GOVERNMENT OF ERITREA
UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP)
GLOBAL ENVIRONMENT FACILITY (GEF)

(PROJECT NO. 00031458)

WIND ENERGY APPLICATIONS IN ERITREA TERMINAL REVIEW

Final Report

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LIST OF ABBREVIATIONS

AFREPREN	Africa Energy Research Network
APR	Annual Project Report (UNDP)
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
DoE	Department of Energy, Ministry of Energy and Mines
EEC	Eritrea Electricity Corporation
ERTC	Energy Research and Training Centre
EU	European Union
FINESSE	AfDB Renewable Energy Programme
GEF	Global Environment Facility
GoE	Government of Eritrea
ha	Hectare
ICB	International Competitive Bidding
ICSU	International Council for Science
Kg	Kilo-gram
kVA	kilovolt-hours
kWh	kilowatt/kilowatt hour
LPG	Liquefied petroleum gas
m/s	meters per second
MEM	Ministry of Energy and Mines
MDG	Millennium Development Goals
MW/MWh	megawatt/megawatt hour
NFA	nakfa
O&M	operations and maintenance
PCE	Petroleum Corporation of Eritrea
PDF-B	Project Development Framework B
PIR	Project Implementation Report
PMU	Project Management Unit
PPA	Power Purchase Agreement
Prodoc	Project Document
PV	photovoltaic
RETS	Renewable Energy Technologies
SCADA	System Control and Data Acquisition
SIDA	Swedish International Development Agency
SME	small and medium enterprise
TA	Technical Advisor
TPR	Tri-partite Review
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
US$	United States dollar (= nakfa 15.0)
WIS	Wind Information System

EXECUTIVE SUMMARY

Eritrea, has acute shortage of modern forms of energy, especially in its rural areas. According to DoE's report for the year 1998, total power consumption was estimated at 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. Biomass at 66.3%, contributed the largest share of final energy supply. Oil products on the other hand provided 31,6 % of the final supply and electricity a mere 2.1%. All the electricity was generated by thermal means using oil products. The DoE survey further reveals that more than 95% of the rural population and 20% of the urban residents do not have access to electricity. If Eritrea is to meet its economic and social goals, huge investments in energy infrastructure and delivery systems will be needed. The need for adequate and sustainable energy resources, occurs against the background of the unavailability of conventional energy resources such as hydro, coal, oil or gas reserves. Eritrea is though, endowed with the abundance of renewable energy sources, whose harnessing would meet some of the challenges in the supply of energy. This country has abundance of solar radiation throughout the whole year, undeveloped geothermal potential and good wind energy regimes.

In the case of wind, preliminary analysis had shown that there is significant wind energy potential in Eritrea. To investigate and verify this, a study, funded by SIDA, was conducted by installing 25 meteorological stations in various parts of the country. The outcome of this study verified not only that there is a large wind resource potential in the region, but also confirmed that there are locations with favorable wind conditions in the middle and northern regions of Eritrea (refer to map below). Wind in these regions, could be widely adopted to provide sustainable energy supplies. However, before this could be achieved, several barriers, such as Capacity /Institutional Barriers, Awareness/ Experience Barriers and Technical Barriers, needed to be addressed.

Inline with this background, this project, which is funded by GEF/UNDP/GoE was initiated. The project is to pilot wind energy technology in the wind rich areas (Assab, Edi, Gahro, Gizgiza, Rahaita, Berasole, Beylul and Dekamhare) of the country. Upon the achievement of feasible results, the aim is to replicate it in other parts of the country. The project implementation is expected to improve the rural communities livelihoods by providing access to sustainable energy services and contribute to reduction of greenhouse gas emissions. Furthermore, the project is expected to remove the identified barriers and contribute to an informed, equipped and sustained policy framework in wind energy adoption and dissemination.

The project has immensely contributed to the removal of technical and institutional barriers affetecting the dissemination of renewable energy technolgies. It has satisfactorly increased institutional delivery, in terms of capacity building and improved awareness. Available evidence, points to the successful achievement of project objectives in the areas of reduction in green house gases and improvement to quality of life. Furthermore, the project has resulted in an informed and equipment framework for the adoption and wider dissemination of wind energy technologies.

Despite the project's success however, a number of issues need to be addressed within the scope of the project or to be taken into consideration in designing future projects.

(i) The projected was characterized by serious delays in the area of procurement of equipment caused by the poor performance of the TA.

(ii) There is need to allow sufficient time for procurement to allow for the necessary steps, including pre-qualification.

(iii) There is need to ensure that the local institutions and the PMU are given training in international wind turbine related procurement procedures prior to the implementation of the project. This would have reduced the project time and mitigated against non delivery by TA.

(iv) The delays could have been avoided if the TA had delivered as expected. The usage of a TA should be revisited to ensure a proper track record and experience in similar projects. The TA should have demonstrated staff competitences and field experience in the relavant activities. Targeted short time assignments should be considered.

(v) The foundation design of wind turbines should involve local local engineers, as international equipment supplies are not necessarily good at areas such as civil works.

(vi) To ensure long-term sustainability, there is need to carry out research on increasing local content of energy technologies - where feasable. This is the most effective way to remove barriers and the development of local industry. The improvement in local content should be complemented by the development of local standards.

(vii) There is need to intergrate the wind energy technology into income generation activities such as water pumping for irrigation, fishing etc. This will directly benefit the private sector, which has a higher penetration rate in farming activities. This will also create a sustainable makert for private sector experts trained in wind energy systems and will ensure continuation of capacity bulding, as the experts will in turn train their employees. The deployment of wind mechanical systems would displace diesel pumps.

(viii) Issues such as frequancy control are very important in intergrating wind energy turbines in small electrical grid systems. The lack of system stability studies has limited the dispatch capacity of the wind farm to 35% of the total energy generated. There is need to carry out system stability studies by power experts in the design of wind systems to be intergrated to the grid.

(ix) System development plans are vital to ensure that wind potential is properly assessed and incorporated in future generation options. There is need to strengthen EEC's planning capacity. This would ensure wind energy systems as part and parcel of the system development plan during the replication phases. Proper system development plans and the associated long term transmission studies (with special focus to potential interconnectors) will ensure the proper integration of Eritrea's wind potential to the East Africa Power Pool, when conditions for pool energy trading become conducive.

(x) More time is needed to evaluate the perfomance of the off-grid systems, since such systems are still being installed. This will ensure adequate performance evaluation.

(xi) The regulator will increasingly play an important role in the future electricity market structure and the involvement of the private sector during the replication phase. There is need to develop mechanisms to build the capacity of the regulator in facilitating future electricity investments.

1 INTRODUCTION

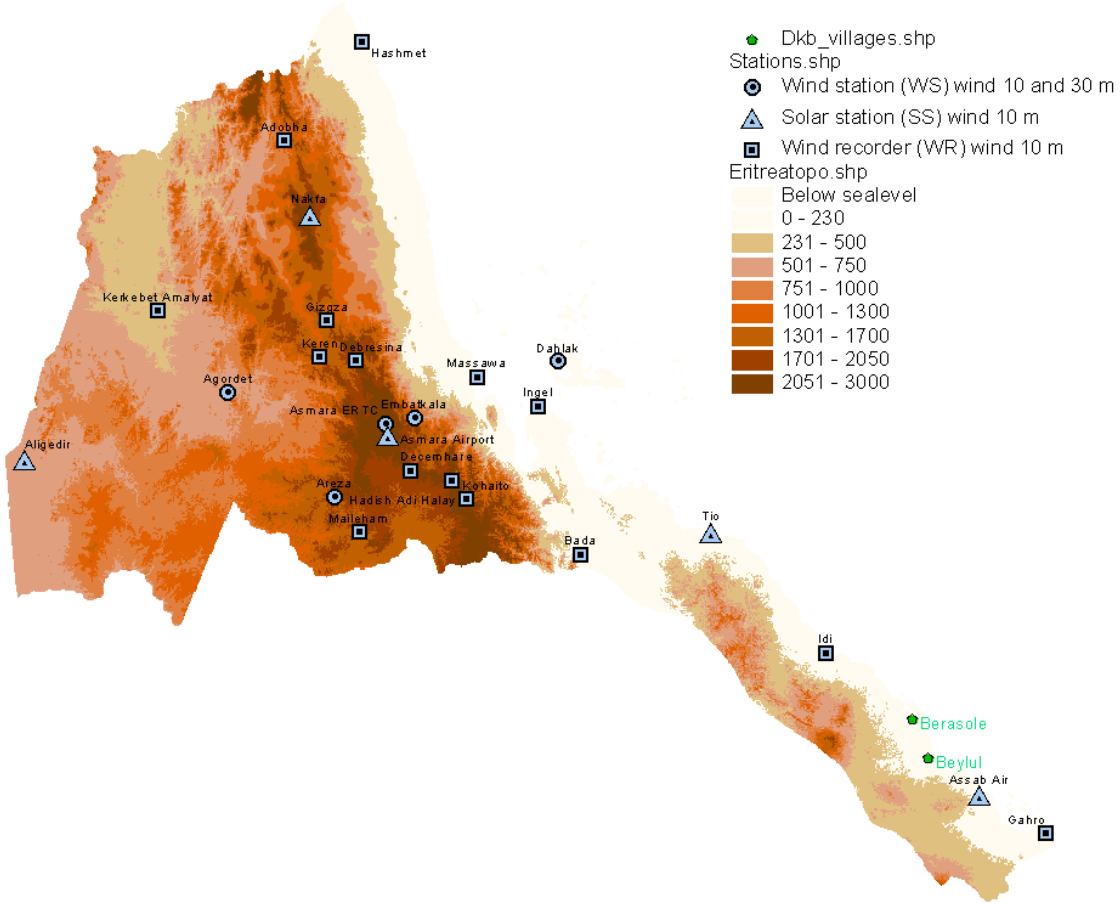
Energy is vital for the development of any nation. It is a driver for economic activities and social growth. Though not explicitly covered under the millennium development goals, it is generally understood that the provision of adequate, safe, affordable, reliable and

environmentally sustainable energy sources is a catalyst towards the attainment of the millennium development goals and towards the mitigation against global warming.

In the context of Eritrea, there are still acute shortages of modern forms of energy, especially in rural areas. Consumption of modern forms of energy is low. According to the Department of Energy (DoE), in 1998 total energy final consumption was estimated at 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. Biomass at 66.3%, contributed the largest share of final energy supply. Oil products on the other hand provided 31.6 % of the final supply and electricity a mere 2.1%. All the electricity was generated by thermal means using oil products. The DoE survey further reveals that more than 95% of the rural population and 20% of the urban residents do not have access to electricity.

If Eritrea is to meet economic and social goals, huge investments in energy infrastructure and delivery systems will be needed. This occurs on the background of unproven availability of indigenous sources of energy such as hydro, coal, oil or gas reserves. Eritrea is though, endowed with the abundance of renewable energy sources, whose harnessing could meet some of the challenges in the energy supply. Eritrea has abundance of solar radiation throughout the whole year, undeveloped geothermal potential and some wind energy rich sites.

In the case of wind, preliminary analysis has shown that there is significant wind energy potential in Eritrea. To investigate and verify this, a study, funded by SIDA was conducted by installing 25 meteorological stations in various parts of the country. The outcome of this study verified not only that there is a large wind resource potential in the region, but also confirmed that there are locations with favorable wind conditions in the middle and northern regions of Eritrea (refer to map below). Wind in these regions could be widely adopted to provide sustainable energy supplies. However, before this could be achieved, several barriers, such as Capacity /Institutional Barriers, Awareness/ Experience Barriers and Technical Barriers, would need to be addressed.



Eritrea wind and solar metering stations: courtesy of ERTC Wind Information System (WIS)

This pilot project on "Wind Energy Applications in Eritrea" is aimed at removing these barriers and demonstrating the technical and economical feasibility of exploiting wind energy in the country. The key component of the project is 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 for electricity generation, water pumping and battery charging. In addition, the project was designed to strengthen the country's capacity in terms of personnel, know-how, governmental institutions/authorities, and private companies with regard to wind energy utilisation.

It was hoped that the attainment of the project's objectives, as enshrined in the *Prodoc,* will remove the existing technical and institutional barriers, and lead to improved institutional delivery, in terms of capacity building and increased awareness on the benefits of the applications of wind technologies. This would invariably lead to the improvement of the quality of life and poverty reduction for the rural population of Eritrea's wind rich regions. Furthermore, it was hoped that the project could contribute to the reduction of greenhouse gas emissions through the displacement of diesel used in current generating plants and kerosene used for lighting by households. Furthermore, it was hoped that the project achievements and lessons would facilitate replication.

Photo: Wider adoption of wind energy could displace diesel used by generation owned by some SME owners in Eritrea

Photo: These children at Beylul deserve a better future. Wind energy will provide improved educational facities due to electrcification

1.1 Purpose of the evaluation

The three immediate objectives of the project are:

(1) To develop necessary personnel and institutional capacities to plan, install, operate and manage 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 electricity 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.

(3) To install eight small scale decentralized wind stand-alone and wind-diesel hybrid systems in the selected wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability of off-grid wind energy systems.

The total project budget was originally US$ 3.89 million, out of which GEF and GoE shared equally. GoE's contribution was later revised to US$ 0.5 million. The total budget was later raised to around USD 4.15 million, when UNDP contributed an additional US$ 258,438 to cover the budget deficit encountered during the project implementation. UNDP also contributed the balance from GoE's original contribution.

A contract for the supply, installation and commissioning of the Assab Wind Farm was signed with a French company, Vergnet S.A., on 30 June 2006. Thus, the construction of Assab Wind Farm, consisting of three wind turbines, with a rated capacity of 275 kW each was commissioned in November 2007 and has been generating power ever since. This wind farm is located at around 6 km west of the town of Assab at geographical coordinates 13^0N 42.7^0E and at an elevation of 232m. Similarly, the contract for the supply, installation and commissioning of small wind standalone (for battery charging), wind-diesel hybrid and wind water pumping systems of capacities 3-30 kW for seven (one site, Ghighza, was later dropped due to cost escalation and the need to conform to the original budget) Eritrean villages was signed with a Turkish contractor- Soyut Engineering and Construction Co. Inc. on 06 May 2008. These sites are expected to be commissioned at the end of March 2009.

The main objective of this evaluation therefore, is to provide the project partners i.e. GEF, UNDP, GoE and any other interested parties with an independent review of the project achievements according to a set criteria of a number of objectives and outcome as outlined in the *Prodoc* and as contained in the terms of reference.

1.2 Key issues addressed

The key issues adressed by the evaluation are stated in the terms of reference (TOR), which is presented in Annexure 1 of this report. In brief the evaluation sought to examine the the following project aspects:

- Achievements of the project in the reduction in greenhouse gas emissions,
- Attainment of an informed and equipped Institutional Framework for renewable energy,
- Creation of a conducive Policy and legal Framework,

- Improvement to quality of life (health and employment creation).
- Project implementation approach and partnerships established,
- Country ownership/drivenness,
- Levels of co-financing made and realised,
- Stakeholder participation and benefits accrued,
- Project sustainability,
- Replication approach,
- Main lessons that have emerged in terms of:

    - strengthening country ownership/drivenness;
    - strengthening stakeholder participation;
    - institutional structure and capacity building;
    - application of adaptive management strategies;
    - efforts to secure sustainability;
    - knowledge transfer; and the role of MME in project implementation.

- Recommendations on how the lessons and experience can be incorporated into the design of similar initiatives in the future,
- Assessment of the financial control systems, including reporting and planning, that allowed the project management to make informed decisions regarding the budget,
- Assessment of the extent to which the flow of funds had been proper and timely both from UNDP and from the project management unit to the field,
- Evaluation of the management of funds,
- Compliance to the GEF incremental cost criteria,
- Extent to which the project has completed the planned activities and met or exceeded the expected outcomes according to schedule and as cost effectively as initially planned.
- Assessment of the monitoring and evaluation systems.

1.3 Methodology and structure of the evaluation

The review was carried out by the evaluator through the preparatory work at home office, a two weeks' mission to Eritrea and the analysis of the data and material and report writing at home office. The evaluator undertook a review of documentation, including the Project Document and other technical reports. The evaluator liaised with all key stakeholders including Ministry of Energy and Mines, representatives of South Red Sea Regional Adminstration, relevant civil society representatives and community leaders, private sector, financing institutions, utility (EEC) personnel and ERTC.

Photos: Evaluator with the local admistration officer and other community members at Berasole

Photos: Evaluator dicussing with the Derder of the Affah- an indigenous group

Structured and semi-structured interviews were organised with key stakeholders and benefiaries to collect relevant information. Data indicators on the performance of the system,

production and related financial costs, tariff mechanism and levels, operation modalities of the wind farm and diesel base load sytems were collected. In addition, data pertaining to socio-economic activities in the project area, nature and level of income generating activities, availabilty usage and costs of alternative energy sources, problems associated with usage of other energy forms and willingness to pay was collected.

An assessment was also carried out to evaluate awareness and perceptions of the project by the various intended beneficaries. Site visits were undertaken to five pilot sites for decentralised sytems and the wind farm at Assab to assess progress achieved.

2 THE PROJECT AND ITS DEVELOPMENT CONTEXT

2.1 Project start and its duration

The Project Document for Eritrea Wind Energy Applications Project was signed on June 2004 and a Project Management Unit (PMU) was set up on August 2004 to manage and execute the project. The duration of the project originally being 3 years, has now been extended and is expected to be terminated by end of March 2009. During the three years, it was envisaged that all three components will have been implemented. The timing took into consideration necessary projects components and essential execution of international missions of experts as effective as possible, thus minimising travelling costs especially with regard to the timing of the training seminars. The critical milestones that were to be implemented are:

- 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

2.2 Problems that the project seeks to address

Eritrea is facing acute shortages of modern energy especially in the rural areas and is generally characterised by low energy consumption levels. The DoE report for 1998 shows an extremely low per capita electricity consumption of only 48 kWh per capita in 1997. 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 fuels, due to hard currency constraints in importing oil products. The use of biomass for cooking, using generally inefficient appliances such as the traditional *mogogo*, has led to unsustainable energy supplies, especially the traditional biomass, and is contributing to carbon emissions and the resultant global warming.

Photo: Reliance of biomass: Fuel wood being sold at Idi – a wind energy pilot site

Currently, electricity is generated only by diesel or fuel oil. The source of energy for lighting is mainly kerosene, which is burnt through wick lamps. The over-reliance on imported fossil fuels does not only burden GoE and divert scarce financial resources from other socio developmental areas, but further contributes to carbon emissions and energy related health problems.

The Government of Eritrea takes cognisance of the role of energy and its catalytic significance in improving the standards of living and the achievement of millennium development goals and acknowledges linkages between availability of modern forms of energy and the need to develop and promote economic growth and social development. The Interim National Poverty Reduction Strategy Paper (I-PRSP), espouses the importance of sustanable energy supply in creating and/or expanding income generation, and improving a host of social services such as education, health care, clean water supply, communications (Semereab,Tsighe, 2007 – in *Journal of Cleaner Production 15 (2007), 178-189 (Available on line at www.sciencedirect.com)*

To demostrate its committment on promoting sustainable energy supplies, the Ministry of Energy and Mines, in consultation with the Ministry of National Development, has in its long-term program (up to 2015) targeted energy development programs as a vehicle to improve poverty alleviation, education, water and environment sustainability, with particular attention to the development of alternative energy resources (Semereab,Tsighe, 2007). The governemnt's strategy is underpind by the following policy initiatives:

- *Energy reform measures:* Develop the regulatory framework to attract private sector participation, restructure EEC to become financially self-sustaining and strengthening the Petroleum Corporation of Eritrea.

- *Investment promotion:* Remove barriers for private sector participation to attract international financing for investment programmes, indigenous energy resources exploration and attracting foreign investment in oil refining and transit storage facilities.

- *Improve sector management capacity:* Improve the capacity and performance of the institutions in overall planning and management, enhance data collection and audit systems, improve co-ordination and strengthen the Ministry of Energy and Mines.

- *Implement "right pricing" policy:* Structure energy pricing to reflect true economic opportunity costs, correct market failures in relation to access to energy services by the poor, promote energy efficiency and conservation and provide tax incentives in the importation of equipment for renewable energy production and the need to expand LPG distribution system.

- *Promote energy conservation and environmental protection at supply and end-user levels:* Introduction of new technology and appliances, concessionary tax incentives, design policies for energy efficient appliances, design incentives for forestation and public awareness campaigns.

- *Promote rural electrification:* Expanding access of electricity to rural poor through financing of investment costs, creation of a revolving Rural Electrification Fund to co-finance investments, develop transparent guidelines to select appropriate technologies and to prioritize the technologies, promote ownership and responsibility among communities, establish micro-finance schemes and link electrification to income generating activities in agriculture, fishery and education, health services, etc.

- *Promote regional co-operation in energy trade:* Consider increased regional co-operation in power systems inter-connection schemes.

- *Keep abreast with modern technology developments:* Enhance research and development and investment in state-of-the art modern technologies, especially renewable energy, including wind energy.

Apart from the above stated national goals, the GoE is considerate of global environmental concerns and its responsibilites, as evidenced by its ratification of the UN Framework Convention on Climate Change (UNFCCC) on 24 April 1995. The GoE has also been financing the Energy Research and Training Centre (ERTC) under the DoE to carry out activities such as adaptation and implementation of renewable energy technologies and implementation of capacity building training programmes in the area of renewable energy technologies.

There has been some success stories in the promotion of some renewable energy technologies, specifically solar photovoltaics. The ERTC has been building up a level of expertise in this field and is disseminating PV systems and the respective echnical expertise

in selected rural communities. This level of dissemination has not been matched by the same level of success in the field of wind technologies.

As already stated, preliminary analysis had shown that there is significant wind energy potential in some parts of 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 these regions could accelerate both rural electrification 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 (Prodoc, 2004). However, several barriers hindered the progress toward widespread adoption of wind energy technology in Eritrea. The project aims at removing these barriers and demonstrating the technical and economical feasibility of exploiting wind energy in Eritrea (Prodoc, 2004).

A Wind Information System (WIS) was developed and implemented at the ERTC. 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. The project further demonstrated that, in the wind rich region of Assab, it would be technical feasible and the economically viable to develop other grid connected wind parks.

Assab has a self contained electrical network, which is supplied by diesel generators. The generation plant has an installed capacity of 8.3 MW with a sent out capacity of 3.7 MW, due to low plant availability resulting from aging of the plant, meeting barely a peak demand in the hot season of 4.5 MW and cold season of 1.7 MW. Wind energy is not only beneficial in replacing fossil fuel used for power generation, but also improves security of supplies and reliability of supplies.

Prior studies had shown that Assab wind park, if connected to the grid, could be a cost-competitive option to be considered in the overall strategy of the development of the electrical power supply system in Eritrea (Prodoc, 2004), provided that GEF financial contributions are utilised to remove the existing barriers.

The SIDA funded project ‘Wind and Solar Assessment’, which was completed in 2002, complemented the PDF-B project and completed the database on wind resources. As part of the SIDA project, a GIS database for renewable energy resources was established at the ERTC, which further strengthened the case for harnessing wind to establish wind farms and wind off-grid systems for supplying electricity and other applications such as battery charging stations and water pumping.

The good wind regimes found in many places in Eritrea makes it possible to save at least part of the diesel costs used for power generation. Other possibilities are to reduce the usage of kerosene and LPG currently used as an alternative to electricty in non-electrified areas. Geothermal is also available and could also be an option for replacing fossil fuel used for electricity generation in Eritrea, but wind provides an electrcity supply option, which could be implemented within a shorter lead time.

Photo: Diesel genset at Idi, which will operate in conjuction with wind, thereby reducing reliance on fossil fuel and enabling access to energy to this unelectrified village.

