KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Electricity Sector Liberalization in Egypt:

Features, Challenges and Opportunities for Market Integration

Shahid Hasan, Turki Al-Aqeel and Hafez El Salmawy

September 2020

Doi: 10.30573/KS--2020-DP20

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

This publication is also available in Arabic.

Legal Notice

Key Points

Egypt began to liberalize its electricity market in 1996. In the two decades since, the authorities have introduced a number of laws and policies to transform the country's electricity industry and make its power sector more efficient, competitive and environmentally sustainable. The key features of Egypt's electricity market and the challenges and opportunities associated with increased participation in cross-border electricity trading are summarized below.

To reduce its rising fiscal deficit, Egypt's government increasingly favors more market-based electricity tariffs and fuel prices that reflect actual costs. However, despite successive fuel price and tariff increases, government spending on energy subsidies has not fallen appreciably. The electricity sector continues to receive government assistance in the form of subsidized fuel prices (oil and gas), financial restricting and guarantees for international loans to limit the increase in end-use electricity tariffs. Considering the political implications of price reforms, eliminating subsidies will remain challenging.

On the supply side, Egypt has achieved remarkable success due to effective policy planning and execution by the government with the active participation of the private sector. Although independent power producers have been allowed to enter the market, the electricity sector remains dominated by state-owned entities in electricity production, transmission and distribution, under the umbrella of a government-owned common holding company.

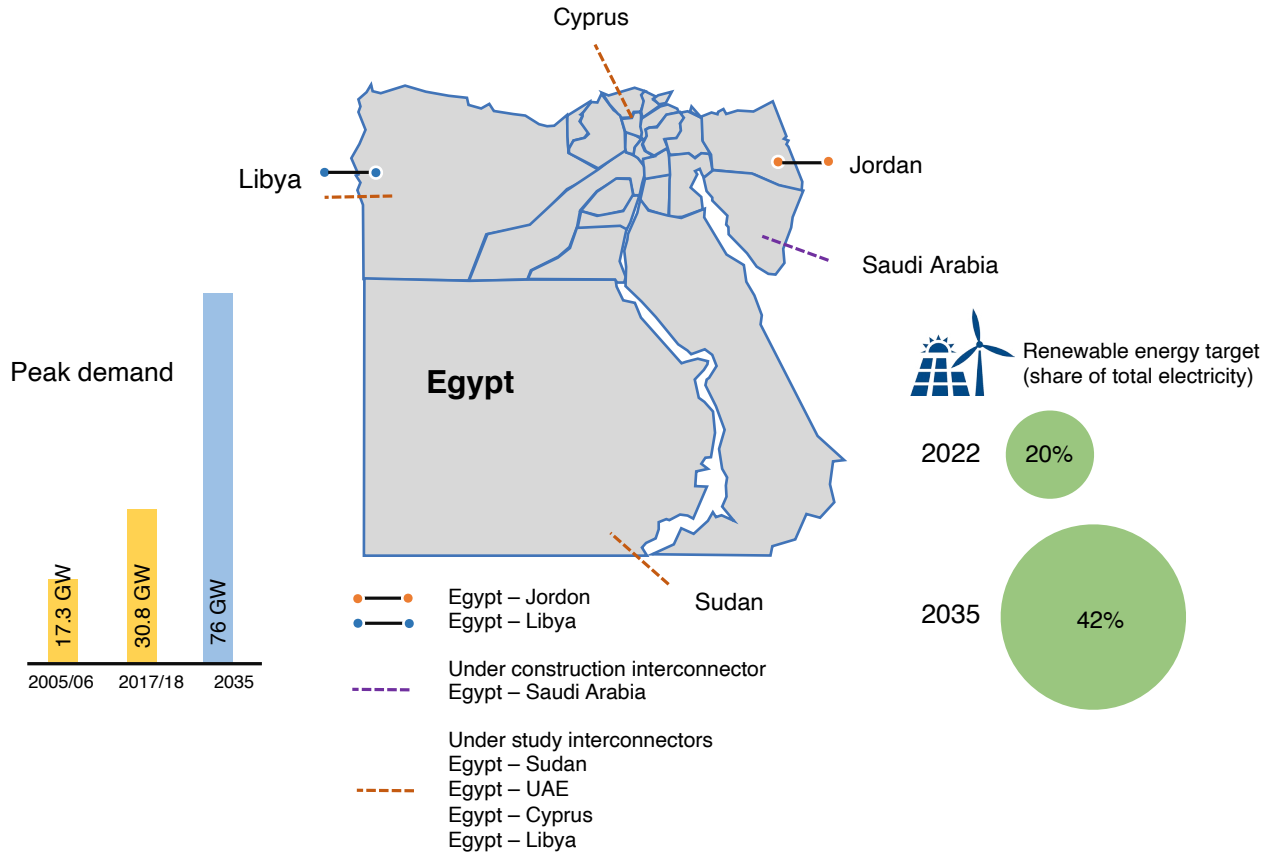
The 2015 Electricity Law proposes structural and other reform measures to gradually transform the performance and governance of the electricity sector. It calls for establishing a fully competitive electricity market that mandates unbundled ownership of generation, transmission and distribution activities, allows third parties grid access without bias, and assures the independence, competency and accountability of the electricity regulatory agency.

The Integrated Sustainable Energy Strategy to 2035 (ISES 2035), approved in 2016, provided a new direction for the growth and development of the electricity industry and wider energy sector. It focuses on enhancing energy security through diversification of supply sources, improving energy and resource efficiency, advancing institutional and corporate governance, and making the energy market more competitive and sustainable.

Egypt aims to establish itself as an energy hub connecting Europe, Asia and Africa by expanding its grid interconnections across the Arab region and beyond.

Key Points

Figure 1. Egypt's electricity demand, cross-border interconnectors, and renewable energy targets.



Source: Collated from multiple sources based on information available in the public domain. The map of Egypt and regional interconnections are for representational purposes and does not show the exact national boundaries and transmission corridors.
GW = Gigawatts

Introduction

KAPSARC has initiated a research project to develop insights that can facilitate the establishment of a well-functioning integrated electricity market comprising the member states of the Gulf Cooperation Council (GCC).[1] It aims to assess the key issues affecting electricity market integration within the GCC and wider Middle East and North Africa (MENA) region to produce insights and policy recommendations that facilitate market integration. The research will examine the features of select countries' electricity markets — including policy, legislation, regulation, market design, system operation and governance — with a view to identifying best practices and ways to foster efficient regional electricity trade. It will also examine the experiences of several regionally integrated electricity markets around the world to see how they can inform policy measures in this region. Ultimately, the project aims to fill knowledge gaps for policymakers and facilitate ongoing efforts toward regional electricity market integration.

The first phase of the research studies the respective challenges and opportunities electricity markets face, focusing on core themes that include reform initiatives, restructuring activities, key market players and associated issues for countries in the region. These country-level assessments will form the backbone for a subsequent, more comprehensive study of regional electricity market design that seeks to develop an approach for the transition toward effective regional market integration. This discussion paper focuses on Egypt's electricity sector.

1. A regional organization comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE.

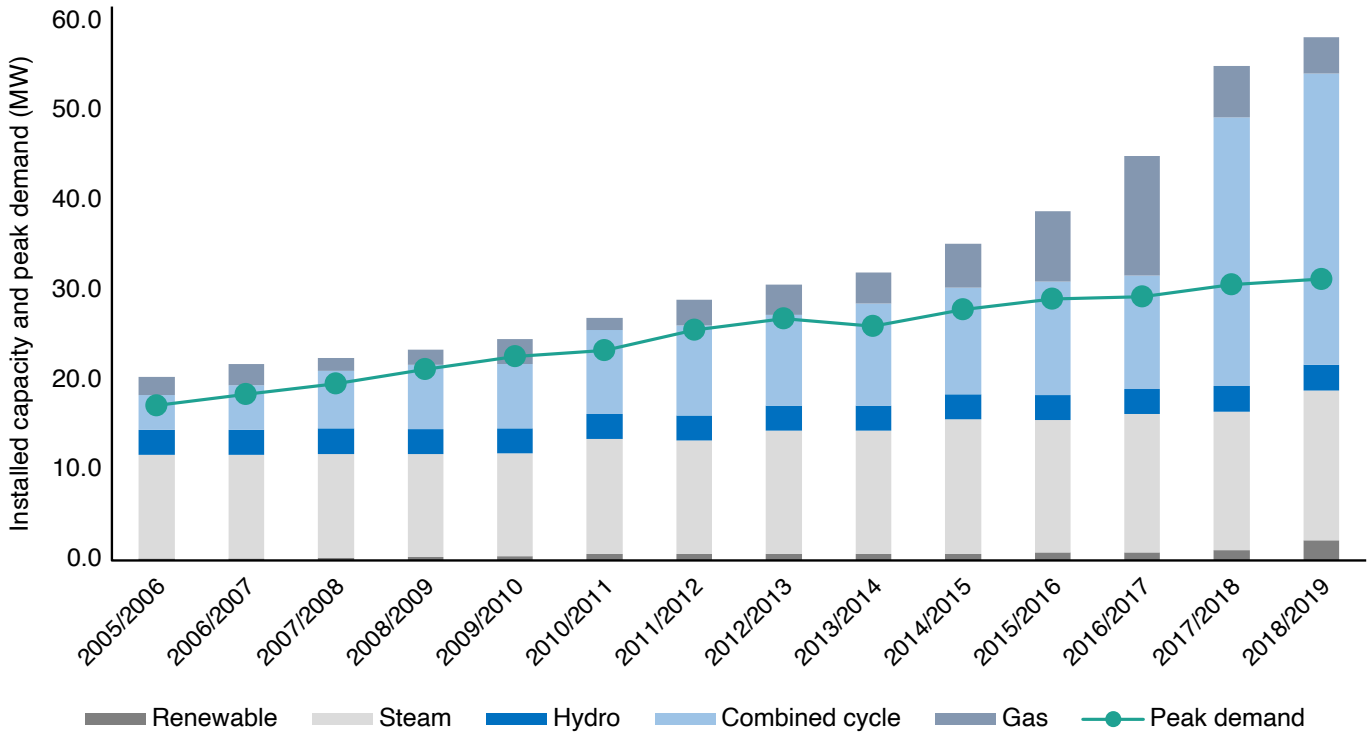
Electricity Supply-Demand: Current Scenario and Future Outlook

Home to 100 million, the Arab Republic of Egypt is the most populous country in the MENA region and the Arab world. Its electricity demand has risen at an average rate of around 6% per year over the last decade, with peak demand climbing from 17.3 gigawatts (GW) in 2005/2006 to 31.4 GW in 2018/2019 (Figure 2). This increase has been driven primarily by industrial development (fueling average GDP growth of 5.3% from 2002 to 2014), population growth (from 65.9 million in 2002 to 99.2 million in 2019) and intensified urbanization (RES4MED 2015, CAPMAS 2020). Although peak demand fell slightly during the political turmoil of 2013/2014, the overall trend has continued upward.

