NREA Danida

Feasibility Report

Zafarana 3, 120 MW Windfarm

Implementing Agency: NREA

Egypt

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Ref.No: 104.O.30.Egypten
RDE file no.:
May, 2004

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Abbreviations and Acronyms

CAPM	Capital Asset Pricing Model
CCGT	Combined cycle gas turbine
CDM	Clean Development Mechanism
CER	Certified Emission Reduction (CDM projects)
DAC	Development Aid Committee
Danida	Danish International Development Assistance
DSCR	Debt Service Coverage Ratio
DNA	Designated National Authority (CDM-project registration)
EEAA	Egyptian Environment Agency
EEHC	Egyptian Electricity Holding Company
EGAS	Egyptian Gas Company
EIRR	Economic Internal Rate of Return
EPC:	Engineering, Procurement and Construction
ERA	Electricity Regulatory Authority
ERPA	Emission Reduction Purchase Agreement
ERU	Emission Reduction Unit (Joint Implementation Projects)
FIRR	Financial Internal Rate of Return
GASCO	Egyptian Gas Transmission Company
GDP	Gross Domestic Product
GHG	Green House Gas
IPP:	Independent Power Producer
JBIC	Japan Bank for International Cooperation
KfW	Kreditanstalt für Wiederaufbau
LFA	Logical Framework Analysis
LRMC	Long Run Marginal Costs
MEE	Ministry of Electricity and Energy
MOP	Ministry of Oil and Petroleum
NBE	National Bank of Egypt
NIB	National Investment Bank in Egypt
NPV	Net Present Value
NREA	New and Renewable Energy Authority
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PJM	Pennsylvania, New Jersey, Maryland
PO:	Purchase Order
PPA :	Purchasing Power Agreement
Price (fob):	Price "free on board" (at the port of export)
Price (cif):	Price "cost, insurance, freight". (port of entry).
RE	Renewable Energy
RORE	Rate of Return on Equity
TA	Technical Assistance
WT	Wind Turbine

Definitions derived from the specific Methodology used in this Report

Economic Cost of Production	Investment costs and O&M costs expressed in factor prices not including costs of externalities and discounted at the economic discount rate of 7% used in Egypt for infrastructure projects.
Economic Cost of Windenergy	Economic cost per kWh of wind farm investment and O&M minus the revenue per kWh from sales of generated CERs.
Financial Cost of Production	Investment costs and O&M costs expressed in market prices and discounted at the financial discount rate of 7% used in Egypt for infrastructure projects.
Investor Cost of Production	Annual O&M costs and tax payments expressed in market prices + inflation-depreciated / devaluation-appreciated cost of annual debt repayments & payments on interest + annual net cash flows sufficient to provide investor with the target after-tax- ROR on invested equity; all discounted at the financial discount rate of 7%.

Definition of Terms – General Definitions

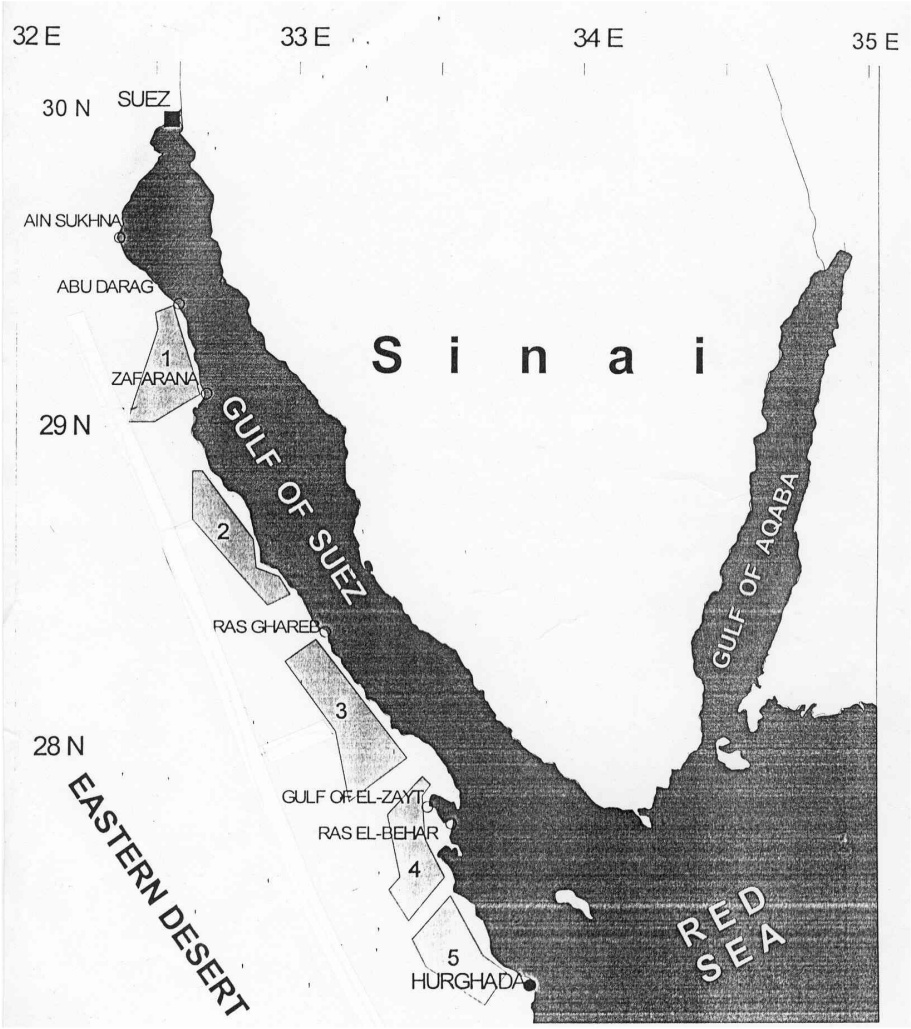
Average load, MW	Total produced energy (MWh) divided by 8760.
Capacity factor	Average load (MW) as percentage of plant capacity (MW) (= generated MWh during a year divided by MW capacity* 8765).
Debt Service Coverage Ratio	Annual operating profit divided by annual amortization payments (interest + repayment on debt)
Deep connection charge	All costs incurred by a distribution/transmission company of connecting a renewable energy generator to the grid, including costs of network strengthening are estimated and included in the connection charge.
Load carrying capability	Replaced investment in MW of thermal power capacity as percentage of the rated maximum MW power capacity of the wind farm.
Load factor	Average load (MW) as percentage of peak load (MW).

Netback Value	The net revenue for a commodity at an upstream point, which is left, after deducting from the market price of a commodity at a specific downstream point in the value chain (e.g. price cif of LNG from Egypt landed in a European port) the price paid to the individual intervening elements of the value chain (e.g. LNG sea transport and liquefaction of NG).
Power System Losses	Difference between the gross production of electricity fed into the grid by the connected power plants and the measured consumption of electricity at final consumer level
Shallow connection charge	A connection charge covering only the direct cost of connecting a windfarm to the nearest or most practical point on the existing network. Costs associated with system strengthening are carried in the general rate base of the network company (and thus, augment the use-of-system charge). A variation on shallow charges is where generators only pay for the actual hook-up to the grid, implying that all line extension and strengthening costs are paid for by the network company ("very shallow" connection costs).

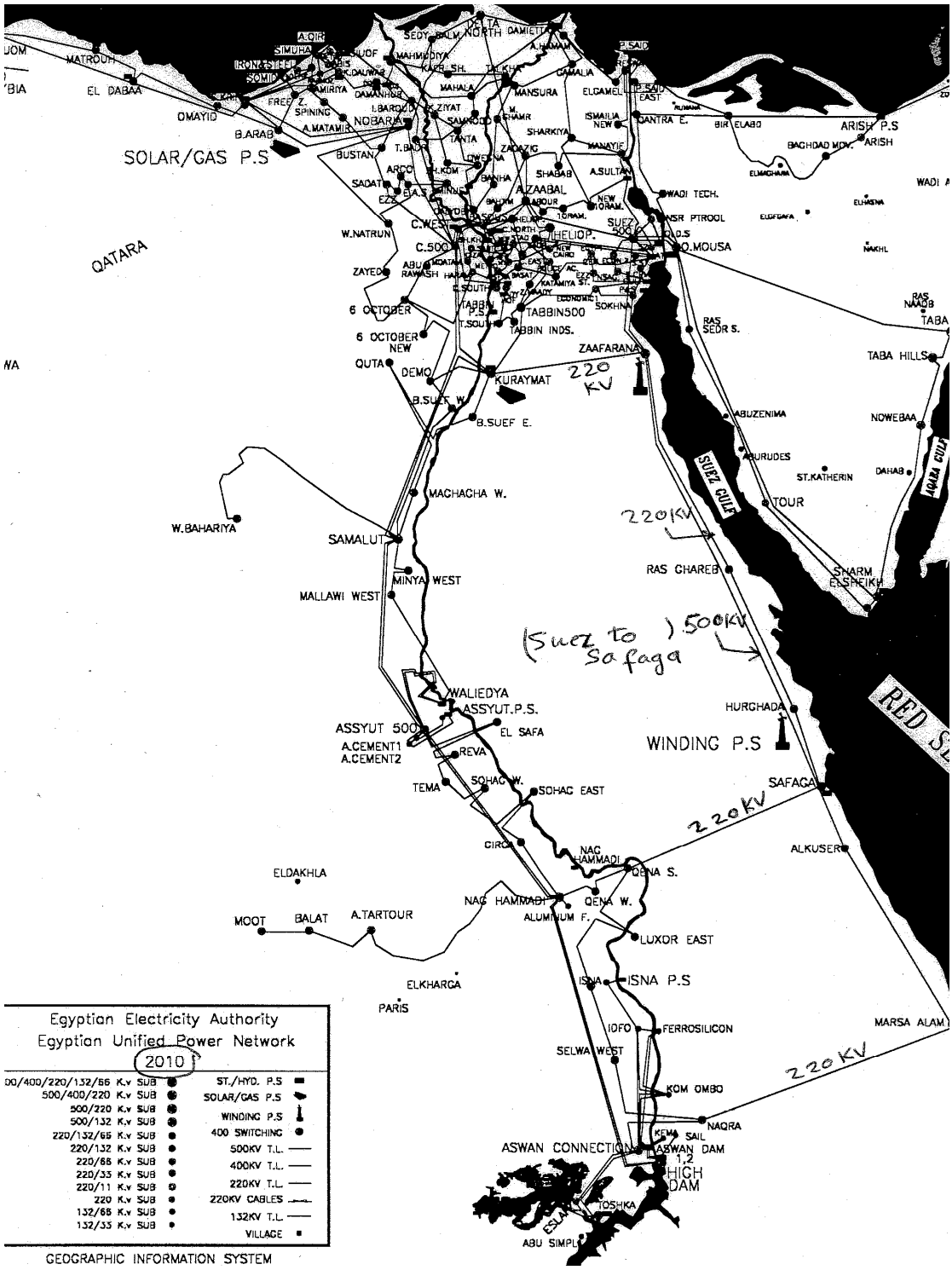
Conversion Factors

Exchange rate (February 2004)	1EURO = 7.65 EGP = 7.45 DKK = 1.24 USD
1 TOE	39.69 MBTU
1 ton of natural gas	1.111 TOE
1 ton of natural gas	1272 cubic meters of natural gas
1 cubic meter of natural gas	0.0346663 MBTU
1 ton of natural gas	2.6115 ton CO_2

Location of Project



National Grid Expansion Plan



ZAFARANA 3, 120 MW WIND FARM

1 INTRODUCTION

The New and Renewable Energy Authority's (NREA's) request for mixed credit finance for the 120 MW Zafarana 3 windfarm was received by the Secretariat for Mixed Credits in September 2003. Previous Danida-assisted windfarm projects at the Zafarana windfarm site managed by NREA were the grant-financed Zafarana 1 project of 30 MW using Nordex 600 kW wind turbines, approved by Danida in 1997 and commissioned in November 2000. The 30 MW Zafarana 2 project with Vestas 660 kW wind turbines, financed by a mixed credit, was commissioned in 2003.

To prepare the feasibility study for Zafarana 3 in collaboration with NREA/EETHC, Danida signed a contract with Wolfgang Mostert; sub-contractors were Tripod for technical windfarm issues and Alfredo Povedano from ICE, the Costa Rican utility for TA on grid impact modelling. The TOR for the contract are attached as Annex I. Ms. Anita Jürgens from the Secretariat for Mixed Credits led a start up mission to Cairo and Zafarana from December 15-18, 2003 accompanied by Wolfgang Mostert (management consultant) and Søren Gjerding (wind energy specialist) from Tripod. The work program for the feasibility study agreed to by Chairman Hosny El Kholy from NREA is attached as Annex II: Debriefing Note. The division of work for the grid impact study for the Zafarana windfarm site between NREA, EETC, Tripod (Kim Dyhre Jespersen, windfarm – grid interface specialist) from Tripod and Alfredo Povedano (power grid planner and windfarm specialist) was agreed to during January-February 2004 (Annexes III and IV). The mission by the consultants Jespersen and Povedano from March 27 to April 8 led to the report attached as Annex V, and to subsequent in-depth modelling work by EETC.

The economic-financial findings in this report are based on preliminary information about the wind potential, as the on-site wind measurement program has not yet been implemented. The three to four months wind measurement program at the site for Zafarana 3 is expected to be concluded by August 2004. Based on correlation with data from the two long-term masts at Zafarana, the data will enable a more reliable forecast of average annual production to be made.

The team would like to express its thanks to all officials and individuals met for the kind support and valuable information which the team received during its stays in Egypt and which highly facilitated the work of the team.

The report contains the views of the consultants, which do not necessarily correspond to the views of Danida or of NREA. All proposals are subject to approval by the two institutions.

2 EXECUTIVE SUMMARY

2.1 Project Description

The 120 MW Zafarana 3 windfarm, proposed for Mixed Credit finance by NREA, is part of the Egyptian Government's investment program for realizing its renewable energy policy target of 600 MW installed windfarm capacity by the year 2010.

The Mixed Credit required to reach financial closure for the estimated project finance (excluding working capital, but including sales tax and import duty) of EGP890 million (DKK867 m), is estimated at DKK721 million (EGP740m) plus a Danida grant to the cost of interest during construction of DKK22 million. NREA prefers a mixed credit with maturity of 15 years and a grace period of zero years; in which case, the interest rate will be 1.5 percent, which after adding the expected on-lending margin of the local bank of 1 percent, results in an interest rate of 2.5 percent being charged to NREA. NREA's own equity contribution is about EGP 19 million financing mainly for project preparation costs. The rest-finance of about EGP109 million (DKK 108 million) comes from a loan from the National Investment Bank to NREA, with a maturity of ten years, an interest rate of 13% and a grace period of two years.

The electricity will be sold on a 10-year PPA to EETC/EEHC. Since the project is to be organized as a CDM-project, it will also get CER-revenue during operation.

The creation of an environmental friendly and cost-effective portfolio of power generation in Egypt, which maximizes the employment and foreign exchange benefits of renewable energy, is the *development objective* of the project. The provision of additional 120 MW capacity at Zafarana and the demonstration at Zafarana of the economic advantages of moving to larger turbine sizes, as well as created capacity in the O&M of these turbines are the *immediate objectives*.

The main *activities* of the project are (1) planning and designing the wind farm and power connection, (2) construction of wind farm incl. building roads, power lines, transformer stations, auxiliary buildings and construction, shipment and erection of wind turbines, (3) commissioning of the wind farm, (4) generation and sale of electricity to EETC's grid, (5) operation and maintenance of the wind farm, (6) preparation of verification certificates, and 7) monitoring wind farm performance.

The *outputs* of the project are a 120 MW wind farm feeding an average 447 GWh per year into the grid, and NREA staff that are trained in the O&M of 1-2 MW WTs.

The main *inputs* without payment of interest during construction and working capital are an estimated:

- DKK621 million (EGP638m) of imported wind turbine equipment, spare parts and technical assistance,

- DKK117 million (EGP121m) of local deliveries in the form of project preparation by NREA, civil and electrical works
- Payment of import duty and sales tax of DKK 117 million (EGP121 million)

2.2 Outstanding Issues and Risks

NREA is about to obtain the necessary land rights and construction permits for the project by the Governorate. The *environmental permit* needs updating. The *generation* license is being prepared by the regulator.

A number of issues are still outstanding early May 2004:

- On the *financial side*, NREA needs to (i) reach an agreement with EETC on the signing of a 10 year PPA for the output of the windfarm, (ii) find buyers to sign the ERPA (emission reduction purchase agreement) for the certified emission reductions (CERs) from Zafarana 3, and (iii) reach agreement with a local bank for the on-lending of the Mixed Credit.
- Essential *project preparation* activities before the organization of an EPC (engineering, procurement, construction)-tender for the windfarm include mine clearing at the site, and the implementation by NREA of a three-to-four months wind measurement program at the specific site for Zafarana 3.
- The grid impact analysis revealed that present grid extension plans of EETC do not allow for an extension of the Zafarana wind farms to a total capacity of more than 345 MW in 2007. To ensure the feasibility of extending the Zafarana wind farms to a total installed capacity of 545 MW, it is assumed that EEHC/EETC will amend the present grid extension plans. Required amendments are (i) a further extension of the existing Zafarana substation to accommodate 5 pieces 125 MVA transformers or, preferably, an additional 22/220 kV substation with sufficient capacity in Zafarana close to the location of the Danida Component III and KfW Phase 4 wind farms; (ii) increased number of overhead lines from Zafarana substation(s) to the existing grid (for instance to Petro Pipeline substation or to Hurghada substation); (iii) increased overhead line capacity either from Zafarana substation(s) to Hurghada or the system along the Nile, or from Ectsadia substation to Petro Pipeline sub-station.

The wind measurement activity is not expected to generate results that substantially change the parameter values and conclusions of this study.

The project has low *technical risks* as the targeted turbine size has a proven track record, and NREA has highly qualified staff for project preparation and O&M.

The *financial and regulatory risks* of the project are substantial:

- NREA carries the direct foreign exchange risk on the Mixed Credit loan as the tariff in the PPA-contract is fixed in EGP. Financial viability calls for the inclusion of a devaluation adjustment clause in the PPA-contract and effective enforcement by the regulator of the adjustment clause vis-à-vis the off-taker EEHC/EETC.

- The high gearing ratio of project finance (equity finance is only 2% of total) exposes NREA to liquidity problems whenever the wind regime in a year is below average.
- The PPA is for ten years, while the Mixed Credit loan is for 15 years.
- Due to politically motivated tariff-setting, power tariffs in Egypt are too low to provide the power companies owned and administered by EEHC with revenue sufficient for financially viable operation. NREA, thus, faces on off-take risk.

2.3 Environmental Impact, Employment and Foreign Exchange

The overall environmental impact of the project is strongly positive. The *negative impact* is limited to noise and to visual disturbances of a landscape, which, looking inland from the sea, is insignificant. Neighbours to be affected by noise are few, mainly NREA operating staff and their families living in houses and located more than 500 meters from the nearest turbine. The *positive environmental impact* comes from the reduction in the project lifetime consumption of 2.3 billion cubic meters of natural gas at the thermal power plants and the associated reduced emission of 4.7 million tons of CO_2 and of an unknown quantity tons NO_X per year.

The Zafarana windfarm will generate about 1,700 man-years of *employment* during its lifetime.

The *foreign exchange impact* of the windfarm is slightly positive.

2.4 Financial and Economic Project Analysis

The *financial project analysis* confirms that the project complies with OECD's criteria for non-commerciality. The financial cost of power at a 7% financial discount rate is 18.5 piaster/kWh on the assumption that Zafarana sells its CERs at a price of €4 per ton CO_2 during 20 years. The value to EETC/EEHC of power supply from windfarms equals the induced avoided financial costs in thermal power generation, which depend on the price of natural gas consumed by thermal power plants.[1] If the gas is priced at its "full cost of supply price" of 24 piaster per cubic meter, the financial value of replaced thermal power production amounts to 8.1 piaster/kWh.

The *financial investor analysis* (project finance based) shows that NREA needs a minimum tariff of 19.5 piaster/kWh for 20 years. At that tariff, NREA will attain an after-tax-rate of return on equity of 8.6%.

The calculation of the EIRR is confronted with three major difficulties.

- *The uncertainty about the long-term price of oil on the international market turns the LNG-price assumptions into guess work*. The relevant gas price for economic rate of return analysis is the opportunity cost of gas consumption at

[1] The cost of gas supply in the production sharing contracts is fixed in US$. The present price of 14 piaster per cubic meter does not cover the national cost of gas production and transport to power plants in Egypt. Three years ago, before the creeping devaluation of the Egyptian pound, it did.

thermal power plants, which is the netback value of natural gas exported as liquefied natural gas, LNG. The market price of LNG is a function of the price of crude oil, which looking backwards over the last 100 years fluctuated around an average price (2004-price level) of US$25/bbl. Presently, concern is rising that the oil price may witness an upwards long-term parameter shift. Early May 2004, the price of Bent crude was US$36.5/bbl.

- *CO_2-reduction benefits are global benefits, which Governments attach different price tags to*. The CER-sales price, expected to be around US$4, is the market price reflecting the concrete monetary benefit for Egyptian society. The Danish Government's cut-off price of US$20 per ton for domestic CO_2-reducing measures reflects the marginal economic value of this global benefit seen through Danish political eyes. Thus, which of the two price tags is relevant?
- *The existence of non-quantifiable benefits reduces the applicability of classical cost-benefit analysis*. One benefit is the "consumption value" of wind energy[2]: its intrinsic value for being a sustainable form of energy. Another is the portfolio value of adding windenergy to the national mix of generators.

The *economic rate of return* of the project, based on the "production value"[3] of wind-generated power, is 8%, assuming a crude oil price of US$25/bbl and a CO_2-reduction value of US$4. Changing the assumptions by either a crude-oil price of US$35/bbl, or a CO_2-price of US$20/ton, increases the EIRR to 12%. The calculations do not take into account neither on the benefit side, the value of non-quantifiable benefits, nor on the cost side, EETC's investments in grid reinforcement and a new substation. A conservative assumption is that the two opposite parameters cancel each other out. Thus, the EIRR is likely to be in the 10-12 percent range.

[2] The "consumption value" of power from renewable energy refers to the premium payments per kWh, which a significant minority of consumers and Governments are willing to pay for the intrinsic value of wind energy as a renewable and "sustainable" source of power generation. This intrinsic quality attribute drives the implementation of renewable energy portfolios in many countries.

[3] "Consumption value" refers to the intrinsic value attached to the quality aspect of wind energy as a renewable source of power supply.

3 THE PROJECT

3.1 Background

The Egyptian Government has a policy to promote use of renewable energy systems in the country to develop productive employment opportunities and reap foreign exchange and environmental benefits. Egypt has at the Gulf of Suez some of the best wind resources in the world, and the development of grid-connected windfarms is the top renewable energy priority in the near to medium term. The objective is to have 600 MW of wind power capacity installed by the year 2010; for 2024 an indicative target is 3000 MW.

The background for this decision is that the Egyptian environment is eminently suited for the development of wind power:

- Egypt along the Gulf of Suez has some of the most promising exploitable wind resource conditions in the world
- Large tracts of desert land are available to install wind farms.
- The considerable installed hydro capacity makes it possible to react "instantaneously" to fluctuations in wind output reducing the need for spinning capacity. The advantage, however, is only partially available as hydropower production is seasonally linked to the water requirements for irrigation.
- The Egyptian power system with more than 17 GW of installed capacity and continued growth in demand is large enough to absorb sufficient wind power capacity and to make a base for local manufacturing of wind turbines in the medium or long term.
- NREA, (the New and Renewable Energy Authority) was established in 1986 as the key national organisation for this promotion of renewable energy in Egypt, and has, supported by donors, built up a strong expertise in project preparation and implementation as well as in windfarm O&M.

NREA's cooperation with Danida began in the early 1990s with the establishment of a pilot wind farm (1.8 MW) and a testing centre for wind turbines at Hurgada. Assisted by Risø, NREA developed the Wind Atlas for the Gulf of Suez and prepared a wind energy master plan to year 2017. Development at Zafarana began with the *grant-financed Zafarana 1 project* of 30 MW, approved by Danida in 1997 and put into operation with Nordex 600 kW wind turbines in the year 2000. The *mixed credit financed Zafarana 2 project* of 30 MW Vestas 660 kW wind turbines was completed early 2003.

3.2 Objectives - LFA

The objective of the project is to assist the Egyptian Government in achieving its year 2010 target of 600 MW installed windfarm capacity, by adding a new 120 MW windfarm to the installed capacity at the Zafarana windfarm site. A sub-objective is

to provide NREA with experience in the economics and O&M requirements of larger than 1 MW wind turbines. The project LFA-matrix is found at the end of this chapter.

3.3 Actors involved in the Project

3.3.1 NREA

NREA, the project promoter and owner, has a staff of around 750 including well qualified professional staff in most renewable energy fields, engineers; technicians, accountants, economists and administrative staff.

Being the owner and operator of the existing 140 MW windfarm capacity at the Zafarana site, NREA has strong experience with the preparation, implementation and operation of windfarms. The staff of about 50 at Zafarana is more than sufficient to cover the operational requirements for the targeted around 600 MW capacity at Zafarana.

The weak point of NREA as project developer and owner-operator is its financial position, which is undermined by factors beyond the immediate control of NREA management. (i) In performing its core Government agency functions, NREA cannot avoid annual operating deficits. Although not established as a so-called "Economic Authority" per se, NREA is viewed by the Government as one. As a consequence no allocations from the state budget are available: NREA is supposed to self-finance its activities by selling its services. Yet, since most activities, other than windfarming, have "public service" character, NREA's service revenue - studies for third parties, conducting tests and issuing test certificates, etc. - is insufficient to cover its annual costs. The financing gap during the 1990s was covered by loans from the National Investment Bank of Egypt (NIB), with the implicit understanding that the loans would never be repaid. (ii) As the PPA-tariff is too low, the sales revenue, which NREA receives as windfarm owner-operator, does not generate a financial – or cash - surplus.

3.3.2 EETC

The transmission company EETC has three roles in the project, the first two relate to the immediate project objective, the last to the development objective of the project.

(i) EETC is responsible for the planning, construction and operation of the transmission line to the wind farm and its connecting substation for the windfarm. It finances the grid connection and carries out the grid impact study, which receives TA financed by Danida under this feasibility study.

(ii) EETC purchases the power from the windfarm, signing the 10 year PPA with NREA. At present, EETC, like all EEHC-companies, is in a weak financial position also, making EEHC a less than ideal off-taker from a risk perspective.

(iii) In the long term planning process, EEHC/EETC has to plan specifically for the integration of wind energy in the National Power System if a high

penetration is to be obtained and a positive capacity value is to be reaped from investments in windfarm capacity.

3.3.3 National Investment Bank of Egypt, NIB

The local finance portion of project finance for NREA's windfarm is 15%, financing import duty and taxes as well as NREA's own costs of development. NIB is expected to provide most of the local finance in the form of a ten year loan, with a two years grace period, and an interest rate of 13%. The size of the loan depends on NREA's operating surplus from ongoing windfarm production. As a starting assumption a self-financing share of 15% is adopted.