The project document identifies the following barriers that need to be removed first, before wind technology could be widely adopted in Eritrea:

a) Lack of existing examples of grid-connected wind parks in Eritrea,
b) Lack of local existing examples of off-grid wind-diesel hybrid systems to gain useful lessons from on the technical and financial perspective, before engaging in commecrial operations of such facilities,
c) Lack of experience inside EEC regarding the installation and the operation of wind turbines; lack of experience inside the Eritrean private sector with regard to the private business,
d) Lack of adequate model contracts, on the basis of which private developers and EEC can negotiate Power Purchasing Agreements (PPAs) and other necessary contracts for such energy trading,
e) Very low level of awareness by the general population about wind energy technologies and the potential they offer.
f) Insufficient technical know-how and the non-availability of adequate wind technology trained manpower resources in the private sector, public sectors and the utility dealing with wind energy,
g) Lack of clearly defined procedures and responsibilities for the initiation, development and the implementation of rural renewable energy projects, and lack of developed and implemented financing mechanisms which take into account the special features of renewable energy technologies,
h) High failure rate possibility of individual grid components and the resulting part-time loss of electricity demand, and
i) Lack of a suitable grid connection ditribution network capacity at the identified wind park location.

2.3 Immediate and development objectives of the project

At the end of the project, it was expected that the existing barriers for a continued and sustainable development of wind energy will have been removed. Barrier removal would enable Eritrea to harness its favourable wind energy resource and reap benefits in the form of cheaper electricity production, expanded rural electrification, development of SMEs in rural areas, boosting food security, improvement in service delivery through the provision of cleaner and sustainable energy supplies in schools and health facilities, cleaner water supplies, etc.

It was also hoped that the implementation of the project would be replicated in Eritrea's villages with a favourable wind regime, benefitting over 60000 households. Furthermore, the project was designed to enhance institutional capacity building measures and ensure that wind applications are embedded in planning, policy formulation, and implementation. In addition, the Eritrean private sector, EEC, ERTC and the Department of Energy would have been empowered to participate in the development of the wind energy technology, making possible the manufacturing and/or maintenance of machine parts.

The improved regulatory framework would be conducive for attracting private investments in the energy sector, and positive experiences will enable them to replicate the project in other areas of the country. Benefits to the global environment in the form of reduced CO_2 emissions would arise both from the demonstration phase of the project, and the replication phases.

The project's developmental objectives could be summarised as follows:

- Introduction of a novel energy mode and technology to the country and the market players;
- Demonstration of the technical, economic, financial and institutional viability of both large and small wind energy applications through investments;
- Measuring the performance and drawing-up of conclusions on the replication potential of these applications;
- Giving models for wind power investments suitable for integration in the GoE rural electrification as well as for the grid based electricity generation;
- Lowering dependence on imported fossil fuels and reducing greenhouse gas emissions from the existing diesel generating facilities in Eritrea through their partial displacement by renewable energy sources;
- Helping the government institutions, local communities and stakeholders in developing their know-how and capacities in planning, installing, operating, maintaining and monitoring wind energy systems.

The project has been built around three components as follows:

1. ***Capacity building component:*** Development of personnel and institutional capacities in Eritrea to plan, install, operate and maintain on-grid and off-grid wind energy systems, and raising awareness among decision makers and players of the wind energy opportunities;

2. ***Assab Wind park pilot investment component:*** To install a pilot small wind park in the high wind area, connect it to the region's grid and test its performance and viability in view of potential capacity increase and replication wind parks elsewhere in Eritrea;

3. ***Decentralised small-scale wind systems pilot investments component:*** Installation of pilot wind stand-alone and hybrid applications in eight rural villages in order to test their viability and suitability for replication. The project pilot sites had been chosen as follows:

Table 1: Pilot Sites for off-grid wind installations

Village	System	Capacity	Households	Purpose
Berasole	Wind-diesel hybrid	30 kW	108	Household electricity, ice-making, desalination
Rahaita	Wind-diesel hybrid	30 kW	117	Household electricity, services
Haleb[1]	Wind-diesel hybrid	30 kW	-	Additional power to the Boat Factory
Edi	Wind-diesel hybrid	30 kW	180	Electricity services
Beilul	Wind stand-alone	10 kW	205	Household electricity, ice-making, services
Gizgiza[2]	Wind stand-alone	10 kW	225	Household electricity, services
Gaharo	Wind stand alone	5 kW	99	Household electricity, services
Gaharo	Wind (electrical)	3 kW		Water pumping
Dekemhare	Wind mechanical	3 kW	30	Water pumping

2.4 Main stakeholders

The main identified project stakeholders are the Project Management Unit (PMU), Department of Energy (DoE), Energy Research and Training Centre (ERTC), Eritrea Electricity Corporation (EEC), Regional administrations, Local administrations, UNDP/GEF and the private sector.

The Project Management Unit

A project management unit (PMU) was to be established within ERTC, initially consisting of:

(i) a national project manager, who will be the day-to-day manager of project activities
(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,

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

Technical Advisor

[1] Haleb was substituted for Edi, which showed more beneficiaries.

[2] Gizgiza was dropped due to financial constraints and as a demonstration site, could easily be represented by other sites.

An international technical advisor, contracted through an international engineering company, would provide support to the PMU when needed. It was 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. 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 was to be the Department of Energy in line with its mandate of overseeing the implementation of several renewable energy projects in Eritrea. The DoE would delegate technical work to the Energy Research and Training Centre (ERTC) but will retain the overall responsibility for the successful implementation of the project.

Eritrean Electric Corporation (EEC)

EEC would install, operate, maintain, and monitor the performance of the Assab wind park. In addition it would provide the necessary technical assistance for installation, operation, and maintenance of the respective diesel plant in the distributed wind energy sites. It would also provide advice on the procurement of spares and consumables. EEC would also provide training on the commercial aspects such as meter reading and bill preparation, especially in the distributed wind sites.

Local administrations

The village administrations were responsible for:

(a) Local administration of individual rural projects,
(b) Protection of the installed systems,
(c) Collection of fees/payments for electricity 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

Private companies would receive training and also carry out some project component, such as civil works during installations. The project envisaged to focus on the private sector through information dissemination and training of engineers, technicians and electricians, model contracts, PPAs etc.

2.5 Results expected

At the end of the project it is expected that the existing barriers would have been removed to facilitate future utilisation of Eritrea's favourable wind energy resource, thereby bringing direct benefits to Eritrea in form of displacing fossil fuels for power generation, reduction of energy costs to the consumer, enhanced and lowering costs for rural electrification.

Rapid rural electrification will in turn stimulate enterprise development and improve living conditions and service provision by schools and health facilities. Productive uses of wind energy, such as mechanical water pumping, will also have been stimulated. The project has the potential for replication in the 316 villages with a favourable wind regime. The lessons learned from this project, and the capacity and experience attained, would create an environment conducive for the incorporation of wind in policy formulation and implementation. The improved regulatory framework would attract private investors to replicate the project. Benefits to the global environment in the form of reduced CO_2 emissions will arise, both in the demonstration phase and during the replication phases.

The table below summarises the project expected objectives, outcomes, and indicators.

Table 2: Project Objectives and out outcomes

Project Objective and Outcomes	***Indicators***
Objective: To promote socioeconomic development and improve people's livelihood by facilitating access and affordability to modern and clean energy services.	a) Assab grid gets an additional of 750 kW wind generated clean and cheaper electricity.
	b) Eight project sites get 3-30 kW clean and affordable electricity.
	c) Poverty in the project sites reduced due to provision of modern, clean and affordable energy services

	d) Small and medium sized enterprises, which improve people's livelihood, flourished
Outcome 1: To develop necessary personnel and institutional capacities to plan, install and operate on and off-grid wind energy systems and increase awareness amongst decision makers in governmental and private institutions both at the community and central level.	a) EEC staff trained on installation, operation and maintenance of the wind farm.
	b) ERTC staff trained on installation, operations and maintannce of the decentralized systems.
	c) Operation and maintenance conducted by private sector, local technical personnel.
	d) Managerial and technical training given to Project Team Members of the Ministry and the private sector.
	e) 80 % of all community leaders in wind rich villages know about the advantage of wind energy.
Outcome 2: To install a 750 kW wind farm at Assab and integrate the wind generated electricity into an existing 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 the high wind speed sites.	a) Assab Wind Farm running and operating smoothly.
	b) Assab Wind Farm contributing about 20 % of the annual electricity consumption.
	c) Generation cost at Assab reduced by at least 30 %.
Outcome 3: To install 8 small-scale decentralized wind standalone and wind diesel hybrid systems in the selected 7 wind rich villages and production sites of Eritrea to demonstrate the technical, financial, institutional and socio-economic viability.	a) Kerosene use for lighting in pilot villages reduced by at least 50%.
	b) At least 80% of the end-users are satisfied and can afford the electricity offered.
	c) Medical hazards (respiratory and eye diseases) due to kerosene use for lighting reduced by 50%

3 PROGRESS MADE TOWARDS ATTAINMENT OF OBJECTIVES

Project Implementation

The project was started well but later experienced serious delays due to non-performance by the Technical Advisor (TA). With the termination of the TA contract and injection of additional financing by UNDP the project picked up momentum but was further delayed by contractual issues, namely breach of contract by the supplier of decentralised systems – *Fortis Wind Energy* of the Netherlands and supply delays by the new contractor – *Soyut Construction and Engineering* Company from Turkey.

On 05 September 2007, a contract for the supply, installation and commissioning of the distributed wind energy sites, was signed between the Department of Energy (DoE) and the Dutch company – *Fortis Wind Energy*. Having received the Advance Payment, *Fortis* suddenly breached the agreement citing Eritrea's country risk, in terms of obtaining insurance guarantees both in the Netherlands and Belgium to provide coverage to implemementation of the project.

The DoE conducted a re-bidding process so as to complete the project by the end of 2008. A Turkish company- Soyut Construction and Engineering Co. Inc. was awarded the tender. Soyut Construction and Engineering also faced unforeseen problems in the shipping of the equipment. Some time was lost to identify a shiping company to transport the equipment to the port of Massawa. Most shipping agencies claimed that due to piracy in the Somalian waters, the

shipping lines to Massawa were suspended. The evaluator was shown the necessary correspondence to this effect. The PMU again worked tiresly and dilligently to find shipping lines ready to transport the equipment providing the supplier with a list of alternatives.

The problems in procurement were some of the challenges, in project implementation, but the main delay was due to non-delivery by the technical advisor. As the project was designed to remove existing barriers in Eritrea, it was expected that the Technical Advisor would assist the PMU in the following tasks:

- Establish database of renewable energy potential (wind and solar) in the country based on the information in ERTC;
- Prepare model contracts, tender documents and tender evaluation for the procurement of goods and services for the wind park and decentralised systems;
- Provide engineering support for the grid reinforcement;
- Supervise the installation of the wind park and decentralised systems;
- Analyse operations and maintenance performances of the installed systems;
- Assist in the implementation of the capacity building measures and coach local counterparts;
- Develop procedures for the implementation of rural electrification projects based on renewable energy;
- Organise and conduct public awareness activities on global and national benefits of wind energy;
- Analyse, develop, and test practicable financing mechanisms for the replication of decentralised wind energy systems.

The insufficient inputs in terms of support for the preparation of specifications and bid tender document, delayed or totally failed to deliver critical inputs such as:

- ***Preparation of acceptable Power Purchase Agreement (PPA), wheeling agreement, design, specifications and bid documents for wind park and grid reinforcement designs -*** submitted with major delays and inappropriate for Eritrea, which has a vertically integrated utility, which is also a single buyer and does not need a PPA.

- ***Delivery of a procedures manual and initial training for decentralised wind energy systems, preparation of the designs, specifications, and bid documents*** – TA was incapable to provide engineering support for the grid reinforcement, which was consequently done by EEC.

- ***Installation of upgraded wind and solar information data base at ERTC*** – not delivered

- ***Delivery of 6 concept reports for follow-up on renewable energy and CDM projects*** – delivered but failed to meet the objectives of providing information on the potential role of CDM in addressing financing of renewable energy technologies and consequently of little practical use.

- ***Installation and commissioning of Assab Wind Park and first three decentralised wind systems-*** not delivered

- ***Installation and commissioning of the remaining decentralised wind systems*** – not delivered.

- ***Final operation and monitoring report of the wind park and the decentralised systems*** – not delivered.

The failure by the technical advisor to support the project caused delays in the project procurement and its overall implementation. This resulted in the project being exposed to unnecessary procurement and shipping risks that later affected the project implementation schedule. The TA lack of delivery was compounded by an unrealistically short time-scale for the procurement of major equipment components, in the background of the need to acquire a learning curve by the PMU, without support from the TA.

The implemantion of the project also resulted in the changes in two sites of the distributed wind energy systems i.e. Gizgiza and Haleb. The changes arose out of the realisation of a budget deficit of USD 82,000, between the budget allocated for the distributed wind energy sub-project and the offer from Soyut. To resolve this, the DoE had either to revise the budget and secure bridging finance or leave out one site. It was decided to leave out Gizgiza. The decision was on the basis that Gizgiza has neither the existing distribution networks nor the village had financial capacity to install the required power distribution network. Since the installation cost for the 10 kW standalone wind turbine at Gizgiza, as quoted by Soyut Wind, was around USD 80,000, the option was, therefore, to leave out the installation of the wind turbine at Gizgiza and implement the rest of the sites.

As to the other site – Haleb, which was one of the sites of the Distributed Wind Energy Systems, where a wind/diesel hybrid was to be installed, it was found that the alternative site – Edi, provided better benefits. This included the necessary financial capacity to put the distribution line and more households would benefit from the system, unlike Haleb, where the system would benefit a non operating fishing venture. Haleb was switched by Edi becuase of its relative advantage over the former. ***The evaluator finds this approach logical, since considerable time was going to be wasted in mobilising the necessary finance and Edi, would in any case serve to provide the necessary experience and useful lessons.***

Barring the above setbacks, most of the envisaged activities were either finalised or would be finalised by the extended new deadline of end March 2009. This conclusion derives from the fact that most of the remaining major activities have been completed and major equipment for off-grid systems have been shipped. The necessary civil works are nearing completion and in most of the sites, the transmission networks are now in place and the diesel gensets have been installed and house internal wiring has been completed.

Photo: Completed powerhouse and grid reticulation at the project site

Photo: Completed foundation at the project site

The procurement of wind technology, installation, capacity building programmes, awareness campaigns, training programmes, implementation guidelines for operation of off-grid systems and establishment of monitoring and evaluation systems have been conducted by and executed

by PMU according to all acceptable guidelines and standards and very efficiently. The project team should be commended for the implementation of the project in a commendably efficient, dedicated and professional manner, and has with the support from DoE, EEC and ERTC been able to launch the project despite limited support from international wind energy specialists as envisaged under the TA agreement.

The assessment below summarises the project success and progress so far in terms of the objectives, outputs and activities spelled out in the *Prodoc* in the three main components.

3.1 Project components

3.1.1 Capacity Building and Awareness Creation

The capacity building component has been included as the means of helping overcome the existing experience barriers in successfully introducing wind energy both into the grid and non-grid systems. It also aims at lowering institutional barriers by improving the know-how base within the local concerned institutions (DoE, ERTC, EEC) and by introducing appropriate processes and procedures. In addition, the component has been designed to remove technical barriers within and outside the grid operations through training.

***"Immediate Objective:* 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 community and central levels."**

***Assessment:* Most capacity building activities have been covered fully with modalities and strategies put in place to effect the only remaining components which are training of the trainers for the technical back up of the wind energy off-grid, and training of local communities on operations of the systems. As part of the supply contract Soyut Construction and Engineering will be training the trainers on Soyut turbines and operations and maintenance procedures. People to be trained have been identified by communities and the list submitted to PMU. On average six people will be trained of which 3 will be employed full time by communities and 3 are to be retained as reserves, in the event a permanent member is not available for any reason e.g. leaving the village. ERTC, which will facilitate the training for wind off-grid systems are ready for the task, once the necessary training is given by Soyut Construction and Engineering. EEC is providing training on the maintenance of diesel gensets. It is enlightening to note that the intended beneficiaries were appropriately selected from their academic background and some have basic skills in maintaining diesel engines for fishing boats. EEC will also provide training in meter reading, bill preparation and revenue collection. (Delivery: very satisfatory)**

(Output) 1.1 Grid connected wind park training

(Activity) 1.1.1. Technical and managerial seminars for EEC staff in Assab and Asmara
Delivered:

- On the job installation and preventive maintenance training for EEC (8 participants) provided by the wind park technology provider (Vergnet S.A.) as follows:

  - Three weeks right after commissioning (operations and maintenance) – December 2007
  - 2 wks (operations and maintenance) – February 2008
  - 3 wks on preventive maintenance – September 2008
  - Complementary training on technical problems to ensure sustainability (on average 8 people) – to be carried on 11 February 2009

- Project Manager, ERTC and EEC staff received training at factory in France; 13-22 December 2006
- Project technical training (2.5 days) by *Soytes Clean Energy and Electrotechnics Industry Co. Inc.* - through a separeate contract.
- to PMU, DoE, ERTC, EEC, UNDP and private Electrical Contractors in Asmara; - 27 -31 October 2008 - 25 participants
- Project management training (2.5 days) by *Soytes Clean Energy and Electrotechnics Industry Co. Inc.* to PMU, DoE, ERTC, EEC, UNDP and private Electrical Contractors in Asmara; - 27 -31 October 2008 - 25 participants
- Renewable energy project planning and analysis software (PROFORM) training (2 days) by TA team to PMU, DoE, ERTC and Petroleum Corporation of Eritrea in Asmara 4- 5 January 2006 - (16 participants).
- Inception workshop (2 days) in conjunction with TA – December 2004

Planned:

- Complementary training for EEC on site by *Vergne*t on 11 February, 2009
- Training of ERTC trainers by Soyut.

Assessment: Vergnet has covered its training share sufficiently and also having full set of operations and maintenance manuals in place in Assab. The provided training has been considered effective and useful by EEC and PMU. The evaluator considers the training provided as having been very satisfactory.

1.1.2. Training for EEC and DoE in supervision and acceptance of civil, electrical and mechanical works.

Delivered:

- EEC and DoE have in the absence of a TA contract fully gained experience in supervision and acceptance of civil, electrical and mechanical works.
- EEC and DoE have been able to suggest modifications on civil works for distributed systems to reduce redundancy and inappropriate designs.

- Suggestions on modifications have been fully accepted and adopted by external contractors as future appropriate designs.
- EEC and DoE have modified the design of wind farm civil works, which was fully endorsed by the external contractor and have been able to solicit and achieve a prolonged warranty period, than is usually the norm.

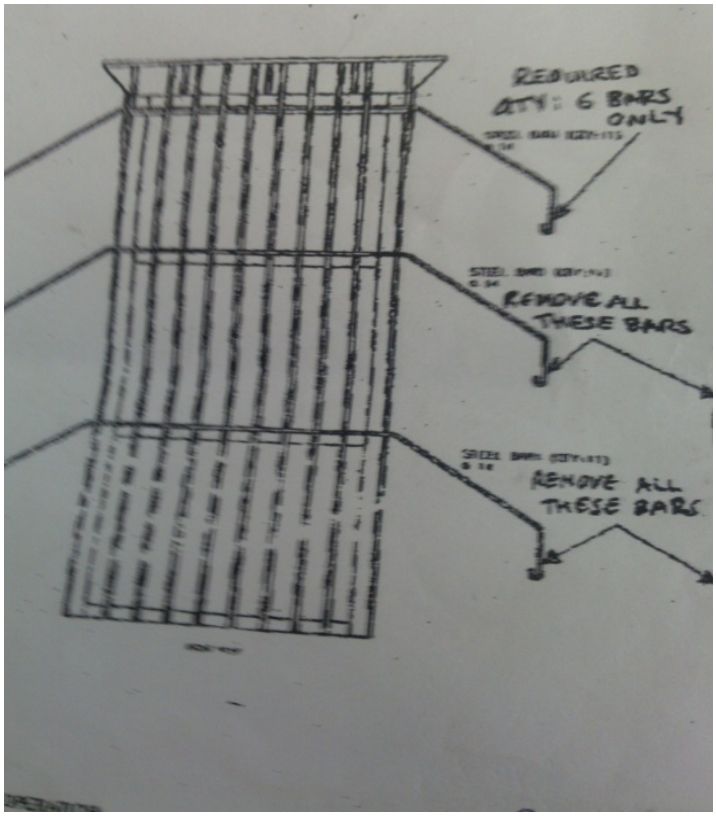


Photo: Modified concrete structures for civil works proposed by DoE and EEC and adopted by Soyut Construction and Engineering

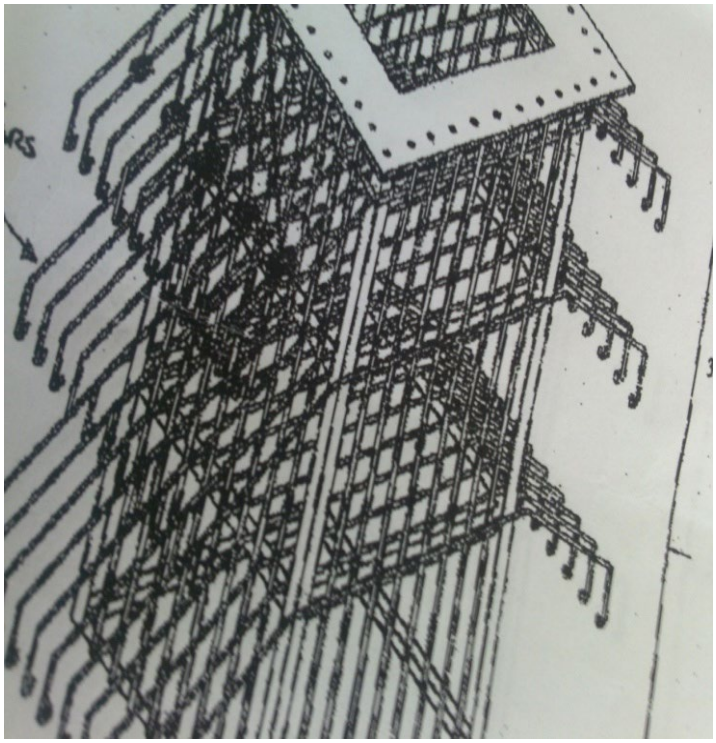


Photo: Original civil works design by external contractor, showing redundant bars and layers

Photo: DoE modified platform design for the distributed wind system showing removal of redundant bars and the design of an elevated platform and widened foundation (to accommodate high water levels due to the proximity to the sea) accepted by contractor

Assessment: ***DoE and EEC have gained useful lessons in accepting civil, electrical, and mechanical works. One useful lesson learnt is during the acceptance of works is that equipment suppliers are generally specialised on equipment designs and are not necessarily strong in civil works. The PMU and EEC were very proactive in assessing designs and recommending innovative solutions that have resulted in external contractors adopting the designs as their own future designs. The objective of this output has been fully met.***

1.1.3. Wind technology study tour abroad.

Delivered:

- Two week study tour in USA for PMU, DoE, ERTC, EEC senior management and UNDP - Country Office was organised by TA as an introductory training in wind technology, wind research and operations of wind parks (5 persons).

Assessment: ***The study tour was considered useful by PMU and was well arranged. It was an eye opener to the main stakeholders and well received. Training to be an ongoing activity to enhance the acquisition of new knowledge and technological trends***

1.1.4. Masters-level fellowship training abroad for one person (Prodoc 2 persons).
Delivered:

- Suitable person and study venue were selected by PMU and TA, but the programme could not materialise due to GoE regulations and current policy.

Assessment: This was an unfortunate incident, hence other existing opportunities, should be explored as opportunities arise. This could have had a long-term positive impact on replication of wind technology.

