

The background of the top section is a high-angle, night-time photograph of a city, likely Cairo, Egypt. It shows a wide river (the Nile) with a large bridge spanning it, filled with cars. The city skyline is illuminated with lights from buildings and streetlights, reflecting on the water. The Siemens logo is overlaid on the top left of this image.

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Ingenuity for life

The Egypt Megaproject

Boosting Egypt's energy system
in record time

[siemens.com/egyptmegaproject](https://www.siemens.com/egyptmegaproject)

Executive Summary

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Initial situation

Starting in 2010, Egypt's main challenge was to ensure stable energy supply for its growing population. Blackouts and power outages, especially during the hot summer months, affected residential and industrial areas alike. At the time, experts cited an electricity shortage of around 20 to 25 percent – while electricity demand rose steadily at more than 4 percent per annum. As a consequence, the energy system not only had to be stabilized, but also required substantial expansion and investment to ensure a reliable power infrastructure that could foster long-term economic development.

Solution

In addition to a fast-track electricity program, in 2015 the Egyptian government selected Siemens to design, supply and deliver the megaproject on a turnkey basis with the aim to boost the country's generating capacity by 45 percent. Siemens made a promise to Egypt and, together with its local partners Elsewedy Electric and Orascom Construction, embarked on delivering this commitment to all Egyptians. In the

scope of this project, Siemens designed, supplied, and delivered three 4.8 GW gas-fired combined cycle power plants and eight 500-kV GIS substations. Crucially, Siemens also trained 600 Egyptian engineers and technicians to operate and maintain the power plants and their state-of-the-art technology.

Result

In January 2017 and after only 18 months since the megaproject's signature, an initial 4.8 GW were fed into the Egyptian grid, constituting a 10 percent surplus over the 4.4 GW of early power contractually promised by Siemens. In completing the megaproject in around 27.5 months after the project's financial close, Siemens managed to set a new worldwide benchmark for the execution of fast-track mega power projects. In addition to the operational training of 600 power plant engineers and technicians, an occupational training center is being established in cooperation with the German Ministry of Economic Cooperation and Development to provide industry-specific, on-the-job training for 5,500 Egyptian engineers and technicians over four years.

Egypt's Energy Challenge (2015)

Starting in 2010, Egypt experienced increasingly frequent and lengthy power cuts and blackouts in all urban centers – especially during the hot summer months. By the summer of 2014, power generation was running at only 70 percent of the installed capacity of 30 GW.

The electricity crisis started to seriously affect residents and threaten the country's economic and service sector. Factories ground to a halt due to the lack of reliable electricity, hampering the economic recovery. At the time, experts estimated the electricity shortage at around 20 to 25 percent.

Aging energy infrastructure

Egypt's energy mix in 2015 consisted of 68.5 percent natural gas, 25.9 percent diesel, 4.7 percent hydropower, and 0.9 percent wind and solar energy.

However, much of the existing energy infrastructure was over 20 or 30 years old and performed with decreased efficiency. Power plants thus consumed more fuel than necessary, further increasing the country's need to import fuel in a time when the domestic exploration of fossil fuels had stalled.

Increasing demand for electricity

In addition, the number of electricity subscribers was projected to rise by 40 percent by 2030 due to Egypt's 2.8-percent annual population growth and the planned electrification of further urban as well as rural areas.

This steady increase in demand resulted in the need to not only stabilize the energy system but also to substantially grow and invest in it. In 2015, the Ministry of Electricity and Renewable Energy established a sustainable reform strategy and policy for national

development, which consisted of two stages:

- Boosting electricity generation, transmission, and distribution
- Building a fast-track rehabilitation and maintenance program of existing power utilities until 2030.