Earlier projections derived from the TIMES-Egypt Model (developed as part of EU technical assistance to support the reform of the energy sector in Egypt) estimate that peak demand will rise from 35 GW in 2018 to 43 GW in 2020, 62 GW in 2030, and 76 GW in 2035. These projections correspond to the medium growth scenario considered in the TIMES-Egypt model, which assumed an average of 5.2% GDP expansion during this period (Figure 3) (EgyptERA 2010). However, actual peak demand in 2018/2019 turned out to be significantly lower at 31.4 GW, making it unlikely for peak demand to reach the above levels in the near future. The slower-than-expected growth in electricity demand can primarily be attributed to the five-year plan for electricity tariff (price) reform implemented by Egypt's Electric Utility and Consumer Protection Regulatory Agency (EgyptERA). Consumers reduced electricity demand as a result of higher electricity tariffs. It was initially expected that demand would resume once this price reform program ended in 2018/19. However, in order to absorb the additional impact of currency devaluation in 2016/2017, the tariff reform program was extended until 2022. Therefore, with the emerging indications of further increases in electricity prices, demand may continue to be dampened.

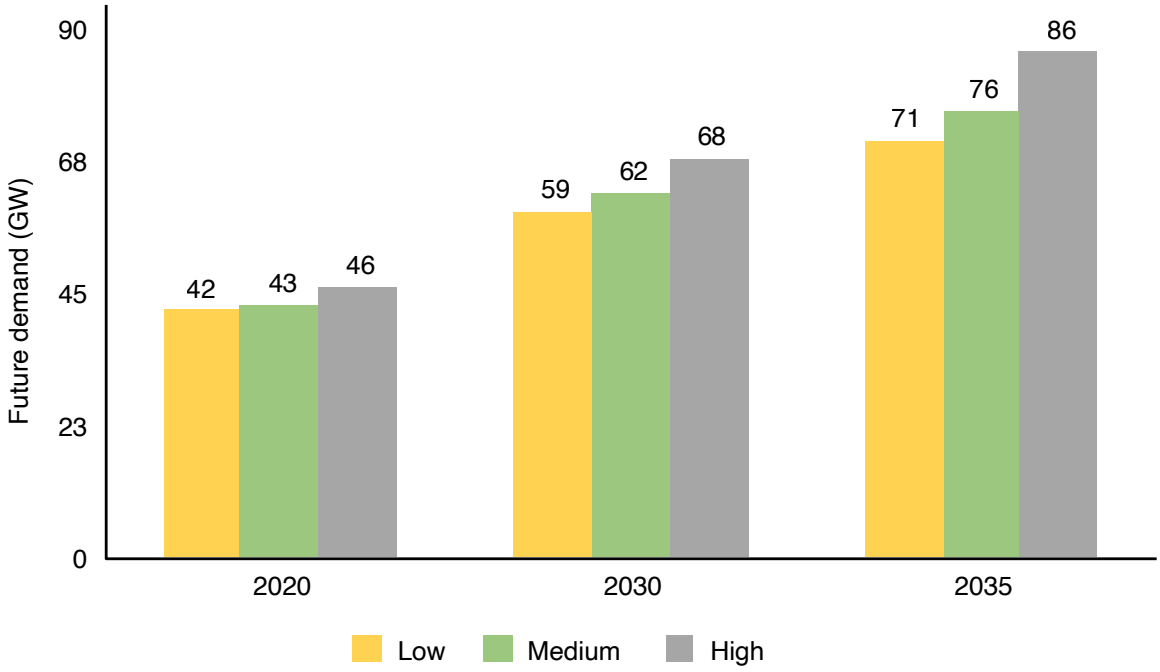
The Integrated Sustainable Energy Strategy to 2035 (ISES 2035), released by Egypt's Ministry of Electricity and Renewable Energy (MoERE) in 2015 and approved by the Supreme Council of Energy the following year, includes electricity production forecasts for 2020, 2030 and 2035. MoERE projected that electricity output would increase at an average rate of 4.48% from 2016/2017 to 2034/2035, lower than the 5.51% recorded from 2001/2002 to 2018/2019. Yet according to a more recent analysis, electricity consumption will rise at an average annual rate of 4.1%, and peak demand by 3.4%, for the period 2020 to 2040 (EU Project on Renewable Energy and Energy Efficiency 2020).

Figure 2. Development of installed capacity and peak load.



Sources: EEHC Annual Reports 2010, 2012, 2017, 2018 and 2019.

Figure 3. Projected peak demand under EgyptERA economic growth scenarios.



Source: EgyptERA 2010.

Electricity Supply-Demand: Current Scenario and Future Outlook

Egypt has long suffered from inadequate power supply and frequent power cuts. In the early 2010s, political turmoil quickened an already impending natural gas shortage and fiscal crisis (Fahim and Thomas 2014). By 2014, the government had accumulated 6.2 billion United States (U.S.) dollars (US$) in debt to gas production partners, which halted maintenance of existing operations and ceased development of newly discovered fields. At the same time, the Egyptian government stopped offering concessions for the exploration of new oil and gas resources, and 3.2 GW of ongoing projects were also delayed.

Ineffective utilization of existing power generation capacity exacerbated the challenges above. Primary causes for this include aging electricity production infrastructure, variation in fuel quality, the adverse impact of high summertime temperatures on the performance of gas-based units, and the dependence of hydropower plants on unstable volumes of irrigation discharge (EEHC 2017). These challenges worsened the electricity supply crisis in 2012-2015 and intensified public frustration.

Following the 2014 elections, the new government responded by launching a drive to modernize Egypt's power sector and improve its electricity infrastructure, primarily through two initiatives.

> To address the fuel supply shortage, the government prioritized increasing natural gas imports. It built a new import facility at El Shokhna on the Gulf of Suez and rented two floating regasification units, facilitating a rise in imports to an average of around US$ 2.5 billion per year from 2015 to 2018. The government also reached an agreement with the foreign gas production partners to reschedule the accumulated debt.

> To expand generation capacity, the authorities launched a 'fast track' scheme for immediate projects in 2015 and a longer-term development plan. The former expedited 3.2 GW of delayed projects and 3.6 GW of new ones (primarily simple gas turbine plants that were later converted into combined-cycle plants to improve efficiency). The long-term plan was expanded to include a 14.4 GW, 6 billion euro mega project that was planned to be commissioned in 2018, comprising three 4.8 GW combined-cycle plants located at Bani-Sueif, Al-Burulus, and Cairo (near the New Administrative Capital) (Tawfeek 2018).

Alongside its push to enhance Egypt's fuel supply and gas-based power generation, the government sought to accelerate the country's transition to renewable energy (RE). To encourage independent private sector RE projects, in December 2014 the government passed law no. 203/2014, which launched a feed-in-tariff program for both solar photovoltaic (PV) and wind energy. This led to private sector development of 1,465 MW of solar PV (Benban Solar Complex) and 250 MW of wind projects in the Gulf of Suez from 2015 to 2017. A bidding program for RE continued, which resulted in offers to build 1,500 MW of new wind projects by the end of 2019. These added to publicly built wind plants with capacities of between 1,160 MW and 140 MW, and a solar thermal hybrid plant, including 20 MW of concentrated solar power (CSP) capacity.

The authorities also took steps to incentivize households and businesses to install solar PV systems. Most notably, EgyptERA adopted a 'net metering' program, which allows customers to set up solar plants within their premises to meet all or part of their electricity requirements, feeding any surplus into the grid with the option to claim it back when needed. Along with rapidly declining prices for solar PV technology, this has led to a rise in

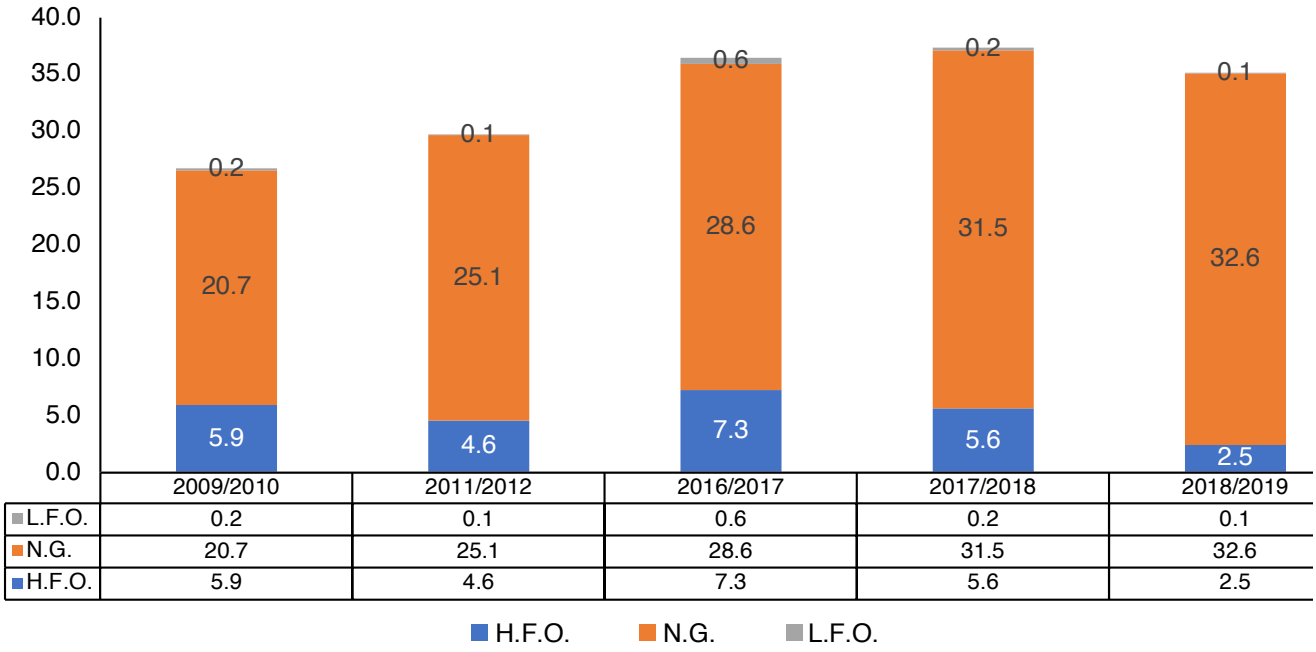
Egypt's installed distributed solar PV capacity to 120 MW as of the end of 2019. This continues to grow aggressively as the total cost per unit of electricity produced by distributed solar PV has fallen below parity with power from the grid. The reason behind the limited total installed capacity is that the net metering scheme has yet to be effectively applied and feed-in-tariff prices were insufficiently attractive to potential investors.

The above efforts to increase traditional and renewable energy capacity raised Egypt's total electricity supply (installed generation capacity) to 58.4 GW by 2018/2019, far above the peak demand of 31.4 GW in 2018/2019. This translates to a reserve margin of around 80%, much higher than the 10-20% called for by standard industry practice, but the government argues that demand will likely increase rapidly in the future as economic growth accelerates (Butter 2019). Furthermore, plants accounting for 13.2 GW of capacity will soon reach the end of their operating lifetimes or be retired due to lack of size or efficiency (Khaled and Abdel 2018).

As of 2018/2019, natural gas accounted for approximately 87% of fuel used for electricity production on an equivalent heat content basis, and heavy fuel oil accounted for virtually all the rest (Figure 4). Despite the high potential of renewable energy sources, in particular wind and solar, their contribution to the supply mix remained very low (2% by capacity and 1.5% by electricity generation). Hydroelectric generation, which has remained relatively stagnant since 2005/2006, represented 5.1% by capacity and 6.8% by electricity generation. Currently, Egypt has neither coal nor nuclear power in its electricity generation mix but both are being explored as part of future energy mix. The use of ultra-supercritical coal-based technology was suggested to mitigate the associated environmental impacts and align with Egypt's 2030 Agenda, which aims to reduce carbon dioxide emissions and the country's overall carbon footprint. However, it is likely that the decision to build a coal-fired power plant might either be postponed or reconsidered following the declining costs of renewables and recent natural gas discoveries. For now, gas-based (especially combined cycle gas turbine [CCGT]) power generation technologies will likely remain the main source of electricity production and by far the most relevant 'price setting' technology in the coming decades (RES4MED 2015).