1.1.5. Cross-training of local experts in on- and off-grid systems.

Delivered:

- Modalities for training of local expects in on- and off-grid systems in place
- Six suitable candidates from each site have been identified
- Only three in each site would be employed by local administrations and the other three would be retained as reserves
- ERTC will be training local experts on operations and preventive maintenance of the wind systems
- EEC will be training local experts operations and preventive maintenance of the diesel gensets, meter reading and bill preparations
- EEC provided training is in progress and EEC has indicated their willingness and commitment to bring their training component to finalisation
- ERTC have indicated their commitment and willingness to execute training to local experts once they have received the necessary training from Soyut Construction and Engineering

Assessment: ***The successful training of local experts is vital for the sustainability operations of the systems, after sales service and replication. The approach undertaken is commendable, since the local experts could now have practical training on the actual systems they will be operating. Prior training would have provided theoretical training,***

that would have had to be repeated in the actual operating environment and this would have had financial implementations and a longer project implementation framework. Experiences garnered from this training should be useful in providing capacity building in Eritrea.

1.2. Strengthening of ERTC to become national centre of competence in wind energy technology

1.2.1. Establish PMU in ERTC

Delivered:

- PMU was properly established at project start-up within DoE.

Assessment: The positioning of the PMU within DoE proper was a good choice and provided it with the better operational links e.g. with EEC, DoE and ERTC.

1.2.2. Training of trainers under ERTC for public and private sector experts.

Delivered:

- Awaiting training from Soyut Construction and Engineering

Assessment: The indication from ERTC is that they are ready for this component of the project. They have been involved in other activities of the project and their output in terms of the wind energy data base was the cornerstone of the project implementation. ERTC has also made inputs in the Project Implementation Guidelines including their role in being trained as trainers so as to train local experts in operations and preventive maintenance of wind systems.

1.2.3. Develop a renewable energy data bank at ERTC.

Delivered:

- ERTC continues to develop WIS and its own renewable energy data storage and library
- ERTC will be continuously collecting system performance data for the distributed systems, analysing the data and submitting data to DoE on quarterly basis in line with Project Implementation Guidelines, of which they were party to its development
- Data base for wind potential in Eritrea and other renewable energy systems such as solar radiation is being continually updated.
- The data collected has been used to implement renewable energy applications such as solar for water pumping (230 centres), solar mini-grid systems for clinics (more than 250 centres) and communication and also provision for solar photovoltaic home systems

Photo: Solar System for Water Pumping – ERTC data has been instrumental in installation of solar for water pumping

Assessment: ***ERTC is still interested in the further development of a wider RE data bank and need further assistance in terms of equipment. This could be considered in the replication phase.***

1.3. Training of engineers, technicians and electricians in the private sector to service future projects.

Delivered:

- Local technicians list submitted to PMU
- Representatives from the Eritrea Electric Contractors Association participated in the Inception Seminar and a technical and management training carried out by *Soytes Clean Energy and Electrotechnics Industry Co. Inc.*in Asmara on 27 – 31 October 2008;

Planned:

- Out of the local experts to be trained by ERTC, three at each site will not be attached to any institution but will be held as reserves to service future projects.

Assessment: ***The private sector base in Energy project is very low. The PMU has prudently created the capacity for private sector participation in wind systems by ensuring that the number of trained local experts far much exceeds the immediate requirements but also could be used for future energy projects.***

1.4. Raising awareness of wind energy potential and role

1.4.1. Awareness campaigns to community leaders
Delivered:

- Information has been shared with the pilot community administration and beneficiaries, who also contributed in kind to the construction of the local power distribution networks and whose properties are now internally wired in preparation for the commissioning of the projects.

Assessment:

The evaluator found the level of awareness and expectations arising from the project very high and highly satisfactory and will be useful for replication.

1.4.2. Awareness campaigns to leaders in private and public sector at central level
Delivered:

- Carried out including study tours
- Part of the awareness campaigns at community level were carried out at the level of Minister. In some sites, the Minister sensitised communities on the project.

Planned:

- More campaigns planned once the technology is in place and operational.

Assessment: ***The view point and experience of the evaluator is that it is easier to carry out awareness campaigns once the technology has been proven. Policy influence without credible field results or prior experience elsewhere to backup claims is often met with scepticism by policy makers and leaders in both the private and public sectors. PMU standpoint of not acting before the action is in place is wholly supported. Any other approach may not be effective to ensure stakeholder buy-in.***

1.4.3. Awareness campaigns for the general public
Delivered:

- Information was shared at inception in a seminar involving representatives from the Regional Administrators, who in turn disseminated the information at local levels. This approach was supplemented by articles in local newspapers and during site visits.

Planned:

- More publicity when off-grid systems start operating.

Assessment: ***During the evaluation the public were found to be very much aware and very prepared for the project e.g. most beneficiaries have already internally wired their houses in anticipation. The levels of project expectations were very high, but at the same time there was anxiety due to delays. In general, members of the public well articulated the potential of the project people's lives and socio economic as far as potential benefits to communities were concerned and there was also some sort of scepticism, with some members stating that they will***

believe when the systems start operating. This underscores the observation that public awareness campaigns will be effective once the systems are operational, in line with the PMU's strategy.

The table below shows the training status in terms targets and achievements.

PRESENT DELIVERY STATUS AND PLANNED CAPACITY BUILDING ACTIVITIES

Output/Activity	Provided by	Targets	Pro doc No.	Completed No. of tar. pers. %	Planned add. No. of targ. pers. %	Comments
1.1. Grid connected wind park training						
1.1.1. Seminars/on-the-job						
Technical	Vergnet	EEC/elect/mech	n.a.	25 100	8 100-	Complementary training in February
Managerial	Consultants	EEC/mid-mgmt	n.a.	25 100	- -	Completed
1.1.2. Supervision, works	TA	EEC /techn.	n.a.	- -	- -	Cancelled
		DoE	n.a.	- -	- -	
1.1.3. Study tour abroad	TA	DoE,PMU,EEC, ERTC sr.mgmt	n.a.	4 100	- -	Completed
1.1.4. Masters trg abroad	For.university	Undergraduate	1	- -	- -	Cancelled
1.1.5. Cross-training in sites	EEC,ERTC	New sites	n.a.	- -	450 70 -100.	Includes every adult member at Gahro who has to be trained on battery care
1.2. ERTC strengthening						
1.2.1. Est. of PMU	Project	DoE/ERTC	2+2	4 100	- -	Completed, Established at DoE, driver has since moved
1.2.2. Specific training	ERTC	Stakeholders	n.a.	- -	6-10 70-100	Additional to ERTC other related training activity.
1.3. Private sector players						
1.3.1. Electric contractors' trg.	ERTC,EEC	Contractors	n.a.	2 100	21 100-	Not major players, some will be trained during ERTC and EEC local experts training involved in awareness activities
1.4. Awareness creation						
1.4.1. Campaigns with communities	ERTC, DoE	Comm.leaders	n.a.	7 100	20-30 +	More could be made aware once the systems are running
1.4.2. Public and private sectors, central level	TA, DoE	Leaders, stakeholders	n.a.	yes	yes	On-going and continuing activity
1.4.3. General awareness	DoE, ERTC	General public	n.a.	yes 10	yes 100	More once wind park and pilots operational.

3.1.2 Installation of the Assab Wind Farm

"Immediate Objective: ***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 technically, financially, and institutionally feasible and can be a least-cost supply possibility in Eritrea at high wind speed sites."***

Assessment: ***The wind park has been commissioned and connected to the grid with a rated capacity of 600 kW as recommended by the supplier to ensure the life span of the turbine and as accepted by PMU after a technical evaluation that concurred with the recommendation of the supplier. The targeted production (2,500 MWh per annum) was exceeded, as the actual energy production was 2862 GWh in 2008. PMU and EEC have performed extremely well and in a professional fashion. All the necessary physical preparations for such a pilot wind park operation have been properly carried out. Technical training as well as setting up of the performance monitoring system was accomplished and the system is operating well with a capacity factor of 50%. (Delivery level: 100%)***

(Output) 2.1. Contractual framework for the first wind park

(Activity) 2.1.1. Contractual arrangements for the wind park until financial closure
Delivered:

- All necessary contracts are in place.

Assessment: ***The bidding and contracting process have been satisfactorily carried out by PMU according to World Bank procurement guidelines***

2.1.2. Prepare model contracts for power purchase and wheeling agreements for grid-connected RE projects
Delivered:

- A locally produced model Power Purchase Agreement (PPA) is in place and takes into consideration local conditions.
- TA had failed to deliver a proper PPA.

Assessment: ***The PPA was supposed to be developed by the TA. The draft that was presented by TA with a substantial delay was not complying to the local electricity market structure but based on the USA retail market. The necessary in-depth consultation process during the preparation and submission was totally missing. As EEC will operate the Assab wind park, no PPA is required in the first place but the current PPA would be useful in the event of private investors coming on board.***

2.1.3. Prepare tender documents, provide support to tender process and give on-the-job training
Delivered:

- Bid processed, procurement completed and the materials delivered to the EEC Assab on July 2008.

Assessment: ***Work has to be undertaken by PMU in accordance with the acceptable World Bank procurement guideline after TA failed to deliver.***

2.2. Install a 750kW wind park in Assab and connect it to the grid.

2.2.1. Formulate an optimal operation strategy for the wind park

Delivered:

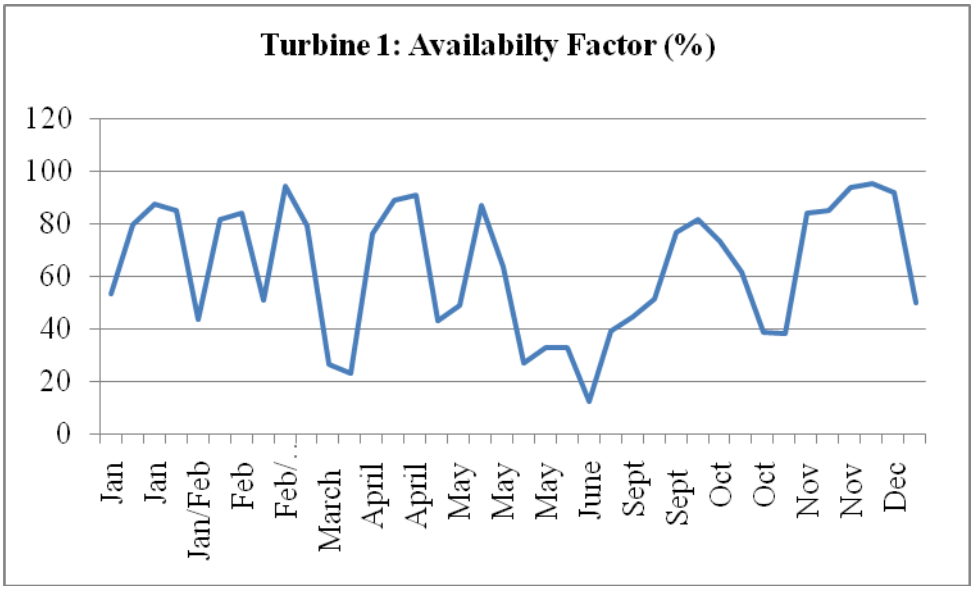
- Configuration and size confirmed by PMU and EEC.
- Committee, comprising EEC, ERTC and PMU setup to follow up on commissioning of wind farm
- EEC has integrated and is operating the wind park according to the Assab grid operation strategies.

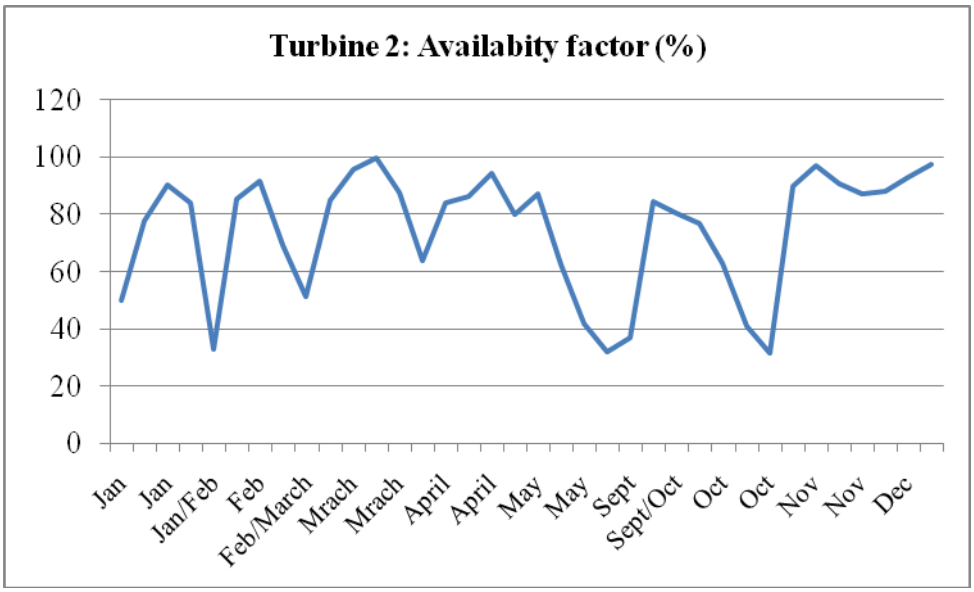
Assessment: ***The current operations strategy is adequate for the conjunctive use of wind and diesel gensets. Due to the need to control frequency within limits and avoid system collapse the operational strategy is 65% diesel generation and 35% wind. This arrangement is functioning well. The initial Commissioning Guidelines provided by Vergnet S.A. were not clear and had missing information on some operations and maintenance procedures. Through persistent request by the PMU/EEC, however, proper commissioning guidelines and the required operations and maintenance manuals were then provided as the result of which commissioning was done satisfactorily.***

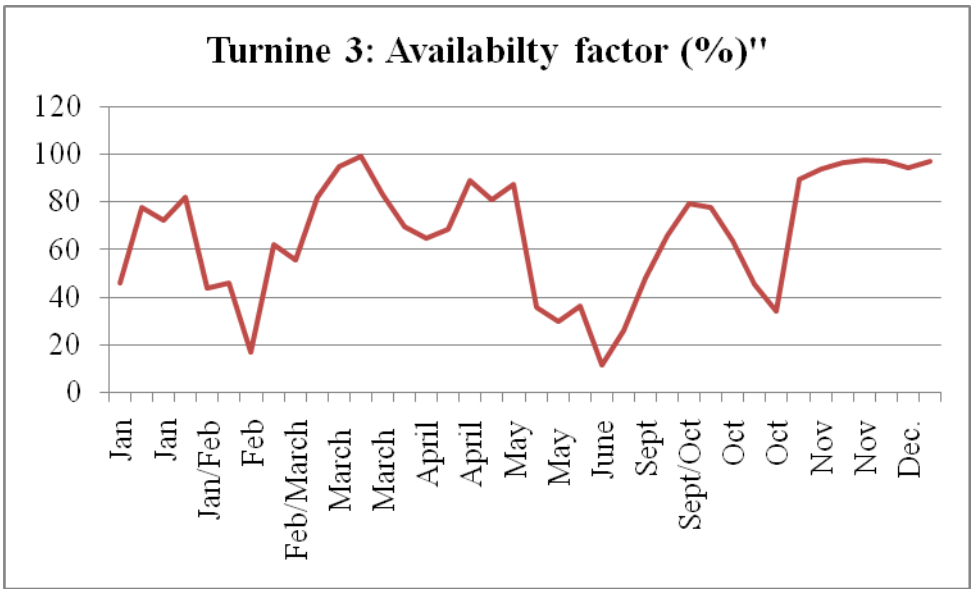
2.2.2. Disseminate operation results to attract further investments

Delivered:

- A weekly production and status report format has been prepared by the PMU and sent to the EEC for implementation.
- Performance and monitoring is being routinely performed by EEC. And PMU
- The information is being shared with ERTC
- The PMU has been documenting this information in a database since Janaury 2008 and some of the information was used to prepare this report as illustrated below:







<u>Assessment:</u> ***The performance monitoring consists of a SCADA system installed at the control room of the diesel power plant and and the control room of the wind farm. The information collected and lessons learnt will be valuable to attract further investment and would serve as model case studies for considering future wind applications in and outside Eritrea.***

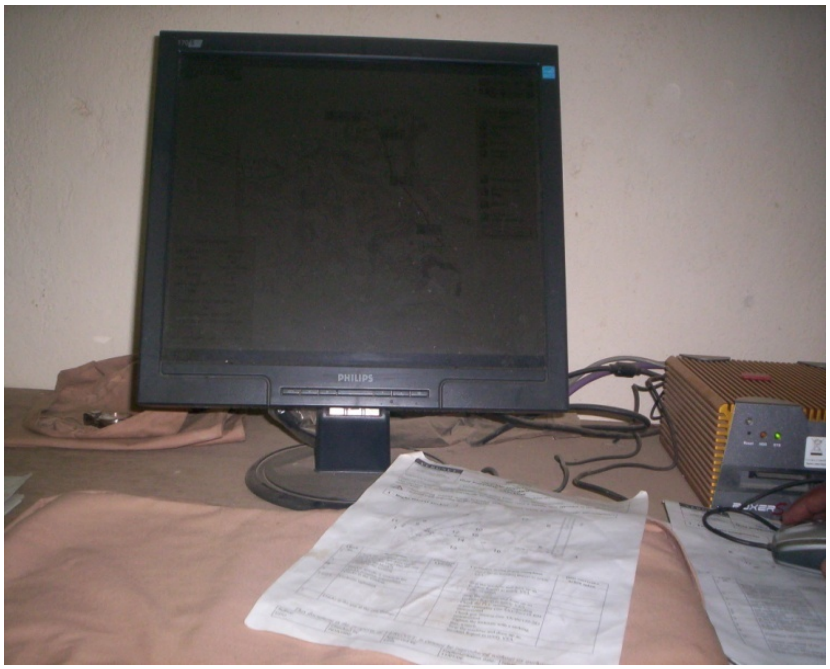


Photo: SCADA system installed at Assab wind farm for performance monitoring

2.2.3. Procure and install the grid connection cable and the wind park substation

Delivered:

- Successfully implemented

2.2.4. Reinforce the Assab grid prior to park connection (incl. 3 cabins)

Delivered:

- Carried out successfully by EEC.

Photo: Switchgear to integrate Assab Wind Farm to the grid

2.2.5. Install the park consisting of three 250 kW turbines

Delivered:

- Successfully commissioned (with adjusted rated capacity of 600 kW by agreement by all parties) on 25 November 2008.

Assessment: ***The installation is operating very well and according to EEC, beyond expectations. Vergnet has performed according to expectations, has replaced on its own account three "noisy" gearboxes and has carried out the necessary training and committed to continue with the training and technical support as per the contract. The handover to EEC has been carried out and EEC appears very committed to the operator's role and functions, and has already integrated the wind farm into the main grid system.***

Photo: Assab Wind Farm up and running

2.2.6. Operate wind park and evaluate performance

Delivered:

- Plant operational and performing satisfactorily
- Evaluation and monitoring system in place including a SCADA system gives status of the equipment, operational parameters and system performance
- Monitoring and evaluation being effectively carried out with weekly data being sent to PMU for analysis
- A hand over document of the Assab Wind was prepared and presented to the EEC Head Office, along all the relevant documentations, on March 2008
- Document was signed by and between the DoE and EEC in July 2008.

Assessment: ***The objectives of this output have been fully met.***

3.1.3 Installation of Eight Small-Scale Decentralized Systems in Rural Villages

"Immediate Objective: ***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-economical viability."***

Assessment: ***The procurement process has been carried out and equipment shipped and awaiting arrival in the next few days. The civil works are 98% complete. The power houses in all sites are complete. Diesel generators in sites requiring them have been installed. The local power networks have been erected in all sites and the materials for the last site (Beylul) have been procured and some delivered on sites. EEC has indicated that the construction of the network will be in place within four weeks. Implementation guidelines by communities have been produced by PMU, circulated for comments, comments incorporated and final guidelines circulated for the implementation phase. Operators of the systems to be trained have been identified and nominees' details sent to PMU. Contract for training of the trainers awarded and training to start as soon as the equipment arrives. (Delivery level 90%;)***

3.1 Procedures in place between local ,regional and central administration levels and across line ministries for identification, implementation and operation of rural wind energy projects.

3.1.1 Analyse existing procedures including delegation of responsibilities.
Delivered:

- Draft guidelines for managing the wind standalone and wind-diesel hybrid systems in the project sites produced by and sent for comments to ERTC, the Administration of the Southern Red Sea Region and the EEC in January 2008.
- Comments incorporated and the final version sent in July 2008 for implementation.

Assessment: ***PMU is using piggy-back approach refined during the implementation of the ongoing rural electrification programme and existing service delivery structures used for example by Regional Administrations in providing closed diesel powered grids to selected villages. The procedures also ride on the back of relevant institutions with experience in electricity supply procedures (EEC) and delivery of renewable technologies (ERTC). Checks and balances have been embedded in financial management systems through having three signatories (two from local administration and one from the Regional Administration. This approach is likely to succeed as most of its components have been tried***

3.1.2. Test the procedures in selected villages and production sites.
Delivered:

- Most of the activities detailed in the procedures have been tested in other programmes developed in consultation with all interested parties
- Implementation of the procedures is in progress

Planned:

- One month trial runs to determine differentiated consumption levels for tariff determination

- Implementation of the tariff based on the affordability and the need to ensure sustainability of operations and maintenance.

Assessment: ***Procedures are based on the current norms in the operations of the Regional and local administrations. They have largely been tested by DoE and EEC in the operation of the wind farm. The procedures take advantage of the existing capacity of local communities in basic knowledge of maintenance of diesel engines used in fishing boats. The procedures have technical backup of EEC, ERTC in major maintenance, procurement, and equipment technical specifications.***

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

3.2.1. Identify financing options successfully applied in other countries and associated lessons learned.

Delivered:

- TA has prepared a generic Project Finance Manual.

Planned:

- no specific plans exist, as TA failed to fully perform the task.

Assessment: ***The task is now urgent, given the need to start work on replication. More concerted efforts need to be made to identify possible source of finance for replication. The project has met its objectives, and the challenge now is securing finance for replication. This is one area, that would need to be addressed in the exit strategy. Given the Eritrean economic context, it is assumed that the investment costs will be fully or substantially covered by donor and GoE grant financing, which will be limited.***

3.2.2. Test the most promising financing models (e.g. micro-finance, soft loans etc.).

Delivered:

- TA was unable to carry out the task.

Assessment: As in 3.2.1

3.3. Five diesel-wind hybrid and three stand-alone systems installed

3.3.1. Prepare, tender and commission the eight pilot projects

Delivered:

- Site selection of the seven villages completed
- Contract signed with a Turkish Contractor- *Soyut* Engineering and Construction Company on 06 May 2008
- Installation and Commissioning of wind turbines expected in January/February 2009.

Assessment: ***In accordance with the contract previously signed with the Dutch Contractor - Fortis Wind, the supply, installation and commissioning was supposed to be completed in June 2008. However, Fortis failed to deliver and a quick re-bidding was done and a new contract awarded to Soyut, who were scheduled to complete the project by the end of December of 2008. The breach of contract by Fortis caused a delay of the project by six months.***

The implementation of the project was further delayed by other external factors such as scarcity of fuel and building materials in the country, which hindered Mussa Ali Construction Company from undertaking the construction of the civil works of the distributed wind energy sites. The delivery by Soyut was also affected by the piracy problem in the region, as it turned out to be difficult to find willing shipping agencies to transport equipment to Massawa Port.

Despite these problems, PMU in the absence of a TA carried out the procurement process well. Experience garnered from the procurement of the wind farm equipment from Vergnet S.A was useful. Delays experienced were beyond the control of PMU.