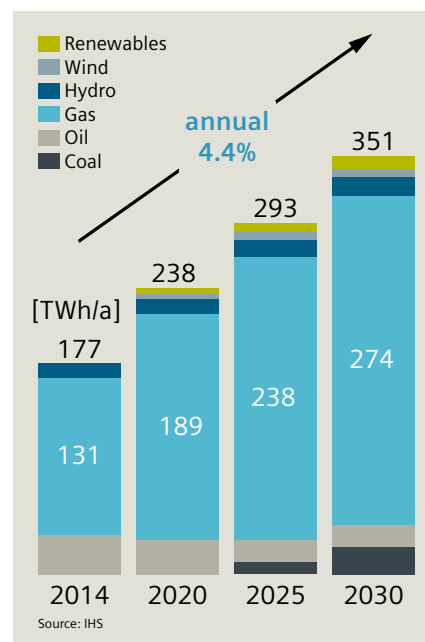
Both axes were needed in order to stabilize the economy and provide opportunities for economic growth. Creating reliable, sufficient energy supply became a strategic priority and was referenced in the Egyptian government's vision for 2030 as a strong pillar for development.

A plan to close the power gap

In March 2015, the Egyptian government announced Egypt's "Vision 2030" during the Egypt Economic Development Conference, held in Sharm El-Sheikh. The goal was clearly defined: By 2030, Egypt should be among the world's 30 most competitive countries and among its 30 strongest economies.

Investments in the energy sector were set as a top priority for Egypt in the initial phase. The objective was to establish a reliable, eco-friendly and affordable energy supply.

Siemens experts had already been carefully analyzing the country's energy system for over two years, developing the so-called "trusted advisor" concept to identify Egypt's challenges in the energy sector. In joint discussions with almost all key stakeholders, including the Ministry of Electricity and Renewable Energy, they determined that the best energy mix for Egypt would continue to rely on natural gas as the most important energy source for the country and suggested to close the power gap with highly efficient, gas-fired combined



Power generation development in Egypt

cycle power plants (CCPP) distributed across the country. CCPP technology results in the best fuel efficiency, which in turn reduces carbon emissions and lowers operating costs. The experts also recommended increasing the share of renewable energy, particularly solar and wind power in areas where the country has huge potential.

Fast-track electricity

In 2015, Siemens contributed to Egypt's Fast-Track Electricity Plan, which aimed at meeting the country's rapidly increasing electricity demand by adding new generating capacity to existing power facilities throughout the country. The project was a result of Siemens' commitment to modernize Egypt's power infrastructure. In cooperation with Elsewedy Electric, the Attaka simple cycle power plant was constructed in a record time of six months, with four E-class gas turbines installed to generate 650 MW that could supply 620,000 households with electricity. In addition, two new 500/220 kV substations were commissioned at Mahmoudia and Assiut power plants. The first Siemens gas turbine generation package in Attaka generated electricity to the grid after only 159 days – a world record for a project of this scale. The project proved Siemens' capabilities of executing critical fast-track power projects.

The megaproject with Siemens

During Egypt's Economic Development Conference in March 2015, Siemens and the Egyptian government reached firm agreements to support the country in its mission to develop a reliable and sustainable power supply. In June of the same year, Siemens signed contracts worth €6 billion for high-efficiency natural gas-fired power plants that will boost Egypt's power generation capacity by 45 percent compared to the country's installed base in 2015.

Together with Elsewedy Electric and Orascom Construction, Siemens was invited to design, supply, and deliver three combined cycle power plants in Beni Suef (to service Upper Egypt), New Capital (to energize the new administrative center east of Cairo and the strategic area at New Suez Canal Develop-



June 03, 2015: Contract signing witnessed by Muhamed Shaker, Minister of Electricity and Energy of Egypt, Siemens CEO Joe Kaeser, the German Vice Chancellor Sigmar Gabriel and the Egyptian President Abdel Fattah El-Sisi.

ment Zone) and Burullus (to supply the Nile Delta and the Mediterranean coast).

Each of them was set to be one of the world's largest gas-fired combined cycle power plants (CCPP) with a capacity of 4.8 GW. Together they would increase Egypt's power generation capacity by 45 percent.

The power plants would be fitted with highly efficient state-of-the-art H-class gas turbines. Siemens promised to start producing 4.4 GW of "early power" in open cycle configuration only 18 months after signing the contract in order to alleviate some of the stress on Egypt's electricity supply.

The contract also included a nine-year service and maintenance agreement.

In addition, the transmission grid would be strengthened with eight new 500kV

gas insulated switchgear (GIS) substations – vital to getting the electricity to where it is needed.

Another key component of the holistic concept to improve Egypt's energy system was the transfer of know-how. As key ingredient to ensuring the success of the megaproject, Egyptian engineers and technicians received hands on training on technical, management as well as leadership skills as part of a specially designed education program carried out between Egypt and Germany.

