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IRENA
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IRENA CASE STUDY 2013
EGYPT WIND ATLAS

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I. NATIONAL CONTEXT

The New and Renewable Energy Authority (NREA) was established as the focal point in Egypt to assess renewable energy resources and to investigate the different available technologies through both studies and pilot projects. NREA is charged with introducing renewable energy technologies to the Egyptian market and to support the local industry initiatives and contributions.

Egypt has given due consideration to its wind energy resources, particularly at Suez Gulf Coast. Studies that evaluate the wind energy resources concluded that Egypt enjoys an excellent wind regime, with wind speeds easily reaching 10 m/sec in the Suez Gulf. In co-operation with USAID, an annual potential wind map for Egypt was published in 1987. Following this in 1996, NREA together with the Risø National Laboratory (Risø) in Denmark developed a Wind Atlas for four-sites on the West Coast of the Suez Gulf. In 2003, a detailed Wind Atlas for these same areas were published, it concluded that the region can host large scale wind farm projects.

THE WIND ATLAS FOR EGYPT

In 2005 the NREA, the Egyptian Meteorological Authority (EMA) and Risø expanded the Atlas to cover the whole of Egypt, with an aim to establish through a meteorological basis a country-wide assessment of the wind energy resources.

The Danish Government were invited to collaborate in the Egyptian Wind Altas programme following the successful conclusion in publishing the Suez Gulf Wind Atlas. The Danish contribution to this Egyptian-Danish project was funded by the Danish Ministry of Foreign Affairs through Danida. The Danish Government allocated a grant of DKK 9 million (about USD 1.5 million) to finance the equipment, payment for consultants for Wind Atlas for the Gulf of Suez and the Wind Atlas for Egypt, and travel. Whilst the NREA covered custom duties, taxes, costs of installations and manpower for project management.

The main objective of the Atlas is to provide reliable and accurate wind atlas datasets to allow for effective evaluation of the potential wind power output produced by electricity producing wind turbine installations in Egypt; special emphasis is placed on those regions where the wind resources are known to be high namely; North West Coast, North East Coast, Gulf of Aqaba, Gulf of Suez, Red Sea Coast, Western Desert.

More than 30 wind masts were erected in several promising sites. The data, collected between 1998 and 2005, were analysed to identify the most viable areas to host wind farm projects.

The Wind Atlas for Egypt presents comprehensive results for the country from this eight-year wind resource assessment programme.

II. MEASUREMENT CAMPAIGN(S) AND CREATION OF THE NATIONAL ATLAS

The Atlas has three main components:

- **Component A:**
  Wind Atlas for the Gulf of Suez (NREA and Risø):
  - 10 wind measurement stations in operation
  - A database of wind atlas data files in WAsP format
  - A report on wind farm planning for the Gulf of Suez
  - A Bird Migration Atlas for the Gulf of Suez and an Environmental Impact Assessment (EIA) study concerning biodiversity and bird migration
  - A Wind Atlas for the Gulf of Suez

- **Component B:**
  Preliminary Wind Atlas for Egypt (EMA and Risø):
  - A database of wind atlas data files in WAsP format
  - Training Courses for professional staff in site characterisation
  - Training Courses for professional staff in WAsP Analysis
  - Software and hardware for wind data analysis and wind flow modelling
  - A preliminary Wind Atlas for Egypt report

- **Component C:**
  Wind Atlas for Egypt (NREA, EMA and Risø):
  - 11 wind measurement stations in operation
  - A database of wind atlas data files in WAsP format
  - A database of all meteorological measurements
  - Training courses for technicians and professional staff
  - A cup anemometer rehabilitation and calibration facility
  - Additional hardware for the wind atlas stations, including safety features
  - A satellite-based, on-line data transmission system for three stations
  - Software packages for wind data analysis and wind flow modelling
  - Mesoscale modelling of Egypt and six regions using the Karlsruhe Atmospheric Mesoscale Model (KAMM)
  - A database of KAMM modelling results

  The wind resource assessment programme has been supervised and managed by a Project Implementation Unit with representatives from the three organisations involved.

The Zafarana wind farm in Egypt. Credit: Wind Power Works

The Wind Atlas was prepared by 15 experts and 4 technicians:

- 5 experts from Risø National Laboratory
- 14 Egyptian; 6 experts from EMA; 4 experts and 4 technicians from NREA for station maintenance and data retrieval.

The study collected wind speed and direction measurements from wind stations located in most parts of the country. Additionally, data from eight standard meteorological stations were included in the analysis. The 22 masts with heights of 25m erected specifically for this Wind Atlas study, also provided information on the following climate characteristics: atmospheric pressure, solar insolation, air temperature and its gradient, atmospheric stability, wind speed profiles, extreme wind speeds, gust and lull wind speeds and turbulence intensity.

The wind data from the 30 stations were analysed using WAsP, according to the procedures and guidelines of the European Wind Atlas (Troen and Petersen, 1989). The roughness (land-use) of the terrain was assessed using topographical maps, aerial photographs, satellite imagery and site visits. The height variations of the terrain – used to assess the influence of the orography on the wind measurements and wind climate estimations – are described in digital terrain models, which have been obtained by digitisation of standard topographical maps or have been generated from Shuttle Radar Topography Mission elevation data.