3.3.2. Install the eight pilot projects.

Delivered:

- Turbine foundation cages delivered at the sites
- Design for the turbine foundation and power houses completed
- Materials for turbine foundation delivered at sites
- Turbine and power house foundation excavation and construction of foundation by *Mussa Ali Construction* Company completed
- Turbines shipped and awaiting arrival in two weeks (at Jedda at the time of complilation of this report)

Planned:

- Installation during February/March 2009.

Assessment: ***Much progress has now been covered. What now remains is the installation of the wind turbines. All other preparatory work has been satisfactorily accomplished***

3.3.3. Operate and maintain the systems

Delivered:

- Electricity committee to be set up in the respective villages to manage the installations
- Billing staff in place based on PMU guidelines
- Diesel procured and installed
- Preparation of metering equipment either in place or being acquired through EEC
- In one site – Berasole, 6 candidates given 5 days training by a Danish company on operations and maintenance of the existing diesel gen set and water desalination system
- Grid construction funded by ZOBAs, and implemented by EEC in place or nearing and under construction in one site (Beylul)
- Internal wiring for premises in place
- Six candidates from each site identified and lists submitted to PMU

- EEC training on the maintenance of diesel generators, meter reading and bill preparation to be given.

Planned:

- Training of the ERTC trainers on wind systems
- Training of local experts by ERTC
- Setting up of tariff system based on affordability and need to recoup operational and maintenance costs.

Assessment: ***The operating principles are realistic and the relevant stakeholders seem to be ready for the task.***

3.3.4. Analyse and disseminate operation results after 1 year of operation and in subsequent years.

Delivered:

- Not yet done
- Framework in place

Planned:

- Will be done as part of the performance monitoring system, when the systems are running.

Assessment: ***A solid monitoring framework has been established to meet the objective of ensuring the technical, financial, institutional, and socio-economical viability of the pilot applications. The project completion date needs to be extended at least until end 2009 to enable sufficient monitoring to take place. Dissemination of the results would be possible only at the very end of this period, when all systems are running.***

3.2 Review of the Logical Framework

The table below summaries the achievements in terms of objectives, activities and outputs.

Table 3: Assessment of the project planning matrix

STRATEGY	INDICATORS	MEANS OF VERIFICATION	CRITICAL ASSUMPTIONS
Global Environment Objective: To reduce Eritrea's energy-related CO_2 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 682000 litres/year **Performance** **Initial analysis shows displacement of 772540 litres of diesel at a penetration ratio of 35% and capacity factor of 50%. The targeted diesel displacement of 682000 litres has been exceeded.** Yearly consumption of diesel used in the villages where a wind-diesel hybrid system has been installed reduced by 6000-8000 liter/year **Performance** **Distributed wind systems are not yet operational but from information collected from suppliers of the diesel generators and the consumption characteristics, the hours the diesel gensets are expected to run, the potential of energy from wind generators the target should be achievable. Also kerosene will be displaced.**	EEA statistics **(EEC generation performance l figures, PMU wind production data)** 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. **Performance** **Generation costs at Assab Wind Farm reduced by 22%.** **Reduction costs at the off-grid systems could not be ascertained since the systems are not yet running**	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 **<u>Performance</u>** **If the cancelled TA contract is taken as a proxy for savings, 11% per kW has been saved. No new initiatives in place yet. Indicator hard to measure since initiatives can be also private.**	Budgets of new wind initiatives	The necessary staff resources inside ERTC, EEC 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 (EEC) for grid connected wind park planning, installation, operation and maintenance developed	EEC takes the lead on expansion of the Assab wind park or any other new wind park **<u>Performance</u>** **EEC has taken lead in the operations of Phase I. Extension not yet envisaged and according to EEC will depend on the demand and supply situation and the availability of financial resources otherwise EEC has no other constraints and are comfortable in adopting wind energy.** The Operation and Maintenance LogBook of the Assab wind park shows that the park is running smoothly within international parameters **<u>Performance</u>** **Park operating smoothly within international parameters. The availability of wind turbines in the first year of operations has sometimes been deliberately low, due to contractual arrangements to defer minor repairs so that they can be carried out by the contractor to facilitate on the job training.**	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 **<u>Performance</u>** **ERTC has been trained by TA, embarked on study tours to USA and were also trained at Vergnet premises. Further training was provided by Soytes Clean Energy and Electrotechnics Industry Co. Inc on technical and managerial issues. ERTC is still to be trained by Soyut during the training of the trainers training module. ERTC has expressed its commitment to train local experts on preventive maintenance of the off-grid wind systems and carrying out major maintenance on the systems.**	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 sufficient experts are available on the national market for future projects (off- and on-grid)	70% of all technical training courses offered to electricians, technicians, engineers etc. are carried out successfully **<u>Performance</u>** **100% of the training carried so far has been successful. Local experts are still to be trained with sufficient reserves to service wind projects**	Project files	
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 **<u>Performance</u>** **100% achievement. The plan is to carry out more awareness programmes with functional systems in place. 100% of community leaders in pilot sites are aware of the advantages of**	Survey	

	wind energy. Awareness programmes have been carried out through publications in newspapers on wind energy and the project in particular. Interviews were held with Ministry of Information on wind energy covered in local newspapers. 100% of all Regional Administrations leaders in wind rich areas attended inception seminar.		
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% **<u>Performance</u>** **The plant has been up and running for one year at a penetration ratio of 35%. The capacity factor has been affected by two main issues. To safeguard system stability, in terms of frequency control, EEC has been dispatching the plants at Assab at a ratio of 35% wind and 65% diesel. This ensures that the statutory frequency limits are maintained. The second factor affecting the capacity factor has been warranty arrangements during on job training. The preventive maintenance training has been broken into two parts, one on commission (three weeks), and another during the first scheduled routine maintenance. In-between equipment malfunction had to be addressed by the supplier. All turbines were out for an average of 12 weeks awaiting the supplier to carry on job training, though outages were of a nature that EEC could have carried out the repairs. Despite these limitation factors, the capacity factor of 44% has been exceeded, as the actual capacity factor for 2008 was an excellent 50%.**	EEA files	Electricity demand will increase over the coming years
Output 2.1: Necessary contractual	Assab Wind Park is up and running by end of	Site inspection	

framework, including model PPA and wheeling agreement, for a first wind park connected to the Assab grid prepared	year 2 of the project **<u>Performance</u>** **Delayed by 15 months due to non-performance of TA. Assab now up and running. No PPA needed as operator and buyer are the same. However, a model PPA template has been developed in the event of private investment which is provided for the legal and regulatory framework** Future wind parks are using the model PPA and wheeling agreement **<u>Performance</u>** **Model PPA prepared.**	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 **<u>Performance</u>** **The plant has been running for one year. The actual energy production for year one was a commendable 2862 GWh.**	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 **<u>Performance</u>** **Systems still being installed. About 70% - 100% households' houses are wired meaning that 70% - 100% kerosene displacement is possible. Will need to be verified when systems are running** 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

	Performance **Will need to be ascertained through surveys once systems are up and running and the end user tariff will take into consideration affordability and need to recoup costs for operation and provide for components replacement.**		
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 eight additional villages and SMEs have installed off-grid wind systems after one year of project completion **Performance** **Not yet achieved. Project is still to be finalised and replication modalities worked out.** ERTC personnel has applied at real projects certification and approval procedures as well as quality assurance activities. **Performance** **Still to be achieved**	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 **Performance** **No specific financing mechanisms developed besides the standard rural electrification practices (cost-sharing). New revolving or partial grants financing instruments have been considered by DoE for wind projects.**	DoE and ERTC records	
Output 3.3: 5 diesel-wind hybrid and 3wind stand-alone systems installed, maintained and	Installed systems are running smoothly according to international standards by end of year 2	O&M files	

operated	**<u>Performance</u>** **Can materialize during year 4. Standards set under performance monitoring system.**		

3.3 Project formulation

The project formulation covers in detail the key challenges facing the energy sector in Eritrea. These are energy for poverty reduction and income generation activities and social development, security and sustainability of supplies and the need to address environmental concerns. These challenges are real and the project formulation identifies critical barriers, in terms of institutional capacity at central, regional and community levels for both the public and private sectors and the appropriate capacity building activities. The project formulation comes up with appropriate strategies to address the identified barriers encompassing awareness creation, capacity building and strengthening of institutions as well as demonstration projects and their dissemination. The project formulation is well outlined and details these objectives and the desired outcomes are covered in detail, and the monitoring and evaluation systems prepared by PMU are well articulated in terms of verifiable and measurable indicators.

3.4 Project Outcomes

3.4.1 Reduction in greenhouse gas emissions

The reduction of carbon emissions is one of the major objectives of the project. Indicators for reduction of CO_2 emission were developed in both project formulation and the existing monitoring and evaluation systems. During the evaluation, indicators pertinent to quantifying the project outcomes in terms of emission reduction were collected. The information collected was adequate to make an informed decision on the level of CO_2 reductions. Based on the production data, a simple spreadsheet model (RETSCREEN) was used to calculate emission reduction arising from the displacement of diesel used for power generation.

The table below shows the performance data, as collected from the field visit and the derived results.

Wind power	600kW
Capacity Factor	50%
Electricity generated (wind)	2862 MWh
Electricity generated (diesel)	12362 MWh
Total electricity generated	14990MWh
Electricity export rate	US$346/MWh
Base load (diesel) available capacity	2800 MW
Diesel 2008 annual consumption	3535124 litres
System losses	15%
GHG emissions base case	13403 tCO_2
GHG proposed case	11503 tCO_2
GHG emission reduction	1900 tCO_2

The wind farm has resulted in the displacement of 772540 litres of diesel. Since the plant was still on a test phase, this is a good achievement (on average 12 weeks were lost due to on job training arrangements and delays by Vergnet to come on site and carry out maintenance that EEC would have carried out in a short time. What this means is that the *Prodoc* target of displacing 682000 litres on operating the system at 44% capacity factor has

been exceeded. Also exceeded is the targeted capacity of 44% (actual was 50%). One limiting factor is the fact that the integration strategy is to dispatch 35% wind and 65% to ensure network stability. This tends to limit the full wind potential.
One lesson to be learnt is that during the design of integrated systems, full system dynamic studies need to be carried out, as issues of frequency control and system stability are of critical importance during the operations of the integrated systems. This should ideally have been undertaken by the TA.

The other issue worth to note is that in the Prodoc, the target for emission reduction is 1701tCO_2. The actual performance was 1900 tCO_2. The project has thus exceeded the *Prodoc* target. ***It can thus, be concluded that the environmental benefits for the wind park, as outlined in the Prodoc have been commendably exceeded.***

The impacts of the decentralised wind power systems have not been similarly estimated due to their small size and varied applications and uses. The displacement rate of the installed diesel generators will depend on the wind speeds and the actual total demand in the villages (no consumption history so far). What is apparent is the large potential to substitute kerosene. Available data shows that in the targeted villages the estimated number of households is 964. Interviews with the leaders of local communities indicate that the off-take rate is between 70-100%.

Data garnered during this evaluation shows that on average, a household uses five litres of kerosene per month. Working on a lower scale of 70% of households using wind power for lighting, the amount of kerosene displaced could be in the region of 40488 litres per annum (assuming 100% kerosene displacement). Even if the monthly average consumption is an unlikely one and a half litres per month, the displacement is still 12146. This is still significantly above the *Prodoc* target of 6000-8000 litres per annum. ***It can then be concluded that, from an environmental perspective the project objectives have been fully met and the chance of exceeding the stated targets is very high.***

3.4.2 Informed and equipped Institutional Framework for renewable energy

The development of alternative and indigenous renewable energy sources are top priority issues driving Eritrea's energy policy. GoE has been proactive in ensuring the harnessing of renewable energy for development. The DoE's primary objective is stated as: *"to avail ample, dependable and sustainable energy for the growing needs of all sectors in Eritrea at an affordable price.* In achieving this broad objective the issues of adequacy, affordability, environmental sustainability, social equity, are of critical importance. The adoption and usage of renewable energy sources to attain these objectives are high on the agenda. Also taking centre stage is the energy security in terms of lessening dependency of imported petroleum products and increase in electricity generation capacity, grid investments, and access to electricity to rural areas. It is realised that the current power sector performance is characterised by inefficiencies and managerial short-comings; hence power sector reforms were top on the agenda.

In line with the policy objectives outlined in Section 2.2 of this report, major activities are being implemented or have been implemented. Since 1991, generation capacity has increased from 30 MW in 1991 to over 130 MW. The lengths of transmission and distribution lines have similarly increased from 150 km to 400 km and from 800 to 1300 km

respectively.EEChas been reformed to operate on commercial principles, tariff reforms implemented and the creation of an enabling environment for private sector participtionthrough the creation of a regulator. To increase access to electricity and to ring-fence the interests of the poor, a Rural Electrification Fund has been setup. Recognising the role of modern energy in poverty reduction and achieving the MDGs, the Government has been expanding energy services to rural areas by using renewable energy sources.

Moreover, there are over 2000 solar PV systems with installed capacity amounting to 900 kW, for applications such as water pumping, powering health centres, schools, communication facilities has been disseminated. Notable achievements include:

- Increasing power generation has increased from lees than 30 MW in 1991 to around 134 MW;
- Increasing the length of transmission lines has increased from less than 150 km to over 350 km;
- Increasimg the length of distribution lines from 800 km to over 1300 km;
- Rehabilitation of power distribution systems
- Installation of wind and solar resources assessment from 25 meteorological stations;
- Pilot wind energy applications project being implemented;
- Dissemination of improved stove is in progress with 29,000 installed
- Emabarking on a massive rural electrcification programme
- Usage of renewable energy technologies for various applications
- Carrying out preliminary sudies on geothermal energy
- Dissemination of improved stoves

Assessment: The project fits in well and is an integral part of the GoE energy policies and investment programmes. Successful implementation and positive results in actual performance of both systems would greatly facilitate the implementation of the GoE policies and investment programmes.

3.4.3 Improvement to quality of life (health and employment creation)

The off grid systems are not yet operational, and as a result, quantitative data on the benefits accrued is still lacking. In the absence of qualitative data, the evaluation relied on qualitative information, on the possible economic, social development, improvement of health, human well-being, and gender benefits.

Health and Education Service Delivery

Amongst the project beneficiaries are health institutions. Important improvements in health and well-being including alleviation of the burden of disease, health systems, food security and better nutrition, water and sanitation are some of the expected benefits. Many of these factors are linked to poverty and lack of supplies of modern forms of energy. The project is expected to improve health service delivery by reducing energy related health problems arising from indoor pollution. Respiratory and eye illness and other diseases caused by the effects of indoor air pollution from traditional fuels and kerosene directly contribute to infant and child mortality.

Lack of electricity in health clinics, illumination for night time deliveries and other physical burdens of firewood collection all contribute to poor maternal health conditions, especially in rural areas. Some of these problems are expected to be mitigated by the implementation of the project. Modern fuels enable improvement in health through provision of clean water through desalination, less laborious means fetching water through water pumping, food preparation, boiling water to reduce water borne pathogens, refrigeration of vaccines, sterilization of equipment, safe lighting and reduced internal pollution. Applications such as desalination will contribute towards the provision of safe water and sanitation.

The project will contribute to attracting and retaining teachers to rural areas due to availability of electricity in homes and schools. After dusk study and class preparation requires quality illumination. Access to modern fuels and technology frees up time for education, facilitating teaching and learning. Children can read during the night and science can be taught in rural schools. In addition, adult literacy classes could be conducted during the night. Government developmental programmes would reach far flung places, thereby increasing developmental programmes dissemination.

Increased Nutrition and Food Security

The project will improve food production and contribute positively to the country's nutritional requirements. Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active health life (ICSU, 2008). In the context of Eritrea food security is one of the GoE's top priorities and this project, the potential for impact in guaranteeing food security. The potential for wind pumping in wind rich regions is very high. Mechanical wind pumping is an old technology, and according to the farm manager at Dekemhare, there used to be more than 20 systems. Given the availability of medium sized workshops and general engineering companies in Eritrea, the possibility of local manufacturing or addition of local content is high. Production of components such as flat blades is not technology intensive and the item that might need to be imported is the pump.

Areas around Dekemhare are very good for farming. The potential to increase food productivity and job creating is very high.

Photo: Water requirements for this thriving field at Gaharo are supplied by a photovoltaic pumping system. To increase food production a wind water pumping system is being installed under the project.

Economic benefits and Income Generation Activities

Since the systems are not yet running, the benefits could not be quantified qualitatively. The assessment below is therefore based on potential according to data available and interviews with targeted beneficiaries.

Food production presents the largest economic benefits and income generating activity. Information collected from Dekemhare shows that the wind systems will be used for irrigation. At the pilot site 30 ha is under intensive cultivation with plans to extend the area under cultivation by a further 10ha. Water is derived from a borehole with a head of 40m. The drilling of the borehole was financed by the beneficiary together with the irrigation systems and storage tanks (4x20m^3). The farming operations started two years ago.

Currently, 21000 vineyards, imported from Greece are under cultivation under nine hectares. It is planned that wine will be produced on the farm. The farm has currently twenty dairy cows and at full production the herd is expected to be 150 dairy cows. The milk processing will take place at the farm and sold at Asmara and other towns. The production of milk is 20 liters per cow per day. The farm also produces cabbages on ¼ ha of land. On average 7000 cabbage heads are produced. In addition, the farm produces 300kg of beans per farming season. The following activities are carried out at the farm and needs energy.

- Grinding of stock feeds
- Dairy processing
- Wine making
- Lighting
- Pumping

- Mechanical processing

The potential income could be calculated from the following information made available during the evaluation:

Table 4: Income from Farming Activities at Dekemhare

Product	**Yearly production**	**Unit price**	**Total income (NFA)**
Wine	Could not be ascertained		
Milk	1,095,000	12 NFA/litre	13,140,000
Cabbages	3000	5NFA/kg (average 2 kgs)	30,000
Beans	300	10NFA/kg	3,000
Total			13,173,000
Total in US$			878,200

The calculations show immense economic and income generation activities. The area lies in a good farming zone with a significant number of farmers, whose sources of fuel for farming activities is diesel. The calculation further emphasizes the need to encourage the need to link energy supplies initiatives to income generation activities.

The above case serves to demonstrate that sustainable energy supplies such as electricity from wind are essential to generate jobs and incomes as well as stimulate industrial activities, commerce, micro-enterprises, and agriculture outputs. During the evaluation it was reiterated that many investors are willing to invest but availabilty of electricity is a barrier. Interest has been shown in investments in tourism given the availability of wide beaches on the Red Sea and unique geological volcanic features unique to Eritrea. ***It is the opinion of the evaluator that wind for income generation activities, particularly irrigation coupled with increase in local technological content should vigorously be explored during the replication phase.***

Photo: Eritrea is endowed with long wild Red Sea coast – Tourist paradise and tourism investment bargain

Photo: Sunrise seen at the background of Eritrea's sand dunes and the Red Sea in the background.

Photo:Volcanic activity unique to Eritrea

Electrcicity also has the potential to substitute firewood, which is scarce in the South Red Sea areas such as Beylul and acquired at distances of 30-40km using trucks and camels. The cost of fuelwood is 20NFA per 100kg (usage 200kg per month). Camel transportation costs are currently pegged at 40 NFA per 40 kg. It is unlikely that social benefits arising from the substitution of fuelwood would be realised. The general perception is that the majority of households would not afford the costs of electrical stoves. Cost indications from Southern Africa, where elctrical stoves are widely used is about US$200 or 3000 NFA, which would be unaffordable in rural Eritrea, where incomes are generally low.

The common fuel used for lighting is kerosene. An average family uses about 5 litres of kerosene for lighting per month. This translates to 60 litres per year. The cost per litre is 12NFA per litre, meaning that the total annual average kerosene costs is estimated at 720NFA per annum or 60NFA per month. The average household tariff is about 2.52NFA per unit. The average household monthly electrcicity consumption is about 50kWh. This means that the average monthly bill is in the order of 126 NFA. Fifty percent of the households use batteries for radios. The total cost per month is 13NFA. The total energy costs would be in the region of 83NFA.

Since the kerosene cosumption levels vary up to 10 litres per month, The cost differential is marginal. This means the benefits accrued through the displacement are marginal and the benefits can only accrue though the usage of advantages for cleaner energy sources with a higher calorific value. It was due to this reason that some households indicated their willingness to pay, based on the replacement value of the kerosene they are using. An added motivation is the fact that the equivalent monthly electricity bill, electricity will offer them, the cooling, which is essential.

Some income generating activities use diesel for power generation. The generators are of the 5kW range and are usually run for four hours. Typical consumption levels of 5kW generators are 8 to 10litres per 8-10 hours. The daily consumption is thus about five litres, resulting in monthly consumption of 150litres of diesel. The diesel is generally procured at a price of 16NFA per litre. The montly diesel cost is therefore in the region of 2400NFA. When operating for 4 hours, the montly electricity would be in the order of 600kWh. The tariff for small business is 2.6NFA per kWh. The monthly electrcity cost would be 1560NFA. This means that for large energy users the project results in significant cost savings and increase in disposable incomes.

It is worth noting that large energy usage is generally associated with income generating activities. ***The conclusion is that for small energy users, the household gain from fossil fuel displacement is marginal but, benefits acrrue from using higher efficient and cleaner energy sources. This is typical for the large users (due to income generating activities, the benefits accrue from both reduction of energy costs and increase in disposable incomes, increased productivity and improved goods and services).***

Sources of Income and Implication on household expenditure.

The sources of income are varied, ranging from salaried employees, such as teachers, health personel and other salaried employees to households, surviving fron subsistence activities. For this category of households, the main source of income is from fishing and trade. Fishing is influnced by factors such as wind. As a result, there are two fish harvest seasons in a year, and the yield is one to two tonnes per season. Assuming the lower case scenario of one tonne per season, the annual yield would be two tonnes. The average price of fish is 2-3NFA per kg. The annual average revenue from fishing would be in the order of 4000 – 6000NFA. This income is used for daily needs including energy. At the average monthly energy costs of 126NFA, the energy cost would be approximately 37.8% of the average monthly income. This figure is very high as the international benchmark average is 10%. What this means is that there are other incomes that sustain the households apart from fishing revenue.

The evaluation sought to determine the nature and level of these additional incomes. It was found out that households derive their incomes from the Arkobkobai plant.

Photo: An Affar woman, at the Village of Gahro shows mats made from the Arkobkobai plant. Wind battery charging sytem will increase her mats making economic activity more productive and increase her income generating activity.

Villagers produce an alocoholic beverage called *doma* from the Arkobkobai plant. The monthly income from *doma* ranges between 300NFA to 500 NFA. The Arkobkobai plant is also a source of raw materials for the production of mats. The monthly mats production is between 7 and 10 sold at a price of 25 NFA. This means that the monthly income from mats is in the region of 175NFA to 250NFA. The plant is also used to produce rope (12-20 ropes per month, with a rope costing 5NFA). The total monthly incomes from ropes is estimated at 60NFA to 100NFA. The total monthly income from these activities and products is conservatively 535NFA. Inclusive of fishing activities the average income is 868NFA. Since the average electricity bill is estimated at 126NFA. The energy costs as a percentage of average monthly income would be a reasonable 14.5%. Monthly income from the above income, and seasonal incomes from fishing is supplemented, if necessary, by income from livestock. The availabilty of income from livestock is as follows:

Table 5: Sources of Income at Pilot Sites

Type of livestock	**Average availability per household**	**Price range (NFA)**
Goats	20	700-900
Cattle	5	1500
Camels	5	1900

The conclusion that can be derived from the analysis is that the available incomes are enough to pay for energy services. However, the availability of incomes is erratic, as some is seasonal (fishing) and some, especially from livestock is on a need basis. This means that the payment mode should be flexible to accomodate frequency of incomes and willingness to pay. The payment mode could be monthly, half yearly, or yearly (as long as payment is upfront).