The Megaproject (2015–2018): A Holistic Approach to Strengthening Egypt's Energy System

The Egypt Megaproject is on the one hand defined by its holistic concept that covers the delivery of technology and support in financing, as well as provision of expertise in order to make a sustainable and lasting contribution to Egypt's energy system. On the other hand, the project set new global benchmarks for fast-track power projects with its precision and speed of planning, engineering, construction, and commissioning.

Financing the megaproject

Signing a €6 billion power deal with the Egyptian Government required financing. Siemens, together with Orascom Construction and Elsewedy Electric, facilitated a very competitive loan agreement backed up by the German government, represented by the German export credit agency Euler Hermes and Italian export credit agency SACE. As a global player and one of the largest German conglomerates in Europe and the world, Siemens managed to secure the financing for such a major project very quickly. In total, the project has been financed by more than 30 banks worldwide.

The signing of the loan agreements of the Beni Suef power plant took place in Cairo on November 22, 2015. Siemens Financial Services (SFS) structured the financing package for Siemens' part in the project. Financial close for the Beni Suef project was reached on December 30, 2015. The signing of the loan agreements for the Burullus and New Capital power plants, implemented by Siemens and Orascom Construction, took place in Cairo on March 9, 2016. Financial close for Burullus and New Capital was reached on March 31, 2016.

Environmental and social action plan

The prerequisite for the financing model was an environmental and social action plan, devised by a special task force in cooperation with the owners and lenders to develop a comprehensive environmental and social impact assessment.

Thus, the impact of the project execution and later of the operations of the power plant were to be continuously monitored. The plan also included

several studies, measures, and audits to ensure the compliance of the project with local and international laws and standards.

Siemens assigned an external international consultant (ERM) to accompany the execution of the environmental and social action plan and report its progress, including all deliverables based on the projects milestones. Quarterly meetings for all stakeholders were held to monitor the progress.

The scope of the project: Power and Gas

The three gas-fired combined cycle power plants built in the scope of the megaproject are sufficient to provide 45 million Egyptians with electricity, increasing Egypt's power generation capacity by 45 percent.

The power plants operate at top efficiency levels of over 61 percent, which translates into tangible emissions and costs savings for Egypt. As a reference, a 1.5-percent efficiency improvement reduces a power plant's annual CO₂ emissions by approximately 320,000 tons.

Each of the power plants in Beni Suef, New Capital, and Burullus was designed in the 4 x SCC-8000H 2x1 configuration and is equipped each with:

- 8 SGT5-8000H gas turbines
- 4 SST-5000 steam turbines
- 12 SGen5-2000H generators
- SPPA-T3000 control system

Both of the power plants in Beni Suef and Burullus operate with wet cell cooling-towers, while the one in New Capital uses an air-cooled condenser

The first SGT5-8000H gas turbine arrives in Egypt at the port of Adabiya in March 2016.



for cooling, which is the first of its kind in Egypt. All 3 power plants run on natural gas as their main fuel, with the option of diesel as a backup fuel.

The **SGT5-8000H gas turbine** was the very first air-cooled H-class gas turbine on the market. Backed by the largest commercially operating fleet in the market, it is the most reliable and tested H-class gas turbine technology available. The gross power output of the SGT5-8000H gas turbine is 400 MW. Statistically, a single turbine can provide electricity for around 1.25 million Egyptians. In combined cycle mode, including the steam turbine, the gross power output is 1200 MW – enough power to supply electricity to more than 3.75 million people. The turbines are also highly flexible and able to quickly react to the demands for additional or reduced output.

The H-class gas turbines delivered to Beni Suef power plant were the first in the whole MENA region.

The **SST-5000 steam turbine** is designed for short start-up times and high operational performance. It features an output range of 120 MW to 500 MW for combined cycle applications. In combination with the SGT5-8000H gas turbine, it achieved an efficiency rate of 61.5 percent, setting a new world record for combined cycle power plants.

