as the technical requirements of modern grids and of larger apparatuses are constantly changing.

Figure 4.2: Trends of drivers of change found in papers related to the energy sector



Note: values in the last year in the plots are not final (due to the referee and publication process). They could be not representing the real number of articles related to each specific topic.

According to the trends in Figure 3.2, the clusters with greater and increasing relevance within the scientific literature related to Egypt are: the advantages and constraints related to the **geographical position,** which in turn further articulates the **availability of energy sources** (including proximity to **energy distribution routes)** and in the issue of **water shortage;** the global issue of **climate change** that is affecting Egypt in various ways; the need for further **infrastructure development**; the rapid

industrial and population growth of the country; the availability of **investments**, both private and from national and international institutions to foster the planned developments; national and international **policies and regulations**; **geopolitical factors;** and last but not least the obvious importance of new **technological developments,** which alongside the introduction of more advanced solutions also allow for new business models, e.g. with the decentralisation of energy production.

The identified drivers of change are also shown in a pictorial way in the tagcloud of Figure 4.3, where the size of each driver is proportional to the number of occurrences of references to the same within the scientific literature.

Figure 4.3: Tagcloud of the drivers of change

The network analysis allows providing more details for each driver:

- Geography is a fundamental driver of change: indeed, Egypt's location made the country extremely rich in terms of **availability of a variety of energy sources**.

  Oil and gas reserves had always been abundant: at the end of 2018, the proven hydrocarbon reserves amounted to 3.3 billion barrels of oil and 77.2 trillion cubic feet of natural gas (International Trade Administration, 2020). The discovery in 2015 of the Zohr gas field, the largest natural gas field in the Mediterranean, is expected to almost double the country's reserves of natural gas, and the recently discovered Noor gas field could be even more significant. Large reserves of shale oil are also present in desert areas, but their exploitation raises environmental concerns.

Such availability has two opposite consequences. On one hand, the new fields are transforming Egypt from being a net importer of energy to a gas exporter, and they will ease the struggle to meet domestic demand in the coming years. On the other hand, Egypt's reliance on fossil sources, coupled with hydrocarbon production being the most relevant industrial activity of the country, presents a major obstacle to its transition towards a 100% renewable energy system.

The abundance of oil and gas reserves has an impact on the job market since the government is making substantial investments in developing and updating its already important petrochemicals sector (e.g., refineries). Moreover, the construction of gas pipelines (such as the Arab Gas Pipeline) and of facilities to produce and export liquefied natural gas will need dedicated workforce.

Moving to renewable sources, historically the largest part of Egypt's electricity comes from hydropower generated by the three large Aswan dams over the Nile (Hegazy, 2015). The Aswan High Dam has a theoretical generating capacity of 2.1GW; however, the dam is rarely able to operate at full design capacity due to low water levels (see below for the water shortage issue). An on-going refurbishment programme is being enacted to not only increase the generating capacity of the dam to 2.4GW, but also extend the operational life of the turbines by about 40 years. Interestingly, the dam includes an on-site training centre with courses specialising in mechanical and electrical engineering.

The geographical position also influences the availability of solar energy. In some areas, the country receives over 4,000 hours of sunshine per year, which is among the highest quantities registered in the world, with an estimate power of 2,000 to 3,000 kWh/m2/year of direct solar radiation. Considering the availability of large areas of inhabited, desert land where solar plants can be safely installed, the country's potential for solar energy is huge. Indeed, in 2019 Egypt completed one of the biggest solar installations in the world, Benban Solar Park, which generates 1.8 GW to power 1 million homes, and in 2021, Egypt signed contracts worth $700 million for 32 solar energy projects which would create 10,000 jobs. In terms of jobs and competencies, it is worth noting that in the country are also present a few national manufacturing plants for photovoltaic panels.

Finally, Egypt enjoys excellent wind along the Gulf of Suez with an average wind speed of 10.5 m/sec. Although the country is a pioneer of wind energy in Africa and the MENA region, with the first pilot dating back to1980, the rate of development for this source is not as fast as that for solar energy; nevertheless, a batch of wind power plants are planned to be installed and operational by 2023 (IRENA, 2018) under a build-own-operate (BOO) scheme. As of today, there are no national manufacturing facilities for wind solutions, but Siemens is involved under an EPC and finance scheme to construct a local manufacturing facility for the wind power plants' blades.

- Egypt's geographical position is not only favourable in terms of energy sources, but also in terms of **proximity to major energy distribution routes**. Apart from the already mentioned system of natural gas pipelines and facilities for liquefied natural gas to export local production, Egypt plays a vital role in international energy markets through the operations of the two Suez Canal transit points and the Suez-Mediterranean (SUMED) pipeline. The Suez Canal is an important transit route for oil and liquefied natural gas (LNG) shipments travelling southbound from North Africa and along the Mediterranean Sea to Asia. Fees collected from the operation of these two transit points are significant sources of revenue for the Egyptian government.

  Moreover, the new European Hydrogen strategy points at new opportunities: locally produced hydrogen could be exported to nearby countries as part of a joint hydrogen strategy between Europe and North Africa, via a new pipeline through Greece to Italy (van Wijk et al., 2019).

- However, the country's geography determines also important drawbacks, mainly in terms of **water shortage**. Most of the Egyptian population lives near the Nile River as the shortage of freshwater resources in remote and rural areas is limiting population settlement and development. In general, currently, Egypt's water supply does not meet its water demand. Therefore, it is necessary to find alternative solutions including **saline water desalination** processes to assist obtaining fresh water for domestic and industrial purposes in* these remote areas (Alaa El-Sadek, 2010). While seawater desalination is a key factor for national development in Egypt, and the government plans to expand the desalination capacity to 2.9 million m^3 per day by 2050 (Molina, 2020), the energy needed for the desalination process represents another challenge due to the additional demand it puts on a system already under stress, still heavily relying on fossil fuels and with increasing prices (Kashyout, 2021).

Hydropower generation also has an uncertain future, in part due to decreasing water reserves caused by climate change (see below), but mainly due to the construction of the great Ethiopian Renaissance Dam (GERD) on the Nile (Abdelhadi, 2020), which is decreasing the river flow and is likely to increase the risk of drought along the Nile if no negotiated international solution is agreed.

- **Climate change** is strongly related to energy in various ways: the need to switch to renewable energies and increased efficiency in order to reduce carbon emissions, but also the increased electricity consumption in households for air conditioning, the worsening of any water shortage issue including the disruption in hydroelectric generation, and last but not least the more severe weather conditions where hurricanes, floods and other natural disasters can damage infrastructures and disrupt the supply of energy. All such problems are present in Egypt (as various keywords emerged from the analysis have highlighted, such as *desert*, *Nile delta*, *low rainfall*, *hot summers* and *huge cities*,), making the country very vulnerable to the negative consequences of climate change.

- The country's **population and industrial growth** constitute another key driver of change. Egypt's population is one of the highest of the MENA area and is growing at a rate of 1.7% every year, with a rapid increase also in urbanisation levels and living standards. At the same time, Egypt is a major economy in the African continent and its industry is the main final energy user, followed by transport and residential. Both factors (demography and industrial development) are responsible of the huge – and constantly increasing - electricity demand of the country. In the recent past, production could not keep pace with demand, leading to blackouts and power cuts, which in turn produced social unrest and economic problems. The need to avoid such shortages has informed many of the national policies (see below); a series of reforms and actions, coupled with the expansion of the natural gas production, have allowed current production to exceed demand. Yet, all future planning will have to consider the ever-increasing demand.

- Another important factor that can favour or hinder the development of the energy sector is the presence of an **adequate transmission and distribution infrastructure**. Part of past energy shortages was also due to an old and inefficient grid. Over the last ten years, Egypt's infrastructure has significantly improved to overcome the heavy load shedding at the beginning of the 2010s. However, despite great progresses and expansions, not all parts of the grid have been included in the retrofit, meaning that grid losses at transmission and distribution levels continue to be a challenge. Adding further efficiency measures would produce immediate economic benefits and create new jobs.

  Other opportunities can be created at the distribution side. For example, to obtain a license for installation of rooftop photovoltaic systems and electrical vehicle charging stations it is now required to submit a grid impact study in advance, which will require new professional profiles able to perform such impact studies.

  Following the construction of new power plants and increased availability of natural gas, since 2017 Egypt has become a net producer of electricity, with a current excess generation capacity of 15-20 GW. As a consequence, another important challenge that Egypt's infrastructure is facing, is related to the ability to **export the surplus** to other countries. As of today, the grid is oversubscribed, with too many power plants feeding on it, and due to the constraints of transmission lines and substation capacities, most of the excess generation is currently wasted, thus making grid expansion, retrofitting, and upgrade of control centres an urgent economic priority. Egypt is therefore planning to export energy through new high-capacity transmission lines set to go in four directions, three via land lines (to Jordan and Saudi Arabia, Sudan, Libya) and one through a submarine cable to Europe, which of course will require new technical competences to be built.

Finally, the planned increase of the contribution from renewable sources of more variable nature is expected to present the grid with a variety of technical challenges that could be addressed with an improvement of the voltage profile and the introduction of smart grid solutions. Thus, if the infrastructure must be ready to accommodate the 42% share of renewables expected by 2035, the country needs professional profiles able to deal with such technologies.

- The energy sector is heavily influenced by **policies, regulations and agreements,** both national and international. This is particularly evident in Egypt where the sector has traditionally been state-driven and many of the production and distribution facilities are publicly owned.

  Over the past years, one of the main priorities of the government has been to avoid power shortages and meet the energy demands of the country, a goal that was reached with a mix of policies, including commissions to foreign companies (such as the construction of three combined cycle power plants by Siemens that almost doubled the country's generation capacity), introduction of new Product Sharing Agreements and other regulations that encouraged external investments (e.g. to foster exploration activities in the oil and gas sector), liberalisation of the downstream gas market, aimed at attracting more investment and sustaining competition, concession of licenses (for example to install solar and wind farms), and direct investments and funding (such as the already mentioned upgrade of the existing infrastructure).

  At international level, oil and gas production in Egypt is still coordinated through OPEC, while a series of bilateral agreements with the European Union has fostered trade of energy and related goods. To establish itself as a central hub for energy and electricity trade, Egypt is also creating an electricity trade market among the Eastern Africa Power Pool (EAPP) countries. Additionally, Egypt has joined several regional and international organisations and associations, such as the Association of Mediterranean Transmission System Operators (MED-TSO) and the Union for the Mediterranean (UFM).

  Egypt is also committed to implement international agreements on climate change: in 2016, it ratified the Paris Agreement and launched a strategy for a **green economy**, and it is now finalizing the National Climate Change Strategy to support its 2030 SDG development agenda. The country is also preparing to host the COP27—the 27th Session of the United Nations Climate Change Conference of the Parties. The government plans to increase its efforts towards sustainability, with an ambitious renewable energy target of a 42% share in the energy mix by 2035 under the framework of the Integrated Sustainable Energy Strategy 2035 (ISES to 2035) and the announcement, in October 2020, of a new target of 60% (Friedrich-Ebert-Stiftung, 2021). Actions to reach this goal include the allocation of various areas to host solar and wind facilities, and agreements with international funding bodies to finance such projects.

  Incentives for renewables were further developed by adding bids, feed-in-tariffs, and third-party access schemes, such as the introduction in 2014 of feed-in-tariff system to support photovoltaic and other projects with a capacity of less than 50 MW boosted the installation of solar and wind solutions (IEA, 2016). The transition is also endorsed by the Electricity Law No. 87 of 2015, which decrees opening up the market to maximise the renewables share in the energy mix, by the Egypt Renewable Energy Law Decree No. 203/2014 that encourages tenders in the form of Build-Own-Operate contracts, and by Decree No. 17/2015 that regulates renewable energy tax incentives. The government is also introducing financial mechanisms to promote the use of solar water heaters in Egypt's residential sector and incentives the local manufacturing of renewable energy equipment.

  Even the removal of existing subsidies to electricity and fossil fuels, that was determined by economic reasons, and has caused a significant increase in energy costs in recent years, has enhanced the desire of consumers, farmers, industries, and commercial businesses for alternative sources of energy, thus increasing the demand for solar panels, especially in remote areas off the main grid where power was generated with diesel generators.

  That said, few recent regulatory actions acted instead as disincentive to renewables, such as for example the discontinuation of the wheeling mechanism (the use of the national grid to transport electricity from private power plants to private users). Net metering has also been discouraged, by introducing an approval requirement and an inclusion fee for systems above 500kW that made many projects uneconomical.

- A topic strictly related to institutional actions and regulations is that of **social awareness**, acceptance, and active support from the population. In general, renewable energy technologies in Egypt are well perceived. However, there is the need to increase awareness about energy efficiency and opportunities from renewables (gaps in the public's knowledge range from details such as energy consumption labels on appliances, to the regulatory frameworks for the installation of solar panels such as feed-in-tariff and net metering). Moreover, the absence of soft loans from banks discourages people from investing in renewable energy systems. To overcome this situation, Egypt has introduced various initiatives to strengthen the capacities of the banking sector to better understand green technologies. Both specialized/professional trainings and educational programmes on renewable energies start to be offered by various centres and institutions, but there is the need to expand the reach of such offer.

- **Investments** are another important driver of change for the Egyptian energy sector, as they are able to shape the future directions of development. While in the past many private investments boosted the oil and gas sector, such as allowing the discovery of new gas fields, now the focus has shifted to renewable energies. International financial institutions and agencies are encouraging sustainable solutions, as well. For example, the President of the European Investment Bank (EIB), recently warned that the era of fossil fuels is coming to an end, being incompatible with climate goals. The World Bank is also supporting Egypt on projects that improve the lives of people, while ensuring that resilience to climate change is strengthened and emissions reduced. Private investors are also steering towards renewables, as clean energy is outperforming fossil fuels both in terms of higher total returns and of stock market revenues (also thanks to the changed attention to environmental issues of society that create pressure on investment portfolios and for companies to report on climate risk and environmental impact).

  Egypt has implemented a reform agenda for investment legislation in several economic sectors. In the energy sector in particular, this law liberalises the downstream gas market in the country, putting an end to the government's monopoly over the gas market, with the goal of attracting more investments and sustaining competition (Elshazly, 2018).

  Another economic reform, supported by the World Bank Group, has been the introduction of a **solar Feed-in-Tariff (FiT)** programme to leverage private sector capital and expertise to support the country's energy goal. An important part of the programme is the *Benban Solar Park*, the world's largest solar installation (World Bank, 2014), completed in 2019 with financing provided by the European Bank for Reconstruction and Development (EBRD), the International Finance Corporation (IFC)[46], and other international financial institutions.

  Other important projects that would have not been possible without external investments are for example a series of large-scale wind farms with a total capacity of 1.2 GW established in cooperation with Germany (KFW), Denmark (DANIDA), Spain (Siemens), and Japan (JICA).

- Energy is vital in modern economies, and energy security is a priority for every country; it is no surprise that **geopolitical dynamics and events** strongly affect the Egyptian energy sector.

  Oil prices and energy demands are heavily influenced by international events and in turns condition the country's choices and priorities. Despite Egypt's commitments on renewable energy

[46] The International Finance Corporation actively took part to many other investments in the Egyptian energy sector, gathering a consortium of nine international banks, which are investing for the first time in Egypt's renewable energy sector. The consortium includes the *African Development Bank*, the *Asian Infrastructure Investment Bank*, the *Arab Bank of Bahrain*, *CDC of the United Kingdom*, *Europe Arab Bank*, *Green for Growth Fund*, *FinnFund*, *ICBC*, and *OeEB of Austria*. Together with IFC, their financing will support six groups of private power companies.

development, the country depends on fossil fuels for its energy security and moreover will continue its policy of prioritizing foreign exchange earnings from hydrocarbon exports to sustain its economy.

Sudden changes in political scenarios may even reverse ongoing trends. It is the case of the aggression to Ukraine: before that event many factors, including drops in oil prices, the development of unconventional sources of oil and gas, European energy agenda based on renewables, as well as the economic slowdown in emerging markets such as China and India, all concurred in diminishing the demand for Egyptian fossil fuels, and actually diverted the attention to new sources such as hydrogen; after February 2022, Europe's search for new energy supplies in the wake of the war is making the export of natural gas again a strong asset for Egypt.

In the long term, however, the shift from fossil to renewables will happen, and the new world energy system will favour those countries that will have managed to seize the opportunity, either by producing and exporting green fuels and electricity, controlling the raw materials used in clean energy, or by gaining a technological edge.

Terrorism is another global factor that may negatively affect the country and the energy industry. This is not only for possible disruptions in the infrastructure or in the production facilities, but more importantly because the increased instability and risk would deter foreign investments and collaborations needed to continue the development of the sector.

Egypt's ambition to become the main point of reference in Africa and Middle East for all aspects related to energy is shaping the future of the sector. There are major steps already being taken by the country's leadership towards this goal of becoming the East Mediterranean energy hub.

For what concerns production, Egypt has already launched a Modernisation Programme for oil and gas, and the recent discovery of the largest reserves of natural gas in the area (Zohr and Noor gas fields) will support such a programme. Investments in solar and wind, and potentially in the future in hydrogen, also go in the same direction. Other actions involved joining existing regional and international organisations (e.g., the Association of Mediterranean Transmission System Operators and the Union for the Mediterranean) and signing a series of new agreements with other countries, for example with Equatorial Guinea or Algeria in the case of bilateral agreements, and with the development of the Suez Canal Economic Zone as multi-national ones.

For what concerns energy trade, Egypt already plays a key role in international energy markets thanks to the Suez Canal route for oil and gas shipments and to the presence of various pipelines. Egypt is also creating an electricity trade market among the Eastern Africa Power Pool (EAPP) countries to further boost its position.

Finally, Egypt aims to become the reference also in terms of competences and training on them. For example, the Multipurpose Applications by Thermodynamic Solar (MATS) plant hosts a training programme in the growing field of concentrated solar power for researchers from Africa and the Middle East (Abd Almoshen, 2018)

- All developments of the sector have been made possible, and will be in the future, thanks to **technological improvement.** In fact, innovation is enabling entirely new directions of business or the exploitation of energy sources not previously possible.

  A detailed discussion of the technological drivers for each subsector will be presented in the next section. The most disruptive and pervasive direction of innovation is related to **digitalisation,** given its relevance in terms of new competences needed in the labour force. Availability of great amounts of data and the rise of AI solutions are the basis of smart grids and better control systems, allowing optimising all aspects of energy production, transmission, and use, from forecasting weather condition to operating plants remotely and without the need for continuous human intervention. Digital solutions are also one of the main causes for the drop in cost of renewable energies and allow smart management of contracts and certifications.

  The downside of omnipresent digitisation and interconnection is the increased risk of cyber-attacks. Global inexperience in handling large-scale cyber-attacks, combined with the greater capabilities of state and non-state actors, are making the security of grids more vulnerable with immediate severe consequences on the entire energy market. Therefore, strong cybersecurity technologies will need to be introduced to the sector, alongside with a skilled workforce (which will imply both a reskilling of existing profiles and the creation of new jobs such experts in grid security).

Other relevant technologies are related to **automation** (which is very important to operate solar and wind large-scale farms), and to **advanced materials** and **additive manufacturing techniques**, which have the potential to revolutionise solar, wind and hydrogen industries. **Integrated solutions** are also promising, such as for example concentrated solar power plants integrating thermal generation, electricity generation, and water desalination.

Finally, not all innovation is related to new technologies, but rather to new business models (sometimes enabled by the new technologies). In Egypt, this is the case of the trend of **decentralisation** for the electric utility business model, i.e., the shift from large, centralised, technology-focused energy solutions to smart, local energy production systems where consumers can generate their own electricity for their own needs, a trend particularly relevant for the thousands of agriculture, residential, and remote utility installations in the country.

4.2 Analysis of patents to study the role of technical innovation

The following discussion is about technology as a driver of change. It is essential to note that the focus is not on technology *per se* but rather on its potential to influence, through its adoption, the demand for employment and skills. From a methodological point of view, the interest is in the *functional* use of technology rather than its performance or actual content. In fact, every technology exists to fulfil a purpose for the user, solve a real-life problem, or provide an advantage. In the theory of engineering design, the purpose is referred to as the *function* of the technology.