Over 99% of Egypt's population has access to electricity as of 2019. On the demand side, residential consumption accounted for 42.4% of electricity sales in 2018/2019, down from 47% in 2015 (Figure 5).

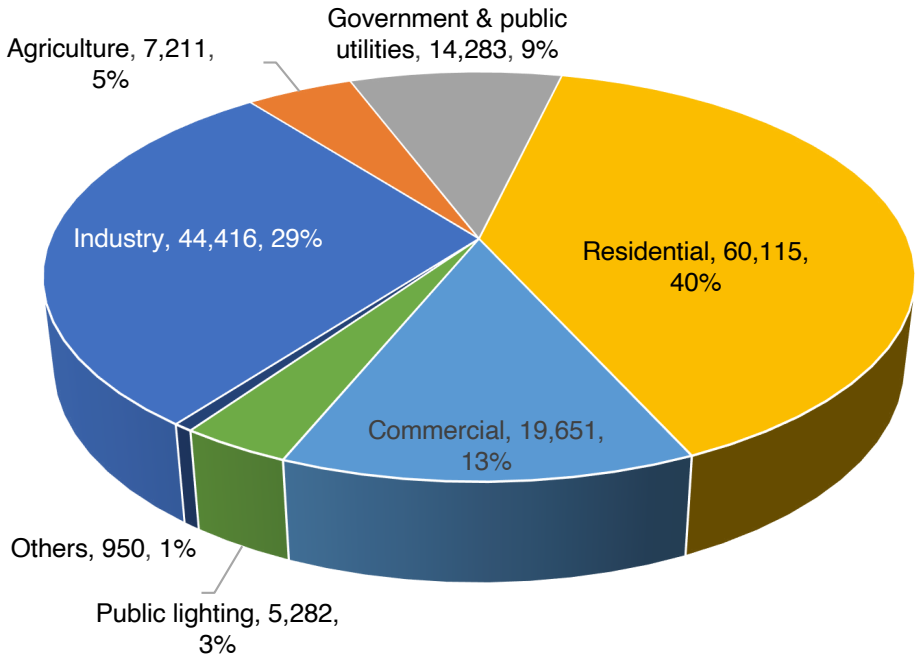
Figure 4. Fuel consumption for power generation, Mtoe.



	2009/2010	2011/2012	2016/2017	2017/2018	2018/2019
L.F.O.	0.2	0.1	0.6	0.2	0.1
N.G.	20.7	25.1	28.6	31.5	32.6
H.F.O.	5.9	4.6	7.3	5.6	2.5

Source: EEHC Annual Report 2010, 2012, 2018 and 2019.
Mtoe = million tonnes of oil equivalent
H.F.O. = heavy fuel oil; N.G. = natural gas; L.F.O. = light fuel oil

Figure 5. Electricity sales by consumer categories (GWh), 2018/2019.

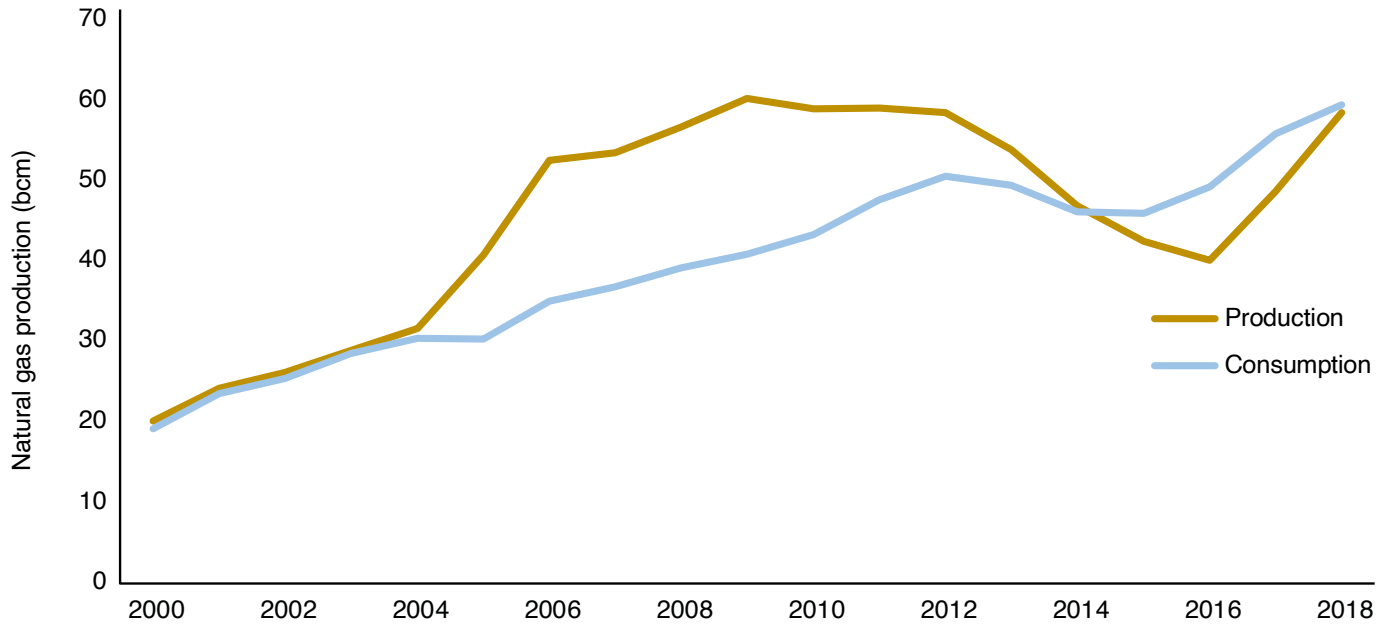


Source: EEHC Annual Report 2019.

The New Energy Sector Strategy and Challenges of Transition

By the early 2010s, Egypt faced a power supply shortfall brought on by rapidly growing electricity demand and declining natural gas production, challenges deepened by the government's failure to develop sufficient supply and distribution infrastructure and address operational inefficiencies. From 2005 to 2013, the country produced substantially more natural gas than it consumed, with output peaking at 60.4 billion cubic meters (bcm) in 2009, versus consumption of 40.9 bcm (Figure 6). Yet by 2015 Egypt was forced to begin importing natural gas to match rising consumption. The dependence on natural gas for electricity production was never a problem when Egypt was producing a surplus. However, when Egypt's natural gas production declined, it deepened the crisis in its electricity sector.

Figure 6. Domestic natural gas production and consumption.



Source: Statistical Review of World Energy—2019, BP.

To meet this burgeoning energy demand and support economic development, the government developed ISES 2035, a blueprint for the future of Egypt's energy sector, as part of an EU-funded technical assistance cooperation project. ISES 2035 aligns with Egypt Vision 2030 (MICT 2015), the national development plan launched by the president in May 2016. ISES 2035, which received Supreme Council of Energy approval in October 2016, aims to ensure continuous, diversified energy security and create the necessary conditions to increase the development of renewables through the engagement of all sectors. The strategy also confirms Egypt's ambition to become an energy hub for Europe, Asia and Africa by expanding grid interconnections across the Arab region and beyond. ISES 2035 includes the following strategic directions (EU 2015) for growth and development of the country's energy sector.

Enhancing energy supply security — As fuel shortages worsened in 2014, Egypt's electricity sector struggled to keep pace with rising energy demand. ISES 2035 stresses the importance of maximizing the utilization of available energy resources and diversifying the energy supply away from oil and natural gas. These steps will not only increase energy security but also improve the sustainability of the energy value chain. Furthermore, ISES 2035 calls for enhancing international interconnections to allow access to less expensive resources and achieve a higher return on investments.

Accordingly, ISES 2035 prioritizes renewables and targets raising the share of RE in the national electricity mix to 20% by 2022 and 42% by 2035. While resetting the ISES 2035 targets in 2015, it adopted the previous goal, set by Egypt's Supreme Council of Energy in February 2008, to increase the share of renewables to 20%, comprising wind (12%), hydro power (6%) and solar PV (2%) by 2020. However, it postponed it by two years. By 2015, renewables accounted for only 2.3% of Egypt's energy mix, making the proposed timeframe less realistic.

As energy security worsened in the early 2010s, the authorities also considered coal-based power generation as a means to end the immediate crisis and diversify the supply mix. As of 2016, EV2030 projected that coal-based power generation would climb as high as 29% of the electricity mix by 2030 (MICT 2015). The Egypt Electricity Holding Company (EEHC) signed a memorandum of understanding in 2015 to develop a 4 GW clean coal power plant. The government also amended the environmental protection law to encompass regulations pertaining to the handling and use of coal and other fossil fuels. However, due to improved economic conditions, surplus electricity production, and the likelihood of additional costs associated with building a special port, planned coal-based power projects were later suspended or cancelled (DNE 2019).

Ensuring the financial sustainability of electricity companies — By the 2010s, years of underpriced electricity left the sector in a state of insolvency. This discouraged much-needed investment and forced the government to increase its spending on energy subsidies, weakening its fiscal position. In response, ISES 2035 prioritizes ensuring the financial sustainability of electricity companies through reforming electricity tariffs to reflect the true economic cost of electricity. The plan also incorporates financial restructuring and other efforts to reduce the firms' cost of credit.

Improving institutional and corporate governance — ISES 2035 emphasizes the importance of independent energy sector regulatory bodies and the need to enable them to effectively achieve policy objectives. It also calls for the further development of energy policy planning processes and creating authorities for monitoring and evaluating energy strategy, including energy efficiency objectives.

Improving energy and resource efficiency — Energy and resource efficiency represent highly cost-effective paths to improving energy security, reducing supply shortages, and mitigating environmental impacts. The National Energy Efficiency Actional Plan (NEEAP), a precursor to ISES 2035 launched in November 2012, aimed to achieve cumulative energy savings of 5% by 2015 through strategic planning, efficiency standards and labels, and public awareness campaigns. The authorities retired the plan in 2015 ahead of the launch of ISES 2035.

ISES 2035 targets reducing 18% of overall energy demand by 2035 through enhanced energy efficiency, focusing on three main sectors: buildings, industry and transportation. The combined savings are expected to be equivalent to 20 million tonnes of oil equivalent (Mtoe) by 2035. To achieve this, the strategy requires electricity utilities to increase their operational efficiency through upgrades to existing generation and transmission infrastructure and adopting new technologies. ISES 2035 also aims to improve transmission and distribution operations to reduce network losses and requires utilities to facilitate the integration of renewables. In October 2018, the Supreme Council of Energy approved NEEAP II (2019-2022), which focuses on achieving the first phase of NEEAP I by strengthening institutional capacity in the energy efficiency space.

Strengthening competitive markets and regulations — To address the dominance of state-owned entities over the energy sector in Egypt, ISES 2035 aims to establish a more competitive and sustainable energy market. This involves liberalizing both the electricity and gas industries to attract investments needed for infrastructure expansion and improving both industries' performance through freer competition. The strategy calls for policies and regulations that create fair and competitive markets, establish and enforce market rules, and ensure effective market surveillance.

