Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized

THE WORLD BANK

ESMAP
Energy Sector Management Assistance Program

THE EMPLOYMENT BENEFITS OF AN ENERGY TRANSITION IN EGYPT

NOVEMBER 2022 // PREPARED BY THE WORLD BANK MENA ENERGY

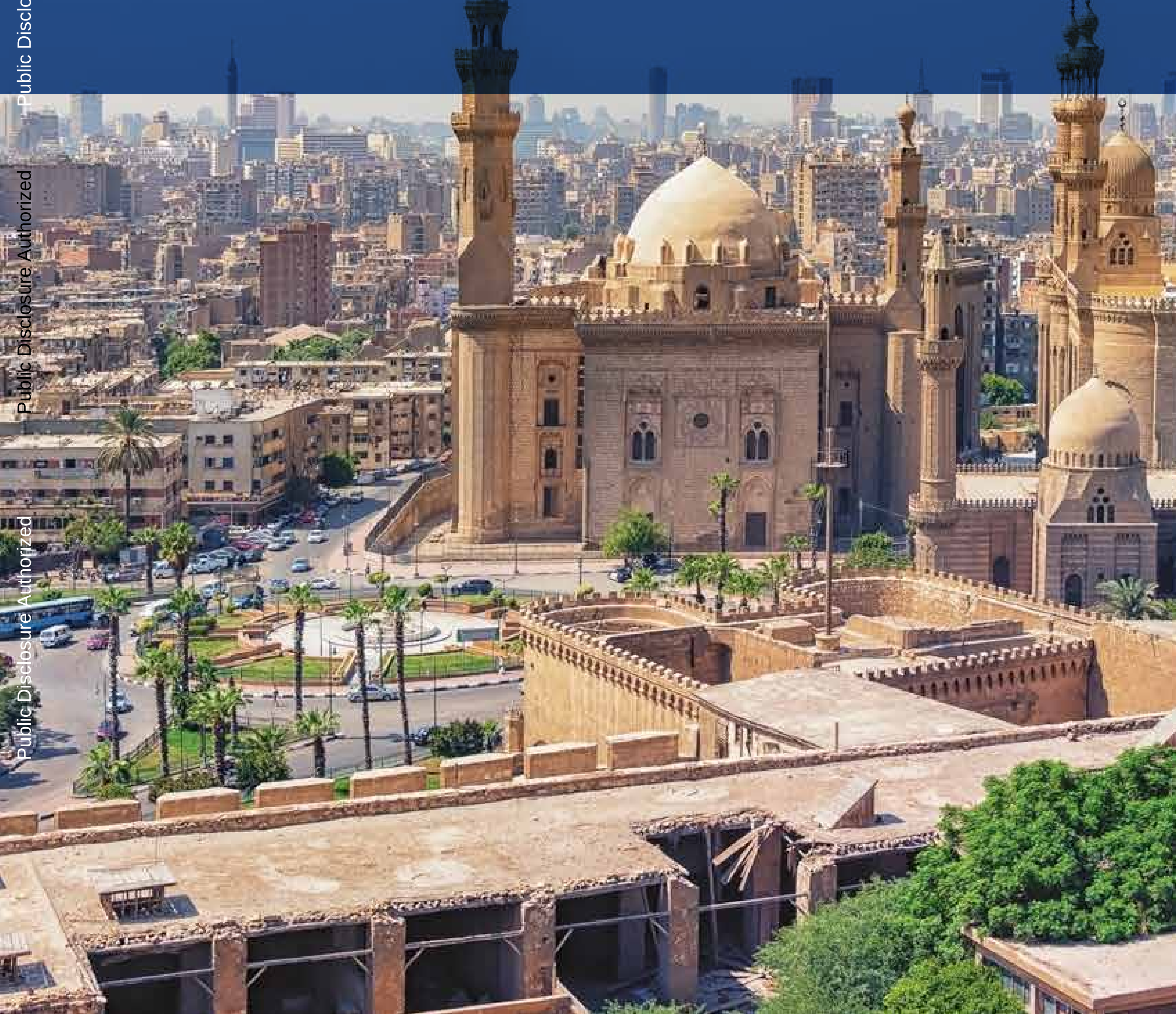


TABLE OF CONTENTS

FIGURES

TABLES

Acknowledgments

ESMAP is a partnership between the World Bank and 24 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. Through the World Bank Group (WBG), ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable, and modern energy for all. It helps to shape WBG strategies and programs to achieve the WBG Climate Change Action Plan targets.

This report on Egypt is one of three country case studies under the umbrella project **The Disruptive Energy Transition and Opportunities for Job Creation in the Middle East and North Africa**, covering Egypt, Morocco, and Yemen. This project, made possible by funding from the Energy Sector Management Assistance Program (ESMAP), was initiated in 2019 in response to requests from various Middle East and North Africa (MENA) governments to explore the nexus between the clean energy transition and employment. The umbrella project is led by Tu Chi Nguyen and Ashok Sarkar (MENA Energy and Extractives Global Practice, World Bank) and includes Abdellatif Touzani, Alona Kazantseva, Arslan Khalid, James Barrett, Kabir Malik, Laure Grazi, Manjula Luthria, Mark Njore, Sarah Moin, Skip Laitner, and Yao Zhao.

The task team wishes to thank senior management in the World Bank, particularly Paul Noumba Um (Regional Director, MENA Infrastructure), Husam Beides (Practice Manager, MENA Energy and Extractives Global Practice) and Erik Fernstrom (former Practice Manager, MENA Energy and Extractives Global Practice), for their continued support and guidance.

Questions on this report may be directed to Tu Chi Nguyen (tnguyen19@worldbank.org), Ashok Sarkar (asarkar@worldbank.org), and Yao Zhao (yzhao5@ifc.org).

Overview

This report investigates the job creation potential of the clean energy transition that has gained momentum over the past years in Egypt. The estimation is based on the Clean Energy Employment Assessment Tool (CEEAT), an Excel-based input-output model that can simulate the economywide net direct, indirect, and induced employment impacts of clean energy technology pathways. In the case of Egypt, CEEAT is calibrated for five such pathways: (i) utility-scale solar; (ii) industrial solar; (iii) rooftop residential solar; (iv) utility-scale wind; and (v) energy efficiency of buildings.

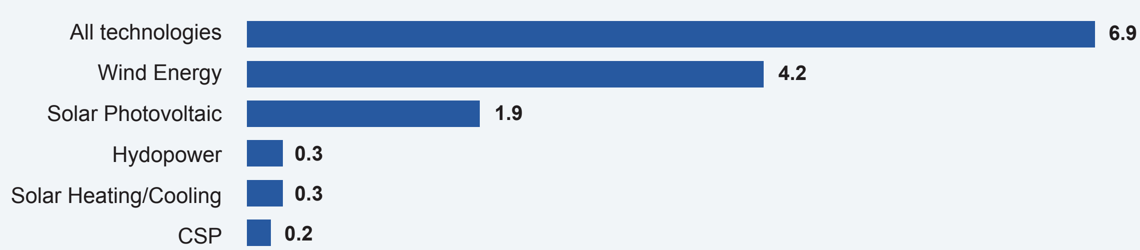
Achieving Egypt's targets for these technologies is expected to deliver a positive benefit of around 2 million net job-years over the 30-year period through 2050, equivalent to an average of 67,000 additional new job opportunities per year. This is 0.2 percent of the 29 million labor force and 2.2 percent of the unemployed in 2020. The results can be much larger if the innovation rate is increased, alongside the share of local content in manufacturing, and other clean energy technologies are leveraged. The early results of the analysis showcase important benefits of striving for a sustainable energy pathway, even for an emerging economy. Not only would jobs be gained, which could inform future strategies for workforce development, but some jobs would be displaced, or possibly shifted. A just transition framework is thus needed to mitigate any negative impacts and maximize the employment co-benefits of a green economy.

