International Renewable Energy Agency

Socio-economic footprint of the energy transition

EGYPT

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About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
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Disclaimer

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Abbreviations

AfCFTA African Continental Free Trade Area

BECCS bioenergy with carbon capture and storage

BEEC building energy efficiency code

BOO build-own-operate

BOOT build-own-operate-transfer

CAGR compound annual growth rate

CAIT Climate Analysis Indicator Tool

CCS carbon capture and storage

CO_2 carbon dioxide

CSP concentrated solar power

DMC domestic material consumption

EDGAR Emissions Database for Global Atmospheric Research

EEHC Egyptian Electricity Holding Company

EFF extended fund facility

EGP Egyptian pound

EgyptERA Egyptian Electricity Utility and Consumer Protection Regulatory Agency

EV electric vehicle

FDI foreign direct investment

FiT feed-in-tariff

GDP gross domestic product

GERD Grand Ethiopian Renaissance Dam

GHG greenhouse gas

GNI gross national income

GoE Government of Egypt

$GtCO_2eq$ gigatonnes of carbon dioxide equivalent

GW gigawatt

GWh gigawatt hour

IPCC Intergovernmental Panel on Climate Change

IPP independent power producer

IRENA International Renewable Energy Agency

km^2 square kilometre

kWh kilowatt hour

MENA Middle East and North Africa

MoERE Ministry of Electricity and Renewable Energy

MOIC Ministry of International Co-operation

MoP Ministry of Planning

MoU memorandum of understanding

MRV monitoring, reporting and verification

$MtCO_2eq$ million tonnes of carbon dioxide equivalent

MW megawatt

NCCC National Council for Climate Change

NCCS National Climate Change Strategy

NDC Nationally Determined Contribution

NREA New and Renewable Energy Authority

NSRP National Structural Reform Programme

O&M operation and maintenance

OECD Organisation of Economic Co-operation and Development

PJ petajoules

$PM_{2.5}$ particulate matter 2.5

PPP purchasing power parity

P2X power-to-X

PV photovoltaic

R&D research and development

SDG Sustainable Development Goal

TARES Technical Support Programme for Restructuring the Energy Sector in Egypt

Tcf trillion cubic feet

tCO_2eq/cap tonnes of carbon dioxide equivalent per capita

TFEC total final energy consumption

TPES total primary energy supply

UNIDO United Nations Industrial Development Organisation

USD United States dollar

Unless otherwise stated, the exchange rate from US dollars (USD) to Egyptian pounds (EGP) used throughout this report is that given by the 15 March 2023 UN operational rates of exchange, *i.e.* USD 1.00 = EGP 30.86.

Executive summary

Egypt is home to a population of around 110 million people, with a young and productive median age of 23.9 years in 2021 (UNDESA, 2022). At purchasing power parity (PPP), it had a gross domestic product (GDP) of USD 1.33 trillion[1] in 2021, making Egypt the third-largest economy on the continent. Under the current World Bank classification, it is considered a lower-middle income country (World Bank, n.d.). Despite enjoying gradual economic growth, Egypt faces challenges including demographic pressures on natural resources, employment and social infrastructure.

Egypt's population growth rate and poverty rate, with 32.5% of the population living under the national poverty line in 2018 (World Bank, n.d.), places significant fiscal and infrastructure burdens on the country's social services. Fiscal space remains limited due to the large interest burden and low revenue mobilisation. Government spending on energy subsidies remains high, leading to continued limited fiscal space for social spending. According to the World Bank, allocations to the health and education sectors remain limited, representing around 1.5% and 2.4% of GDP in the 2021-2022 financial year. Although Egypt strengthened social protection, expanded existing programs and introduced key poverty mitigation measures during the early stages of the COVID-19 pandemic, increasing inflationary pressures call for further intensification of efforts to reduce poverty and improve welfare. Improving the efficiency of public spending, optimising revenue mobilisation to advance human capital, and pursuing structural reforms to unleash the potential of the private sector in diversified activities are necessary to create jobs and improve living standards.

The country's population is heavily concentrated in a small area along the River Nile and in its delta. This is having a significant impact on human settlement and the economy. Egypt's economy and its major settlements rely heavily on natural resources and particularly on the River Nile. This is used for various purposes, including potable water, agriculture, industry, fish farming, power generation, inland river navigation, mining, oil and gas exploration, machinery cooling and electricity generation. This reliance on the river makes Egypt particularly vulnerable to rising temperatures and decreased precipitation in the higher Nile Basins and the eastern Mediterranean coastal zone. Over the past 30 years, temperatures in Egypt have increased by an average of 0.53°C per decade (UNICEF, 2022). As a result, the country is particularly vulnerable to the effects of climate change, which could exacerbate existing inequalities in human development and geographical distribution. The threat of heatwaves, desertification and loss of biodiversity all pose diverse risks, including risks to food and water security.

[1] *In 2017 US dollars.*

Air pollution and waste management are also major environmental challenges in Egypt. Air pollution has a significant negative impact on public health, while waste production is increasing due to population growth, changes in consumption patterns, changes in waste characteristics and inadequate technology for waste disposal. These environmental issues will have a significant impact on Egypt's economy, particularly on its agricultural sector. In 2021, this sector accounted for 15% of GDP, provided jobs for 25% of the work force and provided food, textiles and other products (MOIC, 2021). Due to the expected increase in temperature and possible declines in rainfall, demand for water for agricultural purposes will likely increase, exacerbating the water scarcity problem.

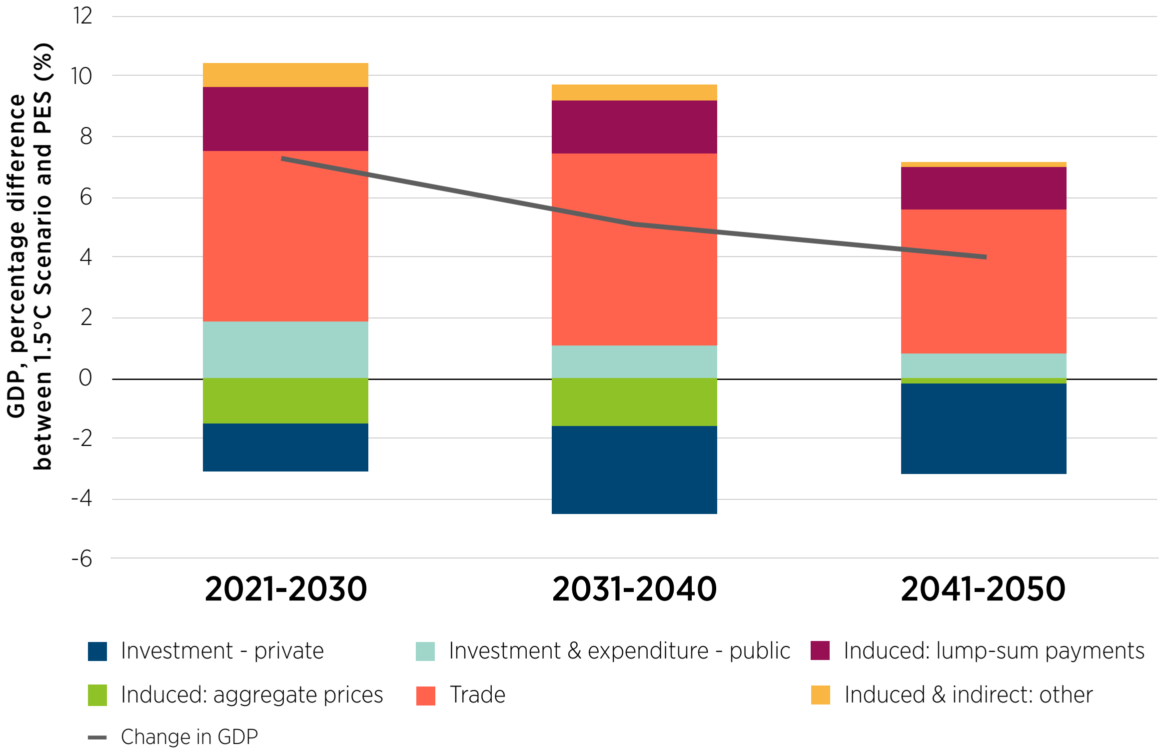
Egypt possesses substantial energy resources, including both conventional fossil fuels and renewable energy, with the former crucial to the country's socio-economic development. Historically a net exporter of oil and gas, Egypt became a net importer in the 2010s due to rising energy use and depleting energy resources. As a result, the energy sector has faced new challenges and barriers, such as intermittent power outages, while the economy has faced an increasing fiscal deficit due to high subsidies on energy prices – subsidies that the government has been reducing.

Egypt is one of Africa's largest energy markets. This is due to the size of its population and the country's historically high levels of access to modern fuels and electricity. This makes Egypt stand out from its southern neighbours (IRENA, n.d.). Globally, the energy sector is the largest contributor to emissions, and this is also the case in Egypt. The total energy supply (TES) increased by an average of 1.5% per year between 2010 and 2020 (UNSD, n.d.), and Egypt is still largely dependent on oil and gas (54.0% and 33.7% of the TES in 2020, respectively). Indeed, natural gas saw an increase in usage of 42% over the 2010-2020 period, with the installation of new electricity generating capacity. This hike has made Egypt Africa's largest gas market, accounting for over a third of the natural gas demand of the entire African continent (Climate Action tracker, 2022). Meanwhile, the share of renewables is low, yet it has been increasing over the last decade, seeing a rise from 6.5% to 7.1% between 2010 and 2020. Renewables are mainly dominated by bioenergy in the form of traditional biomass, which accounts for around two-thirds of total renewable energy supply and is still used by many rural households. Given the pressing need to accelerate the global energy transition, this decade has seen Egypt step up its efforts to transition its own energy system.

The country has been at the forefront of renewable energy deployment in Africa, particularly through its large hydro resources, tied to the River Nile. To meet its growing energy needs and contribute to job creation, Egypt has sought to develop several other forms of modern renewable energy, including through solar and wind projects, since the start of the century. These include the Zafarana wind farm and ambitious plans such as the Green Corridor Initiative for Egypt's renewable energy, a memorandum of understanding (MoU) signed in 2022 to build a 10 GW onshore wind project. As of 2020, the country had the continent's second largest installed capacity of solar energy, after South Africa. Egypt also had Africa's third largest wind power generation capacity, accounting for more than a fifth of the continent's total (IRENA, n.d.).

IRENA's macro-econometric modelling analysis of Egypt shows that the energy transition can boost the country's economy. Over the 2021-2050 period, under the 1.5°C Scenario GDP is 5.5% higher, on average, than under the PES – a difference driven mainly by trade (Figure S1). This positive impact is driven by the change in net trade in fuels, attributable to Egypt's energy transition, energy intensity and dependence on energy imports. Although Egypt is currently a net oil importer and despite it being a major gas exporter, it is at risk of becoming a net gas importer since its natural resources will likely not be able to keep up with domestic energy demand. Indeed, moving Egypt's energy strategy away from fossil fuels towards renewables is expected to have a substantial positive impact, adding USD 63 billion[2] to the country's GDP in 2050 alone. In cumulative terms, lower fuel imports are expected to improve the balance of trade by around USD 1.3 trillion over the 2021-2050 period. This represents around 5.2% of the cumulative GDP under the 1.5°C Scenario over the same period.

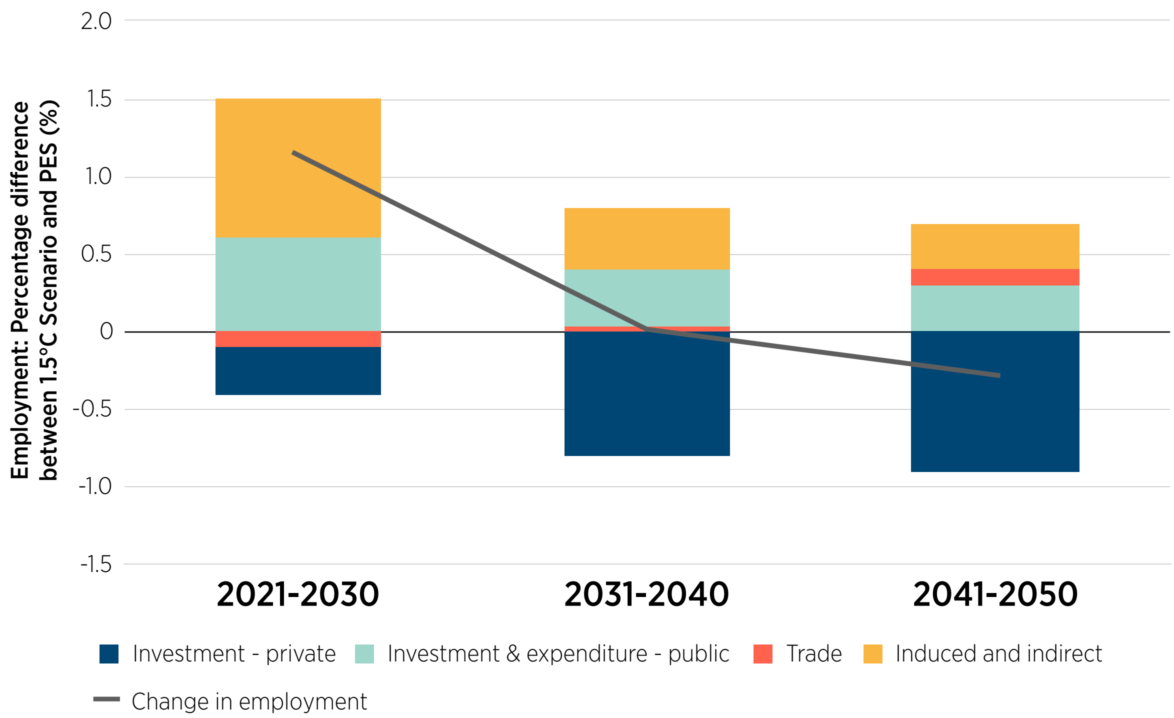
Figure S1: Egyptian GDP: Difference between the 1.5°C Scenario and the PES, 2021-2050 (%)



Under the 1.5°C Scenario, economy-wide employment is, on average, 0.3% higher than in the PES over the 2021-2050 period (Figure S2). Employment peaks in the years up to 2030. From 2030, there is a noticeable decrease in the employment difference between the scenarios, mainly driven by the loss in investment linked to fossil fuel supply. Nevertheless, this decrease is attenuated progressively in the final years, creating over 27 700 additional jobs (representing around 0.1% difference) in 2050. Egypt is one of the main beneficiaries of international financial collaboration flows, while making a relatively small global financing contribution. Increasing international transfers reduce the tax burden on employment wages and effectively expand the labour supply during the initial period. After 2035, consumer expenditure becomes the dominant positive factor. This trend closely follows GDP results, with an increase in consumer expenditure from the lump-sum payment driver one of the dominant positive effects.

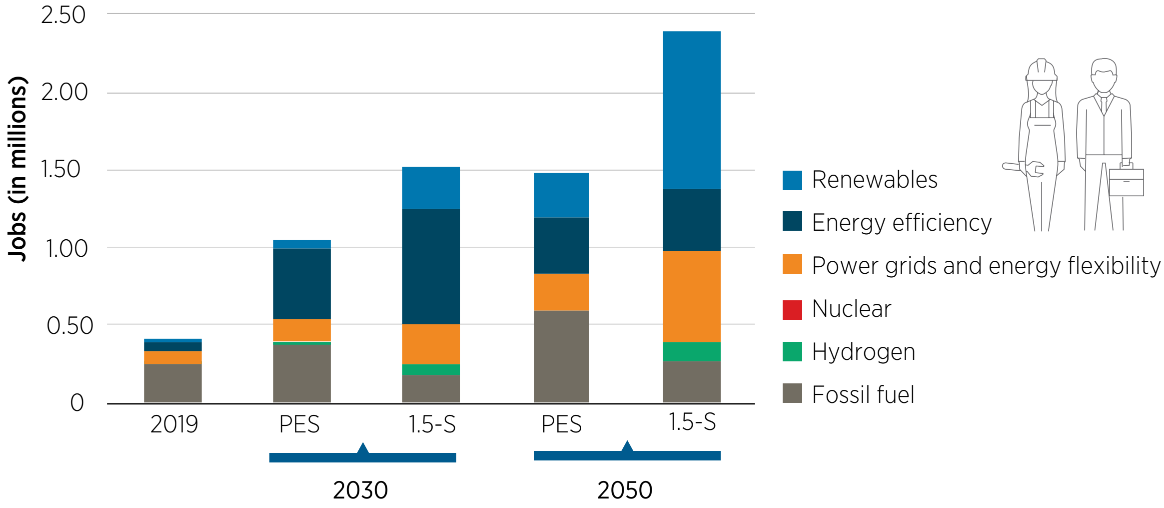
[2] *In 2019 US dollars.*

Figure S2: Employment in Egypt, 2021-2050: Difference between the 1.5°C Scenario and the PES by driver (%)



The energy transition is net positive for job creation in Egypt's energy sector (Figure S3). Total energy sector employment could reach around 1.5 million under the PES and over 2.4 million under the 1.5°C Scenario by 2050. Job losses in fossil fuels are more than offset by gains in renewables and other energy transition-related sectors (*i.e.* energy efficiency, hydrogen, and power grids and flexibility, *etc.*). By 2050, the 1.5°C Scenario sees renewables account for more than 42.2% of all energy sector jobs. It also accounts for around 24% of all jobs in electricity grids and flexibility (0.6 million jobs). Energy efficiency is responsible for a further 0.4 million jobs (representing 16.1% of energy sector employment). It should also be noted that energy efficiency dominates in 2030, representing around 49% of energy sector jobs, because of the frontloaded nature of investment in the sector. In 2050, 10.9% of jobs likely remain in the fossil fuel sector – a major decrease from the current 62.7% (Figure S3).

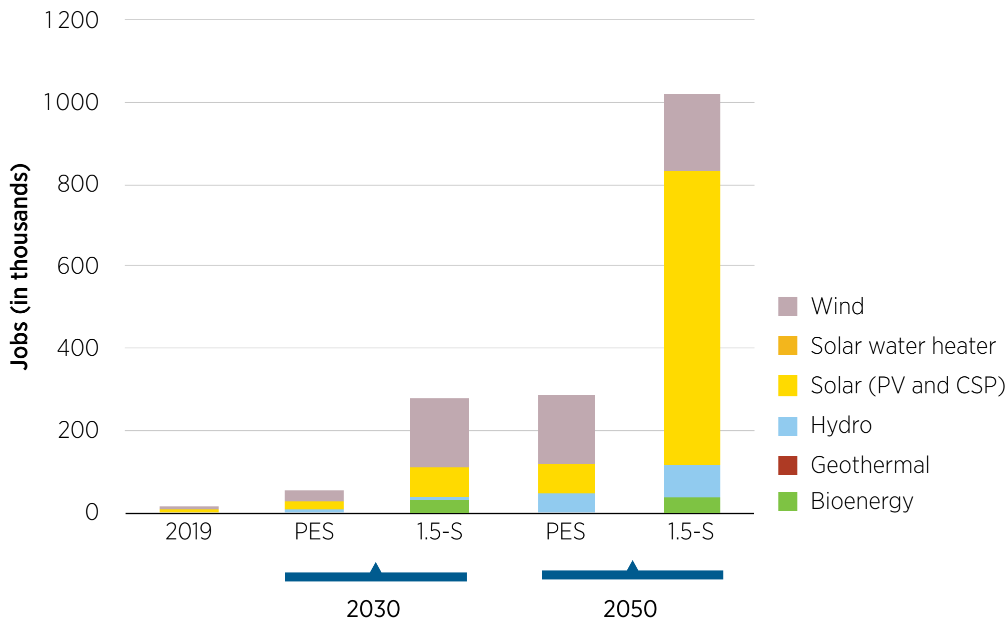
Figure S3: Energy sector jobs under the 1.5°C Scenario and PES, by sub-sector, 2019-2050



Note: 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

The 1.5°C Scenario sees a more significant increase than the PES, with more than five times the number of renewable jobs in 2030 and over 1 million jobs in renewable energy by 2050 (Figure S4). Because of Egypt's fossil fuel dependency, the uptake of renewables is relatively slow, however, compared to the global average, in the early years of the 2021-2050 period, with the transition occurring more rapidly in later years. Solar technologies (mainly PV) are expected to strongly dominate jobs in renewables during the transition overall. Wind would play an important role in first decade of the transition (*i.e.* 2021-2030), representing around 58% of the total renewable jobs in 2030.