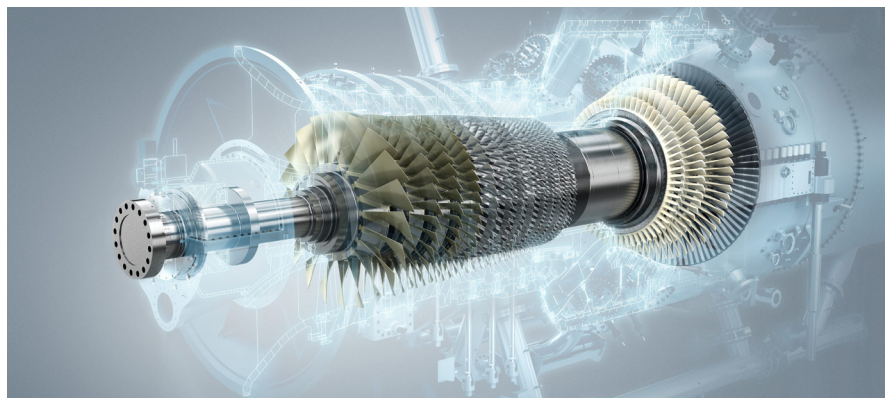
The power plants also feature Siemens **SPPA-T3000 control system**. By supporting operators with targeted cues and guided procedures, the SPPA-T3000 Cue ensures timely and efficient plant performance.

The scope of the project: Energy Management and Digital Services

In order to transmit the electricity to the Egyptian people, Siemens also constructed eight substations located in El Minia, El Beheira, Qalubia, Assiut, and



Maghagha substation in Upper Egypt is one of six substations built to boost Egypt's energy infrastructure.



The SGT5-8000H gas turbine

Al Gharbia governorates. The 500-kV GIS substations are at the core of the power transmission system, featuring reliability as well as very low noise and electromagnetic emissions. Thus, they are well-suited for dense metropolitan areas like Cairo.

They are both digitally monitored and controlled by the substation control and

monitoring system SICAM PAS. As part of the solutions, Siemens also provided cybersecurity measures to safeguard against unauthorized user access, installation of fraudulent software and firmware, introduction of malware, cyberattacks, and incorrect system parameter or equipment settings.



Siemens also offered a US\$120 million grant of the PLM software package to the three biggest and oldest public universities, Cairo, Ain Shams, and Alexandria.

To further enhance and maintain a reliable national grid, a detailed grid stability study was also carried out to investigate the efficiency and stability of the current electricity grid. The aim was to pinpoint critical bottlenecks and provide scenario definition, network performance, and analysis for 2015 and the decades ahead.

The scope of the project: Power Generation Services

The megaproject also comprises nine-year service and maintenance agreements for the three power plants to help ensure the long-term reliability, availability, and optimal performance of the units.

The scope of the project: Training

As a quick response to the instant demand of the three power plants,

Siemens trained 600 technicians and engineers in an intensive six-month educational program between Egypt and Germany, which ran throughout the project's execution. The specially designed, comprehensive curriculum treated both technical and non-technical aspects. The aim was to train the future operation and maintenance staff of the three power plants in all the necessary technical competences as well as interpersonal and behavioral skills.

For the long term, Siemens also partnered with the German Ministry of Economic Cooperation and Development in a Strategic Alliance to strengthen and create three synchronized vocational education and training platforms:

- (i) Developing a three-year Technical Secondary School, Zein El Abedeen School, which will become a School of Excellence for the dual system
- (ii) Upgrading a two-year Higher Technical Institute, which will be the leading qualification provider in mechatronics on this level, in Egypt
- (iii) Establishing a one year vocational training center, the Egyptian-German

The first group of Egyptian engineers receiving their training on an SGT5-8000H at the Gas Turbine Training Center in Berlin.

Technical Academy, located at the Siemens Energy Service Center in Ain Sokhna in the Suez Canal Industrial Development Area, for advanced training in Energy, Industry and other related areas

The three platforms will be interlinked: The School of Excellence leads to the Higher Technical Institute, which in turn leads to the Technical Academy, offering the opportunity for highly skilled employment. Over four years, 5,500 Egyptian engineers and technicians will receive industry-specific, on-the-job training.

