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Water from Wind Power

Report of the evaluation mission of the MDR/DER Renewable Energy Project, Cape Verde.

January 1984.

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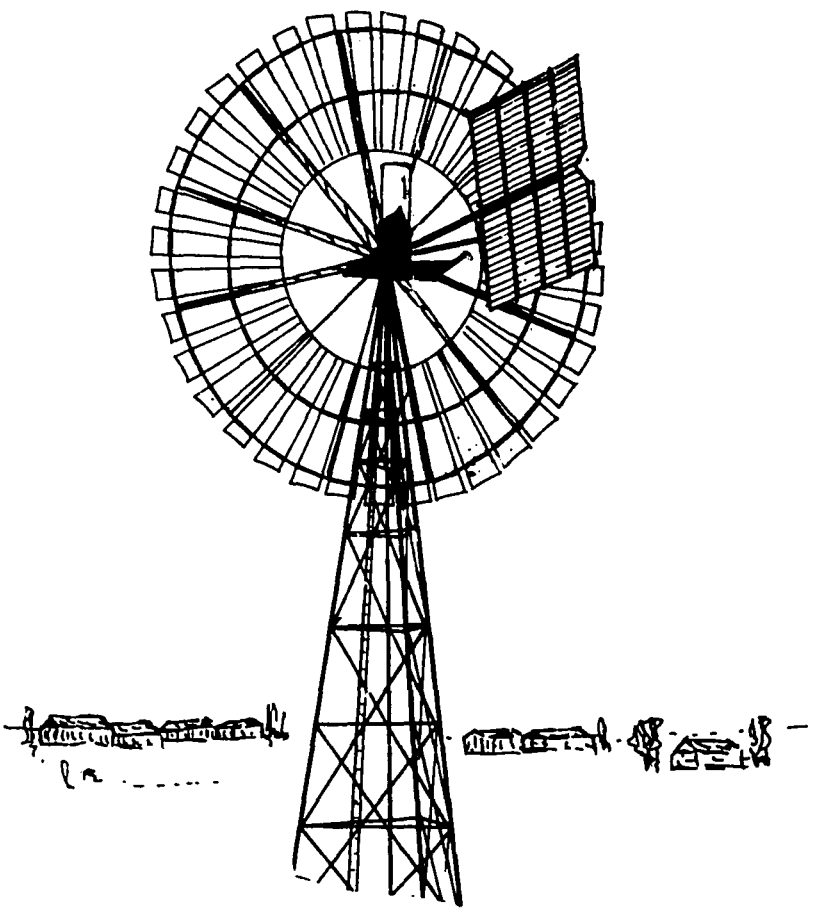

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Preface

Evaluation of this project was carried out by the full evaluation team. The draft report was compiled during the period from 17 to 24 November 1983. On 6 and 7 December 1983 the draft report was discussed with all the Capeverdian authorities involved in the project (see Annexe 1).

For the draft report:
Mr. Joaquim Delgado prepared chapters 5.2, 6 and 11.1.
Mr. Antônio Gomes prepared chapters 5.3, 10.1.
Mr. Allan Miller prepared in part chapter 8.1, 8.2 and 8.3.
Mr. Kees Kempenaar prepared the remainder of the report.

The final report was fully revised by Mr. Kees Kempenaar under the responsibility of the SAWA consultancy commissioned by DGIS.

The evaluation mission wishes to thank the DER team and all MDR departments and personnel involved in this project for their fine co-operation during the evaluation.

The evaluation team also wishes to thank the US AID office of Cape Verde for their support in implementing the typing and copying of our draft report.

The evaluation team
January 1984

Summary

The evaluation team holds the opinion that the continuation of the Renewable Energy Project by DER in Cape Verde is justified. This conclusion is based on the results obtained and on the potential for the practical use of wind energy in the future.

The project provided Cape Verde with a simple method of pumping water by the use of wind energy. The water is well distributed throughout the population and is a good example of a project which is for the direct benefit of the people.

The fact that windmills can pump water more cheaply than diesel pumps is important, and the associated saving of fuel means also a saving of foreign currency.

The local manufacture of mechanical transmission windmills is another important possibility for covering the price of water and for reducing foreign currency.

The lack of Cape Verdian staff members should be resolved as soon as possible, in the interest of Cape Verde.

For the healthy development of the project more attention should be given to:

- ground water problems
- inter-connection with the other MDR departments
- familiarisation of the public in the uses of water, especially in the case of agricultural irrigation
- a longer term strategy to make the project self-supporting in exploitation and maintenance
- lack of management experience.

The collaboration of the project partners, DER, US AID and DHV-SWD, is good. A somewhat more flexible application of the rule of tied aid services could improve the project

At the end of chapters 3 to 11 inclusive we give detailed conclusions and recommendations.

Chapter 12 presents a reaction to the evaluation team of the already known extension plans for the next (third) phase of the project.

Chapter 13 marshals and summarises all the detailed recommendations.

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Acronyms and abbreviations

AWDS	Autonomous Wind Diesel System
CEA	Centro de Estudos Agricolas (Centre of Agricultural Studies)
CVE	Cape Verdian Escudos
DEGAS	Direcção de Exploração e Gestão de Águas Subterrâneas (Direction of Exploration and Management of Ground Water, MDR department)
DER	Divisão das Energias Renovaveis (Division of Renewable Energies, sub-department of MDR)
DGIS	Directoraat Generaal van Internationale Samenwerking (Directorate-General of International Co-operation)
DHV	Consulting Engineers DHV on behalf of SWD
DMR	Direcção de Melhoramentos Rurais (Direction of Rural Improvement, MDR department)
GEP	Gabinete de Estudos e Planeamento do MDR (Study and Planning Office of MDR)
INIT	Instituto Nacional de Investigações Técnicas (National Institute for Technical Investigations in Cape Verde)
MDR	Ministério de Desenvolvimento Rural (Ministry of Rural Development)
SAWA	Consultancy Group for SAnitation and WAter Management, Colectivo de Engenheiros no Domínio de Água e Saneamento
SWD	Steering Committee - Wind Energy Developing Countries
US AID	United States Aid Service

I Introduction

1.1 The objective of the evaluation

The principal objective of this evaluation is to put forward recommendations for the extension of the project after July 1984. The basis of these recommendations is a search for the possibility of realizing a renewable energy project, to be completely integrated with Cape Verdian structures and with other development projects in progress.

1.2 The constitution of the evaluation team

The principal donor participants in the project are:
US AID (aid service of the USA) and
DGIS (aid service of the Netherlands).
In consultation with the Cape Verdian Government it was decided to mount a collective evaluation in which the three main parties of the project would be represented.
The mission consisted of:

a) Cape Verdian Government
Eng. Joaquim Delgado, Agricultural Technician, working in the Groundwater Department of the Ministry of Rural Development (MDR), responsible for the management division.

Mr. António Gomes, Agricultural Economy Technician, working in the Study and Planning Department of the Ministry of Rural Development.

b) US AID

Mr. Allan H. Miller, Senior Research Scientist, working in the Geophysical Fluid Dynamics section of the Geosciences and Engineering Department of the Pacific Northwest Laboratory, operated by Battelle, Richland, Washington, USA

c) DGIS

Eng. Cornelis P. Kempenaar (Kees), Civil Engineer specialising in drinking water and sanitation, working in charge of the consulting engineers SAWA, Utrecht, Netherlands.

1.3 Evaluation programme

1.3.1 Full programme

3 - 16 November 1983	evaluation of the project
17 - 23 November 1983	preparation of the draft report
4 Jan. - 1 Feb. 1984	preparation of the final report.

1.3.2 Observations

The seat of the project is near the capital Praia on the island of Santiago. The main part of the installations is installed on Santiago, but the project has also started on other islands.

To obtain an overall impression of the project and to analyse the special problems which would eventually arise on more isolated islands, the evaluation mission decided to visit the islands of Maio and Santo Antão.

A detailed programme for the evaluation is given in Annex 1.

1.4 Tasks for evaluation

Study and analysis:

a) The project objectives corresponding with the development and the possibilities of Cape Verde, according to the criteria of the two donor parties. The criteria of DGIS are described in Annex 2.

b) The financial, management and personnel capacity of the Cape Verdian Government in relation to present and future project activities.

c) The planning and execution capacity of the project team.

d) Training activities for effective transfer of knowledge and experience within the project staff.

e) The construction and maintenance capacity of the Cape Verdian staff on the long term.

f) Social aspects; relating to the planning and execution of the project and to the benefits for the population.

g) Economic aspects relating to the self supporting nature of the project in the long term.

h) Formulation of recommendations for the extension of the project. In the case of DGIS, the criteria of Category III-d (Annex 2) and the SWD extension proposal of 1983 (ref. 1) will be the basis.

The evaluation team members are not specialists in mechanical engineering, which explains the fact that this subject is not included in the criteria of DGIS (Annex 2) and in the report itself.

II Project characteristics

2.1 Brief history

In 1977 the Ministry of Rural Development in Cape Verde started a project on Renewable Energies. This project started with one Dutch cooperator expert, together with a small Cape Verdian staff. Financial support was given by several donor parties as listed in Annex 3.

In 1979 US AID made a project proposal for renewable energy (ref. 2). This proposal treated a large range of renewable energies. Later on it was adapted several times for the Cape Verdian Government (ref. 3 and 4).

In 1981 the Netherlands embarked on direct participation in the project, formulating a bilateral project between Cape Verde and the Netherlands. This project is based on a study made in February 1981 (ref. 5).

In recent years the chief roles of the donors were:

a) US AID delivery of equipment, tools and provision of transport facilities

b) DGIS - two experts
   - construction of workshop
   - windmills and related hardware
   - transport facilities
   - technical back-up (support).

During the development of the project it was clear that with the available staff the full extent of renewable energy could not be encompassed.

Next it was necessary to solve the problem of water scarcity. In consequence the main task of the project turned out to be a project for pumping water by the use of wind energy.

2.2 Participants in the project

In Cape Verde the Ministry of Rural Development has the responsibility for the project, within the department "Division of Renewable Energies".

The acquisition of equipment for the project from the United States of America is managed by the country office of US AID settled in Praia.

The contribution of the Netherlands (DGIS) to the project is undertaken by DHV, Consulting Engineers on behalf of SWD, Steering Committee Wind Energy Developing Countries.

These are the three parties participating in this evaluation mission; all other parties are listed in Annex 3.

2.3 The objectives of the project

Each participant has his own role in the project, expressed in the project objective descriptions.

a) Cape Verde, MDR/DER:
Use of wind energy for pumping water in rural areas; integrated in the Cape Verdian Governmental Policy for the long term: self reliance in energy supply.

b) US AID:
To assist the Government of Cape Verde to obtain equipment and commodities for expanding its programme for installing windmills for pumping water to be used for irrigation and domestic water supply.

c) DGIS:
Use of wind energy for pumping water in rural areas to be used for drinking water, watering cattle and irrigation.
The following points should be particularly noted:

- Starting local production of the windmills to reduce the requirement for foreign currency, and to create local employment.
- Reduction of fuel consumption which will also bring about a reduction in the use of foreign currency.
- Support for self reliance in management, construction and maintenance.

2.4 Tasks for the project

1. Location of renewable energy installations to cover necessary energy requirements. Concentrate on windmill pumping for water supply.
2. Creation of a project structure with a management, financial, maintenance and exploitation capacity to achieve a self-supporting wind energy programme in the long term.
3. Transfer of knowhow in all project fields.
4. Development of the local construction of windmills.

5. Planning and co-ordination of the integration of the project on a national and regional scale.

6. Formation of the necessary structure for activities preparatory to installation, such as:
   - wind measurements
   - preparation of wind data
   - site feasibility studies
   - output prediction models
   - monitoring.

III Evaluation

3 Wind energy

3.1 Wind regime

From the study of Beurskens in February 1981 (ref 5) more wind data have become available. Study of these data (ref 9) shows that there is no significant change in the Cape Verdian wind regime, so that one may speak of a generally very favourable wind regime.

Windmills cannot be installed everywhere without risk because the favourable wind regime does not always apply. Unfortunately there are only a few wind measurement stations. Based on the data of these stations the Cape Verdian wind regime is studied in general (ref g). However, the differences in wind regimes from site to site are quite large. The decision as to the type of windmill to be installed on the basis of data from wind estimation is nowadays taken after examining the following:

- large scale airflow
- aeolian site analysis
- spot measurements
- impressions of people living in the area
- the experiences of windmills situated nearby is sometimes sought.

It is sometimes possible to use correlation factors to correlate the data of the spot measurements with the data of the longer running measurement stations. However, in practice this does not often happen, because only the airports of Praia and Sal have long term wind measurements.

In the Ribeiras (dry river valley), especially on the rocky islands such as Santo Antão and San Nicolau, no wind measurement station has operated for a long time.

Currently 4 DER wind measurement stations are functioning well on plains.

During the evaluation mission ten anemometers (supplied by US AID) arrived; a localization programme is planned.

Conclusions

-In actual practice, the installation of windmills on a site with a wind regime greatly different from that of the wind measurement stations always runs certain risks, with the possible consequence that the function of the windmills will be less optional than is normally possible with a better network of wind measurement stations.

Recommendations

-Sites of the type where windmills are planned need to be well investigated, and the ten anemometers must be allocated as soon as possible to sites with different wind regimes, according to their importance for the windmill sites in the longer term.

-Enough time must be allowed for the project staff to prepare new wind data, because of the importance in the long term of the windmill programme.

3.2 Wind energy installations

3.2.1 Water-pumping windmills with mechanical transmission

The majority of the installations actually in place are mechanical transmission windmills. The decision of the project to concentrate on these windmills was based on:

- the small risk of failure of the mechanical transmission windmills, which are the only windmills with ample field experience;

- the combination of a rather simple machine which can be introduced and the direct advantage of reducing the water scarcity (lack of rain is an urgent problem on the islands).

During the tour of the sites none of the mechanical transmission windmills were out of commission because of a technical problem in the windmill, the pump or in the transmission. The evaluation mission had the impression that the project staff, installation teams, mechanics and the guards, each in their own place, have the knowledge to install, manage and maintain this type of windmill.