3.3.4 Private bank for on-lending of Mixed Credit

A local private bank will act as the Borrower for the Mixed Credit Loan from the Danish bank connection of the winning turbine supplier, and on-lend the loan to NREA.

The exchange rate risk of the Mixed Credit loan will be born by NREA: the EGP payments to the private bank will be indexed to the exchange rate for currency of the Mixed Credit loan.

3.3.5 Role of Danida and other collaborating donors

Although not directly expressed as a political statement, it is well-known that the Government of Egypt has a strong interest in promoting renewable energy projects, including wind energy, as long as the financial surplus cost is covered by foreign funds – exploiting synergies between CDM finance and donor soft credit / grant finance. The perspective has been and is that donor subsidy support is temporary phenomena as wind farm technology continues to fall in price per kWh due to continued fast technological progress. At a time in a not too distant future, new windfarms will become fully economically viable in Egypt, eliminating the need for further external subsidy support.

For years, NREA and its primary collaborating foreign partners – Danida, KfW/GTZ, JBIC, World Bank/GEF and Spanish development aid – have had an implicit and explicit understanding on promoting windfarm development in Egypt on the above mentioned terms. Differences in opinion concerned the time perspective for the exclusive – monopoly – role of NREA as project developer for windfarms. In view of the financial weakness of NREA, the development of a large-scale market for wind energy in Egypt requires the establishment of a regulatory framework for private investments in windfarms. The Government, therefore, had decided to let NREA invest in the first 300 MW of windfarms and private investors in the next 300 MW.

During investigations it became clear, however, that the establishment of an adequate financing and regulatory framework for private investments is still a few years down

the road.[4] It is difficult to see credible private alternatives to NREA for the 600 MW year 2010 target. NREA is the windfarm developer of choice. KfW financed a 33 MW wind farm at Zafarana, which became operative in March 2001; a further 47 MW farm will be operational by April 2004. NREA signed in December 2003 a grant/soft loan contract for an 85 MW windfarm with Spanish Aid and a soft loan contract with JBIC for a 120 MW windfarm. KfW is in the process of financing a further 80-100 MW.

3.4 Responsibility for the Investment Activity

The responsibility for the investment activity will be split into three parts:

- EETC finances and implements the investment in the grid connection between the wind farm, a new substation and reinforcement of transmission lines.

- NREA finances and owns the windfarm, oversees the overall project activity, signs the contract with the windturbine supplier and has direct responsibility for the investment in the civil (excluding turbine foundations) and electrical infrastructure at the Zafarana site, hiring and supervising a construction firm for that purpose.

- The contract with the wind turbine supplier comprises supply and installation of turbines, construction of foundations, training of NREA staff in turbine O&M, spare parts and two years of O&M.

3.5 Composition of Investment

Table 1: Composition of Investment

INVESTMENT ITEM	EGP	Euro	DKK
1. Cost of Project & Tender Preparation	7,400,916	967,440	7,207,428
2. Cost of Project Development by Investor	0	0	0
3. Wind Turbines, Spare Parts and O&M Support	638,010,000	83,400,000	621,330,000
4. Civil & Electric Infrastructure	102,081,600	13,344,000	99,412,800
TOTAL FIXED INVESTMENT	747,492,516	97,711,440	727,950,228
5. Import duty on imported turbines	46,634,400	6,096,000	45,415,200
6. Sales tax on turn-key contract	74,009,160	9,674,400	72,074,280
7. Interest during Construction	22,202,748	2,902,320	21,622,284
TOTAL INVESTMENT AND FINANCE NEED	890,338,824	116,384,160	867,061,992

[4] A joint Danida-KfW-World Bank-NREA initiative resulted in the report "Development of a Commercial Windfarm Market in Egypt", June 2003.

3.6 Project Finance

3.6.1 Terms of project finance

Project finance comes from three sources:

(i) EETC, using *EEHC sources of funds (equity and loans)*, undertakes the investments in connecting the windfarm to the 220 kV transmission line.

(ii) *NREA secures local finance to the windfarm through own-equity capital and a loan from NIB* to cover: (a) the cost of project preparation – mine clearing and use of own manpower in planning, wind measurements, etc.; (b) the cost of import duty, (c) the cost of sales tax on equipments and materials used for the windfarm – in the model it is assumed that the sales tax is reimbursed the same year, (d) own manpower for project management and supervision during the construction phase.

(iii) The *WT-supplier contract* and NREA's *contract with the construction company for the civil and electrical infrastructure* financed by the *Danida Mixed Credit* (except import duty and sales tax) expressed in DKK (NREA's currency preference).

Danida' Mixed Credit is offered on either one of the following terms:

(a) 10 year loan at 0% rate of interest, and a 3.5% deduction from principal

(b) 15 year loan at 1.5% rate of interest, and 0% deduction from principal

Local bank's on-lending terms are the following:

a. The bank charges a guarantee premium of 0% per year.
b. The on-lending margin for passing on the loan to NREA will not exceed 1%.
c. NREA's payments of interest and repayment of principle on the EGP-loan are indexed to the EGP-DKK exchange rate.

3.6.2 Composition of project finance

The composition of project finance is summarized in table 2.

Table 2: Composition of Project Finance

Composition of Project Finance	EGP	in % of total
NREA own equity	19,206,671	2%
Mixed Credit loan	740,091,600	84%
Danida grant to interest during construction, principal	22,202,748	3%
Loan from NIB to NREA	108,837,805	12%

3.6.3 Use of CDM-project mechanism

The project will be organized as a CDM-project.

The CERs will be sold on a long-term contract to the highest bidder. The buyer will most likely be found through direct contacts and negotiations with NREA. There is a possibility that also the Danish Government might be interested in offering a purchase price.

3.7 LFA: 120 MW Zafarana 3 Wind Farm at Gulf of Suez / Rea Sea, Egypt

	DESCRIPTION	VERIFIABLE INDICATORS	MEANS OF VERIFICATION	CRITICAL ASSUMPTIONS
DEVELOPMENT OBJECTIVE	Environmental friendly and cost-effective portfolio of power generation in Egypt which maximizes employment and foreign exchange benefits	2400 MW installed wind turbine capacity by the year 2024	EEHC power sector statistics	A favorable legal, regulatory and financial climate for wind energy development, continued cost reductions in WTs
IMMEDIATE OBJECTIVE	1) Zafarana windfarm site expanded with 120 MW 2) Experienced gained in O&M and the economics of larger than 1 MW- turbine sizes	The 120 MW wind farm produces around GWH per year Availability of wind farm at least 97%	Commissioning documents Wind farm log (CMS)	Long-term PPA for output from windfarm is signed between NREA and EEHC
OUTPUTS	1) A 120 MW wind farm 2) Staff trained in the operation & maintenance of >1 MW WTs	Taking over documents	Commissioning documents duly signed	
ACTIVITIES	Design of wind farm Construction of wind farm Training of local service team O&M	Actual time schedule and output of each activity	Control of plan of verification	Staff and resources made available according to time/activity plan
INPUTS	15 year mixed credit of DKK 721 million at 1.5% interest rate plus grant of DKK22 million to pay for interest during construction; local finance of EGP128 million		Contracts with involved institutions and companies	Loan approval by Danida Unhindered imports of all equipment and material needed for project

4 PROJECT CONTEXT

4.1 Economy and Energy in Egypt

The 2001 per capita gross national income of $1,490 categorizes Egypt as a middle-income country. The population of 71 million in 2002 grows about 2.1 percent per year, making matching employment growth to the nearly 800,000 new job seekers coming into the labor market each year the main policy challenge. The official estimates put Egypt's unemployment rate in the 8%-12% range.

Foreign exchange bottlenecks, which developed during the late 1990s and early 2000s led to the introduction of a floating exchange regime in 2002 and a creeping devaluation of the EGP from about EGP4.0 per €1 that year to almost EGP8.0 in 2004.

The energy sector in Egypt fulfils the basic infrastructure function of securing energy supply to cover the national demand for energy, and provides foreign exchange earnings through exports of oil and gas. The country's five main sources of hard currency inflows are: tourism revenues (which account for about 5% of Egypt's GDP), remittances from Egyptian workers abroad, oil and gas exports, Suez Canal tolls, and foreign aid.

Oil exports have been declining as production has fallen at mature oilfields and domestic consumption has risen. [5] Natural gas exports are becoming a major source of hard currency revenues.[6] Foreign oil companies began more active exploration for natural gas in Egypt beginning in the early 1990s, finding a series of significant natural gas deposits in the Nile Delta, offshore from the Nile Delta, and in the Western Desert. Natural gas production in Egypt stood at about 3.0 billion cubic feet per day (bcf/d) in late 2002, and is expected to rise to around 5.0 bcf/d by 2007, with much of the increased volume being exported as LNG. Proven natural gas reserves were in 2002 estimated at 58.5 trillion cubic feet (Tcf); probable reserves at 120 Tcf. A small export pipeline to Jordan is near completion,[7] and two LNG projects have been signed.[8]

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[5] Egypt produced an average of about 631,616 barrels per day (bbl/d) of crude oil in 2002. Production peaked at 922,000 bbl/d in 1996.

[6] In addition, the operation of the Suez Canal and the 200-mile Sumed (Suez-Mediterranean) Pipeline with a capacity of 2.5 million bbl/d, provide two strategically important routes for export of Persian Gulf oil.

[7] Egypt, Jordan, and Syria agreed in principle in early 2001 to extend the pipeline into Syria, with eventual natural gas exports to Turkey, Lebanon, and possibly Cyprus. The feasibility of this option is questionable, though, as Turkish demand probably would not support another source of piped gas (beyond agreements in place with Russia, Azerbaijan, and Iran).

[8] Union Fenosa has contracted with EGAS for the supply of natural gas from its distribution grid, and will take all of the LNG output itself for use at the company's power plants and distribution to other users in Spain and elsewhere in Europe. Union Fenosa's two-train liquefaction facility at Damietta is scheduled to begin commercial production in late 2004. The LNG export project at Idku, build by BG in partnership with Edison of Italy, uses natural gas reserves from BG's Simian/Sienna offshore fields,

4.2 The Power Sector in Egypt

4.2.1 Power demand

Power demand, which in 2003 reached 88 TWh, grew by an annual average of 6.5% over the last three decades. This growth rate is forecast to continue.

4.2.2 Power supply

Egypt has an installed generating capacity of 17.75 gigawatt (GW), with plans to add 8.25 additional GW (mainly gas-fired) by 2010. Around 82% of Egypt's electric generating capacity is thermal (natural gas), with the remaining 17% hydroelectric, mostly from the Aswan High Dam. The annual increase in power demand calls for an annual addition of 1000 MW generating capacity.

About 90% of the hydropower potential in Egypt is already exploited. Production at the Aswan dam is defined by water demand for irrigation, and will, thus, not be affected by windfarm output. The thermal power plants that will be affected by an increased penetration of wind energy in the Egyptian portfolio of power supply are gas fired steam turbine plants and CCGT plants, oil fired generation is negligible. New steam turbine power plants have higher cost/MW than CCGT-plants and an efficiency of 41 % as compared to 57% for CCGT plants. EEHC considers *a mix of 30 % CCGT and 70 % steam* with an average load factor of 68 % suitable for load conditions in Egypt. CCGT plants are suitable only for coastal areas on the Mediterranean: if CCGT-plants are placed in areas where temperatures approach 40 C in summer, they could suffer from up to 20 % efficiency loss. In the merit order system, the CCGT plants work on full load basis due to lower fuel costs and because CCGT-plants incur much larger large efficiency losses than steam turbine plants when the plant is operated at partial load.

Generation projects planned by EEHC are two 750-MW natural gas fired plants near Alexandria, a 750-MW addition to the Cairo North power complex, and smaller hydroelectric projects at Nag Hammadi (64-MW) and Asyut.. Egypt also plans to build a part-solar power plant at Kureimat, which will have 30 MW of solar capacity out of a total planned capacity of 150 MW. World Bank/GEF is to provide grant finance to offset the cost difference between the solar capacity and thermal capacity.

Egypt's electric transmission grid is interconnected with Libya and through Jordan with Syria's, Iraq's and Turkey 's electric grid.

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and is scheduled to begin production in 2005. Gaz de France is to be the main offtaker for the Idku LNG project, having signed a contract in October 2002 for 127 Bcf per year beginning in 2005.

4.2.3 Sector Organisation and Ownership

The power sector structure is in a transitional phase, as the government owned electricity sector is being transformed into a more liberal form. The Egyptian Electricity Holding Company (EEHC) was established by law in 2000, replacing the previous state owned vertically integrated power utility EEA.[9] EEHC is a joint stock company (up to now owned 100 percent by the state) holding:

- the Egyptian Electricity Transmission Company (EETC), responsible for ultra high voltage and high voltage transmission, system control and dispatching in Egypt (the National Energy Control Center), and export-import contracts for electricity;
- five Generation Companies, four thermal and one hydropower
- seven Regional Distribution Companies for medium voltage transmission and distribution.

The present electricity market in Egypt is composed of two submarkets: (i) the unified power system of Egypt, and (ii) isolated markets; mainly tourist resorts at the Red Sea and in the Sinai Peninsula. EETC acts as single buyer for bulk power, purchasing electricity from the generators through PPAs and selling it to the distribution companies and HV and EHV customers. The vision of the Egyptian regulator is to gradually transform the market structure from a single buyer based structure to a bilateral contracts market. The gradual phasing into a commercial market would be implemented by Presidential decree.

In addition to EEHC, the power sector consists of a few IPPs selling to EETC: NREA's Zafarana windfarm and three privately-owned power plants under Build, Own, Operate, and Transfer (BOOT) financing schemes [10]; and a few IPPs selling power in the isolated markets.

4.2.4 Legal framework for power sector, rules for IPPs

The current legal provisions for the electricity sub-sector are:

- Law No. 12/1976: Establishing the Egyptian Electricity Authority (EEA).

- Law No. 100/1996: Amending some of the provisions of Law 12/1976 - allowing

[9] The planned privatisation of EEA had been delayed while waiting for the legislative provision to establish a regulatory authority; because of significant differences in the estimates of EEA's share value between the government and its adviser (Merill Lynch); and because of non-payment of electricity bills by state entities - leading to substantial EEA debts.

[10] The Sidi Kerir US$450 million 650 MW gas-fired steam power plant located at the Mediterranean coast, began commercial operation in late 2001.U.S.-based InterGen (a joint venture of Bechtel Enterprises and Shell Generating Ltd.), with local partners Kato Investment and First Arabian Development and Investment, have the 20-year BOOT contract. Electricity tariff is a low 2.54 cents per kWh, due to use of cheap natural gas, supplied by Egypt's Gasco. The other are two 650 MW gas-fired plants, owned by EDF, together costing around $900 million and located near the cities of Suez and Port Said; their tariff is 2.4 cents per kWh.

local and foreign investors to be granted public utility concessions.

- Law No. 18/1998: Concerning provisions related to the electricity distribution companies, the generating plants, the transmission networks, and amending some of the provisions of Law No. 12/1976 - creating eight[11] regional electricity companies out of EEA and maintaining EEA as the national transmission company.

- Law No. 18/2000: Transferring the EEA into an Egyptian Joint Stock Company named Egyptian Electricity Holding Company (EEHC).

- Presidential Decree No. 339/2000: Reorganising the Electricity Utility Organisation and Consumer Protection Agency (EUOCPA) to become the regulatory authority.

- EEHC Administrative Decree No. 32/2000: Concerning the unified commercial statutes for its seven regional electricity companies.

Although EETC is de facto single buyer under the present structure, laws in-force do not prohibit any other entity from participation in the bulk power trade.[12]

4.2.5 Electricity Regulatory Agency

The Electricity Regulatory Agency was established by decree in August 2000. The Minister is the Chairman of the Board, which is appointed by the Prime Minister. Of the ten members, three represent EEHC, three are not civil servants, and four represent the consumers. The functions of the regulator are still evolving.

4.2.6 Power tariffs

<u>Consumer tariffs</u>

The consumer tariffs for electricity are set by the Cabinet of Ministers. Despite the new structure of seven nominally independent distribution companies, the policy of nation-wide unified tariffs is continued. Tariffs have not been changed since 1993. They are now lower than the average cost of supply, undermining the financial position of EEHC.

The deadlock has backward repercussions on:

- *the price paid by thermal power plants for their natural gas consumption* - the price of which has not changed either, and which has become strongly under-priced due to the strong devaluation of the Egyptian pound;
- *the price paid by EETC for bulk power from windfarms*: NREA's PPA-tariff has not been changed during the last two years despite the devaluation.

[11] This was later changed to seven companies.
[12] See M.S. Elsobki and M. Abdel-Rahman:"Market Design for a High Growth Transitional Electricity Sector". Paper, 2003

Tariff group	Energy Tariff (EGP/kWh)	Demand Tariff EGP/kW/month	Power Factor charge
1) Ultra High Voltage			
Kima plant	0.047		yes
Other consumers	0.068		yes
2) High Voltage			
All consumers	0.1134		yes
3) Housing companies	0.0997		yes
4) Medium and Low Voltage			
4.1) More than 500 kW			
All consumers	0.1535	7.3	yes
4.2) Less than 500 kW			
Agriculture	0.07		no
Other consumers	0.18		yes
5) Residential			
0 - 50 kWh/month	0.05		no
51 - 200 kWh/month	0.083		no
201 – 350 kWh/month	0.11		no
351 – 650 kWh/month	0.15		no
651 – 1000 kWh/month	0.21		no
More than 1000 kWh/month	0.25		no
6) Commercial			
0 - 100 kWh/month	0.18		no
101 – 250 kWh/month	0.26		No
251 – 600 kWh/month	0.322		No
601 – 1000 kWh/month	0.41		No
More than 1000 kWh/month	0.43		No
7) Public lighting	0.30		No
8) Average	0.0957		

Bulk tariffs

The Cabinet is not involved in the price setting of PPAs; regulation of bulk tariffs is the prerogative of the Regulator. The principles and procedures are still to be formulated. The anomaly between an *industry structure of independent distribution companies* and the *policy of national tariffs* is solved through the intermediation of EETC, the single buyer:

- A Charge Model determines on an annual basis the fixed components of charges and cash requirements from the *distribution companies* to EETC and from EETC to the *generation companies*.[13] These forecast values are then used to determine the monthly fixed charges and cash payments.
- The variable components of the monthly charges are determined based on actual hourly metered values for generation output and fuel cost, and based on the demand from the distribution companies.
- End-of-year adjustments for uncontrolled factors are factored in to bring the return-on-equity (ROE) of all operating companies to uniformity.

As the procedure does not give individual companies a strong incentive to improve efficiency, it is doomed to be changed within a few years.

[13] See "Market Design for ..".

4.3 Policy and Regulatory Framework for Windfarms in Egypt

4.3.1 Policy making institutions

Two national committees are concerned with industry and energy issues are:

1. the *Parliamentary Committee for Industry and Energy*, which is consulted in connection with major decisions on energy policies and strategies; and
2. the *Governmental Committee for Industry and Energy*, which is responsible for overseeing the adherence to the legislative framework.

The energy sector policies are developed by the Ministry of Electricity and Energy (MEE) and by the Ministry of Petroleum (MOP) in consultation with the Cabinet and the Parliamentary Committee for Industry and Energy.

MEE is the key agency in the electric power sector and has seven authorities operating under its umbrella:

- The Egyptian Electricity Holding Company (EEHC)
- Rural Electrification Authority (REA)
- The New and Renewable Energy Authority (NREA)
- Hydro Power Plants Executive Authority (HPPEA)
- Nuclear Power Plants Authority (NPPA)
- Nuclear Materials Authority (NMA)
- Atomic Energy Authority (AEA)

The Organisation for Energy Planning (OEP) under the Ministry of Planning has the responsibility for integrated energy planning and policy analysis.

4.3.2 Objectives for energy policy

The government's energy policy measures focus on:

- maximisation of exportable oil and natural gas surpluses to earn foreign exchange
- enhancement of natural gas utilisation
- enhancement of energy use efficiency and energy conservation
- promotion of renewable energy

4.3.3 National plans for renewable energy and wind energy

In 1982, a *renewable energy strategy* was formulated as an integral part of the national energy plan in Egypt. NREA was established in 1986 under the MEE to act as a national focal point for expanding efforts to introduce and develop renewable energy technologies to Egypt on commercial scale along with deepening the local capabilities to use, produce and develop its equipment in different applied fields, thus contributing to limit fossil fuel use and, protecting the environment from pollution. NREA is entrusted to plan and implement renewable energy programs in coordination with other concerned national and International institutions.

Specific measures of the renewable energy strategy undertaken by NREA include: (i) renewable energy resource assessment and planning. (ii) research, development, demonstration and testing of the different technologies, (iii) transfer of technology, development of local industry and application of mature technologies; (iv) establishment of testing and certification facilities and development of local standards and codes, (v) education, training and information dissemination programs, (vi) taking advantage of renewable energy environmental benefits allowing financial support of its projects implementation through various mechanisms such as Clean Development Mechanism (CDM), financing RE incremental cost, soft loans, mixed credits, etc.

Since the early 1990s, NREA has invested in acquiring wind energy know-how and set up pilot and demonstration windfarms with financial and technical assistance from donors.

The current renewable energy strategy targets to cover 3% of Egypt's electric energy demand by renewable energy resources, mainly from solar, wind and biomass based technologies by the year 2010. Egypt's wind power plan up to the year 2010 foresees investments in 600 MW of windfarm capacity, around 600 MW of which will be at the Zafarana windfarm site facing the Red Sea and managed by New and Renewable Energy Authority (NREA), the rest at a site located in East of Oweinat.[14] A less firm policy aim is to have 3500 MW of windfarm capacity in place by the year 2022.

The national objectives for renewable energy policy put strong emphasis on the economic cost-effectiveness of chosen technologies. This makes development in renewable energy capacity strongly dependent on donor support.

[14] Egypt operates with five-year plans. 120 MW during 1997-2002, 330 MW during 2003-2007, and 150 MW during 2008-2010.

4.3.4 Incentives for investments in wind energy

Since no efforts have been made so far to develop a framework for private investment in wind power, no specific incentive instruments for renewable energy investments have been introduced in Egypt. Investors can apply for the general tax incentives offered under the Joint Stock Company Law from 1987. Investors can seek tax exemption from the 32% company tax on net profits for a period of 20 years in remote years and 10 years in urban. NREA, the key organisation for the development of wind power in Egypt, has been given access to donors' grants and soft credits for its investments in windfarms.

4.3.5 Cost of connection and use-of-system charges

EEHC (Egyptian Government policy) has supported and is supporting the development of windpower financially through under-priced investment and use-of-system charges:

(i) the 800 MW capacity 220 kV transmission line to Zafarana was constructed specifically to serve the transport needs for the output from the windfarm;

(ii) a "super-shallow connection charge"[15] of zero payment is applied by EETC for connecting the individual Zafarana windfarms to the grid;

(iii) no "cost-of-balancing-power charge" is levied on windfarm output;

(iv) for the transmission tariff in Egypt "postage stamp" pricing policy is used; since NREA sells directly ex-substation, no transmission tariff applies.

4.4 Regulatory Assessment of Zafarana 3

4.4.1 Project ownership, organization of O&M

NREA, as outlined in chapter 3, is fully capable from a technical point of view of preparing, implementing and managing the Zafarana 3 windfarm.

The wind turbine supplier provides by targeted training in the O&M of the new turbine models.

O&M of the Zafarana wind farm is done by NREA after commissioning.

[15] Please refer to the definition section for "deep connection charge" and "shallow connection charge".

4.4.2 Land Ownership, lease of land

A presidential decree allocated an area of 80 km2 at Zafarana site free of charge for NREA *on concession basis by Suez governorate* for its wind energy program.

The land for the Zafarana 3 windfarm is located South of the 80 square kilometres. The Governorate is at the end of the approval process for authorizing the use of the additional land for a windfarm, and the use of the land by NREA. The formalization of the land use rights is done by Presidential decree.

Before construction, the land needs to be cleared for mines; the cost of mine clearance will be charged to NREA.

4.4.3 Compliance with local and regional planning regulations

The proposed area for the project has been assigned by Suez Governorate to NREA for wind farm projects.

No specific construction permit is required for Zafarana 3, as a general construction permit is included in the land rights permission.

4.4.4 Generation concession

The regulator is about to issue a generation license to NREA for its windfarm operations.

4.4.5 Sales of power, the PPA

NREA and EETC have signed five PPAs so far: one for Zafarana 1 for 7 piaster/kWh (due to full grant financing), the other four from 2002, covering Zafarana 2 and KfW 1 & 2 & 3 offer 10 piaster/kWh. The PPAs are valid for 10 years.[16] They state that the PPA-tariff of 10 piaster/kWh is to be revised annually, without, however, specifying a formula for price adjustment. Although the depreciation of the Egyptian pound vis-à-vis the currency of NREA's project debt has increased the cost to NREA, no adjustment has been accepted by EETC/EEHC; a position, which is understandable, since electricity consumer tariffs and gas tariffs are blocked as well. [17] A simple formula, linking 70% of the PPA-tariff to the movement in the exchange rate from EGP4/Éuro to EGP8/Euro would yield a year 2004 tariff of 17 piaster.

The tariff-adjustment clause in the PPA for Zafarana 3 project might look as follows:

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[16] It has not yet been discussed to sign a PPA for 15-20 years period with two steps tariff, but it can be considered.

[17] EETC management needs approval by EEHC management on financial decisions like that.

1) The currency risk of NREA's debt would be shifted to EETC, by linking about 70% of the electricity sales price (corresponding to the share of amortization payments in the NPV of annual expenditure during the first ten years) to the rate of EGP devaluation vis-à-vis the DKK.
2) The remaining 30% of the PPA would be inflation adjusted.

The national regulator was involved in the drawing up of the previous PPAs and will develop a new PPA format. The regulator, however, in safeguarding the commercial viability of the power companies faces a dilemma: drawing up a PPA along the lines outlined above, would increase the financial losses of EEHC until consumer tariffs are increased also in response to inflation and devaluation.

4.4.6 Environmental approval

The requirements for the environmental approval of windfarms are defined in Environmental Law No.4 of 1994. The terms established in Law no. 4 categorize windfarm projects as so-called "Class B"-projects.

EEAA's approval letter of August 1999 with the "Environmental Screening Form (B) for the Zafarana Wind Power Project" is shown in Annex 4. The Screening B form for Zafarana project is for 300 MW. NREA, therefore, will need to secure an extended approval in due time before final signature of the Mixed Credit loan. The approval asks NREA (i) not to exceed the upper limit of noise levels, (ii) to take necessary precautions against accidents and maintain worker safety, (iii) to take necessary precautions to avoid negative impacts on wireless communication and (iv) on migrating birds.

4.4.7 Grid connection contract

No *grid connection contract* is signed between NREA and EEHC for the connection of the Zafarana 3 windfarm to the 220 kV transmission line; and NREA pays nothing for the grid connection.

