



Global Environment Facility

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June 1, 2004

Dear Council Member,

UNDP, as the Implementing Agency for the project, *Eritrea: Wind Energy Applications*, has submitted the attached proposed project document for CEO endorsement prior to final approval of the project document in accordance with UNDP procedures.

The Secretariat has reviewed the project document. It is consistent with the proposal approved by the Council in November 2003, and the proposed project remains consistent with the Instrument and GEF policies and procedures. The attached explanation prepared by UNDP satisfactorily details how Council's comments and those of the STAP have been addressed. I am, therefore, endorsing the project document.

We have today posted the proposed project document on the GEF website at www.gefweb.org. If you do not have access to the Web, you may request the local field office of the World Bank or UNDP to download the document for you. Alternatively, you may request a copy of the document from the Secretariat. If you make such a request, please confirm for us your current mailing address.

Sincerely,

Jr Leonard Good
Chief Executive Officer and Chairman

cc: Alternate, Implementing Agencies, STAP



22 March 2004

Dear Mr. Good,

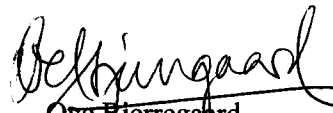
Subject: CC/OP-6 "Wind Energy Application in Eritrea" PIMS No. 179

I am pleased to attach herewith the above-mentioned revised project document which addresses the comments made by Council members from Germany and Switzerland. The UNDP/GEF response to these Council comments is also attached to the project document. The brief was approved at the GEF Council Meeting in November 2003. Also attached is the co-financing letter from the Office of the President, The State of Eritrea..

As per paragraph 29 and 30 of the GEF Project Cycle, we are submitting this project document for circulation to the members of the GEF Council and, subsequently, for your final endorsement.

Thank you in advance for expediting the review and endorsement of this project.

Yours sincerely,


Ove Bjerregaard
Officer-in-Charge

Mr. Leonard Good
Chief Executive Officer and Chairman
Global Environment Facility
Room G6005
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Cc: Mr. Martin Krause, GEF Regional Coordinator

Government of Eritrea

United Nations Development Programme

Wind Energy Applications in Eritrea

The project aims at transforming the market for wind energy applications in Eritrea. Key components are the installation and operation of a small wind park (750 kW) connected to the grid as well as eight decentralised wind stand-alone and wind-hybrid systems in rural villages. In addition, the project will strengthen the country's capacity in terms of personnel, know-how, governmental institutions/authorities, and private companies with regard to wind energy utilisation. Small scale decentralised wind stand-alone and wind hybrid systems will promote sustainable socio-economic development as well as improve the quality of life for the rural population of Eritrea's wind rich regions. Furthermore, the project will reduce greenhouse gas emissions stemming from existing diesel generating facilities in Eritrea by supplying the demand for electric energy with electricity cleanly produced from renewable sources. The project also ensures that the use of wind energy will be considered in future national electrification plans, particularly in wind favourable regions, by demonstrating it as a cost-effective electricity generation technology, which can be replicated throughout the country.

Wind Energy Applications in Eritrea (UNDP)

(ProDoc for CEO Endorsement)

Council Comments and UNDP Response

Comments from Germany:

The global environmental benefit of the project is small when compared to the overall cost of the project. Even after replication, the project will have achieved CO2 abatement at a relatively high cost. On the other hand, the contribution to local sustainable development can be large, and the project introduces a totally new technology to the country, both factors justify the high cost of the project and the significant financial contribution from the country. It is noteworthy that the Government of Eritrea has committed an amount equal to GEF financing in cash to support the project.

The project is promising to support “productive use of modern energy services” but no funds are earmarked for such activities. In fact, the larger component of the project, the on-grid wind farm, will feed its electricity into the power grid and not benefit any unelectrified households.

Recommendation

The Agency should be asked to work on the productive use component and improve it before CEO endorsement of the project.

UNDP response

As correctly noted, the Project Document implies that the pilot wind energy application will stimulate new income generating activities. This is seen more as a spin-off effect and not a specific set of activities within the frame of this project. There is no question that the availability of modern energy in a locality where there was no such energy will definitely contribute to the improvement of household living conditions and the mushrooming of commercial enterprises as manifested by the recently electrified villages and towns elsewhere in the country. In short, it can be said that electricity creates its own demand. For example, within one year after electrification, the number of commercial enterprises rose from 21 before to 190 after in the town of Dibaruwa and from 22 to 74 in Aditekelezan. Attracted by the availability of electricity, entrepreneurs will invest businesses e. g. shops, hotels, restaurants, workshops, etc, in the targeted villages and the improved lighting will stimulate home-based income generating activities especially to women. Observing the pilot wind pumping systems, and the wind-diesel hybrid systems, many will be attracted to convert the well known wind resource into productive use such as ice making for fishermen and pumping salt water into on shore salt fields to produce salt - manifesting the replication effect. Note that these are the most common income generating activities along the Red Sea coast.

Apart from the spin-off effects described above the on-grid wind farm in Assab as well as at the off-grid sites in Haleb, Berasole, Rahaita and Dekemhare the project will further

stimulate productive uses, on the condition that the electricity price is lowered as an effect of the reduced production cost. This assumption will be monitored carefully while the project is being implemented.

The project directly supports productive uses at the off-grid sites in Gaharo and Dekemhare where mechanical wind water pumping will be introduced for irrigation of productive agricultural land. Furthermore at the Haleb site electricity, which will benefit a small a boat factory, will be produced. This is mentioned on page 15 in the Project Document.

Comments from Switzerland:

General Commentaries

The UNDP – GEF Project Wind Energy Applications in Eritrea aims at reducing the country's energy-related CO₂ emissions by promoting both on-grid and off-grid wind energy systems as a substitute for fossil fuel based energy generation. The project focuses on demonstrating the viability of wind energy systems, i.e. one wind park connected to the grid as well as some decentralized wind stand-alone and wind-diesel hybrid systems in rural villages. In addition, the project will strengthen the county's capacity in terms of personnel, know-how, governmental institutions and authorities, and private companies with regard to wind energy utilization.

The project falls under the purview of GEF Operational Programme #6: "Adoption of renewable energy by removing barriers and reducing implementation cost". Activities and outputs of the project are designed to achieve the following three immediate objectives: (i) Capacity development and awareness raising; (ii) Installation of a grid-connected wind farm; and (iii) Installation of eight off-grid wind systems.

Main Concerns

(1) Faulty and unclear analysis of incremental cost: The general principle of the incremental cost analysis should be: Incremental Cost = Cost of Alternative – Cost of Baseline. In the incremental cost analysis on page 11 of the Project Executive Summary document, however, this principle is violated for component 2, component 3, as well as the overall cost of the project. As a matter of fact, it is impossible to make sense of the figures provided in this incremental cost analysis. Moreover, the figures in the Project Executive Summary document do not correspond with the figures in the incremental cost analysis in the actual Project Document. Finally, it is also not clear why the necessary operation, maintenance and reinvestment cost of those existing diesel generator sets that will be replaced by the proposed wind park are not considered to be baseline cost.

UNDP response

The errors in the presentation of the incremental cost calculation have been corrected. All figures, tables and numbers have been updated. Please refer to annex 1 of the Project Document.

Reparation and Maintenance costs are already included as baseline costs (US\$ 80,106 for the Component 2 and US\$ 30,550 for the Component 3). Please see the detailed

Incremental Cost Calculation in the Project Document, Annex I in the tables on pages 29 and 32.

(2) Hardware financing by GEF: In the Project Document it is proposed that GEF finances hardware in the amount of around 0.7 million USD. There is no convincing explanation provided why GEF should finance hardware in the case of this project, even though GEF does not normally finance hardware. This aspect is even more important in the light of the fact that 43% of the overall cost should be covered by GEF, which is unusually high.

UNDP response

Out of the total GEF contribution of US\$ 2,26 million, US\$ 0,7 million are earmarked for hardware which is less than a third of the total.

For the Assab wind farm, the GEF hardware component is for interfacing the output of the wind generator with that of the diesel based Assab grid, which is part of the barrier removal measures. In this case technical barriers must be removed such as the reinforcement of the grid. Wind parks need to be placed where the wind is strong enough whereas diesel systems (baseline situation) can be placed anywhere and therefore no grid reinforcement is needed. Unfortunately, in the case of Assab the best location is at end point of the grid, consequently the grid must be reinforced to "accept" properly the electricity generated in the wind park. This proposal considers that GEF finances 50% of the hardware costs of these technical improvements and the GoE the rest. Please remember that the hardware costs for the wind park itself (USD 1,2 million) are fully financed by the GoE.

The other portion of GEF funds allocated for hardware goes to the pilot and demonstration projects in the rural off-grid project areas. The baseline situation for the rural areas is continuity of no modern energy at all. This project will contribute up to 50% of the hardware costs for the off-grid systems. This is necessary because in Eritrea are not many donors active in the renewable energy field and the government budget is already overstretched. It should be acknowledged that the government is providing USD 2 million in cash co-financing which is significant for a country like Eritrea.

(3) Unclear assumption of feed-in price for electricity supplied to the grid and associated risks: On page 5 of the Project Executive Summary it is mentioned that a feed-in price of 5,9 US\$/kWh is assumed, which is said to be 35% lower than the current generation cost of 9.0 US\$/kWh. This feed-in price is then used to calculate the revenues of the wind park. However, the basis and assumptions for the calculation of the feed-in price and the generation cost is not provided in the project documents. In the project planning matrix a critical assumption is stated with: "Diesel and kerosene prices will not drop more than 30% as compared to average 2003 prices.". Does this mean that in the Power Purchase Agreement the feed-in price will be linked more or less directly to the diesel and kerosene prices? If so, this is certainly a substantial risk for every investor and should thus be discussed together with possible risk mitigation measures in the section " Sustainability and Risks", which is not done in the current version of the project document.

UNDP response

The feed-in price of 5,9 US¢/kWh is an assumed price in order to calculate the RoI. The real price will be negotiated as part of the PPA between EEA and the planned Wind Energy Generation Company. Please note that up to now there are neither IPP nor PPA experiences in Eritrea. Even though international prices of diesel and kero may fluctuate, the PPA agreement is not going to be influenced by such. The PPA agreement between the Independent Power Producers (IPP) and the buying utility, should reflect reasonable profit and capital recovery scheme for the IPP, irrespective of the utility profit margin. A sensibility analysis with regard to the Diesel price variations during the project's lifetime was not carried out, hence we agree that this issue shall be pointed out as a risk. The sustainability and risk section in the ProDoc as been amended accordingly. However, the extraordinary wind conditions in Assab and a proper PPA can easily eliminated this risk.

(4) High Carbon abatement cost: The GEF cost per ton of Carbon avoided due to the project intervention are with \$221 per ton relatively high, which is again an indication that the GEF contribution to this project is relatively high. The fact that a large replication effect is expected cannot fully justify this high abatement cost, as for such replications further considerable investment will be required.

UNDP response

It is true that the Carbon abatement costs are relatively high. In our view this is justified by: 1) a large contribution to local sustainable development and 2) the introduction of a completely new technology (wind) in a developing country with special characteristics.

Conclusions and Recommendations

The project is recommended for approval. It is generally well developed and structured. The project also adopts strategic choices that are fully consistent with GEF strategies. It would be highly desirable, however, if the incremental cost calculation could be made consistent and more transparent, especially in the light of the fact that GEF should finance hardware, that the GEF contribution is with 43% of the total project cost unusually high, and that the carbon abatement costs are with \$221 per ton also relatively high. Furthermore, the overall risk assessment should be improved and mitigation measures should be discussed more thoroughly, especially regarding the critical risk of feed-in prices and electricity tariffs.

UNDP response

All these recommendations have been taken into account for the current version of the Project Document as explained above.

Further Commentaries

- *Cost of CO₂ avoided: On page 5 of the Project Executive Summary a lifetime of 20 years of the equipment is assumed for the calculation of CO₂ avoided. On page 10, however, a period of only 10 years is used for the same calculation.*

UNDP response

We have now updated the calculations using the 20 year time equipment life time horizon. For the GEF component only, the revised figure should be 1,950,561/(34000+350) which is around 57 \$/ton CO₂.

- *Project Planning Matrix, page 13: The indicator provided for output 1.3 is stated as: "70% of all technical training courses offered to electricians, technicians, engineers etc. are carried out successfully". This is not a convincing indicator at all, as it is not clear what would be a "successfully carried out training course". Better would be an indicator that measures concrete results of the training course*

UNDP response

Agreed. The cited indicator has been replaced with this one: "Operation, repair and maintenance services are being carried out by local electricians, technicians and engineers after year 3 of project operation". This indicator measures the success of the training.

- *Project Planning Matrix, page 15: The timeframe for one indicator provided for output 3.1. is stated as "one year after project completion". However, for project evaluation purposes, all indicators should be measurable latest by the end of the project.*

UNDP response

OK. The new indicator reads: "At least three additional villages and SMEs have installed off-grid wind systems by project completion."

- *On page 10 of the Project Document it is stated that a Wind Information System (WIS) has been developed and implemented at the ERTC and that the ERTC is now able to quickly provide information on the wind resources at selected locations. It is not clear, however, which incentives ERTC has to provide this information also to private investors. The concern is that ERTC has a vested interest to monopolize this information rather than allow private investors to become competitors on the wind energy market.*

UNDP response

This concern is without substance. The DoE has the obligation to avail the WIS data to potential users free of charge. Furthermore, it is DoEs and ERTCs genuine interest to attract private investors. Therefore we are confident that ERTC will manage properly the available wind data in order to promote the participation of private investors.

**United Nations Development Programme
Global Environment Facility**

Project Document

PIMS number: 179
Project title: Wind Energy Application in Eritrea
Project number: ERI/03/G
Country: Eritrea
GEF focal area: Climate change
GEF programming framework: OP#6, promoting the adoption of renewable energy by removing barriers and reducing implementation costs
Eligibility: Eritrea ratified the UNFCCC on 24th of April 1995
Duration: 3 years
Estimated start date: January 2004
Estimated end date: January 2007
Implementing Agency: UNDP
Executing Agency: Department of Energy, Ministry of Energy and Mines, Government of Eritrea

Brief Description: The project aims at transforming the market for wind energy applications in Eritrea. Key components are the installation and operation of a small wind park (750 kW) connected to the grid as well as eight decentralised wind stand-alone and wind-hybrid systems in rural villages. In addition, the project will strengthen the country's capacity in terms of personnel, know-how, governmental institutions/authorities, and private companies with regard to wind energy utilisation. Small scale decentralised wind stand-alone and wind hybrid systems will promote sustainable socio-economic development as well as improve the quality of life for the rural population of Eritrea's wind rich regions. Furthermore, the project will reduce greenhouse gas emissions stemming from existing diesel generating facilities in Eritrea by supplying the demand for electric energy with electricity cleanly produced from renewable sources. The project also ensures that the use of wind energy will be considered in future national electrification plans, particularly in wind favourable regions, by demonstrating it as a cost-effective electricity generation technology, which can be replicated throughout the country.