1. Introduction to Clean Energy Employment in Egypt

Deployment of renewable energy technologies and the rollout of energy efficiency programs drive the energy transition in many countries while also bringing significant employment benefits. The clean energy transition[1] holds significant potential for future energy systems. It is also instrumental for green growth across the Middle East and North Africa (MENA) that would allow countries to meet the region's growing energy demand, diversify the energy mix, promote equitable socioeconomic development, build climate change resilience, and create much-needed jobs for the region (IEA 2020a). According to the International Renewable Energy Agency (IRENA 2020a), the renewable energy (RE) sector employed at least 11.5 million people, directly and indirectly, in 2019. Yet, that employment opportunity remains concentrated in a handful of countries, with China, Brazil, India, the United States, and the European Union in the lead. Similarly, it is estimated that there are 1–3 million energy efficiency (EE) jobs in Europe, around 730,000 in China, 472,000 in Canada, 60,000–236,000 in Australia, and 33,000–62,000 in Brazil (IEA 2020a). Recent IRENA estimates suggest that the number of people employed in RE could reach 30 million by 2030 and 42 million by 2050, while EE could employ 21.3 million people with 21 percent higher growth than current plans indicate (Ferroukhi, Casals, and Parajuli 2020). The COVID-19 pandemic triggered lockdowns that have had a major impact on the employment energy sector; 4.3 million jobs directly provided by the energy sector worldwide were affected or lost in 2020 (IEA 2020b). However, in the wake of such losses, widespread support for green, resilient, and inclusive recovery could accelerate the energy transition in many countries and boost job creation.

The clean energy transition has gained momentum over the past years in Egypt and promises to create many jobs. Egypt has a strong comparative advantage in renewables as a result of its geography, with high wind and solar potential (IRENA 2018). However, the share of RE technologies in total electricity generation remains small, accounting for 8 percent (with 80 percent gas and 12 percent oil) (IEA 2020c). Hydropower is the largest source of renewable electricity to date, with more than 2,832 megawatts (MW) of installed capacity in 2020 (around 47 percent), followed by solar PV (28 percent) and onshore wind (23 percent) (IRENA 2020b). As of now, the RE and EE sectors represent just a small percentage of employment in Egypt. The latest estimate from IRENA shows that Egypt had around 12,000 employees across all RE technologies in 2019 (figure 1.1).

FIGURE 1.1 Renewable Energy Employment by Technology, Egypt (number of jobs, in thousands)



Source: IRENA 2020
Note: CSP = concentrated solar power.

The government's ambitious RE and EE targets combined with energy-transition-related investments could generate jobs and unlock employment opportunities for the local population. According to IRENA (2020c), every million dollars invested in renewables would create at least 25 jobs, while every million invested in efficiency would create about 10 jobs. The global employment intensity of all energy-transition-related technologies is about 16.5 jobs per US$ million, with about 19 jobs per US$ million in MENA (IRENA 2020c). In terms of the breakdown of jobs across the value chain, for solar PV, 56 percent of the total jobs are concentrated in operations and maintenance (O&M), 22 percent in manufacturing, and 17 percent in installation and grid

[1] In this note the phrases "clean energy" and "clean energy technologies" or "clean energy investments" refer to the use of renewable energy resources, including solar and wind, via both utility-scale and distributed means, along with efforts toward energy savings and greater energy efficiency.

connection, while for wind 43 percent of jobs are created in O&M, 30 percent in installation and grid connection, followed by 17 percent in manufacturing (IRENA 2018). While manufacturing and installation jobs tend to be temporary, jobs in O&M last throughout the lifetime of a project. In terms of labor requirements and skills, both solar PV and wind projects require a sizable proportion of low-qualified occupations, especially during the construction and manufacturing phases. These projects also require medium to highly skilled workers, such as technicians, operators, engineers, and other specialists (Cote 2019). Administrative, finance, and legal jobs would be created, which could attract more young people to the sector. In other words, both RE and EE would create considerable numbers of decent job opportunities in various phases across the value chain.

RE and EE jobs could help mitigate high unemployment, although labor policies need to be inclusive to ensure that youth and women are equally prepared for these opportunities. Egypt is facing the dual challenge of demographic growth and relatively high unemployment. The total population in Egypt was estimated at 102.3 million people in 2020, with an average growth of 2.1 percent in the preceding 10 years. The working-age population (15–64 years old) has also grown by an average of 1.8 percent or by 1.14 million people on average, while the employed population has only grown by around 109,000 on average.[2] Nearly 52 percent of the population is below the age of 25, including 48 percent females.[3] While the unemployment rate in Egypt was at approximately 9.7 percent in 2019, the youth unemployment rate (ages 15–24) reached 26.5 percent and female unemployment rate was 21.3 percent.[4] Women are more vulnerable to job losses than men across all age groups (the unemployment rate for female youth was 53.4 percent while that for male youth was 18.2 percent).[5] Therefore, the government needs to develop inclusive labor policies to ensure that women and youth can enjoy the employment opportunities and benefits offered by the clean energy transition.

Early evidence shows a positive impact on the number of RE and EE jobs that can be created under different energy transition scenarios in Egypt, but rigorous evidence is still scarce. The study conducted by Plan Bleu[6] in 2011 estimated that the total employment potential from additional EE investments in Egypt is almost 700,000 jobs by 2030. The jobs are almost entirely created by improving the EE of new buildings and in the retrofit and energy-efficient renovation of existing buildings (Plan Bleu 2011). The analysis tool of the Regional Center for Renewable Energy and Energy Efficiency (RCREEE 2017) shows that the number of RE jobs can increase in the future to more than 70,000 people by 2030, under the right framework conditions. More recent RCREEE estimations confirmed these numbers and showed that, for RE, the construction phase creates most of the direct jobs while the O&M phase creates most of the indirect ones. For EE, LED production has created most of the direct jobs while motor technologies have created most of the indirect ones. It also recommends having more manufacturing in the country to increase the local components and associated jobs (RCREEE 2020). Another study, conducted by the Egyptian Center for Economic and Social Rights and Heinrich Böll Stiftung in 2016, analyzed the job creation potential under different scenarios of Egypt's electricity sector development. Under the "business as usual" scenario, the net jobs created in thermal, hydro, wind, solar, and EE by 2030 were estimated at 143,936 (without coal) and 89,860 (with coal). The other scenarios present the following estimates of net jobs creation: "toward zero-carbon" scenario at 152,473, "toward zero carbon with CSP" scenario at 165,670, "toward energy independence" scenario at 161,553, and "toward decentralized energy" scenario at 166,291 (Bottoms 2016).