For a clear impression of the already installed windmills and the installation rate see Annex 4 and the proposal for project extension (ref. 1).

Each installed mechanical transmission windmill has its own "diary" in which all the data (well, water capacity, wind regime etc.) are entered, together with details of the monthly maintenance and checks. These data are brief and conveniently arranged.

Although the mechanical windmills function well, there are still some problems:

- lack of personnel; especially a Cape Verdian mechanical engineer on the project staff;
- transport of the windmills to be installed; bad roads; irregular boat connections between the islands.

Problems due to a lack of coordination between DER - DMR and DEGAS are described in chapter 5 and 10.

Conclusions

- The mechanical transmission windmills already installed are functioning well and consequently make an important contribution towards solving the problem of water scarcity.

- Because of the lack of personnel, concentration of the project on the programme for mechanical transmission windmills is a wise decision.

- The lack of a Cape Verdian mechanical engineer on the project staff obstructs the well-balanced development of the project.

Recommendations

- During the establishment of the third phase of the project programme, the lack of a Cape Verdian mechanical engineer must be one of the main items to be considered.

- The majority of the sites with a very serious water scarcity are nowadays supplied with water; therefore the project staff has to give more attention in future to local construction than to the siting of imported windmills.

3.2.2 Water-pumping windmills with electric transmission

The islands have many plains with a favourable wind regime but on the average the Ribeiras have better wells. A part of the Ribeiras still has quite a favourable wind regime but another part is not favourable for windmills because of lack of wind or excessive turbulence.

For the sites with a bad wind regime and for a plain or a high point with a good wind regime in the neighbourhood, the electric transmission water-pumping windmill can be a good solution (ref. 5). The possible number of this type windmills to be installed is estimated at about 50, which is about 12% of all the water-pumping windmills.

Unfortunately field experience of the project when the Aerowatt system has been installed is very bad. The generator is frequently burnt out and even now the manufacturers do not answer the enquiries put to them by the project. Besides this problem, the Aerowatt system seems to be quite complicated and expensive. For these reasons the project staff decided to stop the Aerowatt experiments.

The SWD developed another type of electric transmission water-pumping windmill. A prototype of this windmill is functioning in the Netherlands and now the SWD propose to introduce a prototype in Cape Verde to gain experience in Cape Verdian conditions.

The Cape Verdians, alerted by their bad experience with Aerowatt, want to see this prototype so as to get a better opportunity to evaluate the possibilities and risks of this electric transmission water-pumping windmill. The director of the project will make this inspection at the end of November 1983.

Conclusions	Recommendations
- About 12% of the water-pumping windmills can use electric transmission which means that a start with a new prototype to gain experience is necessary for the use of this system in the long term.	- During the establishment of the third phase of the project programme the lack of a Cape Verdian electrical engineer must be one of the main items to be considered.
- The failure of the Aerowatt system indicates the importance of developing an adequate machine before selling it to a developing country. Therefore the watchfulness of Cape Verde with respect to a new prototype is very commendable.	- Even without having a Cape Verdian electrical engineer at its disposal the project can mount a pilot project with an electric transmission water-pumping windmill to gain experience. Without a Cape Verdian electrical engineer, however, there is not a good chance of starting a practical programme to install more windmills of this type.
- The lack of a Cape Verdian electric engineer on the project staff obstructs the well-balanced development of the electric transmission water-pumping windmill branch of the project.	

3.2.3 Electricity generation by windmills

In this range two systems need to be distinguished:

- autonomous wind diesel systems (AWSD), attractive for electricity supply in rural areas;
- wind generators connected to urban networks.

The latter is only a possibility in the two cities of Cape Verde, Praia and Mindelo, and on the island Sal. A pilot project in this range has started under the responsibility of INIT, the national institute of technological investments of Cape Verde and therefore outside the scope of this project.

The first possibility is being studied. Last September a Dutch team made a feasibility study, and their draft report is ready (ref. 13).

From an economical analysis of this study it is clear that in practice the continuous electric power demand in the villages is too low for an economically feasible use of the AWDS system. Only at some future time when a continuous demand for electric power is generated, for example by small industries, desalinization and/or cool store facilities, would there eventually be some villages where the AWDS system could be used economically.

Conclusions

- In the short term there is no village in Cape Verde where the AWDS system is economically feasible.

- In the long term the AWDS system may be economically feasible in some villages.

Recommendations

- We need only consider the mounting of a pilot AWDS system in the third phase of the project, when it can be clearly shown that the continuous electric power demand for some villages will have been brought by new developments to a level where the AWDS system will be economically feasible in the longer term for these villages.

- The availability of a Cape Verdian electro-technical engineer should be guaranteed before the start of the first AWDS installation.

4 Non-wind renewable energy

The project started several small schemes of an experimental character in the field of solar and bio-gas energy. Unfortunately, with one exception, all proved failures.

The reasons were:

- technologically bad development
- co-ordination problems.

At present only three small projects are still proceeding:

- the well functioning water still, converting sweet water to distilled water, used for batteries etc., situated on Achada de San Filipe near the project seat.
- a seawater still on Ilha de Maio the design of which is ready. The project has insufficient personnel to start this construction. Co-ordination by the MDR island responsible failed.
- the bio-gas installation on the agriculture centre of San Jorge. The construction was started in June 1982 and is still not completed; it seems that the project staff were not able to give it adequate attention.

Conclusions

- Because of the lack of personnel it was a wise decision to concentrate on the wind energy project.

- The last two, called "small projects", are not advancing because there was insufficient staff to give them adequate attention.

Recommendations

- In the short term a decision must be taken about the small projects of non-wind renewable energy: either to continue them (which is very difficult) or to transfer them to INIT who are also busy with a bio-gas project and who have more personnel.

- Non-wind renewable energy can be beneficial for Cape Verde if pursued in the same way as wind energy; in principle this can be done in the DER project, but only when the project staff has been enlarged with Cape Verdian experts for the non-wind renewable branch. If this is not possible, priority must be given to wind energy.

5 Water aspects

5.1 Introduction

During the evaluation, the mission encountered some windmills either not working, or working far below their capacity for the reason that their wells had dried up, or which gave very brackish unusable water. These examples show the limiting factor of water in the use of windmills for water supply in Cape Verde. In serious cases the windmill will be replaced. A cost calculation for replacement is made in Annex 5.

Water has always been a rather scarce resource in Cape Verde and because of many years drought this problem is greatly augmenting. The situation calls for a well defined policy in the field of water supply and in the control of the ground water aquifers.

For this reason the evaluation team is devoting a special chapter to aspects of the water problem.

5.2 Ground water

Immediately after independence the Cape Verdian Government embarked on a water supply programme in which the number of wells was greatly enlarged to overcome the water scarcity caused by the many years drought.

During the early years of this programme the technical possibilities of achieving a realistic estimation of the capacity of the wells (the pumping tests) were not optimal, with the consequence that some estimates were too optimistic. Therefore the evaluation team broadly discussed the well capacity estimation methods and the programme for investment in relation to the behaviour of ground-water aquifers influenced by the drought and the larger number of wells.

To overcome the water problem in the long term MDR began a programme with the following main aims:

- improvement of the penetration by the construction of check-dams in the dry rivers, construction of banquettes and level-arches on the mountain and hill slopes, and intensive reafforestation;
- improvement in the methodology of pumping tests (well capacity estimation tests);
- control of the behaviour of the ground water aquifers.

5.2.1 Improvement of penetration

With the very low precipitation which has occurred during recent years, ground water potentials have diminished every year. Moreover, when it rains, one cannot profit from all the water that falls, because a major part of it flows as surface run-off directly to the sea.

Precipitation is the natural source of replenishment for the aquifer. Because of the very great irregularity of the rainfall during recent years, and because of the increase in exploitation, it has appeared to be necessary to improve the penetration possibilities, with the aim of preventing the possible seepage of brackish water into the lower regions of the valleys, and the impoverishment or even depletion of the water reserve in the higher zones.

In some coastal areas with high permeability, where the drawdown is significantly higher, one can already observe the effects of salt water seepage. In consequence, various works have already been carried out, to increase the penetration of rainwater and consequently also the groundwater reserves. In the rivers the construction of check-dams to prevent the surface water from flowing to the sea has been stepped up. On the slopes works have been continued for the construction of banquettes and level-arches and for the intensification of tree-planting.

The programme of measures for the improvement of penetration is well developed and making satisfactory progress on all the islands of Cape Verde.

5.2.2 Pumping tests

DEGAS (the groundwater department of MDR) has carried out pumping tests on all tubewells and dug wells, in order to make a study of the behaviour of the wells, which predicts the yields and resulting drawdowns at exploitation and gives representative values of the aquifer characteristics.

Nowadays DEGAS is using two types of pumping tests, i.e.:

A. well test (or yield evaluation test) in which the water levels during the pumping testsare only measured in the well under test, giving the following data:

1) the optimal or advisable yield which can be exploited from the well or tube-well
2) characteristic curve of the well or tube-well
3) efficiency value of the well or tube-well
4) estimate of the aquifer transmissivity
5) preliminary aquifer data.

B. aquifer test in which the drawdowns are observed in wells or in a piezometric well, close by the well under test, in addition to the well under test itself, giving the following data:

1) the aquifer transmissivity
2) storage co-efficient of the aquifer
3) specific characteristics of the aquifer or in relation to its contour
4) presence and situation of the aquifer boundaries

5) data from which one can make a reasonable extrapolation of the drawdown caused in the well or tube-well by a lengthy exploitation
6) efficiency of the well or tube-well.

During the early years of the water supply programme only a part of pumping test A could be realized with the unfortunate consequence that the capacity data of the new wells were not entirely reliable, therefore DEGAS improved this pumping test and now it gives better results.

In more doubtful regions DEGAS is also using pumping test B for more fundamental data to obtain a reliable well capacity estimate.

5.2.3 Ground water aquifer

To get an effective control on the exploitation of the ground water aquifers, DEGAS started an observation and control network of water points in some regions of the island of Santiago. DEGAS is currently trying to improve and complete this network with a study of a hydrological balance of watersheds in close co-operation with hydroclimatological MDR division.

The measurements normally taken are the following:

- yield
- air temperatures
- water temperatures
- pH
- electrical conductivity

- chlorides
- total hardness
- water level
- water sampling for chemical analyses.

For the salinity intrusion, control tube-wells have been drilled in the dry-river estuaries. Some of these wells will be equipped with limnographs, while from others water samples will be taken.
In these the following need to be done:
- monthly check
- conductivity profile
- graph preparation
- comparison with other data obtained.

To control the quantity of the pumped water, for the diesel pumps a daily operation record is made with a fixed pump yield in order to obtain a constant daily volume of pumped water. These volumes are determined by DEGAS.

On the tube-wells equipped with windmills, the yields are estimated by multiplying the stroke volume by the number of strokes in 5 minutes. This method is not effective as the number of hours the pump operates depends on wind (function of the wind speed). To resolve this problem DER needs to install the water meters as soon as possible (see chapter 7.2).

For the water quality control a well equipped laboratory exists in San Jorge in CEA (Centre of Agricultural Studies) where the monthly sample will be sent to be analysed. There, three types of analyses can be done: chemical, physical and bacteriological.

The programme to achieve effective control of the behaviour of the ground water aquifers is now in an initial phase only on the island Santiago.

5.2.4 Relation between ground water and wind

In the programme for new wells, DEGAS made its tube and dug wells without regard to the availability of wind. In certain cases a well, intended to take water from the same aquifer, can be placed on a favourable or unfavourable wind site with almost no effect on its capacity. Therefore DEGAS must give attention to this problem.

Conclusions

- Cape Verde is starting a determined effort to get effective control of the ground water aquifers.

- The pumping tests for the well capacity estimates have been improved.

- The programme for the improvement of penetration is progressing satisfactorily.

- Within the DEGAS department the attention to windmill potential can still be improved.

- DER must install the water meters as soon as possible to obtain information on the total water extraction of each aquifer.

Recommendations

- The control programme on the ground water aquifers needs to be enlarged as soon as possible in all the islands, especially on the agricultural islands such as: Santo Antão, San Nicolau, Fogo and Brava.

- The results of the pumping tests still need to be monitored against the actual amount of water withdrawn daily from the well, and the influence of this daily water withdrawal on the water level in the well. In this way there could be effective control of the need to improve further the methodology of the pumping tests.

- In the programme for new wells DEGAS has to consider the water/wind relation, if possible, in order to locate the well on a site favourable for wind.

5.3 Water policy

Before independence water and wells were in private ownership. After independence all water was nationalized as a first step in the policy which provided that a scarce resource, such as water in Cape Verde, needs to be exploited in the interests of the whole population. Unfortunately the wells constructed by private owners before independence are mostly still in private ownership. And the owners are still selling the water from these wells.

In some regions of the islands people intentionally clogged newly sunk wells, which indicated their strong disagreement with the construction programme for new wells. This disagreement could arise from a serious anxiety that more wells will dry up the aquifer in the short term, or it could be merely a question of self-interest, because the new wells in the ownership of the state made the population more independent of the wells which are still in private ownership.

Chapter 7 describes the difficulties in regions where water prices are different and chapter 10.5 calls attention to a policy for private well owners and the possibility of windmill installation by the DER project.

The evaluation team broadly discussed the plans to overcome this type of problem. From GEP we received information that a special office (commission), the so-called water commission (comissão de água), is preparing an official document, the water

code, in which the law and regulations for future water policy will be defined. Some intentions of this document are known, i.e.:

- Creation of a water company at national level; a company responsible for the distribution of the water and its infrastructure, for exploitation and maintenance.

- Creation of (more) water commissions formed by representatives of different services and the population to coordinate the activities connected with water (note: in several regions with agricultural irrigation these commissions have already been functioning for a long time).

- The population will be asked to participate more in the maintenance and management of the water supply by the habitation commissions (commissões de moradores).

- Equalization, as far as possible, of the water prices on each island.

Conclusions

- In Cape Verde water can be called "oil" and that expresses the stark necessity to have a water policy clearly defined as soon as possible.