Budget Summary (US\$):

| | | |
|---|-----------------------|------------------|
| Costs and Financing (in US Dollar) | | |
| GEF | Project: | 1,950,561 |
| | PDF B: | 315,900 |
| | Subtotal GEF: | 2,266,461 |
| Co-financing (Parallel) | Government (in cash) | 1,940,536 |
| | Government (in kind): | 40,000 |
| | SIDA: | 837,000* |
| | UNDP TRAC: | 26,500* |
| | Danida: | 91,500* |
| TOTAL PROJECT FINANCING: | | 5,201,815 |

*Please note that these funds have been spent already during and after the PDF B phase. Please refer to section A3 and C1 for further explanation.



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Signatures:

For the United Nations Development Programme (UNDP):

Date:

For the Ministry of Energy and Minerals (MoEM):.....

Date:

For the Ministry of National Development (MoND):

Date:

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Abbreviations

| | |
|--------|---|
| DoE- | Department of Energy |
| EEA | - Eritrean Electricity Authority |
| ERTC | - Energy Research and Training Centre |
| GEF | - Global Environment Facility |
| GHG | Green House Gas |
| GIS | - Geographic Information System |
| GoE- | Government of Eritrea |
| ICS | - InterConnected System |
| kWh | - Kilo Watt Hours |
| MFI | Micro Finance Institution |
| MoEM | - Ministry of Energy and Mines |
| MoLG | - Ministry of Local Government |
| MoND | - Ministry of National Development |
| MW | - Mega Watt |
| NPV | Net Present Value |
| O&M | - Operation and Maintenance |
| PCE- | Petroleum Corporation of Eritrea |
| PMU | - Project Management Unit |
| PPA- | Power Purchasing Agreement |
| PV | - PhotoVoltaic |
| SCS- | Self Contained Systems |
| SIDA | - Swedish International Development Assistance |
| SME | Small and Medium Size Enterprise |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WIS- | Wind Information System |

A. Context

A1. Description of sector

Eritrea is a new country located in the Horn of Africa, which joined the community of nations after the UN supervised referendum in 1993. Its total land area is 124,320 km² and its population was 3.2 million in 1999 of which around 80% live in rural areas and 20% in urban and semi-urban settlements. Eritrea was on the path to strong economic and social development until this process was stopped by renewed conflict with Ethiopia during 1999-2000. However, the previous economic and social development is expected to continue after the border dispute with Ethiopia is settled. Despite this economic development, Eritrea is still one of the least developed countries of the world, facing acute shortages of modern energy especially in the rural areas. The comprehensive energy survey of 1998 by the Department of Energy (DoE) estimated the total final energy consumption to be around 619,580 toe of which 68% was accounted by the household sector, 16% by the commercial/public sector, 13% by transport and 3% by industry. The sources of energy were 66,3 % biomass based (fuelwood, dung, charcoal, agriresidue), 31,6 % oil products and 2.1 electricity, which is all generated by thermal means using oil products. It is also noted that more than 95% of the rural population and 20% of the urban residents do not have access to electricity. The survey also shows an extremely low per capita electricity consumption of only 48 kWh per capita in 1997, and the DoE calculated 54 kWh of electricity consumption per capita in 2001. The fact that about 82 % of the generated electric power is consumed in the areas supplied by the Asmara-Massawa Inter-Connected System (ICS) and the balance of 18 % in the rest of the country shows an unequal distribution of the power supply system in the country mainly due to the concentration of commercial and industrial activities around the capital. At present electricity is supplied to about 20 % of the population and is almost exclusively limited to the urban areas.

Eritrea faces major constraints to its efforts to meet the growing national demand for commercial energy. These include inefficient energy production, distribution and consumption, lack of awareness of the need for energy conservation, and a lack of financial and technical capability. In order to facilitate the economic development of Eritrea, further development of the electricity sector is necessary. Partly, this has been achieved with the commissioning of the 88 MW Hirgigo Power Plant in March 2003. However, future developments cannot be based only on the utilisation of fossil energy sources because it scarce hard currency must be used to import oil products.

At present, the energy consumption pattern in Eritrea is clearly unsustainable. Biomass energy, used mainly for cooking purposes and covering basic living needs, contributes to around 80 % of the country's total energy consumption. Biomass is burnt in a very inefficient manner in traditional stoves, and its use is contributing to deforestation, which leads to land degradation and also has a negative impact on the global greenhouse gas emissions balance. Currently, electricity is generated only by diesel generation sets that burn fossil fuels, diesel and fuel oil, which also increase greenhouse gas emissions.

A2. Host country strategy

It is a desire of the Government of Eritrea (GoE) to change this situation through development of sustainable energy supplies. Apart from its national goals, the GoE is considerate of global environmental concerns and the resulting global climate protection goals, as indicated by its ratification of the UN Framework Convention on Climate Change (UNFCCC) on 24.04.1995. Another indicator is the continuous will of the GoE to finance the Energy Research and Training Centre (ERTC) under the DoE, and its activities regarding adaptation and implementation of renewable energy technologies and implementation of comprehensive capacity building activities in this area.

In order to improve upon the current situation the Eritrean government has formulated a National Energy Strategy, with the multiple purposes of:

- Promoting economically and environmentally sound energy sector development through the use of appropriate energy production technology and energy conservation and usage optimisation.
- Implementing a policy of appropriate energy pricing structures that avoids all types of subsidies.
- Diversifying energy sources in order to minimise the country's dependence on dwindling biomass energy resources and imported oil, by promoting private capital participation in hydrocarbon exploration and developing renewable energy resources.
- Modernising and expanding the country's power generation and distribution system and creating an environment for private sector participation in energy development and energy markets.
- Developing capacity through training and establishing the necessary institutional and legal frameworks that can competently manage the sector.

A3. Prior and ongoing assistance

Initiatives have already begun to meet portions of Eritrea's national energy objectives. The following activities are worth noting:

- (1) The ERTC has started with the measurement of solar radiation and wind speeds resulting in the preparation of solar energy maps and wind resource analysis since 1996.
- (2) Several studies regarding the improvement of cooking stoves in Eritrea have been carried out in recent years at the ERTC. At this moment, the production and implementation of new improved cooking stove version is occurring all over the country.
- (3) The ERTC has implemented a programme for providing schools, village water pumps and hospitals in rural areas with small PV systems. A firm capacity of 500 kWp has been achieved to date.
- (4) A study, carried out at the DoE in 1998-1999, has analysed the waste potential in Asmara with regard to its utilisation for energy purposes.
- (5) In the PDF-B activity of this project, the wind potential in the south of Eritrea was investigated.
- (6) A Swedish financed project, started in 1998 and finished in 2002, analysed wind and solar resources in Eritrea with the installation of 25 measurement stations throughout the country. Apart from the provision of software and training, the project also included assistance to revise the legal and regulatory framework for the energy sector.
- (7) In order to review and actualise the outputs of the PDF-B activity, as well as to include the recent developments for promoting the use of renewable energies in Eritrea, UNDP-Eritrea organised a reconnaissance mission in March 2003. The main objective of this mission was to review, update and prepare the draft for the present project proposal.

A4. Institutional framework

The Ministry of Energy and Mines (MoEM) has the overall Government mandate to promote and guide the development of the energy and mining sectors. DoE is responsible for drafting policies, strategies and action programs for the energy sector. The DoE has three Divisions, namely, Energy Management & Development, Energy Research & Training that also manages the ERTC, and Hydrocarbon Exploration and Promotion. The MoEM has established the ERTC to promote Research and Development principally on renewable energy resources and technologies for energy conservation. In 2002, with the financial assistance from SIDA of Sweden, the MoEM was assisted in setting and implementing appropriate energy laws, regulations and standards, thus creating a conducive legal framework for the sector.

The Eritrean Electric Authority (EEA) and the Petroleum Corporation of Eritrea (PCE) are public utilities having administrative and financial autonomies. The activities of both utilities are controlled and overviewed by a Board of Directors whose chairman is the Ministry of Energy and Mines. The

main tasks of EEA include operating the electricity generation, transmission, distribution systems and collecting tariffs. In Eritrea all electricity is generated by thermal power stations that use imported oil. Most of the power utilities in the country are owned and operated by the EEA that operates two system types, i.e. the Inter-Connected System (ICS) and the Self - Contained Systems (SCSs). The total firm capacity of both power systems is around 156 MW. The firm capacity of the SCSs totals 15 MW the largest of which is that of Assab (8 MW). From the total electricity generation of 199 GWh in 2000, 80% was consumed in the areas covered by the ICS and 20% in the SCS; of this total electricity consumption, 44.6 % was accounted by industry, 36.7 % by the household sector and 18.7 % by the commercial and other sectors. The main tasks of the PCE are importing crude and refined petroleum products and ensuring the supply of refined products to the local market. Private oil companies share the distribution market.

B. Project justification

B1. Problem to be addressed and the present situation

An important goal of Eritrea's national energy policy is creating an adequate energy supply sufficient to meet the needs of the entire country. This means that the electricity sector needs to expand the ICS and provide other areas of the country, especially those having prospering economic activities, with electric energy (e.g. Assab). Purely rural areas will potentially have access to at least a minimum supply of electric energy. With financial support from SIDA and the World Bank (grant and soft loan respectively), the Ministry of Energy and Mines has embarked on extending the ICS grid to many of the villages around large cities, major roads, and transmission and distribution lines. Around 14,100 households have benefited from the completed electrification programme 1999-2001, while during the years 2002-2004 more than 46,200 households from villages and rural towns are expected to be electrified. The electricity production demonstration sites for the present project lie at distances ranging from 35 to 100 km from the grid system, and wind water pumping demonstration sites lie at both on- and off-grid locations.

While wind energy applications are non-existent in Eritrea, some PhotoVoltaic (PV) systems have already been implemented during the last years. The ERTC has already built up a level of expertise in this field and is actually disseminating PV systems and the respective know-how and technical expertise in selected rural communities. The level of technical know-how of PV technology is therefore presently higher than it is for wind energy technology.

However, preliminary analysis has shown that there is significant wind energy potential in southern Eritrea. A PDF-B activity was implemented between January 1998 to May 1999 in order to investigate this assumption and determine whether the extensive utilisation of wind energy technology in this region could accelerate both rural electrification in this region and expansion of the grid system of Assab, the major city in southern Eritrea. The wind measurements from the PDF-B activity supported the assumption that there is large wind resource potential in the region. Indications that there are also locations with favourable wind conditions in the middle and northern regions of Eritrea were verified by the Swedish financed project in 1998-2002.

However, several barriers, described below, still hinder progress toward widespread adoption of wind energy technology in Eritrea this project aims at removing these barriers and demonstrate the technical and economical feasibility of exploiting wind energy in Eritrea. With barriers removed, the government and the private sector would be able to develop the electricity sector in a sustainable way on their own after the pilot phase. Pilot projects in selected villages and existing grid(s) will set the stage for the implementation of wind energy technologies in other places of Eritrea.

Presently no grid-connected wind parks or off-grid wind-diesel hybrid systems exist in Eritrea. Both in the existing grids and in off-grid systems, electricity is supplied solely by means of power generation sets, fired with diesel and fuel oil. The good wind regimes found in many places in Eritrea makes it possible to save at least a part of the diesel costs by means of feeding wind electricity in the grid. Other possibilities to reduce the use of fossil fuel for electricity generation in Eritrea are mainly the replacement of the diesel gen-sets with more efficient conventional power generation technologies or, to a certain extent, the use of geothermal energy, but it is reasonable to assume that wind electricity generation is the option which could be realised within the shortest time frame and which would be, at wind favourable sites, a least-cost option.

B2a. Awareness / experience barriers

Barriers pertaining to the lack of experience with wind energy increase the transaction costs for the initial development of wind energy systems. These include:

- (i) no existing example of grid-connected wind parks in Eritrea,
- (ii) no existing example of off-grid wind-diesel hybrid systems in Eritrea (the combination of (i) and (ii) means that there is no tangible example for potential investors or developers, for the economical and technical feasibility of wind energy in Eritrea),
- (iii) no experience inside EEA regarding the installation and the operation of wind turbines; this is of particular importance since EEA is the only company being able to carry out the task of operation and maintenance of larger electricity generation systems in Eritrea. No other company presently exists that possesses a similar amount of technicians or engineers for such kind of tasks,
- (iv) lack of experience inside the Eritrean private sector with regard to the private business opportunities wind park projects offer
- (v) lack of adequate model contracts, on the basis of which private developers and EEA can negotiate Power Purchasing Agreements (PPAs) and other necessary contracts for such kind of projects,
- (vi) a very low level of awareness in the general population about wind energy technologies and the potential they offer.

B2b. Capacity / institutional barriers

Even though the natural resources of wind energy are favourable, the technology for the utilisation of wind energy is not established in Eritrea. The reasons are several general barriers with regard to:

- (i) insufficient technical know-how and the non-availability of adequate trained manpower resources in the private sector, in the governmental authorities dealing with wind energy, and in the Eritrean Electric Authority,
- (ii) the lack of clearly described procedures and responsibilities for the initiation, the development and the implementation of rural renewable energy projects, and
- (iii) the lack of developed and implemented financing mechanisms which take into account the special features of renewable energy technologies,
- (iv) the lack of tested model contracts such as PPAs, wheeling agreements etc.

B2c. Technical barriers

The existing grids are laid out for the operation with diesel generation sets only. They have to be optimised with regard to technical reliability and operation strategy before a wind park can be integrated. For the grid of Assab, a study has investigated the possibilities to integrate a wind park. Technical barriers are here mainly:

- (i) the high failure possibility of individual grid segments and the resulting part-time loss of electricity demand, and
- (ii) the lack of a suitable grid connection possibility at the identified wind park location.

If these barriers are not removed wind energy can not be used cost-effectively and therefore the electricity cannot be sold to the utility.