The project scope in a nutshell

- 14.4 GW of electricity for Egypt's grid
- Approximately 45 percent increase in Egypt's power generating capacity as of year 2015
- 24 H-class gas turbines, 12 steam turbines, 36 generators, 24 heat recovery steam generators
- 145,000,000 man-hours
- Plant area: 2,180,000 square meters (equivalent to more than 300 football fields)
- Total number of trainees qualified to operate state-of-the-art power plant technology: 600





Due to its desert location with no access to water, the **New Capital CCPP** (built together with Orascom Construction) required the implementation of air-cooled condenser technology.



Due to the sloping terrain on the banks of the Nile, major excavation activities and customized plant design were required for the **Beni Suef CCPP** (built with Elsewedy Electric).



The **Burullus Power Plant** (built with Orascom) was one of the most complex construction sites worldwide due to its geographical nature and saline soil.

- Total number of people working directly and indirectly on the 3 power plants: 43,500
- Total number of people directly working in parallel on three project sites: 24,500 (of which 95 percent are local Egyptians)
- Total number of suppliers and subcontractors: 1,073 (of which 73 percent local)

In January 2017, a total of 4.8 GW were fed into the Egyptian grid, constituting a 10 percent surplus over the 4.4 GW of early power contractually promised by Siemens. To this end, 12 H-class gas turbines entered into simple cycle operation, and Etay El-Baroud, Magh-
agha, and Kafr El-Zayat substations were energized. The consortium achieved a world record in delivering 4.8 GW in only 18 months after signing the contract.

In completing the megaproject in around 27.5 months after signing the contract, Siemens also managed to set a new worldwide benchmark for the execution of fast-track mega power projects.

Project implementation: Challenges and achievements

With more than 43,500 workers allocated in the three power plants, 145 million man-hours of labor, and a total plant area of 2.2 million square meters, the challenges encountered during site preparation, engineering, manufacturing, project management, and supply chain management were also on a major scale.

Prior to the construction and erection activities, the site preparation included, e.g., putting down more than 12,000 piles in Burullus, the excavation of more than 1,750,000 m² of rocks in

Beni Suef, and leveling and backfilling of the entire site in less than three months. For providing the water needed for cooling to the sites, a cooling tower system was needed. A high-voltage grid interconnection with the capability to select different voltage levels also had to be built.

In terms of **engineering**, the major challenge was to develop, review, and finalize design of the three power plants in less than three months.

The **manufacturing** planning had to coordinate an array of different Siemens manufacturing locations in Germany, the USA, Austria, etc., and had a very short timeframe of only 18 months to manufacture 24 gas turbines, 12 steam turbines, 36 generators, 24 heat recovery steam generators, 24 bypass stacks, 24 stacks, four air-cooled condensers, and 36 transformers.



Project management had to build a diversified on-shore setup, understand the local laws, and adapt to the surrounding environment in a very short time in three locations in parallel. Also, full provisions had to be made in Germany and at each site to handle all engineering, construction, erection, and commissioning of the power plants on-shore and round the clock.

Supply chain management met the major challenge of globally sourcing, importing, and delivering over 1.6 million tons of material in total with 7,000 containers to the three sites in line with the key project milestones. To achieve this, Siemens had to increase the fleet of trucks by importing additional transport and devices (trucks, lifters) for heavyweight and oversized cargo.

All challenges were facilitated with the support of the relevant authorities due to the high strategic importance of the megaproject.

Project implementation: EHS

For Siemens, work safety is paramount. On every construction site anywhere in the world, the company strives to build a Zero Harm Culture to make sure that every staff member gets home safely and unharmed at the end of the day. To this end, Siemens implemented numerous innovative measures together with its consortium partners to change the culture about EHS and create a zero-harm mindset:

- (i) Practical Safety Training parks and simulation centers at each site to demonstrate the importance of proper PPE & its consequences.
- (ii) A wide-scale customized awareness campaign in Arabic to address workers and supervisors, creating a strong link between construction and EHS responsibilities.
- (iii) Frequent inductions and trainings for all workers. In total, 66,000 workers were given EHS training on the three power plant construction sites.

(iv) Joint EHS teams of Siemens and the consortium partners in one office increased transparency and solidified a collaborative approach with one vision.

(v) Weekly joint management construction site tours with consortium partners.