Instead, connection terms are defined in the *PPA contract*, which includes a frequency variation constraint within 50 Hz + 2% to be applied for power quality.

4.4.8 Project finance – status of financial closure

The expected structure of project finance is shown in sect ion 3.5. EETC finances the cost of connection; NREA its own costs of project preparation, including mine clearing, as well as the cost of import duties and sales tax; the Mixed Credit finances the WT-suppliers contract, civil and electrical works.

NREA and/or the Danish bank contact of the wind turbine supplier (once identified), need to identify a local bank for on-lending the Mixed Credit to NREA. Most likely it will be NBE.

5 PROJECT IMPLEMENTATION AND ORGANISATIONAL ASPECTS

5.1 Plan of Implementation; Time Schedule

The following is a preliminary time schedule outlining the activities and milestones till taking over.

	Notes	Activity	Duration Months	Time
1.		Second draft feasibility study with adjustments		Mid May 2004
2.		Grid System Impact Study by EETC (SIS)	3	March – May 2004
3.		Danida Appraisal mission to Egypt		May 2004
4.		Mine clearing	3	April – June 2004
5.		Appraisal report to Danida		Start June 2004
6.		Presentation to Board of Danida		End June 2004
7.	* 1	Contract for tender assistance to NREA		Mid July 2004
8.		Danida approval		End July 2004
9.	* 2	Preparation of tender documents	1	August 2004
10.		Tender documents sent to WT manufacturers		Start Sept 2004
11.		Wind measurements at the Danida III site	4	July – Oct 2004
12.	* 3	Updated wind study	1.5	Nov – Dec 2004
13.		Tender period & tender closing	3	Sept – Nov 2004
14.		Tender evaluation report prepared by NREA	3	Dec – Feb 2005
15.		Tender evaluation report approved by Danida		Mid March 2005
16.	* 4	Commercial WT contract signed by NREA and approved by Danida		End April 2005
17.		Loan agreement signed by Danish bank and NBE		End May 2005
18.		Contract commencement date		End May 2005
19.	* 5	Design, WT Production, Civil & Electrical work, Installation and Training	24	
20.		Test		May 2007
21.		Completion and taking over		End May 2007

Notes:

1) It is assumed that Danida will sign a short-term contract with a Danish Consultant for tender assistance.

2) A preliminary layout shall be included in the tender material.

3) Based on the on-site wind measurements an updated wind study shall be prepared. The objectives of the updated wind study are 1) to substantiate the AEP estimate presented in this feasibility study and 2) to present the final layout of the wind farm.

4) After the final layout has been determined, the commercial contract can be adjusted accordingly.

5) It is expected that the project will be produced, shipped and installed in batches.

5.2 Organisation

NREA is the key national organisation for the development of wind power in Egypt. NREA has, with the use of appropriate external technical assistance, planned and implemented the wind farms presently operating at Zafarana and Hurghada. Ownership, operation and maintenance of the Zafarana, Component III wind farm will, after commissioning, remain with NREA.

EEHC (or rather its subsidiary transmission company EETC) is responsible for the planning and construction of transmission lines to the large wind power projects.

NREA has successfully implemented the Danida financed Component I and II wind farms, totalling 60 MW. Furthermore, at the adjacent site Phase 1of the KfW soft loan financed 33 MW wind farm has been installed and Phase 2, 47 MW, is currently under construction.

The Danida Component III wind farm will be wholly owned by NREA, who will also be operating and maintaining it using its own staff. NREA will set up a Project Implementation Unit for the preparations, design and supervision, and it has a division dedicated to wind farm operation (already in charge of the Hurghada wind farm and the Danida and KfW financed wind farms in Zafarana).

5.2.1 Tender Support and Project Management Advisor

A Project Management Advisor (PMA) has greatly facilitated the project implementation in respect of the Danida financed Component I and II, and NREA would like to have a PMA included for the preparation and implementation of the Component III.

Due to the compressed time schedule in the tender phase, it is foreseen that the "Tender Support" (TS) shall be based on a short-term contract, and that the PMA for the implementation period shall be found through a bidding process.

It is envisaged that the TS-contract shall cover the following points:

- support to NREA in carrying out a survey of eligible wind turbines for the project
- support to NREA in the preparation of the tendering of Component III
- support to NREA in defining qualification and tender evaluation criteria

- Support to NREA in tender evaluation
- support to NREA in contract negotiations

It is envisaged that the PMA contract shall cover the following points:

- carry out pre-shipment inspections, ensuring that the supply is in accordance with the contract
- support NREA in assessing contract deviations
- be at the site during critical phases of the implementation and to assist NREA in quality control and inspections.

The latter issue shall include inspections of foundations and inspections during test of transformers and WT's.

The TS consultant and the PMA - who are envisaged to be financed by Danida - shall advice NREA, but with no direct responsibility, vis-à-vis the EPC contractor. However, since Danida has a need to be informed about project progress and implementation problems, if any, it is expected that the PMA be required to copy Progress Reports to Danida. Furthermore, Danida shall have the right to ask the TS consultant and the PMA for third-party opinions about project issues without prior approval from NREA.

5.3 Quotation

NREA wishes to follow a qualification and tender procedure that minimises the time required, thus, it has been decided to include the qualification requirements in the tender material. This means that the individual bidder needs to be accepted as complying with the qualification criteria, before their bid can be included in the tender evaluation.

NREA will invite the Danish manufacturers, who are eligible as suppliers according to Danida rules, to submit an offer for the project. It is envisaged that three manufacturers - Vestas/NEGM A/S, Bonus A/S and Nordex GmbH, will be invited to participate in the tender.

The tender shall cover Engineering, Procurement and Construction i.e. an EPC contract, and it shall include wind turbines, civil work, electrical work, CMS, spare parts and a training program in operation, service and maintenance. As an option, the supply of a crane for service and maintenance shall be included. Basically the tender procedures shall follow the lines of the tender for Danida Component II.

However, it shall be noted that the updated wind study, which shall include inputs to determination of the final layout, will be finalised after the tender specifications are prepared (ref. time schedule activity 9 & 12) and thus the bids must be based on a preliminary lay-out. This also means that the bids must include +/- prices for roads and cables, which should not be a problem due to the reasonable flat and homogeneous site area.

Further, the bids shall include service and maintenance, as well as a 2-year warranty of the supply. As an option, extended service and maintenance, and extended warranty for an additional year shall be included.

5.4 Bid Evaluation

It is envisaged that the bid evaluation follows the procedures used in connection with Component II.

The tender evaluation will be based on the EPC price in relation to the calculated AEP as Net Present Values (NPV). The AEP shall be based on the guaranteed power curve and the project wind distribution. The method has been improved, and the evaluation of the financial offers shall be based on the total production cost, covering the expected lifetime of the project.

5.5 Execution of works

As the project shall be tendered as a turnkey project, the EPC contractor shall be responsible for all parts of design, manufacturing, transport, installation and commissioning of the total wind power plant.

It is expected that manufacturing of wind turbine towers, civil work and electrical work will be sub-contracted to local sub-suppliers. It is assessed that companies having the sufficient capacity to carry out these tasks are present in Egypt.

With reference to the four projects already installed and the assessment that transport of wind turbines in the 1 - 2 MW range is possible, it is concluded that execution of an EPC contract should not cause major problems for an experienced wind turbine supplier.

5.6 O&M

In respect of O & M, NREA's organisation is in place. In Zafarana, the technical staff includes 14 engineers and 17 technicians. The engineers have been trained abroad and the technicians have been trained at the site during implementation and service of the four Danida and KfW projects. Each of the four projects installed is maintained by a team consisting of a mechanical engineer, an electrical engineer and four technicians.

The EPC contract, which shall include a 2-3 years service and maintenance contract, will include on-the-job training during erection and commissioning, and during the scheduled maintenance within the guarantee period. After the guarantee period it is planned to contract ad-hoc after-sales services from the supplier. It is assessed that the Technical Assistance (TA) during the preparation and implementation period, and the training by the supplier during the erection and warranty period, will secure the viability of the project.

5.7 Training Needs Assessment

NREA has obtained considerable experience in tendering, contracting and implementing wind farms of the 30 MW size. The service and maintenance of two of

the three existing wind farms, Danida Component I and KfW Phase 1, have recently been transferred to NREA as the service and maintenance contract with the supplier expired. The third, Danida Component II, is still within the guarantee period and, hence, the service and maintenance is still the responsibility of the supplier. KfW Phase 2 is currently being implemented.

NREA has received substantial TA during the process, but can still benefit from further TA during the process of tendering, contracting and implementing.

6 Technical Aspects

6.1 Wind Resources

6.1.1 Wind data

A wind atlas based on wind data from the Abu Darag mast, located approx. 15 km north of the site, has been used for the wind study. The Abu Darag wind atlas is based on wind data measured during a 10-year period (1992-2001) and is part of "Wind Atlas for the Gulf of Suez" made by NREA and Risoe [1]. According to Risoe these 10 years of data ensure the statistical significance and that predictions are representing long-term average.

6.1.2 Wind Resources

An area east of the Component III site has been investigated very thoroughly and the findings are presented in the two reports "Wind Atlas for the Gulf of Suez" and "Zafarana Wind Farm Project, Site Calibration Report for Component I + II".

The reports show that the wind resources at the western side of the Gulf of Suez are strongly dominated by winds coming from the north. Furthermore, the wind resources at the western side of the Gulf of Suez are characterised by higher mean wind speeds near the coastline and decreasing mean wind speeds towards the west.

It has been found that the WAsP program handles the decreasing wind speed towards the west within the Component I site area appropriately.

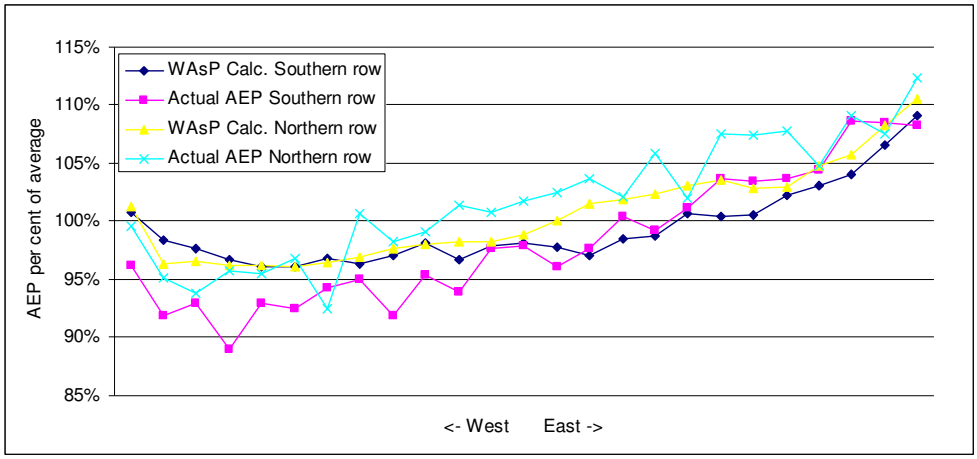


Figure - WAsP predicted AEP and actual AEP (relative to mean values) at Danida Component I site

Ref. [1] also shows that the WAsP flow calculation applying the Abu Darag wind atlas and the terrain description predicts the Zafarana mast and the Mast 7 within acceptable uncertainties. These masts are located at a distance to the coast similar to the Component I and II. The above figure (and annex II) support the finding in ref. [3] that WAsP predicts the decreasing energy resource towards west within the Component I site area appropriately. However, the figure below (and annex II) shows that the mean wind speed predicted by the WAsP model increases after additional 1.5 km to the west of Component I.

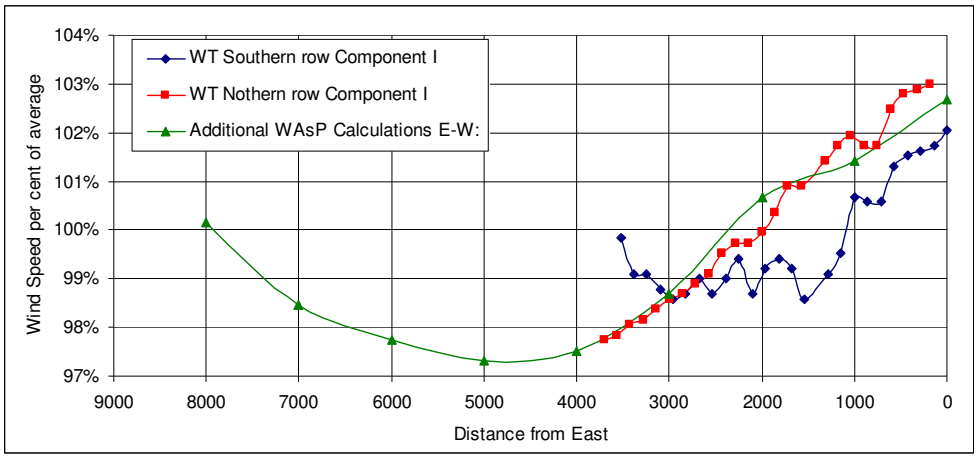


Figure showing the WAsP relatively predicted mean wind speed

This is most likely not correct, as the WAsP model over-predicts the Zafarana West mast, which is located approx. 12 km from the coast (see figure overleaf), by 16 per cent on the wind speed. The reason for this significant discrepancy is - according to ref. [1] - due to pronounced meso-scale effects, which are not incorporated in the WAsP model.

Due to the large discrepancy between the wind atlas prediction and the actual measurement at the Zafarana West mast and the size of the project it is found necessary to install two or three masts at the Component III site area. At the same time, both the Abu Darag and the Zafarana masts shall obtain wind data. Using correlation analysis methods it might be possible to determine the wind resource at the Component III site within an acceptable uncertainty level after approx. 4 months of measurement. It shall be noted, though, that the real uncertainties can only be determined after the data analyses have been carried out.

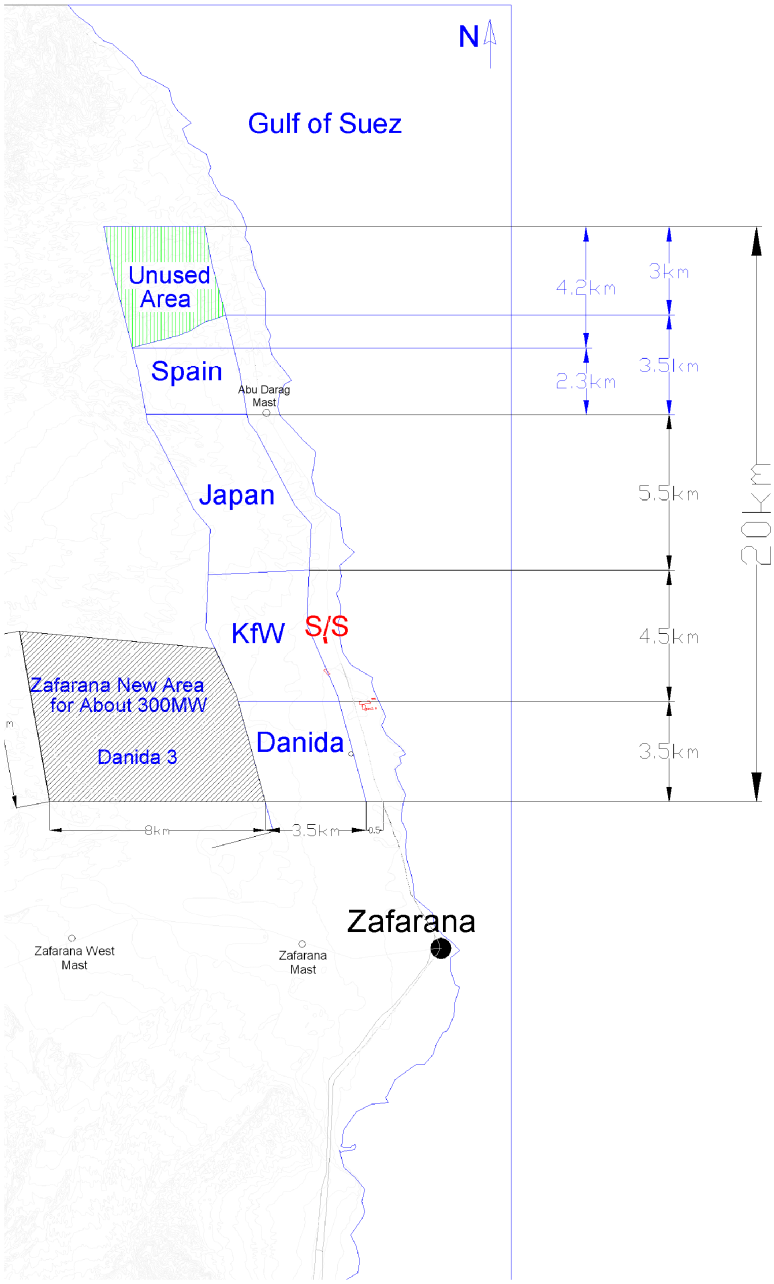
After the wind data analyses reveal acceptable levels of certainty, an updated AEP estimate for the project and an updated micro siting shall be prepared. The analyses shall secure that the project will be installed in accordance with the highest possible AEP, taking other planned projects into account.

Because the Component III site is located as far as 10 km west of the Component I and II sites and with a distance to the coast similar to the Zafarana West mast (see figure below), a correction factor of 0.90, which accounts for the 'WAsP-flow-modelling-inadequacy', is introduced in this preliminary wind study.

6.2 Conditions at the project site

6.2.1 Site location and topography

The Component III site is located on the west coast of the Gulf of Suez, south of Abu Darag and north west of Zafarana. The location of the project site is shown in the figure below.



Location of Zafarana Component III site, existing projects and masts

The site is part of the dessert; relatively flat and without any vegetation. For the preliminary layout the average, maximum and minimum height ASL are 52 m, 101 m and 24 m respectively.

6.2.2 Mean Annual Wind Speed

The mean annual wind speed measured at the Zafarana mast, located south of the site, during 1992-2001 at 25 m above ground level is:

Zafarana mast MAWS at 25 m: 9 m/s

6.2.3 Long-term Variation

The long-term (LT) variations are included in the Abu Darag wind atlas file, i.e. the data used in the AEP calculations represents long-term data.

6.2.4 Wind Direction

The on-site prevailing wind direction is north. Applying the wind atlas and the power curve of a Danish 1 MW and 2 MW wind turbine, it is found that more than 55 per cent of the total annual energy derives from this direction, which - fortunately - is very good for the installation of wind power projects.

6.2.5 Turbulence Intensity

The turbulence intensity is expected to be relatively low due to the topography and is, according to ref. [1], 10 per cent before taking wake effects from the wind turbines into consideration. According to ref. [2] the turbulence intensity at the site during a 5-months period was measured to be approx. 8 per cent.

6.2.6 Extreme Winds

According to ref. [1] the extreme wind speed (50 year, extreme 10 min wind speed at 24.5 m above ground level) based on measurements made at the Zafarana mast is 28.7 m/s.

6.2.7 Temperature

According to ref. [1] the temperatures in the Zafarana area can be described by the following observations made at the Zafarana mast at 2 m above ground level during 1992-2001:

Mean annual temperature: 23.2°C

- Extreme high temperature: 43.2°C

Extreme low temperature: 2.7°C

- Operation temperature range: 2.0°C < T < + 45.0°C

6.2.8 Atmospheric Pressure

According to ref. [1] the yearly mean atmospheric pressure in the Zafarana area (measured at the Abu Darag station at 2 m above ground level during 1992-2001):

Atmospheric Pressure 1011.1 hPa

6.2.9 Air Density

From the temperature and atmospheric pressure, the average air density at the site in hub height is:

Air density: 1.18 kg/m^3

6.2.10 Lightning

The area is exposed to thunderstorms and lightning.

6.2.11 Dust/Contamination

It is the experience from previous projects that the blades of the wind turbines are being contaminated by dust, and this has a negative impact on the power curve.

Furthermore, dust might damage parts in the nacelle and tower, so in order to prevent damages, specific precautions must be taken in order to minimise the dust and sand entering the nacelle and tower.

6.2.12 Earthquake

After a strong earthquake in 1991, a new earthquake code was introduced in Egypt. The code is described in chapter 8 of the Egyptian Code for Loads and Forces on Structures and Buildings, latest edition. According to this code Zafarana is located in earthquake risk Zone 3.

6.2.13 Geological Conditions

The geological conditions at the site have not yet been investigated. Geological investigations shall be carried out when the area has been cleared for mines.

However, there is no reason to believe that the Component III site geology is significantly different from the Component I geology. Therefore, the geological conditions should not constitute any problems.

6.3 Technical Description of the Wind Farm

6.3.1 Wind Turbine

In order to follow the market development, NREA has decided to require that the wind turbines for Component III be in the range of 1000-2000 kW, tower height 50-60 m. The total height of the wind turbine – hub height plus rotor radius - is restricted to 100 m.

All three of the potential, Danish wind turbine suppliers for the project: Vestas-NEGM, Bonus and Nordex are able to supply wind turbines in the specified range.

It is expected that the specific wind turbine offered will be required to have a commercial track record in line with the following:

- Minimum 60 units with more than two years of problem-free track record, and
- Wind turbine availability higher than 95% per year.

The exact requirements shall be determined during the tender preparation period.

Whether the turbine model offered shall be “tropicalized” or specific requirements determined in accordance with the site conditions (temperature, dust, saline air etc.) shall also be decided during the tender preparation period.

Bonus 1 MW wind turbine (height 50 m & diameter 50.2 m) and Vestas 2 MW (height 60 m & diameter 80 m) have been used to calculate the annual energy output.

6.3.2 Wind Turbine Approval

The wind resources in the Zafarana area are known as one of the best in the world and, furthermore, the temperatures are very high. The wind turbine model shall have an IEC Class 1 or a Class 2 approval. If the tender is successful, the approval shall be followed by a site-specific approval issued by a recognised approval institution.

The condition of a “Site-Specific Approval” shall be part of the contract with the manufacturer and the approval shall be issued before shipment of the equipment.

6.3.3 Wind Turbine Towers

The wind turbine towers shall be the responsibility of the wind turbine supplier, but it is foreseen that towers will be produced locally. The towers will be tubular. Maximum wind turbine height (hub height) is about 60 m.

6.3.4 Layout, Wind Turbine Siting

The entire new site area is expected to include approx. 300 MW, out of which the Component III shall account for 120 MW. As the exact location of the Component III wind turbines at the new site area is unknown, two layouts including 320 MW for the 2 MW wind turbines and 336 MW for the 1 MW wind turbines respectively are considered. The annual energy estimate for the 120 MW Component III project is then determined as the average production per WT for the two layouts multiplied by 60 and 120 wind turbines respectively.

The first layout - 2 MW wind turbine - consists of 168 wind turbines in eight straight rows in the east to west direction. The distance between the wind turbines in each row is approx. 280 m (3.5 times the 80 m rotor diameter, D) and the distance between the rows is approx. 1064 m (13.3*D).

The second layout - 1 MW wind turbine - consists of 320 wind turbines in eight straight rows in the east to west direction. The distance between the wind turbines in each row is approx. 195 m (3.6 times the 54.2 m rotor diameter) and the distance between the rows is approx. 760 m (14.0*D).

In the two layouts the wake effect from Component I and II, and KfW phase 1, 2 and 3 has not been taking into consideration, when calculating the annual energy production (AEP) of the proposed wind farm. However, the wind resource is strongly dominated by winds coming from the north including approx. 90 per cent of the energy, and therefore the additional wake loss caused by the existing wind farms is assessed to be insignificant.

After the on-site wind measurements and corresponding data analyses have been carried out, the final layout of the wind farm shall be determined.

6.3.5 Foundation

The foundation calculations shall be in accordance with the actual geological conditions and shall be the responsibility of the wind turbine manufacturer. According to the geological information from the Component I & II, the wind turbine foundations should not constitute any problems.

6.3.6 Transportation

The wind turbine manufacturer shall be responsible for the transport of all wind turbine components to the Zafarana Wind Farm Site.

Transport is possible via shipping to the harbour of either Alexandria or Suez, and further transportation by road. However, it is recommended to use the route via Alexandria harbour, which is supposed to be faster and less costly.

There is a newly constructed harbour just north of the site, and the road from there is good for transportation of heavy and long goods. It is concluded that transport should not constitute any problems.

6.3.7 Crane Availability

The necessary crane capacity will be the responsibility of the wind turbine supplier and can either be temporarily imported or rented in Egypt.

The wind turbine manufacturer shall specify type and size of a service crane, which is suitable and necessary for carrying out service work, repairs and maintenance.

An 80 tons crane was part of Component I, but the size is marginal for service and maintenance of wind turbines in the 600 kW size.

The crane for service and maintenance shall be tendered as an option in the tender.

6.3.8 Lightning Protection

The WTs and their installations shall be suitably protected against damage caused by lightning and over voltages due to lightning.

6.3.9 Central Monitoring System

A CMS shall be included in the wind turbine supply. The wind turbine manufacturer has to supply a Remote Control and Monitoring System for the centralised supervision of the operation and the centralised acquisition of operational data from the individual WTs and the meteorological monitoring masts.

6.4 Annual Energy Production Estimate

AEP calculations are carried out using the Abu Darag wind atlas based on 10 years (1992 - 2001) of data, the wind flow modelling program WAsP 8 and the digitised map of the area, which was an output of the "Site Calibration Project".

In the calculations of the AEP for First layout, the power curve from a 2 MW wind turbine under standard conditions has been used.

In the calculation of the AEP for the Second layout, the power curve from a 1 MW wind turbine under standard conditions has been used.

AEP estimates applying Abu Darag Wind Atlas – First layout

AEP estimate, first layout (60 x 2MW)		
Gross Mean Annual Energy Production (AEP_{Gross}) per WT:	*10303*	*MWh/year*
Net Mean Annual Energy Production (AEP_{Net}) per WT:	*7418*	*MWh/year*
Net Mean Annual Energy Production (AEP_{Net}) – Wind farm:	*445*	*GWh/year*
Net Mean Annual Capacity Factor – Wind farm:	*42.3*	*%*

AEP estimates applying Abu Darag Wind Atlas – Second layout

AEP estimate, second layout (120 x 1MW)		
Gross Mean Annual Energy Production (AEP_{Gross}) per WT:	*4783*	*MWh/year*
Net Mean Annual Energy Production (AEP_{Net}) per WT:	*3396*	*MWh/year*
Net Mean Annual Energy Production (AEP_{Net}) – Wind farm	*408*	*GWh/year*
Net Mean Annual Capacity Factor – Wind farm:	*38.8*	*%*

6.4.1 Correction Factors

In order to obtain the estimated Net Mean Annual Energy Production, AEP_{net}, which actually can be supplied to the grid, corrections and loss factors shall be applied. The following corrections have been included in the estimates presented in the previous section:

Correction factor – ID	***Value***
Air density	*0.98*
Contamination of blades	*0.98*
Turbulence and skew wind	*1.00*
First layout Wake loss / Wind farm efficiency	*0.936*
Second layout Wake loss / Wind farm efficiency	*0.924*
Transformer and line losses	*0.97*
Availability loss	*0.94*
Grid availability loss	*0.98*
Flow model correction	*0.90*
Long-term correction	*1.00*
First layout Combined loss and correction factor	*0.72*
Second layout Combined loss and correction factor	*0.71*

Table - Correction factors

To assess the correction factors, a comparison between the AEP calculated by WAsP and actual AEP for the 63 MW Danida 1 and KfW 1 wind farms - for the financial year 2001/2002 - has been carried out, and the results show:

1- WAsP calculation applying Abu Darag Wind Atlas (using the wind data for the same period) estimate the AEP to 263 GWh/year - including wake loss
2- The actual AEP for the financial year 2001-2002 was 224 GWh/year

This correspond to a correction factor of 0.85, which shall be compared to the above joint correction factor - exclusive the wake loss and flow model correction - of 0.86. The difference between the WAsP calculation and the actual obtained production for the specific year of one percentage point only is within the uncertainty of the calculation and within the uncertainty of the estimated losses, and further adjustments are not introduced.