More local jobs can be generated in Egypt by enhancing local manufacturing capabilities and creating a domestic renewable energy industry. A study completed by the European Investment Bank and IRENA found that Egypt holds a comparative advantage in developing its local content for RE projects across the value chain, particularly downstream segments of project development and O&M. Egypt has the potential to meet a local

---

[2] World Bank's World Development Indicators.
[3] Age structure, Egypt: https://www.indexmundi.com/egypt/age_structure.html.
[4] Unemployment rate, Egypt (modeled ILO estimate): https://data.worldbank.org/indicator/SL.UEM.1524.ZS?locations=EG and https://data.worldbank.org/indicator/SL.UEM.TOTL.FE.ZS?locations=EG.
[5] Youth unemployment rate, female and male, Egypt (modeled ILO estimate): https://data.worldbank.org/indicator/SL.UEM.1524.FE.ZS?locations=EG and https://data.worldbank.org/indicator/SL.UEM.1524.MA.ZS?locations=EG.
[6] Plan Bleu is one the Regional Activity Centers of the Mediterranean Action Plan of the United Nations Environment Programme.

manufacturing content quota for RE components of more than 80 percent. The country is considered an industrial leader in MENA, and it can leverage its mature steel, glass, and cable industries to produce solar and wind components locally (EIB and IRENA 2015). Other factors that could also stimulate the market potential of domestic manufacturing across renewables-based technologies are regional integration and the development of the Pan-Arab Electricity Market (IRENA 2018).

PHOTO 1.1 Egypt's Ben Ban solar plant is the largest in the world with 1.5 GW of capacity

Photo credit: https://www.renewableenergyworld.com/

Despite promising forecasts on the RE and EE employment potential in Egypt, some jobs will be substituted or eliminated, which would require stronger labor and social protection policy measure to mitigate any negative impacts. A shift from fossil fuels to renewables in the energy sector, at whatever scale, will displace some jobs. These losses can be adequately alleviated through a number of policy actions, including stronger social protection policies and programs (Kammen, Kapadia, and Fripp 2004). In cases of jobs' substitution and transformation (changes of job profiles, locations, or sectors), policies will need to promote employment search and matching, reskilling and reorientation, and labor mobility to facilitate reallocation from fossil fuel sectors to clean energy sectors and from one region to another (such as relocation grants, urbanization policies). Despite initial negative impacts, the new jobs created in transition-related technologies would substantially outweigh the jobs displaced in the fossil fuel sectors (IRENA 2020c). However, comprehensive national energy, labor, and educational policies along with multisectoral coordination between different public sector stakeholders are required to facilitate this process.

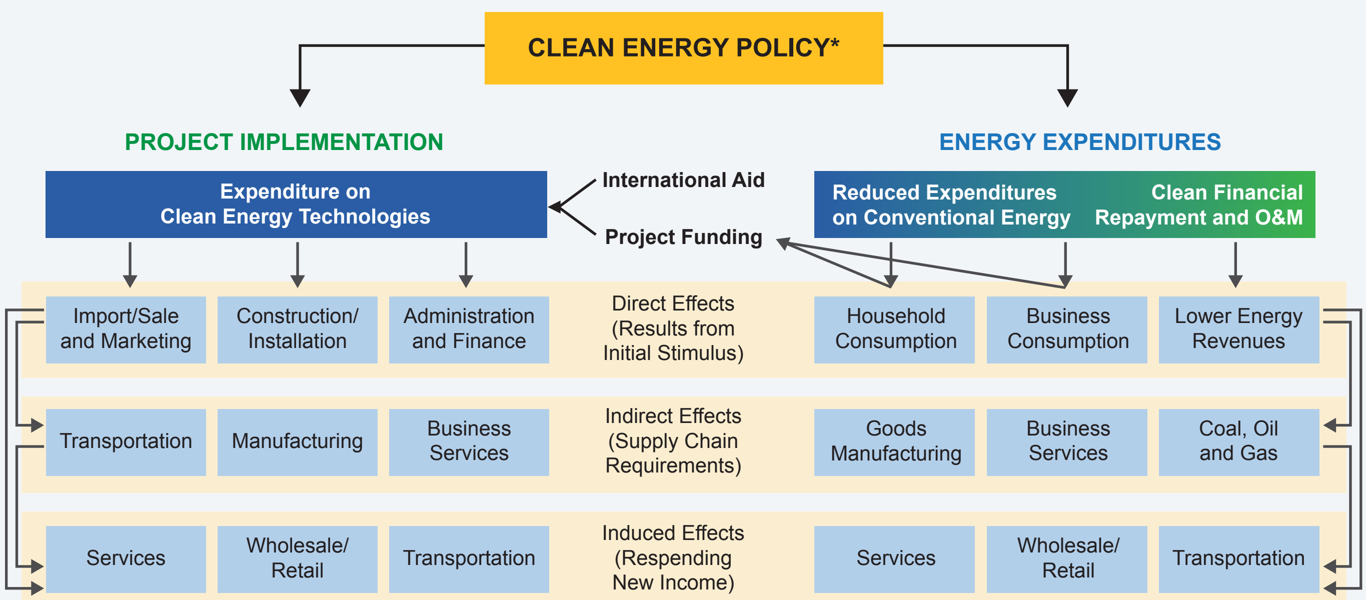
This study looks at the employment impact of the large-scale transition to clean energy resources in Egypt on a macro level. It examines five different technology paths (utility-scale solar PV, industrial distributed solar, residential rooftop solar, utility-scale wind, and buildings' energy efficiency) and, based on the government's targets for each pathway, estimates the net employment gains. The employment impact is derived not only from the investments in each technology pathway but also its associated supply chain and the overall shift in the economy, which benefits from energy and cost savings. The study is structured as follows: section 2 describes the methodology used; section 3 presents the results from different scenarios of clean energy transition; and section 4 concludes with a discussion of the implications of these results and further areas to study.

2. A Tool to Evaluate the Employment Impact of Clean Energy Investments

This study applied the Clean Energy Employment Assessment Tool (CEEAT)[7] to assess, ex ante, the employment impact of the clean energy transition. CEEAT uses an input-output (I-O) table-based approach in Microsoft Excel to estimate the economywide net direct, indirect, and induced employment impacts[8] of different clean energy technology pathways, with a focus on the electricity sector. The tool implicitly compares clean energy investments with comparable investments in fossil fuels (counterfactual) and calculates the net job[9] gain for each clean energy scenario. For each technology pathway, the tool models user-specified RE capacity additions or energy savings from EE, and calculates the size of investments and expenditures in associated sectors. Based on the estimated local content of each sector,[10] CEEAT then calculates the changes in final demand that result from these investments and expenditures, how they are financed, and their impacts on energy markets (changes in the costs and revenues faced by energy producers and consumers and other economic actors).

CEEAT estimates the employment impact by tracking the flow of two different groups of expenditures when clean energy investments take place. The first group comprises one-time ***project implementation*** outlays, such as the cost to bring a power plant online and including all activities required to design and construct the project during its initial implementation phases. The second group involves ***energy expenditures,*** which are the potential net electricity bill savings as a result of the lower cost of EE and RE technologies compared with conventional (fossil fuel) generation, after the plant is built and becomes operational. These include clean energy expenditures such as financial repayments and O&M throughout the lifetime of a project. Figure 2.1 provides a conceptual overview of how these two patterns of expenditure result in direct, indirect, and induced job effects in the economy.