In addition to the measurements, the wind climate of Egypt has been modelled using the KAMM Model. Maps of the predicted mean wind speed and power density at 50 meters above ground level are presented in the Atlas, including maps and data describing the regional wind climate of Egypt. The KAMM simulations capture the main features of the observed wind climate; even though the mean wind speed and energy flux density are sometimes under-predicted.

The Wind Atlas for Egypt confirms the existence of a widespread and particularly high wind energy resource along the Gulf of Suez. With mean wind speeds and meanpower densities of 7 ms-1 –10.5 ms^{-1} and 350 Wm^{-2}–900 Wm^{-2} respectively, estimated for a 50 m height over a roughness class 1.

The Wind Atlas further indicates that the wind energy resource in large regions of the Western and Eastern Desert – in particular west and east of the Nile valley between 27°N and 29°N, and in the north and west of the city of Kharga – are much higher than previously assumed. The mean wind speeds predicted here are between 7 ms^{-1} and 8 ms^{-1} and with power densities measured between 300 Wm^{-2} and 400 Wm^{-2}.

Parts of the Sinai Peninsula also feature relatively high wind energy resources, especially along the Gulf of Aqaba coast and the mountain ridge to the west of the Ajmah Mountain (Gebel El Tih).

The NREA has co-ordinated with the Egyptian Electricity Transmission Company (EETC) to access the grid for these planned wind projects in both the Suez Gulf and West Nile Valley, and initiated introducing this energy source into the future plans of the EETC. A study recommended that to maintain the grid balance until 2020, the total wind energy capacity in mega-watt (MW) from the Suez Gulf region must not exceed a maximum 3000 MW.

The EIA, including bird migration studies, prepared by NREA in co-operation with international consultants and financed by International donors in both the Suez Gulf and West Nile Valley found that there was no real expected impact on migration of bird species in most of the areas allocated for future wind projects.

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III. IMPACT OF THE MEASUREMENT PROGRAMME

Using the Atlas outcomes, the Ministry of Electricity and Energy formulated a wind energy strategy up to the year 2020; the Supreme Council of Energy, in February 2008, approved an ambitious plan to meet 20% of electricity generated by renewables by 2020, including:

- 12% from wind energy, i.e., about 7200 MW grid-connected wind farms; of which 2400 MW from NREA government funded projects and 4800 MW through the private sector
- 6% from hydropower
- 2% from solar energy (concentrated Solar Power (CSP)and photovoltaic (PV))

The policies required to foster an increasing wind contribution into the Egyptian electricity mix consists of two phases:

- Phase 1; will adopt a competitive bids approach by issuing international tenders aimed at the private sector to supply renewable energy. The financial risk for investors is reduced through government guarantees for long-term power purchase agreements. The announcement to submit prequalification documents for the first competitive bids tender for 250 MW wind farms, on a build, own, operate (BOO) basis, in the Gulf of Suez was issued in May 2009. Ten developers were shortlisted in December 2010 and the project is planned to be open for operation by mid-2015.
- Phase 2; will open the electricity supply to market forces through the use of feed-in-tariff that take into consideration the prices achieved in phase 1.
- Third Party Access;investors are permitted to build and operate renewable energy power plants to satisfy their own electricity needs and/or to market electricity to other consumers though the national grid.

A direct impact of the Wind Atlas of Egypt was the allocation, according to three Presidential Decrees, of more than 7600 km^2 of desert lands to NREA, allowing them to host public and private wind farms:

- Approximately 1200 km^2 of desert in the West of the Suez Gulf will host near to 1 140 MW governmental projects and 1 500 MW from the private sector; 750 MW BOO projects and 750 MW independent power producers (IPPs)
- Approximately 6 400 km^2 in the west and east of the Nile river valley.

The NREA will make the land available to the project developers through auction, signing a Usufruct Agreement with the winning developers that have a certain capacity in the region of 100 MW. The land use agreement signed by the investor will be against a payment equivalent to at least 2% of the annual energy generated from the project or its value.

Accordingly, a variety of incentive schemes have been developed and adopted by the Egyptian government to attract both foreign and local direct investments. Attractive investment incentives in combination with some of the best locations for wind farm developments worldwide have created a unique investment opportunity in Egypt.
Approximately 550 MW of wind energy projects have been implemented by the Egyptian government in consecutive stages at the Zafarana area on the Gulf of Suez in close co-operation with Denmark (DANIDA), Germany (KfW), Japan (JICA), Spain and other European partners. The aforementioned projects make NREA the owner and operator of the largest grid connected wind farm in Africa. Additionally, about 1 340 MW governmental projects are under preparation, as well as 1 370 MW private sector projects.

Recently commissioned wind farms have sections managed by European wind turbine manufacturers for specific periods of up to five years under separate operation and maintenance contracts.
In the course of implementing the Wind Atlas for Egypt, several training courses were conducted with both NREA and EMA staff, particularly the use ofWAsP, the Wind Atlas method and the verification of the wind atlas methodology, for example:-

- Training courses for professional staff in WAsP analysis
- Software and hardware for wind data analysis and wind flow modelling
- The physical basis, the roughness change model, the wind atlas analysis model and the wind atlas application model
- Station interconnection and comparison of KAMM modelled and observed wind climates

The Egyptian Wind Atlas project has made it possible to explore and reliably determine the wind resource at any location within Egypt.

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