6.4.1.1 Power Curve Correction

The power curve used in the AEP_{Gross} calculation is valid under standard conditions (15°C, 1013 hPa air pressure and max. 15 per cent turbulence intensity) and the calculations have to be corrected in accordance with the actual site conditions.

The annual average air density at the site is 1.18 kg/m^3. Therefore, a factor of 0.98 is applied in the calculations.

The power curve is valid only if the blades are clean and smooth. In some areas bugs and dirt may build up on the surfaces, which in the long run may harm the blades. This will have a negative impact on the power curve; however, the impact may be reduced by regular washing and polishing of the blades. Due to the dusty environment in the area a factor of 0.98 is applied in the calculations. It should be emphasised that washing the blades periodically must be expected.

6.4.1.2 Wake Loss/Wind Farm Efficiency

Using WAsP 8, the wake loss corresponding to the First layout is estimated at 5.4 per cent and, thus, a loss factor of 0.946 is applied in the calculation. The wake loss corresponding to the Second layout is estimated at 7.6 per cent and, thus, a loss factor of 0.924 is applied in the calculation. Please note that the effect of Component I & II, and KfW Phase 1, 2 and 3 has not been considered. However, it is assessed that the additional wake loss due to the existing wind farms located east of the Component III site is negligible.

6.4.1.3 Transformer and Line Losses

The transformer and line losses depend on the transformers and the dimensions of the cables and are estimated at 3 per cent.

6.4.1.4 Availability Loss

Experienced management companies are able to keep the availability loss as low as 2-4 per cent. But as seen in other projects, the organisations at this stage of utilising wind energy will experience a higher average availability loss. Mobile cranes, which can handle exchange of major components such as blades, gearboxes, generators etc., are available in Egypt and the crane situation is acceptable and should not have a major negative impact on the availability loss.

The availability loss may be reduced by: keeping a good stock of spare parts, proper training of the technicians, as well as having a skilled management and, not the least, having a close contact with the supplier.

An average availability loss of 6 per cent is anticipated for the calculations.

At present, the grid availability is reasonably high and a 2 per cent loss, due to grid problems, has been incorporated in the calculation.

6.4.1.5 Flow Model Correction

Ref. [1] shows that the WAsP model over-predicts the Zafarana West mast, which is located approx. 9 km further to the west than the Component I and II sites, by 16 per cent on the wind speed. This corresponds to an over-prediction of the energy production by 20 per cent for the present wind distribution and power curves. According to ref. [1] this is because of the meso-scale effects, which are not included in the WAsP model. Whether these changes in the overall wind climate between the coastal areas and the area at the Zafarana West mast can be transferred approx. 5 km northwards to the Component III site (see figure below), cannot be clarified before the results from the proposed additional measuring masts at the Component III site are obtained.

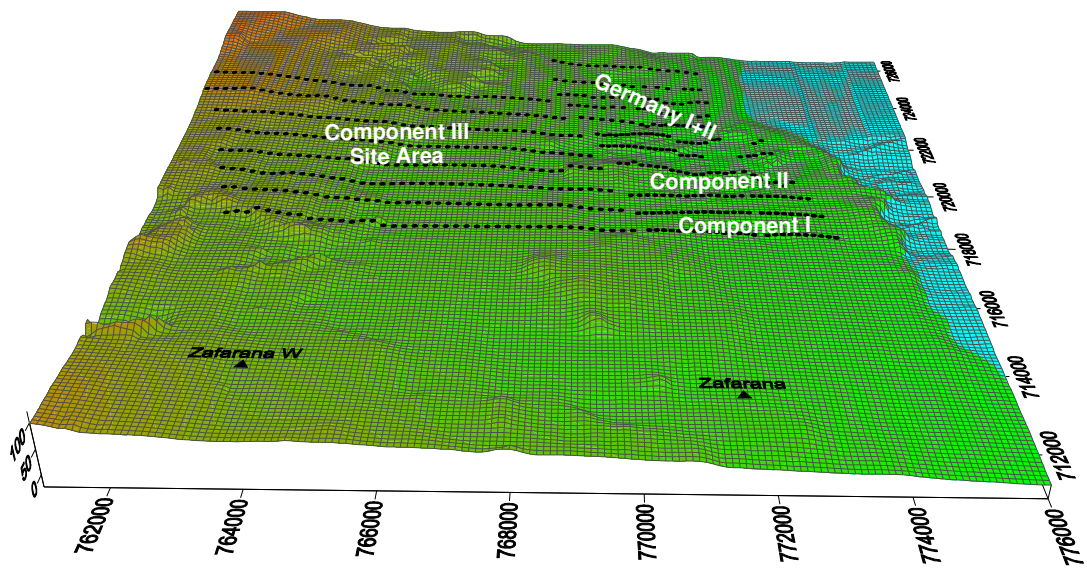


Figure showing a 3D plot of the Zafarana area

However, it is most likely that the same meso-scale effects occur at the westernmost part of the Component III site area as well. Annex II shows that the mean wind speed predicted by WAsP increases significantly towards west within the Component III site

area. Therefore, if no correction - accounting for this 'WAsP-flow-modelling-inadequacy' - is introduced, it is most likely that the calculated energy production from the future Component III wind farm is over-estimated significantly. It is assumed that the 'WAsP-flow-modelling-inadequacy' increases linearly – which is a rough approximation only – from the eastern part to western part of the Component III site area corresponding to a distance of approx. 8 km. This will result in an average flow model correction factor for the entire wind farm area of 0.9 (i.e. 10 per cent correction).

It should be noted that this major reduction factor is very uncertain, and it can only be verified by the wind data obtained from the proposed additional measuring masts erected at the Component III site area.

6.4.1.6 Long-term Correction

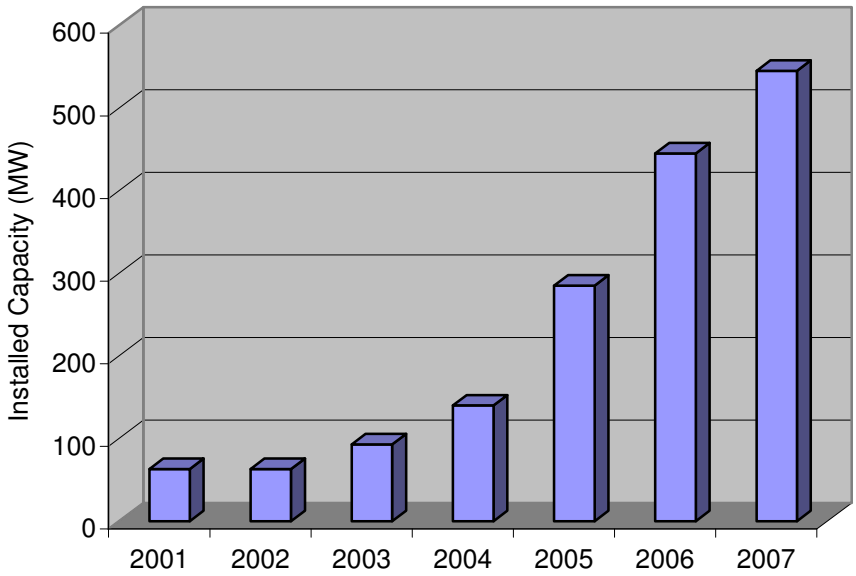
The wind atlas used in the analysis (1992-2001) is long-term corrected. Hence, no long-term correction is applied.

6.5 Infrastructure and Grid Connection

According to current plans the total capacity of the wind farms near Zafarana will be some 525 to 545 MW at the time of commissioning the Danida Zafarana III wind farm. The plan is as indicated in the table below:

Year	Capacity	Comment
2001	63 MW	30 MW financed through bilateral cooperation with Denmark and 33 MW financed through bilateral cooperation with Germany (KfW).
2003	30 MW	30 MW financed through bilateral cooperation with Denmark.
2004	47 MW	30 MW financed through bilateral cooperation with Germany (KfW); will be in operation from June 2004.
2005	85 MW	Financed through bilateral cooperation with Spain.
2005/6.	120 MW	Financed through bilateral cooperation with Japan.
2006/7	80 MW	Financed through bilateral cooperation with Germany.
2006/7	120 MW	Expected to be financed through bilateral cooperation with Denmark.

The exact timing of the three latter projects has not been settled yet and the order may, or may not, be changed. Graphically, the plan appears as the figure below:



Initially it is planned that the power generated in the Danida Zafarana III wind farm – together with the power from the other Zafarana wind farms – shall be fed into the Egyptian national grid by means of the already established 60 km long 220 kV overhead line from the Zafarana 22/220 kV substation to the Petro Pipeline substation (El Ain El Sokhna).

The present design of the existing substation in Zafarana does not allow an extension beyond 500 MVA, which is most likely not sufficient for the 545 MW wind power[18].

NREA and EETC are considering establishing an additional substation in the area. Due to the planned location of the Danida Zafarana III wind farm, it has been suggested to locate the additional substation west of the Danida Zafarana I site. A final decision regarding the location of the substation is not considered critical for the continued development of the Danida Zafarana III project.

The total of 545 MW wind power in Zafarana is considerable, also in the Egyptian electricity system. Hence, system related aspects in terms of load flow, stability etc. must also be properly considered.

An Electric Transmission System Impact Study (SIS) with the objective of establishing whether it is feasible to extend the total installed capacity of the Zafarana wind farms to well above 500 MW at the time of completing the Danida Zafarana III wind farm has been initiated as a collaboration between NREA, EETC and EEHC, and supported by Danida. The Terms of Reference have been prepared (see appendix

[18] Assuming a power factor of 0.96, a nominal load and an availability of 98 per cent, the apparent power, S, from 545 MW wind power will be 556 MVA. I.e.10 per cent above the capacity of the fully extended substation.
This calculation does not consider the power reduction resulting from stall controlled wind turbines' reduced output at high wind speeds. However, considering the expected number of plain stall controlled wind turbines, the impact will probably not exceed 5 MVA.

VIII, "Terms of Reference for Electric Transmission System Impact Study (SIS), Danida Zafarana III Wind Farm"). The specific support in connection with the implementation of the SIS was governed by the Terms of Reference, Wind Farm Models, Electric Transmission System Impact Study (see appendix IX).

6.5.1 Input for System Impact Study

As an input to the SIS, NREA and the Consultant have established and provided following information

1. Duration curve for the power generation from the wind farm for the four seasons (in percentage).
2. Typical daily power variation curves for the four seasons (in percentage).
3. Information regarding lulls.
4. Suggestion for a model of the Zafarana wind farm seen as a whole to be used for the analysis software PSS/E and PSLF (equivalent circuit representation).
5. Parameters for the equivalent circuit representation of the wind farms seen as a whole.

6.5.1.1 Duration Curves

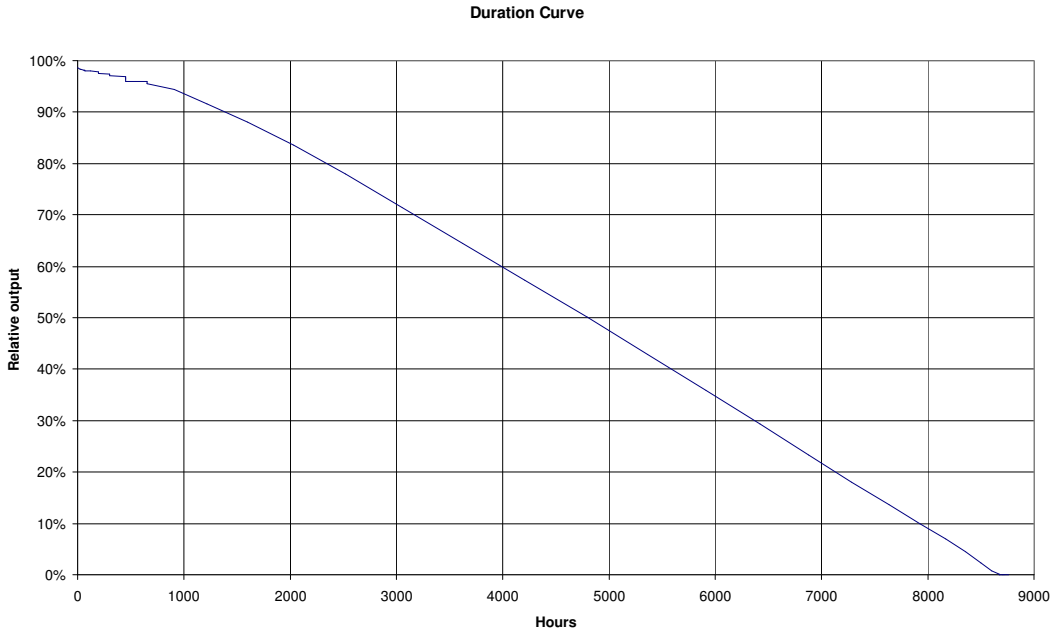
The information regarding duration curves is based on the following key data:

- Wind Atlas for the Gulf of Suez, 1991-2001, Abu Darag 1991-2001 data
- Wind farm power curves for Danida Component I plus KfW Phase 1 as calculated by WAsP 7
- Wind farm power curves for Danida Component II plus KfW Phase 2+3 as calculated by WAsP 7

Accumulated time	Power in per cent (descending)
0	99%
19	98%
30	98%
62	98%
62	98%
68	98%
117	98%
191	98%
195	98%
302	97%
303	97%
452	97%
452	97%
453	97%
453	96%

Accumulated time	Power in per cent (descending)
453	96%
453	96%
651	96%
651	96%
651	95%
904	94%
1219	92%
1595	88%
2031	84%
2521	78%
3055	71%
3622	64%
4205	57%
4791	50%
5364	43%

Accumulated time	Power in per cent (descending)
5909	36%
6417	29%
6877	23%
7283	18%
7633	14%
7927	10%
8166	7%
8354	4%
8496	2%
8600	1%
8671	0%
8671	0%
8676	0%
8702	0%
8715	0%
8760	0%

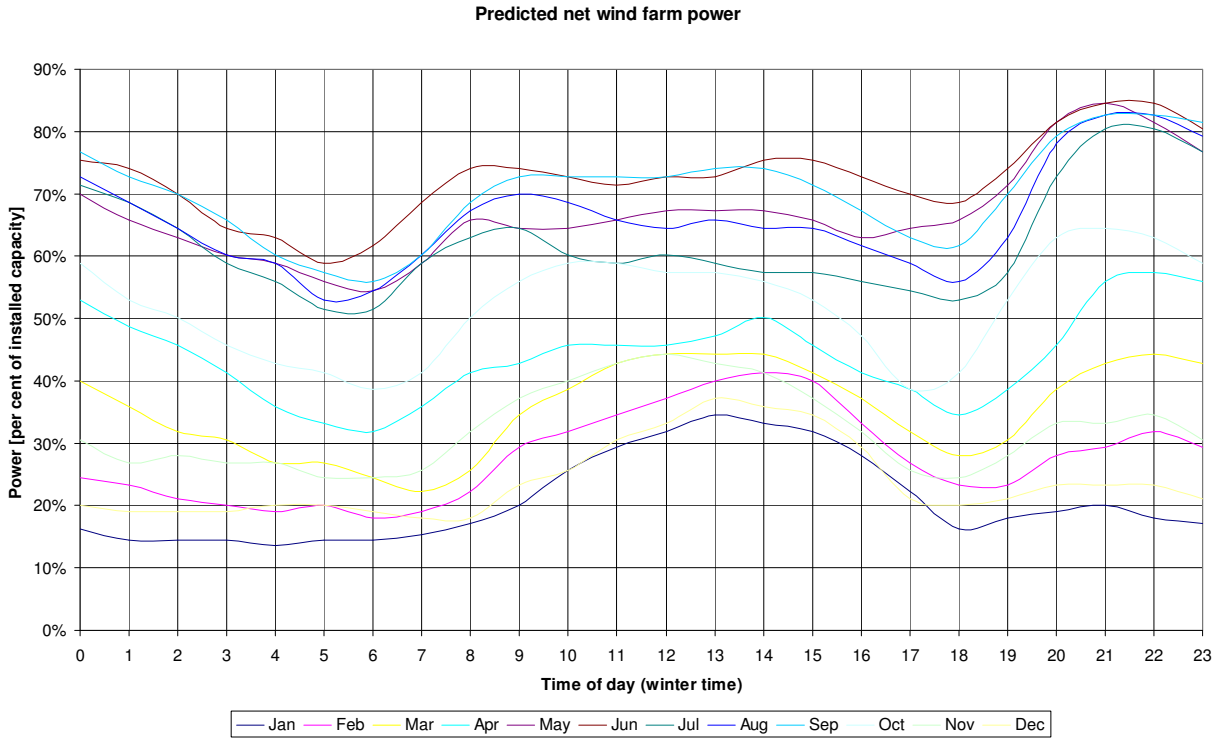


6.5.1.2 Variation Curves

The variation curve is established based on the same three sources as used for the duration curve. Initially, the estimated average power for each month of the year was calculated for each hour of the day. The result is shown in the table:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	16%	25%	40%	53%	70%	75%	71%	73%	77%	59%	31%	20%
1	14%	23%	36%	49%	66%	74%	69%	69%	73%	53%	27%	19%
2	14%	21%	32%	46%	63%	70%	64%	64%	70%	50%	28%	19%
3	14%	20%	31%	41%	60%	64%	59%	60%	66%	46%	27%	19%
4	14%	19%	27%	36%	59%	63%	56%	59%	60%	43%	27%	20%
5	14%	20%	27%	33%	56%	59%	52%	53%	57%	41%	25%	20%
6	14%	18%	25%	32%	54%	62%	52%	54%	56%	39%	25%	19%
7	15%	19%	22%	36%	59%	69%	59%	60%	60%	41%	26%	18%
8	17%	22%	26%	41%	66%	74%	63%	67%	69%	50%	32%	18%
9	20%	29%	35%	43%	64%	74%	64%	70%	73%	56%	37%	23%
10	26%	32%	39%	46%	64%	73%	60%	69%	73%	59%	40%	26%
11	29%	35%	43%	46%	66%	71%	59%	66%	73%	59%	43%	31%
12	32%	37%	44%	46%	67%	73%	60%	64%	73%	57%	44%	33%
13	35%	40%	44%	47%	67%	73%	59%	66%	74%	57%	43%	37%
14	33%	41%	44%	50%	67%	75%	57%	64%	74%	56%	41%	36%
15	32%	40%	41%	46%	66%	75%	57%	64%	71%	53%	37%	35%
16	28%	33%	37%	41%	63%	73%	56%	62%	67%	47%	32%	29%
17	22%	27%	32%	39%	64%	70%	54%	59%	63%	39%	26%	21%
18	16%	23%	28%	35%	66%	69%	53%	56%	62%	41%	25%	20%
19	18%	23%	31%	39%	71%	74%	57%	63%	70%	53%	28%	21%
20	19%	28%	39%	46%	81%	81%	73%	78%	79%	63%	33%	23%
21	20%	29%	43%	56%	85%	85%	80%	83%	83%	64%	33%	23%
22	18%	32%	44%	57%	81%	85%	80%	83%	83%	63%	35%	23%
23	17%	29%	43%	56%	77%	80%	77%	79%	81%	59%	31%	21%

The information is presented as percentages to be used for any development stage. To improve the presentation the data is also shown as curves.



6.5.1.3 Lull Data

Based on the calculations, it is estimated that the output from the wind farms will be less than one per cent of the nominal capacity for approx. 160 hours per year corresponding to two per cent of the time.

6.5.2 Model of the Zafarana wind farms and parameters for the models

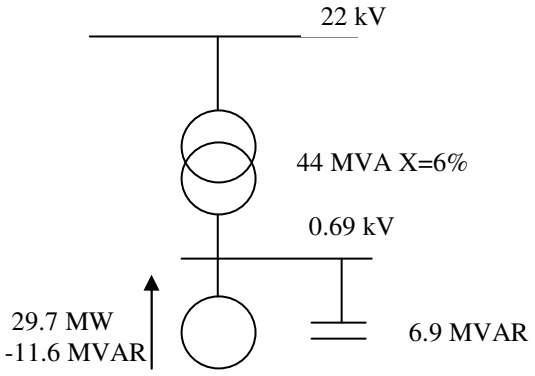
Models of the wind farms to be used in the simulation software packages PSS/E and PSLF have been established during the preparation of the Feasibility Study. As the latter three of the planned wind farms have not been designed yet, the wind turbines to be used for these farms are not yet known. However, for the purpose of assessing the electrical system impact in general terms, models based on generic data are sufficient.

For each of the existing and planned wind farms an aggregate model, which can directly be used in the simulation software packages, has been established. The wind farms have been assumed to be configured as indicated in the table.

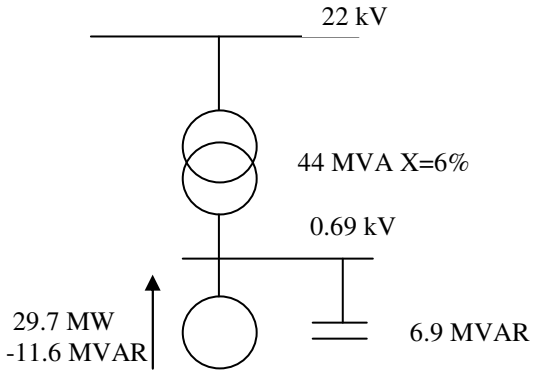
Zafarana Wind Farm Basic Information			
Wind farm	**Number of Turbines**	**Wind Turbine rating**	**Transformer rating and impedance**
1. Danida I (30 MW)	50	600 KW	800 KVA, 6%
2. Danida II (30 MW)	45	660 KW	800 KVA, 6%
3. German I (33 MW)	55	600 KW	800 KVA, 6%
4. German II (47 MW)	71	660 KW	800 KVA, 6%
5. Spanish (85 MW)	100	850 KW	900 KVA, 6%
6. Future 120 MW	120	1000 KW	1250 KVA, 6%
7. Future 80 MW	80	1000 KW	1250 KVA, 6%
8. Future 120 MW	120	1000 KW	1250 KVA, 6%

The established aggregate models are illustrated below.

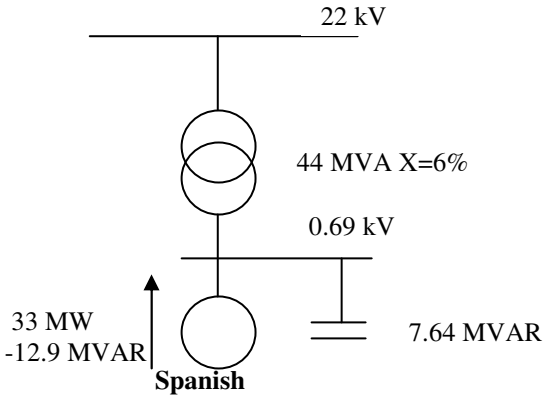
Danida I



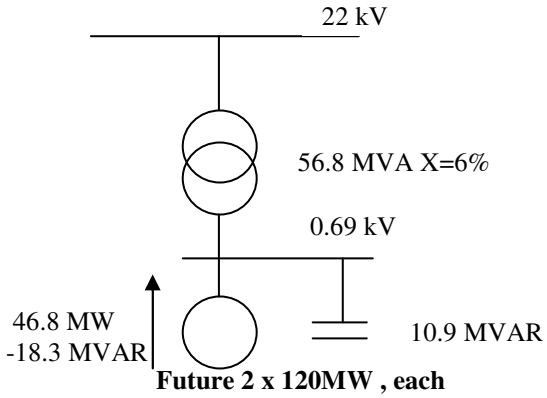
Danida II



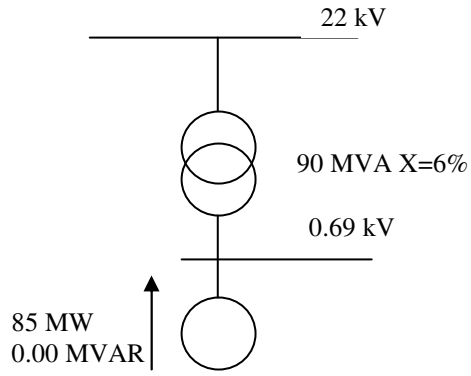
German 1



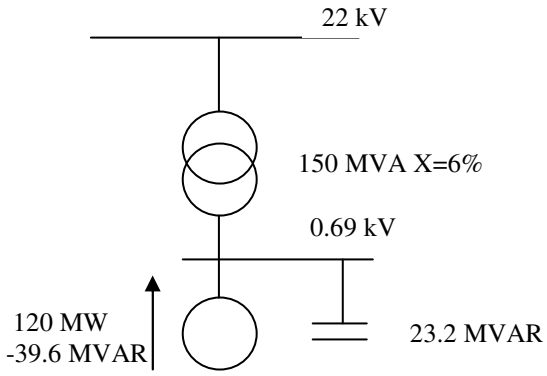
German 2



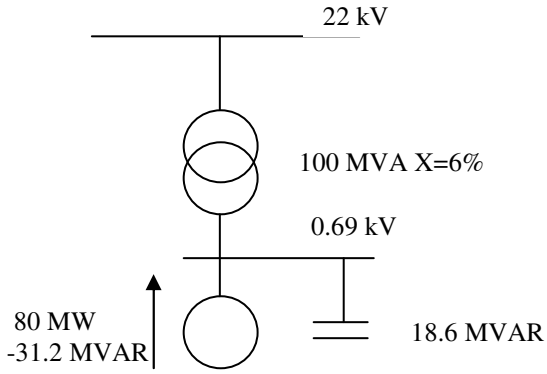
Spanish



Future 2 x 120MW , each



Future 80MW



It is assumed that all wind turbines are compensated for the no-load consumption of reactive power. Typical generator full load and no-load consumption of reactive power were estimated using Vestas data sheets. Spanish machines are assumed to be with variable speed, and to operate with a unity power factor (no consumption of reactive power). Data for step-up transformers was provided by NREA.

For dynamic studies two sets of PSS/E parameters were established based on the available data sheets.