B3. Expected end-of-project situation

At the end of the project it is expected that the existing barriers for a continued and sustainable development of wind energy will have been removed. Future utilisation of Eritrea's favourable wind regime will bring direct benefits to Eritrea in the form of electricity production that is relatively cheaper compared to traditional fossil fuel production. This means that electrification of rural areas can expand faster and be more economically attractive. Rapid rural electrification will in turn stimulate enterprise development; improve living conditions and service provision by schools and health facilities etc. Productive uses of wind energy, such as mechanical water pumping, will also have been stimulated. Of Eritrea's 2500 villages, the 316 with a favourable wind regime¹ will all be in a position to benefit from the lessons learned from this project, and the capacity and experience attained in Eritrea.

Furthermore, the Eritrean private sector as well as EEA and the Department of Energy will have been stimulated to participate in the development of the wind energy technology, making possible the manufacturing and/or maintenance of machine parts. The improved regulatory framework will attract private investors already present in the country, and positive economic experiences will enable them to replicate the project in other areas of the country.

Benefits to the global environment in the form of reduced CO₂ emissions will result, both from the demonstration sites of the project, and from the sustained development of wind energy technology in Eritrea.

B4. Target beneficiaries

The beneficiaries of the project can be split in two groups, (i) the ones that will benefit directly from the project and its activities, and (ii) the larger group that will benefit from its effects after project termination. To the first group belongs:

- the urban population in Assab, who will be secured a more stable and less polluting source of electricity, and an electricity grid ready for higher production in the future,
- the rural populations in the demonstration villages, a total of 977 households benefiting from the demonstration applications², who will benefit both directly and indirectly from the produced electricity and mechanical water pumping. Among other things one important benefit is the reduction of kerosene used for indoor lighting, which causes eye- and respiratory diseases. The local wind energy managers will also gain valuable experience, which can then be exported to other villages in the future. The replication potential is substantive: A total of 316 villages comprised of 60,000 households encounter a favorable wind and solar regime and will benefit from the introduction of renewable energy technologies. SMEs (ice-making for fishing companies, sea water pumping to saltfields, seawater desalination plants) will also benefit through productive use applications of wind. Provision of modern energy services for households and productive use applications will contribute directly to poverty reduction. In addition, households, which are grid-connected, will benefit from cheaper electricity prices once more wind farms are connected to the grid.
- EEA, which will be able to produce electricity cheaper than before, and which will develop its capacity in the area of wind energy applications,
- The Department of Energy, which will also gain experience with wind energy applications.

¹ The 316 identified villages comprise a total of 60,040 households, who are in a position to benefit from wind applications, ranging from electricity production to mechanical water pumping and hybrid systems with either diesel generators or solar PV systems.

² Be'rasoli 108, Rahaita 117, Haleb 200, Gaharo 99, Beilul 198, Gzgiza 225 and Dekemhare 30 households benefiting directly from the demonstration applications. The 99 households in Gaharo benefit from both electricity production and a water pumping system.

To the second group belongs:

- urban and rural populations all over Eritrea, in places with favourable wind regimes, who will benefit both directly and indirectly from reduced costs of electricity,
- the private sector in Eritrea, who will be able to participate both in the manufacturing and maintenance of wind energy systems, benefit from attractive investment opportunities made possible by a clearer legal and regulatory framework, and
- EEA and the Department of Energy, as above.

C. Project strategy and implementation arrangements

C1. Project design strategy

Providing electricity to rural areas is one of the targets of the Eritrean national energy policy. The development of a sustainable energy supply system in Eritrea is another one. To utilise domestic energy resources in order to reduce dependency on imported fossil fuels is a third objective. This project targets all three objectives. It is therefore an ideal fit when considering Eritrea's overall national energy policy. Furthermore, the GoE intends to continue to financially assist the ERTC in order to further promote decentralised rural electrification by means of utilising sustainable energy sources. The project design thus builds upon activities already initiated in Eritrea, and is a natural continuation of these.

In the development of this project, exhaustive consultations have taken place between the Department of Energy, the Ministry of National Development, consultants from Lahmeyer International, UNDP/GEF and the UNDP Eritrea office, the EEA, representatives of the private sector, and field visits have been carried out in all proposed demonstration villages. Furthermore, results from previous activities have been taken into account, including the following:

Results from the PDF-B project 'Wind Energy Applications in the Coastal Areas of Eritrea' were very important for the formulation of activities of this proposed project:

- The PDF-B provided the first complete picture of the available wind resources in southern Eritrea
- a Wind Information System (WIS) was developed and implemented at the ERTC. The ERTC is now able to quickly provide information on the wind resources at selected locations,
- the results of the wind data analysis show a high wind potential in and around Assab and in regions to the south of Assab. Average wind velocities generally decrease towards the north, with significant variation in the mountainous regions. This detailed information is now available for the identification and selection of suitable rural villages for wind-stand alone and wind hybrid systems in the wind-rich parts of Eritrea,
- the project furthermore provides evidence that the wind rich region of Assab would be an excellent example of the technical feasibility and economic competitiveness of grid connected wind parks in Eritrea. The necessary information for conceptual planning and economic assessment of the wind park Assab are now available. The analysis done so far shows that in Assab a wind park connected to the grid can be a cost-competitive contribution to Eritrea's overall electric power supply system, providing that GEF financial contributions will successfully remove the above-mentioned barriers.

The SIDA project 'Wind and Solar Assessment', finished in 2002, complements the PDF-B project and completes the database on wind resources. As part of the SIDA project a GIS database for renewable energy resources was created at the ERTC. The data and information available forms an ideal basis from which to expand rural electrification with sustainable energy utilisation to other parts of the country. It will also be useful for replicating the Assab wind park in other areas of the country.

The failed wind pilot turbine project in Massawa, part of the SIDA project, showed the importance of the know-how about manufacturers of small wind turbines and products in the market, which would be the appropriate for Eritrea according to the existing infrastructure (cranes, roads, etc.). Therefore, potential bidders for supplying the proper wind park equipment were already approached in order to guarantee their participation in the bidding process.

Other earlier projects such as 'Strengthening the Department of Energy', implemented in 1996 and 1997, indicate that the non-availability of electricity in rural areas can hinder commercial activities, resulting in poor living conditions for the people living there. Among others, this has resulted in population migration from rural areas to the cities, also to the city of Assab. It is expected that making electricity available in rural areas will help reduce the migrations of Eritreans from rural areas to the cities. This study also shows that biofuel is the main source of energy in Eritrea and it should be a top priority to search for possibilities to reduce the population's consumption of fuel wood. Although electricity is not the first choice as energy for cooking purposes in rural areas, the proposed project will analyse and test whether the utilisation of wind energy resources is a viable alternative for fuel wood for cooking at reasonable prices in high wind regions.

C2. Project implementation strategy

Initiating sustainable development of a new technology in Eritrea is a great challenge, and requires the careful involvement of all relevant stakeholders in the project, both in order to implement the project properly, and to set the scene for further development after project termination.

Implementation of the wind park in Assab will be implemented in close co-operation with the EEA. The EEA intends to participate in the financing and technical implementation, and later act as operator of the wind park. For future projects, the most probably organisational form is that EEA will be contracted in the frame of an O&M contract by the private wind park owner(s), or the EEA is itself a member of a wind park company.

All stand-alone and wind hybrid systems in rural areas will be implemented in close co-operation with the respective local communities. The community administrations will play an important role by collecting money from the end user beneficiaries, which will cover the running cost during the pilot phase. A rural electrification plan has already been initiated by the GoE and financial resources are being solicited to provide (fossil-fuel generated) electric power to selected rural villages, including some of the demonstration sites of this project. For these sites the wind-hybrid technology will be implemented to reduce fuel use and decrease production costs. The community administration will be in charge of both systems, as is traditional in Eritrea.

Implementation Plan. The flow chart given in the annex provides a summary of the project's implementation plans. The time schedule shows that the total project duration will be three years, during which all three components will be implemented together. Connections between the different project parts have been considered in the time frame so as to make the missions of international experts as effective as possible thus minimising travelling costs especially with regard to the timing of the training seminars. There are several important milestones that must be achieved for the timely implementation of the project:

- Project office set-up: 2 months after project start
- Component 2: - Financial close: 5 months after project start
- - Wind park in operation: 16 months after project start
- Component 3: - All pilot systems in operation: 21 months after project start
- Project completion: 36 months after project start

The implementation plan is elaborated in a figure in annex 3.

C3. Reasons for assistance from UNDP/GEF

The project is eligible for GEF funding under operational programme #6 because it will:

- (i) directly reduce greenhouse gas emissions due to the installation and operation of a grid connected wind park and of isolated wind stand-alone and wind hybrid electricity supply systems, which will displace diesel-fired electricity production, both present and future, and
- (ii) through its barrier removal activities kick-start the sustainable development of wind energy applications in Eritrea, thereby avoiding future emissions while bringing cheap electricity to the Eritrean population

UNDP is in a position to implement this project due to its large country presence, and its Energy and Environment practice area. UNDP has been involved both through the PDF-B, and subsequently in the final technical and financial analyses leading to this proposal. As implementing agency for GEF, UNDP has experience with capacity development and technical assistance in other areas of intervention, and is a trusted partner of the government.

C4. Special considerations

The environmental impacts of this project are positive in several ways. Firstly, contributing directly to CO₂ emission reductions in Eritrea, is the substitution of fossil fuel with wind energy for electricity production. Secondly, with an envisaged increased rate of rural electrification, firewood will slowly be replaced with (CO₂-neutral) electricity for cooking purposes³, and kerosene for lighting will also be replaced. This will lead to improved health for women and children who gather around the smoky traditional stoves, reduced deforestation from reduced use of firewood, and improved quality of life for rural Eritreans, who will be less burdened with the collection of firewood, often to be found only several hours from the village. Deforestation is determined as a major cause for loss of biodiversity in Eritrea, and rural electrification will therefore also have associated benefits for the Eritrean biodiversity.

The innovative features of the project are:

- (i) the implementation of state-of-the-art wind turbine technology,
- (ii) the implementation of a small scale grid connected wind park in Assab
- (iii) the stepwise increase of the share of wind power capacity of the total installed power capacity in an island grid consisting of diesel generators and wind turbines, in order to maximise the potential exploitation of the available wind resource,
- (iv) analysing and demonstrating the technical and economical feasibility of replacing kerosene and wood fuel as the main energy sources for lighting and cooking, with wind generated electricity in regions with very high wind resources.

C5. Coordination arrangements

C5a. Project Management

The Project Management Unit. A project management unit (PMU) will be established, initially consisting of:

- (i) a national project manager, who will be the day-to-day manager of project activities, and must be a person who has experience with both energy systems and project management,
- (ii) a national professional assistant, who will assist the national project manager with technical skills and day-to-day management of the technical aspects of the project, and
- (iii) a national secretary / administration assistant, who will be responsible for the administrative functioning of the PMU,

³ The GoE is promoting the use of electric enjera cookers in electrified areas. Enjera is the local bread in Eritrea, used for most meals, and a highly energy intensive staple food in the country.

In addition, existing ERTC staff, initially 5 professional and 1 support staff, will dedicate 100% of their time during the lifetime of the project, to support the PMU. The PMU will report to the Department of Energy as the executing agency, and will receive supervision therefrom.

Technical Advisor. An international technical advisor, contracted through an international engineering company, will provide support to the PMU when needed. It is expected that the technical advisor will be able to oversee the project initiation, transfer wind energy project management capabilities to the national project manager, and assist in specialised tasks of the project (e.g. certain training components, assistance in the tendering document preparation and the tendering procedures, supervision of installation, etc.). An expert who fulfils the necessary qualification and who possesses the required professional background has therefore to be assigned for this task. The national project manager would then, during the course of the project, take more responsibility including continuous control over the management and supervision of the project.

The Executing Agency. The executing agency of the project will be the Department of Energy. DoE has been responsible for overseeing the implementation of several renewable energy projects in Eritrea, so it has the appropriate experience and knowledge for this role. The DoE will delegate technical work to the Energy Research and Training Centre (ERTC) that works rather independently from the DoE in its day-to-day business, but will retain the overall responsibility for the successful implementation of the project.

C5b. Other stakeholders

Eritrean Electric Authority (EEA). As the only national utility, EEA will play an important role in the project. The EEA will install and operate the Assab wind park under the proposed project. Regarding the rural wind energy project component, EEA has technicians from their own staff which already have the necessary educational background and professional experience to provide technical assistance for installation and O&M of the respective diesel part and the general electrical components of wind-diesel systems. Therefore such technicians will be included in training measures to extend their skills to the technical aspects of entire wind diesel systems. In the future EEA will therefore be a source of technical expertise for such kind of system implementation in Eritrea.

Local administrations. Another important participant in the rural pilot projects will be the local administrations in the selected villages. The village administrations will be responsible for (a) local administration of individual rural projects, (b) protection of the installed systems, (c) collection of fees/payments for electric ity consumed by the rural villages, (d) documentation of statistical data regarding operation using guidelines prepared as part of this project, and (e) maintenance functions including assignment of technicians for this task (after having received proper training by the supplier and ERTC as prescribed in this project). This arrangement builds on a tradition in Eritrea where strong and independent community administrations manage village infrastructure.

Private Companies. As previously stated, a major goal of this project is to involve Eritrean private businesses in their country's wind energy sector. The project will focus on the private sector through information dissemination and the preparation of procedures, training of engineers, technicians and electricians, model contracts, PPAs etc.

C6. Counterpart support capacity

Since this is a long time priority for the GoE, it has committed substantial resources to this project, both in-kind and in-cash. These resources include staff time of the Department of Energy for project management and training, ERTC in particular, and cash contributions to wind energy hardware, grid reinforcement, and operation and maintenance of the installed systems. Furthermore representatives of

the GoE have been very active in the development of the present proposal, indicating a genuine commitment to the success of the project.

D. Development Objective

Global Objective

To reduce Eritrea's energy-related CO2 emissions by promoting both on-grid and off-grid wind energy systems as a substitute for fossil fuel based energy generation thus reducing the country's dependency on imported fossil fuel (diesel)

Development Objective

To promote socio-economic development and improve people's livelihood by facilitating access and affordability to modern, clean energy services

E. Immediate Objectives, Outputs, Activities

The three immediate objectives of the project are:

- (1) To develop necessary personnel and institutional capacities to plan, install and operate on- and off grid wind systems and increase awareness amongst decision makers in governmental and private institutions both at the community and central level.
- (2) To install a small wind farm in Assab and integrate the wind generated electricity into an existing conventional grid thus demonstrating that on-grid wind energy is technical, financially, and institutionally feasible and can be a least cost electricity supply possibility in Eritrea at high wind speed sites.
- (3) To install eight small scale decentralised wind stand-alone and wind-diesel hybrid systems in selected rural wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability.