ISES 2035 emphasizes the need for enhancing the long-term sustainability of the energy sector through competition and efficiency. The strategy also identifies governance and transparency as other cornerstones of a healthy energy market. ISES 2035 calls for clearly delineating the roles of all public and private participants in the energy system, making utilities and industry players accountable for their performance, developing fair, accessible and transparent energy market frameworks, and encouraging private sector investment (Bianchi et al. 2018). It also recommends phasing out government energy subsidies in a socially responsible manner.

Gradual Transition to a Liberalized Electricity Market

Electricity services began in Egypt in 1893 under private concession. In 1962, the government nationalized electricity companies and grouped them into three public authorities for generation, transmission and distribution, and project execution. In 1965, these became a single vertically integrated entity, the Egyptian General Establishment for Electricity, which the Egyptian Electricity Authority (EEA) replaced in 1976 under law no. 12/1976.

Unlike its predecessors, the EEA could propose electricity tariffs, according to guidelines set by the Supreme Council for Electricity, though to implement rates it ultimately required the approval of the Cabinet of Ministers. The same year, the government established the Rural Electrification Authority (REA) to oversee projects that extend access to electricity into less populous areas, and upon completion transfer them EEA. In 1978, EEA created and held ownership of seven geographical distribution companies, and in 1983 spun these firms off into the General Authority for the Distribution of Electric Power (GADEP). Initially, the Ministry of Electricity oversaw both EEA and GADEP, but in 1993 the Ministry of Public Enterprises took charge of the General Authority and changed it to Holding Company for the Distribution of Electric Power (Rana and Ashish 2020). The move was seen as a first step toward privatization, though in the end this never occurred.

Mid 1990s — Engaging the private sector for electricity production

For over three decades after nationalization, state-owned EEA and its predecessors monopolized electricity generation, transmission and distribution services in Egypt. However, in 1996, the government passed law no. 100/1996, allowing the private sector to re-enter the electricity generation sector. The authorities had two main objectives for re-engaging the private sector: to free up state resources for use elsewhere and to increase the operational efficiency of Egypt's electricity sector.

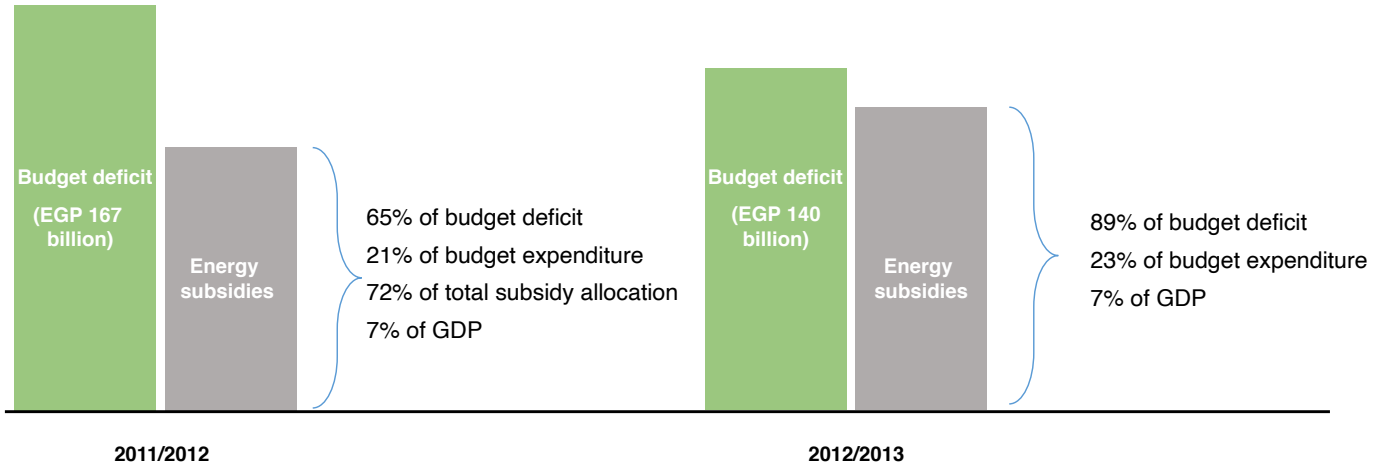
Article 7 of the law permitted both local and international firms to set up electricity-generating plants under build, own, operate, and transfer (BOOT) arrangements with the EEA. A year later, a new investment law provided further incentives to prospective investors by offering them state guarantees to safeguard their business risks. The state utility offered independent power producers (IPPs) 20-year power purchase agreements (PPAs), in line with those elsewhere in the region. From 1996 to 2003, the private sector added nearly 2 GW of capacity, about 10% of the country's total capacity by 2003. However, sharp devaluations of the Egyptian pound (EGP) in 2001 and 2003 caused 12 out of 15 then-planned IPP projects to be shelved (Eberhard and Gratwick 2007) due to expected increase in PPA tariff denominated in U.S. cents per kilowatthour (kWh). These developments forced the government to recalibrate its strategy of engaging the private sector to more fairly distribute market risks. Nonetheless, the early IPP projects helped restart foreign investment after nationalization and made tariffs more competitive.

Early 2010s — Ballooning crisis in the power sector

The Arab Spring (2010-2012) saw mass public unrest across many MENA countries, including Egypt. In its aftermath, Egypt's economy faced growing energy demand, declining oil and gas output, and a rising budget deficit. Public pressure to increase wages exacerbated these challenges by raising the spending power of many households, while artificially low electricity tariffs dependent on government incentives remained fixed. This combination led to higher electricity consumption, which climbed 10.3% in 2012 alone, and ballooning fiscal spending on energy subsidies. For the fiscal year 2011-2012, the budget deficit reached EGP 167 billion (Figure 7) (MoF 2012), equivalent to 90% of Egypt's total spending on subsidies, grants and other social benefits. Energy subsidies alone accounted for EGP 108 billion, equivalent to 7% of its GDP, 21% of the state's entire EGP 516.4 billion budget expenditure, or 72% of its total subsidy allocation (Ghoneim 2014). Spending on energy incentives rose further in 2012/2013.

A significant portion of the subsidies, EGP 17 billion in 2011/2012, went to electricity generators through subsidized fuel prices while incentives provided by electricity companies to consumers reached EGP 11 billion in 2011/2012. Thus, the government supported the electricity sector both on the generation (through oil and gas price subsidies) and retail side to keep consumer tariffs low. Such subsidies not only pose fiscal challenges for the government but also discourage investment in higher operational efficiency, lower-emission traditional carbon-based power generation, and RE.

Figure 7. Growing fiscal deficits and spending on energy subsidies.



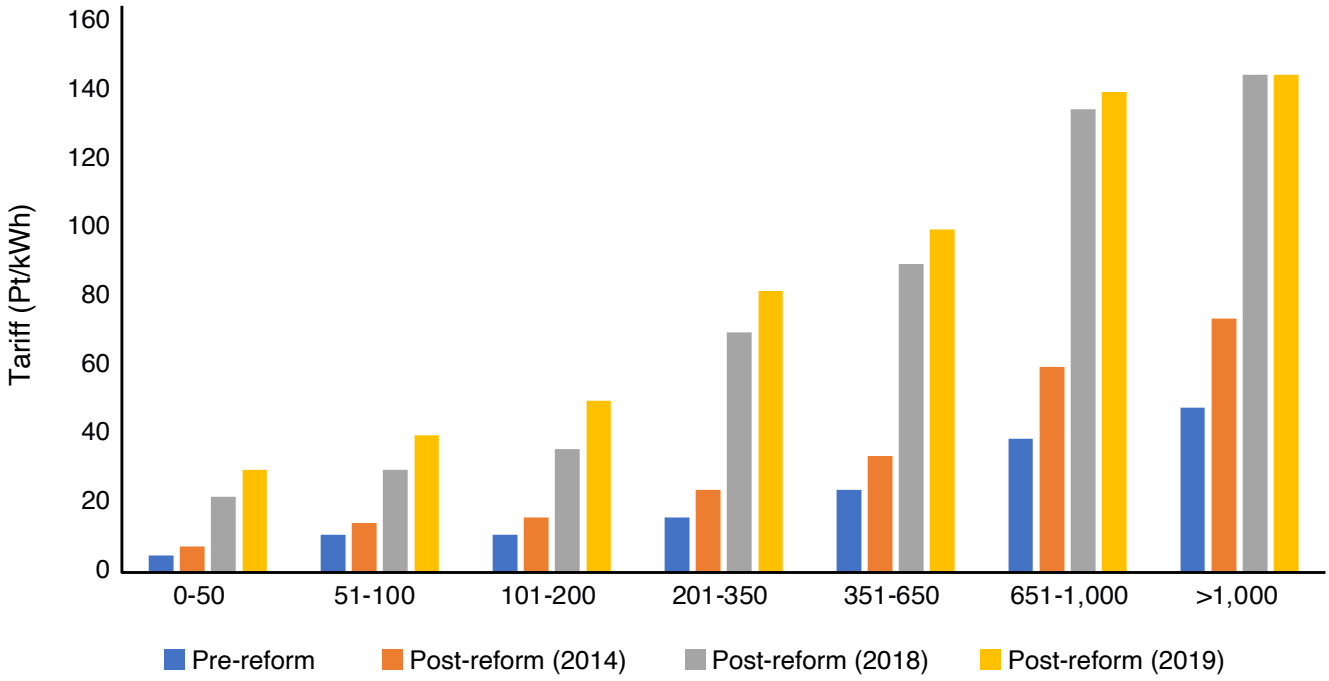
Sources: MoF 2012, 2013.

Although after the establishment of an electricity regulator, i.e., EgyptERA, the EEHC increased the electricity tariffs from 2004 (El-Salmawy 2010), fuel prices also rose, making it difficult for the government to reduce energy subsidies. Poor cost recovery, only around 30% in 2013 (ESMAP 2017), added to the unsustainable economics of Egypt's electricity industry.