Recommendations

- Within the water policy it seems important to consider:
  - population participation in construction programmes for new wells and in maintenance and management of the water supply;
  - an organisation structure (company) responsible for the water distribution and its infrastructure in exploitation and maintenance;
  - an organisation structure for water distribution in the case of irrigation regions (water commissions);
  - water price;
  - ownership relations.

6 Maintenance

6.1 Maintenance in operation

Maintenance is one of the most important activities and the DER, which has always given serious attention to maintenance, is still trying to improve it.

Every month a maintenance schedule for each windmill is presented. All maintenance is schematized on a form (Annex 6) and the mechanic has to write down his findings. This form is placed in each windmill's own file. Afterwards all the mechanical data are collated in an annual survey (Annex 7) which gives a clear indication of the condition of the windmills.

The monthly maintenance work can be summarized as follows:

a) control and observation of the functioning of the complete windmill;

b) lubrication of transmission;

c) a seal substitution in case of water leakage;

d) lubrication of yawing system and other moving parts;

e) measurements of quantity of water pumped at a given moment, ground water level in the well and conductivity.

Unfortunately the measurements of ground water level in the well and of the conductivity of the well water are not always carried out. In fact these measures are not difficult but the mechanic feels himself more directly linked to the windmill than to the problem of water level and quality.

The most frequent problems are:

a) pump rods broken by corrosion;

b) pump rods which come unscrewed;

c) seal problems;

d) broken piston boxes caused by bad well alignment.

While the maintenance scheme is being improved, some technical adaptations have been introduced. The success of these two actions means fewer repairs, especially seal leakage and unscrewed pump rods (see Annex 8). Unfortunately the pump cannot be inspected at frequent intervals, because it takes a long time. This means that the pump will only be inspected when real problems arise with it.

Besides the montly maintenance, a more time-consuming annual maintenance is carried out. With the present scheme of monthly maintenance control and one special annual maintenance, an optimal result is assured.

The costs are estimated in ref. 11. A summary is given in Annex 9. An important datum of the cost estimate is that painting is relatively expensive; painting costs are ca. 75% of the total maintenance costs. Therefore the project has mounted a study of better types of paint, more resistant to the Cape Verdian climate, so as to prolong the protected life of the windmill.

6.2 Education

The project staff is always preoccupied with assembling a good maintenance team with the capacity to execute a preventive maintenance scheme, so as to make the exploitation cost as low as possible. Therefore several courses have been arranged with the object of improving expertise.

DER has already organised a three month extended course in installation, maintenance and repair of mechanical transmission water pumping windmills for six mechanics, one each from the islands of Maio, San Nicolau, Sal, Santo Antão, Boa Vista and the Tarrafal Municipality in Santiago.

This course was prepared and given by the mechanical engineer, Kees Versteegh. The installation of two Dempster windmills in Ribeira Saltos and in Ribeirão Manuel was regarded as a practical exercise. A part of this course was also attended by all DER personnel on executive level.

After this course the six mechanics returned to their islands. Each one received a motorcycle and a box with tools.

This measure improved the maintenance, especially on the other islands. Before the course was inaugurated, maintenance on the other islands was carried out once or twice a year. Today maintenance is also carried out monthly, and a copy of the maintenance scheme is sent to Praia.

In addition to this course, three persons attended another course in São Vicente organised by the technical training centre of Cabenave. The students were two mechanics and one supervisor, and the course had the aim of improving their proficiency in milling, drilling, etc. The first phase of this course is already completed and the students are waiting for the second phase.

Conclusions

- Maintenance has been improved by a monthly maintenance scheme.

- Having a mechanic for each isolated island is an important advance in regard to maintenance.

Recommendations

- The type of repairs and the total maintenance costs must be analysed each year. Should there be radical changes in the circumstances, a new maintenance strategy must be worked out.

- A type of paint capable of diminishing paint costs must receive special study.

7 Social aspects

7.1 Participation of the population

The participation of the population can be divided into three phases:

a) during the design of the installation and its infra-structures;

b) during the installation of the windmill and the construction of the infra-structures;

c) in maintenance and management after installation and construction.

7.1.1 Design period

Most of the windmills are installed in regions with a water scarcity, often very serious, and they have solved an urgent basic need, i.e. the provision of sweet water.

The population normally discussed their wish to solve the water problem with the habitation committee, which has a connection with the municipality, the political party or the MDR region responsible. In all these ways the desire to investigate the possibilities of improving the existing wells or the drilling of new wells makes itself felt. In practice this cooperation is working quite well.

After this stage the population no longer participates. Within the structures of MDR it was decided to install a diesel or a windmill pumping up the water, and the infra-structure is designed to the estimated data of the Ministry.

7.1.2 Installation and execution

There is only a small direct participation of the population during the installation of the windmill and the construction of the infra-structures.

In several cases some people of the region, village, who will gain a direct benefit from the pumped water, are working (paid) in the construction of the infra-structures or painting the windmill after installation.

In fact most of the work for the installation of the windmill and its pump is specialized work needing to be done by a trained team.

Some indirect voluntary work is done, i.e.:

- helping to unload the trucks;
- offering board and lodging to the installation team at reduced prices.

People could do voluntary work during the construction of the infra-structure. In reality, however, that is very difficult to bring about, because the serious drought made the majority of the population very poor, and they have to work for money to survive.

7.1.3 Maintenance and management

As stated above, the windmill and its pump need specialists, and this is also the case for most of the maintenance.

The daily management of the windmill is undertaken by a paid guard. Normally the guard is not trained in the simple tasks of how to manage the windmill and how to sell water. Nevertheless, in some cases the guard does simple maintenance, i.e.:

- lubricating the windmill;
- tightening the pump rod sealing nut.

Occasionally the guard does not belong to the population which is directly benefited and so exhibits less interest.

Conclusions	Recommendations
- For the greater part of the installation and maintenance work with water pumping windmills, specialists are necessary and untrained local people cannot participate.	- Within the project it is not well defined what type of installation and maintenance work can be done by untrained local people and/or by the guard. All guards should be trained to do simple maintenance work.
- Participation during the design period is difficult at the present time of project staff shortage. The need to arouse the interest of the population has not been proved in this project, but in some foreign projects direct participation of the population created more interest and probably a significant influence during the run of these projects.	- From experience of foreign projects, it seems to be important to create a participation structure for the design, especially for the infrastructure such as tap houses, irrigation structure, etc.
- The guard of the windmill must be one of the benefited people, so as to have a social motive to work well.	

7.2 Use of water

The use of water can be divided into:

- drinking water
- irrigation
- cattle.

The great majority of the windmills pump drinking water. Frequently the windmills are installed in places of serious water scarcity. Where the urgent problem is solved, i.e. supplying the basic need of sweet water, it is clear that the water is used optimally to the satisfaction of the population.

On some sites, where the water scarcity is less, people do not always use the water supply optimally, for example for the reason that the water needs to be paid for; other wells (further away but within the reach) give free water.

Cattle breeding on a somewhat larger scale is normally done in the drier regions without well water for irrigation. Therefore water is scarce, with the consequence that the use of new water supply is optimal.

Agricultural irrigation needs a smoothly operating plan:

- water distribution
- work structure: private farmers
cooperatives
state company
- infra-structures: transport
markets.

In the future windmills are going to be used for pumping irrigation water; in that case the structures described above need to be discussed with the population.

These infra-structures should be prepared and set up by the Directorate-General of Agriculture of MDR, in consultation with DER. Actually within DER nobody is well equipped to do this job.

To estimate the use of water by the people is very difficult. The guard is not well informed as to the number of people who frequently use water. Sometimes directly after rain less water is consumed, but the quantity is not known. To improve the design data of the windmill more accurate data are required as to water consumption.

The project has many water meters in stock and has just started a water meter installation programme.

Other problems related to water are described in chapter 5 and 10.5.

Conclusions	Recommendations
- To ensure good use of water there must be a well defined policy for: • water price and management, so that water price never can be an excuse to use free water from elsewhere; • planning and popularisation of agricultural irrigation and all its necessary infra-structures.	- DER is officially not responsible for water price, management and infra-structure problems, but nevertheless within the project staff somebody must take in hand the task of stimulating the responsible MDR departments to define a policy for water price and management and to prepare and set up a popularisation and infra-structure plan for water use.
	- To improve the design data of the windmill and its infra-structure, the installation of water meters for each windmill must be proceeded with as soon as possible.
	- The population is not clear about the difference in water quality from open or closed wells. DER has to contact the Ministry of Social Works to initiate an educational programme about the risks of dirty water.

8 Economic aspects

8.1 Introduction

Two important issues to be evaluated are:

- the economic advantage of local manufacturing of mechanical transmission windmills;
- the economic advantage of fuel import reduction by wind energy use.

Time failed and data were not ready at hand to distinguish between specific situations, taking into account:

- drilling costs for wells differ per island and even per region;
- difference in elevation heads;
- difference in wind regime;
- difference in transport costs per installation; etc.

However the evaluation team is of the opinion that the method and data used lead to a good general estimate of the comparative water cost between the different pumping devices. But it must be observed that the real cost might be somewhat higher or lower than the figures we obtained, depending on the specific site conditions.

The range of water pumping installations from which the costs will be calculated are:

1) an 8' diameter Dempster windmill pumping 20 m^3 per day;
2) a 14' diameter Dempster windmill pumping 50 m^3 per day;

3) a 25' Southern Cross windmill pumping 200 m^3 per day;

4) a locally built 5 metre diameter windmill pumping 100 m^3 per day;

5) a diesel pump pumping 160 m^3 per day, for 300 days per year.

8.2 Cost information

Table 8.2.1 gives the costs for the five installations. The costs are different for each installation. Costs independent of the installation are given in table 8.2.2.

Information about the cost items of table 8.2.1:

- The purchase costs of the Dempsters and Southern Cross are the costs inclusive of transport etc. to Praia;
- The purchase cost of the locally manufactured windmill is taken from ref. 5, appendix H, which seems to be close to the actual cost of construction and installation of the first prototype made by DER.
- The purchase cost of the diesel pump is known in Cape Verde; it is a Lister diesel of 20 m^3 per hour.
- The installation costs of the three imported windmills are based on the experiences of DER.
- The locally manufactured windmill is less complicated so that it is much cheaper to install.

- The installation cost of the Lister diesel pump is not available and so has been estimated.
- The tank cost is taken from the estimates of ref. 6, partly reproduced in table 8.2.3.
- In Cape Verde the capacity of the tank is always taken as being equivalent to two days' reserve.
- The price for a 200 m^3 tank is the equivalent of a 100 m^3 and a 500 m^3 tank and is assumed to cost 950,000 $00 CVE.
- Maintenance costs are estimated according to the experiences of DER, see annex 9.
- The locally manufactured windmill has no gearbox so is likely to be cheaper to maintain.
- The maintenance costs of the Lister diesel pump includes operating costs: fuel, lubricant and an operator; together estimated at 152,160 $00 CVE/ year. The real maintenance costs are estimated at 27,360 $00 CVE/year (see ref. 6). These costs are based on an average operation time of 2400 hours/ year.

Table 8.2.1 Costs for the five different water pumping installations, all in Cape Verdian Escudos, at the level of December 1983

type of installation	purchase costs (including pump) in CVE	installation costs in CVE	tank costs in CVE with tank capacity in m^3 between ( )	maintenance costs in CVE/year
1	132,696 $00	26,396 $50	275,000 $00 (40)	12,257 $00
2	349,240 $00	26,396 $50	560,000 $00 (100)	12,257 $00
3	788,470 $00	49,541 $20	1 500,000 $00 (500)	16,343 $00
4	99,050 $00	20,000 $00	950,000 $00 (200)	10,000 $00
5	136,400 $00	20,000 $00	-	179,520 $00

Table 8.2.2 Costs which are the same for all installations

	in CVE	in CVE/year
well	390,000 $00	
tap house	25,000 $00	
total	415,000 $00	
plumbing	90,000 $00	
guard/well operator		36,000 $00

Table 8.2.3 Cost of tanks from ref. 6

volume	cost
20 m^3	175,000$00
40 m^3	275,000$00
100 m^3	560,000$00
500 m^3	1,500,000$00
1000 m^3	2,500,000$00

Information on the cost items of table 8.2.2:

- The cost of drilling and casing a 4-inch diameter well is provided in ref. 6 for 9,650$00 CVE/metre in 1981. Taking into account both inflation and the larger 6-inch diameter, our average well costs 13,000$00 CVE/metre in December 1983. The average well depth will be 30 metres, so the total cost of the average well is 390,000$00 CVE in December 1983.
- The investment costs for plumbing and the tap house are estimated using the data of the DMR department.

8.3 Economic evaluation

At the present stage of the project all hardware and other investment costs are donated, so in practice no interest needs to be paid.

However, to calculate the cost without interest does not give a realistic picture. In the strategy of self-support it must be the intention that the project can pay all exploitation, maintenance, repair and replacement costs. The project will be able to conclude a future loan for the replacement of windmills or other necessary equipment and/or infra-structure. Therefore to get more realistic figures the cost calculation is made as if a loan had been concluded to finance the project. For a feasible project an interest rate of about 10% is quite normal, but for a basic need project one can sometimes find a cheaper loan of about 5%. Both opportunities are detailed in tables 8.3.2 and 8.3.3 respectively.

To calculate the capital costs of the loan the annuity method is used, i.e. in the period of redemption one has to pay each year an equal amount of money (sum of rate and redemption). The yearly amount of capital costs is related with the capital recovery factor by the formula:

$$\frac{i}{1 - \frac{1}{(1+i)^n}}$$

in which: i = interest rate
n = redemption period

In the calculation the lifetime of the investment is taken as the redemption period.

Another approach to water cost calculation is to say that the actual investment is given but for the replacements the project has to put an amount of money to reserve every year, to allow for replacement of the installation within the necessary time. For replacement after the respective lifetimes the project has to take amortization into account. But at the end of the life span the money will have a different value (inflation). To work out a water price at the prevailing price level it is assumed that internal expenditures will remain the same and that external expenditure will rise by 8%, i.e. an inflation of 8% for foreign equipment, etc., with the consequence that only the windmill/diesel pump purchase costs are amortized with 8% inflation and all the rest with 0%. This method is in concordance with World Bank's practice for third world countries. The amount of amortization in case of inflation is worked out with the following factor:

$$(1 + r)^n$$

in which: r = inflation rate
n = lifetime.