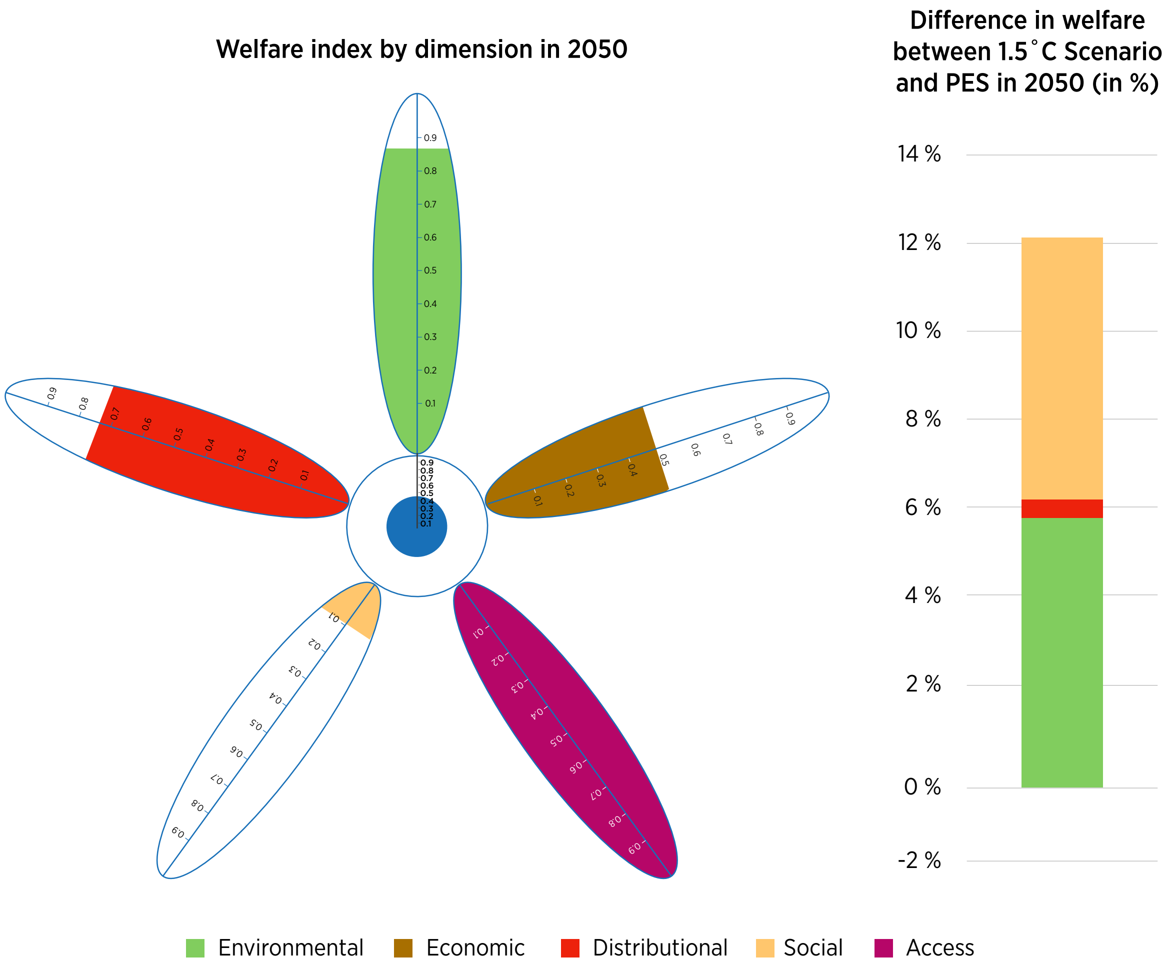
Figure S4: Renewable energy jobs in the PES and 1.5°C Scenario, 2019, 2030 and 2050



Note: CSP = concentrated solar power; PV = photovoltaic; 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

By 2050, in terms of welfare, the 1.5°C Scenario outperforms the PES by 12.2%, with this driven mainly by the social and environmental dimensions (right panel in Figure S5). This analysis has also highlighted some key areas where government action could boost living standards, and the study's social, economic, environmental and distributional dimensions should be considered by policy makers (left panel in Figure S5). Increases in social expenditure, and increases in consumption and investment to improve present and future well-being, offer the greatest potential for progress in the economic and social dimension. There is an opportunity for improvement in environmental policy as well, particularly in the area of GHG emissions reduction. Improving the distributional dimension requires policy action aimed at expanding the distribution of wealth and providing greater budgetary flexibility via higher international financial collaboration flows and carbon taxes.

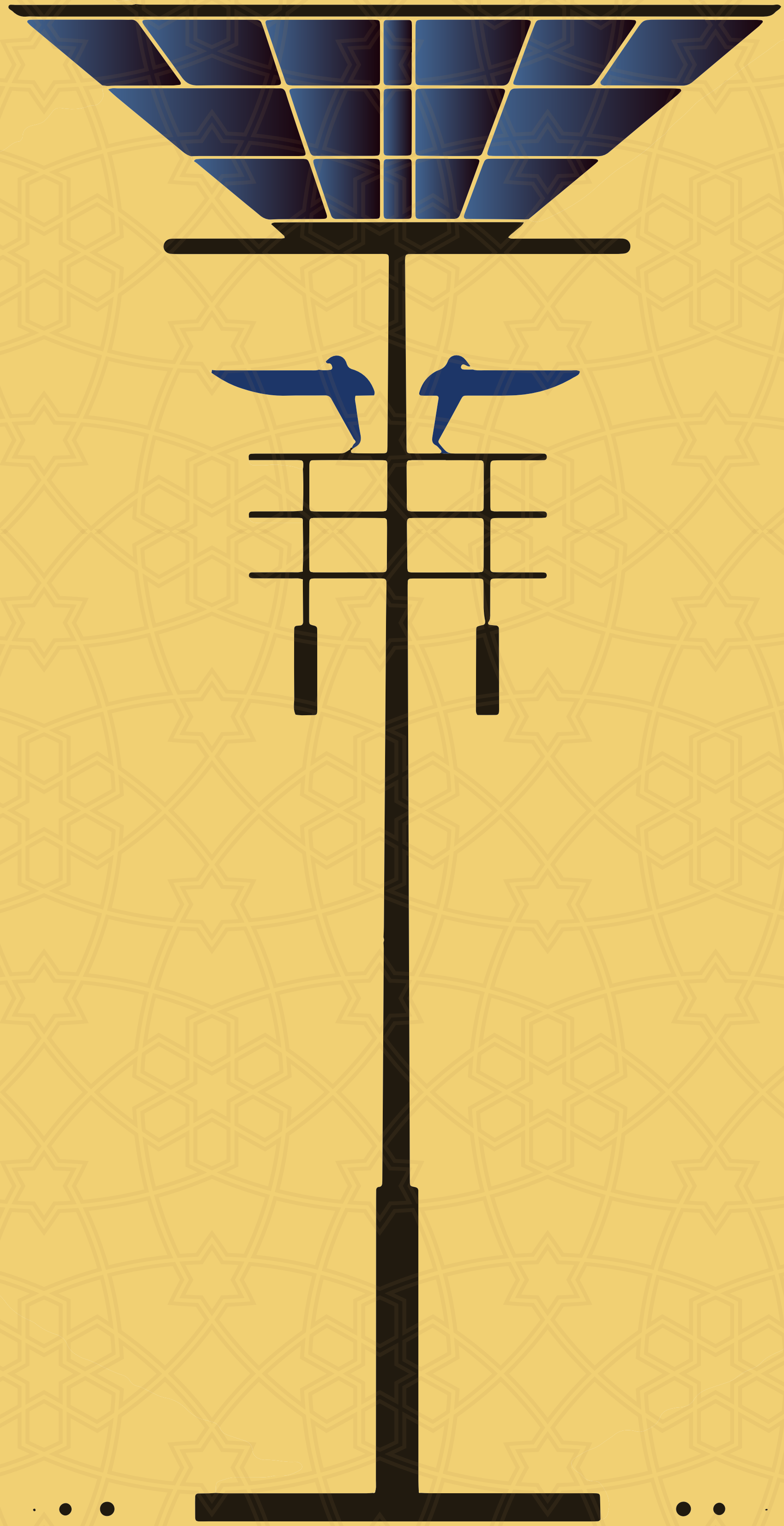
Figure S5: Welfare index in the 1.5°C Scenario (left) and difference in welfare between 1.5°C Scenario and PES in 2050 (right)



Note: In the left panel the five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the welfare index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall welfare Index.

For these benefits to be realised, Egypt will require a comprehensive and holistic policy framework that not only drives forward the transition of energy systems, but also protects people, livelihoods and jobs. Holding the presidency of COP27 – the 2022 United Nations climate change conference – Egypt had the opportunity to play a leading role in global climate policy and action. Addressing the intersection of climate and development requires significant commitments, institutions, regulations and co-ordination. The country has already taken important steps in this regard, with its climate policy evolving from simply adhering to international commitments to developing a long-term strategy to become a regional leader in addressing climate change. Supportive policies tailored to the country's socio-economic circumstances and challenges should go in tandem with the energy transition. Given Egypt's vulnerability to climate change, the security of water, energy, and food are intertwined. In order to accomplish efficient and integrated planning and management of resources, it is crucial to address the different links between the different sectors. A nexus strategy must be used to tackle these connected problems if the world is to meet the SDGs and reduce climate threats. Overall, a successful, just and inclusive energy transition in Egypt can bring about a brighter, more prosperous and healthier future for all Egyptians.

01 Introduction



Egypt is located in northeast Africa and covers an area of approximately 1 million square kilometres (km^2). At purchasing power parity (PPP), it had a gross domestic product (GDP) of USD 1.33 trillion[3] in 2021, making Egypt the third-largest economy on the continent. Under current World Bank classification, it is considered a lower-middle income country (World Bank, n.d.).

Egypt is home to a population of around 110 million people, with a young and productive median age of 23.9 years in 2021 (UNDESA, 2022). Despite enjoying gradual economic growth over the years, Egypt faces challenges, however, including demographic pressures on natural resources, employment and social infrastructure.

The country's population is also heavily concentrated in a small area along the River Nile and in its delta. As a result, the country is particularly vulnerable to the effects of climate change, which could exacerbate existing inequalities in human development and geographical distribution. The threat of heatwaves, desertification and loss of biodiversity all pose diverse risks, including risks to food and water security.

Globally, the energy sector is the largest contributor to emissions, as is the case in Egypt. Given the pressing need to accelerate the global energy transition, this decade has seen Egypt step up its efforts to transition its own energy system. This is important both in addressing the challenges that the country faces and in contributing to global efforts to combat climate change.

Egypt is Africa's third-largest gas exporter and has an energy sector that has traditionally overwhelmingly relied on fossil fuels. These have come both from its own production and from imports.

Egypt is also one of Africa's largest energy markets. This is due to the size of its population – with a very high population density in the capital, Cairo – and the country's historically high levels of access to modern fuels and electricity. This makes Egypt stand out from its southern neighbours (IRENA, n.d.).

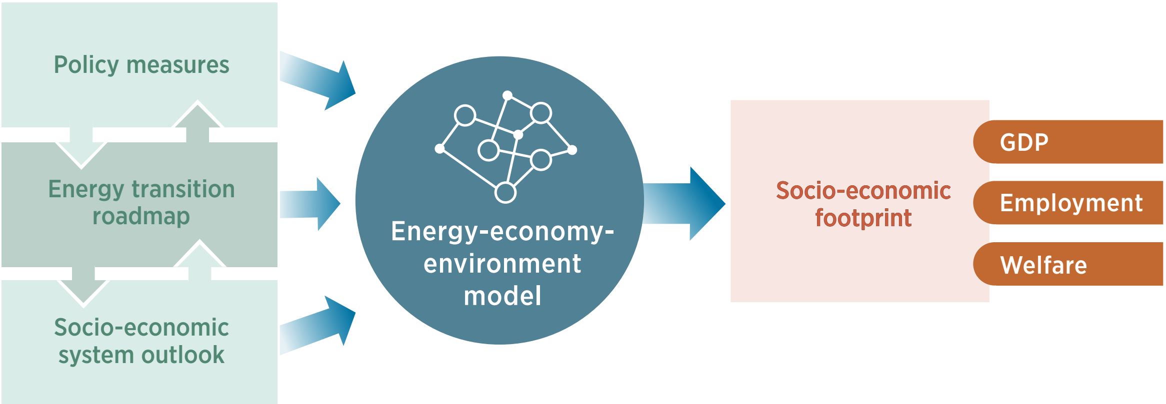
The country has also been at the forefront of renewable energy deployment in Africa, particularly through its large hydro resources, tied to the River Nile. Egypt has also deployed other forms of modern renewable energy, such as solar and wind. As of 2020, the country had the continent's second largest installed capacity of solar energy, after South Africa. Egypt also had Africa's third largest wind power generation capacity, accounting for more than a fifth of the continent's total (IRENA, n.d.). The potential for Egypt to further increase its use of renewable energy is also vast.

Understanding the socio-economic consequences of transition pathways at different levels of ambition is a fundamental aspect of proper planning and policy making. The International Renewable Energy Agency (IRENA) has been conducting research into these intricate issues since 2016 (IRENA, 2016, 2018a, 2019a, 2020, 2021, 2022a, 2022b, 2023a, 2023b, 2023c), analysing key drivers and impacts to inform energy transition planning and implementation on a global, regional and national scale.

In this research, IRENA has emphasised the importance of a holistic global policy framework (Figure 1) to make the energy transition successful and beneficial for the greatest number of people. To speed up the transition and ensure that its benefits are widely shared – and its drawbacks are reduced – several policy components complement and support one another, encompassing a wide variety of technological, social, and economic challenges.

[3] *In 2017 US dollars.*

Figure 1: Socio-economic assessment framework



This socio-economic study has been conducted using the E3ME[4] macroeconometric model. This integrates the energy system and global economies into a single quantitative framework. It analyses the impact of the energy transition on variables such as GDP, employment and welfare to guide energy system planning and policy making for a just and inclusive energy transition at the global, regional, and national levels. Policy makers need to be aware of how such choices will affect people's well-being and overall welfare, and of the potential gaps and hurdles that could affect progress.

At the global level, IRENA explored these issues in its flagship report, *World energy transitions outlook: 1.5°C Scenario Pathway* (IRENA, 2021, 2022a, 2023a) (Box 1). In this, two energy roadmaps are analysed: 1) a scenario based on current plans, called the Planned Energy Scenario (PES);[5] and 2) an ambitious energy transition scenario (1.5°C Scenario)[6] that aims to achieve the 1.5°C goal consistent with the Paris Climate Agreement.

The timeframe of the IRENA analysis is up to 2050 and it concludes that transforming the energy sector can yield widespread benefits. These advantages include: GDP growth averaging an additional 0.5% over the PES through 2030, and energy sector employment reaching 139 million, worldwide – 33 million more than under the PES. Of those 139 million jobs, 38 million would be in renewable energy. Global welfare would be around 20% higher under the 1.5°C Scenario than under the PES. These global impacts will be unevenly distributed across countries and regions, however. This is because they depend on local socio-economic structures and their degree of reliance on fossil fuels and other commodities, as well as on the depth and length of the renewables supply chain, among other factors.

[4] *The E3ME global macro-econometric model (www.e3me.com) is used for the assessment of socio-economic impacts. Energy mixes and related investment – based on the World Energy Transitions Outlook 2022 (IRENA, 2022a) – are used as exogenous inputs for each scenario, as well as climate and transition-related policies.*

[5] *This is the reference case for this study, providing a perspective on energy system developments based on governments' energy plans, as well as other planned targets and policies before 2020, including Nationally Determined Contributions (NDCs) under the Paris Agreement. This report considers policy targets and developments before 2020. Policy changes and targets announced since then are not considered in the modelling exercise, but are mentioned in the chapters in order to provide insights into the latest developments.*

[6] *This scenario describes an energy transition pathway in which the increase in global average temperature by the end of the present century is limited to 1.5°C, relative to pre-industrial levels. It prioritises readily-available technology solutions – including all sources of renewable energy, electrification measures and energy efficiency – that can be scaled up at the necessary pace for the 1.5°C goal.*

BOX 1: WORLD ENERGY TRANSITION OUTLOOK: 1.5°C PATHWAY

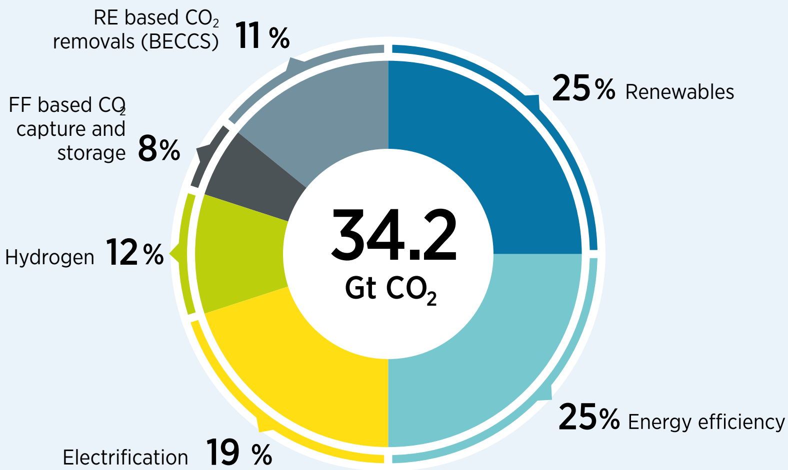
The *World energy transitions outlook* outlines a pathway for the world to achieve the goals of the Paris Agreement and halt the pace of climate change by transforming the global energy landscape. The reports present options for limiting the global temperature rise to 1.5°C degrees and bringing carbon dioxide (CO_2) emissions closer to net zero globally by mid-century. They offer high-level insights into technology choices, investment needs, accompanying policy needs and the socio-economic implications of achieving a sustainable, resilient and inclusive energy future.

IRENAs 1.5°C Scenario considers today's proven technologies, as well as innovative technologies that are under development, but that could play a significant role by 2050.

Figure 2 shows the six main components of CO_2 emissions abatement based on the most recent edition of the *World energy transitions outlook*. Renewable energy plays a key role in the decarbonisation effort. Over 90% of the solutions in 2050 involve renewable energy through direct supply, electrification, energy efficiency, green hydrogen and bioenergy with carbon capture and storage (CCS). Fossil-based CCS also has a limited role to play, while the contribution made by nuclear power remains at the same levels as today.

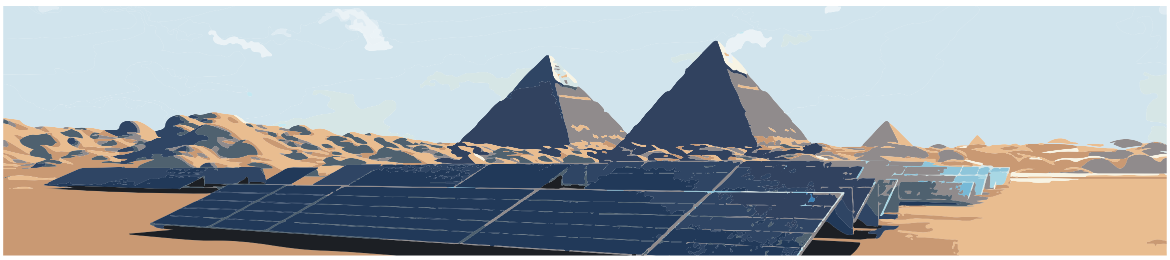
The report presents analysis at a globally aggregated level.

Figure 2: Reducing emissions by 2050 through six technological avenues



Source: (IRENA, 2023a).

Note: CCS = carbon capture and storage; BECCS = bioenergy with carbon capture and storage; FF = fossil fuels; $GtCO_2$ = gigatonnes of carbon dioxide; RE = renewable energy.



This report aims to discuss the socio-economic differences Egypt experiences between the PES and the 1.5°C Scenario. It uses the same inputs and assumptions as the 2022 edition of IRENA's *World energy transitions outlook*.

Under the PES, Egypt's economy is expected to experience strong economic growth, as envisioned in the baseline assumption of the E3ME model.[7] Under this baseline trend, the country's real GDP increases by an average of around 5.0% per year between 2021 and 2050. The Egyptian population is projected to grow by a compound annual growth rate (CAGR) of 1.1% over the 2021-2050 period, reaching over 142.5 million in 2050 (Table 1). Economy-wide employment is also expected to rise, by an average of around 1.4% per year, over the same period.

Table 1: GDP, labour force and population growth projections under the PES

Variable	2021-2030 (CAGR %)	2031-2040 (CAGR %)	2041-2050 (CAGR %)
Real GDP	4.93	6.26	3.71
Economy-wide employment	2.02	1.34	0.92
Total population	2.06	0.66	0.62

Notes: CAGR = compound annual growth rate; GDP = gross domestic product.

IRENA's analysis explores the socio-economic footprint that results from the various assumptions incorporated under particular climate policy baskets. These baskets include a range of measures to support a just and inclusive transition. These include: carbon pricing, international collaboration, subsidies, progressive fiscal regimes to address distributional aspects (see Box 2 and Appendix 1 for more details), investments in public infrastructure and spending on social initiatives. The baskets also include policies that encourage the deployment, integration and promotion of energy transition technologies.

[7] *Baseline forecasts are constructed using a comprehensive set of international data sources. The main source for population data is the United Nations World Population Prospects, while for GDP forecasts, the International Energy Agency World Energy Outlook is used. These are supplemented with data from the International Labour Organisation, the Organisation for Economic Co-operation and Development Structural Analysis database, the World Bank, the Asian Development Bank, the European Commission (EC) annual macroeconomic database, Eurostat, the EC Annual Ageing Report and European Union reference scenario reports. E3ME is a global, macro-econometric model owned and maintained by Cambridge Analytica (www.e3me.com, accessed 11 October 2023).*

BOX 2: IRENA'S CLIMATE POLICY BASKETS

In its modelling, IRENA's socio-economic footprint analysis includes a very diverse set of policies that aim to enable and support a sustainable energy transition. Holistic planning and synergistic implementation can address the multiple interactions between the social, economic and energy systems more successfully than an approach that relies on a limited number of interventions.