Project implementation: CSR and immediate social and economic impact

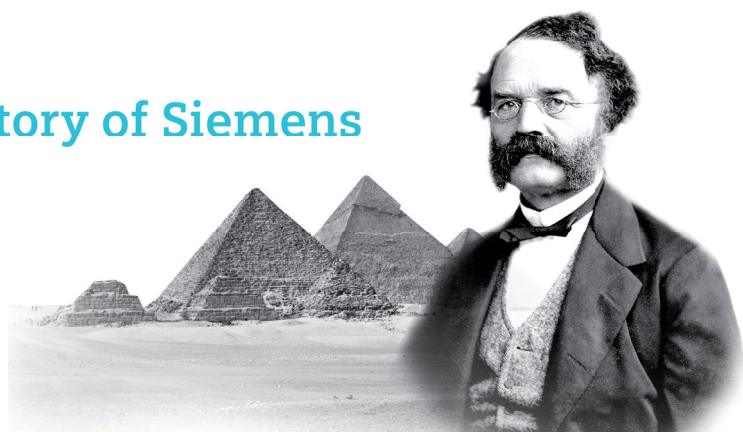
For Siemens and its consortium partners, environmental and social factors such as education, the reduction of carbon emissions, and the support of Egypt's economic growth are paramount. This is why Siemens developed a joint action against corruption and for fair competition in cooperation with local partners to develop a corporate anti-corruption ecosystem within the megaproject.

Thousands of new jobs have been created in the megaproject sites. In addition, security of energy supply will be vital to creating a sustainable economic environment, which will lead to the provision of further employment.

In **Beni Suef**, the local community benefited directly from the creation of jobs and official business entities. These small businesses improved the economic status and living standards of the surrounding local community.

In the entire **Burullus** area, the macro-economic impact was significant, with almost 2000 workers hired and trained from the local Kafr el Sheikh Governorate, in addition to almost 6000 workers from governorates all over Egypt. The commercial area in the vicinity was further developed, with catering facilities now open all year round instead of only in summer.

Milestones in the history of Siemens in Egypt



- 1859**  Laying of the first 5,600 km telegraphic cables in the Red Sea, connecting Suez in Egypt with Karachi
- 1901**  Siemens opened first office in Egypt
- 1936**  Water Flow Drum Counter at Giza Agricultural Museum
- 1999**  Suez Canal Crossing Towers

Siemens landmarks

in Egypt

- 1870**  Laying of 11,000 km Indo-European telegraph line from London to Calcutta through Egypt
- 1930**  Laying Air Cables at Cairo-Helwan
- 1958**  Electrical Tower Train Set Cairo-Helwan
- 2006**  Children's Cancer Hospital Egypt
- 2015**  Attaka Power Plant, Mahmoudia Assiut GIS
- 2017**  4.8 GW connected to the grid
- 2018**  14.4 GW connected to the grid through the world's three biggest CCPP
- 2006**  Nubaria, Talkha & Kuraymat Power Plant
- 2015**  Egypt Megaprojects Deal

The **New Capital** power plant has trained more than 500 students from more than 15 different universities around the world, providing them with hands-on experience working on a megaproject.

Siemens in Egypt: Corporate citizenship and responsibility spanning more than 150 years

Siemens has been active in Egypt since 1859, when Werner von Siemens came to Suez to lay the first telegraphic cables beneath the Red Sea to link Europe via Suez and Aden with West India. After the successful implementation of this first turnkey project, Siemens established a permanent Technical Office in Cairo in 1901. To further develop and expand its business and to serve the customers in Egypt, in 1924 Siemens bought its former agent, A. Brühlmann & Co., Electricité.

In 1992, Siemens Limited Egypt was founded to act as the sales and service organization responsible for the Siemens activities. Since 1995, Siemens has designed, delivered, installed, and commissioned a number of steam and gas turbines as well as combined cycles for several power plants such as Cairo-West, Sidi Krir, Nubaria, New Talkha, and Kuraymat.

In 2004, Siemens delivered the first turnkey gas-insulated high-voltage switchgear station to connect Cairo-North power plant to the national electricity grid.

In 2007, Siemens established a license agreement with Egyptian Advanced Systems (EMAS) for low- and medium-voltage switchgear. To cope with the expanded activities in Egypt, in 2008, Siemens Limited changed its legal form to the joint stock company Siemens Technologies S.A.E.