The current literature on the future of work and skills focuses more on the potential of new technologies, but existing empirical evidence is limited on the actual impact of technology use in companies. By looking at the functional use of the technology – i.e., the actual problem it solves or the actual beneficial uses it enables – it is possible to study its real impact in the real world. Moreover, even if a specific technology is not ultimately adopted, if the need expressed by its functional use is genuine, in the long term, another substitute technology will appear. In this sense, the functional approach allows for an understanding of the obsolescence and/or resilience of certain jobs or occupations and forecasting or even designing the shifts occurring between jobs, and the trajectory of skills from one job to another.

To study how technological innovation has an impact on the development of the sector, there is a strong rationale to choose patents as the relevant data source. More in detail:

- Patents are a significant cost for companies and are thus filed to protect those innovations which are considered relevant to the enterprise and are very likely to be produced on a large scale in the future. Hence, their analysis can provide valuable insight into how technologies are changing and possibly highlight the causes behind these changes. Even more importantly, given their connection to actual business strategies and to industrial production, patents are a reliable indicator of how the new technologies will affect the future skill needs.
- Existing literature (Terragno, 1979; Kütt, 1998) has shown that about 80 per cent of the technical information contained in patents is not available elsewhere due to company policies. Even though this percentage might have changed in recent years, it still makes patents an important source that complements the traditional technical and scientific literature.

To sum up, patents as a unique source of technical information can capture better than any other data the trends of innovation and technological evolution that can have a real impact on the demand for skills.

The analysis of patents presented in the next paragraphs follows two directions:

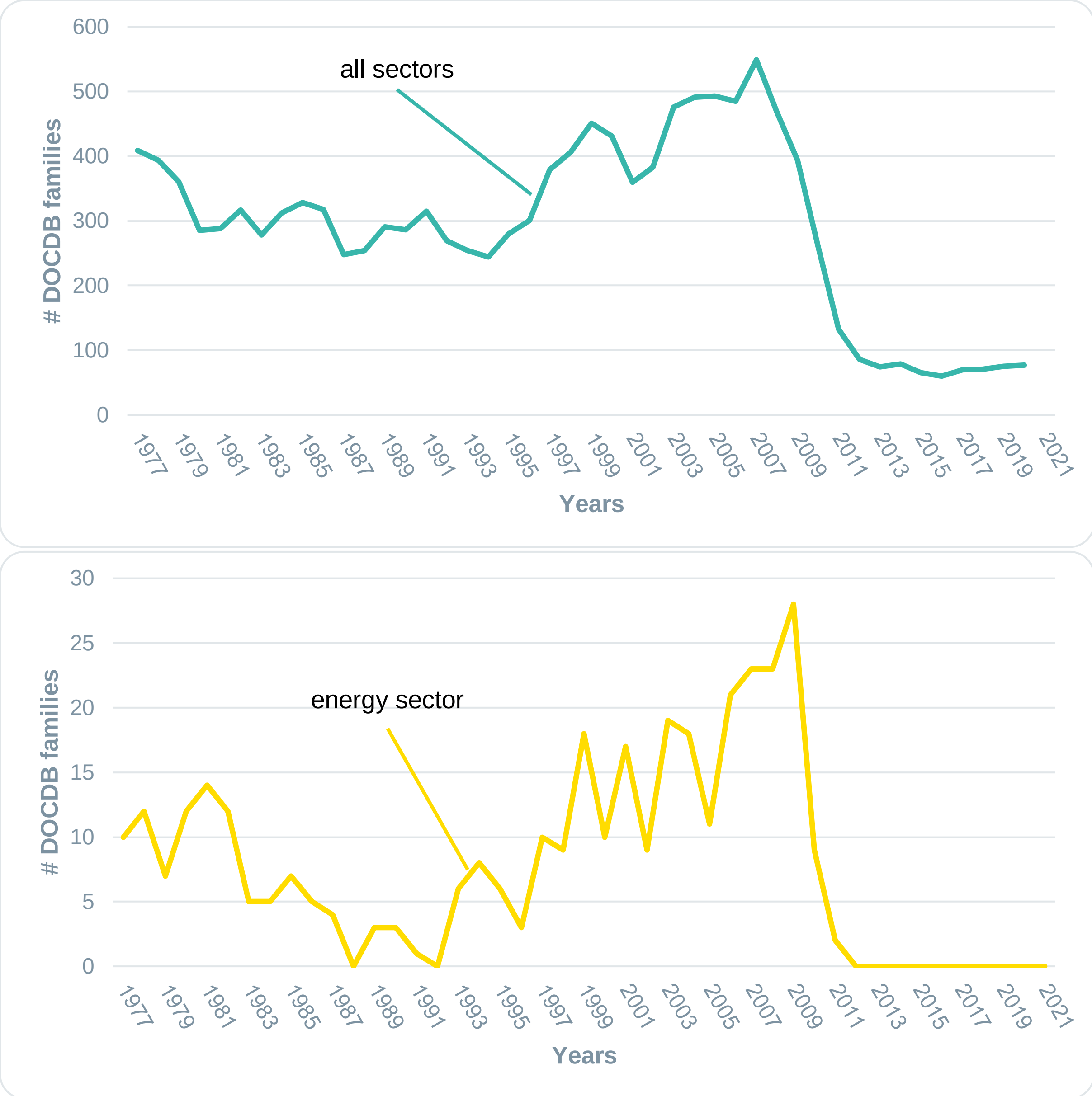
- **patent activity in Egypt** as a whole and in the energy sector in particular, to provide a general understanding on the investments in new technologies in the country (using the number of inventions as an indicator), on their focus over sub-sectors, and on the availability of competences and highly trained human capital in the most advanced areas.
- **In-depth analysis of energy sector** inventions on a global scale (in particular adding European patents) in order to map all innovation trends and the most relevant technologies that, by being adopted in the near future, will shape the need for skills and professional profiles in the sector.

4.2.1 Egyptian patent activity

An initial study can be carried out on the number of patents filed in Egypt without any restrictions in terms of sectors. Such information is useful at the beginning of the analysis to understand the tendency of a country to create innovation within its own borders. More precisely, it is possible to analyse the temporal distribution of the number of Egyptian patent families filed in all sectors.

As for the timespan, the most relevant period for the prediction of the future skill needs is the last 5-10 years (considering the rather long cycle of innovation generation and adoption for the technologies in the field, compared for example to the much shorter cycles of pure ICT). At this stage, it is interesting to look back in time for a longer period (1980 - now) to better understand the dynamics of change that are not strictly technological, but are rather linked to social and economic developments, and take place over a longer period.

Figure 4.4: Egyptian patents



Note: Patent applications are generally published no sooner than 18 months after the filing date, a timeframe often called *secrecy period*. Hence, the number of registered filings of the period 2021-2022 is necessarily under-estimated and was not plotted. The same holds for all subsequent plots having the time dimension on the x-axis.

Figure 4.4 shows the number of patents either i) filed at the Egyptian National Patent Office or ii) issued internationally by companies located in Egypt (both national ones and local branches of multinationals), over the years; the upper plot includes inventions for all sectors of economic activity, while the lower one singles out the subset of inventions directly related to the energy sector. Please note that the two plots have different scales on the vertical axis.

National inventive activity has been constantly sustained since the seventies, with a significant growth in the period starting in 1994 and reaching its peak just before 2010. Around 2010, a period of steep decline in the national capacity to produce innovations (at least patented ones) began, dropping the rate of patent applications by five times less than at its peak just a few years before, and patent filing has not recovered since. A likely cause for such dramatic drop can be found in the economic crisis that hit the country around 2010 and in the following period of social unrest which diverted funding and focus away from R&D activities, reducing the ability to innovate.

Inventions concerning the energy technologies in particular (which will be analysed more in detail in the next section), follow a similar trend of highs and lows, although of course with smaller numerical values. This is no surprise, since the energy sector constitutes the main economic activity of the country, and a strategic area too, and it is thus strictly interconnected with the overall economic and social situation of the country.

The described trend indicates that there is potential for innovation in Egypt, but its deployment is not self-sustained and still heavily influenced by political or economic instabilities.

On the other hand, if we look at the absolute numbers of patents rather than at trends, it is important to note that the fraction of inventions related to energy over the total (around 5%) is smaller than one would have expected given the relevance of the sector for the country’s economy. This may be an indication that the technologies needed over the years have been mainly imported from abroad.

4.2.2 Energy sector patent activity

Egypt has a sizeable number of patents dedicated to energy technologies, but these do not cover all subsectors of interest for the country (for example they do not cover oil & gas transportation or refineries, which are important economic activities for Egypt – see Table 4.1 later on); moreover, the already mentioned drop of inventive activity after 2010 means that the country is lagging behind in its ability to keep pace with technological advances happening in the rest of the world.

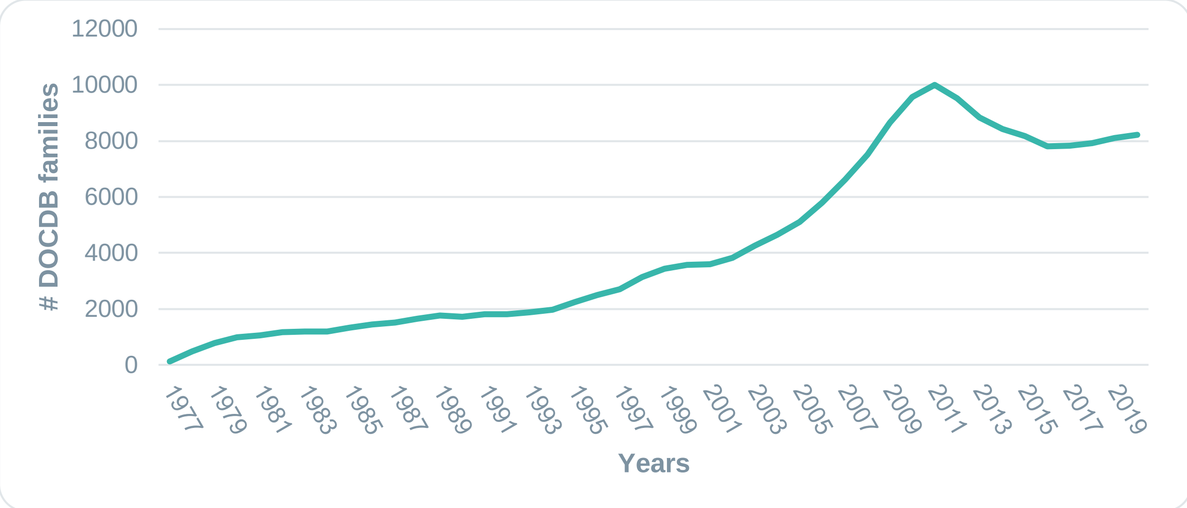
Therefore, it is very likely that many of the new technologies that are needed to advance the Egyptian energy sector will be imported from abroad, especially for those large-scale projects that are funded or realised in partnership with foreign institutions and companies. The energy sector is a global and highly competitive one, and as soon as a new advantageous technology is introduced, it is usually quickly adopted by all players in the world regardless of the country of initial development.

Therefore, to have a complete picture of the new technologies that are entering or about to enter the energy sector and that will shape the competencies needed by the labour market in near future, it is important to integrate data from Egyptian patents with worldwide ones.

Companies usually file patent applications for the same invention in multiple nations to obtain the widest market protection possible. The set of different documents referring to the same innovative idea is called a patent family. To avoid duplicating the estimates of relevance for each technological area that could arise because of multiple filings it is useful to choose only one such document (family representative) for each family. Indeed, International Patent Families are a reliable and neutral proxy for inventive activity because they provide a degree of control for patent quality and value by only representing inventions deemed important enough by the applicant to seek protection internationally (Squicciarini et al., 2013) (van Pottelsberghe et al., 2008) (Frietsch & Schmoch, 2010) (Harhoff et al., 2003). For the present report, European Patents (EP) have been used as representatives for the global innovative activity of the sector. Although some isolated inventions may not get an EP extension, a check confirmed that all technical areas present worldwide are covered in the EP database. Moreover, many of the major development projects ongoing or planned in Egypt are financed by EU institutions or EU-sponsored partnerships and realised by or in collaboration with European-based companies, such as Siemens, ENI and so on.

The overall temporal evolution of patents related to the energy sector is shown in Figure 4.5.

Figure 4.5: Patent families (EP representative) in the Energy sector filed over the years



Inventive activity in the energy sector has been growing over the years with an accelerated pace, especially between 2005 and 2010, likely boosted by the increasing relevance of green technologies to face the climate change issue and the general request for sustainable development. However, after a peak in 2010, the pace of innovation has slowed down at a global level too.

Comparison between Figure 4.4 and Figure 4.5 shows that the situation after 2010 is very different in the two cases. Worldwide, the number of patents (having at least one EP representative) filed has slowed, though the number registered still runs into the thousands every year. This is a rather common behaviour for technologies that are past their ascent stage and heading towards the productivity stage of development (every technology life cycle is usually divided into four stages: (i) R&D and innovation, (ii) ascent and market growth, (iii) maturity and large-scale diffusion, and (iv) decline and substitution). Egyptian patents filed instead dropped dramatically, and no invention at all has been produced in the energy sector after 2012. This is a quite unexpected trend, especially considering the economical relevance of the energy sector in Egypt. A possible reason for it could be the convenience of importing technologies if compared with the expected developing costs. The question arises whether the benefits of such choice surpass the hidden costs: if such trend is not reversed, Egypt may lose whatever competitive advantage it possessed by becoming an importer only of new technologies. A drop in the national R&D capability can lead to serious challenges in terms of the competences that the country will require in key technological areas.

Once a general overview on the sector has been gained, the analysis can be taken one step further by investigating how innovation is distributed within subsectors, as this can provide clues about where the country is more active, in relation to internal drivers and capabilities as well as in comparison to global trends. Aside from the drop patent filing over recent years, the level of innovative activity in a subsector up to 2010 can still provide an indication of where investments are being concentrated and in which direction the energy sector is evolving, both at national and global levels.

Table 4.1 reports the list of subsectors in the energy industry that are relevant for Egypt and for each subsector. It provides the absolute and relative numbers for innovation worldwide (as represented by EP filings) and in the country.

Table 4.1: Distribution over sub-sectors for EP and Egyptian patents in the Energy sector

Sub-sectors	Number of DOCDB families in Europe	Percentage of DOCDB families in Europe	Number of DOCDB families in Egypt	Percentage of DOCDB families in Europe
Energy transmission and distribution	56.447	29,3%	34	8,2%
Fossil fuel energy	30.084	15,6%	99	23,9%
Solar energy	27.472	14,3%	128	30,8%
Hydrogen energy	17.049	8,9%	20	4,8%
Wind energy	14.806	7,7%	27	6,5%
Energy efficiency	12.487	6,5%	6	1,4%
Oil & gas extraction	12.004	6,2%	42	10,1%
Nuclear energy	7.233	3,8%	41	9,9%
Biofuel energy	5.698	3,0%	1	0,2%
Oil & gas transportation	3.671	1,9%	2	0,5%
Oil & gas refinery	3.384	1,8%	0	0,0%
Hydro energy	2.185	1,1%	15	3,6%
Total number of patents	**192.520**	**100%**	**415**	**100,0%**

Data source: European Patent Office; own elaboration. Period considered: 1977-2022

In the last column of Table 4.1, the yellow colour indicates a subsector where the Egyptian inventive activity is, higher than the international average, the pink colour a subsector where it is sensibly lower, and no colour means that there are no great differences between the two. Of course, given the very low numbers of Egyptian patents compared to EP ones in each subsector, even the green values cannot be taken as indicators of competitive advantage; rather, they indicate those subsectors where the country is concentrating its R&D efforts and has a certain degree of autonomy in what concerns technological advancements. Looking at the table, it is clear that there is basically no internal innovation capacity for example in the field of oil and gas refinery, and thus all relevant technologies (or at least ownership of the technologies) are likely to be imported from abroad, while for example solar energy technologies are actively researched in the country and innovative solutions invented by national companies and research centres can sustain more dynamic and autonomous growth.

For a more comprehensive view, a representation of all subsectors' temporal trends is reported in Figure 4.6. As it is clear from those plots, the overall trend in Figure 4.6, with a slowing down of inventive activity over recent years, is followed by almost all subsectors, with two notable exceptions: **energy transmission & distribution**, and **hydrogen** (highlighted in a different colour in the figure), which are instead constantly growing. In the case of the former, the growth is fuelled by the disruptive potential of digital/smart grid solutions in all aspects of transferring energy from multiple production sites to final users in an increasingly more complex network (i.e., a combination of new market needs and introduction of new enabling technologies). As for the latter, while in the past focus and investments in R&D have concentrated more on other renewable sources such as solar and wind, the recent stress given by EU strategies and planning on hydrogen for energy production, storage, and transport, but also as a substitute for fossil fuels in mobility, is pushing the related technologies out of their prototypal stage towards the ascent and market growth stage.

Figure 4.6: Temporal trends of global inventive activity for the various energy subsectors

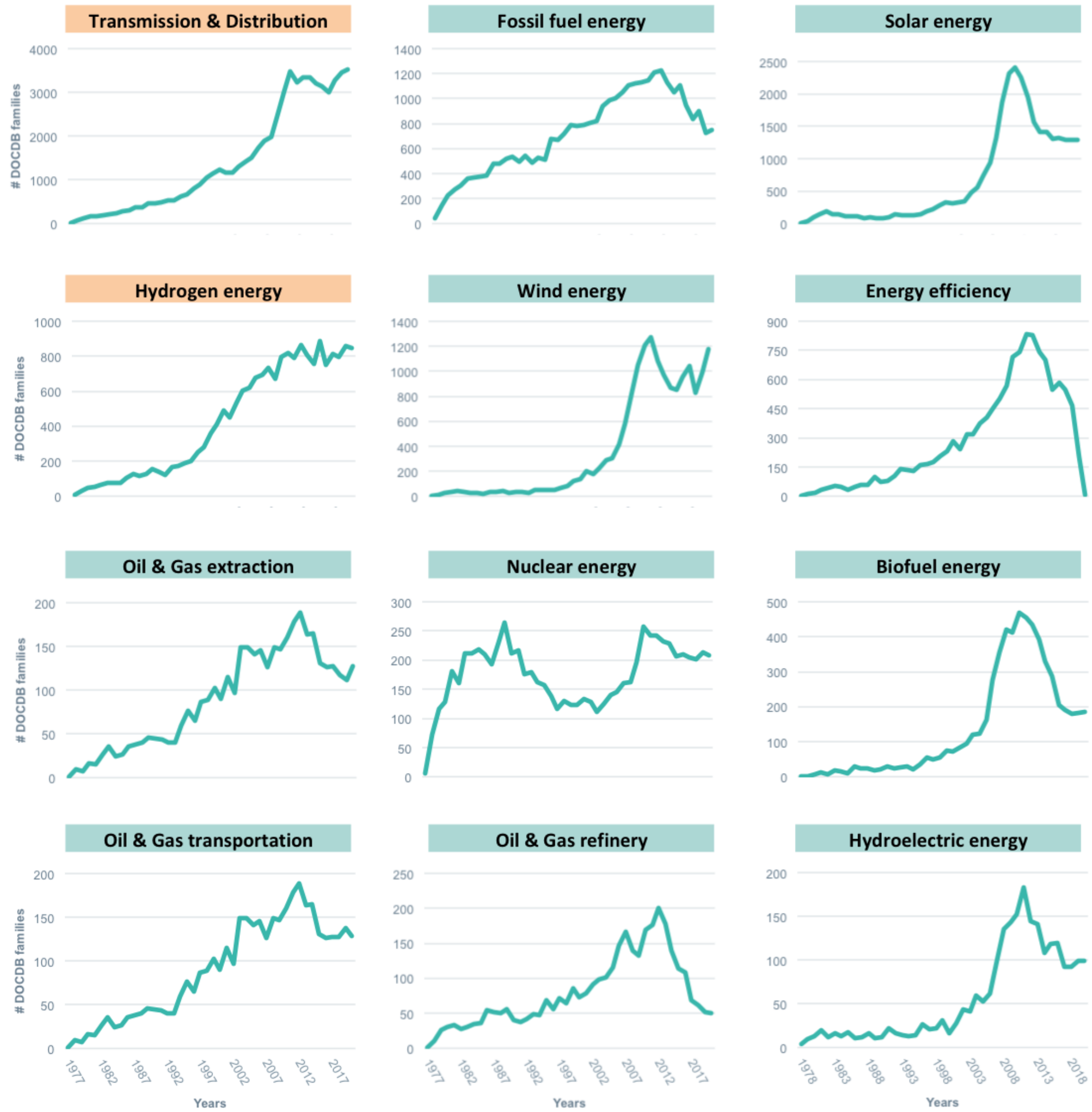


Table 3.2 also presents a list of the top 5 relevant technologies (i.e., technologies with high occurrence and/or growing temporal trends within the patent set) for each subsector. We report a more comprehensive list of the relevant technologies for all subsectors in Annex 1. By looking at such lists (mainly the one in the Annex, the selection in table 3.2 is just for illustrative purposes), it is possible to infer which competences will be needed more by the workforce to take advantage of the new technological innovations. ESCO provides the source for this. It is worth noting that not all of such technologies have a direct match with ESCO, as the database lists general competences (e.g. on solar panels instead of distinguishing between the different types of the same) and is not always updated with the most recent technical advancements (for example, just in the area of solar energy: new techniques such as solar cells arrays, or Concentrated Solar Power, new materials such as Perovskite cells, and all new digital solutions for remote control, weather forecast, etc.; the situation is even worse in the case of technologies related to hydrogen as an energy source). Thus, to provide operational information for

the development of training programmes, it may be useful to integrate results expressed in the ESCO standard format with more detailed analysis of the technological inputs adopted in each subsector (such as those that can be derived from patents).