It should be noted that with a diverse climate policy basket, the final level of carbon pricing needed to bring about an energy transition roadmap depends on the effective implementation of accompanying policies. Since IRENA's analysis includes a diverse policy basket, transition goals can be achieved with significantly lower carbon prices.

IRENA's socio-economic analysis assesses the following policies:

- International co-operation, supporting enabling social policies in all countries and addressing the international justice and equity dimensions.
- Domestic progressive redistributive policies.
- Carbon pricing, evolving over time with carbon prices differentiated by each country's income level and special treatment of sectors with high direct impacts on people (households and road transport).
- Fossil fuel phaseout mandates in all sectors.
- Phaseout of all fossil fuel subsidies.
- Regulations and mandates to deploy transition-related technologies and strategies, including renewables, electric vehicles (EVs), hydrogen and system integration through electrification and power-to-X (P2X).
- Mandates and programmes for energy efficiency deployment in all sectors.
- Policies to adapt organisational structures to the needs of renewable-based energy systems (such as in the power sector).
- Subsidies for transition-related technologies, including for households and road transport.
- Direct public investment and spending to support the transition, with participation in all transition-related investments, but with special focus on enabling infrastructure deployment (EV charging stations, hydrogen infrastructure, smart meters, etc.), energy efficiency deployment and policy expenditure.
- Policies to align international co-operation with transition requirements: earmarking of funds to transition-related investments, increasing social spending.
- Public involvement in addressing stranded assets, both domestically and internationally.
- Policies to align government fiscal balances with transition requirements, addressing domestic distributional issues and aligning deficit spending with transition requirements.

The report is structured as follows: Chapter 2 analyses the current energy sector situation and related challenges and initiatives; Chapter 3 provides historical macroeconomic developments and the findings of the macroeconometric modelling to assess the socio-economic implications of the energy transition in Egypt through to 2050 (GDP, employment, and welfare); and Chapter 4 provides a summary of the findings and policy recommendations for ensuring a just and inclusive energy transition.

02 Contextualising Egypt's energy sector and the need for energy transition

Egypt possesses substantial energy resources, including both conventional fossil fuels and renewable energy, with the former crucial to the country's socio-economic development. Historically a net exporter of oil and gas, Egypt became a net importer in the 2010s due to rising energy use and depleting energy resources. As a result, the energy sector has faced new challenges and barriers, such as intermittent power outages, while the economy has faced an increasing fiscal deficit due to high subsidies on energy prices – subsidies that the government has been reducing.

These changes, however, have also coincided with significant new domestic gas discoveries. These began in 2015 with the discovery of the giant Zohr gas field by the Italian oil and gas company Eni. Nonetheless, rapid growth in natural gas consumption has continued to make the country a net gas importer (IEA, n.d.).

At the end of 2020, the country's proven hydrocarbon reserves consisted of 3.6 billion barrels of oil and 75.5 trillion cubic feet (Tcf) of natural gas (US EIA, 2022). Through the Suez Canal and the Suez-Mediterranean (SUMED) pipeline, Egypt also plays a crucial role in global energy market transportation.

To meet its growing energy needs and contribute to job creation, Egypt has also embarked on several renewable energy projects since the start of the century. These include the Zafarana wind farm and ambitious plans such as the Green Corridor Initiative for Egypt's renewable energy, a memorandum of understanding (MoU) signed in 2022 to build a 10 GW onshore wind project. These initiatives aim to preserve the country's limited hydrocarbon wealth, diversify its economy, better manage shocks from international energy price volatility and make Egypt's post-COVID growth path more sustainable.

The following sub-sections describe the status of Egypt's energy system (section 2.1) and the challenges linked to the energy sector and its transition (section 2.2).

2.1 THE CURRENT ENERGY MIX

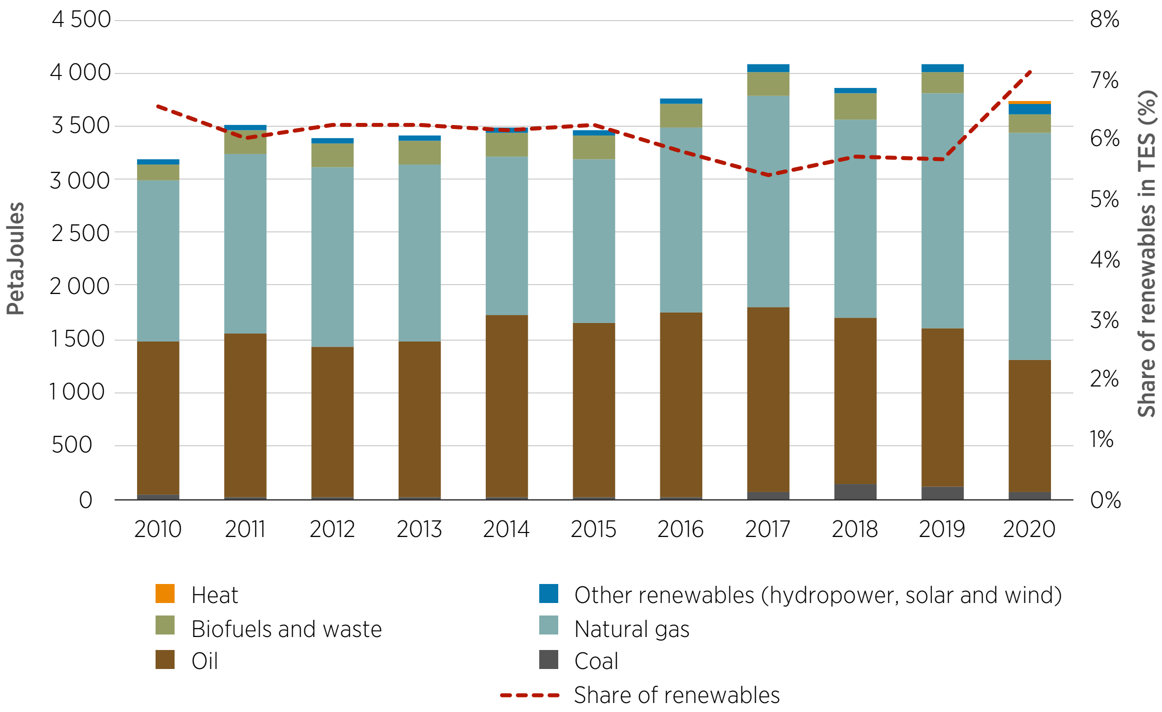
As shown in Figure 3, due to the economic slowdown during the COVID-19 pandemic, Egypt's total energy supply (TES) decreased by 9.3% between 2019 and 2020, to 3 702.2 petajoules (PJ) (UNSD, n.d.). Overall, however, between 2010 and 2020 the TES increased by an average of 1.5% per year.

Natural gas continues to be the largest source of energy, accounting for 57.6% of TES in 2010 and 54.0% in 2020. Oil is second largest source of energy, with around 45.1% in 2010 and 33.7% in 2020.

Egypt is therefore still largely dependent on oil and gas, with oil's declines accounted for in part by the increased use of gas for power generation. Indeed, natural gas saw an increase in usage of 42% over the 2010-2020 period, with the installation of new electricity generating capacity (natural gas and dual-fuel plants). This hike has made Egypt Africa's largest gas market, accounting for over a third of the natural gas demand of the entire African continent (Climate Action tracker, 2022).

Historically, coal accounts for a very low share of TES, although it recorded a slight increase between 2010 and 2020, from 1.4% to 1.6%. Meanwhile, the share of renewables is low, yet it has been increasing over the last decade, seeing a rise from 6.5% to 7.1% between 2010 and 2020. Renewables are mainly dominated by bioenergy in the form of traditional biomass, which accounts for around two-thirds of total renewable energy supply and is still used by many rural households.

Figure 3: Egypt: Total energy supply, 2010-2020



Source: (UNSD, n.d.).

On the consumption side, in 2020, more than two-thirds of total final energy consumption (TFEC) – or around 68.5% – came from fossil fuels. Respectively, oil and natural gas accounted for around 49.4% and 16.5% of that total. TFEC stood at 2 085.3 PJ that year, which was around 9% above the 2010 level (UNSD, n.d.). Renewable energy accounted for around 6.2% of TFEC in 2020.

The largest energy-consuming sectors in Egypt in 2020 were transport (34%), industry (29%), and residential (27%). Commerce and public services accounted for 6.6% and the primary sectors (agriculture, forestry, and fishing) for 2.9% (UNSD, n.d.).

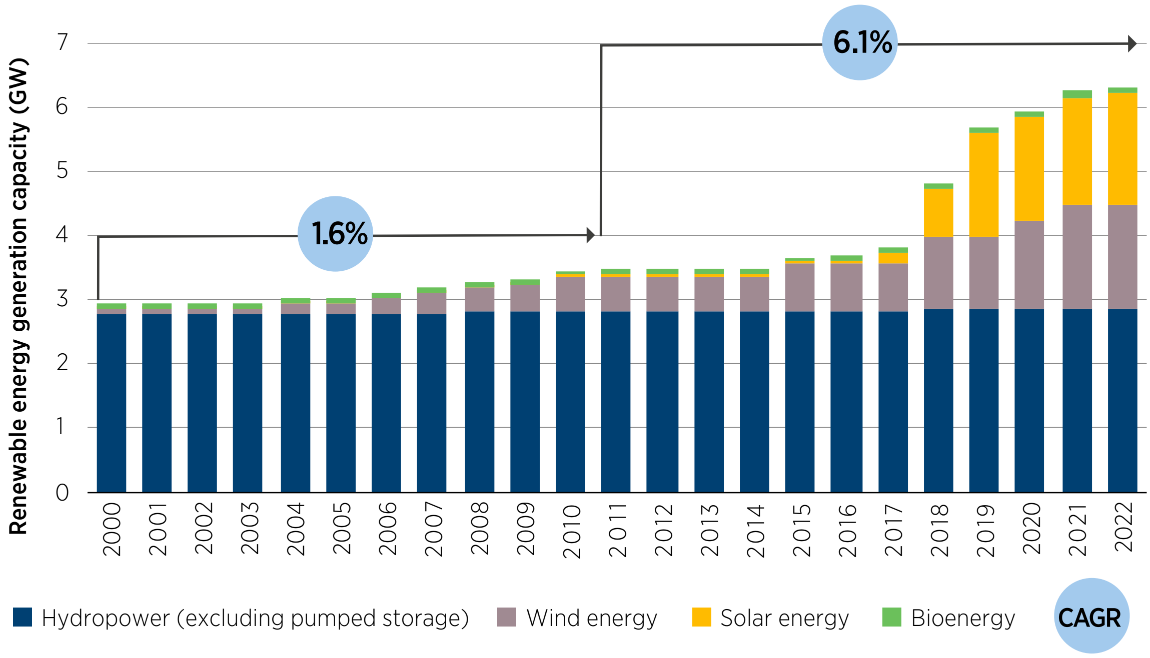
The consumption of electricity in TFEC increased 24% during the 2010-2020 period, to 566.8 PJ. The share of electricity increased from 24% of the country's TFEC in 2010 to around 27% in 2020, which was above the global average that year of around 23% (UNSD, n.d.).

Renewable energy capacity increased 82% between 2010 and 2021. This figure rises to almost 437%, if hydro is excluded (Figure 4). Over the 2010-2022 period, Egypt increased its renewable energy production by around 83.9%, adding over 1.1 GW of wind power and around 1.7 GW of solar power to its renewable energy capacity mix.

After some chronic power shortages, Egypt achieved a surplus in electricity by adding around 28.7 GW of new generating capacity within the 2015-2021 period. This surplus was mainly due to increased capacity in natural gas combined cycle and dual-fuel plants, which accounted for 89% of the capacity added during this period. These fossil fuel power plants were developed to rapidly fill the electricity gap and stop the power outage crises that the country had witnessed in previous years, when rapid demand growth had outpaced peak generation capacity.

It is also worth noting that despite the COVID-19 pandemic and its negative effects on most economic sectors worldwide, Egypt successfully installed 587 MW of variable renewable energy (510 MW of wind and 77 MW of solar) in the 2019-2022 period. Over the same three years, fossil fuel capacities increased by 616 MW. Thus, renewables contributed significantly to an increase in total installed capacities (+1.2 GW) between 2019 and 2021 (IRENA, n.d.).

Figure 4: Egypt: Installed renewable generation capacity, 2000-2022



Source: (IRENA, n.d.).

During the 2010-2021 period, solar energy capacity saw the fastest growth of any energy resource, expanding at a CAGR of 53.4%. In addition, between 2018 and 2021, the electricity generated from solar saw an almost nine-fold increase, from 553.1 gigawatt hours (GWh) to 4 972.5 GWh. Over the 2010-2021 period, wind capacity grew 10.4% (IRENA, n.d.), while wind generation more than quadrupled, from 1 171.4 GWh to 5 269.4 GWh (IRENA, n.d.).

As shown in Figure 4, Egypt's total installed capacity in renewables has also been increasing, with 6 322 MW the total for 2022 (IRENA, n.d.). Of that, 2 832 MW was to be hydro, 1 643 MW wind power, 1 704 MW solar photovoltaic (PV), 20 MW concentrated solar power (CSP) and 123 MW bioenergy (IRENA, n.d.).

Regarding clean cooking and electricity access, it is worth noting that in 2020, 100% of the population had access to electricity, clean cooking fuels and technologies (World Bank, n.d.).

2.2 EGYPT'S ENERGY TRANSITION: CHALLENGES AND INITIATIVES

In 2016, Egypt began a major economic reform and stabilisation programme. This aimed at addressing social and economic issues, including social injustice, rising unemployment and poverty, inflation and the limited flexibility available to the government in its spending choices (Abou-Ali *et al.*, 2023).

Since then, the country's macroeconomic indicators have improved moderately, demonstrating resilience during the COVID-19 pandemic. The reforms and strong policy decisions have increased consumer spending in Egypt. They have also enhanced the country's economic performance and welfare by strengthening the social safety net for low-income households. The country has also achieved a continuous decline in the unemployment rate.

Despite these achievements, however, there are still some challenges that require immediate attention. These fall into three categories: economic, energy sector-specific and environmental challenges. Indeed, as one of the countries most exposed to climate change, Egypt faces significant risks to its economic, social, and environmental sustainability.

Challenges

Egypt's economy and its major settlements rely heavily on natural resources and particularly on the River Nile. This is used for various purposes, including potable water, agriculture, industry, fish farming, power generation, inland river navigation, mining, oil and gas exploration, machinery cooling, and electricity generation. This reliance on the river makes Egypt particularly vulnerable to climate change, which includes rising temperatures and decreased precipitation in the higher Nile Basins and the eastern Mediterranean coastal zone. Over the past 30 years, temperatures in Egypt have increased by an average of 0.53°C per decade (UNICEF, 2022). This is having a significant impact on human settlement and the economy.

Egypt's water security is also highly vulnerable to any developments in upstream countries, including the potential impact of climate change on these neighbours. With an estimated 97% of Egypt's freshwater resources coming from the River Nile (El-Rawy *et al.*, 2021), limitations placed on the resources available by the construction and potential improper filling of various projects upstream in the Nile River basin make Egypt's water security a major concern.

At the same time, the average annual availability of freshwater per capita in Egypt has been steadily decreasing. In 1959, this availability was around 1 893 cubic metres (m^3), yet by 2000, the figure was 900 m^3 and by 2012, 700 m^3 (Aziz, 2020). Currently, the average ranges between 550 and 560 m^3. This level is nearly half the international threshold for water poverty,[8] indicating that Egypt is already in a phase of water scarcity (Al-Kady, 2022). In 2023, the level is expected to drop further still, to 534 m^3 (Aziz, 2020), bringing the country dangerously close to the absolute water scarcity limit. In response to this, Egypt has created a strategic plan to establish seawater desalination plants to meet the country's drinking water needs.

Today, 20% of Egyptians live in coastal areas, which are also visited by 11 million tourists every year. Over 40% of industrial activity takes place in these coastal zones (CBD, n.d.), with rising sea levels posing a significant threat. If, for example, sea levels rise by half a metre, 30% of Alexandria, the second-largest city in Egypt, will be inundated. This will lead to the relocation of nearly 1.5 million people, 195 000 job losses, and land and property losses estimated at USD 30 trillion (Qantara, 2022).

Air pollution and waste management are also major environmental challenges in Egypt. Air pollution has a significant negative impact on public health, while waste production is increasing due to population growth, changes in consumption patterns, changes in waste characteristics, and inadequate technology for waste disposal.

These environmental issues will have a significant impact on Egypt's economy, particularly on its agricultural sector. In 2021, this sector accounted for 15% of GDP, provided jobs for 25% of the work force and provided food, textiles and other products (MOIC, 2021). Due to the expected increase in temperature and possible declines in rainfall, demand for water for agricultural purposes will likely increase, exacerbating the water scarcity problem.

Egypt's population growth rate and poverty rate, with 32.5% of the population living under the national poverty line in 2018 (World Bank, n.d.), places significant fiscal and infrastructure burdens on the country's social services. Fiscal space remains limited due to the large interest burden and low revenue mobilisation. With successive fuel price and tariff increases, government spending on energy subsidies remains high, leading to continued limited fiscal space for social spending. According to the World Bank, allocations to the health and education sectors remain limited, representing around 1.5% and 2.4% of GDP in the 2021-2022 financial year. Although Egypt strengthened social protection, expanded existing programs, and introduced key poverty mitigation measures during the early stages of the COVID-19 pandemic, increasing inflationary pressures call for further intensification of efforts to reduce poverty and improve welfare.

[8] *According to the United Nations, when annual water supplies drop below 1 000 m^3 per person, the population faces water scarcity, while if the level falls below 500 m^3, they face "absolute scarcity".*

In addition, limited productivity and job creation hinder the integration of new workers into the job market, leading to excessive unemployment and the marginalisation of women and youth (Assaad, 2022). Improving the efficiency of public spending, optimising revenue mobilisation to advance human capital, and pursuing structural reforms to unleash the potential of the private sector in diversified activities are necessary to create jobs and improve living standards.

Regarding the energy sector, there are several challenges delaying its development. Natural gas and crude oil production and use continue to be the largest major energy supply and greenhouse gas (GHG) emission sources in the energy industry value chain. Egypt's Integrated Sustainable Energy Strategy ISES 2035 sets lofty goals for the use of renewable energy and the implementation of energy efficiency measures, but in 2020, natural gas and oil together still accounted for around 87.7% of the country's total energy supply (UNSD, n.d.).

In 2022, Egypt will have a surplus of 25.5 GW of available power generation capacity, with the vast majority coming from thermal plants. As a result of this surplus and the relatively short remaining lifetime of gas-based power generation capacity, there seems to be little room and no immediate demand for the integration of renewables into the generation mix. This is especially significant because in 2021, the new thermal, combined cycle power plants (18.4 GW) that were commissioned in 2018 accounted for 25% of the actual generation.

In addition, despite the surplus, the country still undergoes power cuts. The major challenge is to upgrade the infrastructure, with the country already actively working on investment in transmission, distribution and other modern infrastructure crucial to the country.

Initiatives

Holding the presidency of COP27 – the 2022 United Nations climate change conference – Egypt had the opportunity to play a leading role in global climate policy and action.

Addressing the intersection of climate and development requires significant commitments, institutions, regulations and co-ordination. The country has already taken important steps in this regard, with its climate policy evolving from simply adhering to international commitments to developing a long-term strategy to become a regional leader in addressing climate change.

Egypt made a significant commitment to reducing emissions with the submission of its first updated Nationally Determined Contribution (NDC) in June 2022. The NDC includes quantitative targets for emissions reduction. These include mitigating 33% of electricity sector emissions, 65% of the emissions from the associated gases subsector of the oil and gas industry, and 7% from transportation, all by 2030.

The updated NDC also outlines the USD 50 billion needed for adaptation through to 2030 – an amount averaging around 1.6% of annual GDP, depending on the economic growth trajectory from the current GDP of around USD 400 billion. The estimated cost of implementing these targets is USD 196 billion for mitigation, or between 4% and 6% of GDP per year – again, depending on the growth trajectory of the economy (Abou-Ali *et al.*, 2023).

Egypt has restructured its institutional framework for climate action with a national climate change committee headed by the prime minister. In 2020, the government mandated all ministries to increase investments in green projects and apply sustainability standards in their national sustainable development planning. Policies have been formulated and implemented by many ministries, however, leading to fragmentation and co-ordination difficulties. The National Council for Climate Change (NCCC) therefore adopted the National Climate Change Strategy (NCCS) 2050 in May 2022, with all concerned ministries required to develop action plans in co-ordination with the NCCC to address the fragmentation issue. These cross-sector initiatives will bring a positive impact as long as co-ordination and clarity of roles are provided to reduce inconsistency in climate change policy formulation and implementation.

Egypt has already implemented successful reforms in the electricity sector, including the phased removal of energy subsidies, improved power plant and demand-side energy efficiency, and an increase in renewable energy. These efforts have laid the groundwork for achieving the emission reduction targets outlined in the updated NDC. The NDC also emphasises, however, the need for key adaptation actions and the importance of strengthening monitoring, reporting, and verification (MRV) systems.

In addition to the introduction of VAT and the optimisation of the public sector wage bill, a key measure has been a reduction in energy subsidies. In 2013, spending on these accounted for 22% of public expenditure, with fossil fuel subsidies amounting to 7% of Egypt's GDP. This was a figure greater than the combined public expenditure on health and education, which totalled 5% (ESMAP, 2017).