Mid 2010s — Rethinking the reform process

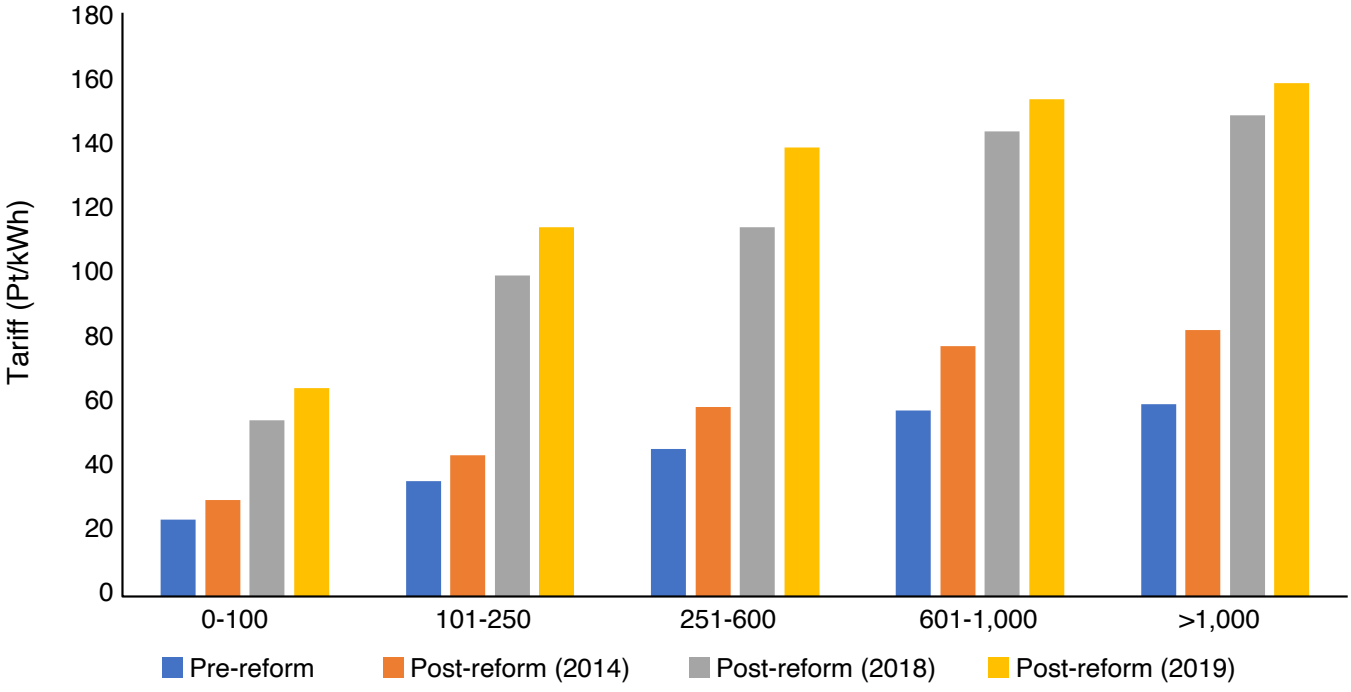
As subsidies continued to hurt the financial performance of the sector and discourage much-needed investment, the government realized that the electricity sector must transition toward a more sustainable and competitive model. In 2013 the authorities requested assistance from the World Bank to provide inputs to redesign the reform strategy. The organization provided a thorough assessment of the ongoing reform process, review of global experiences in subsidy reforms, and alternative scenarios for discussion with the government (ESMAP 2017). Following this, in July 2014 the government announced comprehensive fuel and electricity reforms. EgyptERA increased electricity tariffs by an average of 50% for domestic consumers across various consumption ranges, except the 51-100 kWh per month bracket, for which it limited the hike to 32% (Figure 8). Meanwhile, it raised commercial electricity tariffs by an average of 30% (Figure 9). The authorities also reduced fuel subsidies depending on usage. For energy-intensive industries, the price of natural gas rose substantially (from ~130% for metal industries to ~204% for glass and ceramics industries), but it remained relatively low (~69%) for electricity production, with gas prices only increasing from US$1.77 to US$3.0 per million British thermal units (Btu) (James 2015). As a result of another significant EGP devaluation, in July 2017 EgyptERA increased electricity prices again by an average of 143% for users. However, this time, the price hike most severely affected households consuming 50 kWh or less per month, for which rates jumped 193% on average.

Figure 8. Tariff increase for domestic consumers (pre- and post-reforms).



Source: EEHC Annual Report 2014, 2018 and 2019.
Pt = piastres

Figure 9. Tariff increase for commercial consumers (pre- and post-reform).



Source: EEHC Annual Report 2014, 2018 and 2019.

Market Opening and Unbundling: Past and Future Developments

The electricity sector reforms that started in the late-1990s have been progressively expanded. The key developments, reform strategies, market players and their mandates, design and implementation challenges, and future goals are discussed below.

Late-1990s — The start of structural and institutional reforms

To encourage private investment in power projects, in 1996 the government passed law no. 100/1996, which allowed the private sector to build, own and operate power plants and sell the produced electricity to the EEA, according to concession agreements as well as long-term PPAs. Accordingly, three contracts were signed with a total capacity of 2 GW. Thus, law no. 100/1996 provided the foundation to kickstart the reform program in the electricity sector.

A study of Egypt's energy sector conducted in 1996 by Maryellen Lynch, an international consultant, recommended the following reform measures:

- Corporatization of EEA.
- Developing contracts for fuel supply between the Egypt General Petroleum Cooperation and the electricity companies.
- Dismantling the REA and moving its assets to the electricity companies.
- Allowing private sector ownership of the electricity companies.
- Establishing an electricity regulatory authority.
- Allowing the private sector to invest in power-generation projects through concessions and long-term PPAs with EEA.
- Tariff reforms based on economic considerations and removal of government subsidies.

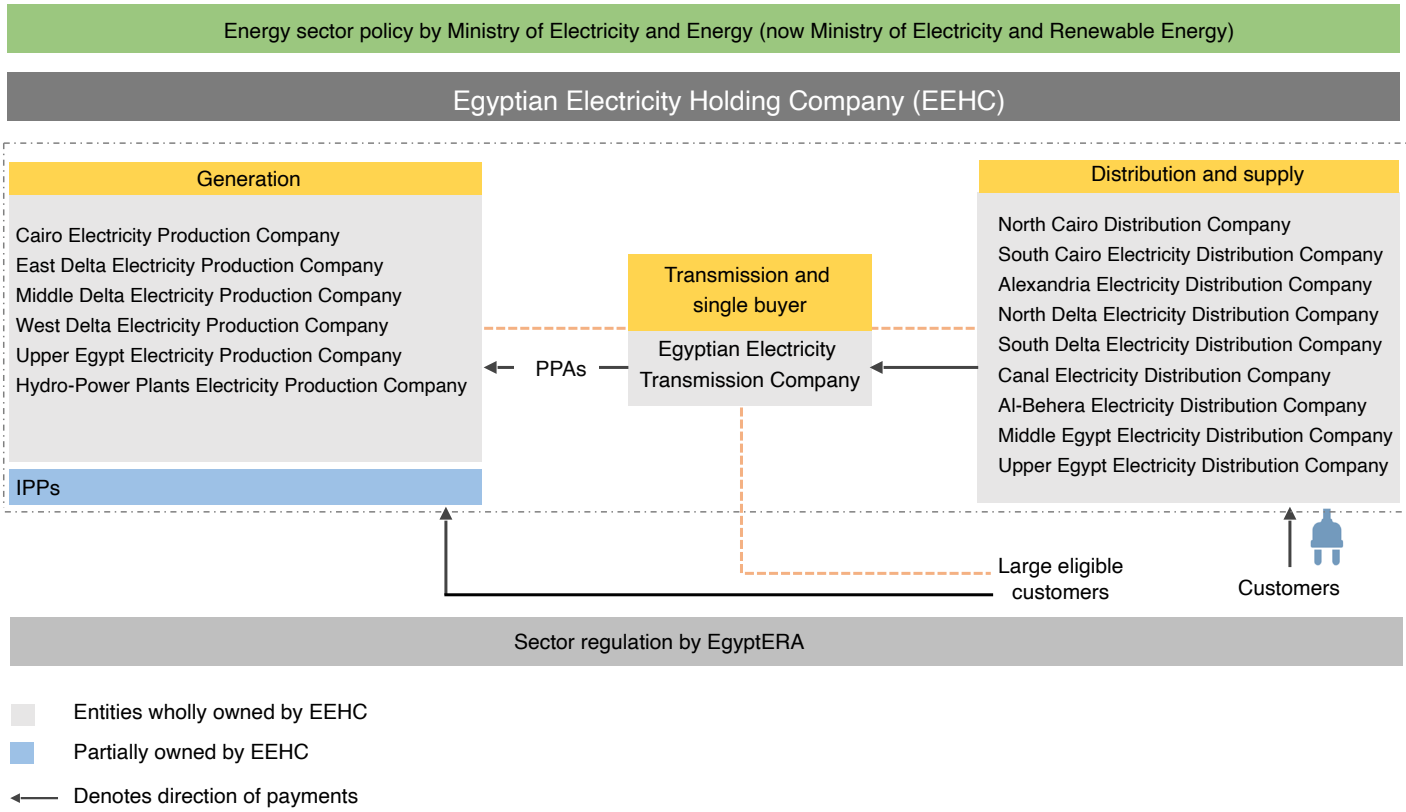
In 1998, law no. 18/1998 reassigned distribution companies to the EEA from the public enterprises ministry. These companies, plus the geographically relevant generation and transmission assets belonging to EEA, formed seven vertically integrated regional companies under the EEA. These companies followed the joint stock corporate law no. 159/1989, which permits up to 49% public ownership through public subscriptions based on approval from the Cabinet of Ministers.

In 2000, the government formed EEHC under law no. 164/2000. It inherited the roles previously played by the EEA and became the entity primarily responsible for planning, execution and operation of the electricity sector. In 2001, EEHC legally unbundled electricity generation and transmission (distribution was already unbundled in 1979). Initially, it carved out five generation companies, one transmission company, and seven distribution companies from the seven vertically integrated regional companies operating under EEA; in 2004, it added one more generation company and two distribution companies. All of these EEHC-affiliated companies were formed as joint-stock companies but no sale of shares to the public ever transpired (Rana and Khanna 2020).

The Egyptian Electricity Transmission Company (EETC) was established as one of the subsidiaries of the EEHC. Unlike the widely adopted restructuring model, where a transmission company is only made responsible for the management, operation and maintenance of the grid, the EETC was also designated as the sole purchaser (and seller) of bulk electricity (Figure 10). However, IPPs could sell power to their direct customers under bilateral contracts. In such cases, the IPPs would sign a connection and use of network agreement with the EETC, which was required to grant transmission access, while the IPPs remained responsible for obtaining the site and the fuel supply to their power plants. The EETC set transmission wheeling charges on the basis of network cost recovery, subject to approval by the regulator i.e., EgyptERA. Yet as of 2018, only two such contracts have materialized. Table 1 summarizes the key business functions performed by EEHC, EETC and distribution companies.

Although the government formulated the first regulatory framework in 1997, EgyptERA was established under Presidential Decree 399/2000 as an independent government body to regulate, supervise, and develop all aspects of the electricity value chain. Its responsibilities included: licensing, performance benchmarking and evaluation, cost of service procedures, and competition and market development. However, EgyptERA essentially played an oversight and advisory role as final tariff and subsidy decisions remained with the Cabinet of Ministers (Rana and Khanna 2020).

Figure 10. Electricity sector institutional structure.



Source: Author's representation.

Table 1. Functions of key entities.

Entities	Key responsibilities
Ministry of Electricity and Renewable Energy (MoERE), previously the Ministry of Electricity and Energy	• Set and implement policies and general development plans for the electricity sector. • Restructure the electricity sector to optimize investments and improve electricity services. • Suggest electricity tariffs to the Cabinet of Ministers for their approval. • Support access to electricity for urban areas and low population communities. • Expand the utilization of new and renewable energy resources and develop peaceful uses of nuclear power. • Publish the statistics and data relating to electric energy production and consumption. • Supervise the study and implementation of important electrical projects. • Provide technical consultancy and services to Arab countries and others in the field of electricity. • Support the regional/international interconnection of the Egyptian electricity grid with other countries.
Egyptian Electricity Holding Company (EEHC)	• Oversee and monitor the activities of affiliated companies as an integrated economic unit. • Coordinate planning and investment and manage finances for the sector. • Develop five-year plans to meet the expected increase in demand by optimizing the use of available energy resources. • Manage the implementation of projects to produce electricity from thermal power plants. • Promote energy efficiency and conservation among suppliers and end-users. • Improve the performance of the power sector to ensure sustainable electricity supply and facilitate economic and social development. • Provide electricity to all customers through available resources at competitive and affordable prices. • Coordinate with the New and Renewable Energy Authority for generation and transmission planning required for renewable energy projects.
Egyptian Electricity Transmission Company (EETC)	• Manage, operate and maintain the transmission grid. • Purchase electricity from generating companies according to demand and sell power to electricity distribution companies and other customers on ultra-high and high voltages. • Cooperate with the EEHC to prepare technical and economic studies to meet the demand on electricity and its stability. • Implement electricity transmission projects approved by EEHC and interconnection projects approved by MoERE. • Conduct forecasting and analysis, including of customer demand and the financial and economic performance of the company.
Distribution companies	• Distribute and sell electricity to customers on medium and low voltage. • Manage, operate and maintain medium and low voltage grids. • Prepare forecast studies on load and energy for customers. • Manage, operate and maintain isolated generation units not connected to the primary grid.
Generation companies/IPPs	• Produce electricity for sale to the EETC and large eligible customers.[2] • Sign a PPA with the EETC and a Fuel Supply Agreement (FSA) with the fuel suppliers.
Electric Utility and Consumer Protection Regulatory Agency (EgyptERA)	• Economic and technical regulation of the generation, transmission and distribution activities in the electricity sector.