Table 3.2: Top 5 most rapidly growing technologies in energy sector patents, by subsector

Sub-sector	Technology
Energy Efficiency	Battery Charging Systems Data Switching Networks Wireless Traffic and Communication modules Insulation Predictive analytics
Solar Energy	Concentrated Solar Power Equipment Solar Cell Array Perovskite cells Remote control and automation Float energy collection device
Wind Energy	Rotor Blades Wind air engine Remote control and automation AI-based weather forecasting Additive manufacturing
Energy Transmission and Distribution	Smart Grid Smart Meter Predictive analytics Underwater Cables High Voltage Direct Current Transmission Systems
Hydro Energy	Hydraulic Actuator Hydraulic Circuit Heating/cooling systems Water treatment systems Control units and systems
Oil&Gas Transportation	Flexible Substrate Sensor System Intelligent Pigging Magnetic Flux Leakage Pipeline Bundle Subsea Pipeline
Oil&Gas Refinery	Refining Machine Vacuum-Drum Filter Catalytic Reformer Hydrocracker Hydrotreater
Oil&Gas Extraction	Acoustic Waves Heat Exchange Tube Directional Drill Submersible Pump Pumpjack
Nuclear Energy	Atomization Electrode/unit Reactor Pressure Vessel Energy Metering Component Nuclear Power Management System Nuclear Fusion
Biofuel Energy	Biofuel Cell Pyrolysis Bed

	Cell Suspension Culture Biogas Flow Controller Hydrogasification reactor
Hydrogen Energy	Methane Reform Device Water Electrolysis Catalysts Fuel Cell Hydrogen Batteries
Fossil Fuel (Thermal) Energy	Precombustion Treatment Synthetic Gas Pressure Vessel Superheater Roaster module

4.3. Conclusion

There are several factors influencing the evolution of the sector: from a necessity of diversification of energy sources to an increased energy consumption by end users. The complete list of the relevant drivers of change includes: the advantages and constraints related to the **geographical position,** which in turn further articulates in **availability of energy sources** (including proximity to **energy distribution routes)** and in the issue of **water shortage;** the global issue of **climate change** that is affecting Egypt in various ways; the need for further **infrastructure development**; the rapid **industrial and population growth** of the country; the availability of **investments**, both private and from national and international institutions to foster the planned developments; national and international **policies and regulations**; **geopolitical factors;** and last but not least the obvious importance of new **technological developments,** which alongside the introduction of more advanced solutions also allow for new business models, e.g. with the decentralisation of energy production.

The country has great potential in terms of producing energy from renewable sources (solar and wind in particular), which makes Egypt particularly favourable for creating new job positions in the sector. Oil&Gas production, traditionally the main driver of the energy sector, has still lot of potential too: thanks to the recent discovery of new, very large reserves of natural gas, the fossil fuel industry is expected to still adsorb a relevant share of future job profiles and skills.

A review of patents in the last 50 years revealed that, beside covering a small portion of the country's overall patents, Egyptian inventive activity in the energy sector has rapidly dropped after 2010. Egypt is lagging in its ability to keep pace with technological advances happening in the rest of the world. Consequently, it is very likely that many of the new technologies will be imported from abroad.

The study of international patent applications revealed twelve clusters of relevant technical areas (in descending order), in which new competences and skills will likely be needed: Energy Transmission and Distribution, Fossil Fuel Energy, Solar Energy, Hydrogen Energy, Wind Energy, Energy Efficiency, Oil & Gas Extraction, Nuclear Energy, Biofuel Energy, Oil & Gas Transportation, Oil & Gas Refinery, Hydro Energy. Particularly, technologies linked to Energy Transmission and Distribution, Hydrogen Energy and Wind Energy show a growing trend of innovation, while Solar Energy's and Biofuel Energy's patenting activity's temporal distribution fit with the typical shape of technologies that are witnessing a market growth. If Egypt decides to pursue a strategy of production diversification, Transmission, Solar and Wind energy-related job profiles and skills should be considered.

5. CHANGING JOB AND SKILL DEMANDS EXPERIENCED BY THE SECTOR

KEY INSIGHTS FROM THIS CHAPTER

- Vertical professions in the energy sector are increasingly correlated with technical areas other than their main field of competence, as many technologies and competences are either general or applicable across different subsectors.
- Future professions in the energy sector are unlikely to be confined to specific energy silos, as they share knowledge and competences required across different energy sources. This suggests that training programs should address the need for common skills across various energy sources.
- The demand for new skills will not be uniform across all subsectors. The hydrogen energy and transmission and distribution subsectors will require more new competences and professional profiles.
- The introduction of digital technologies in the entire energy sector will require various profiles, both technical and business-related, to acquire increasingly transversal skills related to the IT field.
- The energy worker of the future will need to possess a broader set of skills, with digital technologies forming an essential component of the required competencies.

5.1 From technologies to jobs and skills

The present chapter focuses on the implications for employment and skills of the factors driving change presented in chapter 3. It directly addresses the question: **what jobs and skills will be needed to deal with the types of technological innovation increasingly coming on stream in the energy sector**. Having a detailed picture of future skill demand is of considerable importance to many stakeholders, ranging from policy makers to training providers to individuals considering their future career choices. For this reason, it is critically important to have near real time data on technological progress and its impact on skills demand. Skills demand needs to be articulated with respect to specific skills needed in jobs. In doing so, a much more detailed and precise picture of skill needs is obtained compared with that which is derived from looking at qualification levels or broad occupational groups. Access to this type of information can be vital in reducing levels of skills mismatched in an economy and, in turn, improve competitiveness at the sector or national levels (Jagannathan, 2013).

There are various possible ways to link the information on technologies derived from text mining to the possible future skill needs. In this study the list of relevant technologies extracted from the literature (see Annex 1) has been compared, using semantic matching algorithms (i.e., algorithms able to find semantic connections between different concepts based also on contextual information), with the standardised occupational profiles listed by the European classification system ESCO (see glossary). Each occupation in the ESCO database includes a description and a list of competences, skills and knowledge considered relevant - either essential or optional - for that occupation. The semantic algorithm looks for matches between each respective technology with information / data provided on each occupation in ESCO. When a match is found, the occupation is associated with the technology. The entire procedure is automated by using ESCO's API (see glossary), which allows occupational data to be downloaded and processed by software. Table 5.1 provides a few examples of the matching process to illustrate the way in which a technology (e.g., solar cells) is linked to particular skills (e.g., calculate solar panel orientation), and then to an occupation (e.g., solar energy engineer).

Table 5.1 Example of the matching process from patent topics to ESCO skills & occupations

Technological concept	ESCO knowledge/Skill	Type	Correlated ESCO occupation	Relevance
Solar cell	Calculate solar panel orientation	Skill	Solar energy engineer	Essential
Solar cell	Types of photovoltaic panels	Knowledge	Solar energy engineer	Essential
Solar cell	Solar panel mounting systems	Knowledge	Electrician	Optional
Solar cell	Provide information on solar panels	Skill	Renewable energy consultant	Essential
Solar cell	Install photovoltaic systems	Skill	Solar power plant operator	Essential
Solar cell	Solar energy	Knowledge	Energy assessor	Optional
Rotor blades	Test wind turbine blades	Skill	Wind energy engineer	Essential
Wind turbine nacelle	Inspect wind turbines	Skill	Wind turbine technician	Essential
Wind turbine	Research locations for wind farms	Skill	Wind energy engineer	Essential
Wind power plant	Maintain power plant machinery	Skill	Power plant control room operator	Essential
Sensor node	Sensors	Knowledge	Electrical engineer	Optional
Grid voltage	Transmission towers	Knowledge	Cable jointer	Essential
Energy storage device	Forecast energy prices	Skill	Energy analyst	Essential
Smart grid	Mechatronics	Knowledge	Electrical engineer	Optional
Power transmission	Ensure safety in electrical power operations	Skill	Power distribution engineer	Essential
Power transmission	Develop strategies for electricity contingencies	Skill	Energy engineer	Optional
Control systems	Control systems	Knowledge	Electrical engineer	Optional
Pipeline seal system	Repair pipelines	Skill	Gas transmission system operator	Optional
Subsea pipeline	Types of pipelines	Knowledge	Gas processing plant supervisor	Optional
Gas pipeline	Ensure regulatory compliance in pipeline infrastructures	Skill	Gas processing plant operator	Optional
Natural gas distiller	Natural gas liquids fractionation processes	Knowledge	Gas processing plant supervisor	Optional
Natural gas distiller	Natural gas liquids recovery processes	Knowledge	Gas processing plant supervisor	Optional
Natural gas distiller	Gas dehydration processes	Knowledge	Gas processing plant control room operator	Optional

Table source: own elaboration on data from EPO and ESCO

Table 5.1 should be interpreted as follows. In the first column are a list of technologies which appeared in recent patents as revealed in Chapter 3 and, thereby, can be assumed to be relevant to the future needs of the energy sector and those working in it. The second column lists the skills or knowledge sets associated with the technology as defined by ESCO. This is then classified, in the third column, as either a skill or a knowledge set as defined by ESCO. The occupation in which these skills / knowledge are found is listed in the fourth column along with an indication of whether the skill or knowledge is considered as essential or optional for those working in the occupation.

The matching process reveals a wide spectrum of skills and occupations needed to master the technologies indicated in the first column of Table 5.1. This indicates, plausibly, the wide range of skill needs, spread across a wide variety of jobs, which are likely to arise in the energy sector as new technologies are introduced and new sources of energy increasingly come on stream. It needs to be borne in mind that Table 5.1 represents just a selection of the most relevant job profiles to have emerged from the data matching.

5.1.1 Technical skills required by professions – deepening the analysis

The information in Table 5.1 can be reorganised to provide a list of occupations. The information in ESCO is sufficiently disaggregated that information is increasingly being provided about the actual jobs undertaken by people rather than the sometimes-broad range of jobs which comprise an occupation even at the four-digit ISCO level. It is then a straightforward exercise to compile the occupational profile because this is already available in ESCO. In Table 4.2 the example of the solar energy technician is provided which summarises the information provided by ESCO on this particular occupation.

Table 4.2: Occupational skill needs related to a given technology (according to ESCO)

Starting technologies	Related occupations (ESCO match)	Related skills (ESCO match)
Solar cell	Solar energy technician	Electricity
		Use measurement instruments
		Maintain solar energy systems
		Calculate solar panel orientation
		Solar panel mounting systems
		Types of photovoltaic panels

The information contained in Table 4.2 is not the end of the exercise. There are recognised limitations to using ESCO which need to be addressed and overcome. For instance, in some cases the skills or knowledge listed for an occupation are rather general (e.g., the example of electricity listed in the third column of Table 4.2), while specific competences, such as, knowledge of different types of photovoltaic panels, which provide a deeper insight into the competences needed by solar energy technicians (using the example in Table 4.2), are less well covered. Additionally, the depth of knowledge required is largely missing as well.

It is important to note that **not all topics/technologies that emerged from the patent analysis could be matched to ESCO competencies and occupations**. For example, the technology of *solar cell array,* or that of *concentrated solar power* did not find a direct match. It is another indication that existing classifications may not yet encompass references to all the new technologies.

To address the limitation described above and obtain a more complete picture of the knowledge needed to master a given technology, additional information can be obtained from sources other than ESCO. One such source, for example, is **Wikipedia**. To illustrate how additional data sources can be used to supplement the information obtained from ESCO, Wikipedia was chosen for its accessibility, its comprehensiveness, and the structured way in which it presents information. More precisely, for every topic / technology (i.e., the most recurrent terms resulting from the analysis of patents), a corresponding Wikipedia page can be downloaded using web scraping techniques. This then provides a means of providing more in-depth analysis of the specific skills that will be required in an occupation or job linked to the emergence of new technologies. Table 5.3 takes the solar cell technology again as an example to show how additional information on skills demand derived from Wikipedia complements the information from ESCO.

Table 5.3: Expanding occupational skills data provided in ESCO

Starting ESCO Occupation	Skills associated by ESCO	More detailed needed knowledge inferred from Wikipedia
Solar energy technician	Electricity	Power optimiser
	Use measurement instruments	Thin film solar cell
	Maintain solar energy systems	Solar micro inverter
	Calculate solar panel orientation	PV junction box
	Solar panel mounting systems	Solar tracking mechanism
	Types of photovoltaic panels	… and many others

Another limitation of this approach is the future-looking research goal of this study, which may imply a degree of insufficiency in information provided sources such as ESCO and Wikipedia. There is a risk that the data obtained from these sources are derived from observations of the recent past. Accordingly, they might not fully capture the skill needs which arise where a technology is considered to be a potentially disruptive one. By looking at the data provided on **vacancy websites** it is possible to identify emerging skill needs and, importantly, the emergence of new jobs which might not yet be contained in ESCO. To this end, it is possible to search job vacancy websites and extract details about skills and jobs associated with a technology. In the example provided in Table 5.4, a search was made of the Monster.com website to identify the skills and jobs associated with the solar array technology.

Table 5.4 is provided to show how the existing methodology can be extended to incorporate web scraping of vacancy web sites to yield further information on emerging skill needs. Since this approach produces results which are not readily classifiable using ESCO and ISCO, it has not been pursued further in the study.

Table 5.4: Selection of job profiles extracted from online job postings related to solar array

Technology not matched in ESCO	Matched occupational profiles in job postings
Solar Cell Array	Solar array and Battery Engineering Manager
	Roofing Technician
	Senior Design Engineer
	PV Solar Installer
	Engineering Technician III – Solar Array Assembly
	Solar Panel Installers
	Construction Electrical Foreman
	Solar Surveyor

Source: Job postings from monster.com, technologies from analysis of patents from EPO database

5.1.2 Ranking occupations according to potential demand

Once the bridge between a technology and related job profiles has been built, it is possible to estimate the relative importance or relevance of each job profile to the future energy labour market. In other words, it is possible to rank job profiles according to their likely future demand. To assign a numerical relevance score to each job profile, five factors have been weighted in as follows.

1. Whether the job profile is associated with one or more technologies, i.e., its importance grows if it has skills related to more than one technology or topic ('transversality').
2. Whether the associated skills are essential or optional (as defined in the ESCO classification).
3. The weight attached to the technologies and topics to which it has been matched expressed by the normalised number of patents it appears in on a global scale.
4. An adjustment factor to consider the extent to which technology is also actively being researched in the country.
5. The prominence of the sub-sector where the technology is adopted in the country's energy planning.

The final score is determined by the following formula:

$$\boldsymbol{Importance\ of\ Job\ profile\ j(y_j) = \sum_{i=1}^{m} T_{ij} E_{ij} W_i R_i S_i}$$

Where:

$$\boldsymbol{T_{ij} = \begin{cases} 1\ if\ technology/topic\ i\ is\ linked\ to\ job\ profile\ j \\ 0\ otherwise \end{cases}}$$

$$\boldsymbol{E_{ij} = \begin{cases} 1\ if\ technology/topic\ i\ is\ essential\ to\ job\ profile\ j \\ 0.5\ otherwise \end{cases}}$$

$$\boldsymbol{W_i = Importance\ of\ the\ technology\ or\ topic\ i}$$

$$\boldsymbol{R_i = Relevance\ of\ the\ technology\ in\ the\ country's\ R\&D}$$

$$\boldsymbol{S_i = Relevance\ of\ the\ subsector\ to\ which\ technology\ i\ belongs\ for\ the\ country}$$

- The values of T_{ij} are based on the matching analysis exemplified in Table 4.1. The greater the number of correlations the job profile has with the technologies, the higher the T_{ij} value. The value represents the number of appearances of a specific job profile in association with the technologies that have identified from the analysis of patents.
- The values of E_{ij} can be 1 in cases where specific technology is essential for a job, otherwise it is 0.5. The value 0.5 is based on a sensitivity analysis (see Glossary)
- The values for W_i are a combination of the intensity of the signal for a given technology derived from the patent analysis (see Section 3.2), and of its rate of growth over recent years (see Annex 1), on a global scale (occurrence and temporal trend in EP patents).
- The values for R_i are 1 if the technology does not appear in Egyptian patents, and slightly more than 1 if it does, with a multiplication factor proportional to its occurrence in the country's inventive activity.
- The values of S_i are related to how much the sub-sector to which the technology i belongs is considered relevant in future planning for the country (values are estimated combining data mining, desk research and feedback from stakeholders after completing the field research - for example, all solar-related technologies receive a higher weight than hydro-related ones since future demand for skills is expected to grow for the former but not for the latter).

It has to be noted that T_{ij}, E_{ij}, W_i and R_i are specific for each of the hundreds technologies that are entered into the formula, while S_i is, instead, more general nature and pertains to one of the sub-sectors into which the energy sector can be segmented. It is not practical to list all of the values for each technology in the report and an illustrative example is provided instead. Table 5.5 provides a comparison of present and future projections in terms of installed power-generation capacity. The weight *S* for each source is obtained as a combination of two sets of data: i) the present-day relative importance; and ii) the differential increase expected in future years (since any rise in planned capacity will need consequently more workers and new competences in order to be realised).

Table 5.5: Present and expected total power-generation capacity per energy source in Egypt

Table Heading	2019/20	2025/26	2029/30	2034/35
Nuclear	0.0%	3.6%	3.8%	3.3%
Solar (Photovoltaic + Concentrated Solar Power)	2.1%	11.9%	10.9%	15.8%
Wind	4.0%	5.9%	21.6%	26.7%
Hydroelectric	17.1%	20.3%	16.5%	14.0%
Thermal (Coal)	3.6%	2.9%	2.3%	2.0%
Thermal (Oil and Gas)	73.2%	55.4%	45.0%	38.2%

Source: elaboration of data from (IRENA, 2018)

The information in Table 5.5 is then used to construct the weights in Table 5.6. In more detail, the push towards solar and wind energy will lead to an increase in energy from this source by a factor of six or more. This leads to a high value of the respective *S* parameter, even if solar energy is starting from a low base. Oil & Gas also receives a relatively high value for *S*, since at present it accounts for three quarters of the energy production, and even if its contribution diminishes in percentage terms, it will continue to be important in the future with implications for the size of its workforce. Coal has a low S value since it currently constitutes a small fraction of present production, and it is expected to fall further in the future. There is one source, namely hydrogen, for which there are no projections available since it is in a sense a completely novel form of energy production. But since its potential appears to be high, given the current EU strategies, a non-zero value has been attributed to its *S*, which can be updated as more information comes to light.

Another relevant sub-sector is that of **transportation and distribution of energy**. As described above, the Egyptian government has planned important investments in updating and expanding its grid with the main goal of exporting energy to other countries. To determine the relative value of the *S* parameter, the differential increase in grid capacity has been used, again under the assumption that an improvement will need a proportional increase in the size of the workforce.

To make the criteria for the calculation of the *S* parameter more homogeneous between energy sources and other subsectors, planned financial investments may be used instead of planned technical capacities. For this method to be reliable, one needs to consider all types of investments, from national funding to international cooperation schemes and to private investments. Moreover, costs for projects are subject to change over time depending on many factors, while technical capacities are more resilient indicators.