FIGURE 2.1 **Expenditure Flows as They Generate Direct, Indirect, and Induced Effects**



*With non-energy or multiple benefits creating a parallel set of effects beyond those highlighted here.

Source: World Bank

[7] CEEAT was developed as part of the same umbrella project as this report. More details on the tool can be found in the *CEEAT User Guide* available upon request. CEEAT is currently in Beta version and will be available publicly.

[8] Direct employment involves on-site jobs created by an investment; indirect employment involves jobs in upstream industries that supply the equipment (e.g., manufacturing) and support the core activities of clean energy deployment (e.g., finance). Induced employment entails jobs created as people who are directly and indirectly employed by clean energy systems spend their earnings in the economy. This could also include jobs in other sectors that are affected by various macroeconomic feedback (e.g., changes in energy prices).

[9] The difference between gross jobs created and existing or future jobs displaced.

[10] The local content estimation is based on the I-O matrix, which shows how much of the sector activities benefit the local economy and how much are traded.

CEEAT models the net effects of these expenditures as a combination of the following four gross positive and negative impacts: While the first two impacts occur during the first year of the project, the third and fourth occur across the lifetime of a project, as it generates (or saves) electricity.

- **The investment impact** refers to the expenditures spent to set up the project (policy planning, financing, construction, installation, manufacturing, etc.). On the one hand, such project implementation expenditures can yield positive impacts due to the economic activity generated by investments in the sectors involved. On the other hand, if the expenditures are financed by government budget[12], they require an increase in taxes levied on households and businesses, reducing the economic activities in those sectors, hence yielding negative impacts. The net investment impact is the sum of these two opposite impacts.
- **The investment shift impact** is the opposite of the investment impact. The expenditures spent on clean energy technologies take away resources from future conventional fossil fuel energy projects, which negatively impact the associated sectors.
- **The substitution impact** is the result of energy expenditures saved by consumers either through energy efficiency or the introduction of clean energy (if clean energy is cheaper than conventional energy)[13]. These savings are allocated to the three groups of consumers (residential, commercial, and industrial) depending on the customer structure of each country. These consumers then spend in the economy to generate economic activities[14]. In parallel, the spending on O&M boosts the associated sector (for example, services) but also takes away resources from other sectors. Finally, throughout the project lifetime, the domestic loans incurred to pay for the project investment require interest payments, which result in positive economic activity in the finance sector. Again, the substitution impact is the sum of the three positive impacts and one negative impact.
- **The revenue impact** is the opposite of the substitution impact. The energy expenditure savings are beneficial for consumers but create a loss of income for the conventional energy provider.

The domestic final demand (in terms of net expenditures) for each impact is then converted into direct, indirect, and induced employment through employment multipliers (number of jobs per US$1 million) of the corresponding sectors, which are derived from an I-O framework.[15] The gross negative and positive employment impacts are then combined to calculate the net change in employment throughout the lifetime of the clean energy investments**.**

Table 2.1 summarizes the drivers and direction (+/-) of the four employment impact categories.

[12] The model assumes budgets
need to be balanced, so government financing will need to be financed by increased taxes. It assumes that deficits, or external borrowing, will eventually need to be repaid, in which case taxes will need to be used. This is a conservative assumption. There can be more job potential if deficits are allowed.

[13] We assume that the entire price differential is passed to the consumer.

[14] We assume all savings from lower energy costs are reinvested in the economy. This could overestimate jobs created because there could be leakage to savings.

[15] Nonetheless, the feasibility of the I-O approach hinges on the availability of statistical data. For Egypt, employment data from provisional accounts and Social Accounting Matrix tables were integrated with recent I-O tables available through the Organisation for Economic Co-operation and Development (OECD) to generate reasonable proxies for job multipliers. In addition to the existing economic sectors, a clean energy manufacturing sector was added by the team to assess the economic impacts of the technology pathways.

TABLE 2.1 The Drivers and Direction of the Four Employment Impacts

Employment impact channel	Drivers	Job impact
Project investment impact: investments to support clean energy expansion	Stimulates employment: Moving expenditures from capital-intensive to labor-intensive sectors; building up the local supply chain	+*
Investment shift impact: Redirecting funds from other projects/spending to support clean energy investments	Displaces jobs in other sectors (e.g., fossil fuels)	-
Substitution impact: Energy savings from efficiency/renewables re-spent locally	Stimulates employment as consumers (residential, commercial, industrial) spend savings in the economy	+
Revenue impact: Lost energy company revenues	Displaces jobs in the utility sector	-

Source: World Bank
Note: *This can be net negative if the funding comes from the government budget instead of other sources (e.g., domestic/international loans and grants)

Built on the existing body of knowledge and employment impact assessment methods, CEEAT offers unique country-specific insights and adds value to other employment impact assessment methods in several ways. Four key aspects of CEEAT are:

- First, CEEAT is comprehensive in its ability to capture multiple job impact channels from the clean energy transition, on both the positive and negative sides. It therefore provides a more complete view of employment impact compared to employment factor or gross I-O based tools. Furthermore, it measures not only direct and indirect jobs along the clean energy value chain but also induced jobs, hence covering all sectors in the economy beyond the clean energy and associated sectors. This helps decision-makers in evaluating the broader implications of their clean energy plans. It also helps show how clean energy deployment can benefit from, and contribute to, the broader economy of a country.
- Second, it covers multiple clean energy technologies including EE (unlike other work by IRENA, the International Labor Organization, the International Energy Agency, and others, which focus mainly on RE).
- Third, CEEAT is created as a flexible tool such that it can simulate how job results vary according to different policy parameters, which will help policy makers understand which of their policies or country conditions yield the most job benefits.
- Fourth, it looks at the employment impacts not only in the short term (during the implementation of clean energy projects) but also in the long term, throughout the life cycle of the assets. Yet, it is less data- and effort-intensive than general equilibrium models that cover long-term impacts.

CEEAT is based on static I-O tables, which limits its ability to emulate structural changes on the economy over the time horizon, a feature that is found only in general equilibrium models. Nevertheless, it incorporates some dynamic features by allowing for some parameters to change over time to capture the potential of technological innovations and improvements in the country's conditions (for example, labor productivity, local manufacturing capacity, energy costs, and clean energy technology costs and performance). Finally, CEEAT's Excel format does not require know-how in a specialized language or platform and makes data flows visible, allowing easy verification.

3. Preliminary Results for Egypt

3.1. Base Case Scenario

For this note, CEEAT has been calibrated for Egypt's economy and its electricity sector. In the base case scenario, CEEAT simulates the net employment impact of the development of five technology pathways: utility-scale solar; industry distributed solar; residential rooftop solar; building energy efficiency; and utility-scale wind. This uses the government's 2030 targets, where the overall investment for the five technology pathways reaches US$54 billion. The installations are assumed to occur at constant annual rate[16]. The production capacity installed and the EE achieved thanks to this investment results in an equivalent annual *average* generation of 35.8 terawatt-hours (TWh) (92 percent from RE and 8 percent from EE) over the 30-year period through 2050.[17] This represents more than one-third of Egypt's annual generation and eight times its solar and wind electricity production in 2018–2019 (Ministry of Electricity & Renewable Energy 2019). Wind accounts for more than half of the clean energy production with 20 TWh generated on average per year. Utility-scale solar is the second technology with an average of 11 TWh generated annually. The smallest share of clean electricity generation comes from residential rooftop solar with 400 gigawatt-hours per year on average. The weighted levelized cost[18] of electricity service provided by the five technologies is US$85/megawatt-hour (MWh). Wind allows for the cheapest levelized cost of electricity at US$76/MWh while the equivalent cost for EE reached US$125/MWh saved. Table 3.1 provides a summary of the scenario's assumptions for each technology pathway based on the government's targets for 2030.