All amortization is treated as linear. The results of this calculation are given in table 8.3.4.

Working life expectations are based on the experience in Cape Verde and in other third world countries. For both cost calculation methods they are:

Table 8.3.1 Working life expectations

windmill	15 years
diesel pump	5 years
tank	30 years
well and tap house	30 years
plumbing	15 years

Normally in the case of a diesel pump no tank is necessary. But in Cape Verde diesel pumps are sometimes out of work for some days. In drought conditions people are not likely to take risks and almost always quite a big tank is constructed. Therefore for installation 5 two water prices are calculated, one without a tank and one with a tank of 500 m^3 (figures between brackets).

Table 8.3.2 Water cost price calculation for the five installations in case of a concluded loan for the investments (see tables 8.2.1 and 8.2.2) with an interest rate of 10%. Price level at December 1983.

type of installation	1	2	3	4	5
Annual capital costs for: windmill/diesel pump					
purchase	17,446 $00	45,916 $00	103,663 $00	13,022 $00	35,982 $00
installation	3,470	3,470	6,513	2,629	5,276
tank	29,172	59,404	159,118	100,775	- (159,118)
well and tap house	44,023	44,023	44,023	44,023	44,023
plumbing	11,833	11,833	11,833	11,833	11,833
maintenance	12,257	12,257	16,343	10,000	179,520
guard/well operator	36,000	36,000	36,000	36,000	36,000
total	154,201 $00	212,903 $00	377,493 $00	218,282 $00	312,634 (471,752)
water to be pumped in m^3/year	7,300	18,200	73,000	36,500	48,000
cost of water in m^3	21 $ 12	11 $ 70	5 $ 17	5 $ 98	6 $ 51 (9 $ 83)

Table 8.3.3 Water cost price calculation for the five types of installation in case of a loan concluded for the investments (see tables 8.2.1 and 8.2.2) with an interest rate of 5%. Price level December 1983.

type of installation	1	2	3	4	5
Annual capital costs for:					
windmill/diesel pump	12,784 $ 00	33,646 $ 00	75,963 $ 00	9,543 $ 00	31,505 $ 00
installation	2,543	2,543	4,773	1,927	4,619
tank	17,889	36,429	97,576	61,798	- (97,576)
well and tap house	26,996	26,996	26,996	26,996	26,996
plumbing	8,671	8,671	8,671	8,671	8,671
maintenance	12,257	12,257	16,343	10,000	179,520
guard/well operator	36,000	36,000	36,000	36,000	36,000
total	117,140 $ 00	156,542 $ 00	266,322 $ 00	154,935 $ 00	287,311 $ 00 (384,887 $ 00)
water to be pumped in m^3/year	7,300	18,200	73,000	36,500	48,000
cost of water in m^3	16 $ 05	8 $ 60	3 $ 65	4 $ 24	5 $ 99 (8 $ 02)

Table 8.3.4 Water cost price calculation for the five types of installation with annual amortization for replacements; external expenditures 8% inflation, internal 0%. Price level at December 1983.

type of installation	1	2	3	4	5
Amortized costs:					
windmill/diesel pump	28,062 $ 00	73,857 $ 00	166,744 $ 00	20,947 $ 00	40,083 $ 00
installation	1,760	1,760	3,303	1,333	1,333
tank	9,167	18,667	50,000	31,667	- (50,000)
well and tap house	13,833	13,833	13,833	13,833	13,833
plumbing	6,000	6,000	6,000	6,000	6,000
maintenance	12,257	12,257	16,343	10,000	179,520
guard/well operator	36,000	36,000	36,000	36,000	36,000
total	107,079 $ 00	162,374 $ 00	292,223 $ 00	119 780 $ 00	276,769 $ 00 (326,769)
water to be pumped in m^3/year	7,300	18,200	73,000	36,500	48,000
cost of water	14 $ 67	8 $ 92	4 $ 00	3 $ 28	5 $ 77 (6 $ 81)

Two remaining aspects of the project have insufficient local data for water costs to be calculated:

- the electric transmission water pumping windmill
- the combination of a mechanical transmission water pumping windmill and a diesel pump on the same well in order to save fuel.

In the first case reference 8 gives cost information with estimated cost data of an electric transmission water pumping windmill installed in the Netherlands but never used in Cape Verde. These data are too crude to be compared with the other types of installation. As soon as the Cape Verdian data are available, they will be applied to this calculation.

Wind and diesel pump combinations have been tried a few times in the project but their economic value is not known. Before installing more units of this combination it seems necessary to investigate whether the total investment is economically feasible in comparison with the fuel saving.

To obtain information as to the influence of the different investments a breakdown of percentage cost is given in table 8.3.5., 8.3.6., 8.3.7., which stand respectively for loans of 10%, 5% and the amortization method.

Table 8.3.5. Percentage cost breakdown. Price level December 1983

	total yearly costs (CVE)	wind-mill/ diesel pump %	in-stall-ation %	tank %	well and tap house %	plumb-ing %	main-tenance %	guard/ well operator %
Dempster 8'	154,201	11	2	19	29	8	8	23
Dempster 14'	212,903	21	2	28	21	5	6	17
Southern Cross 25'	377,493	27	2	42	12	3	4	10
Prototype 5m	218,282	6	1	46	21	5	5	16
Motor pump without tank	312,634	11	2	-	14	4	57	12
Motor pump with tank	471,752	8	1	34	9	2	38	8

Note: in case of a loan with an interest rate of 10%.

Table 8.3.6. Percentage cost breakdown. Price level December 1983

	total yearly costs (CVE)	wind-mill/ diesel pump %	in-stall-ation %	tank %	well and tap house %	plumb-ing %	main-tenance %	guard/ well operator %
Dempster 8'	117,140	11	2	15	23	7	11	31
Dempster 14'	156,542	21	2	23	17	6	8	23
Southern Cross 25'	266,322	29	2	37	10	3	6	13
Prototype 5m	154,935	6	1	40	17	6	7	23
Motor pump without tank	287,311	11	2	-	10	3	61	13
Motor pump with tank	384,887	8	1	25	7	2	47	10

Note: in case of a loan with an interest rate of 5%.

Table 8.3.7. Percentage cost breakdown. Price level December 1983

	total yearly costs (CVE)	wind-mill/ diesel pump %	in-stall-ation %	tank %	well and tap house %	plumb-ing %	main-tenance %	guard/ well operator %
Dempster 8'	107,079	26	2	8	13	6	11	34
Dempster 14'	162,374	45	1	11	9	4	8	22
Southern Cross 25'	292,223	57	1	17	5	2	6	12
Prototype 5m	119,780	18	1	26	12	5	8	30
Motor pump without tank	276,769	15	1	-	5	2	64	13
Motor pump with tank	326,769	12	<1	15	4	2	55	11

Note: in case of annual amortization for replacements; external expenditures 8% inflation, internal 0%.

In these cost data the investment costs of the new workshop, equipment and the transport means are not integrated; nor are the labour costs for the staff members at higher levels and the administration. For the development of a self-supporting strategy of the project in the long term it is necessary to integrate all the DER costs in the cost price analysis.

As was stated earlier these cost analyses are based on certain assumptions and therefore must be used with care. They provide an estimate and can be used in a cost comparison between the different types of water installations.

Conclusions	Recommendations
- The investment costs for mechanical transmission windmills are a significant part of the total costs, especially in case of the 14' and 25'.	- To reduce the investment costs local manufacturing need to be developed.
- The investment costs of the locally manufactured are significantly lower.	- The capital costs of the tank form such a high proportion of the total annual costs that it is necessary to analyse the possibility of reducing them.
- The tank costs are always a most important part.	- The expense of a guard is significant. Maintenance costs could be reduced if the guard did more maintenance work.
- The expense of the guard is always an important item.	
- It seems that in comparable cases the water cost price of wind pumped water is cheaper than the diesel pumped water, which is a positive consequence for possible fuel (foreign currency) savings.	- The cost calculations of the water pumping windmill (mechanical transmission) combined with the diesel pump on the same well must be investigated with a small complete computer program, before many new installations of this combination are done. This investigation can be done by SWD.

8.4 Foreign currency savings

Foreign currency can be saved in two fields:

- reduction of fuel by using wind energy
- reduction of windmill imports through local manufacture.

8.4.1 Fuel savings

An inventory of all possible tubewells on all islands has been made but unfortunately not of the hand dug wells, so that it is not known how much water can be pumped in the long term by wind energy (see ref. 12). In ref. 5 an estimate was made of energy needed per year for water pumping only on Santiago; this is 755 kWh, all pumped by diesels, which require 755 m^3 diesel fuel. As 75% of this water could be pumped by wind energy, a saving of 565 m^3 diesel fuel can be approached. One litre of diesel fuel costs 20 $ 00, so a saving of 11,300,000 $ 00 CVE/year is possible. 1 $ 00 (dollar USA) = 76 $ 00 CVE, so 148,680 $ 00 dollars USA can be saved annually on foreign currency at the price level of December 1983.

However, it must be said that the estimates and figures used for this fuel saving calculation are somewhat dated and need to be revised. Unfortunately during the evaluation there were no data for this revision, so this fuel saving figure only can be used as an indication and no more.

Fortunately DER had already planned to revise the study of ref. 5 (see ref. 12) in which fuel saving will play an important part.

8.4.2 Saving foreign currency by local manufacture

In the next 20 years it is planned to construct locally in Cape Verde:
- 160 3m windmills
- 90 5m windmills.

The costs of the 5m locally manufactured windmills are 99,050 $ 00, from which the ratio material:labour costs is 2.9:1. All material must be imported, so 73,650 $ 00 of foreign currency is needed for a locally manufactured 5m windmill.

Cost data of the 3m locally manufactured windmills are not known. With the experience of the 5m windmill it is estimated that the material costs (and so the required foreign currency) will be about 50,000 $ 00.

The purchase costs of the imported windmills of comparable size are:
Dempster 8' 132,696 $ 00
Dempster 14' 349,240 $ 00

Foreign currency saving:
(132,696 - 50,000) x 160 = 13,231,360 $ 00
(349,240 - 73,650) x 90 = 24,803,100 $ 00
total 38,034,460 $ 00

In USA dollars:
1$00 USA = 76$00 CVE, so the foreign currency saving is 500,450$00 dollar USA for the next 20 years on a price level of December 1983.

The foreign currency savings of ref. 5 are based on 290 windmills; this calculation is based on 250 windmills.

The data on which this calculation is based are more reliable than those of chapter 8.4.1, but nevertheless the result must be used with care and can only be regarded as a pointer.

Conclusions

- In general the conclusions in the SWD study, on which the second phase of the DER project is based (ref. 5), about the possible foreign currency savings, are correct and not significantly altered.

Recommendations

- The possible foreign currency savings for fuel as well as the reduction of imported windmills indicate the importance of:
  - use of wind energy
  - local manufacture as much as possible and as soon as possible.

- In view of the advantages of local construction of the 3m and 5m windmills, bigger windmills must also be studied.

8.5 Local manufacture - creation of employment

From experience of the construction of the 5m prototype windmill, the necessary labour is estimated at 550 man hours (ref. 5, appendix H). Local manufacture of the 3m windmill is estimated to need 450 man hours.

For the windmills planned over the next 20 years, the employment creation is:

190 x 450 =	85,500	man hours
60 x 550 =	33,000	man hours
total	118,500	man hours

i.e. for each year about 6000 man hours. In Cape Verde an average person works 45 weeks of 40 hours in one year, or 1800 hours/year.

So local manufacture of 250 windmills over a period of 20 years will need 6000/1800 = 3 to 4 persons.

The employment calculation of ref. 5 was based on about 290 windmills in 20 years, this calculation is based on 250 windmills in 20 years, the latest plan described in ref. 1.

Up to now there has been no experience of mass production of windmills, so it is quite difficult to estimate the labour hours for windmill production. Therefore this calculation must be handled with great care and can only be used as a pointer.

Conclusions	Recommendations
- In general the conclusions in the SWD study, on which the second phase of the DER project was based (ref. 5) about possible employment creation are not significantly changed.	-The general lack of employment in Cape Verde and possible creation of employment through local windmill construction indicates the need to construct as many windmills as possible in Cape Verde and to start as soon as possible.

9 Local manufacture of windmills

9.1 Introduction

A locally manufactured windmill can lower the investment cost significantly, which is important for further introduction of the mechanical transmission water pumping windmill in Cape Verde.

Other advantages of the local production are:

- reducing the use of foreign currency necessary to import windmills (see chapter 8.4);
- use of local construction knowledge already available from the traditional windmill manufacturers on the island of São Vicente;
- a certain activation of the local construction workshops and a creation of new work (see chapter 8.5);
- self-reliance in maintenance and servicing, making the use of windmills more attractive and reliable.

The locally manufactured prototype has been installed and is working. However, more time is needed to analyse this windmill completely and to improve the design of the windmill to be manufactured locally. The continuation of this programme planned in the project extension (ref. 1) seems very important. Therefore the evaluation mission decided to visit two construction workshops in São Vicente.

9.2 Possible workshops

The workshops described below were visited by the evaluation team and evaluated as to their potential for windmill construction within the DER construction programme.

9.2.1 Jotanave - Matos

This workshop is a combination of two small private steel construction workshops, i.e.:

Jotanave, a small workshop about 5 years old on São Vicente, constructing: fuel tanks, windmill towers, large steel gates etc. This workshop was started by the owner, a Portuguese with a technical background in steel construction and proficiency in design and making drawings.

Matos, a workshop integrated in a larger family industry for bread and biscuits, Fabrica "Favourita". This workshop has a long experience, made a major part of the equipment used in the bread and biscuit factory such as furnaces, dough mixers, conveyor belts, etc. As well as the construction and maintenance task for the family factory the workshop does a lot of construction work for other people. It has also had experience of:

- construction of windmill towers;
- construction of windmill fans, transmissions and pumps;
- repairing of cars.