Energy subsidies have since been substantially reduced, falling to 1.3% in the fiscal year 2020-2021 (IMF, 2021). Studies, however, show that measures such as energy subsidy reduction, which aim to improve economic health and growth, can have adverse impacts on the poor (Breisinger *et al.*, 2019; Mostafa, 2020). Yet, the poverty rate used by the World Bank as a benchmark for lower-middle income countries[9] was estimated at 22% in 2018, up from 13% in the mid-2010s.

Egypt is among a select group of countries that have initiated sweeping economic and energy subsidy reforms of this magnitude and for a sustained period (IMF, 2013). Those measures have enabled the government to strengthen social safety nets for the poor, using fiscal savings to improve welfare in the country. Egypt's relatively better performance in terms of consumption, schooling and basic public services explains its low poverty rates compared to the Middle East and North Africa (MENA) region average.

Egypt Vision 2030, launched in February 2016, reflects the country's long-term strategic plan to achieve sustainable development principles and objectives in all areas.

The Vision identified a series of targeted development indicators to be achieved by 2020 and 2030. These included several significant targets for renewable energy deployment (MoPMaAR, 2016). The plan originally envisaged that the energy sector's share of GDP should reach 20% in 2020 and 25% in 2030. Renewables' share was targeted at 8% in 2020 and 12% in 2030, along with 21% and 32.5% shares in power generation in 2020 and 2030, respectively (IRENA, 2018b).

At the beginning of 2018, Egypt then launched its *Integrated Sustainable Energy Strategy (ISES) 2035*, which now sets Egypt's target at 42% of renewable in power generation by 2035 (Informa Markets, 2022). Studies are still in progress to raise this share based on a reduction in technology costs and the development of storage. To achieve this target, Egypt has been planning and already implementing several policies aimed at increasing renewable energy investments (Table 2).

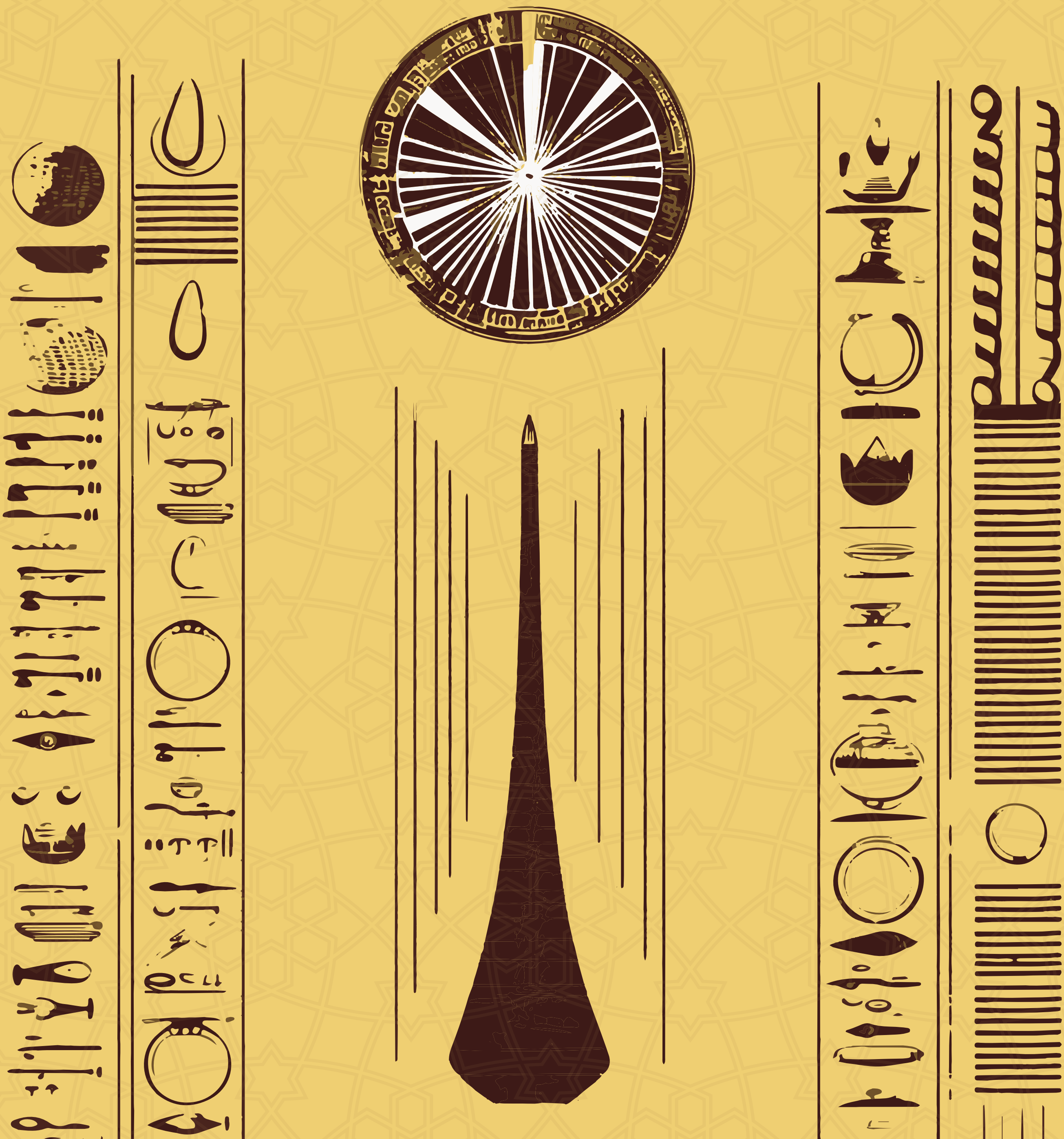
[9] *This is the poverty headcount ratio of USD 3.65 a day, and is the percentage of the population living on less than USD 3.65 a day at 2017 purchasing power adjusted prices. The commonly used USD 1.00-a-day standard (at 1985 PPP) was chosen for the World Development Report 1990 because it was typical of the poverty lines in low-income countries at the time (World Bank, 1990). As differences in the cost of living across the world evolve, the international poverty line has been updated to reflect these changes. The last change was in September 2022, when the World Bank adopted USD 2.15 (2017 PPP) as the current extreme poverty line, which represents the mean of the poverty lines found in 15 of the poorest countries ranked by per capita consumption. The USD 3.65 poverty line is derived from typical national poverty lines in countries classified as lower middle income, as in the case of Egypt. The USD 6.85 poverty line is derived from typical national poverty lines in countries classified as upper middle income (World Bank, 2023).*

Table 2: List of policies to enable the development of renewables in Egypt

Policies to achieve the energy transition		List of initiatives	
Direct policies	Push	National Renewable Energy Strategy 2020 adopted in 2008 and updated in 2012. Egyptian solar plan. Sustainable energy action plan for the power sector (2018). Building energy efficiency codes (BEECs) were introduced in Egypt between 2005 and 2009. They impose mandatory energy performance requirements for residential, commercial, and public buildings in three different code documents.	
	Pull	Cabinet Decree No. 1974/2014 in September 2014 announcing the first round of feed-in-tariffs (FiTs). Cabinet Decree No. 2532/2016 in September 2015 announcing the second round of FiTs. Periodical Decree No. 3/2017 in August 2017 adopting the net metering scheme for solar PV. Cabinet Decree for electricity prices for biomass under FiTs. Periodical Decree No.2/2020 restructuring the net metering scheme.	
	Fiscal and financial	Investment law N.72/2017 sets out the legal framework for the establishment of renewable energy projects and provides incentives for investments in this sector. Exemption from custom duties for electrical and electronic equipment. Exemption from stamp tax and registration fees on all incorporation contracts for EVs.	
Integrating policies		The establishment of an energy efficiency unit in the Ministry of Electricity and Renewable Energy. Egypt Vision 2030 includes target on renewable energy.	
Enabling policies		Electricity tariff reform programme launched in 2014.	Egypt INDC published in 2015.
		Renewable Energy law 2014. Electricity law No. 1974/2014, published July 2015. Egypt vision 2030 and renewable energy targets launched in 2016. Updated plan launched in 2018.	
		Presidential decree No.116/2016 in October 2016 allocating 7 600 km^2 for renewable energy.	
Enabling and integrating policies		Law No. 102/1986 establishing the New and Renewable Energy Authority (NREA) in 1986.	

Note: More details are provided in Annex 2.

03 Socio-economic impact of the energy transition



This section presents the key findings of IRENA's socio-economic analysis of Egypt's energy transition, outlining its potential impact on aggregated economic activity (GDP), employment and welfare. These findings delineate the difference between the 1.5°C Scenario and the PES.

3.1 ECONOMIC IMPACT, AS MEASURED BY GDP

Between 2002 and 2022, Egypt's GDP grew at a CAGR of 4.4%. This was slower than the 5.0% average rate for lower-middle-income economies over this period (World Bank, n.d.). During these two decades, Egypt's highest GDP growth rates were in the 2006-2008 period, when the economy grew at an annual pace of around 7.1% – significantly higher than the 5.5% average of its lower-middle-income counterparts at that time (World Bank, n.d.). Corporate tax cuts, simplification of the tax regime, decreased tariffs and a more conducive business environment were all identified as possible sources of that boom (World Bank, 2021a).

GDP growth slowed in the early 2010s, however, with the economy expanding at around 2.0% a year, on average, between 2010 and 2012. Growth then accelerated in 2019, to 5.6%, but in 2020, fell to 3.6% as a result of the COVID-19 pandemic.

Nonetheless, compared to 2020 GDP growth rates of 3.5% in the MENA region and 3.2% in lower-middle income economies, Egypt's 2020 performance was still remarkable (World Bank, n.d.). Indeed, throughout the first two years of the COVID-19 pandemic, Egypt was one of the only economies in the world to experience positive GDP growth, with 2021 seeing GDP expand 3.3%.

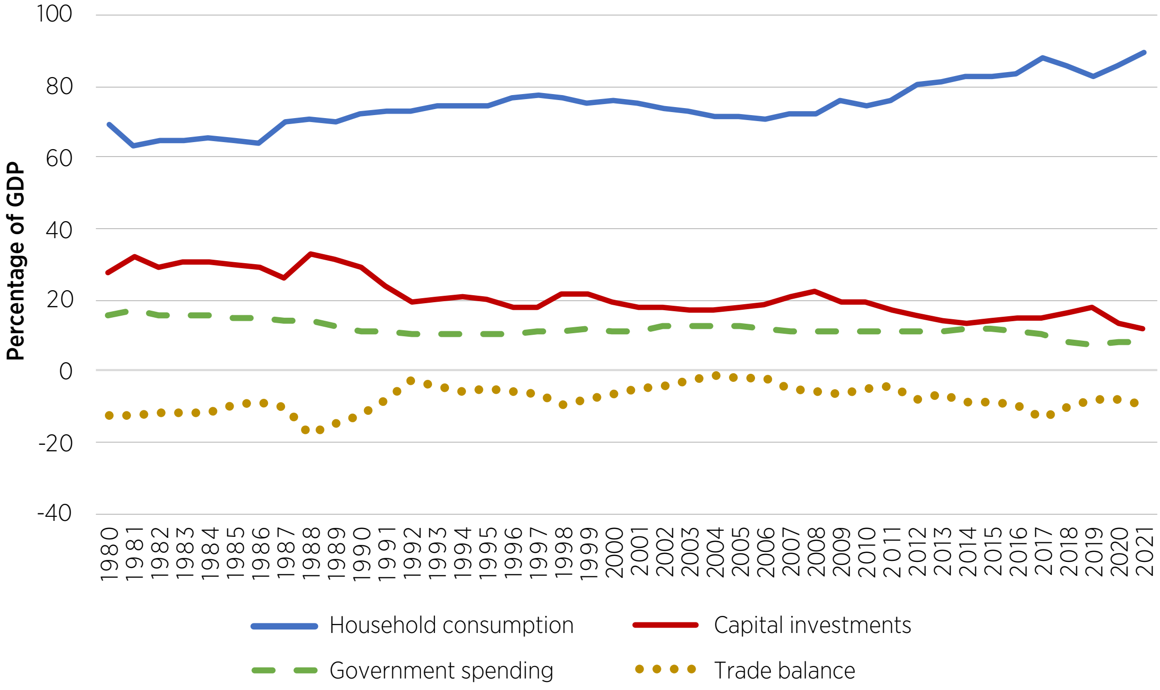
This continued growth was thanks in large part to strong consumer spending. Household consumption in Egypt, at 89% of GDP in 2021 (Figure 5), is much higher than the MENA average of 50%, reflecting a long-standing trend (World Bank, n.d.). In 2020 and 2021, real household expenditure increased by 7.3% and 7.1%, respectively, despite the widespread impact of the pandemic on important sectors such as tourism.

Lower inflation rates were also a major contributor to the Egyptian economy's positive evolution, with several other factors also crucial. These included salary increases in the public sector, a boost in remittances, and government responses to the pandemic (KPMG, 2020; OBG, 2022a). In July 2020, the government launched a series of initiatives to increase consumer spending, including a USD 6.4 billion stimulus package to support healthcare, tourism, construction, aviation and the export sector, foreign direct and indirect investment, remittances, and ordinary citizens. The country's central bank also declared a 3% cut in interest rates, while manufacturers agreed to lower their prices by up to 20% for ration card users. Some products were also discounted by as much as 30% (OBG, 2022a).

Although the share of government spending in Egypt's GDP has been decreasing in recent years – in the 2011-2021 period, for example, it fell from 11.5% to 7.9% (Figure 5) – its absolute level has increased. Over the same 2011-2021 period, for example, it rose from USD 31.7 billion to USD 47.7 billion.[10] This was in line with different government initiatives to support consumer spending and untap potential innovation, while reducing energy subsidies.

[10] *In 2015 US dollars.*

Figure 5: Household consumption, capital investments, government spending and balance of trade in Egypt, 1980-2021



Source: (World Bank, n.d.).

Note: Household consumption = household consumption expenditure (including non-profit institutions serving households); government spending = general government final consumption expenditure; capital investments = gross fixed capital formation; trade balance = exports of goods and services minus imports of goods and services. See (World Bank, n.d.) for more information.

Egypt's level of capital investment[11] is much lower than the 27% average seen in lower-middle income countries and the 22% average for the MENA region. This is because of Egyptian manufacturing's focus on low-to-medium technology industries.[12] Between 2019 and 2021, Egypt's capital investments decreased from 18% to 12% of GDP (Figure 5), which represents a reduction from USD 76.2 billion to USD 55.7 billion[13] (World Bank, n.d.). As the country accelerates industrialisation and changes to high-value-added, high-technology industry, increasing manufacturing investment is therefore a priority.

Egypt has made significant progress on industrial development through reforms[14] aimed at attracting foreign direct investment (FDI) and enhancing productivity. In the future, tailored policies would enhance this attention on high-technology industries and higher-value-added manufacturing. This would help create capacity in local, higher value-added activities and add value to export-competitive sectors such as textiles, clothing, fuels, minerals and basic metals (OBG, 2022b).

On average, under the 1.5°C Scenario, the country's GDP is 5.5% higher than under the PES over the 2021-2050 period. In the year 2050, GDP is 4.6% higher under the 1.5°C Scenario than under the PES.

[11] *Capital investments = gross capital formation. This measures investment in fixed assets (plant and machinery, transport equipment, software and major improvements to existing buildings and structures) plus net changes in the level of inventories (World Bank, n.d.). The result is a proxy for modernisation of the industrial structure (OECD et al., 2021).*

[12] *The Organisation for Economic Co-operation and Development (OECD) classifies manufacturing industries into four categories based on research and development (R&D) intensities (the ratio of R&D spending to firm's revenue). The four categories are: low, medium-low, medium-high and high-technology industries (OECD, 2011).*

[13] *In 2015 US dollars.*

[14] *Egypt's Industry and Trade Development Strategy 2016-2020 and its Inclusive and Sustainable Industrial Strategy 2020-2024 promote trade and value chain integration. The 2017 Investment Law and National Single Window provide international investors with preferential treatment and ease customs processes online. The Digital Egypt ICT 2030 initiative also aims to capitalise on Industry 4.0.*

In cumulative terms, over the same period, the country would be adding around USD 1.2 trillion[15] to the GDP already anticipated under the PES.

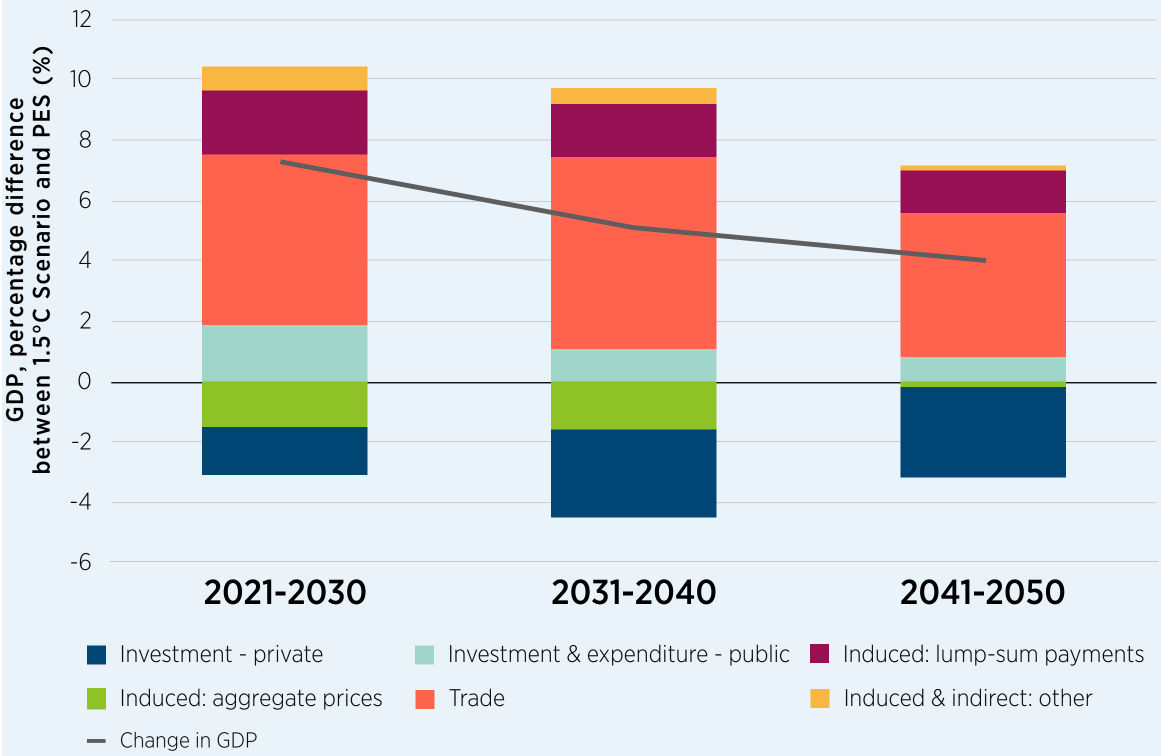
Over the entire 2021-2050 transition, the trade driver plays the most important role in creating the difference in GDP. This is followed by the investment driver during the first half of the transition's first decade (2021-2025) and from 2030 onwards. In the 2025-2030 period, the indirect and induced effects driver takes the second most important role. The different components of the drivers are presented in Box 3.

In 2017, Egypt began revising its governance and regulatory structure in the field of trade promotion. With the complete implementation of the African Continental Free Trade Area (AfCFTA), Egypt will add 32 new free trade area partners (OECD *et al.*, 2021), with the AfCFTA ultimately creating a market of more than 1.2 billion people. Egyptian exports will be able to expand, strengthening relations with Europe, the Middle East and the rest of the world. Continuous efforts will be required to facilitate trade and enhance the infrastructure of continental integration if the country is to fully reap the benefits of the National Structural Reform Programme (NSRP) (2021-24) and Egypt's Vision 2030.

BOX 3: DRIVERS OF GDP GROWTH

To gain a better understanding of the structural elements underlying the socio-economic footprint, IRENA's macroeconomic analysis disaggregates outcomes according to drivers and sectors. The main macroeconomic drivers that have key impacts on GDP difference in Egypt are trade, investment, and indirect and induced effects (Figure 6).

Figure 6: Egyptian GDP: Difference between the 1.5°C Scenario and the PES, 2021-2050 (%)



Trade is the main factor driving a positive GDP difference throughout the transition period, with its impact stronger in the first decade. This positive impact is driven by the change in net trade in fuels, attributable to

[15] *In 2019 US dollars.*

Egypt's energy transition, energy intensity and dependence on energy imports. Although Egypt is currently a net oil importer and despite it being a major gas exporter, it is at risk of becoming a net gas importer since its natural resources will likely not be able to keep up with domestic energy demand.

Under the 1.5°C Scenario, as Egypt moves away from fossil fuels and towards renewables, the reduction in the energy import bill is expected to bring increasingly significant positive benefits, amounting to USD 63 billion[16] in 2050 alone. In cumulative terms, lower fuel imports are expected to improve the balance of trade by around USD 1.3 trillion over the 2021-2050 period. This represents around 5.2% of the cumulative GDP under the 1.5°C Scenario over the same period.

On average, the **investment** driver is the second strongest influencing factor over the whole transition period. It has two components: 1) private investment, 2) public investment and expenditure. Although the investment driver's impact is positive during 2021-2030, it becomes negative from 2030, due to the opposite impact of these two components on the difference in GDP between the scenarios.