2015 — Bringing stalled reforms on track

On July 7, 2015, the president approved law no. 87/2015, known as the 'Electricity Law,' which aimed to deepen structural reforms. It built on the earlier legislation that established private sector concessions for generation (in 1996), unbundling and corporatization of the EEA (in 2000). By this time, various efforts to overcome the chronic power shortages had successfully improved electricity supply and security, and expanded electricity access across the country. However, as explained above, despite electricity price reforms that commenced in 2005, the financial dynamics of the sector remained unsustainable due to continued reliance on government subsidies. Furthermore, reforms had stalled in 2011/2012 due to civil protests during the Arab Spring. The Electricity Law called for several changes to the structure of the electricity industry and paved the way for gradual market liberalization. The transition from the current market structure to a more liberalized and competitive market is expected to be achieved over the next eight years, effective from the date of the Electricity Law (July 9, 2015). The eight-year period set in the law is for the restructuring of the EEHC according to the law. Figure 11 provides a schematic representation of the future competitive electricity market structure. Some of its key features and objectives are summarized below.

Expanding the scope of private sector participation — The Electricity Law simplifies the legal licensing regime for private sector participation (for both domestic and foreign firms) in electricity generation and allows private sector entry into electricity distribution.

Restructuring the electricity industry to improve efficiency and enable competition — The Electricity Law envisions full market liberalization to be gradually achieved. It calls for unbundling competitive (generation and supply) from non-competitive (transmission) activities in the electricity value chain over several phases. The core objective is to establish a fully competitive electricity market, where electricity generation, trading, transmission and supply activities are fully unbundled. During the interim phase, both competitive and regulated markets will coexist for a separate sector of consumers. As the process continues, the competitive market will expand on the expense of the regulated market, until a full competitive market is achieved.

In the first phase of development of the competitive market, monopolistic electricity suppliers will be replaced with competing suppliers, and consumers on high voltage will be allowed to freely choose their electricity suppliers based on bilateral direct agreements and negotiated electricity prices with present/future generation companies (Sharkawy and Sarhan 2015). In the second phase of market transition, ancillary services and stabilization powers will also be provided through the competitive wholesale market. In the regulated market, non-eligible retail consumers on low voltage will pay a regulated tariff to the distribution companies. After the implementation of the third and final phase, the distribution companies can source their electricity from producers and/or authorized suppliers (i.e., traders).

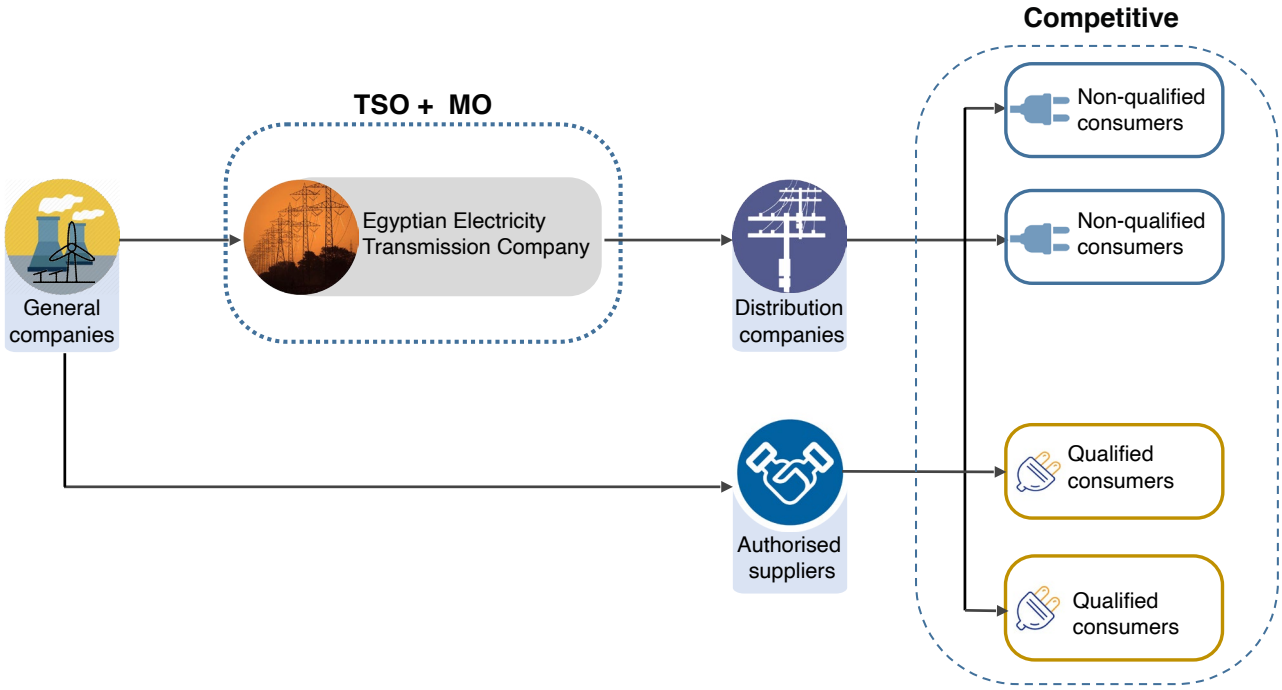
2. However, this was not allowed until the issuance of law no. 87/2015. Yet even after the issuance of the law, this will be subject to the market design document (requested by the law in Article 65) regarding the role of public companies in the competitive market. This market document includes the transitional plan, detailing the phases for market opening.

Encouraging competition through open access and third-party sales — Previous regulatory provisions allowed access to the grid for the third-party sale of electricity. However, the Electricity Law reinforced the need for guaranteed access to the grid without any discrimination for producers (including RE firms) and qualified consumers on a clear and transparent basis.

Creating an independent grid operator to enhance transparency — The Electricity Law requires the EETC to be reorganized as a state-owned entity completely independent of EEHC and other market participants. However, the EETC as a transmission system operator (TSO) will continue to exercise its mandate to manage, operate and maintain the grid, making it available to all parties without bias. An autonomous unit within the EETC that enjoys independent financial and administrative status will serve as market operator (MO) to administer the competitive market. As an MO, it will be responsible for matching and settlement of power supply and demand bids. In addition, EETC will draft the transmission code and market rules (under articles 32 and 33 of the Electricity Law) in collaboration with relevant market participants, for final approval by EgyptERA.

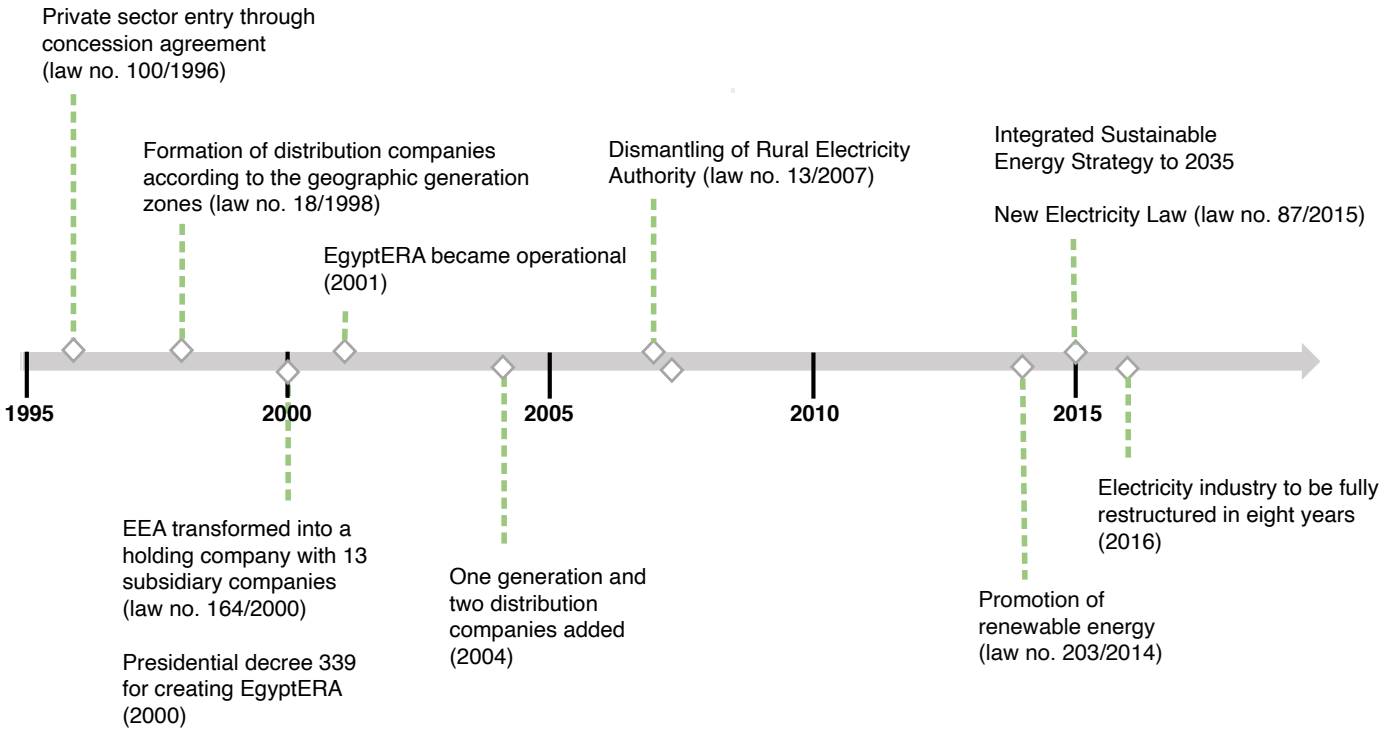
Regulating the sector through an independent agency — The Electricity Law redefines and strengthens the role of EgyptERA by making it an autonomous institution responsible for regulating all electricity sector activities involving producers, transmission operators, distribution companies and end-users. The law expands EgyptERA's mandate for pricing regulation beyond advisory and monitoring, granting the agency power to determine the rules and economic basis for tariff determination and rationalization. It also requires EgyptERA to play a more proactive role in market liberalization and development, and to mediate disputes between industry stakeholders.

Figure 11. Future view of a competitive electricity sector.



Source: Author's representation.
TSO = Transmission system operator; MO = Market operator

Figure 12. Key reform milestones for the electricity sector.