Combining all reasoning and calculations explained above, one obtains the weights *S* actually used in the study (see Table 4.6).

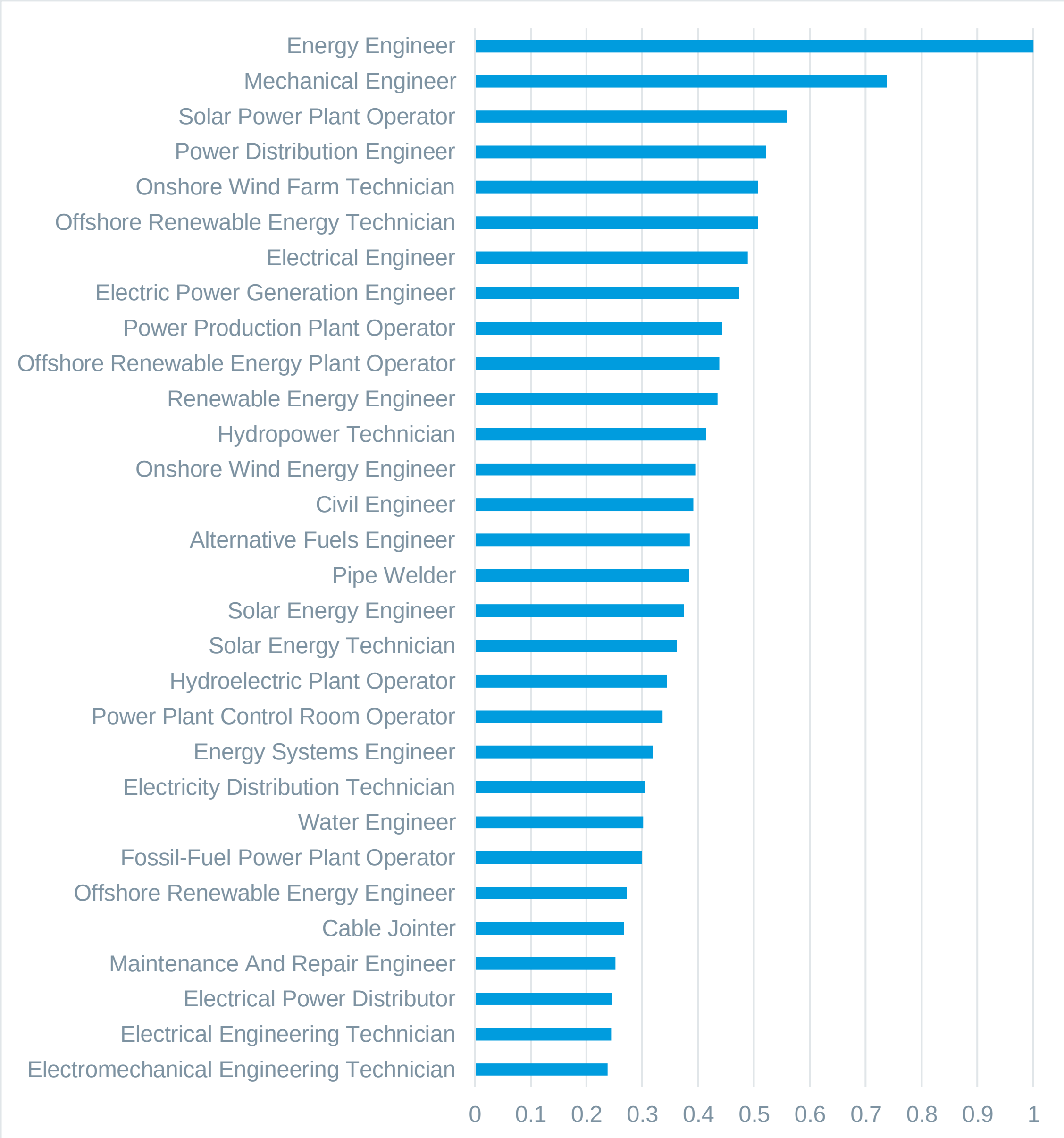
Table 5.6: Weights S_i used in the study for the various energy subsectors

Sub-sector	Normalised weights
Solar energy	1
Fossil fuel energy	0.93
Wind energy	0.77
Energy transmission and distribution	0.61
Oil & gas extraction	0.45
Nuclear energy	0.43
Oil & gas transportation	0.35
Hydrogen energy	0.17
Energy efficiency	0.13
Hydroelectric energy	0.1
Biofuel energy	0.09
Oil & gas refinery	0.08

Source: own elaboration

The application of the formula described to the jobs identified in ESCO as being associated with various technologies produces a ranking as portrayed in Figure 5.1. The ranking shown in Figure 5.1 is indicative of which jobs are of potential interest. A full-scale analysis of the demand for all jobs would require a deeper investigation, use a range of different approaches, and is beyond the scope of the present study. Nevertheless, it provides interesting insights. The jobs ranked highest, and therefore in high demand, are of two types. First, **some of them**, such as *Solar Power Plant Operator*, or *Onshore Wind Farm Technician*, **have a degree of vertical specialisation in technical areas that are fast growing** (e.g., solar and wind energy production), **or are of critical importance** (e.g., *Power Distribution Engineer*). Secondly, **others**, such as *Energy Engineer* or *Mechanical Engineer* **have a more horizontal skill set which means they are in demand in in more than one sub-sector** (e.g., the mechanical engineers because of their knowledge of moving rotors and gears are in demand across many energy sub-sectors).

Figure 5.1: Bar chart displaying the ranking for occupations in the Egyptian Energy sector



To better understand why each profession obtains a higher or lower rank, it is also possible to show the correlation values of each occupation by each sub-sector. Figure 5.2 illustrates by way of a heat map the correlation strength between each energy sub-sectors for the 30 occupations ranked in Figure 5.1.

Figure 5.2: Heatmap showing the relative importance of each occupation by energy sub-sectors in Egypt

Another important evidence from the figure is that **even vertical professions still have a certain degree of correlation with technical areas other than their main field of competence**. This is because many technologies and competences are either general (such as knowledge of electric principles) or are between sub-sectors (for example, the ongoing digitalisation of the entire sector with transversal technologies such as sensors, control systems, remote operation, predictive software etc.) The map provided in Figure 5.2 accordingly provides the important hint that future **professions in the energy sector are unlikely to be located in separate energy silos** since they share knowledge and competences required across different energy sources to a certain extent. This suggests that training programmes will need to reflect the fact that common skills may need to be applied across different energy sources to **ensure that individuals have the skills to move between energy sub-sectors**. For example, traditional gas-fired thermal power plants can be converted and powered by renewable sources such as biogas, provided that the operators possess the skills to apply their existing skill sets in a biogas context. New skills as well may also be needed.

Figure 5.2 provides useful insights by starting from columns instead of rows. This shows the jobs more in demand by a specific sub-sector. Alongside the more obvious specialists less obvious ones are evident. For example, in the wind energy sub-sector, the profile at the top position in the ranking is the *Wind energy engineer.* According to ESCO, the skills for this job include the design and implementation of wind power plant, the installation of plant, research on the best locations for a wind farm, and test activities to improve performance. The adoption, however, of wind solutions requires not only personnel for the operation, installation, and maintenance of wind turbines, but also **jobs linked to support activities**, such as the construction of the wind farm. In this sense the algorithm used to produce Figure 5.2 takes into considerations other profiles such as *Civil Engineers,* who supervise the construction of the wind farms. There is always the danger that these supporting occupations are missed in other types of analysis which capture information on skill demands at the sectoral level but focus on energy-specific jobs and skills.

Looking at the column for the hydrogen energy sub-sector only two job profiles are evident (at least among the first 30 contained in Figure 5.1), *the Energy Engineer* and the *Alternate Fuel Engineer*. As explained previously, this is mainly due to skill classifications such as ESCO not yet being fully up to speed with the skills needed to use this novel, fast developing energy technology. Web-scraping of recruitment websites is likely to provide important clues about emerging skill needs related to hydrogen, alongside more qualitative approaches (which form the next part of the study).

5.2 Technology-related and business-related occupational profiles

Figure 5.1 does not distinguish the listed occupations in terms of competence level required or whether they are technical or non-technical roles. To obtain a more detailed analysis of such aspects, all job profiles identified with the matching algorithm and ranked with the formula of the previous section can be further clust**ered according to the tasks and duties undertaken in the job.** Taking as reference the International Standard Classification of Occupations (ISCO), three main groups can be created:

- Technical professional and associate professional occupations (in the following pages also referred to as “highly skilled profiles”).
- Technical medium and low skilled occupations (i.e., trade workers and machine operators).
- Business services, sales, and other related occupations.

In the following three paragraphs the analysis for each of these categories is presented.

Technical highly skilled job profiles

Technology-related occupations comprise those who are competent to manage and use a given technology. The key assumption is that the growing interest in a certain technology will lead, sudden or later, to a growing need for professionals able to use of that technology. The scale of demand may vary for several reasons, but if that technology is adopted in the country, the related competences and occupations will be needed at least to a certain extent.

Figure 5.3 displays the first twenty-five profiles in the overall ranking that belongs to ISCO 21 and 31 (relevancy scores are normalised based on the highest score and the profiles with a value over a threshold of 0.3 have been shown). By way of reminder, ISCO 21 refers to Scientific and Engineering Professionals, and 31 Associated Scientific and Engineering Professionals.

Figure 5.3: Bar chart ranking the first 25 highly skilled profiles for the energy sector in Egypt

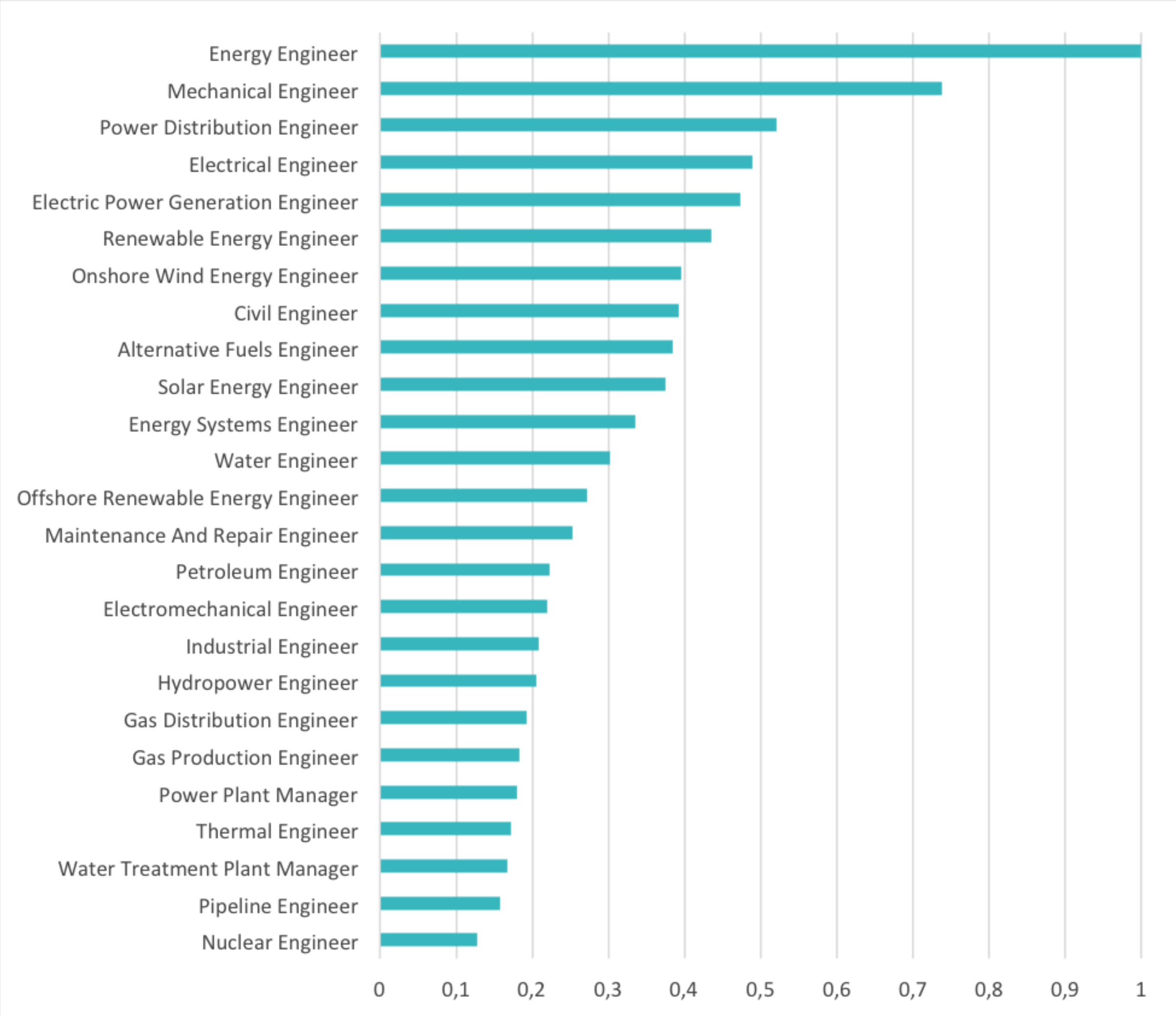


Chart in Figure 5.3 is not substantially different from that in Figure 5.1, and yet having extended the range of scores considered, it is interesting to note that the positions in the ranking immediately after the ones already present in Figure 5.1, which are more skewed towards solar and wind energy sources, are almost all related to more traditional, but still very relevant for Egypt, energy sources, such as oil and gas and hydroelectric power.

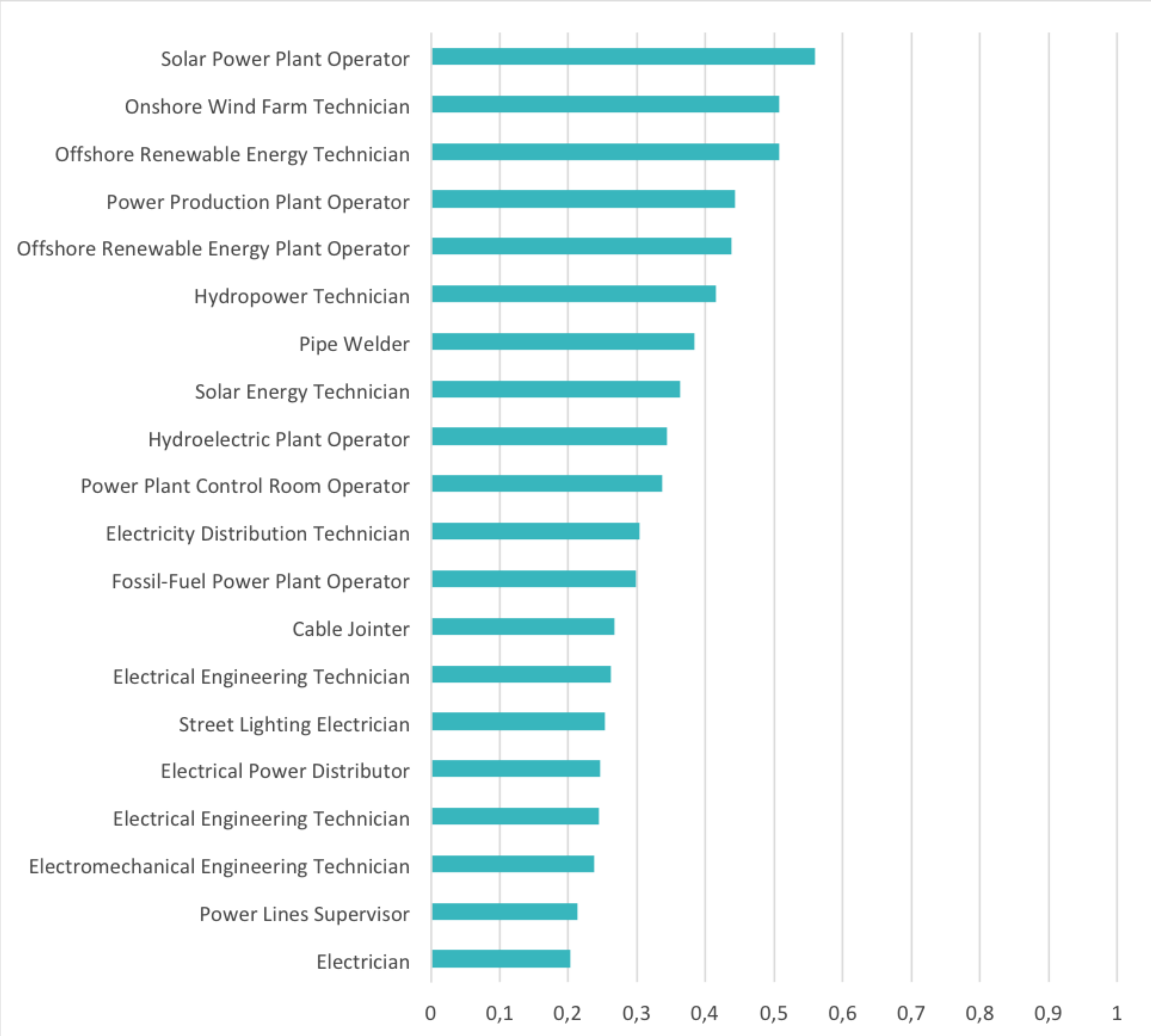
Medium and low skilled job profiles

A similar analysis can be repeated for technical professions with a lower degree of skills, i.e., trade workers and machine operators. These can be classified according to the following ISCO categories:

- Craft and Related Trades Workers (ISCO major group 7)
  - Building and Related Trades Workers (ISCO 7.1)
  - Metal, Machinery and Related Trades Workers (ISCO 7.2)
  - Electrical and Electronic Trades Workers (ISCO 7.4)
- Plant and Machine Operators and Assemblers (ISCO major group 8)
  - Stationary Plant and Machine Operators (ISCO 8.1)
  - Assemblers (ISCO 8.2)
  - Drivers and Mobile Plant Operators (ISCO 8.3)
- Elementary Occupations (ISCO major group 9)
  - Labourers in Mining, Construction, Manufacturing and Transport (ISCO 9.3)
  - Refuse Workers and Other Elementary Workers (ISCO 9.6)

A selection of the first twenty entries of the output generated by the algorithm is shown in Figure 5.4. Due to the normalisation it is possible to note that the average score of medium and low-skilled occupations is lower if compared to high skilled occupations.

Figure 5.4: Bar chart ranking the first 20 medium to low skilled profiles for Egypt energy sector



Here again is a **mix of occupations with skills that can apply to many energy subsectors, together with more specialised profiles**. In a similar way, alongside new professions in the renewables area, the ranking includes more traditional jobs such as those related to Oil and Gas. This is an indication that in the future the se**ctor will still rely on traditional energy skills** but given the strong correlation with new technologies on which the ranking is based, **the ongoing transformation will likely require an upskilling and reskilling** of their competences. In other words, even if job profiles do not change name, it is possible that skills and abilities will need to change given the technological innovations they will be subject to (e.g., digitisation).

Business related job profiles

The analysis also identifies a third category of profiles, i.e., non-technological jobs more related to business aspects such as management, marketing and sales, or export and trade. Such professions, related to energy sub-sectors rather than on technologies, are relevant to the business models that companies adopt and the way they organise production (cf. work organisation). These professions affect the adoption and use of technology in energy.