The investments and expenditures associated with the base case scenario deliver a positive benefit of over 2 million net job-years over the period of 2020–50. The results of the CEEAT base case scenario show that wind allows for the greatest impact with more than 1 million new jobs—representing 53 percent of the overall net jobs creation in the base case scenario. The remaining 47 percent include 23 percent of new jobs created in building energy efficiency, 18 percent in utility-scale solar, 5 percent in industry distributed solar, and 1 percent in residential rooftop solar. If comparing the number of net job-years[19] created by millions of US dollars invested, building energy efficiency and industry distributed solar allow for the highest number (60 and 52 job-years per million of US dollars invested, respectively), while utility-scale solar allows for the smallest with 20 job-years per million of US dollars invested. Wind and residential rooftop solar allow for 41 and 29 net job-years per million US dollars invested, respectively. In terms of installed capacity, wind could result in the highest number with 55 net job-years per MW, followed by industrial distributed solar, residential solar and utility solar at 54, 32 and 18 net job-years, respectively.

---

[16] This may differ from the actual trajectory of investment/deployment. We assume constant annual installations every year due to the lack of details of government plans.

[17] Investments are done over 2020–30 with a lifetime of 20 years up to 2050.

[18] The levelized cost of electricity (LCOE) is calculated based on the assumed investment and O&M costs, annual degradation factor, capacity factor, and how the investment is financed.

[19] To understand how job growth is predicted in the case of the clean energy transition, it is important to define a few employment terms, such as "job-year" and "full-time equivalent." One job-year is full-time employment for one person for a duration of one year, that is, a job-year is "one job for one year." If one person holds one new job for two years, that's two job-years, as opposed to one job. Often, jobs and job-years are used interchangeably; however, referring to jobs created without a duration (say the expected length for constructing a solar facility, or the operational life of a wind farm) can be misleading.

TABLE 3.1 Scale and Characteristics of Five Technology Pathways

Technology pathways	Scenario assumptions		Impact of key technology paths	
	Capacity added (megawatts) by 2030	Investment (US$, millions) by 2030	Annual average electricity service provided/saved (terawatt-hours)	Cost of electricity service provided ($/megawatt-hour)
Utility-scale solar	19,574	17,848	11.1	90
Industry distributed solar	2,000	2,104	1.4	84
Residential rooftop solar	577	635	0.4	87
Building energy efficiency	-9,520*	7,760	2.9	125
Utility-scale wind	19,475	25,871	20.0	76
Total		**54,217**	**35.8**	**85**

Source: Results of the Initial Baseline Assumptions of CEEAT.
*Note: * Estimated total electricity savings (in gigawatt-hours).*

Net jobs are the result of the creation of jobs through investments and their impact on economic activities and the displacement of jobs due to the substitution of traditional fossil fuel electricity plants with clean technologies. The respective shares of the different impact mechanisms (investment, investment shift, substitution, and revenue) differ by technology. Table 3.2 disaggregates direct, indirect, and induced job-years according to the four mechanisms described in the previous section. The majority of jobs is created by savings in energy bills (substitution impact) except for EE, for which the majority comes from the investment impact. These results reflect the comparatively high investments spent on building EE, while the other clean technologies allow a comparatively low energy cost. Job displacement through the investment shift impact captures the employment impact of *not* constructing traditional energy power plants as they are replaced by clean technology. The effect is greater for wind and for utility-scale solar, reflecting the high clean energy capacity deployed in the base case scenario. Similarly, revenues lost by traditional energy suppliers due to wind and utility-scale solar development have a comparatively greater negative impact than for the other technologies.

In terms of direct employment, the services sector has the largest expansion, followed by government, finance, and trade. CEEAT simulates job impact by different economic sectors through tracking the destination of the expenditures on clean energy technologies as well as the expenditures re-spent from energy savings. The services sector has the largest employment expansion in Egypt. Direct employment created in this sector combined with associated indirect and induced jobs in the economy resulted in the creation of around 89 percent of jobs, or 1.8 million net job-years.[20] One of the reasons for such expansion is the amount of expenditures the services sector receives from investments in clean energy technologies (installation and O&M, for example). The other reason is the respending it receives from consumers saving on their energy expenditures. The construction sector would have seen a similar expansion through its involvement in the construction of clean energy projects, but this impact was offset by the reduction in the construction of conventional energy (as the counterfactual). CEEAT results show that the government sector will benefit from the creation of at least 469,000 direct net job-years,[21] mainly due to sales tax and policy development expenditures, while the finance, manufacturing, and trade sectors will see an expansion of 260,00, 209,000, and 158,000 net job-years,

[20] Expenditures flows (expenditures on clean energy technologies and expenditures respent from energy savings) toward each economic sector create direct jobs in the considered sector, as well as indirect and induced jobs spread across the economy and not necessarily only in the considered sector.
[21] Does not include indirect and induced job-years created in the government sector through overall expenditures flows in the economy.

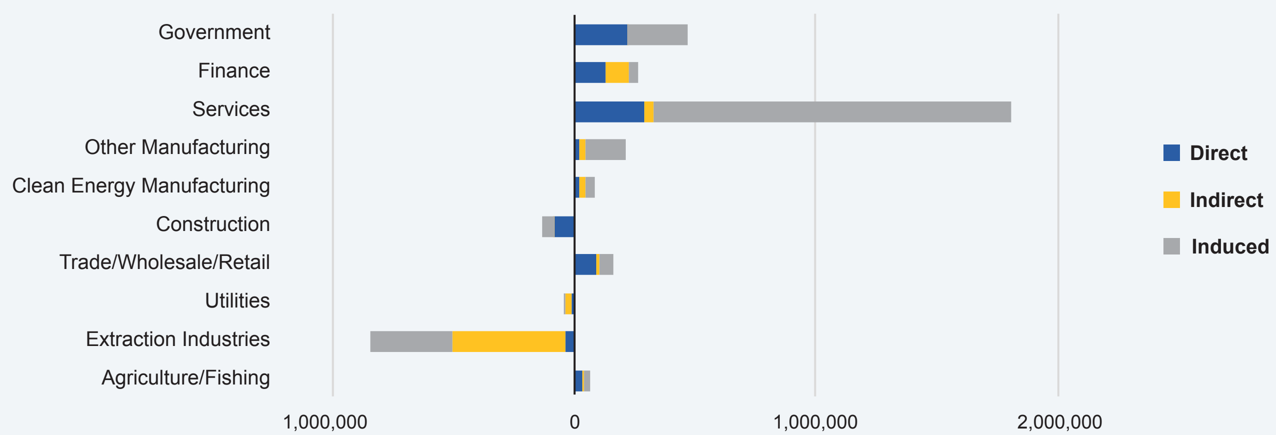
manufacturing, and trade sectors will see an expansion of 260,00, 209,000, and 158,000 net job-years, respectively. The jobs created in the trade sector are caused by the spending on imports, sales and marketing, and purchase of clean energy equipment during the investment phase. Agriculture and fishing sector expansion is explained by respending of energy savings in the sector by consumers. On the other hand, the extraction industries, linked with conventional energy, incur job losses.