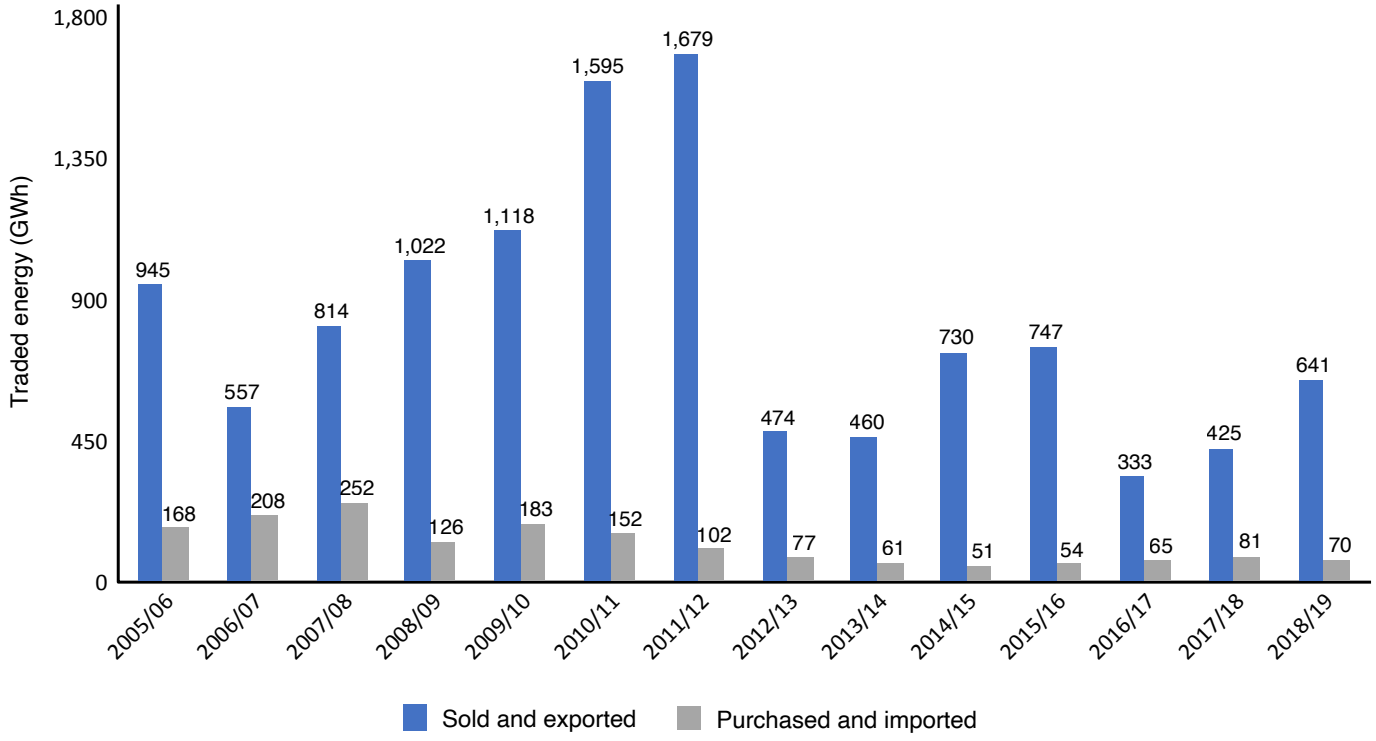


Source: Author's representation.

Evolving Industry Design and Cross-border Electricity Trade

In 1998, the country established its first cross-border interconnections with Libya and Jordan. Although limited in capacity, these saw steady increases in electricity trading (including in-kind exchanges) from 1998 to 2011/2012, when the Arab Spring disrupted MENA economies, including Egypt's. At the same time, the country's declining natural gas surplus further strained cross-border electricity trade (Figure 13). Nonetheless, the government has continued to pursue its vision by adopting new policies to encourage energy trading within the MENA region and beyond (Figure 13). ISES 2035 has reinforced these goals by calling for the Egyptian electricity sector to achieve greater environmental and financial sustainability.

Figure 13. Egypt's electricity trading (including in-kind exchanges) with neighboring countries.



Sources: EEHC 2010, 2014, 2018 and 2019.

Below, key recent and ongoing developments that support Egypt's goal to become an energy hub are highlighted.

- Egypt and Saudi Arabia are developing a 3 GW interconnection between the two countries. It employs 500 kilovolt (KV) high-voltage direct current bipolar transmission technology to connect one substation in Egypt with two substations in Saudi Arabia (in Medina and Tabuk) through overhead lines and a submarine cable across the Gulf of Aqaba (EEHC 2018). This interconnection, when completed, will provide opportunities to trade electricity with other GCC member states through Saudi Arabia.

- Egypt, Cyprus, and Greece signed an initial agreement in 2019 to develop the 2 GW Euro-Africa Interconnector, to connect their grids through the Greek island of Crete. The development, which will be executed as a public-private partnership, has subsequently met delays due to incomplete feasibility studies.

- In 2020, Egypt and Sudan announced plans to increase their existing 70 MW interconnection to 300 MW in the second phase of the linkage by 2021.

- Establishment of the eight countries interconnection project, which includes Egypt, Libya, Jordan, Syria, Lebanon, Iraq, Turkey and the Palestinian Authority. The project encompasses Egypt's interconnections with Libya, Jordan and Gaza.

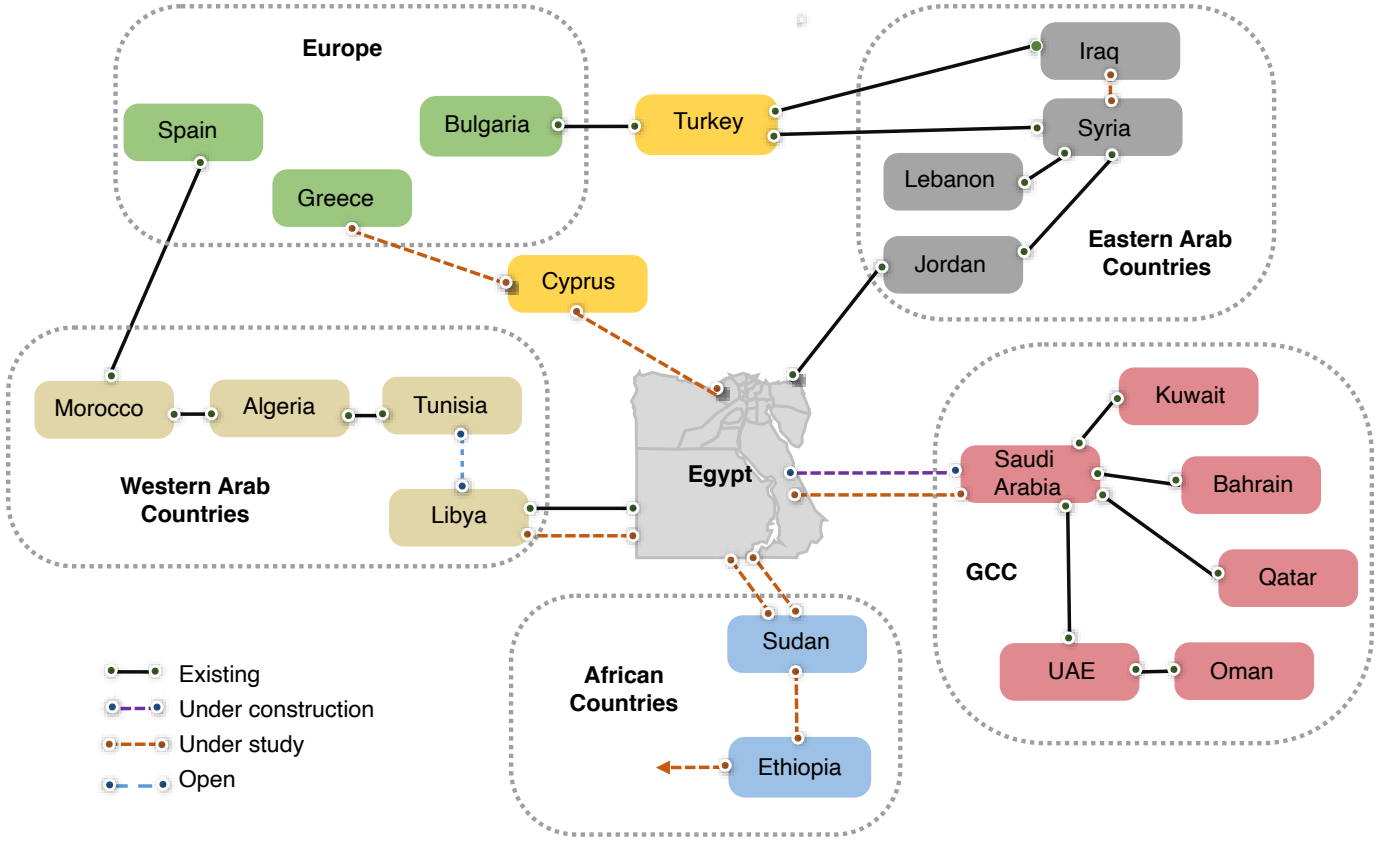
- Egypt has joined the MedRing (Mediterranean Electricity Ring) interconnection project, which aims to link the grids of most of the countries bordering the Mediterranean Sea, thereby also connecting the grids of North African countries to Europe through the existing Morocco-Spain interconnection.

- The Arab Ministerial Council of Electricity, in collaboration with the Arab Fund for Economic and Social Development (AFESD) and the World Bank, is working to establish a common regional electricity market, the Pan-Arab Regional Electricity Market (PAEM). The initiative primarily aims to expand trade exchanges to help meet the growing demand of member countries, including Egypt, in a secure and sustainable manner. Various studies have been completed to examine the compatibility of the legislative and regulatory frameworks of member countries and prepare the market agreements and rules necessary for effective functioning of an integrated regional electricity market. In 2016, the Arab League approved a plan for establishing an integrated Arab electricity market, and in 2017 a memorandum of understanding to this effect was signed by the Arab countries.

Egypt and the other members of the Eastern Africa Power Pool (Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Libya and Uganda) are currently exploring the establishment of an electricity trade market within the bloc.

By joining the Global Energy Interconnection Development and Cooperation Initiative, Egypt aims to benefit in a number of areas, including research on energy strategy, the development of renewable energy, electricity network integration, electricity markets, and energy efficiency and technical consultation on smart grid applications.

Figure 14. Egypt's vision of a central hub for regional and international electricity trading.



Sources: Adapted from EEHC Annual Report 2018.

Summary and Insights

Egypt's government began to reform the electricity sector in 1996 to promote a bigger role for the private sector, and has gradually expanded efforts to improve the performance, governance and sustainability of the electricity industry. In 2000, it took the first major step of corporatizing the EEA into several subsidiary companies under a common holding company. Soon after, EgyptERA became operational, but its powers as a regulator were largely limited to oversight and advisory while key tariff and subsidy decisions remained with the Cabinet of Ministers. The 2015 Electricity Law substantially increased EgyptERA's mandate and independence, making it responsible for regulating all activities ranging from electricity production to consumption. Price setting for both bulk supply and end-use consumption remain an important mandate, but EgyptERA is now required to play a more proactive role in market liberalization and development.

Key features, challenges and opportunities for deeper market liberalization and integration are summarized below.