From the point of view of functions performed, two main distinct groups can be identified:

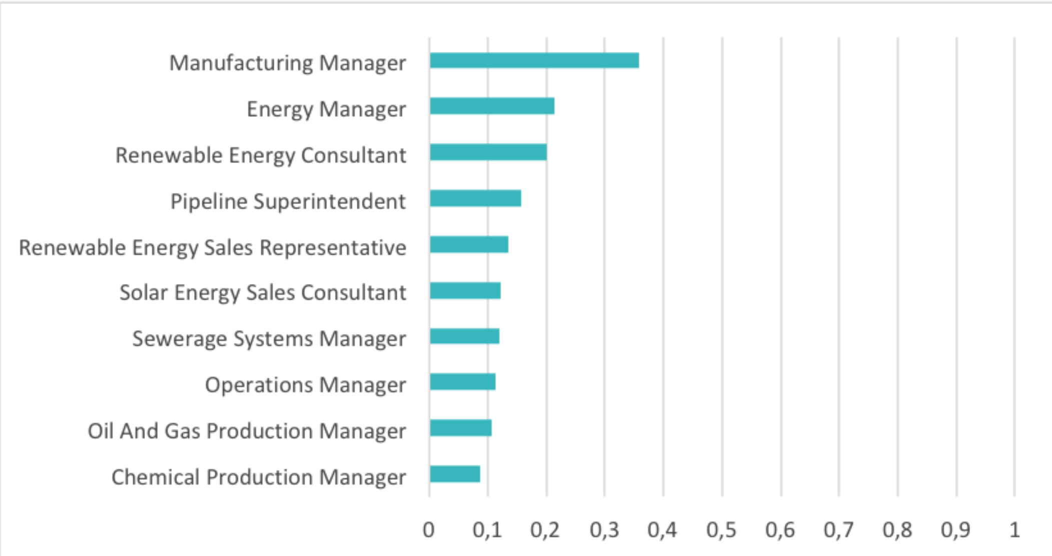
- Business and administration professionals related to the management of the operational aspect of the plants such as manufacturing manager, energy manager, and operations manager.
- Market-oriented consultants and representatives such as renewable energy consultant, solar energy sales consultant and renewable energy sales.

Those can belong to several categories of the ISCO classification of occupations such as:

- Administrative and commercial managers (ISCO 1.2)
- Production and specialized services managers (ISCO 1.3)
- Business and administration professionals (ISCO 2.4)
- Business and administration associate professionals (ISCO 3.3)
- Sales workers (ISCO 5.2)

The ranking of relevance - as provided by the correlation with technologies, according to the formula reported in Section 5.1 - can be applied here to show which business professions are more likely to be affected as a result of technology determined from data analysis (Figure 5.5).

Figure 5.5: Bar chart ranking the first 10 managerial skilled profiles in Egyptian Energy sector



The ranking in Figure 5.5 is indicative of which managerial or sales occupations are likely to be related to the technological changes expected over the coming years. The Energy Manager for example receives a position in the ranking which indicates the importance of process design within the production of electricity. In this sense, both a systemic approach and an overall vision of the processes favour better management of power resources with consequent reduction of losses and an increase in energy efficiency. Sales personnel and consultants will also be needed, especially to increase awareness of the general public about renewable sources and support the diffusion of greener solutions.

The ongoing shift towards renewable energies will undoubtedly necessitate a workforce with appropriate competences. This evolution might also create new jobs, both in terms of net employment and in terms of new professional profiles not previously required.

Regarding the necessary competences, the technological analysis in Section 3 demonstrates that many will be quite specific to each renewable energy source. Most importantly, these new competences are not encompassed by the existing standard classifications.

It is also worth noting that the pace of change and demand for new skills will not be uniform across all subsectors. As shown in Figure 3.6, the innovation rate for numerous subsectors, related to both traditional and renewable energy sources, has slowed down in recent years. This lower innovation speed, coupled with the fact that Egypt has a longer tradition and is better equipped in terms of training in these subsectors (which range from fossil to solar energy) shows that updating workers' skills will be necessary, but should be less challenging for the country. In contrast, two subsectors - *Hydrogen energy* and *Transmission and Distribution* - are experiencing a growing innovation rate. Particularly in the emerging and rapidly expanding field of hydrogen technologies, satisfying the demand for new competences and professional profiles may prove more difficult. Additionally, while *Transmission and distribution* is not a new subsector, its increased significance within the overall national strategy (as highlighted in the drivers of change analysis), and the influx of new technologies will likely result in a higher demand for a different composition of the workforce. Special attention to initial education and upskilling and reskilling in these subsectors will therefore be needed.

Moreover, the introduction of digital technologies in the entire energy sector will require various profiles, both technical and business related, to acquire increasingly transversal skills related to the IT field. The text mining analysis shows the growing importance of smart control systems, remote sensing and actuation, predictive analytics, the use of a combination of Artificial Intelligence and big data for forecasting, identification, and response.

These findings align with similar outcomes in other sectors: the worker of the future needs to possess a broader set of skills, with digital technologies forming an essential component of the required competencies.

6. STAKEHOLDER INITIATIVES TO MEET CHANGING SKILL DEMANDS

KEY INSIGHTS FROM THIS CHAPTER

- Egypt is focusing on diversifying its energy production through various strategies like the Egyptian Solar Plan, the 2035 Integrated Sustainable Energy Strategy, and the Egypt Vision 2030 strategy. Renewable energy sources like solar, wind, and hydropower are considered the main established trends, while clean hydrogen energy generation is an emerging trend.
- Egypt's potential in renewable energy generation is significant, but adoption of new technologies and innovation remains limited. Addressing these challenges will be crucial for Egypt to fully capitalize on its energy resources and meet its goals for a sustainable and diversified energy sector.
- There is a gap in both technical competencies and soft skills, particularly in the renewables and alternative energy sources sector. The demand for digital skills, energy management, and energy efficiency is also growing.
- There is a strong demand for high-level technical skills, especially in renewable power plant design, construction, and maintenance. Soft skills gaps exist in digital technologies, management practices, sales, marketing, and awareness of renewable energy potential.
- Difficulty in finding employees with the right skills has led to consequences like delays in technology adoption, production difficulties, and potential relocation of businesses. To address these issues, the education system needs to update curricula for engineering and technical education to include knowledge of renewable energy technologies and offer practical training for engineers and technicians.
- Companies face difficulties in recruiting qualified personnel and resort to outsourcing, subcontracting, and training programs to fill vacancies. Large companies have established their own in-house training programs, while others partner with education providers or outsource training to external providers.

This chapter analyses the views of companies and key stakeholders on the emerging skill needs of Egypt's energy sector and discusses their initiatives and strategies to ensure these needs are met. The findings presented below are from in-depth interviews conducted with: (i) representatives of large energy consuming companies and companies operating in the field of energy production and the production and installation of energy-related infrastructure (such as electrical household appliances, thermal solar heaters, large- and small-scale renewable energy systems), and (ii) university professors in energy and engineering related departments and representatives of the Egyptian Ministry of Education (MoETE). The companies in which the interviews were conducted included both Egyptian branches of multinational corporations and Egyptian companies. Most interviewed companies were large-sized, with their personnel ranging from one thousand to 43 thousand workers. The majority of these were manufacturing companies operating in the steel, cement, and oil sectors. The remaining companies were SMEs employing 10 to 90 workers each. These companies were all operating on the renewable energy sector (either developing and installing renewable energy systems for companies or producing energy from renewable sources).[47]

6.1. Views on trends in the energy sector

The growing interest in diversifying energy production in Egypt is evident from the introduction and execution of various strategies, including the Egyptian Solar Plan, the 2035 Integrated Sustainable Energy Strategy, and the Egypt Vision 2030 strategy. These strategies and plans place a strong focus on energy generation from sustainable and clean sources. According to interviewed experts, established trends for energy production in the future include **renewables** (mostly **solar and wind** and to some

[47] A total of 18 interviews were conducted. 14 concerned company representatives, two were held with representatives from higher education institutions and two concerned representatives of governmental bodies.

extent **hydropower**) while emerging trends involve clean hydrogen energy generation. Several interviewees referred to **nuclear energy as a potential source**, while an education stakeholder highlighted the potential of **sustainable waste-to-energy** technologies, which is supported by recent studies[48].

As regards change factors in the sector, the findings from interviews confirmed those resulting from the Big Data analysis (Chapter 3). The interviewees mentioned a variety of diverse factors driving change in the Egyptian energy sector but put a special emphasis on the following aspects mentioned most frequently across interviews:

- regulatory changes (such as the abandonment of fuel subsidies that aimed to facilitate competition in the energy market) aiming to facilitated investments;
- technological advancements making the transition from fossil fuels towards renewable energy generation affordable, improving energy efficiency and industry competitiveness;
- the fluctuations in energy prices, which present an opportunity for Egypt to emerge as a major partner in the energy market but also prompt energy self-sufficiency;
- the abundant availability of diverse energy sources (that is, renewable sources such as solar and wind but also the potential of new sources such as hydrogen); and
- Egypt’s advantageous position to export energy to neighbouring countries. Until recently, this included mostly Arab countries through the Eight Countries Electric Interconnection Project and the two major oil pipelines located in Egypt. After the advent of the Russia-Ukraine conflict, the EU has emerged as a major potential client for energy produced in Egypt.

Several interviewees mentioned that concerns about climate change ramifications and the need for sustainability drive the transformation of the energy sector towards alternative sources of energy. The country's commitments to international treaties and agreements regarding fossil fuel use and emission reductions, as well as its will to play a leading role in the decarbonisation of the African continent as a whole also affect policy design and initiatives in the sector. Egypt’s determination in climate change mitigation was lately reflected in hosting the COP27 UN climate summit in Sharm el-Sheikh in late 2022. The most important outcome of this summit was the agreement on moving funds from the developed world to developing countries for climate change adaptation purposes for the first time in history. The EU itself has agreed with the African Union on a new “Team Europe Initiative” on Climate Change Adaptation and Resilience in Africa as part of the EU-Africa Global Gateway Investment Package.[49] On the other hand, only a few interviewees referred to water shortages as a major driver of change. This hints towards a shift of interest towards solar and wind as the main renewable sources of energy.

Technologies that the interviewed company representatives and key stakeholders considered to be key drivers of change in the energy sector include technologies enabling the harvest of renewable energy such as wind and solar power; technologies facilitating energy transmission and distribution (such as smart grids and meters, storage and control units); and advancements in energy management and efficiency (such as energy saving and storage systems, insulation materials, and ‘soft’ monitoring technology based on predictive analytics and information management systems).

Alternative sources of energy such as thermal, nuclear, biofuel and hydrogen were also mentioned by both company and stakeholder representatives as potential future disruptors. It is noteworthy that, despite a high interest on renewables, several companies view that advancements in the fossil fuel extraction industry will continue to drive changes in Egypt’s energy sector. These perspectives could stem from the reservoir discoveries made in the past decade or may also be linked to Egypt's strategic position in the global fossil fuel trade, which, as per some corporate representatives, has improved following Russia's incursion into Ukraine. Representatives of VET providers were less supporting of this view and most of them pinpointed the potential of clean hydrogen energy as the main driver of the future,

[48] Salem *et al.* (2022). Potential of Waste to Energy Conversion in Egypt. Journal of Electrical and Computer Engineering, 7265553. https://doi.org/10.1155/2022/7265553

[49] European Commission. COP27: Team Europe steps up support for climate change adaptation and resilience in Africa under Global Gateway. Press release. 16 November 2022.

along with energy from solar and wind power. Finally, two company representatives stressed the issue of providing energy to remote areas in Egypt and mentioned the potential of hybrid PV-diesel technologies as a reliable energy source for this purpose.

Interviewees expect that implementing the national government energy plans and Strategies will bring about moderate to substantial employment increases in the sector. Interviewed education stakeholders expressed confidence that students currently being trained in newly established Competence Centres of Excellence (COCs) and university undergraduate 4-year programmes will fill in future vacant jobs adequately. Future demand for positions in the renewable energy generation and energy management and efficiency monitoring is expected to be particularly strong. This view is strong across both company and education representatives. One of the latter also pointed the emergence of hydrogen technologies and noted the need for technicians and engineers to be skilled in these technologies. A variety of emerging energy job types were mentioned, most of which concern energy management and require some form of soft and digital skills. (e.g., energy managers, engineers and auditors, data analysts making use of technologies such as Artificial Intelligence, Machine learning, Energy Storage Systems, robotics, and Internet of Things). According to some company representatives, positions in hydroelectricity, nuclear energy and marketing and sales will be also in high demand. A few of them however noted that the shift towards renewables will adversely affect employment in the extraction industries.

6.2. Factors limiting the adoption of new technologies in the energy sector

Egypt's geographic position and climatic conditions enriched it with a huge potential in renewable energy generation and the ability to become an important player in the regional energy market. However, initiatives to adopt new technologies for energy generation, transition and sustainability purposes appear to be limited and concern mostly large (and in many cases foreign based) companies. Innovation is also limited, as was discussed in detail in Chapter 3. The interviewed company representatives and education stakeholders identified various factors contributing to the low adoption of technology and innovation:

- **Macroeconomic instability.** Egypt has faced several crises in the last decade, including the Arab spring and the Covid-19 pandemic. In the latter case, the country resorted to IMF consultancy in 2020 to support its economy and implement necessary restructuring measures. Interviewees consider that such instability (especially in the form of social unrest) disincentivizes potential investors and can drive foreign capital out of the country. Indeed, according to the IMF (2014), the country experienced a sharp decline in foreign direct investment during the post-Arab spring period.[50] Low trustworthiness in the recent past expressed in the inability of the Egyptian General Petroleum Corporation to pay off its debt to foreign operators resulted in them delaying investments in existing and new oil and natural gas projects.[51] Instability also affects exchange rates. The Egyptian pound is constantly losing value against the US dollar, and it exhibited a large devaluation in 2016 after the exchange rate was "liberated" from its partial peg. Although this might have had positive financial effects[52] , many of the interviewees considered exchange rate volatility as a major factor inhibiting the adoption of new technologies in the energy sector. The invasion of Russia to Ukraine in February 2022 prompted another major devaluation of the Egyptian pound and resulted in an additional IMF support package deal.[53,54]
- **Sector structure and (until recently) lack of clear strategy on energy efficiency.** Energy generation sub-sector is dominated by large state-owned companies. This holds both in the case of the fossil fuel extraction and in renewable energy generation and inhibits competition. However, one

[50] International Monetary Fund (2014). IMF Staff Concludes 2014 Article IV Mission to Egypt.

[51] Energy Information Administration (2014). Country Analysis Brief: Egypt.

[52] PwC. The EGP Devaluation: A new beginning. Accessed 25 October 2022.

[53] Reuters. Egypt's pound hits new lows after shift to more flexible forex regime. January 11, 2023.

[54] Reuters. IMF confirms $3 bln loan for Egypt, welcomes exchange rate flexibility. October 27, 2022.

interviewee noted that privatization (through public-private partnerships) is an emerging trend in the sector. This manifests in several agreements for renewable energy generation plants and raises hopes of boosting competition in the renewables sub-sector. Slow decision-making, bureaucracy, and authorities adopting diverging strategies regarding future sectoral trajectory were also mentioned by company representatives as inhibiting the rollout of innovative solutions. In addition, a few stakeholders noted that up until very recently energy efficiency was not given enough priority by authorities, while many pointed the lack of -until very recently- a transparent and sustainable long-term strategy for the country's energy sector.

- **Regulatory framework**. As noted in previous sections, some regulatory restrictions inhibiting the shift towards renewables have been recently lifted (such as fossil fuel subsidies). However, several interviewees noted the need for amending customs rules and regulations to facilitate imports and reducing custom tariffs to some extent. The majority of company representatives noted the absence of a unified platform that should regulate and organize the interaction (electricity distribution, and grid connection) between the renewable energy developers and the national grid management and stressed the need for new regulations which would incentivize the roll out of Private-to-private collaborations in the energy sector and would clarify issues such as wheeling charges. In a similar fashion, education providers noted that a **regulatory framework for supporting the scaling-up of innovative technology** from patented prototypes to production in universities has only recently been established. This framework enables researchers to initiate spin-offs, startups, and incubators within universities to bring patents to production**. The framework however needs further adjustments**, as it currently considers only patented technologies. One interviewee noted that due to bureaucracy this law is not yet implemented in fact, while another pointed to problems related to intellectual property rights for innovations developed within universities.
- **Weak links between industry and academia.** This was mentioned by quite a few interviewees. Education stakeholders elaborated more on the matter: They noted that communication between industry and academia is in general scarce, and this may be due to certain preconceptions from the industry side. They mentioned that that Egyptian companies consider that technological solutions developed within the country might need a long time to fully reach commercialization and they are reluctant to apply these but opt instead for importing ready solutions from abroad. This disincentivizes investing for domestic technology creation in the energy sector. It also calls for certain initiatives that would incentivise companies to invest in domestic innovation. This concerns both companies operating in the energy sector (energy production and installation of energy solutions), but also other companies which seek implementation of sustainable energy solutions.
- **Lack of investments**. Interviewees referred to various reasons such as investment capital constraints, the cost of adopting new technologies, as well as lack of incentives to reach larger electricity generation capacities from renewable sources. One company representative noted that many local stakeholders are not able to cope with the rapid progress of technology advancements in the energy market. Lack of state funding for new laboratories, training courses and facilities, and scarce research opportunities were also mentioned by education providers. One of them noted that some policies to support company innovation via loans and funds for the application and use of modern energy conservation and management technologies were recently rolled-out, but companies appear to find these insufficient.
- **Shortages in workers with sufficient skills**. Interviewed experts and company representatives attributed this to the lack of dedicated theoretical and technical programmes in secondary and tertiary education, inadequate technical training of the existing graduates, and the absence of coordination between education providers and companies in understanding emerging needs and acting jointly towards meeting them. As a result, interviewed companies face difficulties in recruiting workers with the desired skills and resort to various responses to cover their needs (see the discussion below). As far as renewables are concerned, one interviewee noted that candidates for job positions lack both the experience required to work in the renewable energy sector and in general the awareness of renewable energy, its uses and potential. Some company representatives note that, despite the recent roll-out of novel programmes, the response of education providers to emerging market needs

has been rather slow. Two of them noted that emerging job profiles sought the most by large energy consumers (energy managers and energy efficiency engineers) are relatively new and no sufficient education and training is provided for these in Egypt. Given that such jobs will be among the most demanded (as identified by the big data analysis n Chapter 3), the lack of training programmes hints towards emerging recruitment difficulties among domestic labour supply. The lack of workers with sufficient technical ("hands-on") experience was mentioned as a serious issue hampering the diffusion of new technologies by all interviewed education stakeholders.

6.3. More on the emerging but unaddressed skill needs

The lack of workers with the right theoretical skills and adequate technical competencies is undoubtedly an important factor that keeps the Egyptian energy sector from realizing its potential. It creates extra costs for companies within the sector but also makes it difficult for energy consuming firms to achieve better energy management. A gap between demand and supply of soft skills in the sector appears as well. Mismatch between demanded and supplied skills may take many different forms: a company representative noted that several candidates for technical job vacancies lack the required soft skills for the vacant positions. Such skills may include the proficiency in using digital tools and having a thorough understanding of the applications and potential of renewable energy sources. In a similar fashion, all interviewed education providers noted that higher education graduates who opt for technical jobs lack serious technical ("hands-on" or "on-the-job") training. This creates a tendency for engineers with an undergraduate university degree to return to the universities to be taught undergraduate or postgraduate technical degrees (technical diplomas with hands-on practical education). This is something that frequently takes place after employer's requests.
In-depth discussions with company representatives and education providers reveal that unaddressed emerging skill needs in the Egyptian energy market:

- consider both technical and soft (managerial, IT, etc.) skills, but there seems to be a large gap in technical competencies and a growing need for digital skills;
- refer mainly to part of the energy sector concerning renewables and alternative sources of energy rather than the fossil fuels sector; and
- are also marked in the areas of energy management and energy efficiency.

These needs are the result of recent changes in the structure of employment in the country's energy sector driven by the expanding size of the market (especially towards renewable energy generation), increased competition and new strategies announced. For example, one interviewee mentioned that the commitment of the Egyptian Electricity Holding Company to establishing an Energy management team may drive large energy consuming companies to do so as well. Company representatives noted that more people are now required to work in specialist roles in the sector, as workforce composition shifts towards higher level of skills and IT and data analysis jobs. New technologies have changed the content of some jobs substantially: As mentioned by one company representative, tasks for operational sector staff are extended to cover areas like quality assurance.

All Interviewees noted that emerging recruitment needs concern particularly medium-skill jobs, while more than half of them also noted the need for high-skill workers. They also provided more detailed information in terms of job profiles in demand. These are summarized as follows:

- **Technical jobs:** energy efficiency engineers and technicians, sustainability experts, energy auditors, solar energy design engineers (with proven experience in designing renewable power plants), construction engineers (especially those skilled and having a background and experience in renewable power infrastructure) and technicians, electrical engineers and technicians (with experience in installing, operating and maintaining power plant facilities). One interview mentioned increased needs for wind blade maintenance technicians.
- **Managerial jobs:** energy management system operators, energy managers, and sales and marketing jobs.