TABLE 3.2 Distribution of Net Job-years, by Impact Mechanisms

	Utility PV	Industry distributed PV	Residential rooftop PV	Wind	Energy efficiency
Investment impact	594,463	72,915	21,962	923,482	500,566
Substitution impact	941,571	178,806	41,096	2,250,876	261,484
Revenue impact	-334,655	-40,707	-12,616	-599,747	-143,452
Investment shift impact	-842,468	-102,477	-31,759	-1,509,817	-152,551
Total by technology	**358,912**	**108,538**	**18,683**	**1,064,793**	**466,046**

Source: Results of the base case scenario of CEEAT.

FIGURE 3.1 Cumulative Direct, Indirect, and Induced Net Job Creation (job-years) by Sector



Source: Results of the Initial Baseline Assumptions of CEEAT.

3.2 Sensitivity Analysis

By testing the sensitivities regarding the different parameters, CEEAT can help provide insights on how Egypt can overcome potential barriers to achieve an optimal market penetration of clean technologies and maximize the employment impact. This note presents five mechanisms that can be examined to determine the impact of different assumptions on the job creation potential increase. Among these mechanisms are: (i) expanding the scale of investments; (ii) lowering investment costs; (iii) increasing rates of innovation (related to the investment cost and performance of different clean energy technologies); (iv) building up the local production capacity; and (v) utilizing international financing mechanisms with lower interest rates.

This section reviews the impact of more or less "optimistic" targets of clean energy transition and assumptions regarding five parameters. These parameters include clean energy installed capacity, cost of investment, innovation rate, share of domestic financing, and local content of the clean technologies. Clean energy projects' benchmarking, a literature review, and expert estimations allowed for the identification of ranges for these parameters in table 3.3.

TABLE 3.3 Key Parameter Values Used for the Sensitivity Analysis

Variables	Less "optimistic" values	Base case scenario	More "optimistic" values
Clean technologies' deployment by 2030	Solar: 19,935 MW Wind: 17,528 MW EE: -10% of base case scenario	Solar: 22,150 MW Wind: 19,475 MW EE: -2% of BAU	Solar: 24,365 MW Wind: 21,423MW EE: +10% of base case scenario
Investment cost ($/MW)*	PV (utility): US$990,000 PV (industrial): US$1,265,000 PV (residential): US$1,375,000 Wind (utility): US$1,430,000 EE: US$61/MWh**	PV (utility): US$900,000 PV (industrial): US$1,150,000 PV (residential): US$1,250,000 Wind (utility): US$1,300,000 EE: US$55/MWh**	PV (utility): US$810,000 PV (industrial): US$1035,000 PV (residential): US$1,125,000 Wind (utility): US$1,170,500 EE: US$50/MWh**
Innovation rate	1% per year	1% per year	3% per year
Share of domestic financing	Utility (PV and wind): 20% domestic financing Distributed (PV industry and PV residential rooftop utility): 100% domestic financing EE: 100% domestic financing	Utility (PV and wind): 10% domestic financing Distributed (PV industry and PV residential rooftop utility): 90% domestic financing EE: 90% domestic financing	Utility (PV and wind): 0% domestic financing Distributed (PV industry and PV residential rooftop utility): 80% domestic financing EE: 80% domestic financing
Local content of RE manufacturing (%)	PV (utility, distributed): 0% Wind (utility): 10%	PV (utility, distributed): 10% Wind (utility): 30%	PV (utility, distributed): 30% Wind (utility): 50%

Source: Parameters derived from a benchmark of literature review and expert estimates.
Note: *Transmission and distribution costs are set to US$56,000/MW except for distributed technologies.
**Assumption of levelized cost of energy savings (US$/MWh).

To understand the job impact of each parameter, the job results are estimated by varying the result of each parameter one by one while keeping the base case scenario values for the other parameters. Furthermore, two additional simulations have been computed to grasp the overall range of the sensitivity in terms of jobs impact. The first simulation combines the less "optimistic" values of all the five above parameters (low clean energy development targets, high investment costs, no enhanced innovation, high share of domestic financing, and low local content). Conversely, the second simulation includes high targets, low investment costs, enhanced innovation, a low share of domestic financing, and high local content. Table 3.4 shows the results associated with changes in each of the parameters. The results for the parameters are as follows:

- **Clean technologies deployment.** Varying the total capacity of deployed clean technologies in 2030 by 10 percent compared to the base case scenario would lead to an equivalent change in the number of net job-years created.
- **Investment cost.** CEEAT results show that this parameter is negatively correlated to job creation since lower investment costs mean cheaper energy, more savings reinjected in the economy, and thus more jobs created through the substitution effect. The impact is significant as a 10 percent reduction in investment costs would

raise net job-years by 13 percent compared with the base case scenario, while a 10 percent higher investment cost would lower net job-years by 14 percent.

- **Innovation rate.** As defined in the base case scenario, the default assumption in CEEAT is a low innovation rate that presumes technology investment costs, O&M costs, the annual degradation factor, and labor productivity improve at just 1 percent per year with no improvement in capacity factor. This sensitivity analysis entails increasing the rate of innovation to 3 percent annual improvement in technology improvement costs, that is to say, the cost to install clean energy systems would decline by 3 percent annually. In addition, O&M costs, the degradation factor, and labor productivity would improve by 3 percent annually. Finally, the capacity factor would increase by 0.1 percent annually. This change induces a significant increase in net job-years (54 percent or 1 million additional job-years). It is worth noting, however, that whereas improvements in technology costs and performance have a positive impact on job creation, increased labor productivity (as a result of automation, for example) would reduce the number of jobs required for the same level of investments.
- **Share of domestic financing.** The share of domestic financing is positively correlated with job creation. While domestic financing has a higher cost (15 percent interest rate) compared to international financing (6 percent), the repayment cost of domestic financing is reinjected in the local economy, contrary to the repayment cost of international financing, which exits the local economy. The impact of varying the share of domestic financing by 10 percentage points is +/- 3.7 percent.
- **Local content of RE manufacturing.** The share of local content in manufacturing is positively correlated with job creation: increasing the share of locally produced clean technologies induces an increase in job creation. The base case scenario assumes a 30 percent local content for wind turbines and 10 percent for solar PV. If we increase local production of wind turbines to 50 percent and of solar PV to 30 percent (assuming that this does not affect the overall cost of investment), the net employment benefit would increase by 3.3 percent even as the overall cost of clean energy production remains at the same level.