The project will have the potential for very positive economic and income generation benefits. Improved lighting will result in more time for the production of traditional products such as mats and ropes as night time can also be utilised. Activities such as fishing will also benefit from icemaking for storage of fish.

Gender issues

Being the regular users of energy, women will benefit immensely from the project. Lack of access to modern fuels and electricity contributes to gender inequality. Women and children are responsible for most household activities. This takes time away from other productive activities such as education and participation in social events. The project will ensure improved lighting, possibilities for cooling equipment in kitchens increasing comfort and helping daily routines. The health hazards e.g. from kerosene lamps smell and emissions would be reduced. The provision of electrical lighting will provide better opportunities for income generating activities, as the making of mats and ropes are usually carrying out by women. The provision of electrical power will enhance ice-making and food conservation possibilities reducing distances to services. This will improve child care possibilities and amenities.

Minorities issues

The target population consists of numerous indigenous groups and religions living together in harmony, and therefore no evident *minority* issues appear to exist in the project. The project will therefore benefit all citizens of Eritrea. Furthermore, according to the Southern Sea Administration Office, the project will ensure that services are provided to other people who are generally nomadic, by ensuring that they are provided with basic services at central locations. The project will also slow-down rural to urban migration by providing for local income generating activities.

Rating: The project will have highly satisfactory environmental, economic, social development and better well-being benefits, especially in the long term. The potential for income generating activities is immense.

3.5 Implementation approach and Project ownership

The implemntation approach is based on the piggy back approach of the development projects especially rural electrification programme. The approach is simple and utilises synergies of the different strategic players in its execution, with well defined roles of each player. The corner stone of the implementation approach are the implemantation guidelines. These were developed in consultation with all the key stakeholders and more importatly through their inputs. This ensured that their roles and level of participation was defined from the onset and any pitfalls were adressed during formulation. The consultative approach also ensured stakeholder buy-in

prior to implemntation. The implemenation approach included giving well detailed information on the project background, its objectives, necessary agreements and contracts, performamnce monitoring and evalution framework, outputs and procedures, management guidelines, project components, status of the projects, intergration to existing grid (wind farm) and intergration to existing self contained systems consisting of diesel gensets, procured by the South Red Sea Administraion Office and the local electricity grids financed by the South Red Sea Admistration Office and installed by EEC.

The objective of the guidelines were to give all participating stakeholders information on proper management of the facility and guidelines on transfer of ownership. The template on handover of facilities was also included as an appendix to the hand over document. Three copies of handover forms were made availabilbe to EEC, Regional Adnminstration, and DoE. The DoE handover to local admnistration office was done in the presence of the Regional Admnistration.

The documentation to EEC included important information such as the project document, Geotechnical investigation, report and topographical map of the Assab Wind Farm by GEDECC, contract agreement between DoE and Vergnet, technical specifications and bill of quantities for foundation Blocks and Cable trenches of the Assab Wind Farm, two copies of the software – SEMATEC licence and one copy of Windows XP Service Pack.

The technical admistration of the project entails the local admistratiom being responsisible for managing, operating and maintaining the systems. The local admistration, as owners of the systems are also responsible for protecting the systems from acts of vandalism and theft. The local admnistrations have thefore full control over the management and ownership of the off-grid systems and EEC full management of the wind farm.

The local administrations are to monitor operations and maintain each system. Each local admistration has nominated an average of six people to be trained by ERTC (after it has been trained by Soyut). These have been selected according to their academic and technical background. The village technicians are expected to participate in operation and minor maintenance activities, while the technical back up and periodic maintenance are to be carried out by the ERTC, though, the former may eventually take over the task.

to carry out operations and monitoring of the wind systems and trained by EEC on maintenance of diesel systems.The trainees have been chosen on their academic background and some on their basic knowledge on maintaining diesel fishing boats..

Of the trained people three will be fully employed to carry out shift work on operations and maintenance and meter reading and the rest will be used as reserve. Since the electrical private sector in Eritrea is thin, it is hoped that the additional personnel trained in the operations and maintenance system will form a future nucleous of the private sector to service the systems. Major diesel gensets and grid maintenance will be carried out by EEC and ERTC will carry out major maintenance of wind sytems and regular preventive maintenance.

The Finance Department of the local adnmnistration would get training from EEC on bill production. Joint visits will be undertaken by EEC and ERTC on quarterly basis to monitor the systems. The joint team report to be sent to DOE as soon as possible. The local operator will also be logging data according to the prescribed reporting format. ***This format has been reviewed by the evaluator and seems to capture critical wind perfomance data fully without***

burdening the end user and will be very useful for future wnd installations and applications in Eritrea and elsewhere.

An accounting system has been developed for the systems, which detail bill accounting, settlement and financial management. The bill accounting system is designed to ensure system sustainabilty through regular and timeous payment for system usage. Meter reading is carried out on the 15th of each month and bill preparation should be ready by end of the month and distributed by the first part of the month. The latest day for bill preparation is the 13th of each month. Failure to settle the bill would result in a warning being given during the meter reading cycle and disconnection by the end of the month. ***This is a sound utility paractice that would work if it is implemnted without outside inteference. In many utlities, this is the norm but utilities are still saddled with huge revenue losses due to non diconnection of service due to outside influences. The other observation is the need to inbuild mechanism to deal with genuine cases of failure to pay due circumstances beyond the consumer's control. This might arise due to temporary cirucmstances such a death in the family, temporatily affecting the consumer' s ability to pay.***

The core of the mangement structure is the setting up from the beneficiaries an Electricity Committee. The committee overees all the operations of the wind-offgrid systems and consists of three members, two of which shall be signitories to a bank account to be used for banking all payments from the sales of electricty. To maintain financial checks and balances, the third signatory shall be the Finance and Admnistration Officer of the South Red Sea Region.

Revenue collected shall be used for maintenance of system, purchasing consumables and spare parts e.g. lubrication oil and fuel for diesel generators. The purchase of spares and consumables shall be done by the purchase unit of sub South Red Sea Region in collaboration with EEC, DoE or ERTC who will provide technical input. The auditing of funds shall be every two years, by the audit section of the South Red Sea Region audit unit, who in turn can be audited by Audit Corporation.

The machnisms put in place are operating well for other projects such as rural electrification, and appear reasonable enough to ensure financial accountablity.

The implemenation approach takes into account tariff principles to be applied for rate determination. The tariff shall comprise, in line with the current utility practices, a connection fee and monthly consumption charge. The connection fee for small busines has been pegged at 700 NFA to be paid and for domestic consumers at 300 NFA to cover service charges such as meters and connection cables. The monthly tariff has not been set, but will be determined by the EEC and the local admnistration office taking into consideration affordability, consumption levels and cost of service. It is planned that the systems will run for one month to enable the collection of data for rate determination.

Two critical issues need to be highlighted. The first is to ensure that revenue collected should be adequate to cover operational expenses and financial reserves for component replacement. The second is the level of affordabilty, to ensure that the largest number of consumers in targeted villages are connected. ***This calls for an approach, where a financial analysis should have been carried out upfront to dertemine the possible operational costs and the appropriate levels of tariffs households have to pay to afford the service from the system. This would have been followed by a survey to detemrine the level of affordabilty that would be accepted by***

consumers. Running the system for one month might not provide all the critical information needed to determine the system running costs and replacement requiremnts on one hand and the tariff the consumers might be willing to pay.

Rating: The project implementation was characterised by a consultative approach that took on board inputs from the critical stakeholders and this has ensured the necessary stakeholder buy in and active involvement. The partnerships established are effective and well coordinated and the PMU has managed the implementation approach very well and have managed to mobilise all stakeholders to a common objective of ensuring the success of the project, taking into consideration local structures and community priorities. The piggy back implementation approach seems to have been very effective and has established synergies between this project and other developmental projects. Even the site selection was adopted from the local administrations' own developmental master plans. An important lesson is that projects that have a large input from intended beneficiaries stand a bigger chance of success.

3.6 Country ownership/Driveness and Stakeholder Participation

The country's ownership and stakeholder participation has been very high. All critical segment of the energy community contributed positively to the project implementation. The next sections summarises the contribution of the different stakeholders contribute to the project.

Intended Beneficiaries

Beneficiaries contributed directly by providing labour for installation of the local electricity reticulation. Some of them bought electricity meters. If a meter was purchased by individual it needs to be tested by EEC and remains the property of the purchaser. The beneficiaries also carried out their own internal wiring, based on EEC specification and inspected by EEC. They also have the obligation to pay timeously for the energy used.

DOE

DoE has been restructred to establish the regional Affairs Unit. The unit will deal with specific issues of the Regional Administration Offices. The Unit is to liase with the Zoba Administrations for their participation in the implementation of energy projects planned centrally by the organs of the Ministry of Energy Mines, to assess specific energy needs for their planned development programmes, analyse and compile characteristic energy resources such as modern biomass, biogas, geothermal, hydropower, wind, solar, coal, etc. and their potential applications. This would ensure more efficient delivery of energy projects.

DoE hosts the project and has integrated the PMU within its proper structures. DoE through the PMU carries out day to day project management and coordinates the implementation of the project with relative stakeholders. The DoE has been instrumental in introducing wind technology in villages and hands over the projects to the beneficiaries through well documented procedures. DoE has established project monitoring procedures and assesses performance. As an integral part of GoE, DoE has partially financed the project. It shall provide technical assistance to local administration offices in procurement of spare parts for wind turbines and replacement of components and refurbishment of the turbines. It has shown total commitment to the success of the project and wider adoption of wind energy and other renewable technologies.

Energy Research and Training Centre (ERTC)

ERTC is an essential player in the project implementation. The wind data gathered by ERTC has been used to select and design the systems as well as selection of future sites for replication. ERTC will be instrumental for training local experts on the operation of wind systems, preventive maintenance, and assistance in the specification of components during procurement. According to ERTC's own account, they are totally committed to the project and are ready to fulfil their project mandate as soon as the necessary training is provided by the supplier. ERTC will be conducting quarterly monitoring visits to the sites and will be providing technical immediate back up service in wind turbines.

The involvement of ERTC is a continuation in its mandate to disseminate renewable energy technologies. ERTC has installed and ever since has been operating a network of 25 wind and solar measuring stations for the last 10 years and have been collecting data and establishing a data library part of which was used for this project. ERTC**,** in collaboration with line ministries, has installed PV's for more than 60 health centers, PV's for 250 clinics and 230 solar water pumps as well as several solar powered communication failcities. It has also disseminated 200 solar home systems and the promoted efficient biomass stoves.

EEC

EEC owns, operates and maintains the Assab Wind Farm pursuant to training given by Vergnet SA to its technical personnel and General Operation and Maintenance instructions developed by Vergnet. It monitors and makes follow ups of the operation of Assab Wind Farm and sends to Vergnet weekly and monthly reports, especially during the warranty period. It carries out periodically checks and stocks sufficient necessary spare parts and consumables to assure sustainable operations of the wind park. It is the mandate of EEC, to promptly notify Vergnet, should there be any defect or abnormality discovered in the wind park during warranty period. EEC is also responsible for periodically collecting performance reports from the pilot project, which would be useful in preparing large –scale future wind projects. Other duties of EEC include:

- Giving assistance in installation of diesel gensets by local admistrations
- Giving assistance in installation of local electricicity distribution systems
- Inspection of internal wiring of households
- Giving training in operations and maintenance of diesel gensets
- Carrying out quarterly visits in sites with diesel gensets
- Sending quarterly perfomance reports to the DOE
- Carrying out regular preventive maintenance to diesel generators
- Giving immediate backup technical service to the operations and maintenance of the diesel gensets
- Giving training on bill preparations to the local admnistration offices
- In consultation with local admnistration offices, setting tariffs and giving assistance in the procurement of lubrication oil, fuel, spare parts and diesel generators

Regional Administration Office

Regional administration offices have been financing the construction of local electricity networks and the procurement of diesel generators for the hybrid systems, which have been handed over to local administrations. It is to be involved in the monitoring and follow-up the performance of diesel gensets and wind turbines. They are also responsible for timely rectifying problems encountered in the operations of the systems and in the event of technical problems, liaising with DoE, EEC and ERTC. In consultation with DOE and local administration offices, Regional administration offices are responsible for procurement of spare parts required for diesel generators and replacement and refurbishment of the diesel gensets. On the financial front, regional administration offices participate in monitoring cash transactions in procurement of lubrication oil, fuel, and other consumables in consultation with EEC. They are also responsible for auditing accounts and fixed assets of the systems and the dissemination of wind energy facilities in collaboration with DoE.

Local Administration Offices

Local administration offices are the owners of the systems. They provide candidates for training and are responsible for the setting up of Electricity Committee, with controls and manages assets income and expenditure. The local administration offices take care of the ownership during the project phase and the operational phase. They are responsible for safeguarding the facility and respond to households requirements. They ensure, through the accounting unit of the local administration office preparation of bills, revenue collection, banking and paying monthly salaries to staff. Local administration offices are responsible for procurement of spares and consumables in consultation with the regional administration office and informing regional administration offices timely on any unprecedented problems with the management and operations of the systems.

UNDP

The UNDP Office has played an active role in supervising the project progress and facilitated in its implementation. It has provided valuable operational support and positive interventions in providing the complementary financing to cover the initial commitment of GoE as well as to finance the cost overrun of US$ 258,000 in the procurement of the wind turbine equipment for the decentralised component. Both contributions were made quickly and in a flexible manner. In the absence of a TA, UNDP took a positive role to assist the PMU with procurement guidelines. The efficient performance of the UNDP office through the sizeable financial contributions has provided the life-line to the project at a very critical stage**.**

The office has up to now more than fulfilled its function as the GEF implementing agency and has done an excellent job in the present circumstances. Its continuing close co-operation and support is essential for the final stages of the project and in preparation for replication and designing an exit strategy.

Private sector

The involvement of the Eritrean private sector has so far been limited to the utilisation of local sub-contractors by DoE in the civil works at the Assab wind park and off-grid systems. During the initiation workshop of the projects, apart from the governmental and non governmenbtal organization, various potential private firms, which are believed to be engaged in wind energy technology dessimination were also invited and participated. The Association of Electrical

Contractors has also sent its representatives to some of the training programmes under the project. It is expected that more representatives of the private sector will participate in the training of local experts. The number of nominees has been designed to exceed the current requirements. DoE and the private sector contractors have been able to identify design flaws in civil works and recommend practical solutions, that was accepted by international contractors.

The replication phases will most probably offer growing opportunities for the private sector participation in the construction and O&M activities at the parks and villages. This is very much dependent on the GoE overall policies towards the private sector and specifically those of EEC.

Donors

The evaluation had a chance to discuss the project with the World Bank's country office in Asmara. Office categorically stated that they are very much aware of the project and have been receiving progress reports and are very satisfied with the project's objectives and attainments.

Given the need to start working on replication and the financial mechanism, there is urgent need to engage the donor community and other financiers on their active participation in the replication phase. The donor community and financing agencies have the potential to step in either being lead financing agencies or project co-financiers. The World Bank in particular, has expressed willingness to mobilise funds for the replication phases, should the GoE express interest. Donor assistance towards replication investments should be urgently explored, and initial consultations should commence, given the lead time needed for decision making.

Potential financiers to be approached include the World Bank, which has been financing the rural electrification programme and has expressed willingness for mobilising financial resources for wind replication. SIDA has been financing the development of sustainable energy policies for countries in sub-Saharan Africa through AFREPREN, of which Eritrea participated. SIDA has also funded the wind measurement stations in Eritrea. In Tanzania, SIDA has been funding community based local electrical networks. In addition, DoE should intensify the existing operational co-operation with the Brussels based EU Energy Facility, also a potential financier.

The African Development Bank has shown initial interest in the sector and is already financing through FAO desalination and ice-making investments in fishing villages, including Berasole and Edi. In addition, the regional FINESSE renewable energy technical assistance programme would be able to provide support. The same applies to the specialised UN agencies with on-going programmes very relevant to the decentralised wind systems, such as FAO (agricultural water pumping, ice-making and desalination in villages, including two of the pilots sites), UNICEF (water supply projects in several villages with installed diesel generators in place).

A number of private internationally active foundations often support renewable energy projects with positive social and environmental benefits. Private corporations, including the major oil and gas companies (e.g. Shell) have embarked on supporting renewable energy research and pilot projects also in emerging countries. All these potential partners are also worth exploring in this context.

Rating: ***The key participating stakeholders, DoE, EEC, ERTC, regional administration offices local administration offices and households have effectively been integrated into the project and have contributed to the project in a very positive manner. There is need to urgently engage***

donors and other financiers in preparation for the replication phase. More pro-active approach should be taken by PMU and DoE in this respect.

Effectiveness

The project is almost complete and has very satisfactorily addressed its objectives. Indications are that the generation costs have been reduced by 22%. Whether this would filter to the intended beneficiaries remains to be seen, due to the uniform tariff setting mechanism by the regulator. The project seems to be on course to meet its economic, social, and environmental objectives.

Capacity building:

The shortcomings in the performance by the TA have left a gap in the training as well as advisory support designed for the project. However, with the assistance from EEC and UNDP, the void left by the TA has been covered, and this has resulted in the PMU and other participating institutions assuming the TA role earlier with commendable outputs. The absence of the TA has turned out to be a blessing in disguise as financial resources have been saved and PMU had to quickly adapt to capacity building challenges. The procurement process for the wind park was delayed due to insufficient hands-on guidance available for the PMU staff and DoE. However, the procurement for the off-grid systems were executed efficiently, with the problems encountered on risk assessment being beyond the control of PMU.

The role of the TA needs critical review. It would have been easier from the beginning, to have identified wind energy systems procurement training needs and given training to PMU. The PMU had the necessary experience in carriying out internatinal procurements. But what was required is wind-enery related specicifi procurement trainings. This would have saved a lot of time. ***A useful lesson is that, generally in many developing countries, the capacity to carry out projects is there, but what is needed is good coordination skills and confidence building measures to the participating teams. These could be achieved through least cost targeted training, such a short course on international competitive bidding practices.***

Rating: Performance very satisfactory

3.7 Replication approach

Major milestone have been achieved in this project in terms of the project goals, which are the removal of barriers such as Capacity /Institutional Barriers, Awareness/ Experience Barriers and Technical Barriers. In the opinion of the evaluator, these barriers have been largely been removed. The stakeholders have also totally owned the project as evidenced by their level of participation and contribution to the project.

The cornerstone to the satisfatory achievement of the project goals is the existence of strong political will to implement sustainable energy policies and programmes. There are srong synergies between policy formulation and implemantion. ***The major lesson is that strong political will is critical for the success of developmental projects.***

The second lesson is the need to involve the critical stakeholders in decision making in projects involving them, and the intergration of key stakeholders from the onset. This would

ensurethat their concerns are taken earlier on board and their strengths are identified and optimally utilised.

In the case of this project, it was succesfully implemented through adaptive management strategies, that ensured that, local competencies are effectively harnessed to ensure the project's success. In the absence of the TA, critical stakeholders such as ERTC, EEC, regional admnistration offices, local admnistration offices and the beneficiaries were effectively mobilised to ensure the success of the project. Notwithstanding the project success a number of issues need to be addressed, to ensure the strengthening of country ownership, stakeholder participation, capacity building and project sustainability.

Currently, there is a conducive policy environment for the promotion of wind and solar energy technologies. The Government has within its limits, demonstrated its commitment by allocating resources to the development of renewable energy technologies. The effectiveness to deliver the required energy services in an acceptable manner is crucial for their wider dissemination and continued use. For this to be achieved, a number of critical factors need to be put in place.

Local technological development

In Africa, energy planning and development institutions have pursued public procurement approaches, that simply replicate technologies developed by overseas suppliers, without due respect to reduce overseas content ratios through greater domestic involvement in technological development. Wind mechanical systems for water pumping have been developed, adopted and disseminated in Africa, for a long time. Countries such as Kenya, Zimbabwe, and South Africa for example, have been manufacturing and installing wind mechanical systems for a long time, using local content. Most of these systems are functioning well. In Eritrea, wind mechanical systems, have been used before. The country has engineering companies and mechanical workshops that are ideal for the production of wind mechanical systems. Probably, only the pump might need to be initially imported. Given the need to improve on food security and the potential of income generating from farming activities, local manufacture of wind mechanical systems could be pursued. This would strengthen the local capacity of private sector and local industry and open opportunities for manufacturing other related products internally. Partners such as UNIDO could be approached for technical assistance in technological transfer.

Development of local standards

The development of local standards is important for two reasons. The first major objective is that renewable energy technologies are at different stages of maturity. As this project demostrated, international standards, eg for civil works are not necessarily appropriate for local conditions. Due to the proliferation of different technologies, some of which have been a high failure rate, some renewable energy technologies do not command social acceptance. The development of appropriate local standards will improve the reliability of renewable energy systems and improve on systems social acceptance. Local standards will also provide minimum acceptable performance to guide the local private sector during replication of wind energy applications.

The Eritrean Standards Institute is supposed to be responsible for quality control and certification of such technologies but does have the institutional capacity to do so. In view of this, the Department of Energy has taken the responsibility to set standards and guidelines for renewable energy technologies. To this effect the Department has prepared draft

standards/regulations for RETs based on International Standards Organisation. To ensure sustainability and increased role of the private sector, as envisaged in the energy policy, there is need to proactively involve the private sector in the whole process of technological development and dissemination, guided by appropriate local standards.

Increased role of the private sector

The development of energy infrastructure is capital intensive. In Eritrea, investments in the energy sector are largely through the government and other developmental partners, whose capacity to finance energy projects is generally constrained. There is therefore need to reduce the burden of governement in financing energy projects, given that other equally important sectors also need investments that are usually financed or guaranteed by Government.

Eritrea has been implementing energy sector reforms. These power sector reforms, like reforms in other emerging markets have been targeted at attracting private sector investment in the sector. The ability to attract private sector investment in the sector and the resultant improvement in energy supplies could be considered an indicator of the success of the reforms. Generally, three factors argue for the support of private sector investments in the energy sector. These are lack of capital, efficiency improvement and poverty reduction.

Investments in the power sector are capital intensive and as have been stated, GoE's financial capacity is limited. The table below shows the investments needed to improve energy supplies to the poor (2005 -2015).

Table 6: Summary of investment requirements for improving energy access to the poor (in Million USD)

		2005	2010	2015	Total 2005-2015	Average 2005-2015
Rural grid based electrification	Capital costs	3	4	5	43	3.9
	Operating cost	1	1.2	1.2	12.4	1.13
	Total	**4**	**5.2**	**6.7**	**55.4**	**5.04**
Electrification through wind of villages/semi-urban areas	Capital costs	1.2	2	3	22.6	2.05
	Operating cost	0.8	1	1	10.4	0.95
	Total	**2**	**3**	**4**	**23**	**3**
Wind Water Pumping Units	Capital costs	1	1	1	11	1
	Operating cost	0.4	0.4	0.4	4.4	0.4
	Total	**1.4**	**1.4**	**1.4**	**15.4**	**1.4**
Solar PV for schools, health facilities, water pumping, solar home systems, MSMEs	Capital costs	1.64	1.64	1.64	18	1.64
	Operating cost	0.22	0.22	0.22	2.4	0.22
	Total	**1.86**	**1.86**	**1.86**	**20.4**	**1.86**
Improved stoves 400,000 households	Capital costs	0.5	0.8	1.0	8.2	0.75
	Operating cost	0.1	0.2	0.3	2.1	0.2

	Total	**0.6**	**1.0**	**1.3**	**10.3**	**0.77**
Biogas units of different sizes	Capital costs	0.4	0.4	0.4	4.4	0.4
	Operating cost	0.12	0.12	0.12	1.32	0.12
	Total	**0.52**	**0.52**	**0.52**	**5.72**	**0.52**
	Grand Total	**10.38**	**12.98**	**15.78**	**130.22**	**12.59**

Source: Dr Semereab Hebastion

An average of 12.6 Million USD per year is required between 2005 and 2015, bringing the total investment to over 130 Million USD. Significant government and donor support is required to realise the stated energy goals. There is need to seek recourse to private sector to finance and supply energy services. To attract the private sector, Government would need to put in place appropriate policies (that are consistent), incentives and guarantees for the prospective private investor. The involvement of the private sector in itself would not be adequate to achieve the desired results, but other critical factors need to also be in place. These include country-specific macroeconomic and institutional framework and good corporate governance for reforms to work.