Under immediate objective 1 outputs and activities relate to capacity building, strengthening of institutions and raising of awareness. For personnel and institutional capacity building public and semi public authorities such as the Ministry of Energy and Mines and its ERTC and the public utility (EEA) and also the private sector companies are targeted. The awareness raising component is specifically directed at decision makers in the public and private sector including potential end-users of wind energy applications.

Under immediate objectives 2 outputs and activities relate to demonstrate to the Eritrean authorities, private companies, and the public that grid connected wind parks at sites with high wind speeds are economical effective, can contribute to the overall reduction of electricity generation cost, and can reduce the amount of the national budget necessary for oil imports. So far, there are no grid connected wind parks in Eritrea. In the existing grids, electricity is supplied solely by means of power generation sets, fired with diesel fuel. However, due to the good wind regimes, the natural frame conditions in Eritrea would allow to save at least a part of the diesel by means of feeding wind electricity in the grid. Under this component private sector involvement in financing, installing and operating the wind farm will be promoted

Under immediate objective 3 outputs and activities relate to demonstrating in five villages and 3 production sites wind-diesel hybrid and wind stand alone systems. Sites in the Southern and Northern Red Sea Coastal Zone were selected for this pilot phase.

Table: Demonstration Projects

| <i>Type of System</i> | <i>Number of Projects</i> | <i>Villages/ Production Sites</i> | <i>Power Output kW</i> |
|--|---------------------------|-----------------------------------|------------------------|
| Wind-diesel hybrids, integrated to existing or planned diesel system | 3 | Be`rasoli, Rahaita, Haleb* | 30, 30, 30 |
| Wind stand alone system, rural village electrification | 3 | Gaharo, Beilul, Gzgiza | 5, 10, 10 |
| Wind water pumping | 2 | Gaharo*, Dekemhare* | 3, 3 |
| Total | 8 | | |

* These sites are exclusively focussing on productive and social use applications (irrigation for agriculture, drinking water pumping and electricity for a boat factory). At the other five villages the generated electricity will be used for household electrification and small scale businesses.

The demonstration projects will assist the Eritrean institutions and experts to obtain practical experience with this kind of technology, its implementation and operation. This component focuses on wind energy as one possibility for off-grid rural village electrification and also to demonstrate wind technologies for productive uses. It is envisaged to develop, establish and verify adequate procedures for subsequent implementation of renewable (particularly wind) energy projects as part of the overall rural electrification programme in Eritrea. Such procedures should take adequately into account that the government needs to provide the interested communities and SMEs with adequate financing mechanism, which may also include financial incentives.

Outputs and Activities

Each of the three immediate objectives will be achieved by producing a series of related outputs, which in turn will be produced by carrying out associated activities.

Immediate Objective 1: To develop necessary personnel and institutional capacities to plan, install and operate on- and off grid wind systems and increase awareness amongst decision makers in governmental and private institutions both at the community and central level.

Output 1.1: The necessary skills within the utility (EEA) for grid connected wind park planning, installation, operation and maintenance developed.

Activity 1.1.1: Carry out training seminars and on-the job training courses for operation personnel at the wind park in Assab as well as headquarters staff of EEA in Asmara. This training will focus on technical (e.g. wind energy software, wind energy technology, standards and norms) and managerial (procurement and tendering, tariff system) aspects. The reason is that in the future new wind parks are expected in the ICS Asmara-Massawa because the electricity demand is higher here. Also more increase of the electricity demand is expected in the ICS. Therefore, the respective know-how has to be put on a wide basis inside EEA and not only with regard to the operation personnel in Assab.

Activity 1.1.2: Train EEA and DoE staff with regard to the supervision and acceptance of all civil, electrical and mechanical works.

Activity 1.1.3: Support training of EEA, DoE and ERTC senior staff in a wind energy training seminar abroad.

Activity 1.1.4: Enable participation of at least 2 local experts in renewable energy master programs abroad.

Activity 1.1.5: Cross-train local experts at multiple sites so that they all have experience in both on- and off-grid systems, and across a range of technologies.

Output 1.2: ERTC strengthened so that it can take the position of a national centre of competence for wind energy technology, to make available to the governmental organisations the necessary professional expertise, which such authorities need for giving approvals, supervision and follow-up of wind energy projects.

Activity 1.2.1: Establish and institutionalise a Project Management Unit (PMU) within ERTC

Activity 1.2.2: Carry out specific training measures under ERTC's roof for public and private sector experts such as basic seminars and train-the-trainer seminars to extend the general knowledge in technology, economics, environmental benefits and risks, installation, commissioning, certification and O&M of wind energy technologies.

Activity 1.2.3: Develop and establish a renewable energy data bank at the ERTC. Such data bank shall contain, on the one hand, the resource data of wind and solar energy, which are necessary for identification, conceptual layout and cost assessment for renewable energy projects. On the other hand, the data bank shall contain an overview of the operation data of the installed systems.

Output 1.3: Technicians, electricians and engineers in the private sector trained, so that sufficient experts are available on the national market for future projects.

Activity 1.3.1: Hold seminars and training-on-the-job activities during the installation and commissioning phase of the wind park (training to be provided from the wind turbine supplier). Training will focus on installation and particularly O&M activities.

Output 1.4: Awareness about the viability of wind energy amongst decision makers at all levels (including communities) and the general public increased.

Activity 1.4.1: Carry out awareness campaigns for community leaders.

Activity 1.4.2: Carry out awareness campaigns targeted at leaders in the private and public sector at the central level

Activity 1.4.3: Carry out awareness campaigns for the general public

Immediate Objective 2: To install a wind farm in Assab and integrate the wind generated electricity into an existing conventional grid thus demonstrating that on-grid wind energy is technical, financially, and institutionally feasible and can be a least cost electricity supply possibility in Eritrea at high wind speed sites.

Output 2.1: Necessary contractual framework, including model PPA and wheeling agreement, for a first wind park connected to the Assab grid prepared.

Activity 2.1.1: Finalize the contractual arrangements for the wind park project until financial closure.

Activity 2.1.2: Prepare model contracts particularly for the power purchase and wheeling agreements for grid connected renewable energy projects in Eritrea.

Activity 2.1.3: Prepare tender documents and the subsequent accompaniment of the tender procedure, the contract negotiations and the contract preparation, including the necessary training-on-the-job for the involved national companies and EEA.

Output 2.2: A small wind park in Assab connected to the grid having a capacity of 750 kW installed and in operation.

Activity 2.2.1: Formulate a suitable optimal operation strategy for the wind park Assab.

Activity 2.2.2: Disseminate operation results in order to attract further interest in the private sector in further investments in similar kind of projects in the future.

Activity 2.2.3: Procure and install the grid connection cable, and the wind park substation

Activity 2.2.4: Reinforce the Assab grid prior to the installation of the wind park

Subactivity 2.2.4.1: Rehabilitate three cabins in the SCS Assab in order to improve the overall technical reliability of the system

Activity 2.2.5: Install the Wind Park consisting of three 250kW turbines

Activity 2.2.6: Operate the Wind Park and evaluate the performance

Immediate objective 3: To install eight small scale decentralised wind stand-alone and wind-diesel hybrid systems in selected rural wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability.

Output 3.1: Procedures, particularly between local, regional and central administration levels and across line ministries, which allow the identification, implementation and operation of rural, renewable electrification projects, particularly wind, developed and tested.

Activity 3.1.1: Analyse and document existing procedures, together with a precise delegation of responsibilities for the initiation, development and implementation of off-grid wind energy projects.

Activity 3.1.1: Test the procedures in selected villages and production sites.

Output 3.2: Viable financing mechanisms for small-scale off-grid wind systems explored, developed and tested.

Activity 3.2.1: Identify financing options successfully applied in other countries and associated lessons learnt

Activity 3.2.2: Test the most promising models for the Eritrean context, including Micro-Finance Institutions (MFIs), fee for service system, soft loans, etc.

Output 3.3: Five diesel-wind hybrid and three wind stand-alone systems installed, maintained and operated.

Activity 3.3.1: Prepare, tender and commission the eight pilot projects.

Activity 3.3.2: Install the eight pilot projects.

Activity 3.3.3: Operate and maintain the systems

Activity 3.3.3: Analyze and disseminate operation results after 1 year of operation and in subsequent years.

F. Inputs

F1. Government of Eritrea, Department of Energy

The Government of Eritrea will provide funding of USD 2,000,000 in-cash to the project. These funds will be channelled through DoE, ERTC and EEA. In addition, in-kind contributions of USD 40,000 have been calculated consisting mainly of salaries of ERTC and DoE staff.

F2. UNDP

UNDP has provided USD 26,500 from TRAC resources to develop the project proposal.

F3. GEF

GEF has provided a PDF B grant of 315,000 to develop the proposal and has agreed to finance USD 1,950,561 of this full size project.

G. Sustainability and risks

G1. Sustainability

This project is a barrier removal project, and thus has an unfailing focus on sustainability.

- the demonstration sites will show all actors in this field the economical and technical feasibility of using wind power for electricity production and/or mechanical pumping,
- information will be disseminated concerning the progress of the demonstration sites, in order to enable all interested parties to evaluate the future possibilities for themselves,
- a data bank containing nation-wide information on both wind and solar resources will be established in ERTC, which can form the basis for future analysis of the possibilities to extend wind energy applications to other areas of Eritrea,

The implementation of wind stand-alone and wind hybrid systems and the grid-connected wind park will be an excellent model for future power projects, based on the utilisation of renewable energies. Preliminary estimates show that the potential for replicating these grid connected wind parks in Eritrea by the year 2010 is a factor of between 15 and 25 (15 to 25 times the rated power of the grid connected wind turbines which would be installed during this project). The potential for replication of small scale wind stand alone and hybrid systems in the southern parts of Eritrea and in the highlands is a factor of around 30 to 40, related to the number of demonstration projects. In other words: In addition to the 8 pilot villages/ production sites there are approximately 300 villages/ production sites with favourable wind regimes. The potential for replication of small scale wind as a stand alone application or in a hybrid system with PV and/or diesel for rural electrification is around 25 to 35 MW for entire Eritrea.

Replication Potential for Off-Grid Systems

Project Phase

| <i>Project area/location name</i> | <i>Nr. of Villages</i> | <i>Benef. Households</i> | <i>Renewable source</i> | <i>Proposed technology</i> |
|-----------------------------------|------------------------|--------------------------|------------------------------|----------------------------|
| Berasoli | 1 | 108 | Wind - Average speed 6.8 m/s | Wind hybrid |
| Rahaita | 1 | 117 | Wind - Average speed 6.8 m/s | Wind hybrid |
| Haleb | - | - | Wind - Average speed 7.3 m/s | Wind hybrid |
| Gaharo | 1 | 99 | Wind - Average speed 7.0 m/s | Wind stand alone |
| Beilul | 1 | 198 | Wind - Average speed 5.8 m/s | Wind stand alone |
| Gizgiza | 1 | 225 | Wind - Average speed 6.2 m/s | Wind stand alone |
| Gaharo | - | - | Wind - Average speed 7.0 m/s | Wind water pumping |
| Dekemhare | 1 | 30 | Wind - Average speed 6.0 m/s | Wind water pumping |
| Total | 6 | 777 | | |

Replication Potential

| <i>Project area/location name</i> | <i>Nr. of Villages</i> | <i>Benef. Households</i> | <i>Renewable source</i> | <i>Proposed technology</i> |
|-----------------------------------|------------------------|--------------------------|--|-----------------------------|
| Ketema Aseb (Gaharo area) | 21 | 3,140 | Wind power Class 7 (7.0- 9.4 m/s) | Wind stand alone and hybrid |
| Ketema Aseb (Assab area) | 5 | 750 | Wind power Class 6 (6.4- 7.0 m/s) | Wind stand alone and hybrid |
| Gizgiza area | 54 | 9,370 | Wind power Class 5 (6.0- 6.4 m/s) | Wind stand alone and hybrid |
| | 80 | 13,260 | | |
| Dekemhare area | 47 | 17,130 | Wind power Class 4 (5.6- 6.0 m/s) | Wind water pumping |
| Kohaito area | 41 | 3,930 | Wind power Class 4 (5.6- 6.0 m/s) | Wind water pumping |
| | 88 | 21,060 | | |
| Areza area | 87 | 19,780 | Wind power Class 4 + Solar 6 kWh/m ² /day | Wind/PV hybrid systems |
| Kerkebet area | 61 | 5,940 | Wind power Class 4 + Solar 6 kWh/m ² /day | Wind/PV hybrid systems |
| | 148 | 25,720 | | |
| Total | 316 | 60,040 | | |

Sources: Ministry of Local Government
 Population estimation of Eritrea 2001
 Cartography Unit – March 2002
 Renewable resources (wind and solar) assessment
 SIDA (year 2002) and UNDP/LI (year 1999)

Low electricity demand, a potential risk to the sustainability and replication potential of the project, has been minimised through an initially conservative size for both the Assab wind park and the off-grid installations. Sustainability and replicability is ensured because (1) wind favourable sites within acceptable distance to the ICS exist, (2) the ICS grid is sufficiently strong so that a wind park can without significant grid restrictions be integrated and (3) sufficient wind measurements for such sites will be available in time before the final decision of the selected wind park site will be taken.

In terms of financial sustainability it is important to consider the hard currency savings. Total savings in expenses for diesel import after installation of 750kW wind park and off-grid wind systems in 8 villages/ production sites amounts to USD 288,500 per year. Over the lifetime of the equipment (20 years) savings of USD 5,780,000 could be realized. This figure does not take into account the expected installation of additional wind parks and off-grid wind systems after the 3-year pilot project is finished. The savings are expected to be substantially higher because of this replication effect. In addition tariff subsidies could be reduced because generation costs will decrease. This will be an additional saving for the GoE.