A comparison of the above-mentioned profiles with those emerged from the Big Data Analysis (see Figures 5.3. to 5.5. above) reveals that there is a high concordance between the results using data analytics and interviews. For example, the job profile “energy manager” was mentioned by almost all interviewees and appears ranked first in the emerging managerial profiles in Figure 5.5. An additional finding from the interviews complementing the results in Figure 5.5. was that several interviewees pointed the need of software competences for energy management and auditing jobs.

As regards skill needs, high-level technical skills in demand relate to energy control and energy storage systems design (e.g., photovoltaic systems, thermal solar applications), renewable power plants design and construction of renewable power infrastructure, while technician level skills mentioned concerned the installation, operation and maintenance of renewable power plant facilities, grid maintenance, and pipeline maintenance. A particular lack of turbine foundation and wind blades maintenance skills was noted by two interviewees. Several interviewees noted that a lot of tomorrow’s tasks will involve digital skills. They explicitly mentioned the need to upgrade or establish skills related to Internet of Things, use of AI in energy applications, cyber security, web development, data analysis, as well as the use of robotics for remote operation and control.

Apart from those related to digital technologies, gaps in other soft skills appear to concern (i) management practices, sales, and marketing skills and (ii) the awareness of renewable energy, its uses and potential. Some interviewees mentioned that the change in business models (due to privatisation and he need to accommodate sustainability principles) forces firms to change their management approaches and adopt new strategies. One interviewee explicitly noted the need to upgrade the communication and negotiation skills of business job profiles in the sector.

Difficulties do exist on filling several of the above-mentioned job positions. Employers have difficulties on finding people with the right skills, and most interviewees noted that difficulties concern finding both technical and soft skills. Energy producers and energy infrastructure designing and installing companies appear to have the largest problems. Their representatives reported difficulties in filling positions for engineering & technical jobs (such as plant designers, installation technicians, maintenance engineers, other qualified medium skilled workers), but also jobs requiring soft and IT skills such as operations and management technicians, simulator and software program designers, and marketing-related positions. On the other hand, energy consuming companies in the manufacturing sector are concerned with filling energy efficiency and energy managing positions and reported difficulties in finding personnel with the required competences. Interviewees mentioned various consequences of failing to fill these vacancies: delays in introducing new technologies, difficulties to production and reduced levels of customer service that cause business loss. One company representative noted that firms may be forced to relocate in search of better workforce pools, which can adversely affect the local economy and contribute to higher levels of unemployment. The views of education providers are similar, and they point that inadequate training frequently results in bad equipment installation. One of them noted that such failures in installation tend to persist because many business owners (e.g., in small-scale solar panel installation) also have inadequate training. The results are usually losses in efficiency of the installed systems.

Adequately training workers to fill vacant jobs needs updating curricula in engineering and technical education schools to accommodate knowledge of renewable energy technologies. According to the interviewed company representatives and education providers, most pressing needs are to **develop new engineering courses** related to new technologies in the solar and wind power generation (e.g., PV cooling technology) and to emerging technologies for energy generation (such as hydrogen, nuclear, and waste-to-energy), as well as to facilitate **adequate technical (on-site) training** for engineers and technicians (such as in installation of photovoltaic solar cell parks and wind turbines). Company representatives and education providers agreed that curricula should be developed for **high-skilled managerial profiles** such as energy efficiency, management, audit, and conservation. This will address pressing needs within the Egyptian energy and manufacturing sectors.

6.4. Factors encouraging the adoption of new technologies

The limited diffusion of technological innovations in the energy sector up to today can however be potentially offset. The interviewed company representatives and education stakeholders noted some developments that act as facilitators for technology and innovation uptake. Most of these are recent nature and relate to investments planned in the near future, collaborations to upgrade technical education, and geopolitics:

- **Rising demand for energy**: Energy demand has been steadily rising in Egypt in the past decades, owing both to household and industry consumption boosted by gradual economic development. Meeting this demand necessitates adopting new forms of energy harvesting technology, especially renewables. Regarding industry consumption, one interviewee noted that the presence of component and electronic chips manufacturers in the country affects the energy sector.
- **Waste management needs**. Economic development improves quality of life but increases demand for energy and waste generation. According to World Bank estimates, Egypt produces 0.67 kilograms of waste per person per day. Waste-to-energy technologies can turn this problem into a resource. Currently waste-to-energy plants in Egypt involve incineration.[55] However, Egyptian authorities are working towards the implementation of environmentally friendly waste-to-energy solutions, as part of the country's Vision 2030 (Hemidat et al., 2022)
- **Geopolitical developments**. Many company representatives consider that the Russia-Ukraine conflict and sanctions announced by the EU and other entities on Russia's energy sources will positively affect Egypt's position in the global energy market. As a result of its strategic position in the global energy trade routes, its physical proximity to the EU, its rather large reserves of fossil fuels, and its plans to invest heavily in renewable electricity production via solar and wind facilities, Egypt has risen as a powerful ally to the EU. These developments could boost investments in the country's energy sector -including heavy foreign investments stemming from the EU- and facilitate the uptake of new technologies. Several representatives noted that the war is an opportunity for Egypt to expand liquefied natural gas trade with the EU, while others noted that it provides renewable energy stakeholders with an opportunity to showcase renewable energy as an alternative and reliable energy source, compared to coal or petroleum. Their views are that renewables can arise as an attractive alternative to fossil fuels, both from the perspective of securing stable operation and from that of lower prices.
- **New bilateral investment agreements**. Recently, various entities have pledged to help Egypt decarbonize its economy and increase its clean energy generation capacity. Earlier discussions between the EU and Egypt for closer cooperation in energy trade, sustainability and the green transition[56] have recently culminated in the signing of a Memorandum of Understanding (MoU) on a strategic partnership on renewable hydrogen.[57] This aims to support the development of a renewable hydrogen industry and trade across the EU and Egypt, including infrastructure and financing. It will also facilitate investment in renewables and boost the decarbonization process in Egypt. During the recent CO27 hosted in Egypt in October 2022, the EU has also issued a Joint Statement with EBRD to contribute of up to €35 million in support of Egypt's Energy Wealth Initiative. [58] The initiative is part of the country's new Climate change strategy for 2050 launched in May 2022. A similar pledge for this initiative was announced by ERDB, the US and Germany.[59]
- **Partnerships for knowledge diffusion and training**. Several of the interviewed company representatives have recently established partnerships with education institutions to co-operate in the provision of required knowledge for energy sector competences. These partnerships include summer schools and cooperation in the design of energy engineering curricula. A more detailed

[55] Siemens Energy. Waste-to-Energy Technologies for a Greener Future. Accessed 23 February 2023.

[56] European Commission. EU-Egypt Joint Statement on Climate, Energy and Green Transition. 15 June 2022.

[57] European Commission, DG Energy. Memorandum of understanding on a strategic partnership on renewable hydrogen between the European union and the Arab republic of Egypt. 16 November 2022.

[58] European Commission, DG Neighbourhood and Enlargement Negotiations. EU, Egypt, EBRD Joint Statement on the Nexus of Water, Food and Energy. 15 November 2022.

[59] ERDB. Egypt's NWFE energy pillar gathers international support. 11 November 2022.

discussion follows in the next section. In addition, interviewees report that there exist national (such as the Egyptian Ministry of Petroleum) and supranational (e.g., UNIDO, the Solar Energy Development Association, and the Regional Center for Renewable Energy and Energy Efficiency) organizations that can provide training on the required competences, often in co-operation with Egyptian education providers.

- **Reskilling opportunities for low-skilled workers**. Several company representatives noted that such opportunities do exist. These relate to the above-mentioned partnerships and pose an opportunity for low-skilled personnel to be re-skilled and gain the necessary competences to be employed in the energy sector. These can cover part of the demand for qualified workers that are nowadays sought abroad or trained abroad.

6.5. Company training and recruitment strategies

Interviews with company representatives revealed that companies face several difficulties in recruiting qualified personnel and resort to various means for filling vacant positions. A first set of measures concerns recruitment channels for finding people with the right skills. The two most frequently mentioned means of recruiting strategies are outsourcing and subcontracting. These are used to find both technical as well as managerial and marketing positions (such as consultants and energy sales assistants), mainly due to cost effectiveness. Some company representatives noted that they prove particularly useful for filling vacancies related to the design and construction of renewable energy power generation projects. When difficulties persist, companies tend to increase the range of recruitment methods (by e.g., reaching out to foreign job markets and using application service providers). The use of consultancy services to guide towards finding personnel was also mentioned.

A second measure to fill vacancies is by training workers to fill vacant jobs. This can involve both the existing workers within a company or newly hired workers that need to be upskilled to adequately handle job tasks. The latter takes place because young often graduates lack the necessary technical competences ("hands-on" training) to work with new technologies. Training programs for renewable energy competences appear to be particularly hard to find. Large companies specialised in energy-related infrastructure and in renewables particularly, reported that they have **established their own in-house training** to fill this gap. Others **partner with education providers** (colleges and universities) to provide qualified training to both university students and workers (either their own workers or workers willing to up- and re-skill themselves). These training programmes include:

- Summer schools;
- Participating in dual system college teaching;
- Offering internships to engineering students; and
- Coordinating training programmes in cooperation with education institutions.

Other companies (both large ones and SMEs, and both operating in the energy sector or being energy consumers) resort to outsourcing or subcontracting training to **external training providers** such as private companies (usually from abroad) or national and supranational organizations such as UNIDO, which provide training programmes for the required competences. Some representatives noted that **open-source online training opportunities** could be another means to (re)train workers in the post-covid era, while others mentioned that sector associations and TVET schools also provide some training courses related to the energy sector.

6.6. Education provision for the energy sector: Views on challenges and policies

Energy education provision in Egypt

Education provision related to the energy sector in Egypt concerns higher education institutions offering related bachelor's and master's degree programmes in engineering (domestic institutions, branches of international institutions, and partnerships between domestic and international institutions), technical institutes established by higher education institutions that offer training related to the energy sector, and upper secondary education institutions offering energy sector training. Latest additions to this list include the recently developed Applied Technology Schools (ATSs) and Centres of competence (CoCs). Higher education and technical education institutions in Egypt traditionally offer engineering programmes related to the fossil fuels sector, such as the bachelor's and master's degrees by the American University in Cairo[60], the programme offered by the Faculty of Engineering in Pharos University[61] and Future University[62], and the Petroleum Engineering and the Mining & Geological Engineering programmes of Cairo University[63]. Various national University Departments offer programmes dedicated to electrical power engineering, such as the Electrical Power and Machine Programmes in Kafrelsheikh, Minia, and Menofia Universities[64], and the Transmission and Distribution energy networks program provided by the College of Industry and Energy Technology of the newly founded New Assiut Technological University. Programmes and departments dedicated to renewable energy include the Power engineering and sustainable energy department in Suez Canal University[65], Renewable Energy Programs offered by the College of Industry and Energy Technology in New Cairo Technological University[66] and the Delta Technological University[67], and the program of sustainable and renewable energy engineering offered in Mansoura University[68]. Private Universities operating in the country offer also programmes related to energy engineering and renewables, such as the Energy and renewable energy engineering programme offered by the Faculty of Engineering & Technology in the Chinese Egyptian University[69], the Energy Engineering Program of Heliopolis University[70], and the Electrical Power and Control Engineering Program of the Ahram Canadian University.[71] As regards technical academies, the EGT academy[72] is a joint occupational training centre run by Siemens, the GIZ and the Egyptian government. It is expected to provide training to more than 5 000 young Egyptians in the coming years, thus developing a cohort of skilled technicians to ensure the maintenance and repair of renewable power generation and transition equipment.

Challenges

Discussions with representatives from the education sector (ministerial authorities and university professors) reveal that the country's education providers are highly interested in energy-related education, share similar views with company representatives about the importance of renewables and hydrogen, worry for the lack of skills and attempt to take actions to update curricula so that future graduates are adequately equipped. An indication of the sector's interest in energy is that there are now dedicated departments of energy in various universities across the country. There are however multiple challenges. These involve the weak collaboration between industry and academia in developing and updating curricula, lack of strategies for skills anticipation and formal National Occupational Standards for the sector's professions, and insufficient promotion of work-based learning.

As the interviewees report, there are **no substantial collaborations** between universities and industry associations in curriculum development and training and no clear strategy to establish or support such collaborations. Education providers frequently act on their own and set up such collaboration schemes on a 1-to-1 basis with energy firms. The interviewed education providers noted that the technology companies in Egypt operating in the field of renewable energy installation do not participate in such collaborations at all. This may be a factor exaggerating the lack of adequate practical training in these new technologies. Interviewees listed several organizations that could provide support in updating

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60 BSc in Petroleum Engineering, MSc in Petroleum Engineering.

61 Department of Petrochemical Engineering.

62 Department of Petroleum Engineering.

63 Mining & Geological Engineering Program, Petroleum Engineering Program.

64 Kafrelsheikh University, Minia University, Menofia University

65 http://eng.suez.edu.eg/

66 https://nctu.edu.eg/en/college-of-industry-and-energy-technology/#

67 https://dtu.edu.eg/en/renewable-energy-program/

68 https://engfac.mans.edu.eg/en/about-2/scientific-departments-2/renewable-energy-engineering-program

69 https://www.ecu.edu.eg/?page_id=1966

70 https://www.hu.edu.eg/faculties/engineering/academic-programs/

71 https://acu.edu.eg/News/471039.aspx

72 https://www.egtacademy.com/

curricula (the Academy of Scientific Research and Technology, Industry Councils, worker unions, other Ministries, and individual companies). The **absence of Sectoral Skills Councils** in the country is viewed as an obstacle in identifying skill needs and it deprives education providers of a major partner in updating curricula. Such councils could also assist in developing **National Occupational Standards** for occupations in the energy sector, which are currently lacking. A consequence of this can be overqualification and skills underutilisation. As an example, one interviewee noted that "energy technologists"[73] have been graduating from Universities in Egypt since 2015, but due to the absence of a clearly documented job description for them and established qualification standards, they are hired in technician jobs.

Skills anticipation in the sector is not structured. This is a general phenomenon for all sectors. Representatives noted that studies conducted are not consistent and frequently relate to specific sectors. Some form of labour market information is being gathered by the Ministries of Manpower and Planning, but they do not consist of clear skills anticipation tools. The need for these two authorities to collaborate with the MoETE to develop such a tool was pointed.

Challenges related to **work-based-learning** (WBL) involve the lack of general policies to support Academia-industry collaboration, and absence of funding to incentivize companies to engage in it. Representatives notes that there is currently a good 1-to-1 collaboration between companies and technical schools towards WBL, but it is not mature yet and cannot be scaled up without a central policy. One of them noted that lack of funding results in some students paying for WBL themselves. In addition, there are currently no strong incentives given to companies to organize and promote skills development within their premises or facilitate workers' re-skilling.

Interviewed stakeholders also noted the need for a **faster formal accreditation scheme** for new training programmes and curricula. Currently, there is a governmental program accreditation body that evaluates & accredits every university programme, while each programme needs also to be approved by the Supreme Council of Universities. Interviewees pointed that this process could be made faster, especially for short programmes.

Policies

Egyptian authorities have set out reforms in response to these challenges. The reforms discussed below concern technical education in general. As noted by an interviewee, a Law establishing a new **National Authority for Quality Accreditation** of technical education (ETQAAN) was passed in late 2022. ETQAAN is the new authority that is responsible for accrediting programmes in VET and TVET. It will be fully operational within one year and it is aspired that it will help link study programmes in technical education institutions with the labour market. To get accredited according to the new law, study programmes must have identified the needs of the labour market for each specialization offered, what competencies are essential for each, the availability of equipment and training laboratories to deliver the programme, the availability of trainers and administrators, and the evaluation methods to be used in the programme.[74] In addition, a new authority named TVETA that is responsible for the **training of teachers and trainers** in new technologies and subjects has been recently established. New training will put special attention on digital skills, while trainers in the energy sector are included in those to be trained.

As regards **WBL,** one interviewee referred to the work undertaken by the National Center for Technological Dual Education (NCTDE), the mission of which is to monitor the implementation of industry internships through the TVET Dual Education programs. Another representative noted that the MoETE has recently engaged in reforms introducing Schools of Applied Technology (which started receiving students in the academic year 2022-2023). Currently only about 3% of students are receiving WBL, while the target is to reach 10% by 2030. Other reforms include proposed amendments to existing Education Laws to accommodate WBL and facilitate companies to engage in it via various forms of incentivizing. Incentives have been established for students engaging in WBL as well, which include monthly payments and insurance provision during the training period. The interviewee identified Turkey

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[73] Energy Technologist is a degree for a graduate from a Technological University after 4 years study in the area of Energy specialisation. The certificate is a B.TECH Certificate/Degree (i.e. Technologist) in Energy specialisation

[74] Ali, A. New Egyptian Accreditation Body Could Help More Than 2 Million Technical Students Find Jobs. Al-Fanar Media. 22 November 2022.

as a role-model country for Egypt in WBL. They noted that Turkey managed to increase the percentage of students engaged in WBL to 50% within a few years by giving (mostly financial) incentives on companies.

In addition, the MoETE is currently coordinating with the Ministry of Planning to establish **Sectoral Skills Councils**. The relevant presidential decree is currently being prepared and the plan is to have these councils formally established within the next 1-2 years. As regards the energy sector, interviewees noted that the MoETE has cooperated with international agencies (USAID and GIZ) to introduce and/or revise several engineering-related curricula related with renewable energy competences in technical education schools. Many of the revised undergraduate or post-graduate courses involve specializations in renewable energy sources (such as solar, wind, hydroelectric, wave, and geothermal energy generation).

Collaborations between industry and academia

In the absence of formal processes, education providers (universities and technical schools) have established own protocols for collaborating with private companies to develop and update curricula for renewable energy generation. This collaboration involves company representatives being invited to evaluate proposed upgrades in undergraduate and postgraduate degrees and issue their recommendations about desired material. In some cases, as part of the collaboration, company representatives conduct guest lecturing too. Companies participated in such updates involve large electrical, petroleum, and mechatronics companies. One interviewee noted that this collaboration resulted in the development ***of draft teaching occupational standards*** to substitute for the absence of formal National Qualification Standards. The National Center for Technological Dual Education has also pledged to contribute to updating energy-related curricula.

One of the most important and promising collaboration involves the development of **Centres of Competence and Excellence** by MoETE. The First three centres were established by law in early 2022 and involve training in the fields of renewable energy and energy efficiency. Training programmes in the centres will be developed in collaboration with energy industry experts. An interviewee noted that in the next phase of this project, authorities plan to work closely with companies to identify more specific needs in terms of occupations and skills for the energy sector. This will facilitate to further structure training programmes in these centres.

6.7. Overview of interview findings and stakeholder recommendations

Overall, interviews with company representatives and key stakeholders provided a rich source of information on emerging skill needs and enabled a deeper understanding of the existing skills gaps in the country's energy sector and the difficulties in filling these gaps. Regulatory reform, lack of investments and skill gaps were mentioned as the most important reasons hampering innovation in the sector. On the other hand, companies viewed that the rising demand for energy and geopolitical developments will eventually push the sector towards adopting new technologies. Education sector representatives pinpointed the importance of newly rolled-out training programmes and Competence Centres in providing adequately skilled personnel that can work with these technologies.

All interviewed representatives agree that **the future of energy generation in Egypt is based on renewables and** pointed particularly on **solar and wind** power generation. Education providers view that within the next decade energy generation from hydrogen will gain pace. However, all representatives noted that large effort is needed to cover existing skill gaps in the renewable energy sector. These **gaps** concern mostly engin**eering and technician jobs in energy efficiency, designing, installing and monitoring power plants, and construction engineers and technicians experienced in renewable power infrastructure**. Vacancies for **high-skilled positions in energy management** are also many and concern manufacturing companies and other heavy-energy consuming firms that wish to improve their sustainability. However, these gaps are difficult to fill.

The future impact of **digitization** in the energy sector in Egypt is expected to be large and is something that according to various interviewed experts and company representatives, should not go unnoticed by VET providers and relevant authorities. Existing market trends are expected to transform jobs in the energy sector to more digital ones. Future digital skill needs concern to the **use of Internet of Things, Artificial Intelligence and machine learning, robotics, data analysis, cyber security**. These will be important for both managerial jobs (e.g., energy managers, energy auditors), as well as for more technical jobs such as energy engineers (e.g., designers of power plants and energy storage systems) and power plant operators and maintenance personnel. Failing to account for these skills in the coming years could result in a fallback in the introduction of new technologies in energy generation, distribution and savings.