The macro-economic policies of a country are important in determining the country risk and the level of enabling framework for economic development in general. These factors define a country's overall investment attractiveness and are critical in the investor's overall decision to consider a particular country for investment. It is very challenging for industry to develop when the economy is often hit by macro-economic shocks and by financial crises. High volatility in the inflation rate, exchange rates, and interest rates increases the cost of capital and uncertainty in a manner that makes it harder for investors to undertake the kind of long-term obligations that are required by infrastructure projects.

Given globalization and the fact that investors are concurrently comparing investment opportunities in many countries, the failure of a country to meet certain risk and credit ranking thresholds (which reflect the political and macro-economic policies of a country), can exclude them from even being considered by many investors and lenders. Mobilizing private capital into the power sector of emerging markets is also affected by the extent that domestic capital markets and the banking sector have evolved to the level where they can effectively channel domestic savings into domestic infrastructure.

Harmonization of activities and programmes by institutions

The Ministry of Energy and Mines has been pursuing an aggressive approach in providing modern energy services to the rural communities. There is need for other line ministries to take on board energy opportunities identified as least cost options by MEM during the implementation of their energy components of their projects. This calls for closer cooperation and collaborations betwwen the MEM and other line ministries. An assesment by DoE shows the following levels of interractions with other key organisations and proposed solutions

Table 7: DoE interrelationships with other organizations

INTERRELATING ORGANIZATIONS	*NATURE, AREA AND EXTENT OF PRESENT OR FUTURE RELATIONS*	EVALUATION 1-2-3-4-5 FOR LOW, FAIR, GOOD, V/GOOD, EXCELLENT	PROPOSED SOLUTIONS
1. EEA, PCE, ERTC, HD	*MANAGEMENT AND DEVELOPMENT ISSUES IN THE ENERGY SECTOR*	4	MORE INFORMATION EXCHANGE, CONSULTATIONS
2. Ministry of Local Government	- Co-ordination of development programs - Promotion and public awareness - Representation in development programs - Information exchange - Electricity co-operatives	3	- Representation in zobas - Regular meeting - Consultations - Workshops & Seminars - Strengthen Regional Affairs Unit
3. Ministry of	- Public awareness	2	- Press releases

Information	- Promotion		- Consultation - Workshops & Seminars
4. Ministry of Finance	- Budget - Procedures manual - Inspection - Coordination of programs - Information sharing	4	- Regular meeting - Consultations - Workshops & Seminars
5. Ministry of Industry & Commerce	- Coordination of development programs - Information sharing - Laws, Regulations, Standards	3	- Meetings - Consultations - Workshops & Seminars
6. Ministry of Agriculture	- Public awareness - Biomass energy resources issues - Reforestation programs - Information sharing - Co-ordination of research & development programs	3	- Regular meeting - Consultations - Workshops & Seminars - Enhance coordination programs - Develop joint programs
7. Min. of Education	- Training - Energy in curricular - Power for rural schools	2	- Meetings - Consultations - Workshops & Seminars
8. Min. of Health	- Power and hot water for health centres - Information sharing	4	- Meetings - Consultations - Workshops & Seminars
9. Min. of Environment, Land & Water	- Policy issues - Co-ordination programs - Laws and regulations - Information sharing - Pollution from energy	3	- Regular meeting - Identify area of co-ordination - Consultations - Workshops & Seminars
10. Macro policy & Econ. Cooperation	- Financing of programs - Information sharing	3	- Consultations - Workshops & Seminars
11. Asmara University	- Research and training	3	- Regular meeting - Consultations - Workshops & Seminars

Source: DoE: Business Plan-2008

The table shows that though the level of interactions is high, there is still room for improvement.

EEC Planning capacity

Discussions with EEC Head Office in Asmara shows that, though they appreciate the role of wind and if funding was available, there was total absence of long term generation plans, that would incorporate wind energy technology during replication. It appears that they are not yet producing system development plans and are relying upon government to dictate further usage of wind for power generation. The objective of a system development plan is to determine a least-cost generation expansion programme, through an evaluation of technically equivalent alternatives in order to satisfy the forecasted demand under a given criteria.

The technically equivalent options are drawn from feasible options that encompass existing and new internal generating capacities. This is to ensure economic least cost and reliable power supply. During such studies, a broad range of planning issues, such as the size of the units,

output of the units, technologies to use, fuel availability and costs, timing, siting, environmental issues and costs, etc are considered. The availability of the system development plan would have been used to define the role of wind energy technology in future generation plans. There is need to strengthen EEC to use modern planning tools for both generation and transmission planning.

Linkages to other income generating activities and investments

The power demand in Eritrea is generally low to support large investment required for large transmission systems (except in large urban centres, which are connected through 115kV transmission networks). This means that for a foreseeable future, self contained systems are cost effective in meeting local electricity needs. The challenge is to connect local grids to the national interconnected systems. In the absence of large back-borne transmission networks, connecting self contained systems to the national interconnected transmission systems, wind can at the present time be utilised in areas that are rich in wind energy and the benefits cannot accrue to load centres that do not have appropriate wind speeds.

This means that the demand has to be created in wind rich areas such as the Red Sea Region, to support income generating activities and other productive uses, instead of grid extension. There is significant potential for water pumping, especially usage of wind mechanical systems for irrigation. There is also very good tourism potential. There is need to scout for investors to develop tourism infrastructure such as hotels along the Red Sea and use wind energy to provide energy for such infrastructure. Wind energy could be used to support local fishing industry through refrigeration and processing. Integrating wind energy to income generating activities and other investments would ensure sustainable financing and address affordability issues, since the activities would pay for the systems.

Strengthening of the capacity of the regulator to attract private investments

The Government of Eritrea has opened up the power sector and has established the office of the regulator. The functions of the regulator are licensing, promotion of power investment and competition, development of standards and codes and ensuring compliance of the same. The power sector reforms liberalisation allows for competition in the generation and retailing of electricity. Though it is in its infancy stage, the regulator will in future playing a leading role in the liberalised electricity market in Eritrea. In other countries regulators has played a critical role in the development of the energy sector. Through their mandate, the regulators in other countries have been instrumental carrying out energy market transformations. During the replication phases, there would be need to ensure the involvement and capacity building activities for the regulator, since most regulatory functions, currently carried out by MEM, such as pricing, licensing, compliance monitoring amongst others, would need to be carried out by the regulator.

Regional cooperation and the Role of the East African Power Pool

The East African Power Pool has been inaugurated. The existing of the power pool opens up new opportunity for the wind resource in Eritrea. Though, the transmission system is weak and there are no interconnectors, in the long term, the huge wind resource in Eritrea could be used for external markets. DoE and EEC should be pro-active and use the capacity building

initiatives gained from this project, to effectively strategise the usage of wind potential to generate reveue from the planned power pool.

3.8 Cost-effectiveness

Out of the total GEF contribution of US$ 1.95 million, US$ 0,7 million is earmarked for hardware which is 35% of the total. For the Assab wind farm, the GEF hardware component was for interfacing the output of the wind generator with that of the diesel based Assab grid, which is part of the barrier removal process. The proposal considered that GEF finances 50% of the hardware costs the GoE the rest. The baseline situation for the rural areas was considered to be the continuation of lack of modern energy.

The project start-up was timely and efficient, however, implementation started to drag after the initial 6-8 months, due to non-delivery by TA on critical path activities. The TA was selected through international competitive international bidding process and the contract was already in place in November 2004 i.e. within four months of expected project start-up. However, due to non-delivery or poor delivery by TA the contract had to be terminated.

The assessment had the objective to ensure the performance in terms of value for money. In line with UNDP guidelines orders exceeding USD 100,000 are subject to international competitive bidding. Due to under delivery by TA, PMU decided, quite correctly, after consultation with UNDP and in the presence of TA, to apply the most suitable procurement guidelines, i.e. the World Bank ones, for the purpose of international competitive bidding. Since TA failed to prepare design and specifications of the grid connection equipment and works, this had to be sub-contracted to EEC, which has carried out the work with commendable workmanship and adherence to acceptable distribution standards.

The whole equipment procurement process has been substantially slower than is normally expected from this type of procurement task. This was because, in order to get in puts from the TA, the PMU had to make correspondences with the TA, which rather hindered the progress of the project. With the termiantion of the TA's contrcat, however, the work become straight forward and hence resulted in picking up the project's momentum and the project is now expected to be completed by the end March 2009.

The procurement of the wind-farm solicited 22 expressions of interest and subsequently three bids received from the nine invited pre-qualified suppliers. Two of the bidders pulled out during the process, resulting in only one fully responsive bid from Vergnet S.A., selected for contract of US$ 1.832 million and 80% higher than the budgeted amount. The cost per kWh (based on 825 kW) amounts to US$ 2221 and is on a high side compared to international average prices of US$ 1500-1600 for larger units with diesel back-up included. PMU had no option but to accept the bid, due to limited interest by suppliers. The other bid, received by fax, was actually higher (US$3.9 million). The period from prequalification to commissioning in November 2008 was 38 weeks, compared to 16 weeks in the *Prodoc*.

Pre-qualification bids for the off-grid systems were first published in February 2006. The procurement of the off-grid systems had a response of three fully responsive bids. One was disqualified on the grounds of lack of adherence of the original terms, and negotiations were continued with the second ranked bidder - Fortis. All bidders quoted a 55 per cent higher price compared to the budget of USD 930,000 necessitating additional funding to be requested from

UNDP, with attendant delays in the process before the winning bid could be accepted. Fortis failed to deliver citing the fact that they could not find an insurance company willing to cover the financial outlay of the project. This resulted in the contract being terminated a fresh bidding process being carried out. A Turkish company Soyut was awarded the tender and was expected to complete the installations by December 2008. This resulted in delays of 35 months. The perceived danger of piracy in the waters of Somalia meant reluctance by shipping companies to transport the systems to Massawa, thus further delaying the project by three months, and the project is now expected to be completed by end March 2009.

The procurement for the civil works and the Assab Wind Park interconnection line (grid reinforcement) works were sub-contracted to local contractors, in order to ensure cost savings as compared to inviting foreign contractors. Competitive bidding was used as the selection basis following the Government rules as funding came from the GoE budget contribution.

The project delays have been caused by multiple factors, the notable ones being:

- PMU staff did not have prior experience in the wind energy related ICB process and requirements;
- TA failed to provide sufficient technical support to PMU and seriously delayed preparations of bid documents;
- A number of clarifications were required during the bidding process before contracts could be agreed upon;
- There was reluctance by potential suppliers to bid;
- Long negotiating process on details with the selected suppliers.

The table below compares the planned and actual fulfilment of the key milestones in the project (*as per Prodoc*).

Table 8: Performance in terms of milestones

Milestone	**Planned after start-up (July 2004)**	**Actual/ Expected**	**Comments**
Project office set-up	2 months	2 months	PMU was fully manned in August 2004.
Assab wind park financial close (contract)	5 months	24 months	Target unrealistically tight. Additional delay due to protracted and two-step bidding process. First prequalification notice was sent out only in September 2005.
Wind park in operation	16 months	38 months	Delivery and installation have been smooth with exception of delays in civil works mainy because of the extremely hard rock encountered while excavating the cable trenches interconnecting the the three wind turbines with the HV building of the wind farm.

			.
Decentralised units all pilots in operation	21 months	38 months	Delay due to slow performance by TA, protracted bidding process, breach of contract by Fortis and delays in shipment by Soyut due to piracy risks
Project completion	36 months	56 months	Extension to March 2009 due to above delays.

Rating: The procurement process has delayed the project milestones significantly due to the non-performance of the TA, delays in civil works in the Assab Wind Farm component, failed contract negotiations and cost increases necessitating top-up financing by UNDP. Further delays experienced due to breach of contract by Fortis and shipping delays by Soyut. Notwithstanding these setbacks, the procurement process has been conducted according to credible procedures acceptable to the UNDP (World Bank Guidelines). PMU has carried out its task in a commendable manner including Selection Committees in all necessary steps and has detailed the selection processes.

3.9 UNDP comparative advantage

UNDP was in a position to implement the project due to its large country presence, and its energy and environment policies. UNDP has been involved both through the PDF-B, and subsequently in the final technical and financial analyses leading to the project proposal. As implementing agency for GEF, UNDP had experience with capacity development and technical assistance in a range of area, such as procurement of services and experts. It immensely assisted the project by injecting USD 1.7 million and thereby reducing the GoE's contribution from USD 1.95 million to USD 0.5 million.. UNDP was very effective in the facilitation of payments and financial management.

3.10 Linkages between project and other interventions within the sector

This project is linked to other activities and interventions within the sector. The following section summarises the major energy activities within the sector.

Rural Electrification

Rural electrification through grid extension is one of the major priorities of the Eritrean Government. To ensure utility viabilty and affordability to the consumer, a new initiative that promotes capital cost sharing is being implemented. The primary goal is to provide electricity to rural areas from the national grid and decentralised systems (wind, solar, gensets etc.),where feasable. The project is largely being co-financed by GoE and its development partners. Between 1999 and 2001, around 14,100 households in 27 villages and 4 towns benefited from electrification, which was partially financed by SIDA at a total cost of 1.45 Million USD. This was followed up by Phase II electrification programme, again partially financed by Sida, where 32 villages and around 13,000 households were connected and SIDA's finacial contriburion was 203,107 USD for imported components only. Phase III started in 2005 and around 59 villages and 25,000 households and 1400 commercials are expected to be connected at a cost of 11.5 Million USD.

GoE covers the cost of backborne infrastructure whilst consumers cover the low voltage distribution costs. Flexible payment schemes are available to beneficiaries, who are allowed to pay in two or three installments, based on the number of harvests needed to pay full upfront costs.

A Rural Electrification Fund, administered by the Ministry of Energy has been established. The fund shall be used to support the electrification of rural areas as well as areas considered economically non-viable. The contributors to the fund are GoE, donors, 1% levy on electricity sales and community contribution. The World Bank has already committed 1.4 Million USD as seed money and this is expected to encourage other donor contributions.

Energy conservation and efficiency:

Energy conservations and effieciency is being targeted at various levels. A project is being mooted to substitute incandescent lamps with energy compact florescent lights. A project has also been implemented to reduce EEC network losses, which average 22% against an international benchmark of 7%. The tagert is to reduce losses by over 50%. To this intent, EEC in collaboration with the Government has been rehabilitating and upgrading the transmission and distribution systems in the major cities of Asmara and Massawa.

Dissemination of improved stoves: (Adhanet Mogogo)

The aim is to develop and disseminate a more efficient, improved woodstove for baking the local staple food *injera.* The original *mogogo* is very energy intensive in a country characterised by shortage of fuelwood. DoE energy use surveys carried out in 1998 show that about 50 % of the energy used by Eritrean households is for baking *injera. Apart from being energy intensive, t*he stoves produce a lot of smoke resulting in energy related health problems arising from poor air supplies (resulting in excessive smoke inhalation – due to prolonged blowing and usage of kerosene). The stove has also excessive heat losses. ERTC research has dveloped a more efficient stove with 20% energy savings. Over 27,000 stoves have been installed in rural households and more are expected to be installed in the future.

Promotion of Renewable Energy Technologies (RETs)

Twenty five wind and solar monitoring stations have been installed throughout the country. The data has been used for designing this project and identifying future potential sites. There are also plans for local manufacture mechanical wind water pumps in collaboration with a local manufacturers. Over 900 kW aggregate capacity involving over 2000 solar PV systems are in service in the country for applications like powering: health centres/stations, village water pumps, remote primary and junior schools, remote offices, light houses, telecommunications centres, solar home systems and even water pumping for drip irrigation. The Ministry of Agriculture is powering most of the rural livestock vaccination centres through solar PV. ERTC has trained many technicians for the institutions and companies involved in solar business.

Studies on Geothermal Energy

There is potential for georthermal energy in Eritrea. Part of Eritrea is situated in a volcanic area predominantly in the East African Rift Valley. Studies were underatken at the volcanic mountain-Alid, to ascertain the potential for geothermal. The studies indicate an underlying hydrothermal reservoir with a temperature in the range of 250 - 350ºC, and concluded that the water to rock ratio in the reservoir is high enough to support the development of a geothermal power plant. Initiatives are being taken by the Rift Valley countries of Eastern Africa, in collaboration with UNEP, GEF and GTZ, to design a regional project to develop geothermal resources.

Electricity market reforms

Electricity reforms have been undertaken to restructure the state owned utlity – EEC. The objective of the reforms were to improve supply reliablity, low capacity utilization and availability factor, deficient maintenance, poor procurement procedures and low access to electricicity, particularly in rural areas. The nature of the reforms was to liberalise sector and and corporitise EEC to operate on commercial principles in high load centres but assist in rural electrcification. The reforms also targeted the tariff setting to ensure viabilty of the utlility and reasonable returns, with the ring fencing of the needs of the poor through the creation of a Rural Electrification Fund to cater for capital investments. The power sector reform measures were negotiated and agreed upon with the World Bank as a condition for IDA financing of 50 Million USD for the Asmara Power Distribution Rehabilitation and Rural Electrification Project.

EEC will in the short to medium term, continue to be a vertically intergrated utility, providing generation, transmission and distribution services, but the long term vision is to allow Independent Power Producers (IPDs) and Distributors (IPDs) to fully partipipate in generation and distribution, leaving the the transmission system under public ownership. GoE has enacted necessary legislation (*Electricity Proclamation No. 141/2004*) to promote efficiency, safety, environmental protection and private sector involvement in the power sector. Persuant to these proclamations GoE has established the office of the regulator. The Committee has five members three of which are Director Generals from Government Institutions and two from the private sector. The duties and responsibilities of the Regulator are to:

- Promote efficiency, dependability, cost-effectiveness, safety and quality of service and fair competition as well as private and community participation in electricity operations in Eritrea;

- Study, review and determine electricity tariffs and related service charges on the basis of general guidelines and principles issued by the Ministry on setting same and oversee the implementation thereof;

- Initiate and conduct investigation into standards of quality of service provided to customers and monitor standards of overall performance of permit holders;

- Protect the interests of customers, permit holders and the general public;

- Perform such other lawful activities as may be necessary for the attainment of its objectives.

Asmara Power Distribution and Rural Electrification Project

The project is financed by the World Bank, and has the following major components:

- Rehabilitation and Expansion of Urban Electricity Distribution: (33Million USD)
- Rural Electrification (11.5 Million USD)
- Rural Electrification Fund (1.4 Million USD)
- Sector Reform and Institutional Capacity Building (4.5 Million USD)
- Environmental Monitoring (0.5 Million USD)

The works carried out included upgrading and installing substations and transformers, underground cables, overhead lines, distribution poles and constructing transformer cabins. The third phase of the Rural Electrification Program focuses on 60 villages around the four major urban centers of Keren, Barentu, Dekemhare, and Adi-Keih. The project also targets environmental monitoring, power sector reform and institutional capacity building for the Ministry and EEC.

3.11 Management arrangements

The PMU was timely setup according to the envisaged two months after the expected project start-up. To help integrate the project within DoE's overall work programmes, and to achieve maximum coordination with other partners linked to DoE, such as ERTC and EEC, the PMU was physically located within DoE. The staffing requirements followed closely the guidelines provided in the *Prodoc*. PMU is appropriately staffed by a manager with solid technical background in renewable energy, a Proffessional Assistant (mangement graduate), who used to work for the Bank of Eritrea. A secretary and driver were also recruited as part of the PMU team. The driver has since moved to another Government Department and DoE allocates a driver on the need basis.

The financial records appear to be properly managed and the budget situation constantly monitored and adjusted if needed. Budgetary controls have been prudently carried out according to UNDP guidelines. Budgets have been prepared in tabular form and budget lines. Requests for advances have been done on quarterly basis and the request for the next quarterly advance was accompanied by a detailed report of the previous quarter expenditure and the remaining funds were taken into account in the next disbursement. Every year's expenditure was audited by an authorised audit firm and cross checked with UNDP records and reconciled.

Rating: The financial management procedures were highly satisfactory and ensured financial accountability through independent audits and independent financial reconciliation through UNDP records. The PMU was not given any meaningful on-the-job training by the TA, it has managed to handle the project very well and has followed the Prodoc meticulously. The lack of on- the- job training left a gap that has to be filled by PMU, EEC and UNDP

3.12 Financial Planning

The project budget was originally US$ 3.9 million but the final budget was US$4.2 million and was to be shared equally between GEF and the GoE. The arrangement followed GEF's practice of not normally covering major equipment components. The budget is directed to the procurement of equipment and executing civil works, typical of such pilot projects, capacity building, and barrier removal programmes. Given the financial constraints faced by GoE, GEF agreed to finance on a grant basis half of the equipment of the decentralised systems component and the grid reinforcement in addition to the training and technical assistance components. Thus, bulk of the equipment procurement was left to GoE financing, most of which was eventually covered by UNDP. UNDP stepped in to cover the budget deficit of USD258,438 caused by budgetary constraints and cost escalation caused by a 45 per cent higher than expected bid price for the decentralised systems. The table below shows the summary funds disbursed by source.

Table 9: Contribution of funds by source

SOURCE	ORIGINAL		Actual Expenditure	
	USD	% of total	USD	% of total
GEF	1,950,561	50	1,950,561	47
UNDP	-	-	1,698,438	41
GoE	1,940,536	50	500,537	12
TOTAL	**3,891,097**	**100**	**4,149,536**	**100**

The GoE share has been reduced to USD 0.5 million, intended for civil works and other local expenses. In real terms, GoE's contribution is higher than the above figure, due to the significant level of in-kind services. Information collected shows that GoE, through the Red Sea Administration Office paid US$135,000 for the diesel gensets at the wind-diesel pilot sites. Additional costs were incurred in putting the local distribution network in four sites. The actual costs incurred in the putting up the local electricity distribution infrastructure were not available, but international prices for a 15kV line is US$20,000 per kilometre, putting the total costs for the three sites at US$90,000. The costs of putting distribution transformers (on average three at each site and with a capacity rating of 100kVA) would be in the region of US$140,000. The cost of low-voltage service lines would have been around US$100,000, putting the total local electricity grid costs to US$465,000. This is a huge contribution, and demonstrates, GoE's commitment to the project.

The table below shows the budget utilisation by source of funds and funding activities.