Mr. Matos has about 10 people working in his construction and repair workshop. He can work from drawings but is not accustomed to do so. His working style is as follows:

- receive an order
- inspect the site etc. where the order is intended for/going to operate etc.
- start the construction, without proper design drawings
- engaging in much discussion during the construction, always trying to improve the design that he has in mind
- finishing his construction always in good collaboration with the client.

During the last few years these two workshops, both in Mindelo on São Vicente, have co-operated in several construction orders. In the co-operation Jotanave furnished the design and drawing proficiency and Matos furnished his longer local construction experience.

Both workshops only work to order and have no tradition in mass production. Local manufacture of windmills in quantity must be organized so that each windmill is exactly the same, so that every spare part can be used for all windmills. Most of the equipment necessary for the manufacture of windmills is available for use. The Matos family seems to have reserves of money so can eventually buy mass production equipment.

During our mission's visit the possibility of mass production was discussed openly and freely and it seems that these two workshops would like to co-operate, each workshop using its own proficiency and experience.

9.2.2 Onave

Onave is the small shipyard on São Vicente, already about 60 years old. This enterprise was started by the English when they created their bunker harbour Mindelo, the city of São Vicente. After independence the state bought this enterprise and so it is a state company with a certain autonomy under the responsibility of the State Secretary of Industry and Energy.

In fact this company is the origin of all steel construction experience existing in Cape Verde. Before the second world war it was a splendid company. After the second world war the importance of the Mindelo harbour fell and the shipyard suffered a great lack of orders. Nevertheless the steel construction section always managed to get other construction orders. Therefore Onave has also experience in the construction of windmill towers, fans, transmissions and pumps.

The chief of the construction section also constructs and repairs traditional mechanical transmission waterpumping windmills at the weekends in his own small workshop at home. This means that there is considerable experience in this field of work within the Onave family.

The mechanics of Onave are experienced and are accustomed to work with design drawings. Onave too have no experience of mass production.

This splendid history has left quite an amount of old equipment, which is still used, and machinists still get impressive results with it. However, it is almost impossible to produce a given machine part exactly to size, which is essential for mass production. Another influence is the still quite large number of workers in comparison with the number of orders. This is understandable because it is very difficult to discharge people in a country where the unemployment rate is already very high. Unfortunately a large number of workers in comparison with the orders lowers the efficiency of the workers and that may be difficult to change in the future.

Onave planned a project to replace all old equipment; the design phase of this project is running and it is planned that in the coming year the new equipment will be installed. The design is supervised by a Dutch Consultant within the bilateral co-operation of Cape Verde and the Netherlands.

During our mission's visit the possibility of mass production was openly and freely discussed with the director of the company and it seems that Onave is likely to start with the production of windmills.

Conclusions

- In principle both workshops have enough knowledge and proficiency to construct mechanical transmission water pumping windmills.

- Neither workshop has experience of mass production.

- Both workshops have a certain lack of management in co-ordination and organization.

Recommendations

- The first step in the local construction of windmills is a broad and fundamental discussion with these two workshops, analyzing:
  - experience
  - possibilities, capacity
  - collaboration possibilities between these two Jotanave-Matos - Onave.

- The lack of mass production must be taken very seriously before and during the start of local construction.
  A programme must be worked out to overcome:
  - technical problems in mass production
  - management problems in mass production.

10 Project relationship

10.1 MDR departments

The DER is a division of the MDR department DMR (Rural Improvement). The structure of the Ministry is set out in Annex 10.

For the execution of the project DER has direct connections with:

- GEP, the study and planning department, responsible for the preparation and planning of MDR policy, and the accompaniment and support for each project within the MDR.
- DEGAS, the ground water department of MDR, responsible for the ground water wells (those already existing and those newly constructed) and their exploitation.
- DMR, the rural improvement department of MDR, in relation to DER responsible for the infra-structure of water distribution (canalization, public water taps, etc.).

In general one can say that the relations between the project, DER and the other MDR departments are good. The small scale of Cape Verdian society has the advantage that everybody can easily contact everybody else.

Nevertheless during our work visits some inter-connection problems were noticed, e.g.:

- the water-pumping windmill functions well but waterleaks from the pipes and all the taps of the public fountain are defective;
- the water-pumping windmill functions well for some months and yet the construction of the tank or the public fountain is not finished;
- the paint for the windmill was sent a few months ago but the windmill has still not been painted by the MDR delegation;
- after pumping, for example for one year, the well dried up or sea water was coming up.

During the visits to an isolated island as Ilha do Maio it was clear that such problems are more serious. This seems to be quite normal because of the more difficult situation, yet extra attention must be devoted to solving the problem.

All these examples, which are fortunately minimal, show clearly that agreements and co-ordination between DER and the MDR departments need to be improved.

During the mission's meetings with the MDR departments it became clear that these problems are only discussed in an incidental way.

Conclusions	Recommendations
- A structured system of frequent meetings in which each department related to the project participates is essential.	-To improve the interconnection between DER and the MDR departments a collective meeting structure must be organized with, for example, a frequency of once every two months. -To reduce the extra problems of the isolated islands, the MDR departments could start a collective strategy, for example: • Each of the three departments could visit each isolated island twice a year. Each could make a visit every two months, i.e. six times a year. During the visits each department deals with its own business in detail and with the other departments' in general. - The programme for the project extension must be seriously discussed with GEP, DMR and DEGAS so that in the longer term two windmills can actually be installed each month.

10.2 Other projects

In Cape Verde several regional development projects are in progress. Each project has a different sponsor, which speaks for itself.

In the regions where development projects are active, these projects take on the same responsibilities as the MDR departments have in the other regions. During the visits of the mission the same problems were noticed as in chapter 10.1.

The situation that DER, as well as MDR departments, has to co-operate with different development projects, causes a somewhat complicated situation.

Conclusions	Recommendations
The type of problems DER has with the projects are the same as described in chapter 10.1.	- GEP or DMR must arrange frequent meetings with DER and the regional projects to solve liaison problems. (See also the recommendations of 10.1.)

10.3 INIT

INIT is the Cape Verdian National Institute for Technical Investigations. This institute also has a task to perform in the development of the use of renewable energies. MDR and INIT agreed a certain allocation of tasks i.e.

- DER - all wind energy in rural areas
- INIT - all wind energy in urban areas.

The non-wind renewable energies were not involved in this allocation of tasks.

The evaluation mission noticed the absence of frequent meetings between INIT and DER to discuss what is going on in each institute.

Conclusions

- The two institutes INIT and DER, both busy with wind energy, do not have frequent meetings.

- The tasks of the institutes are not satisfactorily defined, especially not in the range of non-wind renewable energies.

Recommendations

- A move to improve the relations between INIT and DER is essential.

- A definition of tasks in the range of non-wind renewable energies must be made soon.

- The two institutes, both busy with wind energy and non-wind renewable energy, must have frequent meetings:
  - for each to be kept well informed about what the other is doing;
  - to prevent things being done twice, e.g. interpretation of wind data, etc.

10.4 Logistics

Unfortunately the project has some logistical problems which influence the progress of the project, and these involve the project staff in much extra effort.

In fulfilling an order these problems can be summarized as follows:

A) Preparation phase

- A lack of documentation for an adequate specification.
- The communication between DER and the suppliers (factories) is slow and difficult.
- The electric equipment normally used in the USA has different characteristics (in voltage, etc.) from those which apply in Cape Verde.

B) Order phase

- It happens that the supplier sends a pro-forma invoice which is not sufficiently detailed or which is even wrongly made out.

C) Transport phase

- Sometimes the packing is insufficient; unfortunately US AID has no control structure.
- Under the rule of the tied aid services of US AID, materials and equipment must be transported by the US merchant service, but unfortunately US ships hardly ever sail to Cape Verde, therefore US AID send its materials and equipment via Lisbon.

As a result:

- there is greater risk of damage, loss and pilfering;
- DER hardly ever plan precisely when materials and equipment will arrive in Cape Verde.

D) Customs phase

- The customs procedure takes a very long time, sometimes more than 3 months.
- Sometimes the papers are not complete and it is impossible to clear customs.

During the first period of the project DER received Dempster (made in USA) and Southern Cross (made in Australia) windmills pumping water by mechanical transmission. Later on during the progress of the installation of this type of windmill, DER decided to install only these types of windmill (see Annex 4) to standardize on three imported types. Unfortunately the Dempster factory has now closed, but DER will receive enough spare parts for all Dempster windmills already installed and for those still in stocks during their working life.

The US AID service is completely committed, that gives normally no problem when material and equipment of good quality can be supplied. But regarding the co-operation with Dutch Aid service and the necessity to standardize, the USA get relatively more profit from the project than

the Netherlands, which seems unjust.

The tied aid services of USA sometimes involves exploitation problems for the project, for example, in case of the Ford pick-up. Cape Verde already decided to standardize the type of pick-up and the Ford pick-up is not favoured because it is of no better quality and has a high fuel consumption.

Conclusions	Recommendations
- Logistical problems in the preparation and placing of the order delay the project.	- For the next phase of the project the preparation of the orders must start earlier to be on time.
- The tied aid services of US AID in certain cases causes difficulties in: • electrical equipment delivery (different voltage, etc.) • delivery of equipment outside the standard types used in Cape Verde equipment very expensive in exploitation costs.	- The difficulties of supplies paid for by US AID need to be fully discussed with the country US AID office in Praia to try to find solutions. For example, in ship transport from USA there seems to be a solution: Cape Verdian merchant service ships regularly sail direct to the USA and back. - In some cases US AID could help the project by a less strict tied aid service; for example electrical equipment, transport means. - During the last SWD mission the customs problems were discussed. The method of solving these problems described in ref. 1 is good and needs to be fully agreed for the next project phase.

10.5 Population

Up to now all windmills have been installed on wells of the State. After independence all groundwater was nationalised by the State. A policy for the wells in private ownership (almost all dug before independence) has not been defined.

The larger farmers show interest in having windmills installed on their private wells.

Especially when private manufacturers construct good windmills (as is planned) the social (income) difference between the bigger and smaller farmers will grow, so that the living standard of the poor small farmer could get worse.

All other relations between the population and the project are described in chapter 7. Chapter 5 describes the population's relations directly linked with the water aspects.

Conclusions	Recommendations
- There is no well defined policy for windmill installation on private wells.	- In the implementation of the Agrarian Reform and/or the Water Code the policy of windmill installation on private wells must receive adequate attention.

11 The project

11.1 Staff and organisation

The organisation of the project is working quite well. It is still on a small scale, so that management problems and the absence of defined responsibilities are not a serious factor.

In practice three sections are working, i.e.:

- overall management of the project, data collection and processing of wind and water;
- the workshop concerned with design, installation, maintenance and repair;
- administration.

A proposal for the organisation structure of DER is made in Reference 10.

Annex 11 describes the present DER structure and team in more detail. At the higher level Cape Verdian participation is not sufficient. Much is done by the Dutch experts who have difficulty in communicating their knowhow because there is no mechanical or electrical engineer.

At the medium level the situation is better. On this level communication of knowhow is partly operative. A design draughtsman is unfortunately still not available. At working execution level there is no real lack of personnel and knowhow transfer works well.

When the present staff at higher and medium levels have been complemented with the three additions:

- a mechanical engineer
- an electric engineer
- a design draughtsman

the project can develop a good staff team with enough capacity and proficiency.

At working level staff growth, proportional to the number of installed windmills to be maintained and repaired, will be necessary. A scheme of the necessary personnel and their capacity is given in Annex 12.

In MDR there is a plan to use the workshop of the project also for motor pumps eventually. In principle there is no objection, but this is only possible under certain conditions. This enlargement of tasks for DER is only possible when the Cape Verdian staff has been augmented at least minimally, again such staff need to be adequately trained for management.

Conclusions

The project is working well but there is a lack of:

- well defined organisation structure (responsibilities for each section);
- Cape Verdian technicians at higher and medium levels;
- management experience within the Cape Verdian staff. This could create problems when the project reaches a larger scale.

- The transfer of knowhow at working level goes smoothly, and the proposal for the expansion of the team for the installation, maintenance and repair is a good start.

Recommendations

- Before the next (third) phase of the project starts an organisation structure needs to be drawn up.
- Without a full complement of higher and medium level staff of Cape Verdians, it will be difficult to put into effect the programme for the next phase of the project and in the long term it will prove inefficient.
- At present the lack of management experience within the Cape Verdian staff is not felt, but in the next phase the project is to be transformed into a "larger scale" project, therefore attention must be paid to management proficiency in the programme of the next phase.
- Should the DER tasks be augmented by the addition of water pumps, the DER staff must be enlarged by at least some members, and the lack of management experience will be felt even more acutely.

- Without adequate management training this measure will not be beneficial to the renewable energy project.

11.2 Finances

Higher and medium level staff members are "established" officers of MDR and paid by MDR. Working level staff are paid by MDR but do not have a fixed contract so they can easily leave when a better job turns up.

All hardware, equipment, windmills etc. are furnished by the donors.

In the long term no strategy has been worked out for making the project self-supporting financially.

Recommendations:

- For the project it is better when people at working level also get a permanent service contract, giving security of employment, since they are more sympathetic to remaining on the project then.
- A strategy for self-support needs to be developed.

11.3 The housing of the project

In October 1983 DER moved into newly constructed housing, and all parts of this housing are well equipped. Annex 11 gives more detailed information.

First impressions indicated that the housing had been well dimensioned and well constructed. Also the type and capacity of the equipment seems to have been well chosen.

Conclusions

- The new housing and its equipment provide good conditions for continuing the project, i.e. for starting the next (third) phase.

Recommendations

- In a year's time it would be worthwhile to investigate whether the housing has proved to be well dimensioned and constructed.

11.4 Project back-up

Back-up of the project is completely done by SWD under the aegis of DGIS.

Back-up is interpreted here in the broad sense of the word, i.e.:

- development of prototypes for the Cape Verdian conditions of climate, wind and water resources;
- support with various engineering matters;
- support for procurement of windmills and hardware;
- support to determine the important technical policies for the project and to help to safeguard project continuity.

The present two experts are working well in the project structure. The principal difficulty which they have had and still have is the transfer of knowhow in the light of the shortage of personnel at higher and medium levels of the Cape Verdian project team.