The economic attractiveness of wind technology in rural off-grid areas will divert some of the investments towards purchase of wind-diesel hybrid or wind stand-alone systems or even small wind parks. Traditionally the capital costs for buying and installing diesel gen-sets are covered jointly by the central government and the community administration and are not recovered. This is likely to continue since the rural incomes are still very low. O&M costs are covered by collecting fees from the end consumers. This project will analyse, suggest and test viable financing mechanisms to accelerate market penetration with wind technologies. If adequate financing mechanisms are in place it is expected that the demand for wind technologies can be met, given the economic and financial attractiveness of wind in Eritrea. Viable financing mechanisms will be explored including the following:

- ✓ Payment capacity of rural households and SMEs
- ✓ Soft loans for capital investment from commercial and development banks and micro-finance institutions
- ✓ Fee for service model

G2. Risks

Technical Risks. A technical risk which is foreseeable at this point and which remains only to a certain extent is that the actual wind speeds in some of the selected villages and production sites may be lower than expected. This risk does not exist for the wind park Assab where measurements very close to the site are now available for more than four years. In the rural areas measurements have been taken at fewer locations and the method for estimating of the wind resources at the many other sites without measurements bear – as it is with all methods available for such kind of wind data correlation and long term wind data estimation - certain insecurity. Primary indicators show that the wind resources south of Assab are so high, however, that some reductions in the actual wind resources compared to the calculated ones will not affect the conclusion that utilising wind energy in that region would be a competitive technology for rural electrification. The case is similar in the highlands (Gzgiza and Dekemhare), where wind measurements from the SIDA project show good wind regimes.

Since industrial facilities to produce components of wind energy systems are presently not available in Eritrea, almost all of the equipment needs to be imported. This bears an implementation risk since equipment, which eventually needs to be replaced during the course of the project, needs to be imported as well, and is therefore costly. This risk has been addressed by securing that suppliers will provide with sufficient spare parts even for the period of time after the pilot phase is over so that it is guaranteed that the pilot systems will not terminate operation due to non-availability of financial resources needed for spare part supply. Offers for wind turbines size 250 kW, planned for the Assab wind park, have been obtained for this purpose.

Table: Wind Data Information for proposed Project Locations

| Project Location | Wind Data Measurements | Average Wind speed | Period of Measurements | Remarks |
|------------------|------------------------|--------------------|------------------------|------------------------------------|
| Assab | Yes | 7.9 m/s | 4 years | Very good Data recovery rate |
| Rahaita | No | 6.8 m/s | --- | From Wind Information System of LI |
| Gaharo | Yes | 7.0 m/s | 3 years | Good Data recovery rate |
| Beilul | No | 5.8 m/s | --- | From Wind Information System of LI |
| Be'rasoli | No | 6.8 m/s | --- | From Wind Information System of LI |
| Gzgziza | Yes | 6.2 m/s | 3 years | Good Data recovery rate |
| Haleb | No | 7.3 m/s | --- | From Wind Information System of LI |
| Dekemhare | Yes | 6.0 m/s | 3 years | Good Data recovery rate |

Implementation Risks. In rural villages the education level is poor and there is a risk that villagers are not able to adequately manage the wind energy technology systems. A lack of technical experience and know-how also exists within the EEA, especially regarding the operation of grid connected wind parks. The project provides for training, however, which includes instruction for EEA operation staff. It is further envisaged that each pilot system installed in rural villages will be accompanied by a careful selection of local villagers who will be properly trained to operate the system. During the pilot phase a programme of regular visits to each of the pilot sites is planned. These visits will ensure that the operation performance of the systems is continuously and competently supervised. The guidance provided for training locals will be followed by a formal review of performance using a standard checklist to determine whether the locals can competently operate the system on their own.

The implementation risk associated with a low electricity demand in Assab was extremely reduced with a conservative wind park size for this pilot phase. Any demand scenario for Assab, on which basis the modular expansion of the wind park can be estimated, is presently vague, due to the uncertain economic development under the present Eritrean conditions.

Another implementation risk relating to the wind park component is associated with the feed-in price, the PPA and the international price fluctuations for diesel. Up to now there are neither IPP nor PPA experiences in Eritrea. Even though international prices of diesel will fluctuate, the challenge is to design a PPA agreement and a feed-in price that is not going to be influenced by such. The PPA agreement between the Independent Power Producers (IPP) and the buying utility, should reflect reasonable profit and capital recovery scheme for the IPP, irrespective of the utility profit margin. A sensibility analysis with regard to the diesel price variations during the project's lifetime needs to be carried out at the beginning of the project to adequately assess and mitigate this risk.

H. Prior obligations and prerequisites

H1. Obligations

Eritrea ratified the UNFCCC on the 24th of April 1995. At the Rio Conference, where the UNFCCC was elaborated, energy played a major role because energy supply and use was recognized as one of the major causes of environmental degradation both at the local level and worldwide. Sustainable energy services are at the same time absolutely essential for development. Eritrea, in an intense process of rebuilding the country after 30 years of independence struggle and a post-independence conflict with Ethiopia, is therefore very much in need of sustainable and reliable energy services for the development

of both its urban and rural areas. At the same time Eritrea tries to live up to its commitment to the UNFCCC, to assist in “*the stabilization of greenhouse gas concentration in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system*”. Eritrea is already seeing negative effects of climate change, through increased frequency of droughts, which plague the country and make it heavily dependent on food aid.

The Government of Eritrea thus has an array of reasons for removing existing barriers for a sustainable development of a clean and cost-effective energy resource such as wind energy.

H2. Prerequisites

- (i) GoE will support the project in cash and in kind as per the project budget
- (ii) GoE will provide data to project staff and consultants as may be required for the implementation of the project activities
- (iii) GoE will provide office space for the PMU, and will second staff as per the project budget

Assistance for the project will be provided only if the pre-requisites stipulated above have been fulfilled or are likely to be fulfilled. If anticipated fulfilment of one or more prerequisites fails to materialise, UNDP/GEF may, at its discretion, either suspend or terminate its assistance.

I. Project review, reporting and evaluation

Monitoring of results and lesson learning is an essential task in which all stakeholders of the project should be constantly involved.

The daily monitoring of the project will be conducted by the PMU, which will submit

- progress reports every six months
- annual reports, and
- a final report.

Each progress report should review the activities for the previous reporting period and provide an assessment of the actual project status. It should also provide an updated time schedule based upon the project status.

Annual Project Report: The Project Management Unit reports annually to the Executing Agency, UNDP and GEF on the project output achievements and outcomes. This is done by preparing Annual Project Reports (APR) after consultation with stakeholders. The new APR/ GEF Project Implementation Report (PIR) format is used. The UNDP Country Office will use the APR to assess performance of the project management and to determine strategies for the future. It will also be supplied to the GEF Monitoring & Evaluation Team.

Evaluation: At the end of the project the executing agency organises an independent evaluation of the project. If necessary, an independent evaluation will also be conducted at the mid-term point of the project life.

Monitoring & Operation of Installed Systems: An evaluation of the operation statistics of the wind park in Assab will take place after one year of operation. Targets will be set regarding technical availability and performance. These targets will be defined and agreed upon beforehand by the operator, the wind turbine supplier and the project management. Actual achieved availability and performance of the systems will be compared with those targets. The O&M contractor of the wind park will be required to submit regular operation reports containing key operational data beforehand so that failures can be identified before the one year evaluation.

For the pilot systems installed in the rural areas a programme of regular visits will be prepared before installation. Together with establishment of communication lines and procedures between the local operators and ERTC, these visits will allow for the close monitoring of the functioning of the system and the performance of the local operators. In addition, the implementation of a database at the ERTC will be a useful tool for reviewing operational data of the pilot systems. This will allow for comprehensive comparisons of the different systems as well as comparisons of the various systems' behaviour over time.

Monitoring by UNDP: UNDP will keep close contact with all partners of the project, especially the project management, and consultants during their assignments. UNDP will also join the project management in field visits, and assist as appropriate in the resolution of any problems that might arise during project implementation. As the GEF implementing agency for this project, UNDP also assumes responsibility for its implementation, as outlined in its National Execution Manual.

J. Legal context

This project document shall be the instrument referred to as such in the Agreement between the United Nations and the Government of Eritrea signed on 11 June 1994.

As support to the executing agency, the UNDP country office will provide support services for some of the activities of the project as identified and agreed upon by all parties, especially in the following areas:

- (i) identification and recruitment of the recruited personnel/experts to undertake specific activities under the project,
- (ii) identification and facilitation of training services,
- (iii) procurement of goods and services.

The UNDP country office will charge 3% of the total project budget for the provision of all the identified and agreed upon services.

The following types of revisions may be made to this Programme Document with the signature of UNDP Resident Representative only, provided he/she is assured that the other signatories of the programme document have no objection to the proposed changes:

- a) Revisions in, or in addition to, any of the annexes of the programme document
- b) Revision which do not involve significant changes in the immediate outcomes, outputs or activities of the programme, but are caused by the re-arrangement of inputs already agreed upon or by cost increases due to inflation; and
- c) Mandatory annual revisions, which re-phase the delivery of agreed programme inputs, or reflect increased expenditure or other costs due to inflation or take into account agency expenditure flexibility.

K. Budget

Project Budget by Component (US Dollar)

| Component Description | GEF Budget | GoE Budget | Total |
|-----------------------------------|-------------------|-------------------|--------------|
| Component 1: Capacity Development | 612,754 | 60,880 | 673,528 |

| | | | |
|------------------------------------|------------------|------------------|------------------|
| Component 2: On-Grid Wind Park | 717,783 | 1,519,166 | 2,236,949 |
| Component 3: Off-Grid Wind Systems | 620,130 | 360,490 | 980,620 |
| Total | 1,950,561 | 1,940,536 | 3,891,097 |

For a detailed budget breakdown please see annex 2.

LIST OF ANNEXES

ANNEX 1: Incremental Cost Calculation

ANNEX 2: UNDP Budget

ANNEX 3: Logical Framework Matrix

ANNEX 4: Terms of Reference for Project Staff

ANNEX 5: Co-financing commitment letter

ANNEX 6: GEF focal point endorsement letter

Annex 1: Incremental Cost Calculation

Component 1

Component 1 activities basically consist of technical assistance (e.g. training, institutional strengthening, awareness raising, etc.). Component 1 intends to build up the necessary domestic capacity for renewable energy project development and implementation in Eritrea, particularly for wind energy projects. Such activities are necessary to guarantee that the implementation of the wind energy technology can continue self-sustainable in Eritrea after the end of this proposed GEF project. In addition, an important objective of Component 1 is to assure that Eritrea's future electricity supply plans include consideration of wind energy technology, which under circumstances such as those in Eritrea deserves as much attention as conventional electricity supply technologies. Activities of component 1 are barrier removal activities towards the goal of achieving a long-term sustainable renewable energy technology introduction in Eritrea.

The total costs for component 1 have been estimated at 0,673 Mil. US\$ (this includes the necessary project management activities, for the entire project for a three year period). Of this, governmental contribution would amount to 0,060 Mil US\$, which would mainly cover the ERTC staff salaries. The remaining GEF eligible part is 0.612 Mil US\$.

Component 2

Baseline. The business-as-usual situation, at the site of the wind park in Assab, is the continuation of the electricity supply by means of using the existing diesel generation sets. Construction of a new power station in Assab would not be planned nor would it be planned to rehabilitate the existing ones in the immediate future. The installed capacity at present exceeds the total load. Furthermore the EEA diesel generation sets have reached about half of their entire lifetime. The diesel generation sets of the port authority are older, but they are still in good condition and no exchange of them due to achievement of the end of lifetime is planned.

The baseline case is therefore the following:

| |
|----------------------|
| Baseline Case |
|----------------------|

| |
|---|
| The electricity supply in Assab will continue by operating the existing diesel generation sets. |
|---|

The GEF Alternative. The GEF alternative is the implementation of one grid connected wind park in Eritrea. By this means the existing barriers for grid connected wind parks in Eritrea will be removed and the development of further grid connected wind parks will be made possible. Due to the very favourable wind conditions, the first choice is the integration of a wind park to the SCS in Assab. This GEF alternative will consist of a small wind park with a rated capacity of 750 kW that will be installed within two years.

There are several issues to be considered regarding the determination of the Incremental cost for the grid connected wind park in Assab:

- The grid system in Assab needs some reinforcement to make it technically feasible to integrate wind power into the system. Additional power switches are needed in several cabins, a specially adapted operation and control strategy that allows the parallel operation of diesel generation sets and wind turbines must be prepared and established, and a strategy to test the

readiness of the necessary grid connections must be developed. Furthermore, a grid connection must be installed. 50% of the grid reinforcement and grid connection costs will be covered by GEF.

- The wind park would result in significant hard currency savings. Total savings in expenses for diesel import after installation of 750kW wind park amounts to USD 286,813 per year. The Net Present Value (NPV) of cost savings over the lifetime of the equipment (20 years) amount to USD 2,872,945. This figure does not take into account the expected installation of additional wind parks and off-grid wind systems after the 3-year pilot project is finished. The savings are expected to be substantially higher because of this replication effect. In addition tariff subsidies could be reduced because generation costs will decrease.
- The wind park generated electricity will be sold to EEA at a price which is to be determined. For this calculation it is assumed that the feed in price is 5,9 cent US/ kWh (80 cent Nakfa/ kWh). This feed in price is 35% cheaper than the current generation cost per kWh which is at about 9,0 cent US (1,22 Nakfa). The annual electricity generation, taking into account a capacity factor of 44%, is 2,490 MWh/ year. The revenue generated is USD 148,124/ year or, calculated over 20 years, the NPV of income would be USD 1,483,726. Compared to the total investment costs of USD 1,027,000 these numbers clearly show the profitability of the wind park. Since these calculations have been done the import price of diesel has increased by approximately 30% which makes the wind park even more profitable. Please find below the calculation tables:

| Input Data, Wind park Assab | | |
|--|---|-----------|
| Costs: | - | - |
| Total investment in US\$ | | 1,027,000 |
| Total O&M in US\$/y | | 40,053 |
| Annual increase of O&M cost in % | | 1 |
| Income calculation figures: | | |
| Annual electricity generation in MWh/y | | 2,490 |
| Contractual feed-inPrice in Nakfa/kWh | | 0.800 |
| Contractual feed-inPrice in US\$/kWh | | 0.059 |
| Saving of Costs | | |
| Fuel costs of EEA in US\$/l | | 0.421 |
| Fuel savings in 1000 l/y | | 682 |
| CO2 savings in t/y | | 1,701 |
| C savings in t/y | | 463 |
| Financing of investment | | |
| Equity: | | |
| Percentage of total investment | | 30 |
| Amount in US\$ | | 308,100 |
| Loan I: | | |
| Percentage of total investment | | 70 |
| Amount in US\$ | | 718,900 |
| Interest rate | | 8 |
| Payback free period | | 2 |
| Number of payback years | | 12 |
| Grant (GEF contribution) | | |
| Percentage of total investment | | 0 |
| Amount in US\$ | | 0 |