Company representatives and other interviewed stakeholders proposed various recommendations to adapt to emerging challenges and facilitate the roll-out of new technologies in Egypt's energy sector. These include:

- **A systematic approach to skill needs analysis**. This requires the cooperation of the energy sector representatives and VET providers.
- Further cooperation between VET providers and the private energy sector for developing and **updating curricula** so the emerging needs are adequately met. A formal strategy is recommended to establish such collaborations.
- Establishing **formal National Occupational Standards for occupations**. This involves all occupations and not only those in the energy sector. Development of a National Qualification Framework began in 2006 but still has not been completed.[75]
- Establishing a **strong system and relevant legal framework for training** (in-house training, apprenticeships, WBL) to strengthen the competences of recent graduates and minimize the dependence on foreign labour and foreign training for labour. One interview noted that internship contracts should be established between the students and the industry rather than between students and their school, as is currently the case.

[75] See this report for a short presentation of the various steps towards the implementation of such a framework in Egypt.

- Developing a framework **supporting the recruitment of fresh graduates** in the energy sector. Interviewed experts mentioned examples of other countries like South Korea and Germany, which could serve as role-models for developing such a framework.
- Undertaking concrete actions to **increase WBL** in the energy sector. This will compensate for the current lack of “hands-on” technical competences. The developed framework should involve **incentives** to companies for engaging in WBL schemes and retaining them after training is finished. It should also involve incentives to students to follow this educational pathway into the labour market. Anecdotal evidence points that about 50-75% of students undergoing WBL want to proceed in higher education institutions instead of entering the labour market. Proposals for effective incentives to companies include financial ones (e.g., tax reduction), while career progression opportunities should be established for students.
- Future training programmes should consider the necessity to **re-skills workers in the oil extraction** industry to transverse into renewable energy sector. This could avoid unemployment in case extraction industry employment decreases in the future as a result of turns into renewable energy generation.

7. A FINAL WORD ON THE FINDINGS

The aim of this report

This report uses a combination of desk research, big data analysis of patents and bibliographical databases, and qualitative research (in-depth interviews) with key stakeholders and companies, to provide a detailed analysis on the future skill needs in the Egyptian energy sector over the short- to medium-term. The energy sector plays an important role in supporting economic growth. Economic growth increases energy demand, which needs to be met by supply if growth is to be sustained. Egypt is a naturally well-endowed country in terms of fossil fuel reserves but also enjoys an abundance of wind and sunlight. It is currently in the process of transforming its energy sector from one dependent upon fossil fuels under public ownership to one having a sizeable renewables sector driven by public-private partnerships. This reflects efforts to exploit its competitive advantages in terms of its natural endowments and geographical position to expand energy exports to neighbouring countries, improve its overall economic performance which has been in doldrums, and attain its sustainability and decarbonisation targets. In summary, Egypt has both the potential and ambition to become the major hub in a newly emerging energy superhighway, in which renewables will enjoy at least equal importance to fossil fuels.

To attain these goals, the country needs to: become attractive to off-shore investments; boost domestic investment activity in renewable energy generation; improve governance in its energy sector; and offer adequate incentives to companies across the economy to go greener by investing in their energy efficiency and management. In addition, the transformation to renewables is potentially skill intensive. The construction of wind and solar farms to their operation and maintenance, alongside the development and upkeep of network grids and pipelines, to the potential development of novel energy sources such as hydrogen, all have their specific skill needs. Added to this the shift to a mixed economy involving public and private sectors implies the implementation of new business models with a concomitant demand for new business skills. Therefore, the continuous supply of adequately trained workers needs to be established, which is also a push factor for investment activity. This study aims to facilitate this by identifying emerging skill needs and the various barriers impeding innovation and skills development in the sector and discussing potential policy recommendations.

Past developments, emerging skill needs and shortages

Developments in the Egyptian energy sector can be summarised as follows: in terms of activities, the sector recently started attracting investments in renewable energy generation, which have manifested themselves in the development of large solar and wind power generation plants. However, various factors appear to jeopardise the sector's future trajectory in terms of investments and innovation. Past and present volatility of the overall economy (particularly in the face of recent geopolitical developments) discourages off-shore investments, and so does weak governance. Despite recent liberalisation and privatisation steps, public ownership continues to inhibit competition to a large extent and discourages the engagement of small and medium enterprises. Bureaucracy continues to inhibit the practical implementation of new legislation, while the absence (until very recently) of a structured strategy for the future of the energy sector was a signal of uncertainty.

In addition, domestic technological innovation related to energy is limited and the country relies almost exclusively on technology imports. The analysis of patents in Chapter 3 reveals that inventive activity in Egypt declines severely after its peak in 2009, while only a small fraction of patents (5%) is related to the energy sector. Energy-related patent activity practically ceased between 2012 and 2019 (last year data were available). This was confirmed by stakeholder interviews and related to: (i) the absence of, until recently, a regulatory framework to support the transfer of Egyptian innovations from patent to production stage; and (ii) the reluctance of the private sector to accept home-based technological innovations.

As regards employment and skills provision, the Egyptian energy sector reveals the persistence of skill mismatches between supply and demand. The labour market across the country is characterised by low activity rates and low levels of female participation, high shares of NEETs and unemployment that appears to be greater for the highly educated. Employment in the energy sector consists of mainly medium-skilled workers, is highly gender segregated, and declined by 5.2% within the last decade. This stands in contrast to the booming growth in foreign investments in new renewable energy plants and suggests that, at the moment, additional labour demand is met via foreign rather than domestic labour.

The mismatch between the supply and demand for skills was confirmed by the analysis carried out in this report. In particular, big data analysis of scientific literature identified various emerging job profiles, while structured interviews with stakeholders confirmed the inability of current skills provision to cater for these needs. Emerging profiles include **high skilled technical professional and associate professionals** (such as energy, mechanical, and electrical engineers, and technicians), **medium and low skilled technical profiles** (e.g., renewable energy plant operators and technicians and oil pipe welders), and **business occupations** related to the energy sector but not its technological aspects. These include plant management jobs such as energy managers and operations managers, and market-oriented consultants, representatives, and salespeople. Some of these profiles are related to renewables while others to the oil industry. Also, profiles with the highest future demand are both highly specialised ones (e.g., Solar Power Plant Operators and Onshore Wind Farm Technicians), and jobs with a more horizontal skill set (such as Energy Engineers or Mechanical Engineers) which are in demand across energy sub-sectors. A few of these jobs are rather new to the Egyptian energy sector but they concern highly demanded managerial positions such as energy managers and consultants.

Interviews with company representatives and stakeholders in the energy sector indicated that there was a **lack of dedicated theoretical and technical programmes** in secondary and tertiary education (especially for highly demanded jobs such as energy management), and insufficient access to continuing training by the existing workforce. Employer representatives noted that skills gaps were more pronounced for technical and digital skills, and that they concern mainly alternative energy source sub-sectors. They pointed towards emerging needs in: (i) **high-level technical skills** related to energy control and energy storage systems design, renewable power plants design and construction of renewable power infrastructure; (ii) **technician level skills** concerning the installation, operation and maintenance of renewable power plant facilities, grid maintenance, and pipeline maintenance; (iii) **digital skills** related to Internet of Things, use of AI in energy applications, cyber security, web development, data analysis, as well as the use of robotics for remote operation and control; and (iv) **soft skills** that concern management practices (especially need for **change management** skills to navigate changes in business models), **sales and marketing**, and the **awareness of renewable energy**, its uses and potential. They noted that upgrades in curricula are needed to accommodate new skill needs (such as digital and managerial) and upgrade existing skills provision (for technical skills).

These skill shortages emerge from various factors, which may be associated with the previously observed weaker skills governance in the country's education sector, or with the limited communication between demand and supply factors in the energy sector. More specifically, the following were reported as contributing to skill mismatches.

- ***Fragmented and limited skills anticipation*** across the labour market as a whole and the energy sector in particular. No framework and established approach for skill needs anticipation.
- ***Absence of a National Qualifications Framework.*** Temporary draft occupational standards have been developed for occupations in the energy sector via partnerships of education providers with leading companies.
- ***Under-developed work-based-learning***: Lack of a supporting framework for academia-industry collaboration. Limited incentives to companies and employees to engage in work-based-learning. Collaborations between companies and technical schools towards WBL takes place only on a 1-to-1 basis.
- ***Weak links between industry and academia with regards to skills anticipation and curriculum development***. Skills anticipation studies are not conducted in a structured manner. A framework to support academia-industry partnerships to gain insights on skills gaps, update curricula, and create

new training courses does not formally exist. Academic institutions take own initiatives to form such partnerships with industries on a 1-to-1 basis.

- ***Limited incentives to industry to promote skills development and facilitate re-skilling.*** *A formal framework guiding the roll-out of such incentive schemes does not exist*.

The demand for skills in the energy sector is changing. Employment across sub-sectors should increase, while the greater uptake of renewable energy projects will drive skills demand towards more high-skilled professional, associate professional, and technician jobs. Technological developments in renewables are also set to increase the demand for STEM professionals. The findings in this report indicate that the local labour market currently appears to be short of several emerging skills, particularly those related to renewable energy generation. This causes companies operating in the renewables sub-sector to seek external training to train domestic workers or to import trained workers from abroad. Failure to adequately match this future demand with supply will most likely result in slower development on the sector.

Final recommendations

Egypt seeks to take advantage of its natural endowments to emerge as a leading hub in tomorrow's global and regional energy markets. To do so, the country needs to re-position itself as an attractive destination for investments related to renewable energy generation and establish a continuous supply of adequately trained workforce to meet the emerging skill needs in the sector. The capacity of the education and training sector to meet skill needs may well shape the strategic choices which employers in the energy sector make with respect to the activities in which they decide to invest and how they organise their workforce.

For Egypt to emerge as an investment attraction and a regional hub for energy, the following actions should be considered by national stakeholders, as identified via a combination of desk research, big data analysis of trends and in-depth interviews with stakeholders:

- Allocate additional funding to support domestic innovation related to the energy sector and attract highly skilled Egyptian researchers from abroad. Stakeholder interviews mentioned the lack of state funding for new laboratories, training courses and facilities, and scarce research opportunities as factors inhibiting domestic innovation.
- Incentivise domestic companies to use technological solutions developed "in-house" rather than importing technology from abroad. This would create more incentives for domestic technology innovation and align with future skill requirements.
- Exploit further the potential of other clean energy technologies, such as hydrogen and waste-to-energy. Waste-to-energy plants relying on energy generation from municipal solid waste through pyrolysis and gasification are currently under development in the country (Hemidat *et al.,* 2022). For instance, the waste-to-energy project by Green Tech Egypt.

As regards meeting the future skill needs of the energy sector, this study identified the following necessary actions to be undertaken by energy sector stakeholders and education and training authorities:

- Develop a systematic approach to skill needs anticipation. This requires the cooperation of the energy sector representatives and VET providers. The ongoing work on the establishment of a labour market information system goes in this direction. It is important that the work done includes granular information about sector skills needs, especially in sectors which are a priority for the country (including energy).
- Expand and formalise the existing fragmented cooperation between VET providers and the private energy sector for developing and updating curricula. A formal strategy is recommended to establish such collaborations.
- Develop stringent quality criteria to be met by training providers licensed to deliver accredited training.
- Set up a system of formal National Occupational Standards for occupations. For the energy sector, this can be based on the existing "draft" occupational standards which have been developed via 1-to-1 partnerships between certain education institutions the private sector.

- A dedicated framework and additional concrete actions are necessary to enhance training opportunities (in-house training, apprenticeships, work-based-learning) within the energy sector. This will bolster the competences of recent graduates and alleviate the current shortage of practical technical skills. Such a framework should provide incentives for companies to engage in these training schemes and retain workers post-training. Moreover, it should offer incentives to students to pursue this educational pathway into the labour market, such as clear career progression opportunities and well-defined pathways for entering the labour market after completing their training. In this regard, drawing from international best practices is crucial. Countries like South Korea and Germany could serve as inspiration for developing a successful framework.
- Improvements in training provision in traditional fossil fuels extraction and refinery sectors needs to take place. This sector will continue to be a vital part of Egypt's energy sector and its skill needs are transforming due to sustainability concerns and digital technologies. Future training programmes should thus consider the necessity to re-skills workers in the oil extraction industry. Reskilling can also concern their potential transition to the renewable energy sector, to accommodate shortages in the latter.
- Exploit the untapped potential of young people and the female population as a source of future workforce in the energy sector. The introductory chapter drew attention to the position of women and young people in the labour market. Women exhibit both relatively high levels of inactivity and unemployment, and young people's NEET rates are relatively high and persistent (especially so for women). The anticipated shift of skill demand towards high-level technical skills such as energy management and sales and marketing jobs is rather favourable for recruiting more women in the sector. Specific incentives, starting from the education system, should be developed to favour the entrance of women and young people in the sector.

Annex 1: Ranking for energy sub-sectors

Table A.1 – Most recurrent or rapidly growing technologies in energy sector patents

Sub-sector	Technology
Energy Efficiency	Battery Charging Systems Data Switching Networks Amplifiers Wireless Traffic and Communication modules Battery Saving Systems Storage units Insulation Power consumption regulators Power efficiency controllers Control units and systems Electric power information management Predictive analytics
Solar Energy	Solar Cell Solar Panel Solar Collector Photovoltaic Power Generation System Concentrated Solar Power Equipment Solar Receiver Parabolic Reflector Light Receive Surface Heat Exchanger Heat Collector Solar Cell Array Photoelectric Conversion Element Photovoltaic Circuit Reflective Layer Perovskite cells Thermoelectric generator Storage devices Control units and systems Remote control and automation AI-based weather forecasting Float energy collection device
Wind Energy	Wind Turbine generators Rotor Blades Wind Turbine Nacelles Rotating Hub Wind Power Plant Wind Turbine Rotor Wind air engine Horizontal axis wind turbine Gearboxes Asynchronous Generators Synchronous Generators Wind Turbine Towers Rotary Shafts Control units and systems Remote control and automation AI-based weather forecasting Additive manufacturing
Energy Transmission and Distribution	Smart Grid

	Smart Meter Smart Server Electric Storage Unit Power Supply Systems Power Transmission Unit Remote terminal units Shift devices Transmission System Communication Device Communication Network Control units and systems Predictive analytics Energy Conversion Device Energy Lift device Energy Transfer Device Wireless Mesh Network Power Transmission Cables Underwater Cables High Voltage Direct Current Transmission Systems
Hydro Energy	Hydraulic Pump Water Turbine Pump Turbine Hydraulic Actuator Hydraulic Circuit Hydraulic System Hydro Power Generation System Water Tank Hydraulic Power Unit Dam Reservoir Heating/cooling systems Water treatment systems Control units and systems
Oil&Gas Transportation	Gas Pipeline Intelligent Pigging Magnetic Flux Leakage Flexible Substrate Sensor System Pipeline Network Transmission Pipeline Branch Pipeline Pipeline Bundle Storage Tank Pipeline Seal System Insulation of Pipelines Subsea Pipeline Thermal energy fluid pipeline
Oil&Gas Refinery	Refining Machine Natural Gas Distiller Distillation Equipment Gas Treat Equipment Petroleum Treat Equipment Fuel Oil Distiller Crude Oil Pipe Vacuum-Drum Filter Catalytic Reformer Hydrocracker Hydrotreater
Oil&Gas Extraction	Production Well Heater Well Acoustic Waves Extraction Branch Pipe Extraction Pump Feed Pump Heat Exchange Tube

	Directional Drill Oil Pumping Drill Crude Oil Pump Submersible Pump Guide Rod Pumpjack Oil Gas Extraction Mechanism Oil Gas Well Treatment System
Nuclear Energy	Control units and systems Atomization Electrode/unit Reactor Pressure Vessel Radiation Protection Equipment Radiation Detector Radiation Source Nuclear Material Energy Metering Component Energy Accumulator Energy generation component Nuclear Power Management System Reaction container Heat Insulator Nuclear Reactor Protective layer Nuclear Fusion
Biofuel Energy	Biogas Reactor Biofuel Cell Pyrolysis Bed Biomass Container Heat Pump Energy Crop Cell Suspension Culture Hydrocarbon Feedstock Biogas Fermenter Fuel Gas Tank Fuel Control System Gasification Unit Fuel Metering Block Chemical Reaction Equipment Biogas Flow Controller Hydrogasification reactor
Hydrogen Energy	Methane Reform Device Water Electrolysis Hydrogen Purification Catalysts Fuel Cell Hydrogen Batteries Steam Reforming Blue Hydrogen Green Hydrogen Hydrogen Plant Hydrogen Tank Hydrogen Vehicle
Fossil Fuel (Thermal) Energy	Precombustion Treatment Thermal Turbine Gas Turbine (Fossil Fuel Energy) Steam Turbine Synthetic Gas Coal-Water Slurry Fuel Coal Power Station Thermal Power Station Pressure Vessel (Fossil Fuel Energy) Furnace Superheater

	Heat pipe Heat pump Heat accumulator Heat exchanger Roaster module

Annex 2: Key stakeholders consulted

The following table lists all the stakeholders which were met during the project, either during the focus group discussion or bilateral online interviews with Egyptian representatives.