The current programmed structure of technical back-up from the Netherlands by the SWD in work visits, short term assistance and frequent correspondence seems to be satisfactory. But it must be pointed out that there are still some points of irritation between the project and the Dutch back-up team. These were caused by a mistake made by the coordinator of the Dutch back-up team, which has in some ways affected the smoothness of communication between the project and this back-up team.

Conclusions	Recommendations
- Back-up by the SWD is functioning quite well and the DER project has a lot of profit of it.	- Changing the coordinator of the Dutch back-up team might improve communication between the project and the back-up team.

12 Proposal for extension of the project

12.1 USAID

That part of the USAID participation which was adumbrated in the project plans has almost all come into effect.

No proposal exists for the possible extension of the USAID participation to the next phase.

The evaluation mission discussed this point with the USAID officer responsible, Mr. Frank Dimond. USAID has not made a decision on what to do with this project in the future. The evaluation report will have a certain influence on the future participation of USAID in this project.

It seems probable that for the next project phase USAID can agree to a continuation of the USAID participation in this project in the area of hardware (equipment and tools) delivery and making available long and short term courses, appropriate to the project.

USAID has not planned to make an extension proposal itself. Any extension proposal for future USAID participation in this project made by Cape Verde will be seriously considered.

12.2 DGIS

Last September DER and SWD made an extension proposal for a third phase for DGIS (ref. 1).

The evaluation mission studied this report and has the following general observations:

a) The proposal analysed the progress of the project honestly in comparison with the plans made in 1981 (ref. 5) which were too optimistic.

b) The proposal takes a realistic view of Cape Verde and of its problems which affect the project in progress.

The following items of the project are covered in greater detail in the extension report:

- The necessity of putting in enough Cape Verdian staff members in the short term as well as in the longer term.

- A well programmed plan:
  - Mechanical transmission water pumping windmills to be installed, with close attention to the possibility of windmills being manufactured locally.
  - Starting with a prototype of an electrical transmission water pumping windmill, followed by the installation of some windmills of this type.

- Starting with a prototype of the autonomous electrical energy system. In September 1983 a feasibility study was made.

- The necessity of transferring knowhow directly, to be effected through long term Dutch experts. Their courses in Cape Verde, Holland and elsewhere cover the fields of:
  - installation, maintenance and repair of the windmills
  - windmill design
  - windmill fabrication
  - necessary wind and water data measurements and processing.

- Support of the project through the SWD by experts and short term assistance.

- A well programmed plan for investigations necessary to improve the wind energy programme and the processing of the data.

- Initiating an organisation structure for the project with responsibilities and time schedules.

- The necessary hardware.

More attention needs to be given to the following points:

- Co-operation with other MDR departments to attain optimal use of the pumped water as soon as possible.

- The plan to install two mechanical transmission water pumping windmills per month seems to be feasible within the DER structure. But even if the MDR departments directly involved should have the possibility to construct an adequate infra-structure this point has not received enough attention.

- Social-economical aspects have to get more attention:

  . when there is more water the information about agricultural possibilities, cattle-raising and sanitary aspects should get more attention;

  . uniform price policy;

  . calculation of all costs, also the amortized cost of the workshop, equipment, etc.

- In the longer term a strategy to make the project self-supporting in repair, maintenance and exploitation.

- The management of the project in the future. Now this problem is not big because the organisation is still on a small scale. But with an installation rate of two per month in the future, the lack of management experience will present certain problems.

13 Detailed recommendations

13.1 Cape Verdian cadres

On the higher and medium levels there is a lack of Cape Verdian staff members. To improve this situation it seems to be necessary to make agreements in the contract for the next (third) phase. In the short term the project needs:

- a mechanical engineer
- an electrical engineer
- a designer draughtsman.

If a well balanced future for the project is to be assured, the mechanical engineer must arrive at least by July 1984 and the electrical engineer at the beginning of 1985.

Even when the project staff has been enlarged with the three above described persons, there will still be no staff member for eventual tasks, such as:
- non-wind renewable energies
- motor pumps.

These tasks can never be well performed because special Cape Verdian staff are not allocated to the project.

At present the project staff has a certain lack of management experiences, during the next (third) phase of the project this must be improved before the project is put on a larger scale.

13.2 Local manufacture

The local manufacture of mechanical transmission windmills is very important for economy in foreign currency, investment saving, employment creation and the development of technology in Cape Verde. It must therefore receive close attention in the next phase of the project.

Currently almost all the serious water scarcity situations have been resolved, so concentration of the project on the installation of imported windmills can be reduced. The next phase should consider a reduction of the imported windmill programme and the promotion of local manufacture, more so than is set out in the plans for the next phase (ref. 1).

The economic and employment arguments for local manufacture are so compelling that in addition to the 3m and 5m windmills, also the larger ones need to receive more attention in the next project phase.

Before starting local construction of windmills, the project must discuss with the workshops:

- their experience
- their potential and capacities
- the possibility of collaboration between Onave and Jotanave-Matos.

The workshops have to be seriously trained in:

- technical problems of mass production
- management problems in mass production

which they are surely going to meet.

13.3 Wind energy - windmills

For optimal use of wind energy and optimal windmill design the data of wind regimes for the several circumstances need to be improved. For the interest of the project the staff must give enough attention to the preparation of wind data.

The start of a practical installation programme of the electric transmission water pumping windmills can only be considered when an electrical engineer has been added to the project staff.

The start of a pilot AWDS system in the next (third) phase can only be considered when it can clearly be shown that the continuous electric power demand for some villages will be raised to such a level by new developments that the AWDS system will be economically feasible for these villages in the longer term.

13.4 Non-wind renewable energy

In the short term DER must take the decision whether to continue or not.

A continuation of the non-wind programme has consequences for the project staff (see 13.1).

INIT has the capacity to take over the non-wind programme.

13.5 Ground water

The DER is not responsible for the ground water aspects (problems). But for the good of the project it is very important that DER should discuss the ground water aspects frequently with DEGAS.

For the good of this project and for the benefit of the whole country DEGAS must go on improving:

- control of the ground water aquifers
- pumping tests for wells.

With regard to favourable wind and water sites for future wells, DEGAS and DER must have good communications, to enlarge the number of eventual mechanical transmission windmills.

To obtain reliable information about the total consumption of water DER must fit water meters to each windmill as soon as possible.

13.6 Maintenance

The maintenance programme has made very good progress. The project staff must continue in this way.

The relatively high costs of repainting calls for an investment in better paint types, which will be more resistant to the Cape Verdian climatic circumstances.

13.7 Social aspects

To achieve optimal use of water the most important points to be established in the short term are:

- water price policy;
- participation of the population (paid or unpaid) in design and construction, especially the infrastructure such as tap houses, irrigation structure etc.;
- popularisation of water use in agriculture;
- policy of windmill installation on private wells.

It is known that direct responsibility for these aspects is not within the scope of DER. But for the good of the project and for optimal use of the water DER must discuss these aspects frequently with the other directly responsible MDR departments and stimulate interest in them.

13.8 Economic aspects

In the next phase a self-supporting strategy needs to be developed for the project.

It is very important to study the possibilities for the reduction of investment costs in tanks.

Another important item to investigate is the possibility of the integration of the guard in the maintenance programme so as to reduce the exploitation costs.

Local manufacture is very important for the saving of foreign currency and for national employment.

The economics of the combination of mechanical transmission windmill and diesel pump on one well must be analyzed before further steps are taken.

13.9 DER - relationships

DER must promote for frequent structured meetings with the other MDR departments involved in the project, to improve:

- build-up of the infra-structure in close coordination with windmill installation;
- popularization of water use in agriculture;
- visits to isolated islands (see chapter 10.1).

In preparation for the next (third) phase the amount of build-up of infra-structure which can be done by the other MDR departments, to achieve the installations of two windmills every month, must be discussed in outline, with full windmill utilisation in mind.

The creation of a structure for the exploitation of the water distribution, and eventually the formation of a national water company, is very important.

13.10 DER - INIT

In general it seems that the relationship between INIT and DER needs to be improved.

A definition of tasks in the area of non-wind renewable energies must be made soon.

For the benefit of both parties, it seems necessary to have frequent meetings:

- for each to be kept well informed about the activities of the other;
- to avoid duplication of effort.

13.11 Logistics

The difficulties with the supply of hardware and equipment and its transport to Cape Verde need to be discussed and resolved with US AID. A less strict tied aid service could be beneficial to the project.

For the next (third) phase the project must conclude an agreement with the customs of Cape Verde or with the Government to facilitate customs clearance procedures for all project material, equipment etc (see ref. 1).

13.12 DER - project

In the short term an organization structure for DER needs to be decided.

To improve the relations of the personnel at working level with DER it seems necessary to give them a service contract.

The project back-up is working smoothly and it is essential that this should continue to be the case.

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13) de Bonte, J.A.N. and Dieleman M., "Autonomous Wind Diesel Systems in Rural Areas in the Republic of Cape Verde". Draft Report, Oct. 1983.

Annex 1: Evaluation team and programme

Evaluation period

The evaluation of the project was carried out over a period of two weeks from 3 up to 17 November 1983. Directly followed by a period of 1 week in which the draft report of the evaluation mission was prepared, i.e. from 17 up to 24 November 1983.

Evaluation team

Eng. Joaquim Delgado, participated during the entire period from 3 up to 24 Nov. 1983;
Mr. Antônio Gomes, participated from 11 up to 24 Nov. 1983;
Mr. Alan Miller, participated from 8 up to 19 Nov. 1983;
Eng. Kees Kempenaar, participated during the complete period from 3 up to 24 Nov. 1983.

Evaluation programme

a) Preparation in Holland:

5 Oct. 1983 Meeting at DGIS
Participants:
Mr. Franta Wychers - project responsible of DGIS,
Mr. Niko Pieterse - Dutch wind energy expert working on the DER project in Cape Verde
Mr. Kees Kempenaar - evaluator
Setting up the evaluation:
- terms of reference (Annex 2)
- procedure
- period.

14 Oct. 1983	Meeting at SWD, THE Eindhoven Participants: Mr. Joop van Meel - wind energy expert working at SWD Mr. Niko Pieterse - Dutch wind energy expert, working on the DER-project in Cape Verde Mr. Kees Kempenaar - evaluator Discussion of the SWD input in the DER-project.
26 Oct. 1983	Meeting at DHV, Amersfoort Participants: Mr. Gerard v.d. Rhoen - project coordinator in the Netherlands from the SWD Mr. Joop van Meel - wind energy expert of SWD directly involved in the DER-project Mr. John da Costa - going to be the new project coordinator in the Netherlands from the SWD Mr. Kees Kempenaar - evaluator Discussion of the back-up support and all other coordination connected with the DER-project.
18 - 28 Oct. '83	Mission preparation time, studying: I. progress project reports I - XIV, technical reports (notas tecnicas), SWD internal evaluation, and some important correspondence all from the period Oct. '81 - Oct. '83. II. other wind energy papers.

b) Evaluation Programme in Cape Verde:

3 Nov. 1983 Start of the evaluation; setting up of the programme and a discussion of the terms of reference of DGIS, in two meetings.

First meeting - participants:

DER project	- Mr. Daniel Livramento, director of the project - Mr. David Cardoso - Mr. Niko Pieterse - Mr. Kees Versteegh
US AID	- Mr. Frank Dimond, project responsible, from the US AID office in Cape Verde
The Netherlands	- Mr. van Gorkum, the First Secretary of the Dutch Embassy in Dakar, Senegal
Evaluation team	- Mr. Joaquim Delgado - Mr. Kees Kempenaar

Discussion of the evaluation programme with all the parties directly interested in the project.

Second meeting - internal meeting of the evaluation team

Establishment of the evaluation program taking into account the wishes of:

DGIS	- formulated in the terms of reference (see Annex 2)
US AID	- formulated by Mr. Frank Dimond during the first meeting

Project staff - formulated by the staff during the first meeting

4 - 8 Nov.'83	Visits to installations on the island of Santiago
9 Nov.'83	Visits to installations on the island of Maio
10 - 11 Nov.'83	a) Meetings with the directors of the following MDR departments: - Rural Improvements, Eng. Vera Cruz - Ground Water, Eng. Carlos Lima Fort - Study and Planning, Eng. Alexandre Pina Discussion of all inter-connection relations with the DER-project. b) Meeting with the General Director of International Cooperation, Mr. José Luis Rocha Discussion of the project within the policy of the Cape Verdian Government. c) Meeting with Eng. Antônio Sabino, the second in command for Cape Verde on the Watershed Management Project on the island of Santiago Discussion of inter-connection relations between the two projects.

12-13 Nov.'83	Visits to the installations on Santo Antão
14 Nov. 1983	Visits to workshops on São Vicente, which may eventually construct parts of the windmills
15 Nov. 1983	Meeting with Mr. Frank Dimond of US AID
16 Nov. 1983	Final meeting with the directorate of the project and the Dutch experts involved in it

During the evaluation the team frequently discussed their experiences in relation to their tasks described in chapter 1.4.

The team had special meetings on 8 and 11 Nov.'83 to introduce Mr. Miller and Mr. Gomes to the evaluation work.

17-24 Nov.'83	Preparation of the draft report, as in the description in the preface

Discussion of the evaluation team and its draft report:

a) in Praia, Cape Verde

6 Dec.'83 - the evaluation team, internal:
Eng. Joaquim Delgado
Mr. António Gomes
Eng. Kees Kempenaar

The comments of Mr. Alan Miller were received by telex in Holland.

7 Dec.'83 I. Meeting DER-project staff and the Evaluation team

II. Meeting General Directorates of International Cooperation and Planning, Mr. José Luís Rocha and Mrs. Dr. Adalgisa Barbosa, with the Evaluation team and Mr. Daniel Livramento, Director of the DER.

b) in the Netherlands

3 Jan.'84 Meeting with DGIS, i.e. Mr. Franta Wychers, Mr. Alert Hamburger and Mr. Jaap Meyer with Mr. Kees Kempenaar.

The comments of DHV-SWD were received by letter at the SAWA office and discussed over the telephone.