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|-----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----------|-----------|
| Year from start | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Income in US\$/year | | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 |
| Expenses: | | | | | | | | | | | | | | | | | | | | | | |
| O&M in US\$/y | | 0 | 0 | 40,858 | 41,267 | 41,679 | 42,096 | 42,517 | 42,942 | 43,372 | 43,805 | 44,243 | 44,686 | 45,133 | 45,584 | 46,040 | 46,500 | 46,965 | 47,435 | 47,909 | 48,388 | 48,872 |
| Loan I | | | | | | | | | | | | | | | | | | | | | | |
| Interest in US\$/y | | 57,512 | 57,512 | 52,719 | 47,927 | 43,134 | 38,341 | 33,549 | 28,756 | 23,963 | 19,171 | 14,378 | 9,585 | 4,793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Payback in US\$/y | | 0 | 0 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 | 59,908 |
| Total payed back in US\$ | | 0 | 0 | 59,908 | 119,817 | 179,725 | 239,633 | 299,542 | 359,450 | 419,358 | 479,267 | 539,175 | 599,083 | 658,992 | 718,900 | 718,900 | 718,900 | 718,900 | 718,900 | 718,900 | 718,900 | 718,900 |
| Total Costs in US\$ | | 57,512 | 57,512 | 112,628 | 107,835 | 103,042 | 98,250 | 93,457 | 88,664 | 83,872 | 79,079 | 74,286 | 69,494 | 64,701 | 59,908 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Expenses in US\$ | | 57,512 | 57,512 | 153,486 | 149,102 | 144,722 | 140,346 | 135,974 | 131,607 | 127,243 | 122,884 | 118,530 | 114,180 | 109,834 | 105,492 | 46,040 | 46,500 | 46,965 | 47,435 | 47,909 | 48,388 | 48,872 |
| Profit/Loss (-) in US\$ before interest payment | 1,027,000 | 148,124 | 148,124 | 47,357 | 46,949 | 46,536 | 46,119 | 45,698 | 45,273 | 44,844 | 44,410 | 43,972 | 43,530 | 43,083 | 42,631 | 102,084 | 101,623 | 101,158 | 100,689 | 100,214 | 99,735 | 99,251 |
| Profit/Loss (-) in US\$ after interest payment | -308,100 | 90,612 | 90,612 | -5,362 | -978 | 3,402 | 7,778 | 12,150 | 16,517 | 20,880 | 25,239 | 29,594 | 33,944 | 38,290 | 42,631 | 102,084 | 101,623 | 101,158 | 100,689 | 100,214 | 99,735 | 99,251 |
| Profit/Loss (-) in US\$ after interest payment | 1,027,000 | 90,612 | 90,612 | -5,362 | -978 | 3,402 | 7,778 | 12,150 | 16,517 | 20,880 | 25,239 | 29,594 | 33,944 | 38,290 | 42,631 | 102,084 | 101,623 | 101,158 | 100,689 | 100,214 | 99,735 | 99,251 |
| Sum of Profit/Loss in US\$ | | 90,612 | 181,223 | 175,861 | 174,883 | 178,286 | 186,064 | 198,213 | 214,730 | 235,611 | 260,850 | 290,444 | 324,388 | 362,678 | 405,310 | 507,393 | 609,017 | 710,175 | 810,864 | 911,078 | 1,010,814 | 1,110,065 |

| | |
|-----|-----|
| ROE | 12% |
|-----|-----|

Internal Interest Rate for NPV 8%

Incremental Cost Calculation

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|--|--|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Year from start | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Cost savings through fuel import red. per year in US\$ | | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 | 286,813 |

| | |
|-----------------------------|-----------|
| NPV of cost savings in US\$ | 2,872,945 |
|-----------------------------|-----------|

| | |
|---|-----------|
| NPV of expenses in US\$, incl. investment payment in year 0 | 1,387,334 |
|---|-----------|

Incremental Cost Calculation

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|--|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Year from start | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Income in US\$/year (Revenue generated) | | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 | 148,124 |

| | |
|---|-----------|
| NPV of Income (Revenue generated) in US\$ | 1,483,726 |
|---|-----------|

GEF co-financing of the wind park can only leverage the cost savings due to reduced need of diesel oil. The investment cost of the wind park itself need therefore to be balanced against the net present value of those cost savings, calculated over the lifetime of the project. These net present value costs are under the base line costs. Since they are higher than the investment cost of the wind park itself, the increment is zero (We have defined increment cost as zero in case the resulting value is negative). The necessary investment cost for the wind park will therefore come from the Government of Eritrea.

It should be pointed out here, that this comparison neglects the O&M costs of the wind park and is therefore not representative of the economic competitiveness of the project. O&M costs (including costs for land rent, insurance, spare parts, etc.) are also not GEF eligible, since they will be refinanced out of the selling of electricity to the power utility. The respective O&M costs have therefore be added in the column of the baseline.

As can be seen, the total incremental costs are 2,15 Mil. US\$. Of this, costs which are due to technical barrier because of a weak existing grid for wind energy generation purposes are assumed by the GoE and EEA at 50%. This results in incremental costs eligible for GEF financing of approx. 0.72 Mil. US\$. 0.41 Mil. US\$ of this would be used for hardware cost components, 0.31 Mil. US\$ would be used for barrier removal and technical assistance to implement the project. The following table shows the total calculation of the incremental cost per cost component. The calculation of the investment cost for the hardware components is based upon the cost estimations carried out during the PDF B phase and quotations from potential suppliers collected in April 2003.

Table: Incremental cost calculation, Grid Connected Wind Park (component 2)

| Incremental Cost Calculation | | | | |
|---|-----------------------------|------------------------------------|------------------------------|-------------------------|
| Component 2: Grid connected wind parks in Eritrea. | | | | |
| | <i>Baseline in US\$</i> | <i>GEF Alternative in US\$</i> | <i>Increment in US\$</i> | <i>GEF Contribution</i> |
| Grid Reinforcement prior to the installation of the wind park | | | | |
| Cabin Port Office | 0 | 197.000 | 197.000 | 98.500 |
| Cabin Military Camp | 0 | 135.000 | 135.000 | 67.500 |
| Local Tax on Equipment ⁴ | 0 | 13.280 | 13.280 | 0 |
| Grid Optimisation for Wind Park Integration: | 0 | 35.400 | 35.400 | 35.400 |
| Subtotal | 0 | 380.680 | 380.680 | 201.400 |
| Finalisation of financial arrangements up to financial close | | | | |
| Subtotal | 0 | 20.400 | 20.400 | 20.400 |
| Preparation of model contracts (contractual framework) | | | | |
| Subtotal | 0 | 35.400 | 35.400 | 35.400 |
| Tendering, company selection, contract negotiation and contract preparation of Turnkey contract | | | | |
| Subtotal | 0 | 51.000 | 51.000 | 51.000 |
| Grid connection | | | | |
| EBCA Cabin | 0 | 135.000 | 135.000 | 67.500 |
| Power Cable, 120 mm ² | 0 | 80.000 | 80.000 | 40.000 |
| Wind park Station | 0 | 140.000 | 140.000 | 70.000 |
| Local Tax on Equipment ⁵ | 0 | 14.200 | 14.200 | 0 |
| Subtotal | 0 | 369.200 | 369.200 | 177.500 |
| Installation of Wind Park | | | | |
| Total Cost International Consultant | 0 | 82.203 | 82.203 | 82.203 |
| Cost National Consultant | 0 | 8.000 | 8.000 | 8.000 |
| Investment Cost Control strategy | 0 | 45.000 | 45.000 | 45.000 |
| Investment Cost Wind Park | | | | |
| Wind turbine | | 765.000 | 765.000 | |
| Two years Defects Liability Period | | 25.000 | 25.000 | |
| Foundation | | 40.000 | 40.000 | |
| Erection, crane work | | 35.000 | 35.000 | |
| Transport (by ship) | | 27.000 | 27.000 | |
| Transformers | | 18.000 | 18.000 | |
| LV cabling | | 67.000 | 67.000 | |
| Planning | | 15.000 | 15.000 | |
| Contingencies | | 35.000 | 35.000 | |
| Total Investment Cost wind park | | 1.027.000 | 1.027.000 | 0 |
| Local Tax on Equipment ⁶ | 0 | 41.080 | 41.080 | 0 |
| Subtotal | 0 | 1.203.283 | 1.203.283 | 135.203 |
| Suppliers Training | | | | |
| Subtotal | 0 | 25.000 | 25.000 | 25.000 |

⁴ For accounting purposes taxes have to be presented in all calculations. However, under the Eritrean tax regulations waivers can be obtained for exempting public institutions from paying any taxes and import duties. Discussions during the preparation of this project indicated that DoE and EEA will obtain the waiver from treasury without any complications. Please also note that all tax amounts listed in the incremental cost calculation table are not counted as government co-financing.

⁵ please see footnote 4

⁶ please see footnote 4

| Operation of Wind Park for a period of one year; evaluation of operation | | | | |
|--|---------------|------------------|------------------|----------------|
| Subtotal | 80.106 | 117.806 | 37.700 | 37.700 |
| Total | 80.106 | 2.202.769 | 2.122.663 | 683.603 |
| 5 % contingencies | | | | 34.180 |
| Total | | | | 717.783 |
| Of the Total are Hardware Costs, incl. Contingencies: | | | | 407.925 |
| Of the Total are for Barrier Removal and Technical Assistance, incl. Contingencies: | | | | 309.858 |

Global and Domestic Benefits. The global environmental objective is aimed at reducing the necessary fuel input to supply the given electric load and thus reducing the resulting GHG⁷ emissions. Apart from direct GHG emission reduction, a significant expected indirect benefit can be seen in the demonstration character of the project in Eritrea. This project will demonstrate for the first time the technically and economically viable parallel operation of a wind park parallel to EEA's grid.

Apart from the global benefits, the project also has domestic benefits. The following table provides an overview of the global and domestic benefits.

Table: Global and domestic benefits of the Wind Park Assab

| | Baseline | Alternative | Increment |
|----------|---|--|---|
| Global | GHG emissions | Reduction of GHG emissions | 1,700 tons CO ₂ /year |
| Domestic | NO _x emissions | Reduction of NO _x emissions | Not quantified |
| Domestic | CO emissions | Reduction of CO emissions | Not quantified |
| Domestic | Lubricant consumption | Reduction of lubricants | Not quantified |
| Domestic | Pollution due to used lubricant | Reduction of pollution | Not quantified |
| Domestic | high fuel consumption | Fuel savings | 682 * 10 ³ l/year |
| Domestic | Corresponding high expenses for fuel import | Corresponding savings in expenses for fuel import | 287 * 10 ³ US\$/year |
| Domestic | No demonstration | Demonstration of the feasibility of grid connected wind park projects for EEA, GoE and Eritrean population. | |
| Domestic | direct job creation: No additional jobs | 1.5 jobs for O&M, several restricted time jobs during construction and installation | 1.5 jobs, several restricted time jobs during construction and installation |
| Domestic | indirect job creation: none | Job creation through initialisation of further wind parks in Assab and in the ICS Asmara-Massawa; indirect job creation in private sector (Consultant, construction companies) | |

Component 3

Baseline. Without the GEF financed project, rural electrification would continue on its current trend. The baseline case is therefore the following:

⁷ GHG: Greenhouse Gases, mainly CO₂ and CH₄

Baseline Case: Eritrea will have a very low level of rural electrification. Villages in close proximity to the ICS and to the SCS of Assab will eventually receive electric power as the grid is extended. Rural villages further from the grid will obtain a low level of electric supply through isolated electricity generation systems. The government will continue its efforts to develop the rural areas and to encourage economic activities therein. Regarding the investigation area of the PDF B activity (southern part of Eritrea), the following will be done: (1) increase the number of agricultural projects and extend already existing agricultural projects, (2) encourage fishing activities in the coastal villages of Eritrea, and (3) set-up a boat building industry in the far south of Assab: The excellent road Massawa-Assab will extend trade and small scale business along the road. Alongside with that there will be electrification of rural villages in the southern part of Eritrea and in villages in central and northern Eritrea with long distances to the ICS, but only on a very low level. This will mainly be accomplished by supplying a few public buildings like schools, health centres, etc. with electricity supply systems that fulfil their basic needs (either diesel generation sets or small PV systems). In a few villages, private entrepreneurs might be able to purchase diesel generators to provide themselves and maybe some neighbours with electricity. The barriers hindering the utilisation of wind energy at wind favourable sites will remain in place. Therefore wind energy will not be among the technologies used for rural electrification.

GEF Alternative. The GEF alternative is the implementation of wind stand alone and wind hybrid systems in Eritrea. By this means, wind energy technology will be considered as an equally fitting technical and economical solution in the overall Eritrean rural electrification planning in wind rich areas.

When determining the extent to which activities in component 3 are eligible for GEF financing, there are two notable aspects:

- Activities of component 3 are clearly “substitutional”(conversions) rather than “complementary”. This is due to the fact that component 3 activities mainly involve the installation and operation of pilot wind stand alone and wind hybrid systems. These systems will either substitute electrification with conventional small scale diesel systems or will meet the end user’s energy needs by offering him a viable replacement (e.g. electric light instead of using Kerosene lamps or cooking food without using wood-fuel).
- Such energy systems have not yet been introduced in Eritrea. Thus governmental institutions or private companies do not yet possess sufficient experience to implement and operate such systems in Eritrea. The ERTC is perhaps the sole entity which may at least have some basic information, including practical experience, with regard to wind and solar resource analysis, theoretical knowledge of wind energy technology and some practical experience in the installation and operation of PV systems. Successful implementation of wind energy applications in a sustainable manner in Eritrea for rural electrification purposes must have the support of both the government authorities and domestic private companies. It is, therefore, of ultimate importance that practical experience among individuals in Eritrea is developed. This can best be accomplished by installing such systems and then operating them. Such a real-life scenario will make it possible to achieve the establishment of the necessary institutions to sustain wind energy systems. This also would be an ideal exercise for creating procedures regarding procurement, approval, and certification for such a pilot project including its

development and implementation. In addition, the project will gather actual feed-back from the real procured and installed systems for future rural wind energy projects. The results will be optimised designed system with reduced investment and O&M cost. The successful implementation and operation of pilot systems is of course necessary in attracting and encouraging other local communities or private entities to begin efforts to install such systems, rather than only operating diesel generators for their power needs. Component 3 remains therefore for the most part a barrier removal activity. The barrier is that of insufficient experience and lack of practical knowledge regarding the implementation and operation of small wind stand alone and wind hybrid systems for rural electrification. However, it is proposed that only 50% of the hardware costs will be covered by GEF funding.