NO.	ORGANISATION (alphabetical order)
1	Alexanderia University
2	Arabian Cement company
3	Beshay company
4	Cemex Assiut company
5	Chemonics Egypt Consultants
6	EEAA
7	El-Araby company
8	EZZ Steel company
9	Egyptian Electric Utility & Consumer Protection Regulatory Agency
10	Egyptian Environmental Affairs Agency
11	Egyptian International Motors
12	Egyptian Solar Company
13	Environics
14	EU Delegation
15	Federation of Egyptian Industries
16	GOPA-Infra, EU/KFW project
17	Industrial Modernisation Centre - IMC
18	Integral RISE
19	Lekela Advisors Limited

20	Ministry of Education and Technical Education
21	Ministry of Electricity and Renewable Energy
22	Ministry of International Cooperation
23	Ministry of Manpower
24	Ministry of Planning and Economic Development
25	Ministry of Trade and Industry
26	MOPCO Fertilizers company
27	Oriental Weavers company
28	National Center for Technological Dual Education
29	New Cairo Technological University
30	NREA
31	Productivity and Vocational Training Department - Ministry of Trade and Industry
32	SHiFTERRA Consultancy
33	SIDPEC Company
34	STI Solar Technology
35	SUEZ STEEL company
36	UNIDO
37	World Wind Energy Association

Annex 3: Glossary

Additive manufacturing	The construction of a three-dimensional object from a CAD model or a digital 3D model. It can be done in a variety of processes in which material is deposited, joined or solidified under computer control.
Artificial Intelligence	A general term used to describe a variety of technologies and approaches that allow computers to solve complex tasks (usually associated with higher cognitive levels), for example: recognition of objects or patterns; classification of entities; simulation and modelling of situations; predictions of future behaviours; generation of constructs similar to existing ones
Competence	Means “the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development” (European Qualifications Framework). While sometimes used as synonyms, the terms skill and competence can be distinguished according to their scope. The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person – facing new situations and unforeseen challenges – to use and apply knowledge and skills in an independent and self-directed way
Cross-sectoral	(Knowledge, skills or competences) – is one of the four levels of skills reusability identified by the ESCO initiative, whereby reusability it is meant how widely a knowledge, skills or competence concept can be applied in different working contexts. Cross-sector knowledge is relevant to occupations across several economic sectors, whereas sector-specific or occupation-specific knowledge is restricted to one specific sector or occupation. See also Transversal knowledge.
Cross-sectoral technology	Adopting the concept of cross-sectorality from ESCO’s skills reusability levels, the term indicates a technology that finds application in many different economic sectors (e.g., Control unit or sensors)
ESCO	The European multilingual classification of Skills, Competences and Occupations. ESCO works as a dictionary, describing, identifying and classifying professional occupations, skills, and qualifications relevant for the EU labour market and education and training, in a format that can be understood by electronic systems. It lists over 3000 occupations and 13.000 skills and competences). For more info, see https://ec.europa.eu/esco/portal/home
Green skills	The knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society.
ISCO	International Standard Classification of Occupations and is an International Labour Organisation (ILO) classification structure for organising information on labour and jobs. It is part of the international family of economic and social classifications of the United Nations. It contains around 7000 detailed jobs, organised in a four-level hierarchy that allows all jobs in the world to be classified into groups, from 436 lower-level groups up to 10 major groups

Job	A set of tasks and duties performed, or meant to be performed, by one person (ISCO-08)
Job profile	The description of a particular work function, developed by the employer or by the HR department of a company, that includes all the elements deemed necessary to perform the corresponding **job**. In particular, it includes general tasks, duties and responsibilities, required **qualifications**, **competences** and **skills** needed by the person in the job
Job title	Identifying label given by the employer to a specific job, usually when looking for new candidates to the position. In the absence of standardised nomenclature, it can coincide with either a description of the **job**, or the **occupation** group the job belongs too
Knowledge	The outcome of the assimilation of information through learning. It is the body of facts, principles, theories, and practices that is related to a field of work or study.
NACE	A four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics, provided by Eurostat. Economic activities are divided into 10 or 11 categories at high-level aggregation, while they are divided into 38 categories at intermediate aggregation
NDCs (Nationally Determined Contributions)	A nationally determined contribution or intended nationally determined contribution is a non-binding national plan highlighting climate change mitigation, including climate-related targets for greenhouse gas emission reductions.
Natural Language Processing (NLP)	An interdisciplinary field at the intersection of linguistics, computer science, information engineering. NLP deals with the interactions between computers and human (natural) languages, in particular how to program computers to process and analyse large amounts of natural language data, starting from the identification of the grammatical and logical parts of speech within a sentence, up to the complex representation of semantic relationships between words
Nice Classification	The Nice Classification (NCL), established by the Nice Agreement in 1957, is an international classification of goods and services for the purposes of registering trademarks and service marks. In the case of goods, 34 classes exist to register trademarks for certain goods. These classes range from Class N° 1 to Class N° 34. For services, there are 11 classes ranging from Class N° 35 to Class N° 45. Internationally, the Nice International Classification System makes a trademark easy to recognize, categorize and register among all signatory countries. It helps businesses to identify the nature of the related good or service and seek adequate intellectual property protection. A new edition is published every five years and since 2013 a new version of each edition is published annually.
Occupation	According to ESCO, an occupation is "a grouping of jobs involving similar tasks, and which require a similar **skill** set." Occupations should not be confused with **jobs** or **job titles**. While a job is bound to a specific work context and executed by one person, occupations group jobs by common characteristics (for example, being the "project manager for the development of the ventilation system of the Superfly 900 aircraft" is a job. "Project manager," "aircraft engine specialist" or "heating, ventilation, air conditioning engineer" could be occupations, i.e., groups of jobs, to which this job belongs)

Occupational profile	An explanation of the **occupation** in the form of: description, scope, definition, and list of the knowledge, **skills** and **competences** considered relevant for it. Each occupation in the **ESCO** database also comes with an occupational profile that further distinguishes between essential and optional knowledge, skills and competences
Profession	An **occupation** requiring a set of specific **skills** and dedicated training
Qualification	The "formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards" (European Qualifications Framework)
Regulated profession	A profession is called regulated if its access, scope of practice, or title is regulated by law
Semantic matching	A technique used in computer science to identify information which is semantically related
Semantic algorithm software	Semantic search is a data searching technique through a software, which a search query aims to not only find keywords, but to determine the intent and contextual meaning of the words a person is using for search.
Skill	"The ability to apply knowledge and use know-how to complete tasks and solve problems" (European Qualifications Framework). They can be described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments). While sometimes used as synonyms, the terms skill and **competence** can be distinguished according to their scope. The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person – facing new situations and unforeseen challenges – to use and apply knowledge and skills in an independent and self-directed way
Soft skills	Usually associated with **transversal skills**, and considered the cornerstone for personal development, also within the context of labour and employment. To distinguish them from other knowledge-based basic skills, they are often referred to as social or emotional skills. They can be further classified into personal skills (e.g., problem-solving, adaptability) or interpersonal ones (e.g., teamwork, leadership)
Text Mining	A general term indicating a variety of techniques that allow computers to extract, discover or organise relevant information from large collections of different written resources (such as websites, books, articles). The first part of any text-mining process implies the transformation of texts in structured representations useful for subsequent analysis through the use of **Natural Language Processing** tools. Sometimes **Artificial Intelligence** techniques are used to perform Text-Mining tasks more effectively
Transversal (knowledge, skills or competences)	The highest of the four levels of **skills** reusability identified by the **ESCO** initiative, whereby reusability it is meant how widely a knowledge, skills or competence concept can be applied in different working contexts. Transversal skills are relevant to a broad range of **occupations** and sectors. They are often referred to as *core skills*, *basic skills* or *soft skills*, the

	cornerstone for the personal development of a person. Transversal knowledge, skills and competences are the building blocks for the development of the "hard" skills and competences required to succeed in the labour market.
Transversal technology	adopting the concept of **transversality** from **ESCO**'s **skills** reusability levels, a transversal technology is relevant to a broad range of **occupations** and sectors and is a building block for more specific technologies (e.g., computerised image analysis)

References

Abdallah, L. (2020). Egypt's nationally determined contributions to Paris agreement: review and recommendations. International Journal of Industry and Sustainable Development, 1(1), 49–59. https://doi.org/10.21608/ijisd.2020.73503.

Abd Almoshen, Rehab, (2018) Egypt's new solar power plant to train African scientists https://www.scidev.net/global/news/egypt-s-new-solar-power-plant-to-train-african-scientists-1x/

Abdelhadi, M. (2020, July 29). Nile dam row: Egypt fumes as Ethiopia celebrates. BBC News. https://www.bbc.com/news/world- africa-53573154

African Energy Commission (AFREC). (2017). Africa Energy Database.

Ahmed, A., Sayed, K. (2020). Development of competency-based training system in Assiut-ITEC: A case study. *Journal of Competency-based Education*, 5, e01217. https://doi.org/10.1002/cbe2.1217

Ahmed, A., Sayed, K. (2021). An extensive model for implementing competency-based training in technical and vocational education and training teacher training system for Assiut-Integrated Technical Education Cluster, Egypt. *Journal of Competency-based Education*, 6, e01245. https://doi.org/10.1002/cbe2.1245

Alaa El-Sadek, 2010. Water desalination: An imperative measure for water security in Egypt, Desalination, Volume 250, Issue 3, Pages 876-884, ISSN 0011-9164, https://doi.org/10.1016/j.desal.2009.09.143.

Ali, A. New Egyptian Accreditation Body Could Help More Than 2 Million Technical Students Find Jobs. Al-Fanar Media. 22 November 2022.

Aliyu, A.K., Modu, B., & Tan, C.W. (2018). A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria. Renewable and Sustainable Energy Reviews 81: 2502-2518.

Amer, M. (2012). Active labour market policies: Mapping of existing initiatives in Egypt', Centre for Mediterranean Integration, report study https://www.cmimarseille.org/sites/default/files/newsite/library/files/en/Active%20Labor%20Market%20Policies%20Mapping%20of%20Existing%20Initiatives%20in%20Egypt.pdf

Atlam, B. and Rapiea, A. (2016). Assessing the Future of Energy Security in Egypt. International Journal of Energy Economics and Policy. Vol, 6(4): 684-700.

Bakr, Noura & Bahnassy, Mohamed. (2019). Egyptian Natural Resources. 10.1007/978-3-319-95516-2_3

BP (2021). Statistical Review of World Energy, accessed May 19, 2022.

CAPMAS (2019) Central Agency For Public Mobilization and statistics-Informatics monthly bulletin, Issue 90 https://censusinfo.capmas.gov.eg/Metadata-en-v4.2/index.php/catalog/389/overview

ECES (2021). The Egyptian Centre for Economic Studies: Egypt's Economic profile and statistics. https://www.eces.org.eg/PublicationsDetails?Lang=EN&C=5&T=1&ID=1277&Egypt%27s-Economic-Profile-and-Statistics---2021

EIA (2022). U.S. Energy Information Administration. Country Analysis Executive Summary: Egypt https://www.eia.gov/international/content/analysis/countries_long/Egypt/egypt.pdf

El-Ashmawi, A. (2019). Enhancing Institutionalized Partnerships between TVET: Institutions and the World of Work in Egypt. UNESCO Regional Bureau for Education in the Arab States – Beirut. https://en.unesco.org/sites/default/files/egypt_study_on_enhancing_institutionalized_partnerships_between_tvet_institutions_and_the_world_of_work_in_egypt_september_2019_0.pdf

El-Shinawi, M. (2022). Presentation in Egypt-EU Union Stability and Social Development cluster

Elbaset, A.A. (2009). Electric Energy Sector in Egypt: A Review. Minia University research papers https://works.bepress.com/dr_adel72/48/

Elshazly, M., & Khodeir, S. (2018). Legislative reforms in the Egyptian energy sector to liberalize the natural gas market. The Journal of World Energy Law & Business, 11(4), 354-359.

Energy Information Administration (2014). Country Analysis Brief: Egypt.

ERDB (2022). European Bank for Reconstruction and Development-Transition Report 2021-22: Egypt https://2021.tr-ebrd.com/countries/#

European Commission. EU-Egypt Joint Statement on Climate, Energy and Green Transition. 15 June 2022.

European Commission, DG Energy. Memorandum of understanding on a strategic partnership on renewable hydrogen between the European union and the Arab republic of Egypt. 16 November 2022.

European Commission, DG Neighbourhood and Enlargement Negotiations. EU, Egypt, EBRD Joint Statement on the Nexus of Water, Food and Energy. 15 November 2022.

Esily, R. R., Chi, Y., Ibrahiem, D. M., & Chen, Y. (2022). Hydrogen strategy in decarbonization era: Egypt as a case study. International Journal of Hydrogen Energy.

ETF (2021a). European Training Foundation. Egypt: Education, training and employment developments 2021. https://www.etf.europa.eu/sites/default/files/document/CFI_Egypt_2021.pdf

ETF (2021b), Case studies on the future of skills: Methodological note for conducting case studies, March 2021, Turin, Skills for the future case studies, methodology.

ETF (2021c) Youth in transition in the Southern and Eastern Mediterranean. Identifying profiles and characteristics to tap into young people's potential. https://www.etf.europa.eu/en/publications-and-resources/publications/youth-transition-southern-and-eastern-mediterranean

ETF (2022), Phase 2: Additional case studies on the future of skills: Revised methodological note, March 2022, Turin, Skills for the future case studies, methodology.

ETF (2023). European Training Foundation. Egypt: Education, training and employment developments 2022. Internal document

Eurostat (2019). Labour force statistics in Enlargement and ENP-South countries-2019 edition. Eurostat Compact Guides. https://ec.europa.eu/eurostat/web/products-catalogues/-/ks-03-19-052

Fahmy, M., & Hussein, N. (2020). "Electricity Regulation in Egypt," Thomson Reuters Practical Law, November 1, 2020. https://uk.practicallaw.thomsonreuters.com/w-028-8626?transitionType=Default&contextData=(sc.Default)&firstPage=true

Friedrich-Ebert-Stiftung (2021), "Sustainable Transformation of Egypt's Energy System" https://epub.wupperinst.org/frontdoor/deliver/index/docId/7892/file/7892_Egypt.pdf

Frietsch, R. and Schmoch, U., Transnational patents and international markets, 2010. Scientometrics, 82(1), 185-200

Harhoff, D., Scherer, F. M. and Vopel, K., "Citations, family size, opposition and the value of patent rights", 2003. Research Policy, vol. 32(8), pp.1343-1363

Hegazy, K. (2015). Egypt's energy sector: Regional cooperation outlook and prospects of furthering engagement with the energy Charter. Occasional Paper Energy Charter Secretariat Knowledge Centre, Brussels, Begium. https://www.energycharter.org/what-we-do/knowledge-centre/occasional-papers/egypts-energy-sector-regional-cooperation-outlook-and-prospects-of-furthering-engagement-with-the-energy-charter/

Hemidat, S. Achouri, O., El Fels, L., Elagroudy, S., Hafidi, M., Chaouki, B., Ahmed, M., Hodgkinson, I., and Guo, J. (2022). Solid Waste Management in the Context of a Circular Economy in the MENA Region. Sustainability, 14, 480. https://doi.org/10.3390/su14010480

Ibrahiem, D.M., & Sameh, R. (2020). How do clean energy sources and financial development affect unemployment? Empirical evidence from Egypt. *Environmental Science and Pollution Research* 27:22770–22779.

ILO (2019). International Labour Organization-Key Labour Market Trends in Egypt, 2018 https://www.ilo.org/africa/information-resources/fact-sheets/WCMS_663785/lang--en/index.htm

ILO (2022a). Trade, investment and employment in the Southern Mediterranean Countries. Thematic Report of the "Mainstreaming Employment into Trade and Investment in the Southern Neighbourhood" project. International Labour Organization– Geneva.

IMF (2020) IMF Country Report No. 20/266 https://www.imf.org/en/Publications/CR/Issues/2020/08/10/Arab-Republic-of-Egypt-Request-for-a-12-Month-Stand-By-Arrangement-Press-Release-Staff-49683

IMF (2014). IMF Staff Concludes 2014 Article IV Mission to Egypt.

International Trade Administration. (2020, December 9). Energy Resource Guide – Egypt – Oil and Gas. https://www.trade.gov/energy- resource-guide-egypt-oil-and-gas

IRENA (2018). International Renewable Energy Agency: Renewable Energy Outlook: Egypt. Technical Report. Abu Dhabi https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf

IRENA, 2021. International Renewable Energy Agency-Renewable Capacity Statistics 2021. Technical Report. Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Apr/IRENA_RE_Capacity_Statistics_2021.pdf

IRENA, ILO (2022). Renewable energy and jobs: Annual review 2022, International Renewable Energy Agency, Abu Dhabi and International Labour Organization, Geneva. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_856649.pdf

Ismail, A., (2014) The Power Generation Crisis in Egypt. Middle East Institute, September 3, 2014, https://www.mei.edu/publications/power-generation-crisis-egypt

ITA (2020). International Trade Administration: Egypt Country Commercial Guide: Renewable Energy. September 15, 2020 (accessed February 2, 2022). https://www.trade.gov/country-commercial-guides/egypt-renewable-energy

Jagannathan, S., & Geronimo, D. (2013). Skills for competitiveness, jobs, and employability in developing Asia-Pacific.

Joint Statement European Union-Egypt (press release 11 April 2022, Directorate-General for Climate Action) https://ec.europa.eu/clima/news-your-voice/news/joint-statement-european-union-egypt-2022-04-11_en

Kashyout, A. E. H. B., Hassan, A., Hassan, G., Fath, H. E. B., Kassem, A. E. W., Elshimy, H., & Shaheed, M. H. (2021). Hybrid renewable energy/hybrid desalination potentials for remote areas: selected cases studied in Egypt. RSC advances, 11(22), 13201-13219.

KIESE and ETF (2020). Key indicators on education, skills and employment 2020, report. https://www.etf.europa.eu/sites/default/files/2020-11/kiese_2020_0.pdf

Kütt, W., & Schmiemann, M. (1998). Quick Scan: a novelty search service in the framework of Euro-R&D programmes. World Patent Information, 2(20), 146-147.

Lund, H. (2007). Renewable energy strategies for sustainable development. Energy, 32(6), 912-919.

Molina, A. (2020, November 23). Sustainability in Egypt. Egypt's roadmap to reaching its sustainable energy goals 2035: Energy transition and modernization of the Egyptian energy sector.

Morsy, H. (2017). Private Sector Diagnostic: Egypt, European Bank for Reconstruction and Development https://www.ebrd.com/publications/country-diagnostics/egypt

OEC (2021). The Observatory for Economic Complexity. Country Profile: Egypt https://oec.world/en/profile/country/egy

Patlitzianas, K.D. (2011). Solar energy in Egypt: Significant business opportunities. *Renewable Energy* 36:2305-2311.

Rady, Y.Y., Rocco, M.V., Serag-Eldin, M.A., & Colombo, E. (2018). Modelling for power generation sector in Developing Countries: Case of Egypt. *Energy* 165:198-209.

Salah, s.i., Eltaweel, M. & Abeykoon, C. (2022) Towards a sustainable energy future for Egypt: A systematic review of renewable energy sources, technologies, challenges, and recommendations *Cleaner Engineering and Technology* (in press) https://doi.org/10.1016/j.clet.2022.100497

Salem, M.E., El-Halim, H.A., Refky, A., Nassar, I.A. (2022). Potential of Waste to Energy Conversion in Egypt. Journal of Electrical and Computer Engineering, 7265553. https://doi.org/10.1155/2022/7265553

Squicciarini, M., Dernis, H. and Criscuolo, C., "Measuring Patent Quality: Indicators of Technological and Economic Value", 2013. OECD Science, Technology and Industry Working Papers, 2013/03, OECD Publishing.

Terragno, P. J. (1979). Patents as technical literature. IEEE Transactions on Professional Communication, (2), 101-104

Van Pottelsberghe, B. and van Zeebroeck, N., "A Brief History of Space and Time: the Scope-Year Index as A Patent Value Indicator Based on Families and Renewals", 2008. Scientometrics 75(2), 319-338.

Van Wijk, A., Wouters, F., Rachidi, S., & Ikken, B. (2019). A North Africa – Europe hydrogen manifesto (S. 32). Dii Desert Energy. https://www.menaenergymeet.com/wp-content/uploads/ A-North-Africa_Europe-Hydrogen-Manifesto.pdf

World Bank, 2014. Arab Republic of Egypt: Providing Affordable Clean Energy.

The World Bank (2021). Egypt's Economic Update, April 2021 https://thedocs.worldbank.org/en/doc/9dbe40280b581a94ff950a11cab42fb3-0280012021/original/4-mpo-sm21-egypt-egy-kcm2.pdf

The World Bank (2022). Egypt Overview https://www.worldbank.org/en/country/egypt/overview#1

U.S. Energy Information Administration, International Energy Statistics database. https://www.eia.gov/international/data/world

UNDP (2020). United Nations Development Programme. Human Development Report. https://hdr.undp.org/system/files/documents//hdr2020pdf.pdf

UNESCO (2021). TVET Country Profiles: Egypt https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=EGY

Ministry of Higher Education in Egypt, accessed May 19, 2022.

Refineries, Egyptian General Petroleum Corporation, accessed May 19, 2022.

Egypt's future in the LNG market, Middle East Institute, accessed May 19, 2022

World Oil Transit Chokepoints, U.S. Energy Information Administration, October 15, 2019, accessed May 19, 2022

Egypt and Jordan to double capacity of interconnection, Energy & Utilities, November 29, 2021, accessed May 19, 2022

Egypt Oil and Gas, Energy Resource Guide 2021, accessed May 19, 2022

Organizational Structure of the Petroleum Sector, Arab Republic of Egypt, Ministry of Petroleum accessed May 19, 2022

EBRD promotes green energy transition in Egypt accessed May 19, 2022

EBRD invests in Scatec green bond, accessed May 19, 2022

EBRD and TAQA Arabia promote private-to-private renewable energy in Egypt, accessed May 19, 2022

EBRD becomes shareholder in Egypt's Infinity Energy, accessed May 19, 2022

EBRD promotes greener urban transport in Egypt, accessed May 19, 2022

EBRD supporting access to renewable energy in Egypt, accessed May 19, 2022

EBRD and EU help SolarizEgypt promote rooftop solar panels in Egypt, accessed May 19, 2022

EBRD assesses low-carbon hydrogen in Egypt, accessed May 19, 2022

Green Tech Egypt. Renewable Waste to Energy. Accessed 23 February 2023.

Egypt Today. Egypt to establish waste-to-energy plant in Giza. 01 December 2022

Siemens Energy. Waste-to-Energy Technologies for a Greener Future. Accessed 23 February 2023.

ERDB. Egypt's NWFE energy pillar gathers international support. 11 November 2022

PwC. The EGP Devaluation: A new beginning. Accessed 25 October 2022

Reuters. Egypt's pound hits new lows after shift to more flexible forex regime. January 11, 2023

Reuters. IMF confirms $3 bln loan for Egypt, welcomes exchange rate flexibility. October 27, 2022.