The public investment and expenditure driver positively impacts the GDP difference over the whole transition period. It also leads the net positive impact of the whole investment driver between 2021 and 2030. Its impact increases in the first half of the first decade of the transition period (2021-2025), before decreasing slightly and then stabilising from 2030 onwards. This is primarily due to the front-loaded investment needs of the energy transition, where most of the public investment occurs in the early years. In addition, Egypt benefits from global climate collaboration largely through the international equity pillar, due to the local population's vulnerability to the potential loss of fossil fuel mining activities. Under the 1.5°C Scenario, this results in an increase in government social spending of more than USD 4.3 billion by 2050 (at 2019 prices) – more than under the PES. This increase includes spending on non-defence services predominantly provided by the government. These include public administration, healthcare and education, which therefore mainly benefit public and personal services.

The impact of private investment is negative throughout the transition period, being the dominant negative driver over the transition. This negative influence also outweighs the positive impact from the public investment and expenditure component from 2027 onwards. Oil & gas extraction is a major economic activity in the country, estimated to contribute a quarter of GDP in 2019-2020. This activity also attracts significant domestic and foreign investment, while playing a critical role in Egypt's ambition to be self-sufficient in energy.[17]As part of the transition, investment in oil and gas is expected to fall drastically and be replaced by transition-related investments. This reduction in oil and gas investment under the 1.5°C Scenario, which would yield a negative impact on the GDP difference, would outweigh the increasing positive effect from private sector investment in transition-related technologies, such as energy efficiency and other end-uses, grids and energy flexibility, and renewables.

Figure 6 illustrates the contribution of **induced and indirect effects** (aggregate pricing, lump-sum payments and others) on driving the difference in GDP. This driver also plays a strong role in improving GDP under the 1.5°C Scenario when compared to the PES. On the one hand, the sub-category 'induced: aggregated prices' and on the other, the sub-categories 'induced and indirect: other' and 'induced: lump-sum payments', have a significant impact on the difference in GDP over the whole transition period when considered separately, with the latter's positive influence outweighing the former's negative role.

'Induced: lump-sum payments' play a key, positive role in creating GDP difference. This is due to changes in fiscal balances influenced by carbon tax receipts, international climate co-operation receipts and policy-driven social investments.

[16] *In 2019 US dollar.*

[17] *See, for example: www.trade.gov/country-commercial-guides/egypt-oil-and-gas-equipment*

Lump-sum payments are introduced in the 1.5°C Scenario to address domestic distributional issues. Egypt is one of the countries that contributes the least to global energy transition funds, while benefitting significantly from these funds' support. Under the 1.5°C Scenario, anything remaining from this international climate investment flow – after social spending and transition-related investments – is allocated towards lump-sum payments to households. By 2050, this sub-category is over USD 19.1 billion[18] higher under the 1.5°C Scenario than it is under the PES. This difference is a figure equivalent to 1.3% of GDP.

This support is also modelled with a focus on lower-income groups, which induces economic activity by increasing household consumption. The effect of this driver on GDP difference peaks in the years up to 2030, decreases slightly in the second decade of the transition (2031-2040) and then stabilises, as carbon tax receipts fall in line with emissions and there is a slowdown in GDP growth.

The 'induced and indirect: other' sub-category, representing changes in consumer expenditure other than those included in lump-sum payments and price effects, plays a positive role in the additional GDP gain over the transition period. This sub-category is of larger magnitude up until 2030, when it starts diminishing and becoming modest, mainly driven by consumer expenditure. Between 2021 and 2030, investment stimulus and international climate collaboration flows that provide financial support to low-income households will boost household spending. The ripple effects decrease, however, and stabilise by the end of the transition period, in line with the evolution of the 'induced: lump-sum payments' driver. In addition, there is a marginal but slightly negative impact from changes in income tax rates on the GDP difference over the entire 2021-2050 period. Differences in revenue and spending between the 1.5°C Scenario and the PES throughout the transition period require increases in income taxes under the 1.5°C Scenario. Low carbon tax revenues cause income tax to rise to fund transition-related investments and oil and gas sector value loss before 2025. In the initial decades, public transition investment and subsidies expands. Carbon pricing and international climate collaboration raise more revenue under the 1.5°C Scenario than under the PES. Hence, income tax reduces as carbon tax rises and the impact of this driver in GDP difference becomes less negative.

The 'induced: aggregate prices' sub-category has a negative impact on overall Egyptian GDP difference. It has a stronger influence during the first decade of the transition period (2021-2030) before decreasing in strength until becoming positive in the final years up to 2050. This is a result of the domestic response to changes in carbon pricing, technology costs, power sector capacity, fossil fuel subsidies and investment expenditure. Under the 1.5°C scenario, the negative impact on GDP difference of aggregate prices is exacerbated by a higher carbon tax and the deployment of high-cost renewable technologies – mainly in the years up to 2035 but also throughout the transition period. This feature is driven by rapid increases in the price of energy use and a limited fall in global fossil fuel prices.

The share of hydro capacity is higher under the 1.5°C scenario than in the PES in Egypt. Hydro has high levelised costs of generation. Substitution away from natural gas to this technology increases costs in the years up to 2035. Nevertheless, the effect of these energy price increases lessens noticeably from 2035, due to substitution away from fossil energy as part of the energy transition – there are thus less emissions to be taxed – along with reductions in demand and lower long-term capital investment requirements. The rapid deployment of renewables (mainly solar PV) between 2030 and 2050 – although also taking place throughout the transition period in the country – as well as the substantial decrease in the price of solar PV featured under the 1.5°C Scenario, lowers electricity costs from 2030 onwards.

[18] *In 2019 US dollars.*

3.2 EMPLOYMENT

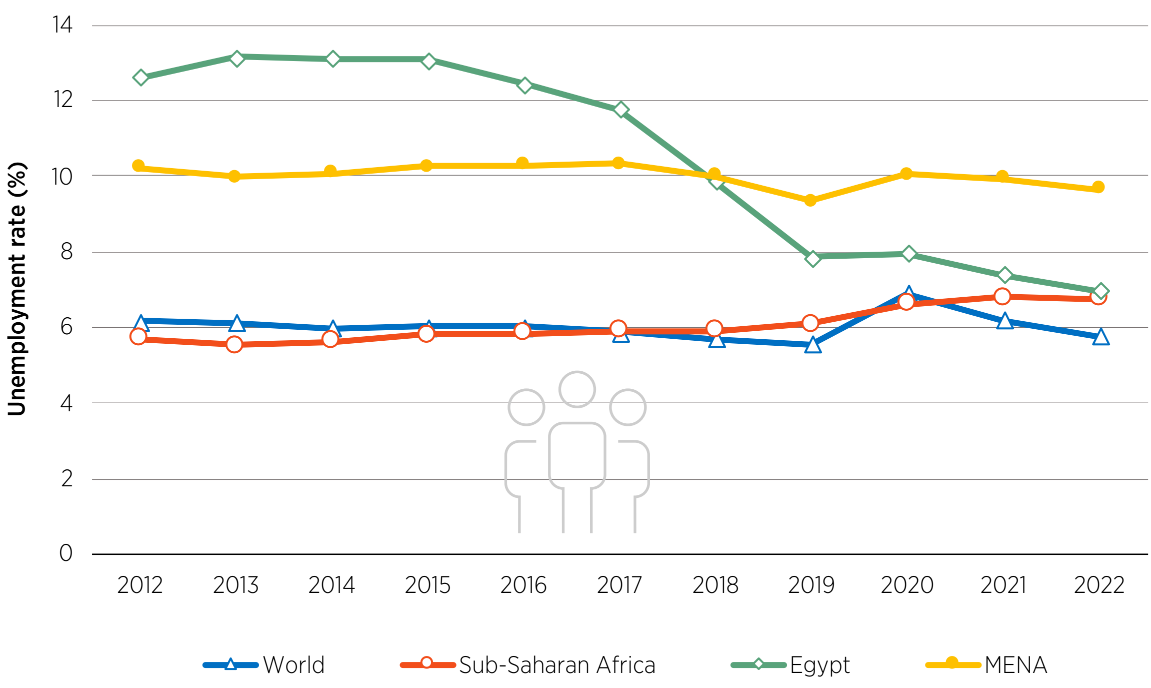
Economy-wide employment

In Egypt, employment has been shifting away from the agricultural sector. In the year 2000, for example, the sector accounted for 30% of total employment, yet by 2021, this figure had fallen to 19.2%. Meanwhile, employment in the industrial sector increased from 21% in 2000 to 28% in 2020.

A large informal employment component, however, is not being captured by these figures. Indeed, the proportion of informal employment in non-agricultural sectors was estimated at around 61%, with the informal sector's contribution to the country's GDP estimated to vary between 37% and 68%, depending on whether the currency demand method or the electricity consumption method is applied (AfDB, 2016).

Unemployment has been gradually decreasing in Egypt since peaking at 13.2% in 2013 (Figure 7). Even during the height of the COVID-19 pandemic, the labour market showed resilience, with a gradual decrease in the unemployment rate continuing from 9.9% in 2018 to 7.0% in 2022 (World Bank, n.d.). This was despite the fact that Egypt's population has been growing much faster than a typical middle-income country – a trend that will likely continue into the foreseeable future. In 2022, the country's unemployment rate was well below that of the MENA region average of 9.6%, but was still higher than the world average of 5.8% and the Sub-Saharan Africa average of 6.7%.

Figure 7: Unemployment rate, 2012-2022 (% of labour force, 15 years old and over)



Source: (World Bank, n.d.).

Egypt's strategic vision for sustainable development aims to bring the unemployment rate down to 5% by the year 2030. Nevertheless, the labour market remains weak, and discrepancies have been observed between genders and working age groups. As is the case in the majority of countries, unemployment among women – at 17.7% in 2020 – is greater than male unemployment, which stood at 6% the same year. A similar gender imbalance could also be seen within the most educated segment of the population in 2020, as the percentage of unemployed male university degree and higher degree holders was 32.4% that year, as against 61% for females.

The country has therefore introduced several policies and empowerment measures to improve the working conditions and general welfare of women (UNDP and MoPED, 2021). Box 4 discusses the status of women in the energy sector in Egypt.

BOX 4: WOMEN IN THE ENERGY SECTOR

Accounting for only 17% of the country's official workforce, women are still under-represented in the Egyptian labour force. Women work mainly in the public administration, education, health and agricultural sectors (DTU DA, 2020). Indeed, around 46% of the workers in the public administration, education and health sectors (which collectively represent 17% of the country's total workforce) are women, followed by women's employment of 31% in the agriculture sector (which represents 23% of the country's total workforce). Agriculture also often offers informal and highly volatile employment.

On the other hand, the official unemployment rate for women was 17.7% in 2020. At 46.1%, unemployment among young Egyptian women was also higher than the MEAN average of 44.8% (World Bank, n.d.). This unemployment rate did, however, decrease to 38.8% in 2021, becoming lower than the MENA region average for that year of 42.1%.

Women participating in the labour market also suffer from under-employment relative to their skills, and are predominantly employees, rather than entrepreneurs. The share of women in senior and middle management positions in 2019 constituted only 7.0% (World Bank, n.d.).

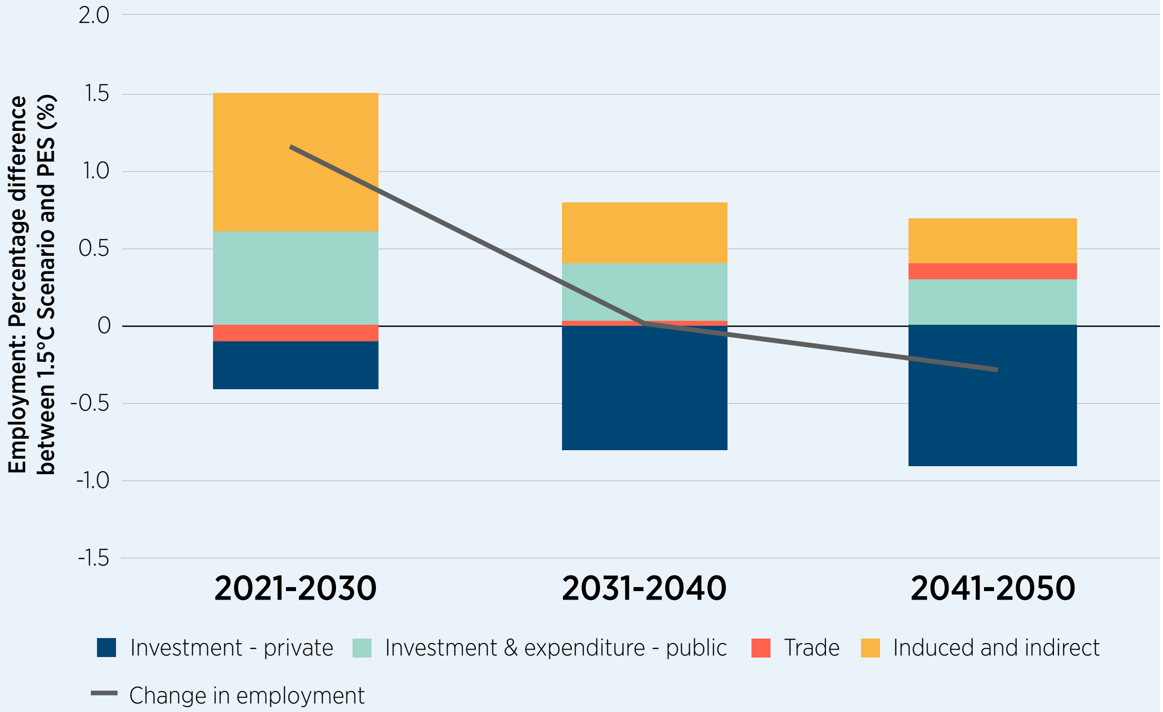
The situation in the renewable energy sector is not that different from the general situation in the country, with 20% of the workers in the sector being women (NREA, 2021). This representation is lower than IRENA's global average estimates, in which women represent 32% of the renewable energy workforce, worldwide (IRENA, 2019b). Despite being underrepresented, however, women in the Egyptian renewable energy sector are more often in managerial positions than in other sectors, with the percentage of women managers reaching 70%, while women in low skilled positions represent only 30% (RCREEE and MEDENER, 2020).

Under the 1.5°C Scenario, economy-wide employment is an average of 0.3% higher than in the PES over the 2021-2050 period. From the first decade of the transition period, the 1.5°C Scenario creates a net gain of jobs over the PES, economy-wide. Employment peaks in the years up to 2030, reaching a 1.4% difference in 2026 – a figure equivalent to more than 432 000 additional jobs. From 2030 to 2040, there is a noticeable decrease in the employment difference between the scenarios, mainly driven by the loss in investment linked to the fossil fuel supply. This decrease is attenuated progressively by the positive impact of indirect and induced effects in the final years. The economy-wide difference creates over 27 700 additional jobs (representing around 0.1% difference) in 2050. This trend is driven by indirect and induced effects, as well as investment, although trade has a negligible impact. Box 5 depicts the various components of the drivers.

BOX 5: DRIVERS OF EMPLOYMENT GROWTH

As with GDP, employment changes are also driven by several different factors. These include trade, investment, and indirect and induced effects. This box provides a brief explanation of the impacts shown in Figure 8.

Figure 8: Employment in Egypt, 2021-2050: Difference between the 1.5°C Scenario and the PES by driver (%)



Compared to the PES, the 1.5°C Scenario creates greater economy-wide employment. This is mainly driven by the 'indirect and induced effects' sub-category, with these occurring throughout the transition period. These effects, combined with investment, impact employment across the economy in the years leading up to 2050 in particular – although they also almost cancel each other out.

There are several sub-components of the 'indirect and induced effects' driver that result in a net positive impact. In the years leading up to 2035, wage effects have the dominant positive role, before being overtaken by consumer expenditure.

Regarding the wage effect, Egypt is one of the main beneficiaries of global energy transition investment flows, while making a relatively small global financing contribution. Increasing international transfers reduce the tax burden on employment wages and effectively expand the labour supply during the initial period. As a result, there is a positive wage effect, with the difference between the scenarios peaking in the years up to 2030. This component changes direction after 2035, however, due to a more constrained fiscal balance. This implies an increase in the tax burden on wages, as there is a decrease in carbon tax receipts, while at the same time, there is a stabilisation of lump-sum payments due to a slowdown in GDP growth.

After 2035, as the wage effect becomes negative, consumer expenditure becomes the dominant positive factor in the 'indirect and induced effects' sub-category. This trend closely follows GDP results, with an increase in consumer expenditure from the lump-sum payment driver one of the dominant positive effects, while the negative influence of the aggregate price level much smaller. Towards the end of second decade (2035-2040), however, the consumer expenditure effect is almost completely offset by a strong negative effect mainly attributable to the loss of fossil fuel supply investment, which in turn leads to job losses.

Yet, public investment in transition-related technologies and sectors and greater social spending – both supported by international climate collaboration flows – also create substantially more new employment across the country in the 1.5°C Scenario than in the PES. This also occurs throughout the transition. The first driver of these additional jobs is front-loaded investment in capital-intensive renewables and other transition-related technologies. during 2021-2030. Public and personal services benefit most from this effect, which is critical in supporting workers whose livelihoods are affected by the transition. During the first decade, the overall number of jobs created by public investment and expenditure is higher than the number of job losses in the sphere of private investment – losses concentrated in the fossil fuel sector.

At the same time, private investment in renewables and other transition-related technologies – such as energy efficiency, power grids and flexibility, and in hydrogen – does lead to additional employment under the 1.5°C Scenario. Indeed, between 2021 and 2030, job creation in these areas averages around 0.12% higher under the 1.5°C Scenario than under the PES, a percentage representing over 2 million additional jobs during the 2021-2030 period. However, the impact on economy-wide employment from private transition-related investment is net negative, due to the loss in fossil fuel supply investment. After 2030, as the phase-out of fossil fuels accelerates, this negative effect becomes stronger and by 2050, around 0.7 million jobs will have been lost because of reduced investment in fossil fuel supply, and over 0.1 million jobs will have been lost because of decreased fuel extraction activities. Given that these jobs have a significant impact, policy intervention is needed to re-train workers for alternative positions and prevent severe disruption to living standards.

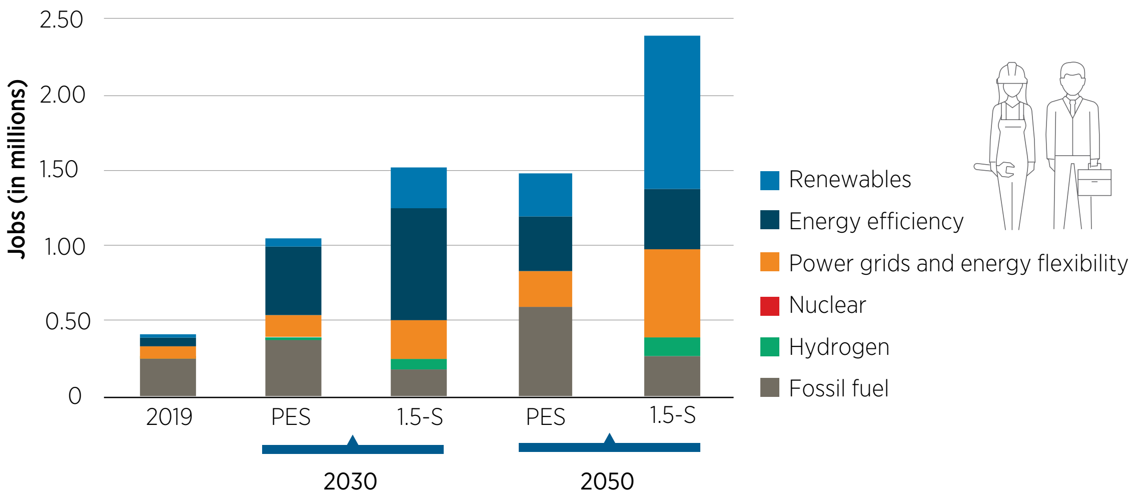
Over the period 2021-2050, on average, trade has a minor negative impact on the economy-wide employment difference between the scenarios. This is despite the fact that while prior to 2040 this driver is marginally negative, after 2040 it shifts to mildly positive. The trade sub-category's impact on employment difference is mainly driven by changes in non-energy sector trade and net trade in fuels. Greater domestic economic activity leads to an increase in demand for imported goods in agriculture, textiles, rubber and plastics, and non-metallic minerals. This increase in imports offsets an increase in manufacturing sector exports, as global demand increases. The net result is only a small differential between the two, negative or positive.

Energy sector jobs

The energy transition is net positive for job creation in Egypt's energy sector, where employment could reach over 1 million in 2030 under the PES and 1.5 million under the 1.5°C Scenario. This compares to around 0.4 million currently (Figure 9). Job losses in fossil fuels are more than offset by gains in renewables and other energy transition-related technologies, such as energy efficiency, hydrogen, and power grids and flexibility. By 2030, the total number of renewable energy jobs increases more than five-fold, from 0.05 million under the PES to around 0.3 million under the 1.5°C Scenario, while other energy transition-related sectors see an increase from 0.6 million to 1.1 million. This effect strengthens in subsequent decades and by 2050, total energy sector employment reaches around 1.5 million under the PES and over 2.4 million under the 1.5°C Scenario.