The following table shows that the total costs of the GEF alternative are 1,072 Mil. US\$. Of this, 0.62 Mil. US\$ are GEF eligible. The GoE will cover 50% of the hardware investment costs. Of the total GEF eligible costs, around 0.30 Mil. US\$ are for TA barrier removal activities, and around 0.32 Mil. US\$ are for hardware costs.

Table: Incremental cost calculation, Demonstration Projects for Rural Electrification (component 3)

| Incremental Cost Calculation | | | | |
|--|-----------------|------------------------|------------------|-------------------------|
| Component 3: Demonstration Projects for Rural Electrification. | | | | |
| | <i>Baseline</i> | <i>GEF Alternative</i> | <i>Increment</i> | <i>GEF Contribution</i> |
| | <i>in US\$</i> | <i>in US\$</i> | <i>in US\$</i> | |
| Pilot Project Preparation | | | | |
| Subtotal | 0 | 31.900 | 31.900 | 31.900 |
| Private sector analysis in Eritrea | | | | |
| Subtotal | 0 | 24.400 | 24.400 | 24.400 |
| International tendering of the stand alone wind and wind hybrid systems | | | | |
| Subtotal | 0 | 79.800 | 79.800 | 79.800 |
| Installation and commissioning of wind stand alone and wind hybrid systems | | | | |
| Hardware Costs Pilot Projects, including transport, installation, spare parts | | | | |
| Subtotal Hardware Costs | 305.500 | 611.000 | 305.500 | 305.500 |
| Local Tax on Equipment ⁸ | 0 | 24.440 | 24.440 | 0 |
| Cost International Consultant | 0 | 76.200 | 76.200 | 76.200 |
| Cost National Consultant | 0 | 20.000 | 20.000 | 20.000 |
| Subtotal | 305.500 | 731.640 | 426.140 | 401.700 |
| O&M for a period of 1 year | | | | |
| Subtotal | 30.550 | 54.950 | 24.400 | 24.400 |
| Analysis of the operation results after one year | | | | |
| Subtotal | 0 | 28.400 | 28.400 | 28.400 |
| Total | 336.050 | 951.090 | 615.040 | 590.600 |
| 5 % Contingencies | | | | 29.530 |
| Total | | | | 620.130 |
| Of the Total are Hardware Costs, incl. Contingencies: | | | | 320.775 |
| Of the Total are for Barrier Removal and Technical Assistance, incl. Contingencies: | | | | 299.355 |

⁸ please see footnote 4.

Global and Domestic Benefits. The following table provides with an overview of global and domestic benefits of the baseline and the alternative and the corresponding increment.

Table: Global and domestic benefits of the implementation of the decentralised hybrid system pilot project

| | Baseline | Alternative | Increment |
|----------|--|---|--|
| Global | GHG emissions associated with the provision of electricity by means of diesel generation sets. | Reduction of GHG emissions | 150 – 200 tons/year of CO ₂ savings through pilot projects over lifetime (48 t/year of C). An order of magnitude more for replication potential . |
| Domestic | NO _x emissions | Reduction of NO _x emissions | Not quantified |
| Domestic | CO emissions | Reduction of CO emission | Not quantified |
| Domestic | Lubricant consumption | Reduction of Lubricants | Not quantified |
| Domestic | Pollution due to used lubricant | Reduction of pollution | Not quantified |
| Domestic | high fuel consumption | Fuel savings | 120 – 160 * 10 ³ l of diesel oil savings over lifetime |
| Domestic | No demonstration | Demonstration of the technical feasibility and reliability of renewable based hybrid system for rural electrification in Eritrea Enabling the GoE and the local communities to consider such systems as a potential alternative instead of rural electrification via single diesel generation sets. | |
| Domestic | No economic development | Initiation of economic activities through availability of electricity | |
| Domestic | Migration from rural to urban | Reducing the potential migration from the rural villages to urban | |
| Domestic | No awareness regarding wind hybrid systems and few awareness regarding PV systems; no respectively few technical expertise regarding this technology in the rural villages available | Increasing awareness regarding this technology and creation of technical expertise regarding installation and operation of such system in rural villages | |

Using the total GEF contribution gives a unit abatement cost of \$110 per ton of carbon for the entire project without counting the replication effect. This figure would change dramatically taking into account the replication potential which is a factor of between 15-25 for on-grid and 30-40 for off-grid.

Incremental Cost Analysis Summary Table

| Project Activity | Baseline | Alternative | Increment |
|--|---|--|--|
| Component 1: Capacity Building / Institutional Strengthening / Public Awareness Increase. | <p>SIDA supports Government in preparing wind and solar potential assessment as well as legal and regulatory framework for energy sector.</p> <p>Insufficient know-how and the non-availability of adequate trained manpower resources in the private sector, in the governmental authorities and in the national utility, dealing with wind energy projects</p> <p>Decision-makers not fully sensitized with regard to the role that wind energy can play in rural electrification and as electricity source for existing grids.</p> <p>Consumers are not fully aware of the potential of utilizing renewable energies, as an alternative to kerosene, to obtain safe and efficient lighting/electricity services in off-grid situations.</p> <p><u>Cost: US\$ 837,000 (SIDA)</u> Total: US\$ 837,000 (SIDA)</p> | <p>Training and awareness programmes will be carried out to assist Government and private sector implementing sustainable wind energy systems.</p> <p>Assistance will be provided to ERTC and EEA to develop, implement and manage wind energy systems.</p> <p>Cost: US\$ 612,648 (GEF) US\$ 60,880 (GoE) <u>US\$ 837,000 (SIDA)</u> Total: US\$ 1,510,528</p> | <p>Institutional, legal and regulatory basis for renewable energy market with private participation is created.</p> <p>Local expertise is created for developing, implementing and managing wind energy systems.</p> <p>Incremental cost: US\$ 612,648 (GEF) <u>US\$ 60,880 (GoE)</u> Total US\$ 673,528</p> |
| Component 2: Grid connected wind parks in Eritrea. | <p>The electricity supply in Eritrea (and particularly in Assab) will continue to be provided by the existing diesel generation sets.</p> <p>Future increase of electric energy demand will first be covered by the existing diesel generation sets, which will be replaced by new ones after their expected lifetime expires.</p> <p><u>Cost: US\$ 80,106 (GoE)</u> Total: US\$ 80,106 (GoE)</p> | <p>Implementation of first grid connected wind park in Eritrea. By this means the existing barriers for grid connected wind parks in Eritrea will be removed and the development of further grid connected wind parks will be made possible.</p> <p>A small wind park with a rated capacity of 750 kW will be installed interconnected to the SCS in Assab within two years.</p> <p>Cost: US\$ 717,783 (GEF) <u>US\$ 1,519,166 (GoE)</u> Total: US\$ 2,236,949</p> | <p>EEA is prepared to develop and implement wind parks in Eritrea.</p> <p>Private sector increased awareness among the public at large, decision-makers, and consumers of the benefits of wind parks as an energy source for existing grids.</p> <p>Incremental cost: US\$ 717,783 (GEF) <u>US\$ 1,439,060 (GoE)</u> Total: US\$ 2,156,843</p> |
| Component 3: | Electrification in rural areas will be performed. In larger | Develop an appropriate curriculum and train | Pool of local experts available to |

| | | | |
|--|--|---|---|
| <p>Demonstration Projects for Rural Electrification</p> | <p>villages around the Asmara-Massawa ICS and around the existing SCS (and therefore also around Assab) this will be done by grid expansion, whereas in the villages further away it will need small diesel generation sets or low level rural electrification for basic energy needs with some few Solar Home Systems (SHS). Many households will cover their lighting energy demands with kerosene lamps.</p> <p>No local expertise to properly size, install, maintain and repair decentralized wind energy systems for rural electrification.</p> <p>Cost: <u>US\$ 336,050 (GoE)</u> <u>US\$ 91,650 (Danida)</u> Total: US\$ 427,700</p> | <p>local experts to properly size, install, maintain and repair wind stand-alone and hybrid systems.</p> <p>Assist the private sector to prepare business plans and access loans for expanding the market of wind energy systems for rural electrification.</p> <p>Establishment of small-scale productive uses for wind energy i.e. water pumping for drinking and irrigation</p> <p>Design, pilot, and evaluate financing systems through the pilot demonstration projects.</p> <p>Formulate and implement capacity development program to train operators to safely and properly handle wind energy systems.</p> <p>Cost: US\$ 620,130 (GEF) US\$ 91,650 (DANIDA) <u>US\$ 360,490 (GoE)</u> Total: US\$ 1,072,270</p> | <p>properly design, install, maintain and repair wind stand-alone and hybrid systems.</p> <p>Public and private sector better prepared to formulate business plans to access loans for wind energy systems in order to expand market.</p> <p>Valuable experiences designing financial mechanisms for wind energy systems in rural electrification programs are obtained.</p> <p>Incremental Cost: US\$ 620,130 (GEF) <u>US\$ 24,440 (GoE)</u> Total: US\$ 644,570</p> |
| <p>Total Costs</p> | <p>Total: US\$ 1,344,806</p> | <p>Total: US\$ 1,950,561(GEF) <u>US\$ 2,869,186 (GoE+Danida+SIDA)</u> Total: US\$ 4,819,747</p> | <p>Total: US\$ 1,950,561 (GEF) <u>US\$ 1,524,380 (GoE)</u> Total: US\$ 3,474,941</p> |
| <p>Global Environmental Benefits</p> | <p>CO₂ emissions over 20 years in Assab due to diesel generation sets operation.</p> <p>GHG emissions associated with the provision of electricity by means of diesel generation sets or by using kerosene for lighting.</p> | <p>34,000 tonnes CO₂ avoided emissions over 20 years through wind energy adoption in the grid of Assab.</p> <p>Reduction of GHG emissions through wind stand-alone and wind hybrid systems adoption.</p> | <p>In Assab, emissions are reduced by 34,000 tonnes CO₂ over 20 years.</p> <p>Approximately 350 tonnes of CO₂ emissions reduced in 20 years. An order of magnitude more for replication potential in entire Eritrea.</p> |
| <p>Domestic Benefits</p> | <p>High fuel consumption in the SCS Assab.</p> | <p>Fuel savings through the interconnection of a small wind park to the grid of Assab.</p> | <p>Fuel savings of 682,000 liters of Diesel per year.</p> |

| | | | |
|------------------------|--|--|---|
| <p>Benefits</p> | <p>Corresponding high expenses for fuel import in Assab.</p> <p>Diesel generation sets are installed in the selected villages for pilot phase or most rural households continue using kerosene for lighting, being exposed to smoke and soot.</p> <p>Lubricant consumption and pollution due to used lubricant.</p> <p>Job creation: No additional jobs.</p> | <p>Corresponding savings in expenses for fuel import.</p> <p>Diesel and kerosene savings in the selected villages for pilot phase and reduction in exposure to kerosene smoke and soot</p> <p>Reduction of lubricants and pollution.</p> <p>Jobs for O&M of the wind energy systems, several restricted time jobs during construction and installation, and indirect jobs.</p> | <p>Savings in expenses for Diesel import in Assab are 286,000 US\$ per year or 2,87 Mio. US\$ in 20 years.</p> <p>Wind stand-alone and wind hybrid systems adopted saving between 120 and 160 thousand liters of diesel over 10 years.</p> <p>Reduction in exposure to indoor air pollution from kerosene. Not quantified.</p> <p>For the wind park Assab 1.5 jobs, several restricted time jobs during construction and installation, and indirect jobs.</p> |
|------------------------|--|--|---|

ANNEX 2: UNDP Budget



United Nations Development Programme

ERI/03/Gxx - WIND ENERGY

Budget - Revision "A"

Main Source of Funds: 1G - Global Environment Trust Fund/Cost sharing

Executing Agency: NEX - National Execution

| Sbln | Description | Execution | Funding | | Total | 2004 | 2005 | 2006 |
|---------------|--|-----------|---------|------------|----------------|---------|---------|--------|
| 013 | PROJECT SUPPORT STAFF | | | | | | | |
| 013.01 | Secretary / Administration Assistant | NEX | GEF | Net Amount | 9,000 | 3,000 | 3,000 | 3,000 |
| | | | | W/M | 36 | 12 | 12 | 12 |
| 013.02 | Driver | NEX | GEF | Net Amount | 6,408 | 2,136 | 2,136 | 2,136 |
| | | | | W/M | 36 | 12 | 12 | 12 |
| 013.99 | Line Total | ----- | | Net Amount | 15,408 | 5,136 | 5,136 | 5,136 |
| 015 | MONITORING AND EVALUATION | | | | | | | |
| 015.01 | Duty Travel (DSA for Main Technial Advisor and Experts) | NEX | GEF | Net Amount | 98,000 | 62,000 | 24,000 | 12,000 |
| 015.02 | Duty Travel (Government and Project Staff) and car hire | NEX | GEF | Net Amount | 70,837 | 23,612 | 23,612 | 23,612 |
| 015.03 | Mid-Term and Final Evaluation | NEX | GEF | Net Amount | 40,000 | | 20,000 | 20,000 |
| 015.99 | Line Total | ----- | | Net Amount | 208,837 | 85,612 | 67,612 | 55,612 |
| 016 | MISSION COSTS | | | | | | | |
| 016.01 | International Flights | NEX | GEF | Net Amount | 52,200 | 25,200 | 19,800 | 7,200 |
| 016.99 | Line Total | ----- | | Net Amount | 52,200 | 25,200 | 19,800 | 7,200 |
| 017 | NATIONAL PROFESSIONALS | | | | | | | |
| 017.01 | National Project Manager | NEX | GEF | Net Amount | 36,000 | 12,000 | 12,000 | 12,000 |
| | | | | W/M | 36.0 | 12 | 12 | 12 |
| 017.02 | National Professional Assistant | NEX | GEF | Net Amount | 25,200 | 8,400 | 8,400 | 8,400 |
| | | | | W/M | 36.0 | 12 | 12 | 12 |
| 017.99 | Line Total | ----- | | Net Amount | 61,200 | 20,400 | 20,400 | 20,400 |
| | | | | W/M | 72 | 24 | 24 | 24 |
| 21 | SUBCONTRACTS | | | | | | | |
| 021.01 | Technical Advisor (Engineering Firm) | NEX | GEF | Net Amount | 495,000 | 255,000 | 165,000 | 75,000 |
| 021.02 | 50% of grid connection - wind park | NEX | GEF | Net Amount | 343,500 | 343,500 | | |
| 021.03 | Investment, control device for wind park | NEX | GEF | Net Amount | 45,000 | 45,000 | | |
| 021.04 | 50% of procurement, supply, installation and commissioni | NEX | GEF | Net Amount | 305,500 | 305,500 | | |