TABLE 3.4 Sensitivity Analysis Results of the Clean Technology Path

		Utility PV	Industry distributed PV	Residential rooftop PV	Wind	Energy efficiency	Total job-years	Change in %*
Base case scenario		**358,912**	**108,538**	**18,683**	**1,064,793**	**466,046**	**2,016,972**	
EnR targets**	Low	323,009	97,684	16,805	958,341	419,050	1,814,890	-10.0%
	High	394,795	119,392	20,529	1,171,300	512,553	2,218,569	10.0%
Investment costs**	High	262,771	94,811	16,630	928,771	437,004	1,739,988	-13.7%
	Low	455,052	98,385	20,736	1,200,815	495,089	2,270,077	12.5%
Innovation**	High	601,462	138,848	31,305	1,824,827	512,379	3,108,821	54.1%
Local content**	Low	347,771	108,063	18,540	1,021,176	466,046	1,961,596	-2.7%
	High	381,193	109,488	18,970	1,108,410	466,046	2,084,108	3.3%
Domestic financing**	Low	326,525	107,630	18,724	1,017,847	472,451	1,943,177	-3.7%
	High	391,299	109,446	18,642	1,111,739	459,641	2,090,767	3.7%
Lowest scenario		**193,615**	**83,960**	**14,857**	**746,572**	**399,272**	**1,438,277**	**-28.7%**
Highest scenario		**808,369**	**139,809**	**36,537**	**2,208,853**	**585,033**	**3,778,601**	**87.3%**

Source: CEEAT results. *Note*: *Compared to base case scenario. **Base case scenario assumptions for the remaining parameters.

Overall, net job-years creation could range from 1.4 to 3.8 million in the lowest and highest scenarios respectively. This correlates to -29 percent up to +87 percent of net job-years created compared to the base case scenario. Wind utility-scale technology remains the main source of job creation with 747,000 net job-years in the case of the lowest scenario and 2.2 million in the case of the highest scenario. Moreover, the combination of "optimistic" values for all parameters (highest scenario) lowers the average cost of clean energy production by around 32 percent, from US$85/MWh down to US$58/MWh and boosts the average annual production of clean energy from 36 to 46 TWh.

4. Conclusions and Way Forward

With its vast potential for renewable energy (starting from a low baseline), Egypt's electricity sector is poised to bring significant employment benefits for the local population as it transitions to clean energy. In the base case scenario, the current government targets are expected to deliver a positive benefit of 2 million net job-years over the 30-year period through 2050, with around 1 million new jobs in the economy due to investments in wind technology, followed by 466,000 net job-years due to building energy efficiency, 359,000 net job-years in utility-scale solar, 109,000 net job-years in the economy due to industry distributed solar, and 19,000 net job-years due to residential rooftop solar[21]. The improvements in certain parameters can result in an increase of up to 3.8 million net job-years. Cost reduction and innovation promoted by enhanced technology deployment will positively impact job creation. In addition, enhancing local manufacturing capabilities and creating a domestic RE industry can have a positive impact on jobs. Building on its established wind market, Egypt's electricity sector successfully localized 30 percent of overall wind farm requirements and has the potential to meet higher local manufacturing content. Local manufacturing can also create opportunities for clean technology exports in the growing regional markets, and thus further foster jobs dynamics. Furthermore, with the deployment of other technologies such as supply-side EE, demand-side management, battery storage, electric vehicles, sustainable cooling and heating, the job creation potential may increase significantly.

Although CEEAT builds evidence on the job creation potential of the clean energy transition and disruption along the value chain in Egypt, it does not intend to provide a precise estimate of the associated employment potential. This note aims to provide policy makers with a better understanding of how and where clean energy investments can create (or displace) jobs across the economy. An in-depth study will be needed to further classify the skills and occupations of jobs created, substituted, transformed, and displaced by the scale-up of clean energy pathways as well as the quality of jobs along the supply chain. Furthermore, CEEAT allows policy makers to test the impact of different parameters so as to better inform their policy making. As an example, CEEAT points out that increasing the innovation rate from 1 percent to 3 percent induces 1 million additional net job-years (+54 percent) compared to the base case scenario. A 10 percent change in investment cost induces around 13 percent change in jobs creation and a 10 percent change in clean technology targets induces a 10 percent impact on jobs as well. By changing parameters, new insights may emerge that can further increase both economic and employment benefits.

This methodology, nevertheless, does pose certain limitations. The calibration of CEEAT for Egypt uses data collected from available sources and makes assumptions where data are missing. These data and assumptions will need to be validated and regularly revised to align with the changing ground realities. Additionally, CEEAT does not suggest or compare alternative measures and policy instruments beyond the five technology paths consistent with the government's current targets. According to the sensitivity analysis, pursuing more ambitious goals may result in additional job creation. The tool does not incorporate a general equilibrium model and, as such, does not assess the impact of changes in behavior or the interactions with changes in electricity and other energy prices, and changes in other market dynamics that might amplify or weaken overall job impacts. Certain limitations of the model may lead to over or underestimation of employment. CEEAT excludes price and income effects; assumes homogenous labour and perfect labour mobility across sectors and locations – all of which could lead to overestimation of jobs. However, the exclusion of co-benefits such as improved health, capable

[21] We have compared our results with other regional and international studies using different methodologies and found the results to be similar in order of magnitude.

workforce, and more competitive and productive industry may lead to underestimation of jobs. Finally, while CEEAT models dynamic aspects of the economy it remains rooted in I/O methodology, which means that as the structure of the economy changes in the simulated period (up to 2050), the actual employment is likely to vary from the our estimates.

Despite promising numbers, the prospects of tapping into RE and EE employment potentials remains a challenge. The challenges to job creation revolve around key dynamics related to the energy transition: (i) shrinking traditional fossil-centric sectors and the emerging role of RE and EE; (ii) technological disruptions and opportunities; (iii) development of local manufacturing and value chain capacity; (iv) private sector growth; and (v) human capital development with inclusive policies to promote participation in labor market by youth and women. In order to enjoy the employment benefits of the clean energy transition and based on the evaluation of the opportunities and challenges for realizing the job impact, further development is required of comprehensive cross-sectoral policies covering energy, industry, labor markets, social protection, education, and skills development.

Based on the CEEAT results, the World Bank team will conduct analytical deep-dive analyses on the challenges and opportunities of RE and EE job creation and transformation, develop recommendations of specific policies, and engage in policy dialogue and multi-stakeholder consultations. Beyond CEEAT, it is also critical to assess the ability of the national economy and society in Egypt to meet the job potential, which is the purpose of the next steps of this analytical work. Specific policies and building blocks that need to be put in place to capitalize on the potential gains of emerging employment opportunities and associated benefits will be discussed with government and sector stakeholders. They will pertain to the issues of: (i) private sector development, investment, and industrial policies to facilitate increased private capital investment, and the share of local content; (ii) labor market policies that should be introduced or strengthened to facilitate the transition of people across jobs, firms, and sectors to meet the demand for new types of skills and jobs across the electricity sector value chain; (iii) education and skills development policies and systems to prepare the workforce for the new job opportunities and requirements, as well as policies and investment in research and development capacity; (iv) social protection policies to facilitate the transition of workers across new sectors and into and out of the job market; and (v) policies to promote youth and women participation in sectors related to clean energy.

References

Bottoms, I. 2016. *80 Gigawatts of Change: Egypt's Future Electricity Pathways*. North Africa and Tunis: Egyptian Center for Economic & Social Right and Heinrich Böll Stiftung. https://tn.boell.org/sites/default/files/80_gigawatts_of_change_-_en_-_pages.pdf.