Parameters for dynamic studies					
Parameter	PSS/E term	Set 1		Set 2	
		Value (Ω)	Value (PSS/E)	Value (Ω)	Value (PSS/E)
R1	L	0.0046	4.81 pu	0.0048	5.86 pu
X1	L1	0.044	0.068 pu	0.0816	0.126 pu
XM	L'	3.06	0.152 pu	3.72	0.289 pu
X2	To'	0.0552	2.14 s	0.108	2.54 s
R2	H	0.0043	3.00 s	0.0040	3.00 s

NREA is trying to acquire additional data sheets to improve the model parameters of the existing machines. Typical parameters will be used for future Wind Farms throughout the System Impact Study.

6.5.3 Status of the System Impact Study (SIS)

At the time of finalising this Feasibility Study, the System Impact Study was not finalised, but significant progress has been achieved and important preliminary results obtained.

6.5.3.1 Contingency Study

An EEHC/EETC planning criterion is that it shall be possible to handle single contingencies without overloading any equipment or disrupting power supply to any consumers; this is called the 'single contingency criterion'. In addition to this, it is a criterion that realistic and/or probable multiple contingencies do not cause power disruptions.

Seven contingencies have been studied for year 2004 with maximum system load with 140 MW Wind Farm generation, and for year 2007 with maximum and minimum system load with 545 MW Wind Farm generation in Zafarana. The contingencies as well as the screening process were limited to the Canal Zone Power System. Multiple contingency studies have not yet been carried out.

The contingency study included assessment of:

- Thermal overloads
- Voltage violations
- Voltage stability by means of VQ curves

6.5.3.2 Flicker and short circuit

Flicker and short circuit studies have been performed.

6.5.3.3 Transient Stability

One transient stability case was studied to test the dynamic wind turbine models.

6.5.4 Preliminary Results

In the following the preliminary results of the analyses carried out in connection with the System Impact Study are listed.

A. In the year 2004, the two times 75 MVA transformers, presently installed in the Zafarana substation, will be loaded up to 96% each at maximum wind farm generation. I.e. single contingency criterion is not met and the Zafarana substation transformer capacity will have to be extended to meet the criteria.

B. In the year 2007, maximum wind farm generation at Zafarana (545 MW) will cause one of the Ectsadia - Petro Pipeline circuits to be overloaded to 166 per cent of the thermal rating if the other is tripped. I.e. single contingency criterion is not met. If the system is not reinforced sufficiently, generation in the Zafarana wind farms has to be reduced to a maximum of 345 MW in this situation, to limit the load of the Ectsadia - Petro Pipeline circuit.

C. In the year 2007, maximum wind farm generation at Zafarana (545 MW) will cause one of the Petro Pipeline - Zafarana circuits to be overloaded to 120 per cent of the thermal rating if the other is tripped. I.e. single contingency criterion is not met. If the system is not reinforced sufficiently, generation in the Zafarana wind farms has to be reduced to a maximum of 454 MW in this situation, to limit the load of the Petro Pipeline - Zafarana circuit.

D. The Zafarana 220 kV/22 kV substation was modelled in the 2007 base case with five 125 MVA transformers in parallel. With this design the short circuit level exceeds 100 kA. Thus, the 22 kV bus bar has to be split into sections to keep the short circuit level below wind farm equipment short circuit capacity.

E. No voltage flicker or voltage stability problems were found during this preliminary study.

F. Neither stability problems nor other problems were observed when simulating the extreme contingency of tripping the full Wind Farm generation capacity (545 MW) simultaneously.

It was also analysed whether reinforcement consisting of a 220 kV double circuit transmission line from Zafarana to Hurgada, presently considered, will be sufficient to prevent the overloads described in B. and C. above. The analyses have shown that this reinforcement is not adequate.

The results will be further described and commented in the final System Impact Study to be finalised by EEHC/EETC during the month of May 2004. The following studies and activities are expected to be carried out by EEHC/EETC to complete the System Impact Study:

- Review the simulations carried out during the preliminary study.

- Simulate credible multiple contingency to assess the impact to the grid (bus faults and the tripping of the two circuits of double circuit lines) and document consequences.
- Identify possible solutions to the single contingency overload problems of the Ectsadia - Petro Pipeline and the Petro Pipeline - Zafarana transmission lines. Probably several reinforcement alternatives must be simulated and studied to find satisfactory solutions.
- Identify possible solutions to the credible multiple contingency problems.
- Complete the planning of the Zafarana substation.
- Perform transient stability studies.
- Impact of the wind generation on the regulating reserve of the Power System.
- Draft and finalise the System Impact Study Report including description of required amendments of the presently adopted grid extension planning made necessary by the extension of the Zafarana wind farm.

6.5.5 Summary of assumptions/pre-requisites with regard to the electrical grid.

The preliminary analyses (including single contingencies only) have shown that present grid extension plans do not allow for an extension of the Zafarana wind farms to a total capacity of more than 345 MW in 2007. The analyses have also shown that a reinforcement consisting of a 220 kV double circuit transmission line from Zafarana to Hurgada, presently considered by EEHC/EETC, is not adequate to increase the acceptable capacity of Zafarana to 545 MW. Further, multiple contingency analyses to be included in the final System Impact Study might lower the mentioned limits even more, and/or other problems might be identified.

Hence, to ensure the feasibility of extending the Zafarana wind farms to a total installed capacity of 545 MW, it has been assumed that EEHC/EETC will amend the present grid extension plans and implement necessary extensions in due time for the planned extension of the Zafarana Wind Farm. At this stage, following required amendments of the EEHC/EETC plans have been identified:

- A further extension of the existing Zafarana substation to accommodate 5 pieces 125 MVA transformers or, preferably, an additional 22/220 kV substation with sufficient capacity in Zafarana close to the location of the Danida Component III and KfW Phase 4 wind farms.
- Increased number of overhead lines from Zafarana substation(s) to the existing grid (for instance to Petro Pipeline substation or to Hurghada substation).
- Increased overhead line capacity either from Zafarana substation(s) to Hurghada or the system along the Nile, or from Ectsadia substation to Petro Pipeline sub-station.

Following the multiple contingency analyses further, necessary amendments to the currently adopted planning might be identified and, thus, assumed implemented to ensure the feasibility of a capacity of 545 MW in Zafarana.

7 ENVIRONMENTAL IMPACT AND SOCIAL ACCEPTABILITY

7.1 Studies of Environmental Impact of Zafarana Windfarms

Danida has financed the two most important environmental studies on Zafarana wind farms, which are: "Atlas of bird migration at the gulf of Suez – Egypt, June 2002" and "Environmental Risk Assessment for establishment of a Wind farm at Zafarana, August 1996".

The conclusion of the ERA concerning the environmental risks was:

- The potential risk for bird mortality from the chosen location of the Zafarana wind farm can be rated as slight.

- No important bird habitats occur within the project site and risk for collision during landing and starting up of nocturnal migration in the morning and evening is likely to pose no or little risk as only few migrants utilise the area during the day.

- No negative impacts on environmental issues like erosion, noise, hydrological systems, public safety and socio-economic issues have been identified for the wind farm at Zafarana.

The ERA proposed the following mitigating actions during the phase of construction as well as operation, which must be incorporated in the project:

- Retain unattractiveness of the project site and its vicinity to birds. Within a radius of 2-5 km around the wind farm any introduction of vegetation, open waters, sewage ponds and open dumps should be avoided.

- Any intensive illumination of the wind turbines should be avoided to reduce attractiveness to nocturnal migrants,

- Any major new supporting infrastructures for the wind farm have to be assessed carefully for the impact on nature conservation assets, including bird migration. All power transmission and electric connections within the wind farm should as far as possible be underground cables to minimise risk for collision with birds.

- Good environmental practice during construction work must be applied by the contractor and an action plan for environmental considerations during construction should be required as an integrated part of the Contractor's tender.

7.2 Negative Environmental Impacts and Mitigation Measures

The *negative impact* is limited to the expected very modest impact on bird population. Neighbors to be affected by noise are few and located more than 500 meters away. The visual impact of the windfarm on the landscape is positive, rather than negative, as the landscape inland is rather monotonous and barren. The impact on local fauna, on water quality, on air pollution and on agricultural activities is zero. Erosion is not considered to be caused by the project neither by the civil works within the site nor in connection with the construction of the assess roads. No evidence indicates any archaeological or cultural value that could prevent the project to be implemented.

The *mitigation measures* as dictated in the environmental B approval seem to be adequate. However, since the towers for the new 1-2 MW windturbines are much higher than the towers of the original 600 kW wind turbines for which the approval was given, one may ask a bird expert for a control check of whether the original mitigation measures need any further adjustment.

7.3 Positive Environmental Impact

The *positive environmental impact* comes from the reduction in the consumption of 2.3 billion cubic meters of natural at the thermal power plants and the associated reduced emission of 4.7 million tons of CO_2. Another positive environmental impact, which is not quantified, is the reduction in the emissions of NOx.

The economic analysis assigns two different values to CO2-reduction. The base case value of US$4 per ton, equals the expected price of CERs to be sold from Zafarana[19], the alternative price is US$20 per ton, reflecting the marginal, politically accepted cost of CO_2-reduction measures in Denmark.

[19] The price is in the optimistic upper end: recent international CDM-contracts have shown prices ranging from US$3.2-3.9.

8 DESIGNING ZAFARANA 3 AS A CDM-PROJECT

8.1 Compliance with the Project Additionality Criterion

NREA intends to organize the Zafarana 3 project as a CDM-project. NREA has first-hand experience with the CDM-procedure already: the JIDA-financed 120 MW windfarm at Zafarana is structured as a CDM-project. The proposed *baseline methodology* for the project was submitted in December 2003 to the CDM-Board for approval.[20]

Providing an adequate baseline methodology is a technical issue. The substantive issue for CDM-project approval is whether the project satisfies the *additionality criterion*. It has two interpretations, turning the condition into the fulfilment of two criteria:

- interpreted in a soft manner as "*environmental additionality*", it must be shown through the baseline scenario that the project, compared to alternative production methods, reduces lifetime CO_2-emissions in the production process.

- the hard interpretation of "*project additionality*" insists on proof that the project, being more expensive without CER-revenue support than alternative production methods, would not be implemented, if the CDM-project option did not exist.[21]

The Zafarana 3 project satisfies both interpretations:

1. Environmental additionality is documented by the estimated CO_2-reduction of 5.3 million tons.
2. Project additionality is documented by the fact that the CER-revenue for the Zafarana 3 windfarm, based on a price of €4/ton CO_2 (=1.6 piaster/kWh), is insufficient to bridge the gap between the financial cost of production of 20 piaster/kWh) and the estimated financial value of the induced savings in thermal power production of piaster 8.1/kWh (= the PPA-tariff in a free market situation). The NPV of the future CER-revenue amounts to EGP66 million equal to 8.5% of the cost of investment in the Zafarana 3 windfarm.

[20] Unless a CDM-project uses an approved baseline methodology, the proposed methodology must be submitted to the CDM-Board for approval. In December, no approved baseline metholodogy for windfarms existed.

[21] *CER-payments to CDM projects* are not subsidies, but payments for a side product. They have the same effect as a subsidy given to the kWh-output of renewable energy projects, reducing the tariff required to break even. This advances the commercial viability of renewable energy projects.

8.2 OECD Rules on Mixed Credits and the Marrakech Accord

According to OECD rules mixed credits must have a subsidy content of at least 35% - meaning that the net present value of the annual amortization payments (subsidized interest payments + repayment on principal) must be 35% lower than the NPV of annual amortization payments of a standard export credit. The subsidy element is registered by donors as development aid at the OECD's DAC (Development Aid Committee).

If the Mixed Credit is used to co-finance a CDM-project, the arrangement must not contravene the Kyoto Protocol's Marrakech Agreement that "*public funding of a project is not to result in a diversion of ODA (Official Development Assistance) from Annex-1 parties"*. Any funding for CDM is to be additional to- and not substituting for funds flowing from Annex 1 countries to developing countries.

The interpretation of the non-diversion clause has, in principle, been settled by the definition of the new ODA reporting rule at the annual meeting of the OECD's Development Assistance Committee in April 2004, which confirms that co-financing through Mixed Credits is possible *as long as DAC-funds are not used to purchase CERs* and *do not give the aid donor any right to the purchase of the CERs*.

When a project is submitted for registration to the CDM-Board, the CDM-Project Design Document requests inclusion of "an affirmation that public funding does not result in a diversion of development assistance". The PDD does not state which party is to affirm; thus either the donor country or the host-country can sign that declaration. But, only the donor country can clarify what the situation is for "mixed credits". Since Danida has a long tradition of using DAC-funds to co-finance renewable energy projects, including in Egypt, that declaration can be made.

8.3 Structuring Zafarana as a CDM-Project

8.3.1 Separation of Mixed Credit and ERPA

The Danish Government's purchases of carbon credits are split between purchases of CERs made by the Ministry of Foreign Affairs from CDM-projects and purchases of ERUs (emission reduction units) made by the Ministry of Environment from JI (joint implementation) projects. Thus, a Danish Government purchase of CERs from Zafarana 3 would be negotiated by the Ministry of Foreign Affairs, which also negotiates the Mixed Credit with NREA.

The funds used by the Ministry of Foreign Affairs for purchases of CERs are not ODA-funds.

8.3.2 Single ERPA, multiple ERPA, or spot-market sales?

NREA, after sounding out the market, will have to decide which strategy maximizes its CER-revenue from the Zafarana 3 project. Whether it is:

1. to offer one single ERPA to investors,

2. to divide the estimated CERs for sale into a number of ERPA's of different sizes, which then are offered to different investors;

3. to sell a large share of the CER's via long term ERPAs and keep a smaller share for sales on the spot market.

The third option promises the highest rate of return to NREA but with the risk that in the end, prices may turn out to be lower. On the one hand, it may seem more realistic to expect the CER-price to increase during the 2008-12 period; please refer to the present gap in prices between CERs and EU-AUs (EU-Allocation Units) shown in table 6, next page. The prices of EU-Aus, on the other hand dropped 50% between end-March and early May 2004 from €13 per ton to €6.5 per ton.

The annual output of windfarms depends on the wind regime that year. At Zafarana annual fluctuations of around 15% up-and-down are recorded. Thus the ERPA could be for the 85% "guaranteed" annual CERs, with the rest being sold on the spot market.

8.4 Expected CER Revenue

It is evident from the large price ranges shown in table 6 that there is no international market for certified CO_2-reductions, but a number of separate markets.

Table 3: International Carbon Market - Price Trends Years 2002-2004

	Price per ton CO_2
EUAs (EU Allowance Unit)	€11.5-13.5 (price March 2004)
ERUs (Emission Reduction Units)	US$ 3 to 8
CERs (Certified Emission Reductions)	US$ 1.50 to 5.00
National allowance schemes (e.g. UK)	~ US$ 18 (periodically)

The PCF-price limit of US$4 per ton CO_2 was assumed to reasonably reflect the "free market price" of CERs during the early high risk period when the international rules for CO2-emissions and allowances were very uncertain. Yet, the perception prevails on the market, that the upper limit represents the free market value of CERs even now, after the PCF-pilot exercise is over. It is therefore reasonable to assume a CER-price for Zafarana 3 of 4-5 Euros per ton. The financial model assumes a price of €4/ton.

The financial-economic model assumes that technological progress increases the energy efficiency of steam turbine plants in Egypt, reducing the average emission

from 0.50 kg CO_2/kWh in year 2007 to 0.43 kg CO_2/kWh in 2026. This gives a starting CER revenue per kWh of 1.6 piaster, falling to 1.4 piaster in 2026.

CDM project developers can chose between: (i) a crediting period for a maximum of seven years, which may be renewed at most two times or (ii) a maximum crediting period of ten years with no option for renewal. For wind farm projects the obvious choice of crediting period is three times seven years. It is not 100% clear at project start how many emissions per kWh can be claimed during the second and third periods, as the baseline is reconsidered after each seven years. But the long term power expansion plan of EEHC provides good guidance.

9 ECONOMIC AND FINANCIAL VIABILITY

9.1 Data

The assumptions used in the economic and financial analysis of Zafarana 3 are documented in the following sections of the report:

- the economic and financial cost of investment in Zafarana 3 in section 3.5,
- the composition and terms of project finance for Zafarana 3 in section 3.6;
- the net energy production of 512 GWh/year is based on the estimate in section 6.4
- the cost assumptions for replaced thermal power are provided in Annex I.

No sensitivity analysis was made of the impact of changing key assumptions. The reason is that the most critical assumption, the annual windfarm output estimate, is preliminary, awaiting the initiation and completion of a wind measurement program at the site.

9.2 Results of Financial Analysis

9.2.1 Critical assumptions

The most contestable assumptions for the financial analysis relate to the cost of investment, to the annual cost of windfarm O&M, to the PPA-tariff, to the financial discount rate, to the rate of inflation, and to the rate of devaluation.

The installed cost of investment for the windfarm is estimated at €806 per kW before payment of import duties and sales tax, and at €937, including these items. The validity of the cost estimate has been checked against the cost experience of previous windfarms at Zafarana. To compare the figures for these investments have to be corrected for (i) rate of inflation in Europe, (ii) devaluation of EGP, (iii) normal annual cost decrease in investments in new windfarm, due to technological progress, (iv) economies of scale in going up from 30-40 MW to 80MW and then 120 MW.

The cost of investment of previous projects is summarized in table 7a.

Table 7a: Cost of investment of previous windfarms at Zafarana

Date of Tender	MW	DKK	Local, EGP	DM	Euro
Danida 1 1998, september	30	187,343,410	9,000,000		
KfW 1 1998, october	33		22,099,001	47,519,250	
Dankida 2 2002, august	30	183,638,392	10,590,000		
KfW 2, June 2002	47		33,847,913		36,607,085
Spanish, July 2003	85		107,710,063		58,471,226

The figures from table 7a are in figure 7b translated into current and fixed prices per MW.

Table 7b: Cost per MW of windfarm tenders for Zafarana

Zafarana, Date of Tender	Euro/kW, current price	Euro/kW, 1998 price level[1)]
Danida 1 1998, September	919 [2)]	919
KfW 1 1998, October	917 [3)]	917
Danida 2 2002, august	902 [4)]	840
KfW 2, June 2002	948 [5)]	883
Spanish, July 2003	871 [6)]	798
Danida 3, January 2005	806 [7)]	712

1) Rate of inflation in EU = 1.75%. 2) €1=DKK7.45, DKK1=EGP 0.50 3) €1=DM2, 1 DM= EGP 1.7 4) DKK1=EGP 0.59. 5) €1= EGP 4.26 6) €1= EGP 6.91 7) €1=EGP 7.65

The higher cost per kW of KfW2+3 in 2002 compared with Danida 2 is difficult to understand without knowing the potential differences in the scope of the contracts. The decline in the installed cost per kW from Danida 2 to the Spanish windfarm in 2003 is in line with (or slightly lower than) what can be expected from the increase in scale and from "autonomous annual cost reductions. The increase in scale from the Spanish farm to Danida 3 should reduce the installed cost of MW by about 5%, autonomous cost reductions during two years another 5%. Thus the cost of investment estimate for Zafarana 3 seems to be reasonable.

The cost estimates for individual components of windfarm O&M are shown in table 7.

Table 4: Cost Assumptions for O&M during Project Lifetime

1. Annual O&M		
Windfarm staff (management + technical, administrative)	3,774/MW	Euro/year increasing per year with GPD/capita increase
Insurance, annual	0.6%	of cost of "turn-key" contract
O&M consumables, and increase in real terms per year	5,560/ MW	Euro/year from year 3 with 3% annual increase in real terms
Office cost, vehicles operation & replacement, telecom	1,258/MW	Euro/year 0.8% of windfarm inv.
2. Overhaul after 10 years	20.00%	of cost of "turn-key" contract
3. Decommissioning of site, year 21	0.00%	of cost investment in civil and electrical works

The O&M cost assumptions lead to an annual cost of O&M amounting to about 3% of the initial cost of investment, whereas windfarm experiences in Germany and in Denmark point to a cost of 5%. The 3% figure may be optimistic, yet, one should note that labor costs in Egypt are lower, that the 545 MW Zafarana windfarm is much larger than the 10-40 MW windfarms seen on-land in Europe, and that NREA has no charges for lease for the land, for the substations set up by the transmission company and for balance costs.

The PPA-tariff it not yet fixed. The financial analysis in this study assumes a tariff of 17 piaster per kWh. This tariff is derived by applying the devaluation-adjustment formula in section 4.4.5 to the year 2002 PPA-tariff of 10 piaster/kWh. The 17 piaster seem to be reasonable, as they provide NREA with a 9% rate of return on equity. Yet,

due to the conflict of interest between EETC and NREA outlined in annex I.9 page 65, the PPA-tariff negotiation will be tough.

The financial discount rate should reflect the cost of capital on the market for private investment in Egypt. No in-depth analysis of this has been made to establish the cost of capital; a 7% discount rate is used, as this is the rate used in project analysis in Egypt of infrastructure projects.

No adjustment is made in the financial and cash-flow analysis for the rate of devaluation and of inflation; both are fixed at zero.

9.2.2 Financial results for NREA

The *financial project analysis* for NREA (total cost of investment and total cost) shows a F-IRR of 6.7% and a NPV, at a 7% discount rate, of minus 20 million EGP. The *project financial cost of production*, after deduction of CER-revenue of 1.5 piaster/kWh is 18.5 piaster/kWh.

The *investor cost of production* (based on de facto project finance) is 19.9 piaster/kWh before deduction of CER-revenue and 18.4 piaster net pf CER-revenue. The *after tax rate of return on NREA's equity* is 8.6% if NREA is paid a tariff of 19.9 piaster per kWh.

9.2.3 Financial results for EEHC as hypothetical investor

The financial result for EEHC as hypothetical investor in the wind farm is negative. The market price of power is below the LRMC of power production. One reason is subsidized prices for the consumption of gas at the thermal power plants. The financial value of the savings in EEHC's thermal power system if the gas tariff for power plants was to be priced at the national cost of gas production and transport to the thermal power plants is 8.1 piaster/kWh. That is much lower than the investor cost of production of 19.9 piaster/kWh.

9.3 Results from Economic Analysis[22]

9.3.1 Methodology

The economic value of windfarm production is the avoided cost per kWh of replaced thermal power (including the cost of environmental damages). For clarity of discussion it is useful to distinguish between the *productive value* and the *consumption value* of output from grid-connected renewable energy generators. [23]

[22] For details, please refer to Annex I.

[23] The distinction between the *productive value* and the *consumption value* of a good can be explained as follows. A consumer entering a store to purchase a briefcase is confronted with a range of models

(a) The "productive value" of power supply to the grid

The term "*productive value*" refers to the value of power supply from thermal power plants and windfarms within the national/regional production function for power supply. The "productive value of windfarm power supply" equals the *saved* (or *avoided) costs in thermal power generation* that result from the introduction of wind energy. [24] When a study, as this feasibility study, does not have access to results from advanced power planning models that calculated the avoided costs in the power system, use is made of "rules of thumb" estimates. The contentious issues in these estimates concern:

1) The capacity value of windfarm capacity. A power system requires *reserve capacity* to cover the demand for peak power when units are hit by unscheduled production stops. The ability of windfarm capacity to reduce investments in thermal power capacity, whilst keeping the loss of load probability constant, is debatable.[25] The report applies the rule of thumb formula "*60% of the capacity factor of the windfarm"* for the "capacity credit" [26] of wind energy. This means that 1 MW capacity of a windfarm with a capacity factor of 43% is assumed to replace 0.26 MW of thermal power in an optimal power expansion plan. The saved investment is a 30%/70% mixture of CCGT- and steam turbine plants.

2) The value of O&M savings, mainly fuel consumption, is based on the *average energy efficiency of steam turbine plants* during the lifetime of the wind farm. The efficiency is estimated to increase gradually from 33% in 2004 to 43% in the year 2024.

3) The economic cost of gas consumed by the thermal plants is estimated at its opportunity cost, which is the netback value of natural gas exported to Europe in the form of LNG. It is 52 piaster per cubic meter; the tariff charged is 14.

4) The increase in the costs of balancing power from the introduction of intermittent power generation. The phasing in of intermittent wind energy in real-time power scheduling imposes additional costs for *balancing power*. Estimates of these costs vary and are depend on the specific configuration of

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and a wide range of prices. Two briefcases having the same size and approximately the same design can have widely different prices. They fulfill the productive function of transporting papers, laptops and other utensils from home to office equally well: having similar designs, they arrange the contents in a way that suits the user, and being equally durable, their cost of use, once purchased, is the same. Yet, some consumers will purchase the low cost, others the high cost model. The expensive model uses high quality leather, which looks good and smells nicely, the other synthetic leather. Some consumers like that aspect so much that they are willing to pay the extra price for it. Thus, although the "*productive value*" of the two briefcases is the same, the "*consumption value*" is not.

[24] The power system expansion plan defines the least cost portfolio of proven power technologies, which can cover the forecast future demand at the required quality – reliability, loss-of-load probability, environmental performance, security of supply, – defined by the regulatory authority. The "productive value" of power supply from a new power technology under consideration can then be identified by modeling the difference in the expansion plan with and without a specified percentage contribution coming from this technology.

[25] Please refer to Annex I.2.

[26] Definition: "the capacity value of a windfarm accepted by the regulator and the system operator".

the power system. A rough basic estimate is around €1/MWh. Yet, as the author of this study has no information on the situation and cost of balancing power in Egypt, this cost item is not included neither in the financial analysis (EEHC does not charge NREA for cost of balancing power) nor in the economic analysis.

5) The economic cost of the environmental damages imposed by thermal power plants. The economic value of the environmental benefits in Egypt from *reduced SO_2 and NO_X emissions* was not estimated in this report. SO_2 reduction is insignificant as little diesel and fuel-oil fired power generation is replaced during the lifetime of the windfarm. No estimate was given of the economic cost of NO_x-emissions, as the author of this report had no knowledge of existing studies in Egypt on health and economic impact effects of air-born pollution in general and of NO_x-emissions in particular. The economic value of *reduced CO_2-emissions* is set at the assumed market price of the CERs from Zafarana 3, estimated at €4 per ton; a sensitivity analysis uses a price of US$20/ton.

6) The economic costs of the environmental damages imposed by the windfarms. They concern mainly the *visual impact of windfarms on the landscape* and the *impact on birds*. The impact of noise and of flickering shadows is normally handled by simply not placing windfarms near populated buildings, which is the case in Zafarana. At Zafarana, the visual impact can be said to be zero: the landscape there is boring and the few people who live there, normally face the sea from their houses. The bird issue has been analyzed in a consultant report; no real reason for concern was identified. Consequently, the cost of environmental damage from windfarms is set at zero in this report.

7) The economic value of the price certainty of RE-supply versus the market risk and macro-economic damage imposed by fluctuating prices of fossil fuels on the international market. Fluctuating fuel prices impose macro-economic chocks to the economy of fuel importing countries, which lead to losses of GDP compared to a situation with better price stability. The macroeconomic damage of fluctuating fuel prices can be internalized by adding a risk premium to the cost of production of conventional power plants: based on CAPM theory, a lower discount rate is used to deflate the cost of fuel in the annual costs of O&M. In Egypt, *price fluctuations on the power market* due to changes in the price of fuel are not an issue: production is based on hydropower and on domestic natural gas. Unless the national gas market in Egypt undergoes a major restructuring, the increased penetration of windfarm electricity on the national power market does not seem to provide economic benefits in terms of reduced volatility in domestic power prices.