By 2050, the 1.5°C Scenario also sees renewables account for more than 42.2% of all energy sector jobs. It also accounts for around 24% of all jobs in electricity grids and flexibility (0.6 million jobs). Energy efficiency is responsible for a further 0.4 million jobs (representing 16.1% of energy sector employment). It should also be noted that energy efficiency dominates in 2030, representing around 49% of energy sector jobs, because of the frontloaded nature of investment in the sector. It is estimated that 5.2% of all energy sector jobs are in hydrogen and 1.6% are in vehicle infrastructure. In 2050, 10.9% of jobs likely remain in the fossil fuel sector – a major decrease from the current 62.7% (Figure 9).

Figure 9: Energy sector jobs under the 1.5°C Scenario and PES, by sub-sector, 2019-2050



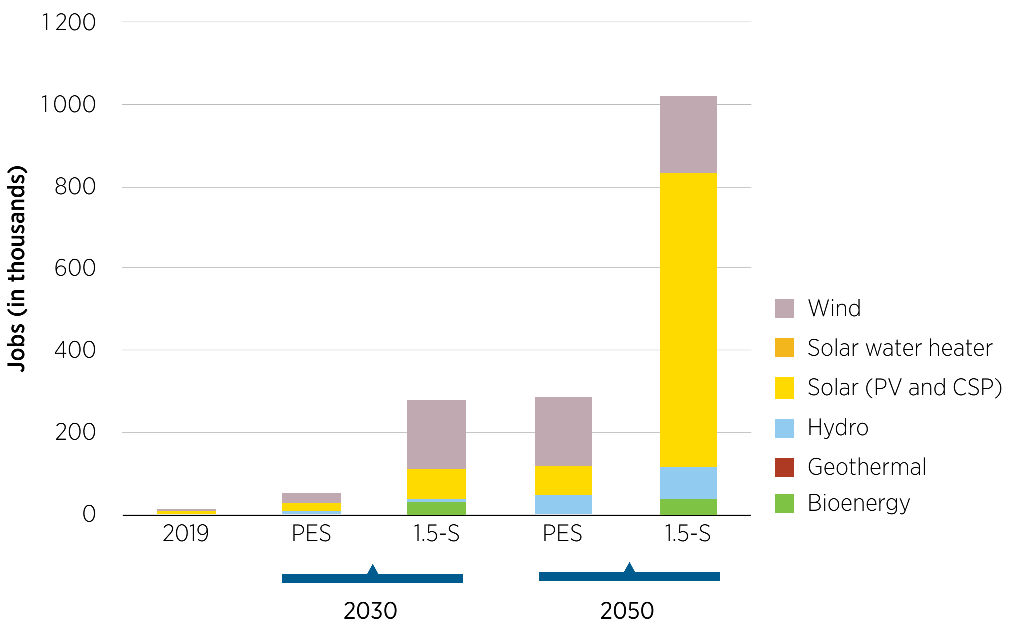
Note: 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

Renewable jobs

As already noted, the number of jobs in renewable energy in Egypt is expected to increase throughout the transition (Figure 10). Under the PES, renewable job numbers increase from the current level of around 14 200 to over 50 000 in 2030 and around 290 000 in 2050. The 1.5°C Scenario sees a more significant increase than the PES, with more than five times the number of jobs in 2030 and over 1.0 million jobs in renewable energy by 2050. Because of Egypt's fossil fuel dependency, the uptake of renewables is relatively slow, however, compared to the global average, in the early years of the 2021-2050 period, with the transition occurring more rapidly in later years.

Solar technologies (mainly PV) are expected to strongly dominate jobs in renewables during the transition overall. Under the 1.5°C Scenario, in 2030, solar technologies could account for 26% of the total number of jobs, or around 71 000, with this rising to 70% – around 720 000 – in 2050. Wind represents 58% of the jobs in 2030, but this falls to 18% in 2050, when hydro could be employing around 80 000 people and bioenergy around 40 000 (Figure 10).

Figure 10: Renewable energy jobs in the PES and 1.5°C Scenario, 2019, 2030 and 2050



Note: CSP = concentrated solar power; PV = photovoltaic; 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

3.3 WELFARE

While GDP is the standard measure of economic output, the concerns of citizens go some way beyond it. GDP does not include or value factors that are not priced into the market, such as human health, fulfilling jobs and environmental quality. In addition, while climate change will likely have negative consequences for future GDP, it will also have a significant impact on societies, economies and nature that no measure of GDP will capture.

In light of this and to incorporate some of the aspects of social well-being impacted by the energy transition, IRENA has developed and upgraded a welfare index (IRENA, 2016, 2019a, 2020, 2021, 2022a, 2022b, 2023b, 2023c). This indicator has five dimensions relating to the energy transition: economic, distributional, social, environmental and access. Each dimension is also composed of two indicators (Figure 11).

Figure 11: Structure of IRENA's energy transition welfare index

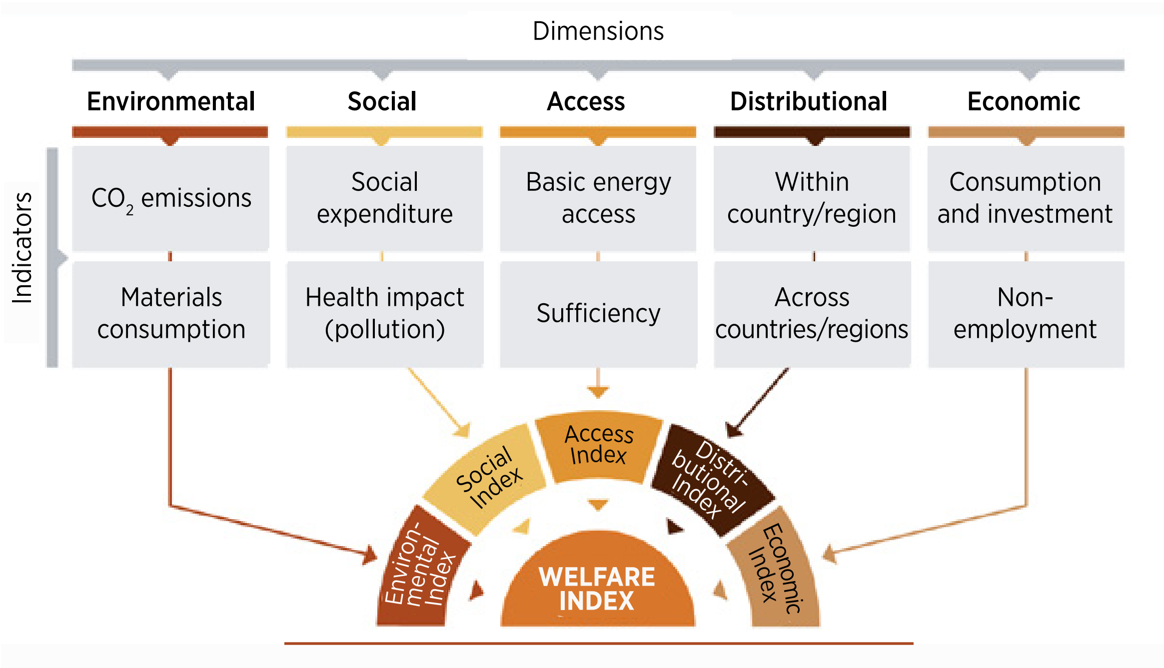
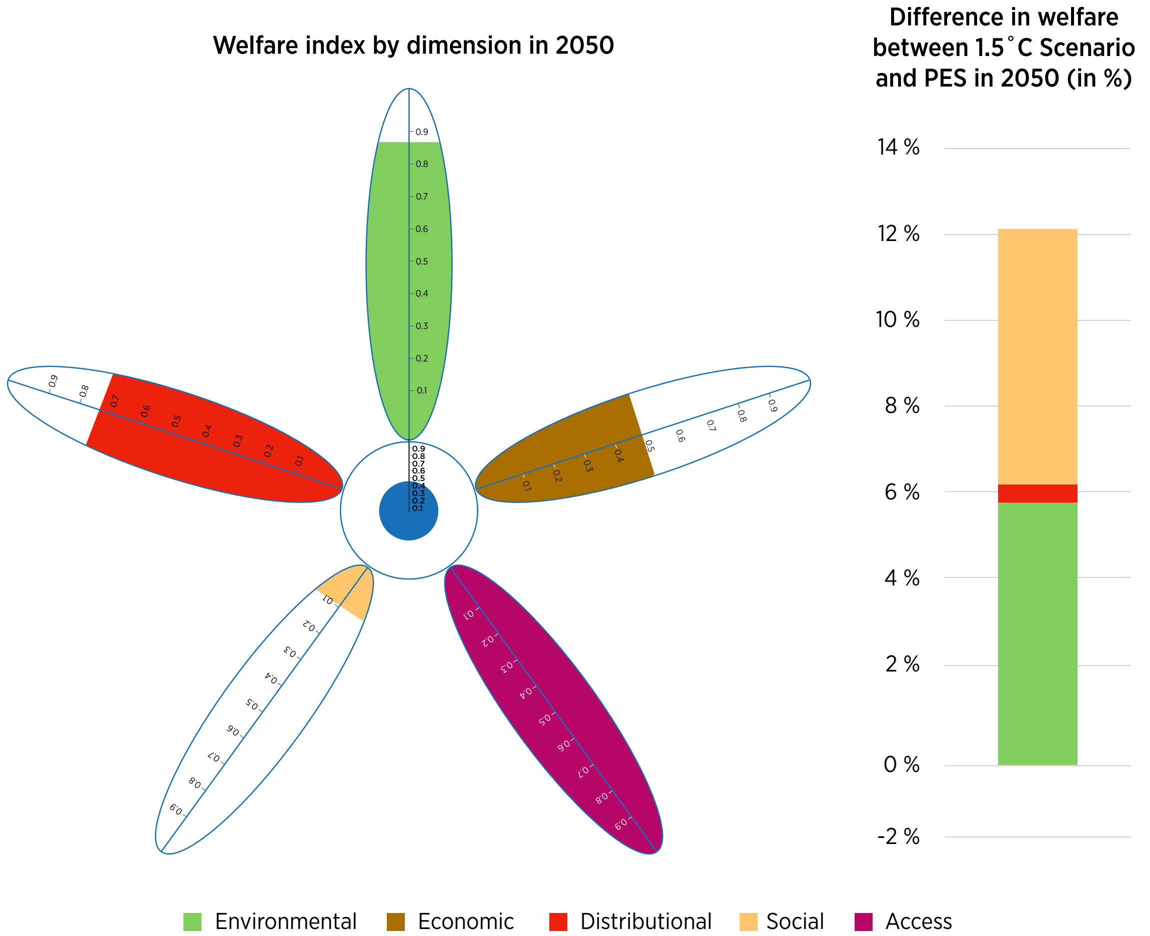


Figure 12 shows the welfare index for the 1.5°C Scenario in 2050 and then the difference between that scenario and the PES. Both representations also show the contribution made by each of the five dimensions. Under the 1.5°C Scenario, by 2050, the welfare index is 12.2% higher than under the PES (right panel in Figure 12).

The welfare index and its dimensional contributions under the 1.5°C Scenario (left panel in Figure 12) provides a clear indication of where policy action should be focused in order to improve welfare in Egypt. On a scale from 0 to 1, an overall welfare index of 0.48 is achieved by 2050 under the 1.5°C Scenario, indicating significant room for improvement in welfare. The rest of the section will delve into each of the dimensions.

Figure 12: Welfare index in the 1.5°C Scenario (left) and difference in welfare between 1.5°C Scenario and PES (right), 2050



Note: In the left panel the five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the welfare index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall welfare Index.

Social dimension

The social dimension of the welfare index consists of two indicators: social expenditure per capita and health costs per person linked to energy system-related air pollution.

Generally, the rapid growth of social expenditure throughout the world in the second half of the 20th century was propelled by an increase in the public financing of health care and education (Ortiz-Ospina and Roser, 2016). In Egypt, between the fiscal years 2010/2011 and 2019/2020 the education budget averaged around 10.7% of total government spending and approximately 3.2% of GDP.

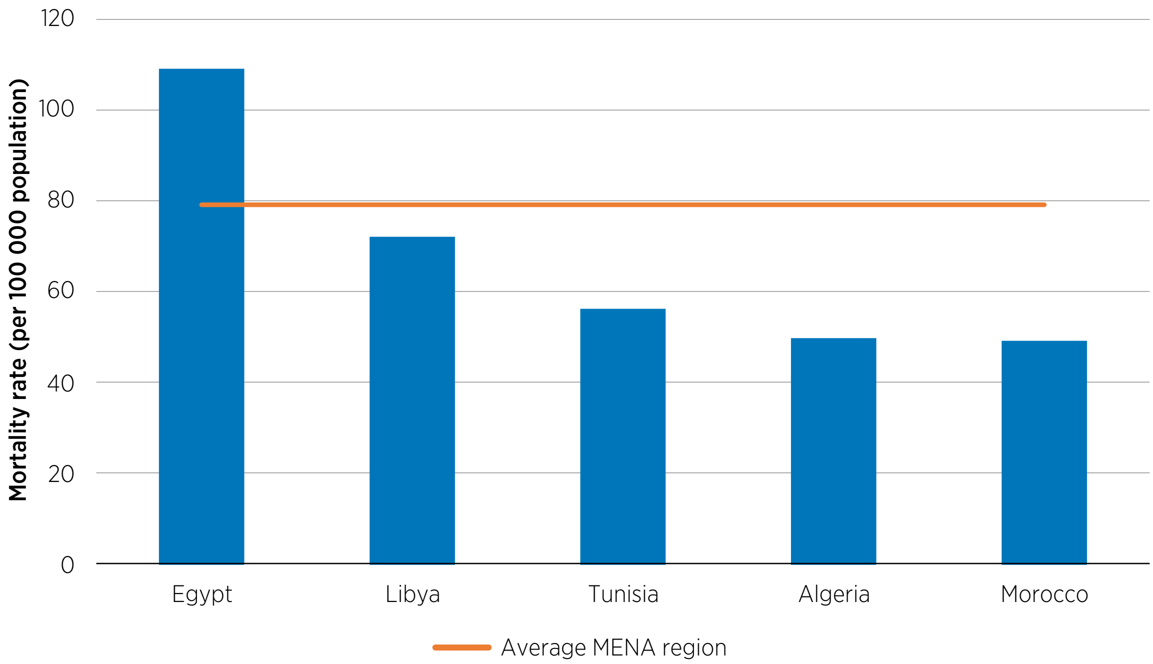
In the fiscal year 2019/2020, the approved budget for functional government spending on both pre-university and higher education was approximately EGP 132 billion (around USD 4.3 billion). Although this was a significant increase on the roughly EGP 48 billion (around USD 1.6 billion) allocated in fiscal year 2010/2011, education spending as a share of total government spending fell over this period, from 12% to 8.4%, while its share of GDP also declined, from 3.5% to 2.1% (UNDP *et al.*, 2021). It should be noted that these figures are both lower than international and MENA standards. Over the same period, the average share of education in total government spending in the MENA region was 14.3%, while education's average share of GDP was 11.3% (UNDP *et al.*, 2021).

When it comes to health, Egypt's life expectancy rose from 69.7 years to 71.0 years over the period 2010-2020. This was, however, below the international average and the averages of all the neighbouring countries in the MENA region, except for Yemen and Djibouti (World Bank, n.d.). In addition, infant mortality rates fell from 24.1 deaths per 1 000 live births to 16.2 deaths between 2010 and 2021. This was lower than the maximum targeted by the United Nations Sustainable Development Goal (SDG) of 25 deaths per 1 000 births (World Bank, n.d.). Regarding the health pillar of the World Economic Forum 2019 Global Competitiveness Index, Egypt came 104th out of 141 countries.

When it comes to government expenditure on health, it is worth noting that this jumped from EGP 20 billion (around USD 3.6 billion) in the fiscal year 2010/2011 to EGP 73 billion (around USD 4.34 billion) in 2019/2020. The latter figure was around 4.8% of total governmental spending and 1.4% of GDP (UNDP, 2020).

The impact of climate change – through heat waves, dust storms and extreme weather events – will further affect public health, with increased respiratory disease a particular concern.[19] Indeed, despite reforms, the integration of more renewable energy into the energy mix and improvements in air and water quality, Egypt still suffers from persistent problems of air, soil and water pollution. The effect of these pollutants on health was estimated at 2.5% of GDP in 2017, with air pollution caused by particulate matter 2.5 ($PM_{2.5}$)[20] in Greater Cairo causing nearly 12 569 deaths that year (UNDP *et al.*, 2021). As Figure 13 shows, in 2016, Egypt saw the highest mortality rates due to air pollution in North Africa – exceeding the MENA average. Yet, in 2019, the country's per capita cost of damage to health was USD 155,[21] below the North Africa average of USD 177 and substantially lower than the Middle East average of USD 1 168 (CE, n.d.). Without effective action, however, even this apparently moderate level might rise alarmingly.

Figure 13: Mortality rate attributed to household and ambient air pollution, Egypt and its North African neighbours, 2016 (age-standardised, per 100 000 population)



Source: World Bank, n.d.

[19] See, for example, https://climateknowledgeportal.worldbank.org/sites/default/files/2021-04/15723-WB_Egypt%20Country%20Profile-WEB-2_0.pdf (accessed 13 October 2023).

[20] $PM_{2.5}$ refers to tiny particles or droplets in the air that are 2.5 microns or less in width.

[21] In 2019 US dollars.

In recent years, Egypt has made great efforts to expand its skilled workforce by implementing reforms in the education sector in support of the country's growth plan. The World Bank has also approved a USD 500 million loan for Egypt as part of its efforts to promote sustainable and inclusive growth within the framework of Vision 2030. Egypt's education reform project will thus be supported over five years to improve access to quality pre-school education, modernise the exam systems for state schools, strengthen the capacity of teachers and administrators and increase the role of technology in the system.

In addition – and to reduce the gap between graduates' skills and job market needs – in 2015, the Government of Egypt (GoE) established an independent ministry for vocational education. Previously, responsibility for this field had been scattered over 35 different ministries and/or authorities.

Under the 1.5°C Scenario, the largest welfare improvement takes place in the social dimension. The main factor contributing to this is public health, which is significantly improved in comparison to the PES, owing to better air quality. Under the 1.5°C Scenario, fossil fuel use is reduced in favour of renewable energy and increased electrification of end uses, which in turn significantly reduces air pollution. Under the PES, however, continued reliance on fossil fuels is expected to have a worsening health impact.

In addition, in the 1.5°C Scenario, Egypt benefits greatly from global financial collaboration flows, which leads to a higher level of government social spending than under the PES. In per capita terms, between 2021 and 2050, this spending rises from USD 163.3[22] to USD 227.8.

Nonetheless, policy measures alone are not enough to provide improvement in the social dimension. The main factor impacting this is public health, which is significantly improved under the 1.5°C Scenario in comparison to the PES, owing to better air quality. A negligible improvement in the social expenditure indicator drags down the absolute social dimension, which reaches 0.08 under 1.5°C Scenario by 2050 (left panel in Figure 12), indicating room for improvement in overall welfare by further improving the social expenditure indicator.

Environmental dimension

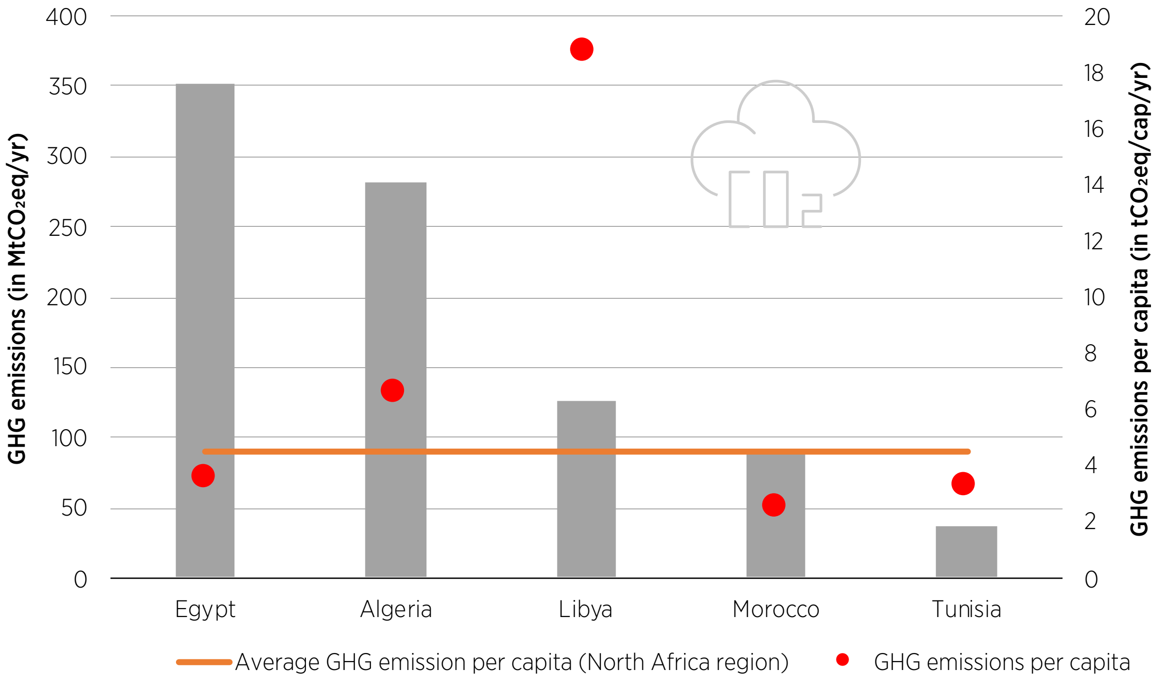
The two indicators of the environmental dimension are: 1) GHG emissions and vulnerability to climate change, and 2) the depletion of natural resources through consumption of materials. The latter is measured in domestic material consumption of metal ores, non-metallic minerals and biomass for food and feed.