| | | | | | | | | |
|---------------|--|-------|-----|------------|------------------|------------------|----------------|----------------|
| 021.05 | Support of national consultants to PMU | NEX | GEF | Net Amount | 18,750 | 6,250 | 6,250 | 6,250 |
| 021.33 | Line Total | ----- | | Net Amount | 1,207,750 | 955,250 | 171,250 | 81,250 |
| 030 | TRAINING | | | | | | | |
| 032 | Other Training | | | | | | | |
| 032.01 | M.Sc. Education, wind energy (1 person) | NEX | GEF | Net Amount | 20,000 | 20,000 | | |
| 032.02 | Demonstration seminars and visits to manufacturers and | NEX | GEF | Net Amount | 55,000 | 55,000 | | |
| 032.03 | Technical Training | NEX | GEF | Net Amount | 21,760 | 10,880 | 10,880 | |
| 032.04 | Managerial Training | NEX | GEF | Net Amount | 18,200 | 18,200 | | |
| 032.05 | On the Job Training & materials | NEX | GEF | Net Amount | 25,720 | 7,430 | 12,860 | 5,430 |
| 032.06 | Suppliers Training Workshop - Assab | NEX | GEF | Net Amount | 25,000 | 12,500 | 12,500 | |
| 039 | TRAINING TOTAL | ----- | | Net Amount | 165,680 | 124,010 | 36,240 | 5,430 |
| 040 | EQUIPMENT | | | | | | | |
| 045 | Equipment | | | | | | | |
| 045.01 | Computers, laptop, printers and accessories | NEX | GEF | Net Amount | 22,000 | 21,000 | 500 | 500 |
| 045.02 | Vehicle (four wheel drive) (2) | NEX | GEF | Net Amount | 40,000 | 40,000 | | |
| 045.99 | Line Total | ----- | | Net Amount | 62,000 | 61,000 | 500 | 500 |
| 049 | EQUIPMENT TOTAL | ----- | | Net Amount | 62,000 | 61,000 | 500 | 500 |
| 050 | MISCELLANEOUS | | | | | | | |
| 053 | Sundries | | | | | | | |
| 052.01 | Office stationaries and consumables | NEX | GEF | Net Amount | 15,000 | 5,000 | 5,000 | 5,000 |
| 053.02 | Vehicle running costs | NEX | GEF | Net Amount | 18,000 | 6,000 | 6,000 | 6,000 |
| 053.03 | Contingency | | | Net Amount | 144,486 | 50,000 | 50,000 | 44,486 |
| 059 | MISCELLANEOUS TOTAL | ----- | | Net Amount | 177,486 | 61,000 | 61,000 | 55,486 |
| 096 | SUPPORT COSTS | | | | | | | |
| 096.99 | Line Total | ----- | | Net Amount | | | | |
| 099 | BUDGET TOTAL | ----- | | Net Amount | 1,950,561 | 1,337,608 | 381,938 | 231,014 |

ANNEX 4: Logical Framework Matrix

| STRATEGY | INDICATORS | MEANS OF VERIFICATION | CRITICAL ASSUMPTIONS |
|--|--|---|--|
| Global Environment Objective: To reduce Eritrea's energy-related CO2 emissions by promoting both on-grid and off-grid wind energy systems as a substitute for fossil fuel based energy generation thus reducing the country's dependency on imported fossil fuel (diesel) | Yearly consumption of diesel used for the Assab grid reduced by 682,000 liter/year after installation of wind farm Yearly consumption of diesel used in the villages where a wind-diesel hybrid system has been installed reduced by 6000-8000 liter/year | EEA statistics Community administration statistics | Diesel and kerosene prices will not drop more than 30% as compared to average 2003 prices |
| Development Objective: To promote socio-economic development and improve people's livelihood by facilitating access and affordability to modern, clean energy services | Generation costs of electricity reduced by 30% at the Assab grid and the off-grid sites. | EEA statistics and community administration statistics | There will not be a new war between Ethiopia and Eritrea |
| Immediate Objective 1: To develop necessary personnel and institutional capacities to plan, install and operate on- and off-grid wind systems and increase awareness amongst decision makers in governmental and private institutions both at the community and central level | Amount of money spent on international wind energy experts and consultants reduced by 50% per kW installed capacity for new wind energy initiatives in Eritrea as compared to the baseline year 2003 Awareness: Number of requests for information / assistance that ERTC (as the national knowledge center for wind energy) get on this topic increased by 100% per year after year 2 of project operation as compared to baseline year 2003 | Budgets of new wind initiatives ERTC files and records | The necessary staff resources inside ERTC, EEA and DoE will be available and motivated to provide the necessary services to governmental authorities, local communities and other partners Staff turnover will be reduced and qualified staff can be attracted and retained |
| Output 1.1: The necessary skills within the utility (EEA) for grid connected wind park planning, installation, operation and maintenance developed | By the end of the project EEA has taken the lead on expansion of the Assab wind park or any other new wind park The Operation and Maintenance LogBook of the Assab wind park shows that the park is running smoothly within international parameters | Planning docs and contracts of new wind park initiatives O&M LogBook | Staff turnover will be reduced and qualified staff can be attracted and retained |
| Output 1.2: ERTC strengthened so that it can take the position of a national centre of competence for wind energy technology | ERTC has the budget, human capacity and vision documented in an institutional strategy to operate wind energy systems in Eritrea | ERTC files | GoE has the budget and political will to strengthen ERTC |
| Output 1.3: Technicians, electricians and engineers in the private sector trained, so that | Operation, repair and maintenance services are being carried out by local electricians, technicians | Project files | |

| | | | |
|---|--|---|--|
| sufficient experts are available on the national market for future projects (off- and on-grid) | and engineers by the end of project operation. | | |
| Output 1.4: Awareness about the viability of wind energy amongst decision makers at all levels (including communities) and the general public increased | 80% of all community leaders in wind rich villages know about the advantages of wind energy systems by the end of the project | Survey | |
| Immediate Objective 2: To install a wind farm in Assab and integrate the wind generated electricity into an existing conventional grid thus demonstrating that on-grid wind energy is technical, financially, and institutionally feasible and can be a least cost electricity supply possibility in Eritrea at high wind speed sites. | Assab Wind Park is up and running and operating smoothly as per international standards by end of year 2 of the project with a capacity factor of 44 +/- 5% At least one additional wind park or extension of the existing wind park is at the stage of financial closure by the end of the project | EEA files | Electricity demand will increase over the coming years |
| Output 2.1: Necessary contractual framework, including model PPA and wheeling agreement, for a first wind park connected to the Assab grid prepared | Assab Wind Park is up and running by end of year 2 of the project. Future wind parks are using the model PPA and wheeling agreement | Site inspection Contracts of future projects | |
| Output 2.2: A small wind park in Assab connected to the grid having a capacity of 750 kW installed and in operation | Assab Wind Park is up and running by end of year 2 of the project | Site inspection | |
| Immediate Objective 3: To install eight small scale decentralised wind stand-alone and wind-diesel hybrid systems in selected rural wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability | Kerosene fuel use for lighting in pilot villages reduced by 50% by end of the project 80% of the electricity end users are satisfied and can afford the electricity offered | Medical statistics and reports End-user survey | Kerosene prices will not drop more than 30% as compared to average 2003 prices |
| Output 3.1: Procedures, which allow the identification, implementation and operation of rural electrification projects using renewable energy resources, particularly wind, developed and tested | At least three additional villages and SMEs have installed off-grid wind systems by project completion. ERTC personnel has applied at real projects certification and approval procedures as well as quality assurance activities. | DoE and ERTC records ERTC records | |
| Output 3.2: Viable financing mechanisms for small-scale off-grid wind systems explored, developed and tested | Eight additional villages and SMEs are financing their off-grid wind energy systems using the mechanisms developed by the end of the project | DoE and ERTC records | |

| | | | |
|--|--|-----------|--|
| Output 3.3: 5 diesel-wind hybrid and 3wind stand-alone systems installed, maintained and operated | Installed systems are running smoothly according to international standards by end of year 2 | O&M files | |
|--|--|-----------|--|

ANNEX 5: Terms of Reference for Project Staff

Terms of Reference for a Technical Advisor

Wind Energy Applications in Eritrea

Introduction

The Ministry of Energy and Mines (owner of the project) intends to execute a project of *wind energy applications in Eritrea*. The Ministry has secured finance from GEF and the Government of Eritrea. The three project components are:

- ◆ To develop necessary personnel and institutional capacities to plan, install and operate on- and off-grid wind energy systems and increase the awareness amongst decision makers in governmental and private institutions and the benefiting communities;
- ◆ To install a small wind park with a capacity of 3X250 kW to be connected to the Assab EEA conventional grid thus demonstrating that on-grid wind energy is technically, financially, and institutionally feasible and can be a least cost electricity supply possibility in Eritrea at high wind speed sites;
- ◆ To install eight small-scale decentralised wind stand-alone and wind-diesel hybrid systems in selected rural wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability.

The project areas are known to have very good wind energy regimes and data is available to substantiate this. The project also ensures that the use of wind energy will be considered in future national electrification plans, particularly in wind favourable regions, by demonstrating it as a cost-effective electricity generation technology, with the additional benefit of avoiding greenhouse gas emissions.

Objectives

2.1 Consultant services by a Technical Advisor are required to plan, design, specify, and supervise the establishment of small wind turbine in Assab and the eight decentralised wind-hybrid and/or wind stand alone systems in wind rich regions of Eritrea.

2.2 Another major objective is to plan and organise institutional and human capacity building needs so that local staff are enabled to plan, install and operate a grid connected or decentralised wind energy systems in the future.

Scope of the services

The Technical Advisor shall provide all professional and technical services and other related support in accordance with internationally recognised practices for the consulting services. The duration of the project is three years, from January 2004 to December 2006. The Energy Research and Training Centre (ERTC), the Eritrea Electric Authority (EEA), and a Project Management Unit (PMU) will be the major counterparts for the Technical Advisor at work in Eritrea. Specifically, the Technical Advisor shall arrange and provide the following services and training for what is necessary to achieve the objectives stated above.

In conjunction with the PMU and the ERTC staff, the Technical Advisor shall:

- ◆ Establish of database of renewable energy potential (wind and solar) in the country based on the existing information in ERTC.
- ◆ Prepare model contracts, tender documents, tender evaluation, for procurement of goods and services for the wind park and the decentralised wind energy systems, etc
- ◆ Provide still required engineering services for the grid reinforcement.
- ◆ Supervise the installation of wind park and off-grid wind energy systems
- ◆ Analyse operations and maintenance performances of the installed systems
- ◆ Assist in the implementation of capacity building measures (human and institutional) as outlined in the project document in country and abroad. This includes coaching of local counterparts.
- ◆ Development of procedures (top down and bottom up) for implementation of rural electrification projects based on renewable energy
- ◆ Organise and conduct public and private awareness on the global and national benefits of wind energy
- ◆ Analyse, develop and test practicable financing mechanisms for replication of decentralised wind energy systems

Qualification of the Technical Advisor

The Technical Advisor or his sub-contractors are required to have demonstrated experience in the analyses of wind and solar resource potentials; design, operations and construction of small wind parks and decentralised wind-diesel, wind-solar or wind stand-alone systems, as well as wind mechanical water pumping. It is preferred if the Technical Advisor is a single small-sized company having few core staff members with at least 10 years experience in the stated fields.

Work organisation

The Technical Advisor will assist and report to the PMU. Its advisory and training services are expected to be 12 man-months during the first year, six man-months during the second and three man-month during the third year.

Terms of Reference for a Project Manager

Wind Energy Applications in Eritrea

Introduction

The Ministry of Energy and Mines (owner of the project) intends to execute a project of *wind energy applications in Eritrea*. The Ministry has secured finance from GEF and the Government of Eritrea. The three project components are:

- ◆ To develop necessary personnel and institutional capacities to plan, install and operate on- and off-grid wind energy systems and increase the awareness amongst decision makers in governmental and private institutions and the benefiting communities;
- ◆ To install a small wind park with a capacity of 3X250 kW to be connected to the Assab EEA conventional grid thus demonstrating that on-grid wind energy is technically, financially, and institutionally feasible and can be a least cost electricity supply possibility in Eritrea at high wind speed sites;
- ◆ To install eight small-scale decentralised wind stand-alone and wind-diesel hybrid systems in selected rural wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability.
- ◆ A Project Management Unit (PMU) shall be established to manage and co-ordinate the project execution. Its office will be within the premises of ERTC and shall have a Project Manager, an assistant whose background is in economics, business management or accounting and a secretary. Its budget is from the project funds.

Duties and Responsibilities of the Project Manager

The Project Manager shall be a national that is capable to provide all the managerial and technical services as per the duties and responsibilities of the PMU stipulated in the project document. The duration of the project is three years, from January 2004 to December 2006. The PMU reports to the Department of Energy and the UNDP Asmara Office and its collaborators at work are the Energy Research and Training Centre (ERTC), the Eritrea Electric Authority (EEA), and the Technical Advisor (TA) to the Project.

Specifically, the Project Manager shall manage and co-ordinate the following services and training for what is necessary to achieve the project objectives.

In consultation with the Department of Energy and the TA, the Project Manager shall:

- ◆ Establish own office and ERTC work group as outlined in the project document
- ◆ Prepare tender documents for the Technical Advisor and process
- ◆ Manage and co-ordinate the day to day affairs of the project
- ◆ Manage and co-ordinate the training programs envisaged in the project.

- ◆ Process financial requirements and submit fund utilisation reports to UNDP Asmara Office
- ◆ With the assistance of the TA prepare tender documents for potential contractors for the wind farm and decentralised wind systems in rural areas.
- ◆ Prepare quarterly project progress reports to the Department of Energy and annual report to UNDP, Asmara Office
- ◆ Assess needs and prepare local sub contracting tasks for specific studies of significance to the project
- ◆ Supervise and evaluate the performance of the TA and all involved contractors.

Qualification of the Project Manager

The Project Manager should have a postgraduate degree in the applied or pure sciences with at least 10 years of experience in energy or related disciplines. Preference shall be given to candidates that have proven experience in the co-ordination of projects.

ANNEX 6: Co-financing commitment letter

On file with GEFSEC.

ANNEX 7: GEF focal point endorsement letter

On file with GEFSEC.