Table 11: Budget utilisation by source of funds and funding activities

	2004		**2005**		**2006**		**2007**		**2008**		**2009**			**%**
	Disbursement by		**Disbursement by**		**Disbursement by**				**Disbursement by**		**Disbursement by**			**from Total**
	Govt	**UNDP**	**Govt**	**UNDP**	**Govt**	**UNDP**	**Govt**	**UNDP**	**Govt**	**UNDP**	**Govt**	**UNDP**	**Total**	
Management														
	7843.83	6725.33	19120	186	19120		1883.63	137.83	3487.33					
	3096.52	41544	6852.59	90.09	806.67		19126.37	13.45	3155.76					
		213.89	3598.02	839.69	830.78		181.67	-28.54						4
		497.36	1669.28		1413.91		87.52							
							19.05							
							4361.9							
							20.46							
Sub total	10940.4	48980.58	31239.89	1115.8	212721.4		25680.6	122.74	6643.09				146444	
Development														
	4767.08			84000		814705.2		135094		74250		290000		
						366474		185368		15899				83
						365000			712201					
									24750					
Sub total	4767.08			84000		1546179.2		320462		827099			2782507	
Monitoring														
	2862.19				6409	635	4139.67		3841.41					
			11809.78				10503.86			22000		20000		3
Sub total	2862.19		11809.78		6409	635	14643.53			3841.45	22000		20000	82201
			Capacity Building											
				71400		3846		23284.9		99064				
				13673		11520		1534		5685				10
				39000				1199		89640				
				43.91										
Sub total				124117		15366		26017.9		194389			359889	
Total													3371042	100

The major expenditure items were as follows:

Table 10: Project major expenses

Asssab Wind Farm	US$1,832,370
Grid connection	US$172,560
Distributed wind energy systems	US$99,000
Technical advisor	US$945,000
PMU expenses	US$210,400
Total	US$4,149,536

ASSESSMENT: ***UNDP was flexible to provide additional funding to meet the additional costs associated with price escalation. The original cost estimates for the turbines and equipment were not realistic, in light of the small number of units ordered and the impact this has on pricing.***

3.13 Monitoring and evaluation

Monitoring of results and lesson learning is an essential task in the project implementation. The PMU conducted daily monitoring of the project and submitted regular reports to UNDP. The PMU has produced Project Implementation Reports (PIR) for 2005, 2006, 2007 and 2008 as per the UNDP and GoE requirements. Similarly the Mid Term Review was conducted in August 2008. Project Annual Progress Reports were produced for the periods July 2004-June 2005; July 2005-June 2006, and July 2006-June 2007 and December 2008.

Two Tripartite Review Meetings (TPR) have been held and the last TPR is awaiting the Terminal Evaluation Report. During the TPR slow progress was noted, recorded and extension granted. The two major contributions by UNDP to the budget and the termination of the TA contract were other main decisions during TPR meetings. The project duration was also agreed to be extended by one year until December 2008. ***The TPR mechanism has helped to take early diagnostic measures to rescue the project and ensure its success.***

Progress and major problems have been recorded in great detail, including all steps in procurement. The reasons for delays and the equipment cost overrun are properly reflected. PMU has also prepared technical papers, including on setting the Assab Wind Park production targets and estimates, and the impact of the de-rating of the Assab Wind Farm units from 825 (3x275kW) to 600kW (3x200kW).

A solid project monitoring and evaluation system has been put in place. Joint quarterly visits will be undertaken at off-grid wind systems by EEC and ERTC to monitor the systems. The joint team report is to be sent to DoE as soon as possible. The local operator also logs data on a continuous basis. A state of the art SCADA

monitoring system has been put in place for the Assab wind farm. The system monitors critical equipment status and systems performance as follows:

- Equipment status
- Mean wind speed
- Active power
- Reactive power
- Yaw error (Nacelle misalignment)
- Brake pad wear rate
- Power factor
- Brake pressure
- Cable twist
- Rotor speed
- Pitch angle

The monitoring system has capabilities for storing and displacing system production data and is equipped with event loggers, alarms and fault displays. The wind park performance and equipment status can be viewed locally at the tower base at the control room of the wind farm and that of the diesel power plant. Reports are submitted to DoE for evaluation and a copy is also sent to EEC Head Office in Asmara.

Assessment: The project monitoring systems put in place is state of the art and is ideal for monitoring and evaluation. The implementation of the project itself has been continuously monitored by project partners and a Midterm review has been carried out. Project Review reports have been produced on annual basis and these have been complemented by Tripartite Review meetings. The rating is highly satisfactory.

3.14 Sustainability

The project was a success and it is imperative that gains achieved are sustained. The project has been implemnted on the background of appropriate energy policies and has led to improved institutional capacity of delevering altrnative sources of energy such as wind. The likelihood of continuation of project outcomes/benefits after completion of GEF funding will depend on a number of factors. The project implementation approach is based on the need for beneficiaries to contribute towards operations, maintenance and equipment replacement. This means that the tariff should cover operational and replacement costs. During the evaluation, tariff levels have not yet been set and the system was supposed to the run for a month before tariffs are set, based on cost recovery and affordability. This posses a risk on sustainabilty, in the event that affordable levels do not match the cost of service. This might lead to underfunding for maintenance and operational purposes. This might be mitigated by provision of funds or state subsidies to keep the systems

running at the required level of reliability and sustainability of the Assab Wind Farm.

Sustainability will also depend on the progress made in preparations for replications. The key determent will be vailability of finance. Donor finance will be critical in ensuring sustainability, given the financial constraints. There will be need to quickly mobilise the required resources. Institutions such as the World Bank have indicated willingness to contribute in funding should they be approached. Also a number of institutions have funded energy projects in Eritrea or other countries. This need to the approached.

To gain maxumum benefits, there is need for an approach that maximises on income generation activities. This would need the support of the private sector. Local technological adoption of systems such wind mechanical sytems for water pumping would ensure the sustainability of the project and build local capacity . This could be coupled with appropriate reaserch and development, that would also ensure the sustainability of ERTC's research programme.

Other critical areas that needs attention are local standards, improved stakeholder interraction and utlity long term transmission and generation planning.

Assessment: The sustainability of the project is, due to the above factors, assessed to be satisfactory. Since components of the projects are still to be finalised it is possible that the sustainability of the project would move to very satisfactory, especially if the level of cost recovery is adequate to sustain the operations and maintenance of the systems and finance could be mobilised for the replication phase.

3.15 Extent of Incorporation of the Mid-Term Review recommendations

During the mid-term project review the need for a new TA to spearhead outstanding issues, not completed or carried out satisfactory during the tenure of the terminated TA was highlighted. The new TA contract was to cover the following issues:

a) Development of the methodology, benchmarks and indicators as part of the project monitoring mechanism,
b) Analyse existing procedures including delegation of responsibilities between local, regional and central administration levels and across line ministries for identification, implementation and operations of wind energy projects,
c) Design work programmes, responsibilities and operation modalities, including cost recovery tariffs.
d) Preparation of missing training programmes such as training EEC and ERTC in supervision and acceptance of civil, mechanical and electrical works,
e) Strengthening ERTC to become a national centre of excellence in wind technology,

f) Improving level of awareness in villages,
g) Increased publicity in wind rich villages
h) Involving potential donors and starting to prepare for the replication phase.

A new TA contract was not considered to cover the above issues. The engagement of a new TA contract would have further delayed the project and negatively impacted on the project costs. There is ample showing that bidding and negotiating for contracts have been the major weakness of the project. In any case, there was no guaranty that the new contract would in the remaining time frame performed adequately to meet the objectives. It should be remembered that in the *Prodoc,* the project manager was supposed to progressively take over the project tasks from the TA, thus demonstrating the level of capacity building that would have been attained in meeting the project's gains, in terms of institutional capacity and capacity building. The PMU and other key stakeholders have commendably executed the above tasks as evidenced by the following observations.

Development of the methodology, benchmarks and indicators as part of the project monitoring mechanism

The PMU has put in place an excellent, yet simple to implement monitoring mechanism, that would be useful for replication phases. The system is based on continuous field data logging via a SCADA system or data templates of critical performance data. The capabilities of the monitoring system actually goes beyond monitoring, but is also used for practical purposes during system operations. During the visit the SCADA monitoring system was used for outage coordination and scheduling of diesel generation units at Assab. The mean wind speed was used to determine the availability of the wind turbines to be dispatched during maintenance of a diesel generator set. The available monitoring system is built upon a hierarchy of five approaches, namely local data logging, field visits, data submission, evaluation and practical application. Useful benchmarks and performance indicators have been developed and have formed the basis of system guarantees and warranties with suppliers. These are clearly documented in hand the over document. The development of the methodology, benchmarks and indicators as part of the project monitoring mechanism did not require a new TA contract, since they have been commendably implemented by the PMU and local stakeholders. Maximum use and cost savings were made by deriving maximum use of equipment suppliers.

Existing procedures including delegation of responsibilities between local, regional and central administration levels and across line ministries for identification, implementation and operations of wind energy projects

These have been satisfactorily covered in the "Decentralized Wind Energy Facilities Management Guidelines"prepared by the PMU. The delegation of responsibilities between local, regional and central administration levels are clearly outlined, with inputs

from the relevant stakeholders. The need for interaction with other line ministries has been identified and is one of the critical outputs of the DoE's business plan. There was therefore no need to waste financial resources on a new TA. The PMU has acted prudently to use in-house resources to execute the activity.

Strengthening ERTC to become a national centre of excellence in wind technology

ERTC data base has been instrumental in the design of wind energy systems. It has participated in various project training components and will be training local experts in wind energy systems. ERTC is fully committed to the project. It is carrying out research in various energy initiatives such as renewable energy research, training, dissemination, and energy and energy applications e.g. improved cookers, biomass, desalination, and water pumping. It has facilities such as library, woodworks, computer networks, and renewable energy data base. It is within their mandate to promote renewable energy sources and ensure sustainability. The current challenges are to expand the wind measuring stations and technology adaptation. In this regard, they require one turbine for study and research on local manufacture. These issues are better addressed through funding, not a new TA contract. It is strongly recommended, that ERTC's needs are urgently addressed in the replication phase.

Improvement of awareness in pilot villages and villages with high wind speeds

Awareness levels in pilot sites were found to the very high, with the major concern being, when systems will start delivering electricity. A number of campaigns have been carried out to stakeholders in wind rich regions. The plan is too carry out more awareness programmes when the system are fully operational, to ensure optimal buy-in by stakeholders. The evaluator fully concurs with this approach.

Involving potential donors and starting to prepare for the replication phase

This activity was affected by the non performance of the TA. It needs to be urgently pursued to ensure the project sustainability and project continuation during the replication phase.

3.16 Exit Strategy

The project is now coming to an end. There is need to come with an exit strategy. The exit strategy will hinge on two three critical factors, namely need to mobilise funds for replication and execution of outstanding activities. The following activities are outstanding:

- Finalisation of the installation of the local grids at Beilul,
- Installation and commissioning of the distributed wind energy sites,

- Operation and maintenance (O&M) training to be given to trainers from ERTC by the Turkish Company "*Soyut* Engineering and Construction Co. Inc. - the contractor of the village projects,
- O&M training is to be given to the village technicians by ERTC,
- Performance monitoring and evaluation of the Assab Wind Farm and the Villages sites,
- Implementation of the awareness raising campaigns and activities on wind energy technology,
- Involving the potential donors and starting to prepare for the bridging into replication phases.

These activities are at critical stages of implementation and time need to be made available that the commissioning and subsequent monitoring and awareness programmes are successfully carried out.

GEF and UNDP are financially supporting this project to present good cases for such replication. The major risk for replication is securing funding. UNDP should in co-operation with GoE and the key donors start exploring financing possibilities and modalities for replication. As already highlighted during the mid-term review, a joint advisory body should take over to manage and direct efforts on replication. This would provide a smooth exit strategy for UNDP and GEF and ensure sustainability of the project's achievements.

3.17 Recommendations

The project has immensely contributed to the removal of technical and institutional barriers affetecting the dissemination of renewable energy technolgies. It has satisfactorly increased institutional delivery, in terms of capacity building and improved awareness. Available evidence, points to the successful achievement of project objectives in the areas of reduction in green house gases and improvement to quality of life. Furthermore, the project has resulted in an informed and equipment framework for the adoption and wider dissemination of wind energy technologies. The following usefull lessons have been gained from the implementation of this project.

a. The clarity of roles by the various stakeholders and the involvement of the stakeholders during the decision making stages, coupled with strong political will are critical for the success and ownership of projects.

b. There are strong synergies between the project and other ongoing energy activities. These synergies were very usefull in designing the different delivery modes and also ensured social acceptability of the project by the different players.

c. The implementation modalities were based on tried and tested principles, which ensured its success.

d. The monitoring mechanism is very effective and will be very useful for future wind energy activities and the operation of the wind farm.

e. The local project mangement was outstanding, and has managed to successfully implement the project with minimal inputs from the TA.

f. The project is on track to meet its objectives as outlined in the *Prodoc*

Despite the project's success, a number of issues needs to be addressed within the scope of the project or to be taken into consideration in designing future projects.

i. The projected was characterized by serious of delays in the area of procurement of equipment. There is need to allow sufficient time for procurement to allow for the necessary steps, including pre-qualification.

ii. There is need to ensure that the local institutions and the PMU are given training in wind energy related international procurement procedures prior to the implementation of the project. This would have reduced the project time and mitigated against non delivery by TA.

iii. The delays could have been avoided if the TA has delivered. The usage of a TA should be revisited to ensure a proper track record and experience in similar projects. The TA should demonstrate staff competence and field experience in the relavant activities. Targeted short time assignments should be considered.

iv. The design of energy systems should take into consideration local conditions, as international equipment supplies are not necessarily good at areas such as civil works.

v. To ensure long-term sustainability, there is need to carry out research on increasing local content of energy technologies - where feasable. This is the most effective way to remove barriers and the development of local industry. The improvement in local content should be complemented by the development of local standards.

vi. There is need to intergrate the wind energy technology into income generation activities such as water pumping for irrigation. This will directly benefit the private sector, which has a higher penetration rate in farming activities. This will also create a sustainable makert for private sector expects trained in wind energy systems and will ensure continuation of capacity bulding, as the experts will in turn train their employees. The deployment of wind mechanical systems will displace diesel pumps.

vii. Issues such as frequancy control are very important in intergrating wind technologies in small power systems. The lack of system stability sstudies has limited the dispatch capacity of the wind farm to 35% of the total nery generated, though the system can run with a capacity factor of 44%. There is need to carry out system stability studies by power experts in the design of wind systems to be intergrated to the grid.

viii. System development plans are vital, to ensure that wind potential is properly assessed and incorporated in furure generation options. There is need to strengthen EEC's planning capacity. This would ensure wind energy systems are part and parcel of the system development plan during the replication phases. Proper system development plans and the associated long term transmission studies (with special focus to potential interconnectors) will ensure the proper integration of Eritrea's wind potential to the East Africa Power Pool, when conditions for pool energy trading become conducive.

ix. More time is needed to evaluate the perfomance of the off-grid systems, since such systems are still being installed. Some time is needed before the performance could be evaluated and more awareness being created with with credible field results.

x. The regulator will increasingly play an important role in the future electricity market structure and the involvement of the private sector during the replication phase. There is need to develop mechanisms to build the capacity of the regulator in facilitating future electrcity investments.

Annexure 1: Terms of Reference

The Evaluator will evaluate the project's achievements according to the following Project Review criteria:

a) Outcomes

- Assess progress towards attaining the project's environmental objectives and outcomes. This should include the extent to which the project contributed to: (a) Reduction in greenhouse gas emissions; (d) Informed and equipped Institutional Framework for renewable energy (e) Conducive Policy and legal Framework; and (f) Improvement to quality of life (health and employment creation).

b) Implementation approach

- Review the clarity of roles and responsibilities of the various individuals, agencies and institutions and the level of coordination between relevant players. Assess the level to which the Logical Framework Approach (LFA) and performance indicators were used as project management tools;

- Evaluate any partnership arrangements established for implementation of the project with relevant stakeholders involved in the countries/region;

- Describe and assess efforts of UNDP in support of the implementing agencies, regional and national institutions;

- Make recommendations as to how to improve project performance in terms of effectiveness and efficiency in achieving impact on institutional and capacity development and the targeted conservation concerns.

c) Country Ownership/drivenness

- Assess the extent to which the representatives of the participating countries (including governmental officials, civil society, etc.) were actively involved in project implementation.

d) Co-financing

- Assess whether the governments and other partners have maintained financial commitments to the project and undertake a reconciliation of the co-financing pledged and realised.

e) Stakeholder Participation and benefits accrued

- Assess the level of public involvement in the project and comment as to whether the scope of public involvement has been appropriate given the broader goals and objectives of the project;

- Review and evaluate the extent to which project benefits have reached the intended beneficiaries.

f) Sustainability

- Assess the likelihood of continuation of project outcomes/benefits after completion of GEF funding; and describe the key factors that will require attention in order to improve prospects for sustainability of project outcomes. Factors of sustainability that should be considered include; institutional capacity (systems, structures, staff, expertise, etc.) social sustainability, policy and regulatory frameworks that further the project objectives, financial sustainability.

g) Replication Approach

- Describe the main lessons that have emerged in terms of: strengthening country ownership/drivenness; strengthening stakeholder participation; institutional structure and capacity building; application of adaptive management strategies; efforts to secure sustainability; knowledge transfer; and the role of M&E in project implementation. In describing all lessons learned, an explicit distinction needs to be made between those lessons applicable only to this project, and lessons that may be of value more broadly.

- Make recommendations on how the lessons and experience can be incorporated into the design of similar initiatives in the future.

h) Financial Planning

- Assess the financial control systems, including reporting and planning, that allowed the project management to make informed decisions regarding the budget;

- Assess the extent to which the flow of funds had been proper and timely both from UNDP and from the project management unit to the field;

- Evaluate the extent of due diligence in the management of funds and financial audits.

i) Cost effectiveness

- Assess compliance with the incremental cost criteria (GEF funds used to finance a component of the project that would not take place without GEF funding and securing co-funding and associated funding); and

- Assess the extent to which the project has completed the planned activities and met or exceeded the expected outcomes according to schedule and as cost effectively as initially planned.

j) Monitoring and Evaluation

- Review the project's reporting systems and their efficiency; and

- Review the implementation of the project's monitoring and evaluation plans including any adaptation to changing conditions (adaptive management) – and specifically, assess whether the lessons, insights and recommendations of the mid-term evaluation were applied successfully to re-direct the project.

Annexure 2: Itinerary

Friday 23 January 2009/Saturday 24, January 2009	Travel Harare - Johannesburg – Cairo
Sunday 25 January 2009	Travel Cairo - Asmara
Monday 26 January 2009 a.m	UNDP: Briefing/PMU/DoE :Start of discussions
Monday 26 January 2009 p.m	Travel by car to sites
Tuesday 27 January 2009	Visit and discussions with local administration and communities at Edi, Berasole and Beylul
Tuesday 27 January 2009	Visit and discussions with local administration and communities at Edi, Berasole and Beylul
Wednesday 28 January 2009	Visit and discussions with local administration and communities at Rahaitaand and Gahro
Thursday 29 January 2009	Meetings with South Red Sea Region Administration Meeting with EEC Assab Regional Manager Assab Wind Park site visit Visit to Assab Thermal Power Plant and meeting with the Power Plant Manager at Assab
Friday 30 January 2009	Travel by car to Massawa
Saturday 31 January 2009	Travel by car to Asmara
Monday 1 February 2009	PMU project review
Tuesday 2 February 2009	PMU project review Meeting at ERTC
Wednesday 3 February 2009	Meeting at Eriquip Meeting representative of Mereb Construction Travel to Dekemhare
Thursday 4 February 2009	Meeting with World Bank Asmara Office Meeting with EEC Head Office PMU project review
Friday 5 February 2009	PMU/DoE project review
Saturday 6 February 2009	UNDP project review

Sunday 7 February 2009	Travel to Cairo
Monday 9 February 2009	Travel to Harare

Annexure 3: List of persons interviewed

Ministry of Energy and Mines, Department of Energy (DoE)

Dr. Semereab Habtetsion, Acting Director General and Director, Energy Development and Management
Mr. Abiy Ghebremedhin, Project Manager, PMU
Mr. Teshome Berhane, Professional Assistant, PMU
Mr Tesfai Ghebrehiwot, Energy Planner, DoE

Energy Research and Training Center (ERTC)

Mr. Debesai Ghebrehiwet, Director
Mr Mesghina, Researcher
Mr Jemal, Researcher

Eritrea Electric Corporation (EEC) - Asmara

Mr.Woldemicael Berhe, Manager, Generation and Transmission Division

EEC -Assab

Mr. Salomon Ghebretensae, Assab Branch Manager
Mr. Habtom Netserab, Assab Power Plant Manager

Beylul Pilot Village

Mr. Isa Ahmed – Local Administrator

Berasole Pilot Village

Mr. Mohamed Saleh Hamedu , Head of Local Administration
Mr. Ismael Mohammed Fadil, Chairman of Fishing Association

Edi Pilot Village

Mr. Mahmud Ali, Head of Administration of Central Denkalia
Mr. Assmeroen, Musa Ali Construction Company Site Supervisor

Rahaita/Gahro Pilot Villages

Mr. Abdulkadar Daudi Mohamed , Derder (King of the Affar)

Gahro Pilot Villages

Mr Burhan Mohamed Ali, Head of Local Administration

Red Sea Administration Office

Mr Mebrahtu, Unit Head

Eriquip

Mr. Berhane Neggasi, General Manager
Mr. Asheber Araya, Operations Manager

Dekemhare

Mr Estifanos, Awcan, Plantation Manager

United Nations Development Programme (UNDP) – Country Office

Mr.Isaac Habte, Programme Analyst, Environmental and Sustainable Development

The World Bank Resident Mission
Mr Chris Loovelane, Country Manger

Annexture 4: List of documents reviewed

1. Annual Project Report (APR/PIR) for UNDP/GEF Projects (2005), Wind Energy Applications in Eritrea
2. Assab Wind Farm Performance and Status Report for year 2008
3. Annual Work Progress Report for the year 2008
4. Handing over document of Assab Wind Farm to the EEC
5. Decentralized Wind Energy Facilities Management Guidelines
6. Executive Board of the United Nations Development Programme and of the United Nations Population Fund (2006), The Evaluation Policy of the UNDP
7. Heiko Noro, Parola International Associates (2007), Wind Energy Applications in Eritrea – Mid-Term Review
8. Ministry of Energy and Mines, Department of Energy (2007), 2007 Energy Status Report for Eritrea
9. Ministry of National Development, (2006) Wind Energy Applications Pilot Project in Eritrea
10. Wind data EXCEL Files
11. DoE/PMU (2008), Annual Progress Report for the Year 2008
12. Semereab Habtetsion, "Energy Sector Reform Initiatives and Implications in Eritrea", *Journal of Cleaner Production* 15 (2007), pp.178-189
13. United Nations Development Programme, Terms of Reference for Terminal Evaluation-Wind Energy Applications in Eritrea
14. United Nations Development Programme EEG and GEF (2008) Annual Performance Report (APR), 2008
15. ICSU Regional Office for Africa, Sustainable Energy in sub-Saharan Africa
16. UNDP, GEF APR/PIR 2006 – Climate Change
17. Wind Energy Application in Eritrea –Tri Partite Review Meeting 14th December 2007
18. Olympian Diesel Generating Set Technical Manual
19. EEC Records on Assab Wind Farm Generation Staus and Costs of Generation Stations

Annexure 5: Questionnaire used and summary of results

General information

- Current energy policies and programmes
- Energy balances and consumption levels – Review of energy balance and any surveys
- Integration of project in GoE power and energy policies – review of the of the policies
- Electrification levels and programmes (rural and urban)
- Project strengths
- Project constraints

System Technical Data

- Peak demand
- Installed national generation capacity (integrated systems and self contained systems)
- Firm capacity, energy generated by plant
- Energy used for generation, quantities and costs
- Forced and planned outage rates
- Availability factor
- Capacity factor
- Current generation constraints
- Generation cost per plant
- Energy sent out
- Tariffs by consumer category
- Energy sold
- Number of connections
- Wind energy production
- Plant operations and maintenance costs
- Labour and overheads
- Assab system demand
- Debtors days and payment ratios
- Useful lessons

Capacity Building and Awareness

1.1.1 Technical training and managerial seminars for EEC staff in Assab and Asmara

✓ Quality and effectiveness of the training:

- Reviewing on the nature of training and content of training materials
- Interviews with staff that received training on appropriateness and effectiveness of the training received

✓ Useful lessons learnt for activity 1.1.1
✓ Performance – Seminars/on the job:

1.1.2 Training of EEC and DOE in supervision and acceptance of civil, electrical works and mechanical works

- ✓ Interview with PMU on the progress made and need for further training.
- ✓ Perfomance:

1.1.5 Cross training of local expects in on - and off- grid systems

- ✓ Assess the availability of training plans in preparation for replication

Strengthening of ERTC in wind energy Technology

1.2.1 Establish PMU in ERTC

- ✓ Assess any constraints faced by the PMU in DoE and possible solutions to for further work and project roll out
- ✓ Proficiency in procurement

1.2.2 Training of trainers

- ✓ Status and implementation modalities
- ✓ Appropriateness for the target audience and their perceptions

1.2.3 Development of wind data base

- ✓ Status, progress and way forward (assessment of further needs)

Training of engineers technicians and electricians in the private sector to service future projects

- ✓ Seminars for the Association members on installation and O and M - Progress in training, nature and content of training, effectiveness and constraints
- ✓ Number actually trained by organization
- ✓ Assessment of operations and maintenance carried out by local engineers, technicians and electricians

Raising of awareness of wind energy potential role

1.4.1 Campaigns with communities

- ✓ Availability of structured work plans for information dissemination in villages
- ✓ Achievement in terms of dissemination numbers by type of audience
- ✓ Progress in spread of information to other potential targets – public and private sectors, central level

1.4.2 Awareness companies to community leaders in private sectors and public sectors at public level

- ✓ Progress in identification of audience
- ✓ Coverage

1.4.3 Awareness to public

- ✓ Nature of campaigns
- ✓ Performance in actual number of dissemination by type of dissemination modes

Installation of the Assab Wind Farm

- ✓ Constraints, solutions and lessons learnt

2.1.2 Prepare model contract for PPA and Wheeling Agreement for grid connected project

- ✓ Progress on the review of the PPA by local lawyers and power specialists
- ✓ Review of the PPA for Assab prepared by DoE and EEC

2.2.1 Formulate an optional operation strategy for wind park

- ✓ Review progress in ensuring that Assab is running connected according to Assab operational strategies
- ✓ Review EEC'S System Development plan vis vis the role of wind
- ✓ Evaluate the plant's evaluation and monitoring system and plant performance, constraints and solutions in place or proposed solutions

2.2.2 Disseminate operation results to attract further investments

- ✓ Availability of operational performance records
- ✓ Mode of dissemination of plant performance
- ✓ Targeted audience

2.2.3 Procure and install the grid connection cable and the wind park substation

- ✓ Ascertain status

Installation of 8 small scale decentralized systems

3.1.1 Analyse existing procedures including delegation of responsibilities.

- ✓ Analyse roles and responsibilities
- ✓ Progress
- ✓ Ownership
- ✓ Tariff recovery modalities and levels
- ✓ Expenditure on electricity substitutes
- ✓ Quantities used
- ✓ Flexibility and ability to pay
- ✓ Progress in training

3.1.2 Test procedures in selected villages and production sites

- ✓ Availability of procedures
- ✓ Benchmarks used

✓ Progress achieved

Viable financing mechanisms for small-scale off grid systems explored

3.2.1 Identify financing options successfully applied in other countries and associated lessons learned.

✓ Progress in exploring, developing and testing appropriate financing mechanism
✓ Review of the financing manual
✓ Lesson learnt
✓ Usefulness of project finance manual

3.2.2 Test the most provision financing models : as above

✓ Progress in securing finance for the replication phase

Five diesel-wind hybrid and three stand-alone systems installed

3.3.1 Prepare, tender and commission the eight pilot projects

✓ Progress
✓ Lessons learnt

3.3.2. Install the eight pilot projects.

✓ Project progress and timelines

3.3.3. Operate and maintain the systems

✓ Proposed plan

3.3.4. Analyse and disseminate operation results after 1 year of operation and in subsequent years.

✓ Progress in developing a solid monitoring framework for with the immediate objective of ensuring the technical, financial, institutional and socio-economical viability of the pilot applications.

Logical framework review

✓ Review of the logical framework, in view of comments on the relevance and applicability of the original indicators developed therein in line with the missing performance monitoring system

Operational performace

Progress in attaining the following pitfalls:

- ✓ Insufficient emphasis put on procurement support and training needed by PMU.

- ✓ Lack of clearly defined plan and objectives for a performance monitoring and evaluation system

- ✓ Unrealistic reliance of availability of GoE counterpart financing

Implementation and management

- ✓ Milestone achieved and new milestones
- ✓ Constraints and mitigation
- ✓ Useful lessons
- ✓ Detailed work plan
- ✓ Equipment and services procured
- ✓ Impact of procurement on project implementation

Procurement

- ✓ Review of equipment and services procured and updates
- ✓ Reasons for any variations

Budget

- ✓ Provide project budget status by expenditure and financing source and give explanations of major variations
- ✓ Impact of budget deficit on project implementation

Report monitoring

- ✓ Review of submitted project progress report
- ✓ Areas needing future attention

Stakeholder involvement

DoE

- ✓ TOR of DoE in project implementation
- ✓ Actual implementation activities
- ✓ Status and constraints
- ✓ Useful lessons learnt
- ✓ Linkages to the project of ongoing DoE activities
- ✓ Level of project financing in cash and kind
- ✓ Availability of replication strategy

ERTC

- ✓ Project TOR
- ✓ Progress in system operations
- ✓ To Status of monitoring and evaluation

EEC

- ✓ Status of system performance monitoring
- ✓ Financial evaluation and evaluation of other benefits
- ✓ Maintenance and operational experiences and constraints
- ✓ Existence of replication plans in the system development
- ✓ Review of any commercial agreements such as connection agreement and power purchase agreements

Regional Community Administrations

- ✓ Level of involvement
- ✓ Progress in construction of distribution systems

Community Village Administration

- ✓ Level of involvement
- ✓ Level of awareness
- ✓ Plans of for replication and involvement
- ✓ Progress in covering operational costs as part of installation costs
- ✓ Financial and technical capacity to run the systems
- ✓ Availability of data submission procedures and nature of data submitted

Donors

- ✓ Existence of strategies to integrate other donors
- ✓ Level of awareness, involvement and sharing of results
- ✓ Linkages of project to other ongoing donor assistance projects

Private Sector

- ✓ Strategy for involvement
- ✓ Progress achieved
- ✓ Plans to improve integration

Impacts

- ✓ Reduction in electricity costs
- ✓ Substitution of other energy forms
- ✓ Cost of other energy forms
- ✓ Average tariff for different consumer categories
- ✓ Improvement in standards of living
- ✓ Increase in income generation activities and disposable incomes
- ✓ Reduction in cost of outages
- ✓ Reduction in generation capital costs
- ✓ Lowering of system losses
- ✓ Level of revenue collection
- ✓ Substitution of imported fuels for generation
- ✓ Reduction in maintenance costs

- ✓ Increase in grid connections
- ✓ Energy consumption by different economic activities

Gender Issues

- ✓ Number of beneficiaries
- ✓ Contribution of project to address gender concerns in energy supplies and economic and social issues
- ✓ Involvement of minority groups

Environmental Benefits

- ✓ Levels of displacement of fossil fuels
- ✓ Savings in CO2 emissions

Annexure 6: Usefull information collected during the evalutaion

Source of Income

Product	Monthly Quantities	Unit Price	Monthly Total
Doma (Alcoholic Beverage)	-	-	300-500NFA
Rope	12-20 Ropes	5 NFA	60-100 NFA
Mats	7-10 Mats	25 NFA	175-250 NFA
Fish	1-2 Tonnes	2-3 NFA/kg	1000-3000 NKF

Cost of other Energy Sources

Source	Monthly Quantity	Unit Cost	Total Cost
Kerosene	5	12 NFA/Litre	60 NFA
Firewood	200 kg	20 NFA/100kg	40 NFA
Batteries	140 Pairs	13 NFA/Pair	1,820 NFA

Electricity Tariffs

Tariff Category	**Nakfa/kwh**		**Fixed monthly charge**			
	Present	New	Present		New	
			1 Phase	3 Phases	1Phase	3Phases
71	2.27	2.52	6.00	15.00	10.00	20.00
72	2.95	3.25	10.35	31.10	15.00	41.00
73	2.94	3.20	2.94	3.20	15.00	41.00
74	2.33	2.60	-	65.00	-	82.00
75/76	1.53	1.80	-	65.00	-	85.00

Generation Costs

Item Description	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total Co	
	Qty (Lts)	Cost (NFA)	Qty (Lts)	Cost (NFA)	Qty (Lts)	Cost (NFA)	Qty (Lts)	Cost (NFA)	Qty (Lts)	C
Light Fuel	532,312.00	8,414,788.10	1,111,056.00	17,563,573.31	1,286,277.00	20,333,466.82	748,917.00	11,838,879.85	3,678,562.00	58
Lubricants		361,376.90		655,350.35		609,419.32		486,950.47		
Labour		161,729.19		171,683.67		158,073.85		162,029.82		
Material		2,949.28		3,069.00		3,069.00		3,069.00		
Gen. Energy Cost		541.00		498.04		506.69		518.22		
Total	532,312.00	8,941,384.47	1,111,056.00	18,394,174.37	1,286,277.00	21,104,535.68	748,917.00	12,491,447.36	3,678,562.00	60

Assab power plant installed and firm Capacity

	Generators Installed	**Firm Capacity**
Blackstone	4x 563kw	B1 1x350kW
		B2 1 x 350kW
		B5 1x 350kW
		B6 1x 380kW
Caterpillar	900kW	1x 600Kw
Wartsilar (heat rate 8482)	1x 2000kW	1200
	1x 2000kW	1200
Wind	3x 200 (According to wind variation)	3x200

Wind Turbine- Main Characteristics

- Manufacturer — VERGNET S.A.
- Type and rated power — GEV MP 275 KW
- Axis of the rotor — Horizontal
- Orientation of the rotor — Crown orientation-natural orientation by Propeller downstream, corrected by hydraulic eng.
- Heigt of the hub — 55m
- Roter diameter — 32m
- Rotation speed of the rotor — 31 rpm at Low speed or 46 rpm at High speed

- Operation wind speed Limitation — 11.5/s (200kW)
- Cut –in wind speed — 4m/s
- Maximum wind speed (production mode) — 20m/s (29m/s instantaneous)
- Maximum wind speed (tower down) — 45m/s
- Survival wind speed (tower down) — 85m/s
- Power control system — Pitch Regulation
  Active control with hydraulic system

Rotor GEV MP

- Manufacturer VERGNET S.A.
- Material of the blades Epoxy glass
- Number of blades 2
- Legth of the blade 16m
- Material of the rotor Cast iron GS
- Total weight 1 900kg

Gearbox

- Manufacturer Bonfiglioli
- Type Planetary with rectified teeth, gear ratio 1 ; 32.1
- Weight 1 200kg
- Number of floor 2
- Maximun power 275 kW
- Cooling by oil circulation

Regulation System of GEV MP

- Manufacturer:VERGNET S.A
- Type :Hydraulic control driven by PLC
- Regulation of the power by variable chock
- Aerodynamic braking
- Variations of shock by hydraulic actuators embarked in the propeller
- Oscillating Hub with return springs

Generator of GEV MP

- Manufacturer ABB
- Type Asynchronous bi –speed
- Nominal slip 0.92%
- Tension 400V
- Frequency 50HZ
- Cos Phi with full load 0.83
- Rated power 275 kw at 40c
- Output with full load 95.8%
- Rotation speed 1 514 rpm or 1010 rpm
- Weight 1 100kg
- Service S1
- Index of protection IP IP 55
- Cooling mode IC 411
- Class of insulation F reinforced
- Heating F
- Grid connection mode Specialized electronic box
- Maximum current to the grid connection 0.5In

MONTHLY AVERAGE WIND SPEED AND DIRECTION OF GAHRO AT 10 m HEIGHT

	2000		2001		2002		2003		2004		2005	
	speed	***Direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***
JANUARY	8.7003	139.63	8.0138	171.71	N/A	N/A	8.6164	354.77	9.1319	355.54	8.6927	355.4
FEBRUARY	7.9696	140.34	8.6617	168.41	10.383	354.72	8.589	354.79	8.8187	355.6	8.7753	3.775
MARCH	8.9402	140.87	N/A	N/A	9.7719	354.74	8.5496	354.8	8.6462	355.54	8.9784	125.95
APRIL	7.2345	138.79	N/A	N/A	8.5553	354.75	8.6129	354.79	7.915	355.49	9.7717	128.91
MAY	5.3988	332.69	5.6013	354.72	5.2459	354.76	7.7579	354.8	5.2024	355.49	5.7705	7.9178
JUNE	5.7912	358.66	6.3356	354.74	6.1687	354.77	5.8634	354.8	5.6745	355.45	5.5377	333.19
JULY	6.0184	335.63	6.7657	354.76	5.5141	354.76	8.1767	354.78	6.5978	355.41	7.4346	308.5
AUGUST	6.0606	328.09	6.2848	354.73	6.165	354.76	6.1857	354.78	6.9476	355.4	5.5812	326.05
SEPTEMBER	5.8269	76.947	6.1783	354.71	5.4345	354.76	5.3669	354.78	5.309	355.41	5.1963	340.73
OCTEBER	5.6837	130.44	7.4505	354.72	8.6265	354.76	8.1549	354.8	8.453	335.38	7.7461	126.97
NOVEMBER	7.9517	354.7	N/A	N/A	8.9507	354.76	9.6797	354.79	9.0868	355.37	9.1925	129.82
DECEMBER	N/A	N/A	N/A	N/A	8.0112	354.77	8.306	355.1	8.765	355.4	N/A	N/A

MONTHLY AVERAGE WIND SPEED AND DIRECTION OF DECEMHARE AT 10 m HEIGHT

	2000		2001		2002		2003		2004		2005	
	speed	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***
JANUARY	6.366057	30.465	6.621	29.163	N/A	N/A	5.9233	29.189	4.9826	25.174	5.1563	26.046
FEBRUARY	6.237353	30.147	6.035	30.522	N/A	N/A	5.5298	31.224	5.7026	30.587	6.0369	29.781
MARCH	5.975021	30.987	5.086	31.014	N/A	N/A	5.6736	31.084	5.6694	34.485	5.5634	33
APRIL	5.375835	40.657	N/A	N/A	N/A	N/A	5.5181	32.938	5.4988	33.911	5.9221	33.687
MAY	6.42773	37.572	5.855	30.58	N/A	N/A	5.3785	37.983	6.4124	35.307	5.6404	31.924
JUNE	6.192262	22.539	6.027	221.85	5.3744	230.96	6.2226	309.58	N/A	N/A	5.9771	25.69
JULY	6.146324	231.59	5.765	220.35	5.7233	226.6	6.0062	230.92	6.2316	233.23	5.8396	229.2
AUGUST	5.929269	236.16	N/A	N/A	5.8076	223.84	5.3708	219.98	5.6069	221.94	5.5022	218.07
SEPTEMBER	5.378767	43.073	N/A	N/A	5.796	37.364	5.8132	43.254	N/A	N/A	6.0018	39.107
OCTEBER	6.04946	33.792	N/A	N/A	5.9963	34.247	6.4811	33.213	5.7914	34.546	6.7158	32.822
NOVEMBER	5.708172	31.973	N/A	N/A	5.7097	31.456	5.9576	34.081	6.0223	32.297	6.4941	32.295
DECEMBER	5.776999	29.688	N/A	N/A	6.0024	30.315	6.3059	31.287	6.2371	29.249	6.1538	31.873

N.B. Wind speed in m/s while direction is degrees clock wise taking Norht as reference (e.g. 90 degree meeans the wind is coming blowing form east)
N/A means data is not available

Electricity Generation and Sales from EEC systems in GWh

Generation		**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Thermal	Public(ICS & SCS)	179.70	186.03	204.61	201.43	224.44	249.10	264.06	273.02	278.25	257.88	**275.50**
	Auto(APR & APA)	32.51	NA	-	-	-	0.49	2.82				
	Private, Municipalities	NA	7.52	7.75	7.98	8.22	8.47	8.72	8.98	9.15	9.43	9.71
Solar PV		0.66	0.88	0.92	0.95	1.00	1.11	1.22	1.33	1.45	1.56	1.68
Total Generation		**212.87**	**194.43**	**213.28**	**210.35**	**233.66**	**259.17**	**276.82**	**283.33**	**288.86**	**268.87**	**286.90**
Consumption (ICS &SCS)												
	Residential	49.11	51.30	55.33	55.31	63.22	71.67	78.55	84.52	90.36	85.72	91.0
	Commercial	25.65	26.78	28.47	27.78	47.97	57.73	60.93	59.78	62.95	54.95	57.5
	Small industries	31.09	26.28	29.07	26.58	38.11	37.51	38.76	27.85	40.08	27.39	30.9
	Big Industries	35.47	37.69	42.08	47.26	23.02	23.26	24.08	31.68	18.34	33.06	34.8
	Street Lighting	2.35	3.32	3.56	2.79	3.54	3.18	3.42	4.23	4.29	3.07	3.8
	APR & APA own use	21.22										
	Residential	NA	5.76	5.90	6.07	6.25	6.44	6.63	7.83	8.07	8.31	8.56
Consumption (NON EEC)	Commercial	NA	1.08	1.11	1.14	1.17	1.20	1.24	2.28	2.34	2.41	2.48
Total Consumption		**164.90**	**152.21**	**165.52**	**166.93**	**183.28**	**200.99**	**213.63**	**218.17**	**226.44**	**214.92**	**229.14**
Own use(ICS+SCS)		7.30	8.40	7.80	8.98	9.84	12.74	17.52	17.30	16.37	16.79	14.55
Distribution losses		28.60	32.36	38.26	38.15	38.67	43.48	43.60	47.67	45.86	36.89	42.85
Distribution losses from private, municipality generators												
Statistical difference							***1.96***	***2.07***	***0.20***	***0.19***	***0.26***	***0.35***

Fuel inputs at thermal plants

Diesel	Public (ICS + SCS)	13.80	13.64	17.71	17.89	18.62	11.98	9.87	8.82	8.28	6.97	6.43

	Assab Port	0.88	NA	NA	NA	NA	NA	0.88				
	Public (ICS + SCS)	24.00	25.61	26.58	27.25	37.92	45.33	50.65	53.83	52.33	49.62	52.56
Fuel Oil	Refinery	29.69	1.59	NA	NA	NA	NA	NA				
	Public '000' ton						0.24	0.39	0.73	0.83	0.70	0.77
Lubricants	Refinery						NA					

MONTHLY AVERAGE WIND SPEED AND DIRECTION OF GIZGIZA AT 10 m HEIGHT

	2000		2001		2002		2003		**2004**	
	speed	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***	***speed***	***direction***
JANUARY	6.4224	48.538	6.4695	46.622	6.1654	50.916	6.123	56.522	5.1379	40.11
FEBRUARY	7.0705	47.88	6.7818	50.056	6.1063	55.898	5.9327	55.45	6.2626	40.359
MARCH	6.9829	49.722	5.0057	57.308	5.4865	58.84	5.6693	56.199	6.3643	41.682
APRIL	5.4622	48.884	6.2551	51.273	6.876	54.705	6.1514	56.881	5.0789	37.373
MAY	5.6485	43.594	5.2091	44.925	5.103	54.82	5.1144	54.786	4.425	30.234
JUNE	5.3661	242.77	5.8348	242.59	N/A	N/A	5.9796	252.22	2.1868	328.98
JULY	5.1379	40.11	7.1133	238.2	6.7162	244.97	7.5907	241.96	N/A	N/A
AUGUST	6.2626	40.359	N/A	N/A	6.9649	242.51	6.7616	242.64	N/A	N/A
SEPTEMBER	6.3643	41.682	N/A	N/A	4.2603	49.392	4.4038	283.57	N/A	N/A
OCTEBER	5.0789	37.373	5.4363	52.717	5.8672	55.461	5.8688	34.966	N/A	N/A
NOVEMBER	4.425	30.234	6.0147	56.6	6.0134	57.573	5.8043	38.111	N/A	N/A
DECEMBER	2.1868	328.98	6.1828	55.393	5.8921	54.08	5.8845	38.296	N/A	N/A

N.B. Wind speed in m/s while direction is degrees clock wise taking Norht as reference (e.g. 90 degree meeans the wind is coming blowing form east)

N/A means data is not available

Asseb Airport mean wind speed in m/s and direction in degrees

		Jan	Feb	Mar	Apr	may	Jun	Jul	Aug	Sep	Oct	Nov	Dec	A_{mean}
2000	10 m	8.26	7.53	8.82	6.62	5.91	5.28	5.15	5.05	5.27	5.16	9.28	8.38	**6.72**
		134.57	*132.56*	*134.03*	*121.05*	*11.06*	*352.32*	*341.95*	*336.67*	*56.33*	*106.19*	*140.36*	*138.58*	***118.40***
	30 m	9.14	8.40	9.70	7.38	6.78	6.09	5.89	5.76	5.82	5.73	10.17	9.26	**7.51**
		132.76	*131.13*	*133.39*	*121.81*	*2.56*	*345.24*	*334.40*	*331.34*	*51.91*	*105.23*	*138.32*	*136.65*	***118.32***
2001	10 m	8.32	8.49	9.27	7.94	5.39	5.58	5.59	5.37	5.65	7.15	8.87	9.65	**7.27**
		134.95	*132.55*	*135.38*	*131.67*	*34.51*	*327.58*	*326.93*	*336.30*	*96.56*	*128.49*	*139.62*	*143.26*	***123.05***
	30 m	9.15	9.31	10.14	8.75	6.07	6.57	6.52	6.09	6.20	7.84	9.80	10.61	**8.08**
		133.15	*130.48*	*133.88*	*129.76*	*31.08*	*322.70*	*322.04*	*330.38*	*94.52*	*125.87*	*137.17*	*140.82*	***122.39***
2002	10 m	7.57	10.64	9.66	8.86	4.62	5.47	5.17	5.11	5.32	8.50	8.74	7.46	**7.32**
		136.09	*140.30*	*139.56*	*138.73*	*349.44*	*336.53*	*21.24*	*344.23*	*64.83*	*135.87*	*140.06*	*136.22*	***126.03***
	30 m	8.37	11.65	10.64	9.75	5.32	6.37	5.84	5.80	5.86	9.36	9.70	8.28	**8.14**
		133.89	*138.04*	*137.68*	*137.16*	*344.49*	*331.52*	*12.48*	*338.23*	*60.63*	*133.45*	*137.45*	*133.43*	***124.74***

Idi

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	M
2000	4.92	4.79	6.14	5.14	4.05	4.07	3.46	3.77	3.86	3.60	5.90	5.56	
	106.92	*96.46*	*85.07*	*N/A*	*6.98*	*0.48*	*10.93*	*352.38*	*35.79*	*64.91*	*117.85*	*113.63*	
2001	4.96	5.03	5.87	N/A	N/A	3.78	3.64	3.79	3.85	4.43	5.38	6.42	
	103.75	*99.21*	*99.67*	*N/A*	*N/A*	*323.81*	*350.36*	*353.77*	*52.74*	*96.66*	*118.78*	*123.20*	
2002	4.77	7.05	6.68	6.52	3.57	4.14	3.46	3.59	3.79	5.22	5.71	4.86	
	85.21	*116.14*	*96.76*	*93.77*	*352.88*	*333.40*	*0.73*	*8.29*	*48.34*	*107.14*	*116.70*	*109.63*	
2003	5.23	5.32	5.52	6.01	4.75	3.73	3.76	3.51	3.77	N/A	N/A	N/A	
	106.09	*70.16*	*54.76*	*89.11*	*90.54*	*346.60*	*332.30*	*1.64*	*349.29*	*N/A*	*N/A*	*N/A*	
2004	5.72	5.66	5.72	4.91	3.49	3.86	3.71	4.03	3.70	5.26	6.24	6.26	
	101.17	*88.46*	*89.30*	*85.67*	*2.25*	*339.91*	*342.39*	*334.85*	*17.37*	*108.93*	*119.09*	*118.56*	