The installations visited are listed in Annex 3.

Annex 2: Terms of reference for the evaluation mission.

1. In 1981, the Netherlands made available a sum of Nfls. 3,117,000 as part of the co-operation with Cape Verde on the wind energy project. The project document provides for the production and installation of windmills over a period of five years. The financial injection referred to above is in respect of the first three years (July 1, 1981 to July 1, 1984, inclusive).

2. Both the Cape Verde and the Netherlands governments deem it important that, before the present three-year project period elapses, there should be an evaluation of the activities to date.

3. The task of the mission is to evaluate the wind energy project. The mission is to compare the project objectives and implementation plan with the work actually carried out and the results achieved. The study is to cover any problems encountered during the project's implementation. The mission is also to make recommendations concerning any follow-up work needed and the necessary assistance for this. Financing by the Netherlands of any follow-up will be partly dependent on the outcome of this evaluation.

4. Important considerations as regards the evaluation referred to under item 3 are:

a) That the project document makes, among others, the following claims:

"On the basis of the wind regime of the Cape Verde Islands and present oil prices, windmills can pump water more cheaply than diesel pumps" and "A project proposal has been worked out which aims at local production of 75% of all windmills needed. The remaining 25% will have to be imported". "Assuming this production split is achieved, there will be an annual foreign currency saving of US$ 450,000 for materials and extra employment of about 7000 man-hours per year".

These claims must be subjected to critical scrutiny, particular attention being given to the merits of the proportion of locally produced to imported windmills as seen from both the technical and economical point of view.

b) To ascertain to what extent a transfer of know-how has actually been achieved.

c) To assess what persons/groups have been directly affected by the project activities and to what extent.

d) To assess the desirability of extending the present main objective of using wind energy to provide drinking water to include other applications like irrigation and seawater desalination.

e) To assess whether the institutional framework within which the project is supposed to function is satisfactory for the achievement of the project objectives.

f) To assess longer-term maintenance problems: whether the Cape Verdians themselves will be capable of maintaining and repairing the windmills once installed.

5. The mission will be briefed prior to departure by the DGIS (Directorate-General for International Co-operation), the SWD (Steering Committee for Wind Energy in Developing Countries) and the consulting engineer. In Cape Verde, the mission is to have talks with the Secretary of State for Co-operation and Planning, the Ministry for Rural Development and both Cape Verde and Dutch members of the project team.

6. The mission will comprise one Dutch representative and one or more Cape Verde representatives. If possible, a representative from the Dutch Embassy in Dakar will also accompany the mission. The mission will last not more than 14 days; the exact duration is still to be fixed.

7. A joint Cape Verde/Dutch "aide-mémoire" will be drawn up on the spot and will be submitted to the appropriate Cape Verde authorities. Within two weeks of his return, the Dutch representative on the mission is to submit a final version of the report to the DGIS. This report will be in Dutch and, after translation into Portuguese, will be submitted to the Cape Verde government.

8. The evaluation exercise is to include a meeting of the joint evaluation team in order to draw up a schedule of work, talks with parties involved in the project (both governmental and non-governmental), visits to the project sites, study of the relevant documents, concluding meetings and the preparation of the report etc.

9. Relevant documentation includes:
   - the project document: "Wind energy for water pumping in Cape Verde"; H.J.M. Beurskens, Feb. 1981, SWD 81-1;
   - notes on the project exchanged between the Dutch Embassy in Dakar and the Cape Verde Government;
   - the contract between DHV and the Dutch Government (Ministry of Foreign Affairs, DGIS);
   - progress reports;
   - internal project evaluations;
   - the criteria of Cat. III-d

The criteria of category III-d are:

In 1981 a "special energy programme" was established under the Netherlands development aid budget. The programme is additional to the regular bilateral and multilateral programmes, and already include several energy activities.
The special energy programme focuses primarily on:
- assistance in energy analysis and energy planning;
- provision of energy for people in rural areas, mainly through biomass related activities;

- application of new and renewable energy sources;
- energy efficiency.

Although no common criteria are laid down, the following indicators are important in assessing projects in especially the field of rural energy provision and use of new and renewable sources:

- pilot function (replicable);
- aimed at the availability of energy for the proper region;
- involvement of the local population (men and women);
- primarily meant for basic energy needs of families, small farmers or small local industries;
- promotion of the use of inexhaustible or renewable, locally available, sources of energy;
- close look not only into technical aspects, but also into social aspects, economic aspects (comparison with other energy sources, production, financial prospects), environmental aspects and institutional aspects.

Assistance is given as a grant, usually to be matched by partial local financing. Activities can include feasibility studies, training, demonstration, small investment projects.

Basically, the programme is aimed at the Netherland's "target countries", and (other) low income or least developed countries. Special attention is presently being given to the target countries Kenya and Indonesia.

Annex 3 SURVEY OF PROJECTS OF D.E.R.

project no. according to CV-budgets	donor	D.E.R. no.	name	situation
projecto 1	UNDP (Non-conventional energy demonstration project)	1.1 1.2 1.3	Bicycle Wheel Wind Turbine Elektro Darrieus	São Martinho (Santiago)=João Varo Achada de São Filipe (Santiago) Achada de São Filipe (Santiago)
	CIMADE (Private French Agency)	1.4.1 1.4.2	Solar pump The guard's house a) WESP (THE-III) b) Solar still c) Solar cooker d) "Family cooker" e) Solar water heater	Achada de São Filipe (Santiago) Achada de São Filipe (Santiago)
projecto 2	CIMADE	2.1	Aerowatt (Guinard wind driven electrical waterpumping system) 4.1 KW	Achade Baleia (Santiago)
projecto 3	Church World Services (CWS) UNICEF	3.1 3.2	25 Dempsters of 8' 10 Dempsters of 14'	Santiago 9, Maio 4, Sal 4, São Nicolau 4, Boa Vista 4 Santiago 2, São Nicolau 2, 6 to be chosen (Tarrafal?)
projecto 4	SWD	4.1	Construction of prototypes (THE-II)	1 prototype on Achada de São Filipe
projecto 5 Serviço geral da D.E.R.	SWD USAID SWD/USAID	5.1 5.2 5.3	Construction of workshop Equipment of workshop Materials	Achada de São Filipe (Santiago)

Annex 3 (continuation) SURVEY OF PROJECTS OF D.E.R.

project no. according to CV-budgets	donor	D.E.R. no.	name	situation
projecto 6	SWD	6.1	20 Southern Cross 25'	
	FAC (Fonds d'Aide et Co-opération, France)	FAC-1	2 Aerowatt/Grundfos combinations (electrical-submersible pump) 4.1 KW	(São Nicolau)
		FAC-2	2 Aerowatts 350W for lighthouses	(São Vicente)
		FAC-3	3 Aerowatts Ø 1 m for windmeasurements	2 Tarrafal (Santiago) 1 (Santo Antão)
		FAC-4	4 Aerowatt 60 KW (?)	Porto Novo (Santo Antão)
-	DGIS (Holland)	DGIS-1	3 Southern Cross 25'	(Santo Antão)
-	USA - embassy projects	USA-1	Biogas-installation	São Jorge (Santiago)
		USA-2	"syphon" waterlifting device	Picos (Santiago
		USA-3	Solar still	Ponta Cais (Maio)
-	USAID	USAID-1	Aeropower for the laboratory of crop protection	Achada de São Filipe (Santiago)
-	Canadian-embassy	CAN-1	1 Dempster 8' 2 Dempsters 14'	Figueira Seca (Maio)
-	ICCO	ICCO-1	2 Southern Cross 25'	Achada Baleia (Santiago)
-	Swissaid	Swissaid -1	Winddriven cooling cell	Fogo, Mosteiros

Annex 4: List of installed windmills

Semester		Site	Windmill	Pump height	Ph.L.	Ribeira/ Achada
1e 78	X	S. Filipe	Dempster 8'	38	34	A
1e 78		Portete	Dempster 8'	14	8	R
2e 78	X	Lém Duque	Dempster 8'	16	6	R
2e 78	X	Pensamento	Dempster 8'	17	8	R
2e 78	X	Granja	Dempster 8'	17	7	R
1e 79	X	Calheta M.	Dempster 8'	21	16	riso
1e 79	X	Cascabulho M.	Dempster 8'	13	8	A
1e 79	X	Brigadinha M.	Dempster 8'	16	6	A
1e 80	X	Santa Cruz	Dempster 8'	20	14	R
1e 80		Trindade	Dempster 14'	48	47	A
2e 80	X	Granja	Dempster 14'	20	12	R
2e 80		Poço Verde S.	Dempster 8'	28	8	riso
2e 80		Tapadona S.	Dempster 8'	-	-	riso
2e 80		Palmeira S.	Dempster 8'	16	7	riso
2e 80		Palmeira S.	Dempster 8'	-	-	riso
1e 81		Chã do Norte S.N	Dempster 8'	35	30	A
1e 81		Bélém S.N	Dempster 8'	23	18	A
2e 81		Bélém S.N	Dempster 8'	23	18	R
2e 81		Chã dos Penedos	Dempster 14'	35	34	A
2e 81		Chã dos Penedos	Dempster 14'	50	47	A
2e 81	X	S. Filipe	Dempster 14'	45	36	A
2e 81	X	Achada Baleia	Southern Cross 25'	60	51	A
1e 82	X	Ponta Furna	Dempster 14'	65	57	A
1e 82	X	S. Filipe	Southern Cross 25'	55	39	A
1e 82	X	Chã de Arroz SA.	Southern Cross 25'	27,5	11-16	R
1e 82	X	Picoteiro S.A.	Southern Cross 25'	9	1-5	R
2e 82	X	R. Corujinha S.A.	Southern Cross 25'	48,5	10-15	R
2e 82	X	Flamengos	Dempster 14'	20	7	R
2e 82		Mendes Faleiro	Bomba Manual	15	14	R
1e 83	X	Calheta M.	Dempster 8'	25	20	riso
1e 83	X	Morro M.	Dempster 12'	33	18	R
1e 83	X	Figueira Seca M.	Dempster 8'	20	4	R
1e 83	X	Ribeirão Manual	Dempster 14'	80	75	A
1e 83	X	Saltos, A. Laje	Dempster 14'	20	12	R
1e 83	X	S. Filipe	Protótipo	40/60	35	A
2e 83	X	Flamingos	Southern Cross 25'	?	?	R

All sites marked with X were visited by the evaluation team.

Besides the windmills the evaluation team visited:

Santiago:
- CEA, the Centre of Agricultural Studies, in San Jorge, especially to see the Laboratory facilities for water analysis;
- in Tarrafal, destroyed wind measurement installation supplied by Aerowatt;
- Achada Granda, destroyed wind measurement installation, supplied by Aerowatt;
- San Filipe area with several pilot projects, the majority working badly;
- Achada de Baleia, mechanical wind measurement installation, working well;
- Aerowatt windmill with electric water pump, windmill is destroyed.

Santo Antão:
- Ribeira Torte, a possible future site for a mechanical transmission windmill
- Ribeira de Figueral, an anemometer
- Ribeira de Torre, two possible future sites for mechanical transmission windmills.

São Vicente:
- workshop Jotanave
- workshop Matos
- shipyard Onave
- education centre of Cabnave in Ribeira Julião.

Explanation of the abbreviations for the sites on the islands:

M = Maio
S = Sal
SN = San Nicolau
SA = Santo Antão

Without means situated on Santiago.

Ph.L. = Phreatic Level
Ribeira = situated in a dry river
Achada = situated on a highland
riso = situated on a plain.

Annex 5: Estimate of cost of dismounting and re-mounting windmills

Necessary team: 6 persons, i.e.:
- 2 mechanics
- 3 auxiliary workers
- 1 truck driver

Necessary time:

Type of work	Necessary time (days) windmill types	
	8' and 14'	25'
A Dismounting:		
pump	1	1
fan	1	3
mounting the crane	0.5	1
wind vane	0.5	0.5
head	-	0.5
yawing system	0.5	2
tower	2	5
total	5.5	13
B Cleaning:		
only 3 auxiliary workers	6	12
C Installation:		
see labour list of 1982	9.5	15.5
D Painting:		
1 painter and 1 auxiliary worker	6	10

Necessary material:

- Paint for the windmill
- Concrete for foundations
- Pipes: in general 8 of 2½" for the Southern Cross 25' and 6 of 1" - ¾" for the Dempsters 8' or 14'

Costs

The total team for 1 day:

2 mechanics 350 $ 00/day	700 $ 00
3 auxiliary workers 170$/day	510
1 truck driver 320 $ 00/day	320
truck costs per km 12 $ 00, in general 100 km/day	1,200
total	2,730 $ 00

Cleaning team

3 auxiliary workers 170$/day	510

Total costs

		windmill type 8' and 14'	25'
1.	Dismounting	12,815 $ 00	30 290 $ 00
2.	Cleaning	3,060	6,120
3.	Mounting, labour costs	7,589	12,837
	transport	14,440	23,560
4.	Painting, labour costs	3,060	6,120
	transport	9,120	18,240
5.	Paint, concrete etc.	14,610	29,250
6.	Canalization	7,410	25,600
	total	72,104 $ 00	152,017 $ 00

Note: The costs for transport and labour are almost identical.

As regards transport, it is estimated that the average distance is 50 km. Transport costs have a considerable influence on total expenditure.

Annex 6

MDR - RENEWABLE ENERGIES

Windmill maintenance and repair sheet

Place..... *Name and number of windmill*.....

Date..... *Mechanic*.....

Time of arrival..... *Time of departure*.....

NOTES

1. *Does the windmill pump water? Yes. No, because*.....
2. *Does water leak from the gasket? No. Yes, because*.....
3. *Does the windmill open and close properly? Yes. No, because*.....
4. *Does the equipment make a noise? No. Yes, because*.....
5. *Does the rod or tube suffer from vibration? No. Yes, because*.....
6. *Are bolts missing or loose? No. Yes (where?)*.....
7. *Any other damage to the windmill? No. Yes (what?)*.....
8. *Do portions need painting? No. Yes (which?)*.....