Siemens has actively supported the sustainable, long-term economic growth of Egypt and the improvement of its citizens' quality of life for over 150 years through the application of technology in the fields of power generation, rail networks, healthcare, building technology, and industrial solutions, and the proactive transfer of knowledge and technical expertise.

As a technology powerhouse that stands for engineering excellence, innovation, quality, and reliability, Siemens continues to support the country in its endeavor to build a modern infrastructure for Egyptian citizens in the fields of electrification, automation, and digitalization.

Reaching the Goal (2018)



“When strong partners wholeheartedly agree on a goal and give their best to reach that goal, amazing things happen.”

Joe Kaeser, CEO of Siemens AG

From 2013, when preliminary studies for the strengthening of Egypt’s energy system began, until 2018, when the megaproject was successfully delivered on time, Siemens invested a great deal of time, effort, and passion to solve Egypt’s energy challenges. Together

with the Egyptian government and various stakeholders, Siemens focused on providing holistic solutions that were sustainable and acceptable at a competitive cost level for the country.

This is how the government of Egypt achieved three goals at the same time:

- Securing power supply
- Expanding and future-proofing the generation capacity
- Developing localized energy expertise and know-how inside Egypt through a trained task force of Egyptian engineers and technicians, as well as various local subcontractors, and setting up the educational structures to empower future generations.

An achievement based on strong partnership

Since establishing its first permanent office in Egypt in 1901, Siemens has been a trusted partner to Egypt.

SIEMENS
Ingenuity for Life

The power of a promise - 14.4GW in 27.5 months!

24 H-Class gas turbines

connected from **Beni Suef, Burullus and New Capital** power plants to provide electricity for

45 million Egyptians



8 substations are energized to efficiently distribute the generated electricity

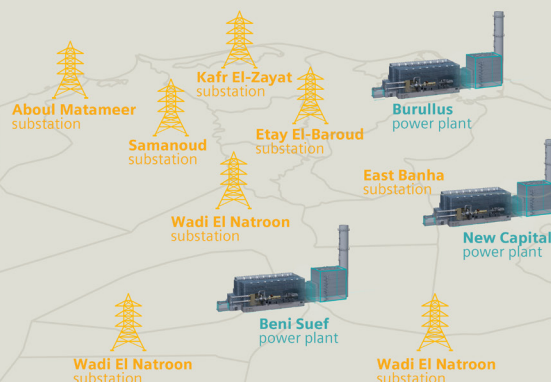


Siemens to provide **sustainable service and maintenance** through its **digital services** for the three power plants



The three power plants in total numbers:

4,207,000m ³ backfilling	845,700m ³ concrete	6,800,000m electrical cables used	450,000m piles
3,750,000m ³ excavation	78,000t of steel structure	79,550t re-bar	
24,600 workforce of which 95% are local Egyptians	145,000,000 man-hours per month	600 Egyptians trained in Operation and Maintenance	Electricity for 45 million Egyptians



Of course, given its sheer scale, the megaproject stands apart from previous engagements and has benefited greatly from the support of the public authorities, in particular the Ministry of Electricity and Renewable Energy and the EEHC, the Ministry of Petroleum and other governmental authorities, as well as strong cooperation with the Egyptian business partners, Orascom Construction and Elsewedy Electric.

A blueprint for other customers

In completing a project of this scale in record time, Siemens has gained invaluable expertise in conducting megaprojects that are able to strengthen and reshape the energy system of a country significantly.

The experience of working with more than 1,000 suppliers and subcontractors, 73 percent of which were local companies, has been exhilarating. With up to 24,500 people working in parallel adopting the zero-harm mindset, the Egypt megaproject has proven that speed and safety are complementary, not mutually exclusive.

For countries that are looking to improve and future-proof their energy system, Siemens offers the experience of implementing a world-class project – in scope and in speed.

Abbreviations

BMZ	Federal Ministry for Economic Cooperation and Development
CCPP	combined cycle power plant
CSR	corporate social responsibility
EEHC	Egyptian Electricity Holding Company
EHS	environment, health and safety
EPC	engineering, procurement and construction
GW	gigawatt
MENA	Middle East North Africa
MW	megawatt
PPE	personal protective equipment

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