8) The macro-economic value of increased foreign exchange earnings due to increased LNG-exports. As lack of foreign exchange has been a factor slowing down the Egyptian economy; foreign exchange earnings have a shadow value to Egyptian society, which is higher than the current exchange rate.

(b) The "consumption value" of power

The term "*consumption value*" of power, a term coined for this report, refers to the differential prices consumers are willing to pay per kWh when confronted with a portfolio of choices between power from conventional thermal energy and renewable energy technologies. Since the kWh delivered to the consumer is exactly the same, the "productive value" of the output coming from each type of generation is identical as far as the consumer is concerned.[27] Yet, some consumers are willing to pay extra for *quality attributes of power that are not included in the traditional economic cost production function for power supply*. The optimal penetration for power supply from windfarms is, therefore, not established by a comparison of their cost with the avoided cost of natural gas fired power.

The existence of a niche demand for renewable energy on the power market is served by power distribution companies and power retailers who market "*green electricity*" to consumers. The "*economic value*" of this RE-power supply, sold on a free market, is equal to the price these consumers are willing to pay, which is much higher than the "avoided cost of natural gas fired power plants" (unless very high estimates are made of their environmental cost). The marketing of green power, however, is confronted with a barrier problem. Market surveys for green electricity in OECD countries often report that 30-40% of consumers are willing to pay extra for green electricity. Yet, when asked to sign a contract for green electricity purchase, typically only 1-2% of consumers sign up. The difference is too large to be explained by a "feeling good" effect in a survey where there is no commitment. A major reason is that a large majority of potential green consumers are willing to pay extra if everybody pays, but not if they are the only ones. In the eyes of these consumers, the size of the free renewable market is smaller than their preference; yet, their potential demand does not show up on the free power market. The result is that the free market for green electricity does not reveal the optimal penetration of RE-supply.

The barrier problem of an unsatisfied notional demand for green power is solved through political intervention. Discussions on national energy policy lead to the adoption of a *policy target for the penetration of RE*, such as the 3500 MW-target for wind farms in Egypt, which creates a market for RE larger than the free green electricity market. Whereas the consumer value for "green consumers" may have an indefinable flavor to it, politicians who argue for higher penetration levels of RET, are more concrete, referring to specific "non-power system related benefits" such as employment, balance of payment, economic growth. Whereas the productive value is about micro-economics, the consumer value seen through political eyes is partly about macro-economics, partly of environmental ethics. For this reason, Annex I includes a calculation of the foreign exchange and employment impacts of windfarms. However, no attempt is made to estimate a "consumption value". It is set at zero in Egypt.

[27] Also in this case we have exceptions: some firms buy "green power" because of the image value in their strategic positioning on the consumer market.

(c) Replacement value of 1 kWh of windfarm output = "a" + "b"

The replacement value of one kWh of wind power production is estimated at 14.4 piaster. How the figures is derived is shown in table 8.

Table 5: Replaced savings in thermal power per kWh of windfarm output

Replaced cost item in thermal power	**piaster/kWh**
Gas savings	12.2
Non-fuel O&M savings	0.2
Saved thermal power investment	2.0
Economic value of 1 kWh wind energy[1)]	**14.4**

1) The value of saved CO_2 emission not included in this figure.

9.3.2 Economic Analysis – conceptual difficulties

The calculation of the EIRR is confronted with three major difficulties.

- *The uncertainty about the long-term price of oil on the international market turns the LNG-price assumptions into guess work*. The relevant gas price for economic rate of return analysis is the opportunity cost of gas consumption at thermal power plants, which is the netback value of natural gas exported as liquefied natural gas, LNG. The market price of LNG is a function of the price of crude oil, which looking backwards over the last 100 years fluctuated around an average price (2004-price level) of US$25/bbl. Presently, concern is rising that the oil price may witness an upwards long-term parameter shift. Early May 2004, the price of Bent crude was US$36.5/bbl.
- *CO_2-reduction benefits are global benefits, which Governments attach different price tags to*. The CER-sales price, expected to be around US$4, is the market price reflecting the concrete monetary benefit for Egyptian society. The Danish Government's cut-off price of US$20 per ton for domestic CO_2-reducing measures reflects the marginal economic value of this global benefit seen through Danish political eyes. Thus, which of the two price tags is relevant?
- *The existence of non-quantifiable benefits reduces the applicability of classical cost-benefit analysis*. One benefit is the "consumption value" of wind energy[28]: its intrinsic value for being a sustainable form of energy. Another is the portfolio value of adding windenergy to the national mix of generators.

[28] The "consumption value" of power from renewable energy refers to the premium payments per kWh, which a significant minority of consumers and Governments are willing to pay for the intrinsic value of wind energy as a renewable and "sustainable" source of power generation. This intrinsic quality attribute drives the implementation of renewable energy portfolios in many countries.

9.3.3 Results

The *economic rate of return* of the project, based on the "production value"[29] of wind-generated power, is 8%, assuming a crude oil price of US$25/bbl and a CO_2-reduction value of US$4. Changing the assumptions by either a crude-oil price of US$35/bbl, or a CO_2-price of US$20/ton, increases the EIRR to 12%. The calculations do not take into account neither on the benefit side, the value of non-quantifiable benefits, nor on the cost side, EETC's investments in grid reinforcement and a new substation. A conservative assumption is that the two opposite parameters cancel each other out. Thus, the EIRR is likely to be in the 10-12 percent range.

The foreign exchange impact of Zafarana 3 is somewhere between neutral and slightly positive.[30]

The lifetime employment impact is about 1,700 man-years.[31]

9.4 Conclusions from Financial-Economic Analysis

The estimated economic rate of return is somewhere between 10 and 12 percent, satisfying Danida's cut-off criterion of a minimum 10 percent economic rate of return.

If NREA gets a tariff of around 20 piaster/kWh, the project should be financially sound.

[29] "Consumption value" refers to the intrinsic value attached to the quality aspect of wind energy as a renewable source of power supply.
[30] For details, please see Annex I.10
[31] For details, please see Annex I.10

10 RISK ANALYSIS AND ASSUMPTIONS

The project has low *technical risks*:

- The wind data are acceptable, and will be strongly improved once the measurement program is completed.
- The technical preparation of the project is professional.
- The wind farm will be adequately staffed; and the involvement of the supplier in the operation of the wind farm during a two years period will allow for adequate training in the O&M of the new turbine model.
- The envisaged size of turbine is well-tested in commercial operation.

The *financial and commercial risk* is high due to the volatility of annual windfarm output and the regulatory uncertainties surrounding the approvals of power tariffs:

- The *volatility in annual revenue* caused by the fluctuating wind regime will in years of lower than average production make it difficult for NREA to service the debt in those years, due to the high gearing ratio of project finance (equity finance is only 2% of total).
- NREA carries the direct foreign exchange risk on the Mixed Credit loan as the tariff in the PPA-contract is fixed in EGP. Financial viability calls for the inclusion of a devaluation adjustment clause in the PPA-contract and effective enforcement by the regulator of the adjustment clause vis-à-vis the off-taker EEHC/EETC.
- Due to politically motivated tariff-setting, power tariffs in Egypt are too low to provide the power companies owned and administered by EEHC with revenue sufficient for financially viable operation. NREA, thus, faces on off-take risk.
- The PPA is for ten years, while the Mixed Credit loan is for 15 years.

The *regulatory* risk is high, but difficult to estimate objectively and, thus, to quantify (for risk analysis). Governance in Egypt operates according to its own logic. The de facto risk is much lower than judged against normal, free-market standards.

ANNEXES

Annex I: Economic Value of replaced Thermal Power Production

I.1 Economic value of windfarm production defined as avoided cost

The economic value of windfarm production is equal to the economic value of the cost savings in the national power system. These consist of "*internal"* cost savings in the power system, which are savings in costs of the power utilities, and of "e*xternal" benefits*, which are avoided damage costs for society from reduced emissions in thermal power production.

How will the electricity output from the windfarms affect the operation of the power system? Windfarms have, next to hydropower, the lowest short term marginal cost of production, and, since the "wind-fuel" cannot be stored, windfarms will "always" occupy the first place in the merit order of production in the national power system. Fluctuations in wind farm production lead to upward and downward adjustments in medium and peak load thermal power production. [32] Egyptian thermal power plants are either gas fired steam turbine plants or CCGT plants in a 70/30% ratio, oil fired generation is negligible. In the merit order system, the CCGT plants work on full load basis due to lower fuel costs and because CCGT-plants incur much larger large efficiency losses than steam turbine plants when the plant is operated at part load. Since CCGT-plants operate in base load mode only, they will only in exceptional cases be affected by the penetration of windfarm generated electricity.

The conclusion is that windfarm production reduces the output from steam turbine plants only. The *calculation of fuel-savings* (and variable non-fuel O&M costs) is, therefore, based on the *average net energy efficiency of steam turbine plants*, which in 2004 is 37.5%, increasing gradually to 42% by the end of 2024.[33] The CO_2 savings per kWh of windfarm output decrease from 0.50 kg CO_2 per kWh in2004 to 0.44 kg in 2024.

The value of *replaced investment in thermal capacity* per MW windfarm capacity, on the other hand, is based on a *70%/30% mix of thermal capacity*.

[32] Part of the fluctuations will be handled by adjustments in hydropower production. But due to the constraints on hydropower operation from the priority need of letting water flows be determined by irrigation needs, this can be ignored.

[33] The sensitivity analysis in this report includes, however, also the impact of using the overall average for the thermal plant mix. The overall efficiency of thermal power (CCGT+ST) is expected to increase from 40% in 2004 to 48% in 2024.

I.2 Cost structure of CCGT- and steam turbine plants

The assumed costs of thermal power production in Egypt, which are used for the calculation of the avoided cost savings, are shown in table 9.

Table 6: Cost Data for Gas fired Thermal Power Plants in Egypt

Cost Data for CCGT and Steam Turbine Power Plants	EGP/MW	Euro/MW
Cost of Investment average CCGT and Steam from 2004	3,097,634	404,919
- Investment in CCGT plant in 2004	2,382,795	311,477
- Investment in Steam Turbine Power Plant in 2004	3,403,993	444,966
Annual operating hours during lifetime	5,957	68%
Non-fuel cost of O&M: fixed costs, EGP per MW per year	57,606	7,530
Non-fuel cost of O&M: variable cost, EGP/kWh	0	0.000282
Operating lifetime	40	Years
Efficiency of CCGT, years 2004 and 2024	57%	
Average efficiency of steam turbines, years 2004 and 2024	37.5%	42%

I.3 The capacity value of wind power

The "*capacity value of wind power"* refers to the savings in investment in new conventional power generation capacity due to the availability of wind farm capacity. The size of the capacity value depends on how expansion plans for thermal power are affected by the growth in new wind farm capacity.

A power system must have sufficient *reserve capacity* to cover the demand for peak power when units are hit by unscheduled production stops. The cost of that is part of the average kWh-cost of production of thermal power supply. The ability of windfarm capacity to reduce investments in thermal power capacity, whilst keeping the loss of load probability constant, is debatable.

Wind farm capacity is not "firm capacity" like thermal power. It depends on the availability of wind. This leads some power system planners to conclude that wind farms have no impact on the investment programme in thermal power capacity. Statements to support that claim refer to the fact, that, at times, the combined production of all windfarms attached to a national/regional system is close to zero. Spain, for example, has witnessed a day when the total output from 2600 MW of windfarms amounted to 8 MW. This view is too simple. An *optimised power expansion plan* aims at the level of capacity, which provides the system with the optimal "*loss of load probability" (or LOLE, "loss of load expectation"*) [34]. It is assumed in this feasibility study that in order to promote a least-cost system of electricity supply, the regulator will require the system operator in charge of preparing the long-term power system supply and demand forecasts, to take the value of windfarm capacity is taken into account when the need for new generating capacity is

[34] In economic terms optimality of the power system is defined by the equation: "cost of investment in marginal additions to capacity = marginal reduction in loss of load probability in MWh multiplied by the cost of per MWh of lost load at the level of consumer".

estimated. In that case, one can be certain that the windfarm program will save thermal capacity. Probability analysis is multiplicative, not additive: what is the probability that the large thermal unit goes down on that rare day when all windfarms are not producing?

Sophisticated simulation models for the power system can estimate the investment needs in thermal power for cases with and without wind farm production. The power planning models WASP 4, for example, is capable of modelling the capacity value of stochastic sources of power supply. Based on the difference in the resulting thermal power expansion plans - the objective contribution of wind energy to the reduction in the loss of load probability - one can see how many MW of thermal power capacity are replaced by a MW of wind farm capacity. This, the "*load carrying capability"* – or *"capacity value"* of wind power, is expressed as a percentage of the rated MW-capacity of the wind farm.

Provided that windfarm capacity is properly integrated in national power planning, the load carrying capability depends (i) on the local wind regime, (ii) on the specific characteristics of the integrated power system, (iii) on the level of penetration of wind-generated electricity and (iv) on the degree of the concentration of installed national wind farm capacity. Geographical dispersion has an "averaging" effect, which reduces the impact of fluctuations. Both for very short-term variations, which affect power quality (voltage flicker and voltage steps), but also the variability of wind farm output on longer timescales (minutes upwards). A high concentration increases the system risks on the transmission grid compared to a scattered distribution of windfarm capacity, and thus, reduces the capacity value. But typically, for wind farms in reasonably good wind areas with 25-35% capacity factor, these simulation exercises result in an estimate of the load carrying capability of somewhere between 15%-22% of rated power.[35]

In the USA, the Standard Market Design rules proposed by the Federal Energy Regulatory Commission provide for wind farms to participate in the capacity market. PJM Interconnections, (which serves Pennsylvania, New Jersey and Maryland) allows wind generators to claim and sell capacity credits within its six-state operating area, providing wind generators with a revenue equal to around US$0.01/kWh.[36] The capacity value is based on a three year rolling average of a wind-farms actual performance during PJM's peak hours. Until that three year average is established , PJM sets the capacity value of the turbine's nameplate rating.

EEHC has not made model-simulations of the impact of windfarm capacity on the capacity needs of thermal power. In the absence of power system modelling, a simple rule-of-thumb method is to use the wind farm's *"capacity factor"*[37] as an estimate of

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[35] Simulations in Ireland for wind energy capacity up to at least 800 MW resulted in a capacity credit of about 20%. An early paper on the ESB system determined a capacity credit of 35% of wind capacity for the first few megawatts (i.e. approximating to the annual capacity factor), falling to 14% for 2000 MW and 11% for 3000 MW. See pp. 40, of Commission for Energy Regulation/OFREG NI: "The impacts of increased levels of wind penetration on the electricity systems of the Republic of Ireland and Northern Ireland: final report", 2003.

[36] Windpower Monthly, volume 19, no. 6, June 2003, pp.44.

[37] The ratio of average to rated power of the wind farm = "annual delivered MWH to the grid/(installed MW x 8760)".

the load carrying capability of wind power. This is an overestimate of the true capacity value, which needs to be adjusted to a more realistic level, in particular, when capacity factors as in Egypt are very high. This, even though the output of the Zafarana windfarm shows a good match between the production profile and the load curve of the national power system during a day and during the seasons. This report, therefore assumes that *the "capacity value" or "load carrying capacity" of wind farms is equal to 60% of the capacity factor*.

For the 45% capacity factor of a Zafarana wind farm, the 60% assumption, therefore results in a replacement of 0.27 MW of new thermal power capacity for each 1 MW of windfarm capacity. On a kWh basis, the *capacity value of windenergy is equal to 3.5 piaster per kWh.*[38]

Generators in a conventional power system deliver a range of so-called *ancillary services*. These are essential services that operators use to control the power system such as operating reserve and reactive power, short-circuit current contribution and black start capability. Wind farms are unable to produce these ancillary services in a dispatchable, controllable way.

I.4 Savings in cost of annual O&M at thermal power plants

1 kWh delivered into the public grid by a wind farm replaces 1 kWh of thermal power production, except for corrections for differences in transmission and distribution losses caused by power transport to a center of demand located either far away from the windfarm (downward correction, as the thermal power plants presumably are located closer to the area of consumption) or to nearby local consumption (upward correction). [39]. In the financial model, one kWh of replaced thermal power production thus saves:

- the *cost of fuel consumption* per kWh, based on a conversion efficiency of replaced thermal power production of 37.5% in the year 2004, increasing gradually to 42% by 2024;
- the full *variable non-fuel cost of O&M* per kWh at the thermal power plant.

The parameters for cost of non-fuel O&M are shown in table 10.

Table 10: Non-fuel O&M costs in thermal power

O&M fixed:	9.35	USD per kW/year
Variable O&M	0.000350	USD/kWh
O&M fixed:	9.35	USD per kW/year

[38] Please note that the way the capacity value is calculated, the *capacity value per kWh* of windfarm production is the same for all capacity factors.

[39]). The calculations in this report following 1 kWh wind = 1 kWh thermal assumption do not take into account the fuel consumption of spinning reserve, which is needed to adjust national generation for any shortfall caused by short-term fluctuations in windfarm output. The fuel consumption of the extra windfarm-related spinning capacity has to be deducted to arrive at the true savings in natural gas consumption. But, the size of this "extra share" is difficult to estimate: because demand fluctuates, spinning reserve is needed in any case; technically, the fluctuation of windfarm production has an impact like negative demand.

I.5 Financial tariff and economic price of gas at power stations

The major uncertainty in the O&M calculations relates to the estimation of the price of gas at the power stations, the economic cost calculations as well as the financial tariff.

(a) Estimating the financial tariff of gas in year 2007 and beyond

Whereas the prices in the production sharing contracts for gas exploration, development and production are fixed in dollars, the price of gas paid by the power plants is fixed by the Government in EGP independently of the exchange rate or of the rate of inflation. Devaluation, therefore, leads to a decoupling between the cost of production of gas and the tariff paid by the power plants, until the Government adjusts the tariff. The *gas price of EGP 0.14 per m3* for thermal power plants, which in year 2000 was equivalent to US$1.05 per Mbtu, had due to the devaluation of the Egyptian pound dropped to US$0.72 in March 2003 and to US$0.67 in March 2004.

The *issue* in the forecast of the financial price of gas in 2007 is how to approach the facts (i) that the price of gas charged to the power stations is fixed by political will in Egypt, (ii) that the year 2004 price of EGP 0.14 per m3 is very low, (iii) that the gas price has not been changed for many years and (iv) that it is lower than the *domestic LRMC of gas supply to power stations* of US$1.15/mbtu: the average wellhead price in recent contracts is US$1.05/mbtu, the marginal cost of pipeline transport to the power plant adds US$0.005/mbtu.

Table 7: Fuel Cost Data – Financial Cost

Price of Natural Gas	EGP/MBTU	€/MBTU	EGP/m3
Fuel price at power plant in Egypt, year 2002	4.039	0.53	0.14
Average gas price in recent production sharing contracts	6.469	0.85	0.22
Average cost of transmission cost of gas to power plant	0.598	0.08	0.02
Expected fuel price year 2007 (=economic domestic LRMC)	7.067	0.92	0.24

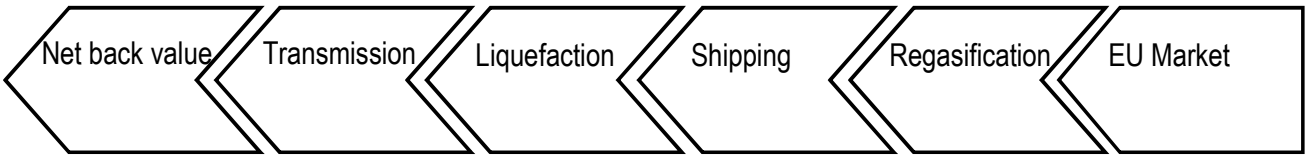
Worldwide experience cautions against underestimating the political unwillingness to remove price subsidies. Yet, it is not good methodology to assume in financial analysis that a politically fixed price, which is artificially low by national historical standards, will not be increased in coming years. The financial cost calculations in this report assume that the present under-pricing is temporary, and that the Egyptian Government sooner or later fixes the gas tariff again at a level, which reflects the full domestic cost-of-supply of US$1.15/mbtu. All figures in this report on the financial cost of thermal power from the year 2007 and onwards are, therefore, based on a gas tariff of 24 piaster per m3.

(b). Estimating the Economic Cost of Gas

Opinions differ about the *correct approach to fix the economic price of gas* in Egypt.

One school of thought insists that the *domestic LRMC of supply* of gas to the power stations (above estimated at 24 piastre/m^3) reflects the economic value of gas in Egypt. That assumption is too simple in view of the importance the Egyptian government attaches to the promotion of gas export as a foreign exchange earner. Consuming gas at the power stations has an opportunity cost: it could have been exported in the form of LNG to the European market, which has a huge and growing import demand.[40] Two LNG-trains are in place already, and Egypt can continue to add to its export capacity by building new LNG trains in the foreseeable future: there is a pipeline of four to six[41] additional projects. Under these conditions, the economic price (or value) of gas is equal to the *netback value of LNG exports to Europe plus the value of saved transport costs to the power plant*.

The calculation of the net-back value of LNG assesses the LNG export chain. From the market value at the export market – most likely in EU – backwards in the process of treating and transporting the LNG:



Exporting of natural gas as LNG includes 5 main stages in the LNG-Chain:

- Gas production (or purchase of gas from producers)
- Transmission to the export harbor
- Liquefaction of the gas
- Loading and ocean transporting
- Reception and regasification

[40] Technically speaking, this approach assumes that the amount of Egyptian gas exports is not constrained by the size of the European gas market, ie, Egypt will be a price taker. In view of the strong growth in the EU's demand for gas imports in general and for LNG in particular, this is a realistic assumption.

[41] Egypt exports *natural gas by pipeline* to Jordan. In the future gas may be exported also to Libya. These two markets, however, are demand constraint; meaning that the price taker condition is not fulfilled.

(c) How to forecast the price for LNG

Historically, the price of gas has been linked to the price of crude oil. Although there is a trend towards a decoupling of the prices, the relationship still holds. The forecast price of LNG in this report is, therefore, linked to the price of crude oil per barrel. The netback price is based on an *oil price assumption of US$25 per barrel*. This is about 20 percent higher than the historical long-term average of US$10/bbl (in 1985-price level) of the last 110 years. The reason is the recent downwards adjustments in proven gas reserves by inter alia Shell, the relative decline during the last ten years in annual investments in exploration and development by international oil companies, and the continued growth in energy demand from China and from India seem to indicate a long-term upward shift in the price of hydrocarbons.[42]

With these assumptions, the resulting economic price of gas, see table 11, is 50 piaster per cubic meter, which is more than three-and-half times the present price of 14 piaster.

Table 8: Economic Price of Natural Gas based on Netback Value of LNG Exports

Economic price of NG based on Netback price of LNG exports	EGP	EURO	
Oil price assumption 2004-2023, price per barrel of oil		20.1	per barrel
LNG (cif) as function of oil price, using historic data for relationship		3.2	/MBTU
Cost of ship transport		-0.43	/MBTU
Cost of liquefaction		-0.9	/MBTU
Transport from natural gas reservoir to liquefaction plant		0.0	/MBTU
Marginal cost of transport of NG from well-head to power plant, 5%		0.004	/MBTU
Economic price of Natural Gas consumed at Power Plant	14.543	1.9	/MBTU
Economic price per m^3 of gas consumed at power plants	0.50	0.066	per m3

The output of the 545 MW windfarm capacity at Zafarana, of which the 120 MW windfarm is one component, saves about 500 million cubic meters of gas per year. This, combined with the perspective of further windfarm investments at other sites, is enough gas to impact the ability of Egypt to increase LNG-exports.

I.6 Reduced line losses - value of distributed power

Decentralised power production, which is located nearer to a centre of demand than the centralized thermal power stations that otherwise supply the required power, reduces the line losses in the transmission and distribution grid. The loss reduction depends on how much output is consumed by consumers living close to the wind farm.

[42] In NPV-terms the 20% here and now price increase assumption equals an annual 3% increase in the real price of oil during 20 years if the starting price is US$21 per barrel.

Table 9: Impact of Windfarm on Line Losses in Transmission and Distribution

Impact on Line Losses in Transmission and Distribution System	
Saved regional line losses due to local wind power production	0%

The calculations in this report assume that the transmission (and distribution) losses of bulk supply of electricity are the same for windfarms and for thermal power plants, meaning that 1 kWh of wind farm output replaces 1 kWh of thermal power. In the short term, the output from Zafarana is sent exclusively northwards to the Port of Suez centre of demand. Once the Zafarana-Hurghada transmission lines has been build, the physical stream is likely naturally to go southwards to the Hurghada centre of demand.

I.7 Cost of intermittent supply

The cost of "firming and shaping" intermittent wind energy into a "usable product" – the cost of catering to demands of shortfall and excesses of generation on a virtual imbalance market - are not negligible. The subject was reviewed at length in the February 2004 issue of Windpower Monthly. The cost of intermittent supply will decrease over the next decade as new technology enables grid operators to better manage intermittent supply. Better windfarm technology can also improve the quality of supply, albeit at a cost. It was estimated in Spain that the cost of (i) boosting accurate production forecasts to 30 hours ahead and (ii) making wind plant provide the reactive power needed by the grid would each add €0.005/kWh to production costs.[43]

Since the cost of intermittent supply is not included in the economic cost estimate (or deducted from the estimated avoided cost of thermal power), the economic value of windenergy is slightly overestimated.[44]

[43] See Wind Power Monthly, June 2003:"Industry fears dip in investor confidence". The costs may be overstated as the calculation is done by a lobby group arguing for an increase in windpower tariffs.
[44] Milborrow D, "Penalties for intermittent sources of energy", submission to UK Performance and Innovation Unit energy review, 2001. "Costs may be incurred as follows: (1). To keep additional generation capacity in readiness (to meet demand if wind is unavailable); (2) To obtain additional flexibility from generators or demands to maintain energy balance in each metered period (half-hourly in the UK); (3). To obtain additional flexibility from generators or demands to maintain power balance continuously within half-hourly trading periods. This will be a mixture of response (automatic frequency sensitive action) and reserve (manually instructed action) of various speeds of delivery and endurance. At low penetration levels the flexibility costs are not significant. However, as the amount of intermittent production increases, these costs will increase. The studies mostly suggest that the costs of these services add up to about £0.5/MWh at 2% wind, rising to around £1/MWh at 10% penetration."

I.8 External economic benefits: pricing of environmental benefits

Damage costs or abatement costs?

Wind power produces no emissions during operation. Coal power plants emit SO_2, NO_x, CO_2 and particles emissions into the air, and pollute soils and water resources with heavy metals and sludge. In Egypt, where natural gas is used as the almost exclusive fuel in thermal power plants, only the NO_x and CO_2 emissions are relevant. The better environmental performance of wind farms saves the costs imposed on society by the environmental impact of thermal power production. [45].