1. Policy and strategy

By the early 2000s, rapidly growing electricity demand, operational inefficiencies in the sector and the government's failure to add sufficient generation and grid infrastructure caused Egypt's power supply to begin to fall short of demand. The subsequent slowdown in domestic natural gas production deepened the electricity supply crisis and forced Egypt to begin importing gas in 2015. That year, the government released ISES 2035, a blueprint that set a new direction for the growth and development of the energy sector, including the electricity industry. It aims to ensure energy security through diversification of energy supply, including increased deployment of renewable energy technologies. ISES 2035 retains the government's previous target for renewables to provide at least 20% of the power generation mix, but extends the deadline by two years to 2022. It also adds a second-phase target of 42% by 2035, with the private sector expected to deliver most of this capacity.

2. Market structure and design

Since 2000, the market design and structure has not changed significantly. The 2015 Electricity Law proposes structural and other reform measures to gradually transform the performance and governance of the electricity sector and establish a competitive market both at the production and retail end. While this law empowers the EETC to play an important role in market liberalization by setting out market rules (to be approved by EgyptERA) for commerce and settlements in collaboration with other market participants, the responsibility for overseeing the overall sector developments remains with EgyptERA. In the current market structure, the law gives an ownership-independent status to the EETC and adds several important mandates to its current jurisdiction. Going forward, the proposed autonomous MO with financial and administrative independence within the EETC is also likely to add credence to good governance in market operations. MO will be responsible for matching and settlement of the power supply and demand bids in accordance with the applicable rules in the competitive market. The establishment of the market will be according to the market design document which will be proposed jointly by EgyptERA and the Ministry of Electricity and Renewable Energy and approved by the Cabinet of Ministers.

3. Energy hub and market integration

ISES 2035 also envisions Egypt as an energy hub between Europe, Asia and Africa and calls for expanding grid interconnections across the Arab region and beyond. Currently, Egypt trades electricity (including in-kind exchanges) with Jordan and Libya, but several further-reaching developments are underway at various stages of research and implementation. These include the 3 GW Egypt-Saudi Arabia interconnection; an expansion of the Egypt-Sudan interconnection from 70 MW currently to 300 MW by 2021; the 2 GW Euro-Africa interconnector that will link Egypt to Cyprus and Greece; the ambitious Med-Ring project to connect the grids of Mediterranean countries in Africa and Europe; and PAEM, the Arab region electricity market backed by the World Bank, among others.

4. Subsidies, price reforms and energy security

Energy subsidies, though undesirable from a market viewpoint, are present in various forms and to degrees in most systems. However, ballooning subsidies in Egypt during the early 2010s became unsustainable and caused the fiscal deficit to rapidly rise. To put this situation into perspective, the budget deficit for the year 2011-2012 was equivalent to 90% of the spending on subsidies, grants and other social benefits. Energy subsidies alone were 72% of the total subsidy allocation, equivalent to ~7% of country's GDP. These trends continued to worsen in 2012/2013.

To address the impending fiscal crisis, the government announced comprehensive fuel and electricity price reforms in July 2014. The original plan was to align the prices with the cost of service by 2019. However, the devaluation of the EGP in 2017 resulted in a substantial increase in the cost of service due to the increase in fuel prices valued in international currencies. Accordingly, the reform program has been extended by three years (2022) to absorb this additional impact. However, reducing the cross-subsidy to a reasonable level to be socially responsible may lead to an extension of this target.

On the supply side, undoubtedly, Egypt has achieved remarkable success. From 2014, when the government started its push to strengthen energy infrastructure, to 2018, the electricity sector has added 14.4 GW of generation capacity. This has been made possible by the concerted efforts of the government, including effective planning and execution by an independent regulator, and the growing participation of the private sector.

References

Renewable Energy Solutions for the Mediterranean (RES4MED). 2015. "Country Profiles - Egypt." http://www.res4med.org/wp-content/uploads/2017/05/RES4MED-Day-Egypt-2015_Country-profile.pdf

Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA). 2010. "Towards a Sustainable Power Sector in Egypt". Presentation by Dr. Hafez A. El-Salmawy, Managing Director, EgyptERA.

Egyptian Electricity Holding Company (EEHC). 2010. "Annual Report 2009/2010." http://www.moee.gov.eg/english_new/EEHC_Rep/2009-2010en.pdf

———. 2012. "Annual Report 2011/2012." http://www.moee.gov.eg/english_new/EEHC_Rep/2011-2012en.pdf

———. 2014. "Annual Report 2013/2014." http://www.moee.gov.eg/english_new/EEHC_Rep/2013-2014en.pdf

———. 2015. "Annual Report 2014/2015." http://www.moee.gov.eg/english_new/EEHC_Rep/2014-2015en.pdf

———. 2017. "Annual Report 2016/2017." http://www.moee.gov.eg/english_new/EEHC_Rep/2016-2017en.pdf

———. 2018. "Annual Report 2017/2018." http://www.moee.gov.eg/english_new/EEHC_Rep/2017-2018en.pdf

———. 2019. "Annual Report 2018/2019." http://www.moee.gov.eg/english_new/EEHC_Rep/2018-2019en.pdf

Fahim, Kareem, and Merna Thomas. 2014. "Blackouts in Egypt Prompt Accusations." *The New York Times*, August 22, 2014. https://www.nytimes.com/2014/08/23/world/middleeast/blackouts-in-egypt-prompt-accusations.html

Tawfeek, Farah. 2018. "'Egypt has achieved the impossible in the field of electricity': Sisi." *Egypt Independent*, July 25, 2018. https://ww.egyptindependent.com/egypt-has-achieved-the-impossible-in-the-field-of-electricity-sisi/

Butter, David. 2019. "Egypt: Sisi's power surplus." Castlereagh Associates. September 3, 2019. https://castlereagh.net/egypt-sisis-power-surplus/

Ministry of Communications and Information Technology, Government of Egypt (MICT). 2016. "Egypt Vision 2030." http://mcit.gov.eg/Publication/Publication_Summary/1020/

Daily News Egypt. 2019. "EEHC postpones signing Oyoun Moussa coal plant contracts." September 17, 2019. https://wwww.dailynewssegypt.com/2019/09/17/eehc-postpones-signing-oyoun-moussa-coal-plant-contracts/

Bianchi, M., Lorenzo Colantoni, Federico Mascolo, and Nicolò Sartori. 2018. "Assessing EU–Mediterranean Policies in the Field of Energy from a Bottom-up Perspective: The Case of Egypt." MEDRESET working paper, December 2018. https://www.iai.it/en/pubblicazioni/assessing-eu-mediterranean-policies-field-energy-bottom-perspective-case-egypt

References

Eberhard, Anton, and Katharine Nawaal Gratwick. 2007. "From state to market and back again: Egypt's experiment with Independent Power Projects." University of Cape Town Graduate School of Business working paper, October 2007. https://www.gsb.uct.ac.za/files/Egypt_IPP_Experience_April_2006.pdf

Ministry of Finance, Government of Egypt (MoF). 2012. "Final Account of the State's General Budget for the Fiscal Year 2011/2012." http://www.mof.gov.eg/MOFGallerySource/English/PDF/final%20aacount2011-2012.pdf

———. 2013. "Financial Statement of State's General Budget for Fiscal Year 2012/2013." http://www.mof.gov.eg/MOFGallerySource/English/PDF/Financial-Statement2012-2013.pdf

Ghoneim, Ahmed Farouk. 2014. "Egypt and Incentives: A Country Living Beyond its Means." Middle East Institute. May 5, 2014. https://www.mei.edu/publications/egypt-and-subsidies-country-living-beyond-its-means

El-Salmawy, Hafez A. 2010. "Egyptian Power Sector Reform and New Electricity Law." EgyptERA.

Energy Sector Management Assistance Program (ESMAP). 2017. "Energy Subsidy Reform Facility—Egypt." March 2017. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/873871506492500301/pdf/120075-WP-PUBLIC-26-9-2017-12-41-5-FINALESMAPCountryBriefEgypt.pdf

Rana, Anshul, and Ashish Khanna. 2020. "Learning from Power Sector Reform: The Case of the Arab Republic of Egypt." Policy research working paper no. WPS 9162. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/344841582641079201/Learning-from-Power-Sector-Reform-The-Case-of-the-Arab-Republic-of-Egypt

Sharkawy and Sarhan. 2015. "The New Electricity Law Explained." https://www.lw.com/thoughtLeadership/egypt-new-electricity-law-explained

James, Laura M. 2015. "Recent Developments in Egypt's Fuel Subsidy Reform Process." International Institute for Sustainable Development. April 2015. https://www.iisd.org/gsi/sites/default/files/ffs_egypt_lessonslearned.pdf

Central Agency for Public Mobilization and Statistics, Government of Egypt (CAPMAS). 2020. "Egypt Statistical Yearbook 2020—Population 2020." https://www.arabdevelopmentportal.com/publications/?field_country_target_id=921&field_topic_target_id=All

Khaled, Mohamed Shehata, and Abdel Gawad. 2018. "Integrated Resource Planning in the Egyptian Electricity System" (master's thesis). Cairo: Ain-Shams University. http://www.eulc.edu.eg/eulc_v5/Libraries/Thesis/BrowseThesisPages.aspx?fn=PublicDrawThesis&BibID=12492115

European Union (EU). 2015. "Integrated Sustainable Energy Strategy" for Technical Assistance to Support the Reform of the Energy Sector (TARES), European Delegation of the European Union to Egypt, http://eeas.europa.eu/archives/delegations/egypt/press_corner/all_news/news/2016/20160718_en.pdf

Notes

Notes

Notes

About the Authors

Shahid Hasan

Shahid is a research fellow at KAPSARC, where his current research focuses on electricity sector transitions in the Gulf Cooperation Council (GCC) member states, and development of a regional electricity market in the GCC, Middle East and North Africa (MENA) region. He previously consulted extensively on policy, regulatory, and market design issues for governments, electricity regulators, public utilities and the electricity industries in India and Southeast Asia.

Turki Al Aqeel

Turki is a senior research associate at KAPSARC focusing on energy transitions, electricity market regulations and policy, digitalization, power system modeling, and renewable energy policy. He has worked for several multinational companies, including ABB and Woodward. Turki holds a Ph.D. in Electrical Engineering and an MBA from Colorado State University, and is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE).

Hafez El-Salmawy

Dr. Hafez El-Salmawy is Professor of energy engineering at Zagazig University, Egypt. He is a consultant at the World Bank, European Commission, European Bank for Reconstruction and Development, Common Market for Eastern and Southern Africa and Regional Centre for Renewable Energy and Energy Efficiency. He has previously served as the Executive Chairman of EgyptERA (2006-2015) and President of the Association of Mediterranean Regulators for Electricity and Gas (2014-2016). He has provided technical support in the areas of regulations, restructuring, renewable energy and energy efficiency to many countries, including Saudi Arabia, Lebanon, Iraq, Syria, Yemen, Sudan, Zanzibar, Djibouti and Mongolia.

About the Project

KAPSARC has initiated a regional electricity market integration research project to explore the potential opportunities that could be harnessed by developing a common electricity market in the GCC and wider MENA region. The initiative examines a range of issues related to electricity market integration, including how power pools have been developed in other regions and their potential application in MENA. The project will focus on understanding and examining electricity market policy, regulations, legislation, market design, market structure, and system operations to identify best practices and provide insights into policy issues. It will produce reports and other findings intended to fill existing knowledge gaps and facilitate ongoing efforts toward regional electricity market integration.

مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

www.kapsarc.org