Egypt's use of energy resources has been a major cause of environmental degradation (World Bank, 2021b). The country is also highly vulnerable to climate change. Rising temperatures are expected to severely affect Egypt's coastal waters, water resources, agriculture and food security, as well as its energy system, which itself is ill-prepared to cope with the effects of climate change (World Bank, 2021b). Egypt's Nile Delta is considered one of the world's three 'extreme' vulnerability hotspots (UNDP, 2018), with up to 15% of the country's most fertile arable land already affected by increasing saltwater intrusion from the sea. Some studies suggest increased evaporation rates due to rising temperatures could decrease water availability in the River Nile by up to 70% (World Bank, 2021b). With the country's needs for potable water, agriculture, industry, fish farming, power generation and cooling of machinery all served by the Nile, the prospects are nothing less than dramatic.

Cities, too, will be affected. It is estimated that a rise in sea levels of half a meter would mean the demolition of 30% of Alexandria – the second largest city in Egypt. This would cause the relocation of nearly 1.5 million people, the loss of 195 000 jobs and loss of lands and property that could reach USD 30 trillion (UNDP *et al.*, 2021). The World Bank suggests sea level rises along the country's coasts will affect approximately 2.4 million people by the 2080s (World Bank, 2021b).

[22] In 2019 USD.

Figure 14: Total and per capita GHG emissions in North Africa, 2019



Source: Emissions Database for Global Atmospheric Research (EDGAR), (Crippa *et al.*, 2021); Climate Analysis Indicator Tool (CAIT) database (Climate Watch, 2022).

Notes: $MtCO_2eq/yr$ = million tonnes of CO_2 equivalent per year; $tCO_2eq/cap/yr$ = tonnes of CO_2 equivalent per capita per year.

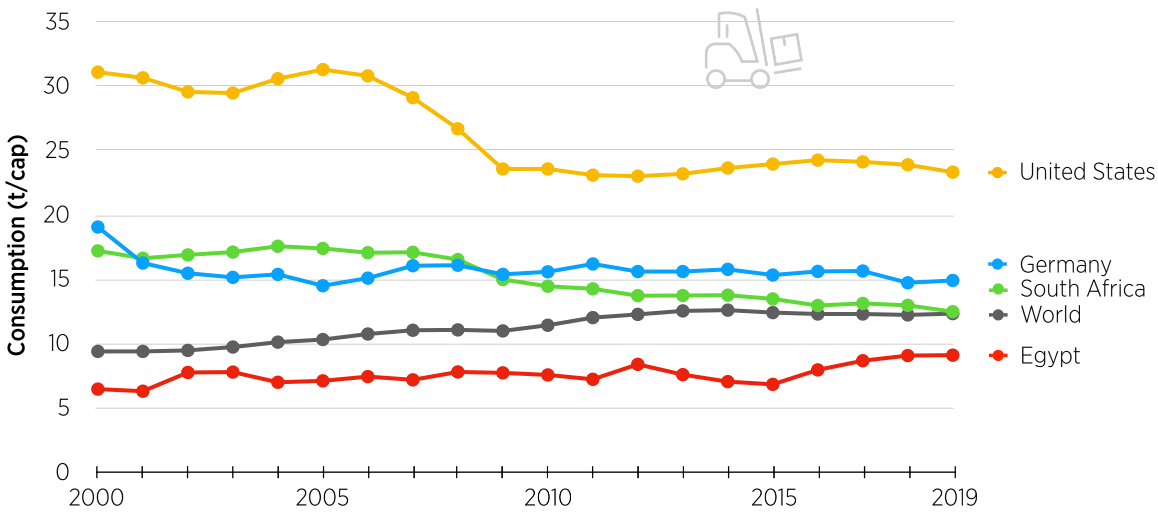
Annual GHG emissions in Egypt have been increasing over the years. In the year 2000, the country's total GHG emissions stood at 185.4 million tonnes of CO_2 equivalent ($MtCO_2eq$), but by 2019, as Figure 14 shows, the total was 352.0 $MtCO_2eq$. The 2019 figure represented around 0.7% of global GHG emissions (Crippa *et al.*, 2021; Climate Watch, 2022).

Indeed, Egypt is North Africa's largest GHG emitter, with its emissions representing around half of Germany's – and with Germany the world's 10th largest emitter in 2019. Considering GHG emissions per capita that year, Algeria and Libya emitted significantly more than Egypt and the rest of the North Africa countries, however (Figure 14). Egypt's GHG emissions were 3.5 tonnes of CO_2 per capita (tCO_2/cap) in 2019, which was also substantially lower than that of developed countries such as the United States (17.5 tCO_2/cap), Germany (8.6 tCO_2/cap), or emerging economies such as Russia (13.2 tCO_2/cap) and Brazil (6.9 tCO_2/cap).

Egypt's energy sector represented 74.1% of the country's total GHG emissions in 2019 *(*Crippa *et al.*, 2021; Climate Watch, 2022). This was slightly below the world average of around 75.6% and the North Africa average of 79.5%. Compared to the world average, the country has higher share of industrial emissions, at 8.5%, with the global average around 6.1% and the North Africa average 7.6%.

Regarding the environment dimension's second indicator, Egypt's domestic material consumption (DMC) was 8.9 tCO_2/cap in 2019 (OECD, n.d.). This was lower than the global average of 12.33 t/cap and significantly lower than in advanced economies such as Germany and the United States (Figure 15).

Figure 15: Domestic material consumption per capita, 2000-2019



Source: (Our World In Data, n.d).

For Egypt, a comparison between the 1.5°C Scenario and the PES shows that the environmental dimension is the second largest driver of significant welfare improvement. The CO_2 emissions indicator is entirely responsible for these added improvements, as the 1.5°C Scenario markedly reduces global cumulative CO_2 emissions, when compared to the PES. By contrast, material consumption in Egypt – the other indicator of the environmental dimension – is low under both the PES and the 1.5°C Scenario. Hence, the resulting index for this indicator does not contribute significantly to environmental improvement in either scenario.

Distributional dimension

The distributional dimension measures income and wealth inequalities within and across regions and countries. The most widely used metric for assessing such income disparities is the Gini index, which ranges from 0 (complete equality) to 100 (complete inequality). In Egypt, this index went from 28.3 in 2012 to 31.5 in 2017, showing increasing inequality (World Bank, n.d.).

The distributional dimension in IRENA's analysis differs from the Gini index, however, and is based on the quintile ratio.[23] This is the ratio of the highest quintile of income/wealth distribution to the lowest quintile of income/wealth distribution.

Such an analysis shows that over the period 1995-2021, income inequality increased in Egypt, with the quintile ratio rising from 5.4 to 6.6 (WID, n.d.). This 2021 ratio was still lower than in South Africa (18.1) or the North Africa regional average (59.4), however. During the same period, wealth inequality in Egypt was much more pronounced than income inequality – as can be observed across the world (Piketty, 2013; WID, n.d.), standing at -85.6 in 2021. This was substantially lower than in South Africa, where the wealth quintile ratio of around -27.6 was the highest in the world. The Egyptian ratio was also slightly lower than in Nigeria, which scored -74.4, and lower than the North Africa region average of around -79.9 (WID, n.d.).[24]

[23] A quintile refers to any of five equal groups into which a population can be divided according to the distribution of values of a particular variable. Thus, the lowest-income quintile refers to the poorest 20% of a given population, the second quintile encompasses the next 20% moving up the income ladder, and so on.

[24] The higher the wealth quintile ratio is, the higher the wealth inequality.

An analysis of the distributional dimension shows that there is a positive, if moderate, difference between the 1.5°C Scenario and the PES in Egypt (right panel in Figure 12). Increased fiscal space, made possible by international climate collaboration flows under the 1.5°C Scenario, allows for higher public expenditure – such as subsidies to support the transition and public transition-related investment. This leads to a slightly more equitable distribution of income. Under the 1.5°C Scenario, by 2050 the absolute distributional dimension reaches 0.72, which is slightly higher than the 0.70 achieved under the PES (left panel in Figure 12). This indicates progress, although 0.72 is still higher than the global index of 0.36 achieved under the 1.5°C scenario – indicating significant room for further improvement. Indeed, although the climate policy basket under the 1.5 °C Scenario includes actions that aim to improve income distribution, more effort is required to bring the country's distributional inequality down.

Economic dimension

The two indicators of the economic dimension are: 1) a measurement of consumption and investment per capita; and 2) a measurement of non-employment. The second indicator is calculated as the ratio of the share of the working-age population (those aged from 15 to 64 years) that is within the 14-24 age group and is neither employed nor under education.[25]

Egypt's household consumption and investment more than doubled between 2000 and 2019 (World Bank, n.d.). Despite this, in per capita terms, the value of the country's consumption and investment in 2019 was slightly lower than the North African average – at USD 2 885.4[26] as opposed to USD 2 946.0. Egypt's level was also more than two times lower than the Middle East regional average of USD 7 120.8, although almost two times higher than the African regional average of USD 1 585.5 (CE, n.d.).

The unemployment rate in Egypt was 7% in 2022. This was lower than the MENA average of 9.6% and lower than Morocco (10.5%), Algeria (11.6%), Tunisia (16.1%) and Libya (20.7%). Non-employment in Egypt, which has remained at an average of 40.9% over the past decade, compares similarly and is slightly lower than North Africa's average of around 42.6% (CE, n.d.; World Bank, n.d.).

While social and environmental dimensions significantly improve under the 1.5°C Scenario, the economic dimension of welfare is almost the same between the two scenarios. Under the 1.5°C Scenario, the consumption and investment indicator is not substantially better than under the PES and even slightly declines in 2050. By then, however, under the 1.5°C Scenario Egypt sees a slight improvement in the non-employment indicator.[27] Overall, though, under the 1.5°C Scenario, the dimension sees no improvement over the PES.

[25] *'Non-employment' is used instead of unemployment or employment metrics because of its more comprehensive gauging of the social implications of paid work, which is the main goal of a welfare index.*

[26] *In 2019 US dollars.*

[27] *The state of not having paid work, excluding young people (aged 15 to 24 years) getting an education. Non-employment is hence calculated as the share of the working-age population (aged 15 to 64 years) that is neither employed nor too young (aged 15-24) and getting an education. Non-employment is used instead of unemployment or employment metrics because of its more comprehensive gauging of the social implications of paid work, which is the main goal of a welfare index. Indeed, while unemployment and employment are evaluated as shares of the labour force, non-employment is defined on the basis of the entire working-age population (not only the part of it belonging to the labour force). Hence, beyond a short-term lack of paid work, this measurement also captures a long-term lack of paid work (which is excluded from the labour force) (IRENA, 2021).*

Access dimension

The access dimension is measured by two indicators. The first measures the share of the population with access to basic energy services. The second is an evolution along an 'energy ladder' that assesses the progress of energy usage to cover energy services and provide energy sufficiency.

Egypt reached universal energy access in 2016 (World Bank, n.d.) and by 2019, it had a daily, per capita daily total final energy consumption (TFEC/cap) of 17.7 kilowatt hours (kWh). This was almost half the global average of 37.2 kWh and below the North African average of 18.6 kWh (CE, n.d.).

By 2050, the access dimension achieves its maximum value of 1 under both the PES and 1.5°C Scenario (left panel in Figure 12). It therefore sees no improvement under the 1.5°C Scenario over the PES, in contrast to the social and environmental dimensions. Under both scenarios, Egypt's energy consumption reaches sufficiency level by 2024/2025.[28] This is assumed to be 20 kWh per capita per day, in line with the literature (Millward-Hopkins *et al.*, 2020).[29] This also implies that in Egypt, the energy accessed is not only basic, but also sufficient.

[28] *This indicator has been defined as the required level of energy consumption for decent living, but no more.*

[29] *The authors estimated the sufficiency level between 11.6 kWh/capita/day and 30.4 kWh/capita/day according to the scenarios across all 119 countries of the Global Trade Analysis Project, depending on the scenarios considered. See www.gtap.agecon.purdue.edu/databases/regions.aspx?version=9.211, accessed 14 October 2023.*

04 Summary and way forward

IRENA's macro-econometric modelling analysis of Egypt shows that the energy transition can boost the country's economy, create more jobs and promote people's well-being.

Over the 2021-2050 period, under the 1.5°C Scenario GDP is 5.5% higher, on average, than under the PES – a difference driven mainly by trade. Under the PES, the country's GDP is expected to grow by around USD 1.1 trillion[30] between 2021 and 2050. Indeed, changing Egypt's energy strategy away from fossil fuels towards renewables is expected to have a substantial positive impact, adding USD 63 billion[31] to the country's GDP in 2050 alone.

In addition, by 2050, employment is likely to be 0.3% higher under the 1.5°C Scenario than under the PES. By 2030, the number of people employed in Egypt's energy sector may have already risen from the current 0.4 million to over 1.0 million under the PES and 1.5 million under the 1.5°C Scenario. In the latter, 42.2% of the energy industry workforce will work in renewables by 2050, representing around 1.0 million jobs. Work associated with power grids and energy flexibility will account for another 24.0%, or 0.6 million jobs, while employment related to energy efficiency will increase by 16.1%, or 0.4 million jobs.

In the 1.5°C Scenario, solar technologies account for 25.3% of renewable energy jobs in 2030 (about 71 000 people) and 70.2% in 2050 (over 0.7 million people). Wind represents 60.8% of renewable energy employment (around 170 000 jobs) in 2030 and 18.3% (over 187 000 jobs) in 2050. As many as 77 500 people could be employed in the hydro sector by the latter year, too, while bioenergy is expected to have over 39 000 jobs by that time.

By 2050, in terms of welfare, the 1.5°C Scenario outperforms the PES by 12.2%, with this driven mainly by the social and environmental dimensions. This analysis has also highlighted some key areas where government action could boost living standards, and the study's social, economic, environmental and distributional dimensions should be considered by policy makers.

Increases in social expenditure and increases in consumption and investment to improve present and future well-being offer the greatest potential for progress in the economic and social dimension. There is opportunity for improvement in environmental policy as well, particularly in the area of GHG emissions reduction. Improving the distributional dimension requires policy action aimed at expanding the distribution of wealth and providing greater budgetary flexibility via higher international climate collaboration flows and carbon taxes.

Supportive policies tailored to the country's socio-economic circumstances and challenges should go in tandem with the energy transition. Given Egypt's vulnerability to climate change, the security of water, energy, and food are intertwined. In order to accomplish efficient and integrated planning and management of resources, it is crucial to address the different links between the water sector and these other sectors. A nexus strategy must be used to tackle these connected problems, if the world is to meet the SDGs and reduce climate threats.

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[30] *In 2019 US dollars.*

[31] *In 2019 US dollars.*

A carbon tax might help strengthen the positive effects of sector-specific efforts on the overall economy, if implemented within the framework of the medium-term revenue strategy and with complementary measures in place to mitigate any negative effects. Resources would also have to be provided to support private sector investments in adaptation and mitigation. The transition to renewable energy can also be aided by the rationalisation of energy subsidies through energy reform initiatives.

Air pollution can be addressed by adopting an integrated, multi-sectoral approach that includes low-emission innovations. It is crucial to make the necessary effort to decarbonise the oil, gas and electricity sectors because international commerce – including new trade regulations and preferences shifting towards lower-carbon-content items – can create transition opportunities for Egypt's economy. Fossil fuel demand is set to drastically decrease, which will cause Egypt's output to plummet even before 2030. An early accelerated decarbonisation means that Egypt will no longer be needing to import fossil fuels and will thus save substantially on import bills, while also avoiding acute energy shortages, such as that of 2013/2014.

High overall fiscal deficits threaten macroeconomic resilience. In Egypt, interest payments take up 39% of total expenditure, while tax revenue remains low. This highlights the importance of international collaboration and support from advanced economies. Adoption of a global collaboration fund will mean that countries such as Egypt will be able to have greater fiscal space to not only support the energy transition, but also to invest in infrastructure related to social well-being, by increasing spending on the education and health sectors.

Efficient public spending could help direct more public resources toward activities that help attract private investment and increase productivity, support macroeconomic resilience, and redirect resources away from activities that drive citizens toward low-skilled employment. Active labour market programmes, digital job boards, and income-generating asset and skills training can help provide more job opportunities.

Egypt's transition to a cleaner and more sustainable energy system has the potential to address many of the country's pressing social, economic and environmental challenges. By reducing the country's dependence on fossil fuels and increasing investment in renewable energy, Egypt can improve access to reliable and affordable energy for all its citizens, but particularly for those living in poverty. This shift can also create new job opportunities and promote economic growth. Additionally, renewable energy can help reduce air pollution and GHGs, improving public health and mitigating the multiple impacts of climate change. Overall, a successful, just and inclusive energy transition in Egypt can bring about a brighter, more prosperous and healthier future for all Egyptians.

References

Abou-Ali, H. *et al.* (2023), *Keys to climate action Chapter 3 – Climate action in Egypt: Challenges and opportunities*, Working Paper #180.3, www.brookings.edu/wp-content/uploads/2023/02/Chapter-3.-Climate-action-in-Egypt-Challenges-and-opportunities-1.pdf

AfDB (2016), *Addressing informality in Egypt*, Working Paper, African Development Bank Group, www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Working_paper_-_Addressing_informality_in_Egypt.pdf

Al-Kady, B. (2022), "Egypt officially enters state of water poverty", *Al-Monitor*, www.al-monitor.com/originals/2022/01/Egypt-officially-enters-state-water-poverty

Assaad, R. (2022), "Beware of the echo: The evolution of Egypt's population and labor force from 2000 to 2050", *Middle East Development Journal,* Vol. 14, https://doi.org/DOI:10.1080/17938120.2021.2007649

Aziz, M. (2020), "Egypt's water challenges: Beyond the dam saga"*,* Ahram Online, www://english.ahram.org.eg/NewsContent/1/64/359272/Egypt/Politics-/Egypts-water-challenges-Beyond-the-dam-saga-.aspx

Breisinger, C. *et al.* (2019), "Energy subsidy reform for growth and equity in Egypt: The approach matters", *Energy Policy*, vol. 129, pp. 661–71, https://doi.org/10.1016/j.enpol.2019.02.059

CBD (n.d.), "Country profiles - Egypt", Convention on Biological Diversity, www.cbd.int/countries/profile/?country=eg

CE (n.d.), "E3ME Database", Cambridge Econometrics, https://www.e3me.com/features/

Climate Action tracker (2022), *Natural Gas in Africa-Why fossil fuels cannot sustainably meet the continent's growing energy demand*, Climate Action Tracker, www://climateactiontracker.org/documents/1048/CAT_2022-05_Report_NaturalGasinAfrica.pdf

Crippa, M. *et al.* (2021), *GHG Emissions of All World Countries: 2021 Report*, No. EUR 30831 EN, https://op.europa.eu/en/publication-detail/-/publication/45c88a84-2d65-11ec-bd8e-01aa75ed71a1/language-en

DTU DA (2020), *Labor market profile - Egypt 2020/2021*, Danish Trade Union Development Agency, www.ulandssekretariatet.dk/wp-content/uploads/2020/09/LMP-Egypt-2020-final1.pdf

Egypt Today (2021), "Electric cars to be manufactured in Egypt mid-2022", www.egypttoday.com/Article/3/105118/Electric-cars-to-be-manufactured-in-Egypt-mid-2022-Minister

El-Rawy, M., *et al.* (2021), "Impacts of decreasing Nile flow on the Nile Valley aquifer in El-Minia Governorate-Egypt", *Alexandria Engineering Journal*, vol. 60, pp. p2179-2192.

ESMAP (2017), *Egypt*, Energy subsidy reform facility, World Bank group, https://olc.worldbank.org/system/files/120075-WP-PUBLIC-26-9-2017-12-41-5-FINALESMAPCountryBriefEgypt.pdf

IEA (n.d.), "Data and statistics", International Energy Agency, www.iea.org/countries/egypt

IMF (2013), *Energy subsidy reform in Sub-Saharan Africa: experiences and lessons*, International Monetary Fund, Washington D.C., www.imf.org/external/pubs/ft/dp/2013/afr1302.pdf

IMF (2021), *Arab Republic of Egypt: 2021 Article IV Consultation, Second Review Under the Stand-By Arrangement-Press Release; Staff Report; and Statement by the Executive Director for the Arab Republic of Egypt*, IMF Staff Country Reports, No. 2021/163, International Monetary Fund, Middle East and Central Asia Dept., https://doi.org/10.5089/9781513592046.002

Informa Markets (2022), *Egypt Energy Sector*, Market Report, www.egypt-energy.com/content/dam/Informa/egypt-energy/en/pdf/Egypt%20Energy%20Report-16-5%20.pdf

IRENA (2016), *Renewable energy benefits: Decentralised solutions in the agri-food chain*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2016/Sep/Renewable-Energy-Benefits-Decentralised-solutions-in-agri-food-chain

IRENA (2018a), *Global transformation: A roadmap to 2050*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2018/Apr/Global-Energy-Transition-A-Roadmap-to-2050

IRENA (2018b), *Renewable energy outlook: Egypt,* International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf

IRENA (2019a), *Global energy transformation: A roadmap to 2050*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Apr/Global-energy-transformation-A-roadmap-to-2050-2019Edition

IRENA (2019b), *Renewable energy: A gender perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Jan/Renewable-Energy-A-Gender-Perspective (accessed 31 January 2022).