SPECIFICATION

1. *Water level*.....
2. *Conductivity*.....*µmho*
3. *Number of strokes in 5 minutes*.....
4. *Counter reading at start of 5 minutes*.....
5. *Counter reading at end of 5 minutes*.....

WORK TO BE CARRIED OUT *(checking and/or lubrication)*:

Springs for the mill and shock absorber ☐

Cables and shackle pulleys ☐

Grease cups and nipples ☐

By-pass tube assembly ☐

Place asbestos in the gasket or check the linings ☐

Drain air chamber. Was it full? Yes. No.

Note: If lubrication was necessary, signify here ☐

REPAIRS AND MODIFICATIONS

Type of work done.....

Defects found.....

Parts replaced.....

Other remarks.....

Annex 7:

Summary of specification and maintenance of windmills

Year_____ Pump No._____ Hole/well_____ Site_____

Mark and type of pump_____ Stroke_____ Cylinder diameter_____

Characteristics of hole/well_____

Characteristics of installation_____

MONTH	DAY	COUNTER (m^3)	WATER LEVEL (m)	YIELD (m^3/h)	SALINITY (µs/cm)	WORKING PERIOD (H)	OBSERVATIONS, PARTS USED
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							

Annex 8: Defects in 1983

Summary of major defects or repairs over and above normal maintenance work on the island of Santiago:

wear and corrosion	
shaft or tube punctured	4x
loose shaft	1x
piston cage damaged	1x
wood from inside the pump	1x
cleaning the hole	1x
total 1983	8x

Note: This is a summary of 15 windmills on Santiago, from which the two latest were installed in April and May 1983. Two windmills are not functioning because the well dried out or the water was too brackish.

In 1982, there were 17 defects for 13 windmills, in 1981, 6 defects for 9 windmills. In both years many repairs were carried out to individual mills, shafts, seals, etc. In 1983 this was reduced chiefly because we solved the problem of loose shafts.

Annex 9: Cost of maintenance

Cost of maintaining a Dempster windmill

Monthly cost

One hour per month is needed for each windmill. Travel and fuel expenses were spread over all the windmills, but merely within the municipality of Praia.

1 mechanic	38$00
1 assistant	30$00
1 driver	26$00
fuel	100$00
grease	14$00
TOTAL	208$00

Annual expense on each windmill	2,496$00

Annual cost

Painting

1 first class painter for 12 days	3,540$00
1 assistant for 12 days	1,176$00
colouring	3,650$00
gasoline at 100$00 per day	1,200$00
3 litres of oil at 65$00/l	195$00
Total cost of paint	9,761$00

Total cost of annual maintenance	12,257$00

The cost of a major repair like, for example, lifting and mounting a pump, generally needs a day's work. The team comprises four persons:

2 mechanics at 38$00 per hour	76$00
2 assistants at 30$00 per hour	60$00
1 driver at 26$00 per hour	26$00
Total	162$00
7.5 hours of work per day	1,215$00
fuel	200$00
TOTAL	1,577$00

This is exclusive of any extra parts that may be required.

Table 1: Annual cost of one windmill

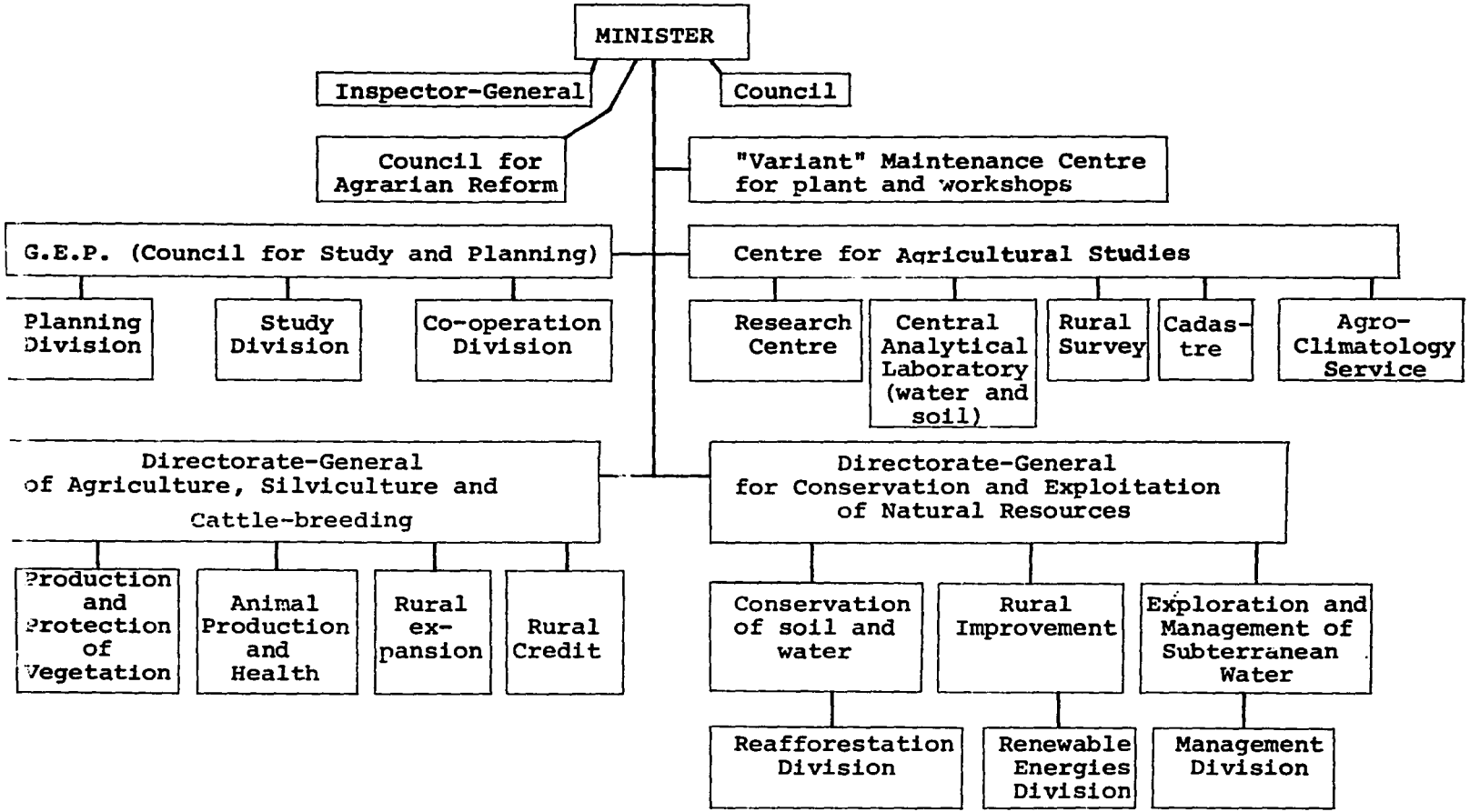
Mill No.	Annual flow (m^3/year)	Repairs in 1982	Total cost of repairs	Cost of maintenance	Total cost
1	4640	2	3154$00	12257$00	15411$00
2	4730	3	4731$00	12257$00	16988$00
3	4204	0	-$-	12257$00	12257$00
4	4138	2	3154$00	12257$00	15411$00
5	4204	2	3154$00	12257$00	15411$00
6	5256	2	3154$00	12257$00	15411$00
9	11738	3	4731$00	12257$00	16988$00

The cost of the paint accounts for 75% of the annual maintenance and the total amount of fuel used for some 20%. Labour is relatively cheap.

Annex 10:

ORGANISATION CHART

MINISTRY FOR RURAL DEVELOPMENT



Annex 11: DER

Composition of the DER team (Dec. 1983)

Higher level:

- Daniel Livramento, Physicist, Director of DER
- Niko Pieterse, Electrical Engineer, Dutch Cooperator, responsible for general management, anemometry, electrical wind generators and the electrics in general, site measurement for new windmill locations
- Kees Versteegh, Mechanical Engineer, Dutch Cooperator, responsible for workshop management, training of the mechanics, installation maintenance and repair of the windmills, construction of prototype.

Medium level:

- David Cardoso, Agricultural Technician, responsible for the administration and processing anemometry data with the computer.

Working level:

- Workshop: 1 supervisor
  3 mechanics for windmills
  2 mechanics on different levels
  1 painter
  2 auxiliary painters
  4 auxiliary workers
- Administration: 1 chief
  1 typist
  1 librarian
- Storehouse: 1 storekeeper
- Servants: 3 for which one is responsible for the kitchen and the canteen

Today, DER is housed in a new building financed by the Dutch Government, and located on "Achada de San Filipe".

This housing consists of:

- administration
- technical office
- construction workshop
- measurement apparatus room
- storehouse
- power plant.

The construction workshop has equipment to produce local windmills and their spare parts. The equipment is financed by US AID, the most commonly used items being:

- a engine lathe 12" swing x 48" hollow spindle w/motor
- 1 chuck and wrench for above
- 1 milling attachment for item 1
- 1 lathe tools, set for item 1
- 1 drill press
- 1 vertical mill, 2 H.P. motor
- 1 bench grinder, double end, pedestal 8" diameter, med. and fine wheels, 1" wide, w/motor, guards and water tank
- 1 power hack saw and motor w/coolant tank and pump
- 1 sheet metal brake, manual, mild steel cap., 96" x .090"
- 1 sheet metal roller manual, capacity 48" x .090"
- 1 hydraulic press, manual 25 T
- 2 oxyacytelene medium duty welding and cutting set
- 1 air compressor, elect. driven, complete w/hose, chucks etc.
- 1 arc welder, D.C. 200 A., diesel drive
- 1 concrete mixer, 4 cu. fit.
- 1 portable 7" circular saw, electric with 3 extra combination saw, rip saw and abrasive blades

- 1 portable orbital sander, electric with 10 packs assorted abrasive refills
- 1 portable electric nibbler shear, cap. .80" mild steel
- 1 portable electric drill, variable speed, reversible 1/2" capacity, medium duty with extra jacobs chuck and key
- 5 RPM counter totalizing type, mechanical rotating input
- 5 stroke counter totalizing type, lever actuated
- 1 gasoline internal combustion engine (to be modified for biogas digester) 3 HP 4 cycle 1 cyl. horiz. shaft with dual fuel Marvel-Schehler special carburettor
- 1 diesel electric generator 50 H 3 220 VAC phase voltage 380 V line voltage 50 KVA with 10% spare parts.

A computer for processing the anemometry data, is located in the measurement apparatus room.

Important wind measurement apparatus:

- 2 hand-held anemometers with anemometer cups, direction and wind speed readout in m/sec on a sweep dial
- wind spectrum analyzers for measuring and recording wind speed frequency distribution
- wind-operated odometers.

To support the work of maintenance and installation DER has the following vehicles:

- 1 tip-up truck
- 1 old jeep
- 1 car Renault R_4
- 6 motorcycles
- 1 Ford pick-up
- 1 landrover with a trailer on the way

Annex 12: Estimate of necessary workshop personnel

Actual workshop personnel:

- 1 supervisor
- 3 mechanics for windmills
- 2 metal workers/welders
- 4 auxiliary workers
- 1 painter
- 2 auxiliary painters

Type of work:

a) preparation and actual installation
   0.5-0.75/month with a team of 4 persons

b) painting
   6-8/year with a team of 2 persons

c) maintenance of 10 windmills
   2 days/month for a team of 2 persons

d) repair of 10 windmills
   2 days/month for a team of 4 persons

Personnel required, based on the current situation and experience:

a) Installation
   2 per month:
   on Santiago, 2 teams 4 persons (1 mechanic, 3 auxiliaries)
   on the other islands, 2 mechanics and 2 temporary auxiliaries

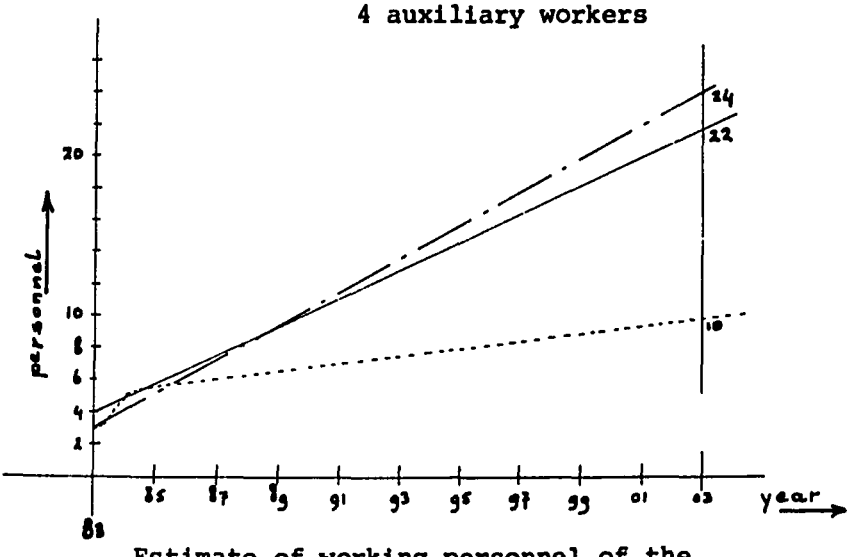
b) Maintenance
   at the end of a 20 year period
   about 300 windmills
   3 teams of 2 persons (120 work days);
   each team: 1 mechanic
   1 auxiliary

c) Repairs
for 300 windmills, in total 240 work days; or 3 teams of 4 persons;
each team: 1 mechanic
3 auxiliaries

d) Re-painting
On the average it is estimated that 200 windmills need to be re-painted in one year
1 re-painting takes 3 weeks, i.e. 17 windmills/team per year; or 12 teams of 2 persons

Total:	Installation:	2 mechanics	6 auxiliaries
	Maintenance:	3 mechanics	3 auxiliaries
	Repairs:	3 mechanics	9 auxiliaries
	Painting:	24 persons	
	Total:	8 mechanics,	18 auxiliaries
		and 24 painters	

Extra for the workshop:
2 metal workers/welders
2 mechanics
4 auxiliary workers



Estimate of working personnel of the workshop from now over a period of 20 years.

Note: Everything is based on the present experience within a small scale project. If management proves effective, it may be possible to reduce the number of personnel.