There are two ways to calculate the *value of environmental costs*:

- by estimating the *damage costs* imposed on external members of society by the *negative effects of pollution*;
- by estimating the costs of *abatement measures* to avoid pollution.

Both methods have their uncertainties and weaknesses. The logical procedure is to choose the lowest estimate: if damage costs are lower than the cost of a specific abatement, then it is not economically rational to implement the abatement measure.

Value of reduced NOx emissions

The World Bank financed study "Egypt: Energy-Environment Review" of April 2003 by ERM, estimated the damage costs of *NO_x emissions* in power production at US$473/ton (EGP 2932 at exchange rate 6.2) and of SO2-emissions at US$1462 per ton (EGP 9064).

The author of this study did not have data on the NO_x and SO_2-emissions per kWh of the gas fired turbine plants in Egypt. Therefore, the value of reducing these emissions is not taken into account in the spreadsheet analysis.

[45] Defined as an economic benefit of an activity, which is not included in its market price.

I.9 Result: Sum of Internal and External Benefits

Adding the different benefits of windfarms, we get the results summarized in table 13.

Table 10: Economic and Financial Value of 1 kWh of Windfarm Output Year 2007

1. Savings on O&M Costs in Steam Turbine Plants	EGP/kWh	Euro/kWh
Displaced non-fuel O&M cost in steam turbine plants	0.002	0.000
Value of saved fuel in steam turbine plants, financial cost	0.059	0.008
Value of saved fuel in steam turbine plants, economic cost	0.122	0.016
Subtotal: saved financial costs for thermal power system	0.061	0.008
Subtotal: saved economic costs for thermal power system	0.124	0.016
2. Saved Investment in new Power Plant Capacity (steam + CCGT mix)		
Investment in thermal power capacity saved by 1 MW wind farm	0.29	MW
Annual output of windfarm, kWh per MW installed capacity	4,267,769	MWh
	EGP	Euro
Value of saved investment in thermal MW capacity by 1 MW wind	905,478	118,363
Financial/economic value divided by NPV of future annual kWh-output	0.020	0.0026
4. Financial and Economic Value (excl. Environmental benefits)	EGP/kWh	Euro/kWh
Financial value of savings in thermal power system, excluding environmental benefits	0.081	0.011
Economic value of savings in thermal power system, excluding environmental benefits	0.144	0.019
5. Saved CO2-emissions due to electricity generation from windfarms		
Replacement value of wind energy adjusted for transmission losses	100%	
Replaced CO2 emission per kWh of windfarm production	0.496	kg CO2
Price of 1 ton of CO2 replacement sold on international market	4	Euro
	EGP/kWh	Euro/kWh
Revenue from C02 replacement certificates per kWh wind energy	0.015	0.0020
6. Total Economic Value of 1 kWh of Windfarm Production including CO_2	0.159	0.021

Table 13 estimates the *" economic value without including the value of CO2-savings"* at 15.9 piaster per kWh in 2007. That value, due to higher energy efficiencies and lower costs of future investments in thermal power plant falls to 15.7 piaster in the year 2026.

The logical *"bottom of the line" tariff for wind energy, which a profit-maximizing system operator* would be willing to pay to a windfarm in year 2007, is equal to the financial value of the "internal savings in the power system of 8.1 piaster/kWh.[46] The additional revenue from CO_2-certificate sales, increases the total income from windfarm operation to 9.6 piaster per kWh. This is 55% of the year 2004 financial cost of production – without deducting CER-revenue – of 17.3 piaster per kWh. Productivity improvements in the technology of steam turbine plants reduce the financial value of the cost savings in thermal power plants to 7.4 piaster/kWh in 2024;

[46] Year 2002/03 tariffs for power (presumably before adjustment for devaluation) are 8.5 piaster/kW for CCGTs, 11.5 piaster for BOOT-projects and 10 piaster for NREA's windfarm PPAs.

and the average financial value during the 20-years lifetime of the windfarm to 8.1 piaster.

The economic value is higher than the *financial value of the savings to the national power system of 8.1 piaster per kWh*. This is due to the difference between the "LNG-netback value price" for power plants of natural gas (=50 piaster/m^3) and the "national cost coverage" price for gas (=24 piaster/m^3), which the financial model uses. For *EETC the rational "value for EETC based" PPA-tariff* is to pay 8.1 piaster per kWh in 2007, assuming that a full-cost coverage price is introduced by then. This tariff with the CER-revenue added would provide NREA with a revenue of 9.6 piaster per kWh. That falls short of the 17.3 piaster/kWh, which NREA needs to cover its cost of production.

I.10 The Foreign Exchange Impact of the Zafarana Windfarm

The devaluation of the Egyptian pound since 1998 has made policy makers in Egypt very sensitive to the foreign exchange impact of projects. The foreign exchange impact of the windfarm program is analyzed below.

(a) Components determining the Foreign Exchange Impact

On the input side, wind farms consume foreign exchange through:

- the import content of the investment in the wind farm;
- the import content of expenditure on O&M during the lifetime of the farm.

Through their electricity output, wind farms generate foreign exchange through:

- the revenue from the sales of CO_2-certificates on the international market;
- the netback value of increased LNG supply for exports;
- the import content of saved investment in thermal power capacity;
- the import content of saved non-fuel O&M at thermal power plants.

(b) Import Content of Windfarm Investment and O&M

The economic cost of production of windfarms is very investment intensive.[47] The cost assumptions in this report lead to a year 2007 15%/85% split between the share of O&M and the cost of investment in the cost of production. The share of O&M is lower than the 70%/30% split often seen in international projects. The reason is that annual O&M at Zafarana is estimated at about 3% of the initial cost of investment, whereas windfarms in Germany and in Denmark experience annual O&M costs of 5% of initial investment.

Table 14 summarises the assumptions and the end-result of these in terms of import-content and import expenditure per kWh. The investment in composed of (i) project development cost, (ii) WT supplier contract and (iii) civil & electrical infrastructure. NREA's costs of project preparation, estimated at 1% percent of the total cost of

[47] Economic cost is used instead of financial cost, because import duties and financial costs are all purely domestic cost items with no impact on imports.

investment have an import content of zero. The civil and electrical works, which account for 14 percent, are done by Egyptian construction firms; due to use of some imported material, the work may have an import content of 10%. The WT-supplier contract, excluding the foundations, amounts to 85 percent of total investment, before cost of finance during construction. The local costs of that part of the contract comprise the cost of the towers, cost of local transport of material to the site; site visits by foreign staff during construction as well as monitoring and maintenance services during the warranty period. Overall the import content of the WT-suppliers contract is about 80%.

Table 11: Import Content of Windfarm Production, Years 2004 and 2014

	Year 2007
Import Content of Investment	86%
- WT supplier contract, excl towers and foundation	80%
- Project Preparation	0%
- Civil and Electrical Infrastructure	10%
Sub-total:	70%
Import Content of O&M	14%
- Consumables and overhaul investment	80%
- All other costs	10%
Sub-total:	46%
TOTAL IMPORT CONTENT	66%
Economic Cost of Production, piaster/kWh	14.8
Import Content of Production, piaster/kWh	9.8

The import intensive cost items in O&M are overhaul investments and consumption of spare parts, which together make up 52% of the estimated cost of O&M. Since the import content of consumables is linked to the manufacturing share of investment, the same percentages apply.

Altogether, the total import content of the cost of windfarm production amounts to 12 piaster/kWh, or about 66% of the economic cost of production.

(c) Foreign Exchange Impact from Savings in Thermal Power Production

The foreign exchange impact of replaced thermal power production is summarized in table 15. The calculation assumes that windfarm investments in Egypt continue to be implemented also after Zafarana 3, and that this is recognized both:

1) By EETC as power system planner, taking windfarm capacity into account, when the need for investments in new thermal capacity is evaluated - otherwise, Zafarana 3 has little capacity value.
2) By the Ministry of Oil and Petroleum and by the oil and gas companies in Egypt in their forecasts of future national gas consumption and production, enabling them to take the impact of windfarms on national gas consumption into account, when LNG-export contracts are signed.

Table 12: Foreign Exchange Impact of replaced Thermal Power Production

	2007 plant	
Capacity value piaster per kWh WT-output	2.0	piaster/kWh
Import content of saved investment in capacity	65%	
Saved import expenditure on thermal capacity	1.3	piaster/kWh
Saved non-fuel O&M piaster per WT-kWh	0.002	
Import content of non-fuel variable O&M	40%	
Import expenditure on non-fuel variable O&M	0.0009	piaster/kWh
Value of gained LNG-exports, piaster/kWh	12.2	piaster/kWh
TOTAL foreign exchange cost of thermal power	13.5	piaster/kWh

Net Foreign Exchange Impact of Windfarm Production

The above assumptions result in a positive foreign exchange impact for the Zafarana 3 windfarm of 3.7 piaster per kWh (without taking CER-revenue into account) and of 5.2 piaster per kWh (once CER-sales are included).

Tabel 2: Net foreign exchange impact

2007 windfarm	**piaster/kWh**
1. Import content of Windfarms,	**(9.8)**
Import content of investment	(8.9)
Import content of O&M	(1.0)
2. Foreign Exchange Saving Thermal Power	**13.5**
Import expenditure per kWh due to investment	1.3
Import expenditure cost of O&M,	0.0
Value of lost LNG-exports	12.2
3. Revenue from sales of CO2-certificates	**1.5**
4. Foreign exchange saving from windfarms	**5.2**

One should be aware of, though, that these numbers overestimate the foreign exchange impact in practice. First, the time lag in the realization of the foreign exchange savings is not discounted properly in the spreadsheets: the potential savings in investment in thermal power capacity will first come several years after the windfarm has become operational, saved natural gas consumption due to the electricity production coming from Zafarana 3 is not exported "immediately" in the form of increased LNG-exports. Secondly, some of the positive foreign exchange benefit from the exported LNG is siphoned off as profits to the foreign joint-venture partners in gas extraction in Egypt. Thus, it is more realistic to state that the foreign exchange impact of the Zafarana 3 windfarm is neutral, or slightly positive. Future windfarms, however, will have a clear positive impact, as the cost of investment falls, Egyptian co-manufacturing increases and power and natural gas planners have accepted the impact of windfarms in their work.

I.11 Employment Impact of the Zafarana Windfarm

Windfarms have little negative impact on the employment in thermal power. Some labour is saved in daily maintenance and some in the replaced construction of new thermal power capacity.

The team, which prepared the Force 12 report, estimated the employment impact of windfarms at 35 man-years per installed MW windfarm. This worldwide average includes employment in windturbine manufacturing (WT-manufacturers and their sub-suppliers), project preparation, civil and electrical works at windfarms and O&M of windfarms during their lifetime. This means that for individual countries, the impact of a national investment program will be always be lower than the world-wide average, because of the import content in hardware and software.

Since the import content of the Zafarana 3 windfarm is above "world-average", it is assumed that the lifetime employment impact is 40% of the above estimate, or 14 man-years per MW, yielding a total employment generation of 1,700 man-years.

When evaluating the low employment impact, one needs to remember that Zafarana 3 is part of a very initial effort to expand wind-energy and wind-manufacturing in Egypt.

Annex II: December Debriefing Note, List of Persons met

Debriefing Note
Feasibility Study for Zafarana Danida 3, 120 MW windfarm
Anita Jürgens, Wolfgang Mostert, Søren Gjerding
Visit to Egypt, December 14-18, 2003

1. Introduction

To start up the preparation of the feasibility study for Zafarana Danida 3 to be prepared under contract with Danida by Wolfgang Mostert (contract holder) and Tripod (sub-contractor), Wolfgang Mostert, management consultant / regulatory economist and Søren Gjerding, wind energy specialist paid a fact finding visit to Cairo/Zafarana from December 15 (start of work) to December 18, 2003. Mrs. Anita Jürgens, Secretariat of Mixed Credits, joined the team on the days of December 17 and 18, heading the mission. Mr. Martin Mikkelsen, counsellor at the Danish Embassy in Cairo joined the team during initial meetings at NREA and participated in the visit to the Zafarana site.

The team would like to express its sincere appreciation to Chairman Hosny El Kholy and his efficient NREA-staff for managing to set time aside to assist the team in collecting required information - despite being deeply involved in contract negotiations for the 85 MW Spanish-financed and 120 MW Japanese-financed windfarms. We would also like to use this opportunity to congratulate NREA for having reached agreements on the two new sections of the Zafarana farm.

2. Size of windfarm and size of turbines

NREA decided to expand the size of the windfarm from 60 MW to 110-120 MW and in the tender material to go for a wind turbine size ranging from around 1 MW to around 1.5 MW. The precise size of the wind farm will depend on the number of turbines that can be installed without non-economic wake loss.

Maximum wind turbine height – to tower (hub height) - is about 60 meters.

3. Regulatory, financing and economic issues

The team kindly asks NREA by January 20 – or earlier if possible - to furnish the information asked for in Annex I. The information mainly concerns the status of permits and contracts.

PPA. The key unsolved issue for the feasibility study is the PPA that will be drawn up. In this regard it was encouraging to hear from the national electricity regulator, that he will insist on a tariff capable of covering the costs of NREA; the present tariff level being too low.
Environment. The team would like to draw attention to the fact that the environmental authorization for Zafarana is for a 300 MW windfarm only; and that,

therefore, a new approval may be required since the windfarm increases beyond that size.

Economics of turbine size. The team was asked by NREA engineers in the feasibility study to present the economics of going up into higher sizes of turbines.

Finance. The feasibility study is prepared for a traditional Mixed Credit loan of ten-years or 15 years; depending on NREA preference. Financial modelling will be made for both. The team held preliminary discussions with staff from MIBank and Egypt National KN on the possibility to replace the Mixed Credit loan upon commissioning by either a revenue bond issue (MIBank) or a lease finance arrangement (KN). At present international interest rates, a 10-year mixed credit would have a zero interest rate, half a year grace period, and a 1% deduction in principal; a one year mixed credit a 30% deduction in principle. At a maximum 1.5% on-lending rate, a 13% bank interest rate, and a zero devaluation rate, the long-term mixed credit is least-cost arrangement.

4. Wind study and windfarm technical issues

Windfarm site. For the Danida 3 wind farm NREA has decided to use the site South of Danida phase 1 instead of the alternative site located West of Danida phase 2. The site has a better wind regime.

Wind measurements. The mine clearing at the site is expected to be finished by March 2004, by which time NREA will set up two measurements masts in April for a 4-5 months period. This is perfect timing, coinciding with period of peak production from the wind farm.

Wind study. NREA agreed to the proposed division of labor between Mr. Søren Gjerding and Mr. Usama Said Said for the preparation of the wind study (Annex II). Mr. Said will prepare a draft according to the outline in Annex II; Mr. Gjerding will do the quality control and incorporate the results of the study in the feasibility report. NREA provided production and availability data for Danida 1 for each wind turbine on a monthly basis to assess the production potential at each turbine site. The material is used to estimate decrease of power production going from East to West.

Transmission system impact study. The plans by EETC for the sub-station are to install a total of four transformers in the end, each having a capacity of 125 MVa. The Danida ESPS foresaw that a system impact study be made; since the ESPS has been dropped, such a study, while being a priority, is not in the immediate pipeline. Mr. Kim Dyhre is expected to discuss the specifications for the system impact study for a 530 MW-sized Zafarana windfarm with EETC, presently the national system operator.

5. CDM

NREA will develop the project as a CDM-project. In response to questions from NREA, Ms. Jürgens made clear that Mixed Credits had no mandate to express any opinion on the possibility for Danish purchases of CERs (certified emission reductions). Danida will form a policy on combined CDM/Mixed Credit projects,

once the DAC'ability of Mixed Credits used to co-finance CDM-projects has been confirmed by international agreement.

6. Request for open international bidding

In the light of the upcoming merger between Vestas and Micon, NREA expressed concern about lack of effective competition in the tender for the EPC-contract for Zafarana 3, if it was restricted to wind turbine manufacturers from Denmark. NREA expressed that Bonus, so far, had not shown any interest in the Egyptian market, not having participated in the previous two Danida tenders for Zafarana. NREA was not interested in turbines from Nordex. Therefore, NREA requested Danida to consider going for an open international tender, like KfW and the Japanese.

The team expressed that the size of the contract made it likely that Bonus would bid this time.

Ms. Jürgens made it clear that, as for now, Danida's Mixed Credit policy was to restrict the tender to Danish suppliers, but promised to pass on the request to the decision making levels in Danida.

7. Time table for project preparation

Tentative Time Table 2004-2005

Visit to Cairo by Mr. Kim Dyhre from Tripod to look at the impact of the windfarm on the transmission system	Mid-January, **2004**
Draft wind study and other requested information from NREA emailed to consultants	January 20
Draft feasibility study emailed to NREA	Second week of February
Team visit headed by Mr. Christian Sørensen from Danida	Third week of February
Second draft feasibility study with adjustments in response to NREA comments	March
Wind measurements at Danida 3 site	April-July
Updated wind study	Early August
Final feasibility study + draft appraisal report	End-August
Presentation to Board of Danida	End-September
Signing of Agreement: Danida-NREA	End-October
Signing of PMA-contract	October
Draft of pre-qualification documents and of draft tender documents	November
Pre-qualification documents sent to WT-suppliers	December
Pre-qualification evaluation approved	January **2005**
Tender documents sent to pre-qualified WT manufacturers	Early February
Tender closing	End-March
Tender evaluation report approved by Danida,	June
Commercial WT contract approved by Danida and signed by NREA	July
Loan agreement signed by Danish bank and NBE	August
Final approval of Mixed Credit from Danida	September

The time table is tentative and may be changed during the preparation of the feasibility study.

8. COWI PMA contract

NREA expressed the wish that the PMA contract be amended to include Zafarana 3 also.

Cairo, December 19, 2003
Wolfgang Mostert

Annex I: Debriefing Note Zafarana 3 Feasibility Study
Requests for Information Inputs from NREA to the Feasibility Study
Wolfgang Mostert, Cairo, December 17, 2003

1. List of all necessary **approvals and permits** needed to set up a windfarm in general, and for Zafarana 3 in particular. Status of obtaining the approvals and permits. (please see table at the end)

2. Information on **environmental framework** for windfarms.
- What environmental laws and regulations are applicable for windfarms. What do they say about the requirements for environmental approval?
- What document confirms that windfarms are category B projects?
- What is the procedure for obtaining approval / environmental clearance for a windfarm, and for category B projects in general? Are any institutions other than EEAA involved in the environmental approval process?
- What environmental studies have been prepared for the Zafarana windfarm(s)? What is the title of the "study" referred to in the 1999 approval letter from EEAA, point 5, and who prepared it? What were there main environmental conclusions and recommendations in that study?
- The screening B form for the Zafarana project attached to the 1999 approval letter is for a 300 MW windfarm at Zafarana. Is NREA going to prepare a new letter to EEAA asking for a approval for expanding the windfarm beyond 300 MW? If yes, has the application procedure for obtaining environmental clearance for the expansion to include Zafarana 3 been started?

3. Information on the **grid connection contract**.
- What are the contractual requirements for connecting the windfarm to the grid? Is a formal grid connection contract signed for each expansion; or are all individual parts at Zafarana covered under one single grid connection contract? If so, when was the grid connection contract signed?
- What conditions are fixed in the grid connection contract between ETC and NREA? Technical specifications for operation of the windfarm and required power quality? Payment for grid connection – who pays what costs?

4. Information on the **PPA:**
- What national power sector regulations are relevant for the signature of the PPA – defining the principles for fixing the PPA-tariff and its approval procedures?
- To what extent is the national regulator involved in approving the PPA between NREA and EETC. What is his role?
- Has the regulator been involved in designing a new standard PPA-format for windfarm contracts between NREA and EETC? Or does the regulator envisage developing a new PPA-format?
- How is the specific situation at Zafarana handled in the PPAs – Zafarana being one single windfarm site, where one single windfarm developer is developing sections one by one with different financing sources and costs of finance? Will all PPAs be offered the same tariff and length of period, or is each issue decided in bilateral negotiations for each separate section of the windfarm?

- The PPA signed January 24th 2002 for Danida 2 is for ten years. Is that length of contract a fixed standard or negotiable from contract to contract?
- If yes, has it ever been discussed to sign a PPA for a 15-20 year period with a two-step tariff: a high upfront tariff (equal to the length of loan maturity) and a low tariff afterwards (when the loans are repaid)? The "selling argument" would be that EETC pays a higher initial tariff in return for getting a low-cost source of supply in the longer run.
- Are the terms in the PPA for the German windfarm different from the terms fixed for ?
- Has a tariff-adjustment formula been defined, linking, at least part of the tariff to inflation and/or movements in the exchange rate?
- Will there be one single PPA-tariff for all parts of the Zafarana windfarm (German, Spanish, Japanese, Danish), or will separate contracts be signed for each expansion of the windfarm
- Have PPAs been signed already for the Spanish and the Japanese sections of the windfarm

5. **Landownership/land lease**. The feasibility study for Zafarana 2 states that "NREA has been given the ownership of the entire area of the Zafarana site from the Government". Is that correct; or did NREA receive a lease/concession for the land? The land to be used for Zafarana 3 falls outside the 80 km2 of land that by Presidential decree was allocated to NREA? We understand that an additional 70 km2 covering the area envisaged for the Danida 3 windfarm has been transferred to NREA. Is that an ownership transfer or a lease? Which authority signed the ownership transfer/lease agreement with NREA, and when was is signed? If it's a lease, it which year does it end? Does NREA pay a lease fee or is it free of charge? NREA will have to pay for mine clearance – correct?

6. Expected **Lending arrangement** for Danida 10 year mixed credit loan.
   - Which bank will on-lend the loan to NREA? National Bank of Egypt?
   - What is the on-lending margin of the bank for passing on the loan to NREA? For Zafarana 2 the onlending margin of NBE was 2%.
   - What additional financing fees are charged by the on-lending bank such as commitment fee and guarantee fee, etc. For Zafarana 2, the NBE charged a guarantee premium of 0.6% per quarter (was that for remaining balance of loan or for total initial principal throughout the repayment period?).
   - Is the on-lending loan from the local bank to NREA fixed in piaster linked to the foreign exchange rate of the mixed credit loan taken by the local bank?
   - What is your preferred currency for the mixed credit loan – DKK, Euro or US$?

7. **Generation License**. Has NREA already obtained the generation license from the regulator? What does the generation license contain? Is it a general generation license for NREA or for the Zafarana windfarm in particular? For what size of windfarm is it valid – the whole 550 MW? Is it possible to get an English language version of the license?

<u>Timing for providing the written inputs</u>:

About January 20, 2004

Status of Authorizations, Permits and Contracts for Creation of Windfarm

Item	**Involved Authorities**	**Status (document and date)**
Land rights		
Construction permit		
Generation license		
Environmental Approval		
Grid Connection contract		
PPA		
….		
….		

Annex II to Debriefing Note: Technical Assessment. Draft outline

16th December 2003
Document No: 161203-2.514
Prepared by Søren Gjerding

1. Introduction

The technical part of the feasibility report deals with the following issues:

- Assessment of the annual energy production from the proposed wind farm.
- Assessment of the layout of the wind farm.
- Wind measurements.
- Wind turbine.
- Conditions at the project site.
- Other relevant technical issues.

The first draft issue shall be prepared by NREA. During the preparation the Danish Consultant shall carry out support on a running basis by e-mail communication. In the end the Danish Consultant shall carry out QA and prepare the final input to the feasibility study.

This note outlines the issues to be covered by the draft technical assessment.

2. Technical Issues

Location

The Zafarana Wind Power Project, Component III site is located on the west coast of the Gulf of Suez. The project site is located just west of Danida Component I and II or, as an alternative, just south of the Danida Component I project.

Layouts and AEP calculations shall be carried out for both alternatives.

Wind data

The wind data used for the wind study shall be presented.

An assessment of WAsP's capability to calculate the AEP in the specific area shall be presented. The assessment shall either be based on calculations (comparison – prediction / measurement) or by reference to other studies. If reference to other studies is used, the studies shall be annexed.

At a very early stage it shall assessed, whether additional wind measurements are required in order to secure the reliability of the wind study. If additional measurements are required, proposal for siting and equipment shall be presented.

Wind Turbine

The capacity of the wind turbines is limited to 1000 – 1500 kW and the tower height to approximately X m. A representative wind turbine in the 1000kW – 1500 kW range shall be selected for the calculations.

Wind Turbine Approval

Primarily due to the strong winds and the high temperatures at the site it is recommended that, prior to the shipment of the equipment, a site specific approval of the selected wind turbine will be issued by an internationally recognised approval institution. It shall be assessed, whether the wind turbines should be "tropicalized" due to the site conditions.

Layout, Wind Turbine Siting

Preliminary lay-outs covering the two alternative areas shall be presented.

Annual Energy Production Estimate

The estimate of the annual energy production (AEP) for the two alternative layouts in average per single wind turbine shall be calculated and presented.

Local contractors

Comments in respect of availability in Egypt of appropriate capacity in regard to tower manufacturing and civil work at the site shall be presented.

Technical Conclusion

The technical conclusion shall be presented.

3. Technical Assessment of the Project

Site Conditions at the Zafarana Wind Farm Site

Site location

The Zafarana Wind Power Project, Component II site is located on the west coast of the Gulf of Suez, south of Abu Darag and north of Zafarana. The location of the project site shall be determined and presented by co-ordinates and on maps attached.

Wind Resources

Assessment (and presentation) of the wind resources in the area. (The site have been investigated very thoroughly as part of the two projects "Wind Atlas for the Gulf of Suez" and "Zafarana Site Calibration Project".)

- Mean Annual Wind Speed
- Assessment - The wind resources at the Zafarana III site.
- Long Term Variation, Comments
- Wind Direction, Comments.
- Turbulence Intensity, Comments.
- Extreme Winds, Comments.
- Temperature, Comments.
- Air Density, Comments.
- Lightning, Comments.
- Dust/Contamination, Comments. Dust might damage parts in the nacelle and tower, but in order to prevent damages, ref. [3] specifies that precautions shall be made in order to minimize the dust and sand, entering the nacelle and tower.
- Earthquake, Comments.
- Geological Conditions, Comments.

Assessment of Wind Turbine, Layout etc.

Wind Turbine

In order to follow the market development, NREA has decided to require that the wind turbines for Zafarana III be in the range of 1000 kW to 1,500 kW. Whether all tree potential Danish wind turbine suppliers for the project: Vestas-NEGM, Bonus, and Nordex, are able to supply wind turbines in the specified range shall be investigated.

It is expected that the specific wind turbine offered will be required to have a commercial track record in line with the following:

- Minimum one unit with more than 2 years of problem-free track record.
- Minimum 20 units with more than one year of problem-free track record, and
- Minimum 30 units in operation before the closing date of the tender.

Comments in respect of whether the turbine model offered should be "tropicalized" in accordance with the site conditions (temperature, dust, saline air, etc.).

Wind Turbine Approval

The wind resources in the Zafarana area are known as one of the best in the world and, furthermore, the temperatures are very high.

Comments in respect of requirements to approvals. An IEC Class 1 or a Class 2 approval. The approval should be followed by a site-specific approval if the tender is successful.