IRENA (2020), *Global renewables outlook: Energy transformation 2050*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020

IRENA (2021), *World energy transitions outlook: 1.5°C pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook

IRENA (2022a), *World Energy Transitions Outlook 2022: 1.5°C Pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022

IRENA (2022b), *Socio-economic footprint of the energy transition: Japan*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Sep/Socio-economic-Footprint-of-the-Energy-Transition-Japan

IRENA (2023a), *World Energy Transitions Outlook 2023: 1.5°C Pathway*, Vol. 1, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023

IRENA (2023b), *Socio-economic footprint of the energy transition: Southeast Asia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jul/Socio-economic-footprint-of-the-energy-transition-Southeast-Asia

IRENA (2023c), *Socio-economic footprint of the energy transition: Indonesia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/Socio-economics-of-the-energy-transition-Indonesia

IRENA (n.d.), "Statistics data", International Renewable Energy Agency, www.irena.org/statistics

KPMG (2020), *Egypt: Government and institution measures in response to COVID-19,* https://kpmg.com/xx/en/home/insights/2020/04/egypt-government-and-institution-measures-in-response-to-covid.html

Lynx (2020), *Egypt's evovling policy framework for electric vehicles*, LYNX Business Bulletin, Lynx Strategic Business Advisors, www.lynxegypt.com/assets/pdfs/EVs-Policy-Regulatory.pdf

Mahmoud, M. (2021), *Prospects and Challenges of Green Hydrogen in the Arab Region: Readiness of Sustainable Energy Programs*, Organization of Arab Petroleum Exporting Countries, https://oapecorg.org/media/47b72cb5-2cca-45f8-96ae-162a1cfbe723/480327881/%D9%86%D8%AF%D9%88%D8%A9%20%D8%A7%D9%84%D9%87%D9%8A%D8%AF%D8%B1%D9%88%D8%AC%D9%8A%D9%86/4_%20Dr%20Maged.pdf

Millward-Hopkins, J. *et al.* (2020), "Providing decent living with minimum energy: A global scenario", *Global Environmental Change*, Vol. 65, https://doi.org/10.1016/j.gloenvcha.2020.102168

MOIC (2021), *Annual report*, Ministry of International Cooperation, https://mmd-moic.s3.eu-west-1.amazonaws.com/files/ENGLISH-Moic-Report-2021-Digital-Spreads-pages_1.pdf

Moneim, D.A. (2021), "Egypt's CIB issues $100 mln green bonds, first for private sector", Ahram Online, https://english.ahram.org.eg/News/416318.aspx

MoPMaAR (2016), *Sustainable Development Strategy: Egypt's Vision 2030*, Ministry of Planning, Monitoring and Administrative Reform, https://planipolis.iiep.unesco.org/en/2016/sustainable-development-strategy-egypt%E2%80%99s-vision-2030-6301

Mostafa, Z. (2020), "Strategy for electric car manufacturing in Egypt imperative", *Daily News Egypt*, www.dailynewsegypt.com/2020/02/21/strategy-for-electric-car-manufacturing-in-egypt-imperative/

NREA (2021), *Annual Report 2021*, New & Renewable Energy Authority, http://nrea.gov.eg/Content/reports/Annual%20Report%202021(En).pdf

OBG (2022a), *Will increased middle class spending fuel the Egyptian economy?* Oxford Business Group, https://oxfordbusinessgroup.com/reports/egypt/2022-report/economy/spending-power-household-consumption-patterns-are-expected-to-be-a-driver-of-growth-supported-by-a-burgeoning-middle-class

OBG (2022b), *Egypt shifts towards technology-intensive manufacturing*, Oxford Business Group, https://oxfordbusinessgroup.com/reports/egypt/2022-report/economy/focus-on-local-higher-value-added-activities-targeted-as-emphasis-shifts-towards-more-sustainable-technology-intensive-manufacturing

OECD (2011), *ISIC Rev. 3 technology intensity definition - Classification of manufacturing industries into categories based on R&D intensities*, Organisation for Economic Co-operation and Development, www.oecd.org/sti/ind/48350231.pdf?_ga=2.199298670.1967803927.1679895661-1505470242.1679895661

OECD (n.d.), *"OECD data",* Organisation for Economic Co-operation and Development, https://data.oecd.org/materials/material-consumption.htm

OECD, *et al.* (2021), *Production Transformation Policy Review of Egypt: Embracing Change*, Achieving Prosperity, OECD Development Pathways, Organisation for Economic Co-operation and Development, www.oecd-ilibrary.org/development/production-transformation-policy-review-of-egypt_302fec4b-en

Ortiz-Ospina, E., and Roser, M. (2016), *Government Spending*, OurWorldInData.org, https://ourworldindata.org/government-spending

Our World In Data (n.d.), *Domestic material consumption per capita, 2000 to 2019,* https://ourworldindata.org/grapher/domestic-material-consumption-per-capita?tab=chart&country=EGY~USA~OWID_WRL~DEU~ZAF

Piketty, T. (2013), *Capital in the Twenty-First Century* (2014th edition), Belknap Press: An Imprint of Harvard University Press.

Qantara (2022), Sinking Alexandria faces up to coming catastrophe, https://en.qantara.de/content/cop27-and-the-middle-east-sinking-alexandria-faces-up-to-coming-catastrophe

RCREEE and MEDENER (2020), *Mapping EE and RES market potential areas with high impact on local economy and job creation: Tunisa, Egypt and Lebanon,* Regional Center for Renewable Energy and Energy Efficiency, MEDENER, https://rcreee.org/wp-content/uploads/2020/04/v3_15_a32_impact-map-eco-and-job_final.pdf

REGLOBAL (2021), *Siemens Energy signs MoU with EEHC in Egypt,* https://reglobal.org/siemens-energy-signs-mou-with-eehc-in-egypt/

Reuters (2020), *Egypt becomes first Arab country to issue Green bonds with $750 million deal,* www.reuters.com/article/egypt-bonds-int-idUSKBN26K1MJ

UNDESA (2022), *World Population Prospects 2022,* United Nations,Department of Economic and Social Affairs, Population Division, https://population.un.org/wpp/Download/Standard/Population/

UNDP (2018), *National Adaptation Plans in focus: Lessons from Egypt,* United Nations Development Programme, www.adaptation-undp.org/sites/default/files/resources/naps_in_focus_lessons_from_egypt.pdf

UNDP (2020), *Human development report 2020: The next frontier - Human development and the Anthropocene*, United Nations Development Programme, https://hdr.undp.org/system/files/documents/hdr2020pdf.pdf

UNDP and MoPED (2021), *Egypt Human Development Report 2021*, United Nations Development Programme and Ministry of Planning and Economic Development Egypt, www.undp.org/egypt/publications/egypt-human-development-report-2021

UNICEF (2022), *Egypt – Climate change,* www.unicef.org/egypt/climate-change#:~:text=Stronger%20warming%20has%20been%20documented,the%20younger%20generations%20of%20today

UNIDO (2021), *Egypt Country Profile*, United Nations Industrial Development Organization, https://iap.unido.org/country/EGY

UNSD (n.d.), *Egypt - Energy balance visualization,* United Nations Statistics Division, https://unstats.un.org/unsd/energystats/dataPortal/

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

Waheed, H. (2017), *Regulatory Framework to develop RES projects in Egypt,* RES4MED, www.res4med.org/wp-content/uploads/2017/05/StrategicOutlook_Egypt-RES4MED-Day-Egypt_WAHEED.pdf

WID (n.d.), "Income and wealth inequality", World Inequality Database, https://wid.world/data/

World Bank (1990), *World Development Report 1990: Poverty*, World Bank, https://openknowledge.worldbank.org/entities/publication/6db831cb-da31-5fa6-a754-0dc7182ef75b

World Bank (2021a), *Unlocking Egypt's Potential for Poverty Reduction and Inclusive Growth: Eqypt Systematic Country Diagnostic Update*, World Bank, https://doi.org/10.1596/36437

World Bank (2021b), *Egypt Country Profile*, https://climateknowledgeportal.worldbank.org/sites/default/files/2021-04/15723-WB_Egypt%20Country%20Profile-WEB-2_0.pdf

World Bank (2023), World Bank Country and Lending Groups, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

World Bank (n.d.), *World Development Indicators,* World Bank, https://databank.worldbank.org/source/world-development-indicators#

WRI (2022), *Climate Watch Historical GHG Emissions*, World Resources Institute, www.climatewatchdata.org/ghg-emissions?end_year=2020&start_year=1990.

Appendix 1: Carbon pricing, international collaboration, subsidies and progressive fiscal regimes

Due to the regressive implications of carbon pricing, its levels have been reduced by half in this analysis, compared to previous reports (IRENA, 2020, 2021). Carbon pricing is also higher under the 1.5°C Scenario than under the PES. In addition, under the 1.5°C Scenario, carbon prices are higher for high-income countries than for less wealthy ones. So, while the figure for high-income economies in 2030 is around USD 150/tCO_2[32] and for low-income countries, USD 30/tCO_2, Egypt's carbon price for that year is set at USD 105/tCO_2.

In most cases, the macroeconomic modelling assumes revenue neutrality in government fiscal balances. The policies used to implement revenue neutrality depend on the progressiveness of the applied policy basket. In the PES, when government revenues increase (for instance through carbon prices), income taxes decrease, and vice versa. This approach has regressive implications, however, as the wealthiest households generally pay the lion's share of income taxes and benefit accordingly from higher tax cuts. By contrast, in the policy basket used for the 1.5°C Scenario, revenues are recycled through lump-sum payments that target lower-income households progressively: 60% of the payments go to the lowest-income quintile, 30% to the second quintile and 10% to the third quintile. Progressive distributional policies help mitigate the regressive effects of the energy transition and climate change itself.

Another key assumption of the climate policy baskets is the level of international collaboration. Whereas no additional collaboration is assumed in the PES, the 1.5°C Scenario policy basket does include enhanced levels to address the climate change challenge and the structural aspects underpinning an unequal distribution of burdens and responsibilities. Within this framework, all countries contribute to a joint effort according to their respective capability and responsibility in terms of climate equity.[33] Under the 1.5°C Scenario, between 2021 and 2050 international collaboration is equivalent to 0.7% of global GDP. In contrast – and given that current commitments and climate finance pledges have not been met – the PES does not consider international climate collaboration flows.

[32] *In 2019 US dollars.*

[33] *Based on the Climate Equity Reference Calculator (see https://calculator.climateequityreference.org/, accessed 16 October 2023).*

Appendix 2: Energy policy in Egypt

Through the Technical Support Programme for Restructuring the Energy Sector (TARES), representatives from the Egyptian electricity, renewable energy and petroleum sectors prepared a study on the optimum mix of technical and economic energy up to 2035.

This project had several parts and came up with several scenarios. The most important part, however, was the project's support for the Integrated Sustainable Energy Vision to 2035, adopted by the Supreme Council of Energy in October 2016 and designed to be used as the reference for Egypt's energy planning (NREA, 2021).

While Egypt delayed setting formal renewable energy targets for a long time – and had no formal renewables target in its NDC – this changed with the launch of MoPMaAR 2016. At the time of writing, Egypt has a target of 42% renewable energy in power generation by 2035. As shown in Table 3, solar and wind power are the key technologies (Informa Markets, 2022). Biomass is not listed, but also has great potential (Box 6).

Table 3: Energy mix objectives for 2035

	Share in power generation (%)
Solar PV	22
Wind power	14
Solar CSP	3
Hydroelectricity	2
Nuclear	3
Thermal power plants	55.7

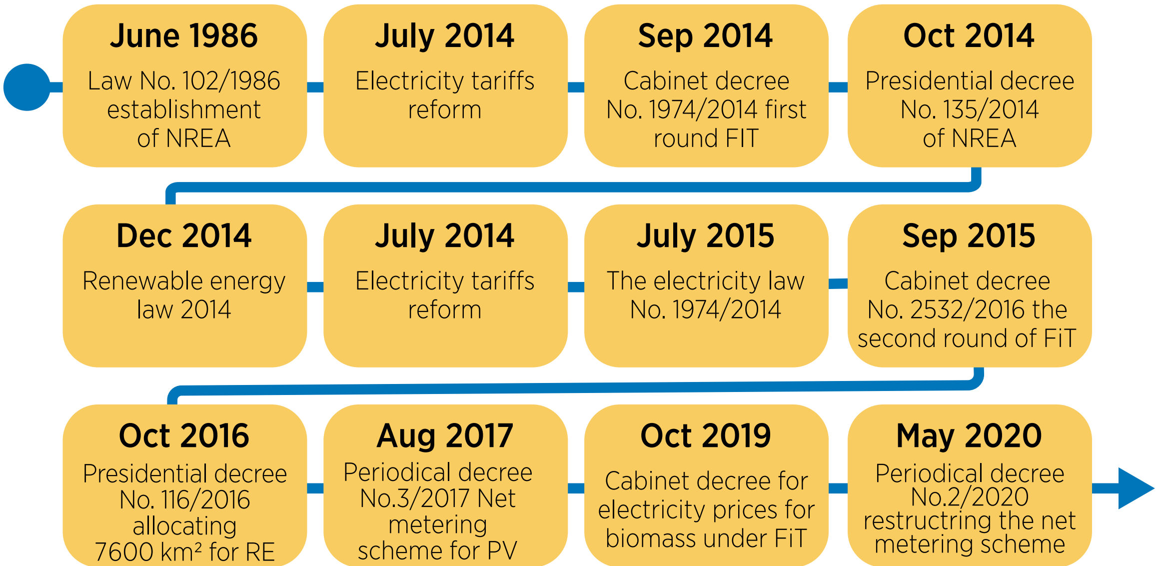
Source: MoPMaAR 2016.

BOX 6: BIOMASS IN EGYPT

More than 30 million tonnes of solid biomass waste are produced annually from both agriculture and municipal resources in Egypt. Although agricultural residues account for the lion's share of the solid waste generated, sustainable usage of this substantial quantity of bio-residues continues to present a formidable challenge for the country. Promoting sustainable energy generation using biomass will ultimately help in bridging Egypt's energy gap using indigenous resources (IRENA, 2018b).

These targets and plans should be supported by strong policies, sound legislation and strong monitoring and evaluation systems. Egypt has progressed well in this regard and Figure 16 shows the main developments in its energy legislation since 1986 – developments which have successfully paved the way for more renewables.

Figure 16: Renewable energy regulations



Source: NREA, 2021.

A merchant independent power producer (IPP) scheme was put into force in 2012. Since then, several projects have been commissioned using the build-own-operate-transfer (BOOT) and build-own-operate (BOO) systems. In March 2014, the name of Ministry of Electricity and Energy was amended to become Ministry of Electricity and Renewable Energy. In July 2014, a five-year tariff reform programme was announced and adopted, allowing the price of electricity generated by renewable energy to decrease gradually and hence increase investment. This tariff plan was revisited recently and revised in order to alleviate the impact of the COVID-19 pandemic on Egyptian consumers. The revised version prolongs the plan from its original end date of fiscal year 2021/2022 to fiscal year 2024/2025 .

In September 2014, the Egyptian cabinet approved FiTs for electricity projects produced from solar PV and wind, with prices issued via prime ministerial decree in October the same year. That month, the NREA establishing law was also amended to allow for the NREA to establish companies by itself, or in partnership with the private sector, in order operate and maintain renewable energy projects.

Two months later, the renewable energy law was issued and on 12 July 2015, the new electricity law was issued. The law allowed for the establishment of a competitive electricity market based on bilateral contracts. It also adopted the concept of eligible customers. In addition, it allowed third party access. The law also allows for the establishment of a transmission system operator and provides assurances of its independence (Waheed, 2017). In September the same year, the cabinet decree for FiTs was issued and was implemented in October 2016. Electricity prices for biomass under the FiT scheme were announced in October 2019. Notably, net metering did not take long to be applied in Egypt, as it was announced in August 2016 and then restructured based on Periodical Decree No. 2/2020 in the year 2020 (NREA, 2021).

When it comes to industrial policy aimed at accelerating inclusive and sustainable industrialisation, one of the most recent developments in the Egyptian market was the signing of the five-year Programme for Country Partnership (PCP) with the United Nations Industrial Development Organization (UNIDO). In euro (EUR) terms, this is worth some EUR 172 million. It aims to support Egypt's transformation in line with the country's policies and development strategies, as well as with the United Nations partnership development framework for Egypt and the SDGs (UNIDO, 2021).

Given the developments above, Egypt's regulatory framework has focused on wind and solar, while not giving major attention to the exploitation of the country's biomass potential. Nevertheless – and since electricity prices for biomass under the FiT were announced in October 2019 – the exploitation of biomass is expected to develop steadily in future.

According to the NREA, the country currently has 12 MW of installed capacity in biomass, 10 MW of which are in Algabal Alasfar. Some 2 MW have been installed by the private sector, 3 MW are under construction and 51 MW are under development by the private sector. Furthermore, the country has 300 MW of planned projects to be initiated in the coming years (NREA, 2021).

When it comes to the transport sector, recent years have seen significant progress in policies regarding EVs. The Egyptian government has signalled a strong determination to increase dependency on these vehicles by creating an enabling framework for local EV manufacturing and the gradual roll-out of a framework for EV licensing and operation. The framework includes customs breaks for importing EVs and their components. It also includes setting a competitive tariff for electric charging, with efforts still ongoing to enhance Egypt's electric charging infrastructure. The Egyptian Electricity Utility and Consumer Protection Regulatory Agency (EgyptERA) will be responsible of setting prices for charging EVs, annually. EgyptERA will also be responsible for issuing licenses for EV charging stations.

Incentives to encourage EV development also include a fixed, 2% customs fee on all imported machinery and equipment related to them. There is also an exemption from stamp tax and registration fees on all incorporation contracts, finance and mortgage contracts, with this running for five years after an EV-related company registers.

Additional incentives under consideration include: subsidies of approximately EGP 50 000 per EV for the first 100 000 locally-produced cars; public sector companies being required to replace 5% of their fleet with EVs on a yearly basis; specific programmes to provide financing for electric taxi purchases; and other financing systems to facilitate purchase of personal EVs (Lynx, 2020).

Additionally, in co-operation with China, the Ministry of Military Production has developed an EV industrial strategy with three main phases: 2019-2024, 2025-2030 and 2031-2040. The main pillars of this strategy include the establishment of local manufacturing, which will create more jobs in renewable energy and has a target of 65% local EV industrialisation technology by 2035. The strategy also aims to place Egypt at the forefront of EV exports by the end of 2040, while reducing the health and environmental risks resulting from the use of fossil fuels by 75% by the year 2040. This, the strategy indicates, means increasing the EV market share to 2% in 2030 and 5% in 2040 and increasing the rate of industrial input by 50% (Mostafa, 2020).

One of the main stakeholders in this field is the Ministry of Public Enterprise Sector. In June 2021, this announced that Egypt would manufacture EVs, starting in 2022, with an eventual capacity of 50 000 cars. The ministry also announced that the country would build 3 000 charging stations, where 6 000 cars could be charged at the same time. Most of the stations are to be built near homes or workplaces (*Egypt Today*, 2021). Finally, the EV strategy won't only include personal vehicles, taxis, and private cars, but it will also include public transportation, such as public buses, with special charging stations set up for this purpose.

In addition, in September 2020, Egypt became the first country in the MENA region to sell green bonds, with a USD 750 million, five-year issuance (Reuters, 2020) Following this up, in June 2021, Egypt's Commercial International Bank (CIB) issued a further USD 100 million in green bonds. That issuance was the first of its kind for Egypt's private sector. The bonds are expected to be linked to various climate-supporting initiatives, including green buildings, energy efficiency, renewable energy, water and wastewater management, and clean transportation (Moneim, 2021).

As previously mentioned, Egypt is currently following international trends and exploring every avenue for GHG emissions reduction, while at the same time, bridging its energy gap. The country has therefore recently started exploring green hydrogen. This is expected to offer long term opportunities for integrating a higher share of renewable energy into the grid, while also enabling the export of renewable energy to third countries. Green hydrogen can also help decarbonise sectors that are often difficult to decarbonise, such as transport, oil, gas, steel, and mining (Mahmoud, 2021).

In this regard, Egypt has formed a ministerial committee, signed several hydrogen-focused memoranda of understanding (MoUs) and conducted a study for the future of green hydrogen. Moreover, in March 2021, the Ministry of Electricity and Renewable Energy announced the implementation of an experimental project for the production of green hydrogen in Egypt. For this, Minister of Electricity and Renewable Energy Dr Mohamed Shaker signed and MoU with the chief executive officer of Siemens to start discussions and begin a study on implementing the project. This will be a first step in the expansion of this field and possibly lead to future exports (REGLOBAL, 2021).

In the light of these rapid first moves, Egypt could become one of the leading countries in the MENA region in terms of hydrogen. The country has an unprecedented opportunity to achieve very rapid progress in producing green hydrogen, using it both locally as a reliable alternative to depleted sources of energy, and as an export commodity to European countries looking for clean energy.

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