Cote, Sylvain. 2019. Renewable Energy and Employment: The Experience of Egypt, Jordan and Morocco

Kammen, Daniel M., Kamal Kapadia, and Matthias Fripp. 2004. *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* Berkeley: Renewable and Appropriate Energy Laboratory (RAEL), University of California.

EIB (European Investment Bank) and IRENA (International Renewable Energy Agency). 2015. *Evaluating Renewable Manufacturing Potential in the Mediterranean Partner Countries*. Abu Dhabi: IRENA. www.irena.org/publications/2015/Dec/Evaluating-Renewable-Energy-Manufacturing-Potential-in-the-Mediterranean-Partner-Countries.

Ferroukhi, R., X. G. Casals, and B. Parajuli. 2020. "Measuring the Socioeconomics of Transition: Focus on Jobs." Technical Paper 2/2020, IRENA, Abu Dhabi. https://www.irena.org/publications/2020/Aug/Measuring-the-socio-economics-of-transition.

IEA (International Energy Agency). 2020a. *Clean Energy Transitions in North Africa*. Paris: IEA. https://www.iea.org/reports/clean-energy-transitions-in-north-africa.

IEA. 2020b. *Energy Efficiency 2020*. Paris: IEA. https://www.iea.org/reports/energy-efficiency-2020.

IEA. 2020c. "Country Profiles: Egypt." IEA, Paris. https://www.iea.org/countries/egypt.

IRENA. 2018. *Renewable Energy Outlook: Egypt*. Abu Dhabi: IRENA. https://www.irena.org/publications/2018/oct/renewable-energy-outlook-egypt.

IRENA. 2020a. *Renewable Energy and Jobs: Annual Review 2020*. Abu Dhabi: IRENA. https://www.irena.org/publications/2020/Sep/Renewable-Energy-and-Jobs-Annual-Review-2020

IRENA. 2020b. "Data & Statistics: Renewable Technologies: Egypt." IRENA, Abu Dhabi. https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies.

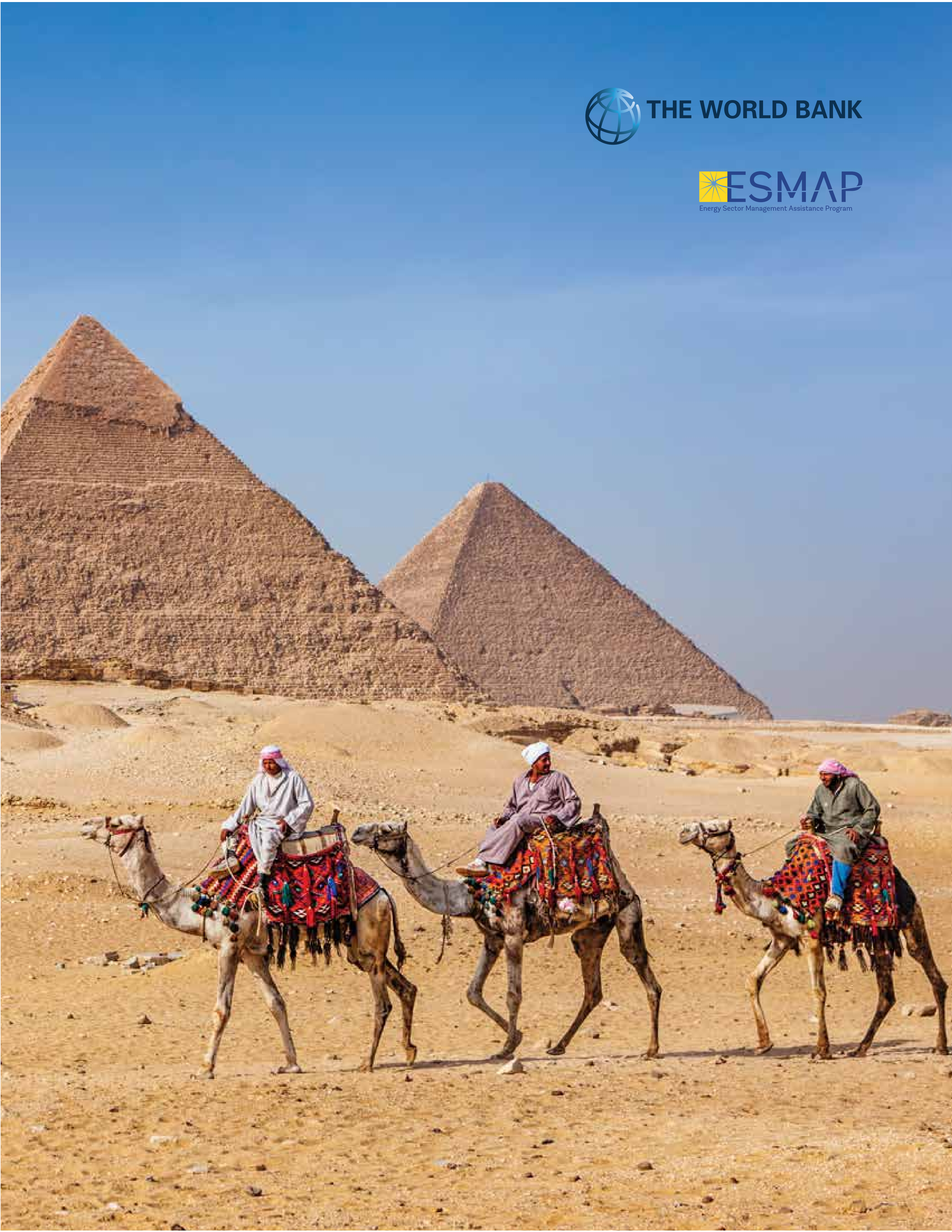
IRENA. 2020c. *The Post-COVID Recovery: An Agenda for Resilience, Development and Equality*. Abu Dhabi: IRENA. https://www.irena.org/publications/2020/Jun/Post-COVID-Recovery.

Ministry of Electricity & Renewable Energy. 2019. *Egyptian Electricity Holding Company: Annual Report 2018–2019*. Arab Republic of Egypt: Ministry of Electricity & Renewable Energy. http://www.moee.gov.eg/english_new/EEHC_Rep/2018-2019en.pdf.

Plan Bleu. 2011. *Impact on Employment and Trainings of Development in Rational Use of Energy and Renewable Energy Sources in SEMCs*. Marseille, France: Plan Bleu. https://planbleu.org/en/publications/impact-on-employment-and-trainings-of-development-in-rational-use-of-energy-and-renewable-energy-sources-in-semcs/.

RCREEE (Regional Center for Renewable Energy and Energy Efficiency). 2017. *The Socio-Economic Impacts of Renewable Energy and Energy Efficiency in Egypt: Local Value and Employment*. Eschborn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.rcreee.org/sites/default/files/report-final_rcreee_website-_13-02.pdf.

RCREEE. 2020. *Mapping EE and RES Market Potential Areas with Higher Impact on Local Economy and Job Creation: Tunisia, Egypt, and Lebanon*. Brussels: meetMED Secretariat. https://www.rcreee.org/sites/default/files/v3_15_a32_impact-map-eco-and-job_final.pdf.



THE WORLD BANK

ESMAP
Energy Sector Management Assistance Program