Wind Turbine Towers
The wind turbine towers shall be the responsibility of the wind turbine supplier, but it is foreseen that towers will be produced locally. The towers will be tubular. Assessment of optimal hub height for the project, shall be included.

Layout
The layout of Component I is two nicely shaped rows in the east to west direction. The distance between the wind turbines in each row is approximately 3.3 times the rotor diameter D and the distance between the rows is approximately 17*D.

Foundation
The foundation calculations shall be in accordance with the actual geological conditions and shall be the responsibility of the wind turbine manufacturer. Assessment and comments in respect of foundation shall be included.

Transportation
There is a newly constructed harbour just north of the site and the road from there is good for transportation of heavy and long goods. Assessment of whether transport should constitute in any problem are needed.

Crane Availability
Assessment of necessary crane capacity in respect of O & M shall be presented. An 80 tonnes crane was part of Component I, but according to NREA the size is marginal for service and maintenance of wind turbines in the 600 kW size. Comments in respect of whether a crane for service and maintenance should be tendered as an option in the EPC tender.

Lightning Protection
Comments.

Central Monitoring System
A CMS shall be included in the wind turbine supply. Comments.

Annual Energy Production Estimate
The AEP calculation(s) shall be presented including all basic information.

Gross Mean Annual Energy Production (AEP_{Gross}) estimate: x,xxx MWh
Net Mean Annual Energy Production (AEP_{Net}) estimate: x,xxx MWh
The correction factors can be seen in table 1.

Correction Factors
In order to get the mean annual energy production, which actually can be supplied to the grid (AEP_{Net}), corrections and loss factors shall be applied. Assessment and comments shall be included:

Correction factor – ID	Value
Air density	
Contamination of blades	
Turbulence and skew wind	
Wake loss / Wind farm efficiency	
Transformer and line losses	
Availability loss	
Grid availability loss	
Long term correction	
Combined loss and correction factor	

Table 1: Correction factors

Power Curve Correction

- Assessment of necessary power curve corrections, if applicable. (air density, dusty environment, etc.)
- Wake Loss/Wind Farm Efficiency
- Presentation of the wake loss calculations.
- Transformer and Line Losses
- Assessment of the transformer and line losses.
- Availability Loss
- Assessment of expected availability loss based on experience.
- Long Term Correction
- Comments.

Electrical Issues

The wind farms in Zafarana are connected to the "Zafarana" sub-station adjacent to the site. An overview of the total plan for wind farm installation shall be presented. Plans for upgrading the capacity of the sub-station shall be presented. Furthermore, status and/or plans for carrying out System Impact Study shall be presented.

Information Necessary for the Danish Consultant

The following information and documents will be made available for the Danish Consultant in order for the consultant to carry out QA and prepare the final input to the feasibility study.

- Wind atlas for the Gulf of Suez (Book and CD).
- Wind data (and WAsP files) used by NREA in the calculations.
- Digitized map including roughness information. Furthermore, boundaries of allocated land (project site).
- Co-ordinates of wind turbines – both lay-outs
- Co-ordinates of measuring masts

- Power curves (and Ct curves) used in the calculations
- System Impact Study (SIS)

Annex III: List of Persons met

NREA
Mr. Hosny el Kholy, Chairman
Ms. Laila Saleh, Vice Chairman
Ms. Wagida Wagih Rasem, Vice Chairman for Finance
Mr. Anwar Haiba, Chairman for Projects and Operation Maintenance
Mr. Georgy Rafik, Director of Technical Affairs Sector
Ms. Laila Georgy Youssef, Director General for Wind Energy
Mr. Usama Said Said, engineer, wind energy specialist
Dr. Eng. Mohammed Mostafa El-Khayat, wind energy department

ERA
Dr. Mohammed El Soukhi, National electricity regulator

MIBank
Mr. Ahmed El-Shal, Central Corporate Group

Egypt National Company KN
Mr. Khaled El-Mesilhy, Manager of Projects

Danish Embassy
Mr. Martin Mikkelsen, counselor

Annex III: Grid Impact Study, TOR + Jan 2004 Debriefing Note

Debriefing Note
Preparation of Terms of reference for the Electric Transmission System Impact Study
Danida Zafarana 3 Wind Farm

Danida ref.: 104.O.30.Egypten
TWE document 040120-1.514
TWE ref. 2.514

Danida has engaged Wolfgang Mostert as contract holder and Tripod as sub-contractor for the task of, together with NREA, upgrading the pre-feasibility study presented by NREA to a full scale feasibility study, to enable Danida to undertake a desk appraisal of the project. Mr. Kim Dyre Jespersen of Tripod Wind Energy came to Egypt in January 2004 to establish the Terms of Reference for the System Impact Study to be carried out as part of the Feasibility Study.

Mr. Kim Dyre Jespersen arrived to Cairo on 17th January, held all-day meetings with NREA and EETC 18th to 20th January, debriefed with NREA's chairman Mr. Hosni Hassan El-Kholy in the afternoon of 20th January and with the Danish Embassy in the morning of the 21st January. Mr. Kim Dyre Jespersen then left Cairo later 21st January.

The Electric Transmission System Impact Study shall form part of the Feasibility Study. The primary objective of the Electric Transmission System Impact Study is to establish whether the electrical system can accommodate the total installed capacity of 545 MW of the Zafarana wind farms at the time of completing the Danida Zafarana 3 wind farm in 2007.

A preliminary draft ToR was sent to NREA in advance of the mission to form the outset for the discussions. The mission was completed having established the Terms of Reference in a final draft version, which has been preliminarily agreed to by NREA and EETC, but which also needs to be finally reviewed and finally approval by NREA and EETC.

During the mission it was realised that NREA is not immediately in a position to provide the input required for EETC to initiate the study. Various approaches were discussed, and NREA finally decided to request Danida to include technical assistance on these critical issues under the current assistance programme to establish the Feasibility Study. Assuming this assistance be provided relatively prompt, the time schedule for completing the Feasibility Study will not be affected.

The final draft Terms of Reference are attached.

Prepared in Cairo on 21st January, 2004.

Kim Dyre Jespersen

Terms of Reference
Wind Farm Models
Electric Transmission System Impact Study
Danida Zafarana 3 Wind Farm

TWE document 040212-1.514
12th February, 2004 – kdy
TWE ref. 2.514

Introduction

Previously, Danida has financed Zafarana wind farm component one on a grant basis, and component two on a mix of grant and mixed credit financing (total of 60 MW). The Egyptian New & Renewable Energy Authority (NREA) has now approached Danida for financing of component three. Component three is now foreseen to have a capacity of 100 to 120 MW and the wind farm is expected to be commissioned by mid 2007.

In addition to the Danida financed wind farms at Zafarana, KfW has financed a 33 MW wind farm now in operation and a 47 MW farm presently being implemented. Contract for an 85 MW wind farm financed by the Spanish Government was signed 17th December, 2003, and plans for a 120 MW wind farm financed by the Japanese Government are far advanced. Finally, a new KfW project of 80 MW is being developed. Thus, the total wind farm capacity in Zafarana, when looking at the timeframe up to 2007 will be some 525 to 545 MW. Current planning includes 270 MW of installed wind power capacity in Zafarana by 2005.

Danida has engaged Wolfgang Mostert and Tripod Wind Energy for the task of preparing the feasibility study, to enable Danida to undertake a desk appraisal of the project. It is anticipated that the Egyptian Electric Transmission Company (EETC) shall carry out the System Impact Study – possibly in co-oporation with the National Energy Control Centre (Load Dispatch) because these organisations are in possession of the required knowledge and tools, and much of the necessary data.

It has been agreed that NREA inter alia will provide:

1) Suggestion for a model of the Zafarana wind farm seen as a whole to be used for the analysis software PSS/E and PSLF (equivalent circuit representation).
2) Parameters for the equivalent circuit representation of the wind farms seen as a whole.

Grid data, for instance in terms of static grid data, load patterns and variations, voltage level and voltage fluctuations, average frequency and frequency variations, grid availability / uptime, potential grid connection points, and conditions for grid connected equipment and plants to be provided by EETC.

During a mission in January 2004 it was realised that NREA is not immediately in a position to provide the input required for EETC to initiate the study. Various approaches were discussed, and NREA finally decided to request Danida to include technical assistance on these critical issues under the current assistance programme to establish the Feasibility Study.

These Terms of Reference have been prepared to describe the technical assistance regarding the model of the Zafarana wind farm. The terms have to be approved by NREA and EETC.

Objectives

The primary objective of the Technical Assistance regarding the model (Model-TA) is to assist NREA in establishing the required information in respect of the items 4 and 5 of the 6th section of the Terms of Reference for the Electric Transmission System Impact Study (annexed).

As a second objective it shall be assured that NREA can provide the items 1 and 3 of the above mentioned section.

Output

The output shall be:

- Description of a number of 'aggregate' or 'reduced equivalent' PSS/E models of wind farms relevant for the Zafarana projects,
- Description of appropriate parameters for the models,
- Successful import/implementation of these models in EETC's PSS/E analysis tool,
- Results of the analyses carried out with the models (possibly as preliminary results as EETC may have to carry out more analyses with the models before their conclusion can be presented), and
- A debriefing note, which among other issues presents
    - The activities and achievements of the Model-TA mission,
    - The analyses carried out,
    - The (preliminary) results, and
    - Proposals for further analyses to be carried out in the short and long term.

The descriptions of the models shall be annexed to the debriefing note.

Scope of Work

Only the part of the Egyptian National Electric Grid significantly affected shall be included in the analyses. Considering the size of the wind farms in Zafarana compared to the total Egyptian electric grid, it is anticipated that the analyses comprise Zafarana, El Ein El Sukhna, Ataqa, and other lines and substations affected in the Canal Zone.

It is expected that transient stability and system protection analyses are not needed at this stage of the project, and because of the size of the total installed wind farm capacity in Zafarana compared to the total installed capacity in Egypt.

Methodology - Activities

The Model-TA shall be given in the form of on-the-job assistance by an Expert with the required knowledge and experience regarding PSS/E and models of wind farms. It is anticipated that the Expert comes to Cairo on a mission together with Mr. Kim Dyre Jespersen, who is already on the team. After introductions, the Expert shall work with EETC at the offices of the relevant departments and together with engineers of NREA and EETC carry out the activities. Concluding the Expert's mission a debriefing note shall be prepared and presented to the involved entities.

After introductions, Mr. Kim Dyre Jespersen shall assist NREA in establishing the items 1 to 3 of the 6th section of the Terms of Reference for the Electric Transmission System Impact Study

It is anticipated that the duration of the Expert's stay in Cairo shall be ten days and that Mr. Kim Dyre Jespersen's stay shall be four days.

The working language is English and all written documents shall be prepared in the English

language.

Input

EETC will make available the PSS/E analysis tool. Further, grid data, for instance in terms of static grid data, load patterns and variations, voltage level and voltage fluctuations, average frequency and frequency variations, grid availability / uptime, potential grid connection points, and conditions for grid connected equipment and plants will be provided by EETC.

NREA will provide information regarding the planned wind farms in Zafarana.

Staffing

NREA and EETC will each provide the staff required from their side to receive the assistance and meet the objectives.

An Expert with thorough knowledge and experience regarding PSS/E, models of wind turbines and wind farms, and regarding transmission system analyses shall be engaged by Danida. The Expert shall need to be engaged for a total of thirteen days; one day for preparations, ten days for the stay and a total of two days for travel to and from Cairo

Mr. Kim Dyre Jespersen shall be using a total of four plus two days for this particular task.

Timing

The mission shall be initiated as soon as possible, probably around the beginning of March, 2004.

Annex IV: TOR for Zafarana Feasibility Study

Egypt

TERMS OF REFERENCE
for

Feasibility Study

of

Zafarana wind farm (Component 3)

Background

Previously Danida has financed Zafarana wind farm component 1 on a grant basis and component 2 on a mix of grant and mixed credit financing. The Egyptian New & Renewable Energy Authority has now approached Danida for financing of component 3.

Component 3 is foreseen to have a capacity of 60 MW and will be situated west of components 1 and 2. The size of component 3 could vary between 50 and 100 MW, and the optimum size should be analysed in the feasibility study.

Danida has received a pre-feasibility study dated August 2003. Further, the project has been given priority by the Ministry of Foreign Affairs as a project eligible for Danish mixed credit financing. Based on this and the thorough knowledge gained from the previous two projects, Danida has decided to carry out a full scale feasibility study in cooperation with NREA.

In addition to the Danida financed wind farms at Zafarana, KfW has financed a 33 MW wind farm now in operation and a 47 MW farm presently being implemented. Plans for a 70 MW wind farm financed by the Spanish Government and a 120 MW wind farm financed by the Japanese Government are well advanced.

Objectives

The objective of the consultancy services covered by these TOR will be -in cooperation with NREA - to upgrade the presented pre-feasibility study to a full scale feasibility study utilizing already collected experience from previous and planned wind farms at Zafarana, to enable Danida to undertake a desk appraisal of the project.

Output

The output of the consultancy services are:

- Debriefing Notes from the missions to Egypt with all major findings and recommendations and a Process Action Plan for the further work, discussed with NREA before departure and signed by the consultant.

- A Feasibility Report prepared according to guidelines in the annex to these TOR on Danida Mixed Credit Standard Form, Feasibility Study, and with references to already collected material on the Zafarana projects.
- A Project document according to Danida guidelines.

Scope of Work

The scope of work to be carried using these terms of reference shall include, but not necessarily be limited to the information required in the attached Danish mixed credit standard form for wind energy projects, feasibility studies. Further, any relevant additional information with regard to a following desk appraisal shall be collected. If different solutions are applicable e.g. with regard to technical and financial issues, the different solutions shall be described and assessed.

The following issues to be analysed may be highlighted:

- The need for the project
- The sufficiency of existing wind data and the need, if any, for additional data.
- The sufficiency of the electric grid connecting existing and future wind farms to the national grid, and the need, if any, for reinforcement of the grid.
- The environmental risks
- The financial analysis incl. financial solvency of the borrower to service the loans, size of the Power Purchase Agreement and status for renegotiation of this based on depreciation of the Egyptian pound and inflation in Egypt, and analysis of using the CDM option. The financial analysis shall include different options, and recommend on the best form of financing.
- Analysis of options (for instance NREA or EEHC) as responsible for Operation and Maintenance of the wind farm based on status and findings from existing and planned wind farms and short and long term objectives in Egypt for operation of wind farms.
- Implementation analysis for the project incl. use of local contractors, a Danish "turnkey" contractor, and use of a consultant incl. TOR for such services

5. Methodology

The consultant shall work closely together with the relevant Egyptian counterparts and the Danish Embassy. The methodology the mission should apply shall include, but not necessarily be limited to:

5.1 Collect, study and analyse relevant available background documents;

5.2 Discuss the background documents with relevant ministries, authorities, institutions, and other interested parties;

5.3 Provide outputs in accordance with clause 3;

5.4 Discuss with the Secretariat for Mixed Credits and BFT in Danida before departure for Egypt, and present and discuss the mission findings, conclusions and recommendations to the Egyptian Authorities, The Embassy and the Secretariat for Mixed Credits/BFT.

The Study is foreseen in the following phases:

Phase a:

- Study relevant background material, prepare a detailed programme for the first mission and hold meeting with the Secretariat for Mixed Credits and BFT well in advance of departure.
- Mission to Egypt to collect data, start cooperation with NREA, etc and agree on collection of outstanding information, if necessary, prepare outline feasibility study and hold debriefing.

Phase 2:

- Collection of outstanding information.
- Write draft feasibility study and forward to Danida and NREA (5 copies).

Phase 3:

- Mission to Egypt for discussion of the draft feasibility study and finalize investigations. Hold debriefing on feasibility study and outline Project document.
- Finalise the Feasibility study and the Project Document (5 copies)
- Discuss these documents with Danida prior to forwarding them to NREA.
- Finalize the documents (10 copies) after receiving comments from NREA, etc.

Staffing

The team shall include:

- Mr. Wolfgang Mostert, Economist, team leader;
- Mr. Søren Gjerding, wind energy specialist.
- Mr. Kim Dyre (part time) as wind energy and electric grid specialist.

SBK may participate in the first and/ or the second mission to Egypt. BFT may participate in part of the mission to Egypt in phase 3 as preparation for the desk appraisal.

Timing and Input

Phase 1 is scheduled to take place in December 2003, and the mission in phase 3 to take place in February 2004.

It is estimated that the team shall need a maximum of 14 man-weeks for the consultancy, with five man-weeks for phase 1, three man-weeks for phase 2, and six man-weeks for phase 3.

Background documents

The following key documents will be made available for the study:

- NREA's Feasibility Study dated August 2003.
- Development of a Commercial Wind Farm Market in Egypt, June 2003 for MEE/NREA, The World Bank and Danida.
- CDM Projects dated September 2003 (draft) for Danish Energy Agency.
- Wind Power Projects in the CDM dated December 2002 by Risø
- Brief Guidelines concerning Danida's mixed Credit Programme for Developing Countries, March 2003.
- OECD guidelines for officially supported export credits.

Outline TOR prepared by Secretariat for Mixed Credit in October 2003.
Revised TOR 13.11.03 and 18.11.03 by BFT/ Christian Sorensen

Annex V: References

[1] "Wind Atlas for the Gulf of Suez 1991-2001"
Mortensen, Niels G. and Usama Said Said.
NREA/Risoe April 2003

[2] "Pre-feasibility Study for a Pilot CDM Project for a Wind Farm in Egypt"
Final report – Task 2.1
October 2001, NREA/Risoe

[3] "Zafarana Wind Farm Project. Site Calibration Report for Zafarana 1+2
Hansen, Jens Carsten and Mortensen, Niels G.
May 1999, Risoe

[4] "Input to the Feasibility Study, Zafarana Wind Farm, Danida, Zafarana III"
Technical Assessment, Draft outline
Said, Usama Said
January 2004, NREA

[5] "Development of a Commercial Windfarm Market in Egypt"
Wolfgang Mostert Associates
June 2003

Annex VI: Transmission Impact Study - Briefing Note

Wind Farm Models
Electric Transmission System Impact
Danida Zafarana 3 Wind Farm
Briefing Note

Prepared by Alfredo Povedano
08.04.04

1. Introduction

This document is prepared in relation to the System Impact Study (SIS) to be carried out be EETC/EEHC in respect of extending the Zafarana wind farms to a total installed capacity of 545 MW. As an input to this study it has been requested by EETC and agreed to by NREA that NREA shall provide models for the wind farms models to be implemented in PSS/E for the System Impact Study.

This Briefing Note describe the results required by the Terms of Reference:
TWE Document 040212-2.514, 1 pages
4th March, 2004 – kdy
TWE ref. 2.514

This document contains a brief description regarding the work carried out with EETC engineers to implement Wind Farm Models with appropriate parameters, PSS/E representation, and preliminary results of the System Impact Study. Further analysis to be carried out by EETC is also described.

2. Activities

EETC provided Load Flow base cases for years 2004 and 2007 and dynamic data file for year 2007. The base cases contain detail representation of all the Egyptian Power System and interconnected Systems.

Mr. Kim Dyre Jespersen provided typical Wind Farm daily generation curves for each month of the year as a percentage of total installed capacity.

Models for each Wind Farm were implemented using typical Manufacturer Data for load flow analysis. Constant (and semi variable) speed machines were compensated for no load, variable speed machines were assumed reactive power neutral (only the Spanish Wind Farm). Wind turbine parameters for the existing machines were not available during the preliminary analysis. It is believed that the data used to implement the models is adequate for the Feasibility Study. All new Wind Turbines were assumed to be constant speed machines except for the Spanish Wind farm. Wind farm models were introduced in EETC PSS/E base cases.

Seven contingencies were studied for year 2004 maximum load with 140 MW Wind Farm generation and for year 2007 maximum and minimum load with 545 MW Wind Farm generation at

Zafarana. The contingencies were limited to the Canal Zone Power System as well as the screening process.

The contingency study included assessment of:
a. Thermal overloads
b. Voltage violations
c. Voltage stability by means of VQ curves

Flicker and short circuit studies were performed.

The dynamic models for induction generators used for transient stability analysis were reviewed as well as the procedure to obtain PSS/E model parameters from Manufacturer's data sheets. Two sets of typical parameters were calculated based on Manufacturer data sheets.

PSS/E does not contain models for variable speed Wind Turbines.

One transient stability case was studied to test the dynamic Wind Turbine models.

NREA is searching for data sheets to improve the model parameters of the existing machines. Typical parameters will be used for future Wind Farms through out the System Impact Study.

Annex 1 shows the Schedule and further details regarding the activities.
Annex 2 shows the Load Flow models and parameters for the dynamic studies.

3. Preliminary Results

The following are preliminary results of the System Impact Study.

a. Zafarana 2*75 MVA, 220 kV/22 kV transformers will be loaded up to 96% each in year 2004 with maximum Wind Farm generation (without the Spanish Wind Farm) if no reinforcement is installed. Single contingency criteria is not met.

b. With 545 MW Wind Farm generation at Zafarana in year 2007, tripping of one Ectsadia - Petro Pipeline circuit overloads the other circuit to 166% of the thermal rating. To prevent this overload, generation at Zafarana has to be reduced below 345 MW. Single contingency criteria is not met.

c. With 545 MW Wind Farm generation at Zafarana in year 2007, tripping of one Petro Pipeline - Zafarana circuit overloads the other to approximately 120%. Single contingency criteria is not met.

d. The Zafarana 220 kV/22 kV substation was modeled in the 2007 base case with five 125 MVA transformers in parallel. The short circuit current with this arrangement exceeds 100 kA. The 22 kV bus bar has to be split in two sections to keep the short circuit level below equipment short circuit capacity.

e. No voltage flicker or voltage stability problems were found during this preliminary study.

f. No problem was observed when simulating the extreme contingency of tripping all the 545 MW Wind Farm generation simultaneously

The 2007 planned reinforcement consisting of a 220 kV double circuit transmission line from Zafarana to Hurgada proved to be not adequate to prevent the overloads described in b. and c. above.

4. Further Analysis to be carried out by EETC

The following studies and activities should be carried out by EETC to complete the System Impact Study:

a. Review the simulations carried out during the preliminary study.
b. Simulate credible multiple contingency to assess the impact to the grid (bus faults and the tripping of the two circuits of double circuit lines) and document consequences.
c. Solve the overload problems of the Ectsadia - Petro Pipeline and the Petro Pipeline - Zafarana transmission lines. Probably several reinforcement alternatives must be simulated and studied to reach a satisfactory solution.
d. Complete the planning of the Zafarana substation.
e. Perform transient stability studies.
f. Impact of the wind generation on the regulating reserve of the Power System.
g. Write the System Impact Study Report.

ANNEX 1: SCHEDULE AND ACTIVITY DETAILS

Wind Farm Model T-A Schedule		
Date	Task	Comments
Mon 29.03.04	1. Introductions 2. Presentation 3. Review of Terms of Reference	
Tue 30.03.04	1. Preparation of equivalent models to use for the existing WFs (one equivalent for each WF). The model represents the active power, reactive power, shunt capacitors and step - up transformers. (One model for each wind farm). 2. Preparation of a LF peak load base case for year 2004. The base case should represent actual operation of the power system	
Wed 31.03.04	1. Include the existing WF models in the peak load case for year 2004, total of 140 MW 2. Prepare a LF base case for minimum load with WF at maximum load. 3. Run PSS/E with the WF models and check for inconsistencies. 4. Agree on the set of contingencies that will be studied in detail for year 2004. Contingency study shall be limited to the Canal Zone power system.	Only maximum load case was studied
Thur 01.04.04	1. Perform contingency study on the 2004 system peak load and minimum load.. Document voltage and thermal violations	Only maximum load case was studied
Fri 02.04.04	Free	
Sat 03.04.04	1. Presentation of the voltage stability procedure 2. Perform Voltage Stability studies for the 2004 case (with WF models) using QV curves. Determine reactive power reserves and margins for every contingency. Document reserves and voltage at collapse for every contingency 3. Prepare an equivalent model for all WFs connected to Zafarana substation (year 2007). Exclude variable speed WTs. Assume 100% of new WTs will be constant speed machines. 4. Calculate approximate maximum P and Q variations based on the Turbulence Intensity. 5. Calculate maximum approximate voltage variations at the Zafarana 220 kV bus bar. 6. Compare to International flicker standards	Flicker calculated for the maximum load case
Sun 04.04.04	1. Preparation of the equivalent models to use for the WFs commissioned on 2004 - 2007. The model represents the active power, reactive power, shunt capacitors and step - up transformers (one model for each wind farm) 2. Preparation of two LF peak load base case for year 2007, with 545 MW total capacity 3. Preparation of minimum load LF base case with WFs for year 2007, with 545 MW total WF capacity	Minimum load base case was not available
Mon 05.04.04	1. Perform contingency study on the 2007 system. Document voltage and thermal violations. 2. Voltage Stability studies for the 2007 cases using QV curves. Document reserves and voltage at collapse for every contingency 3. Three phase short circuit studies	Maximum load contingency studies were done on Sun, minimum cases on Mon
Tue 06.04.04	1. Flicker study for the 2007 case minimum load	

Wind Farm Model T-A Schedule		
Date	Task	Comments
Wed 07.04.04	1. Calculation of dynamic parameters for constant speed machines. 2. AP meets NREA Chairman to present and discuss preliminary results. 3. Preliminary results are discussed with EETC engineers	
Thu 08.04.04	1. Test the dynamic models. 2. Write Briefing Note	

ANNEX 2: WIND FARM MODELS AND PARAMETERS

Zafarana Wind Farm Basic Information			
Wind farm	**# Wind Turbines**	**Wind Turbine rating**	**Transformer rating and impedance**
1. Danida I (30 MW)	50	600 KW	800 KVA, 6%
2. Danida II (30 MW)	45	660 KW	800 KVA, 6%
3. German I (33 MW)	55	600 KW	800 KVA, 6%
4. German II (47 MW)	71	660 KW	800 KVA, 6%
5. Spanish (85 MW)	100	850 KW	900 KVA, 6%
6. Future 120 MW	120	1000 KW	1250 KVA, 6%
7. Future 80 MW	80	1000 KW	1250 KVA, 6%
8. Future 120 MW	120	1000 KW	1250 KVA, 6%

Wind Farm Models

Dynamic Parameters Case 1			
Manuf. Parameter	Value (ohm)	PSSE Parameter	Value
R1	.0046	L	4.81 pu
X1	.044	L1	0.068 pu
XM	3.06	L’	0.152 pu
X2	.0552	To’	2.14 s
R2	.0043	H	3.00 s

Dynamic Parameters Case 2			
Parameter	Value (ohm)	PSSE Parameter	Value
R1	.0048	L	5.86 pu
X1	.0816	L1	0.126 pu
XM	3.72	L’	0.289 pu
X2	.108	To’	2.54 s
R2	.0040	H	3.00 s

For all cases:
KVA base = 733 KVA
V base = 0.69 kV

A 660 KW induction generator is assumed with a nominal power factor of 0.9
Vestas Data Sheets.

Inertia constant is estimated from typical data.

Annex VII: Financial and Economic Spreadsheet Tables