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Consultant: Prem GROVER

# REVIEW AND ASSESSMENT

# OF

# NEW AND RENEWABLE SOURCES OF ENERGY PROGRAMME

# IN

# ZIMBABWE

(CLT 89/340 - PPD/AREA/AFR)

Technical Report*

Prepared for the Government of Zimbabwe
by the United Nations Industrial Development Organisation

Based on the work of Prem D.Grover,
expert in New and Renewable Sources of Energy

United Nations Industrial Development Organisation
Vienna

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* This document has been produced without formal editing.

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# EXECUTIVE SUMMARY

Zimbabwe has relatively well developed industrial and commercial farming sectors and endowed with minerals and other natural resources including potentials for hydropower, coal deposits and adequate supply of fuelwood. But there are also extensive regional imbalances in supply and demand for energy and availability of infrastructure facilities. With the result nearly 80 percent of population is still dependent on traditional wood fuel leading to extensive deforestation, specially in densely populated communal areas.

Through planned development policies the Government is fully committed to bring about equity distribution of developmental benefits to rural masses and aims at raising their standard of living. Notable strides have been made to provide primary health care and education facilities even in remotest areas of the country. However, non-availability of commercial energy to these centres is proving impedimental for their optimal functioning. For the commercial energy is basically geared to meet the requirements of industries, mining activities, commercial farming and urban population.

One of the goals of development policy is to achieve self sufficiency and security in energy supply and eliminate regional imbalances and prevent environmental degradation. With commendable energy development programmes, the controlling constraints are such that even after 30 years of continued development fifty percent of the population will have no recourse to commercial energy.

Considering these limitations and need to provide energy through alternative means the government has accorded due importance to the development and dissemination of new and renewable sources of energy(NRSE). An exclusive section under Department of Energy has been created to formulate such activities and implement NRSE programmes. Many industries have also started manufacturing PV systems, wind mills, solar water heating appliances and efficient cook stoves. However, the progress is rather slow and its impact on rural population is negligible.

This programme needs strenghthening and related fiscal policies so formulated as to provide desired incentives both to manufacturers and users of NRSE technologies.

Furthermore, there are many constraints for effective formulation and implementation of these programmes. The major ones are:

1. Non-availability of trained man power at all levels.

2. Lack of infrastructural facilities and instruments for monitoring NRSE systems and providing technical back-up services to systems installed in fields.

3. Scarcity of funds leading to formulation of programme o adhoc basis.

4. Lack of indepth awareness about NRSE technologies and data with the planners to appreciate the potentials and limitations of these systems.

These limitations have been addressed during this study and one of the main recommendations is to set up a small, yet functional Prototype Testing and Training Centre (PTTC) incorporating a technology park under the Department of Energy. The technical assistance and foreign exchange component for procurement of prototypes and monitoring instruments can be provided by UNIDO and the Government of Zimbabwe provides the facilities and meets the recurring budget. This centre would have the training, testing and development components and a permanent exhibition of prototype systems to bring about general awareness about these technologies.

Initially, the PTTC can be started in the premises of National Training Centre of Zimbabwe Electricity Supply Authority and later it could be incorporated as a satellite station of proposed Scientific Industrial Research Centre (SIRDC) being planned by the Government.

With industrial base, Zimbabwe is comparatively well placed to claim this national centre which could be converted into a regional cooperative institution extending facilities initially to SADCC countries and later to P.T.A. region.

## ACKNOWLEDGEMENT

The author would like to thank UNIDO for assigning him the present fact finding mission to Zimbabwe and grateful to Ms.R.Toure, Dr.R.O.Williams and Mr.J.Fredrick (Harare) of UNIDO for their active assistance.

The author is indeed indebted to Mr.K.Kangai, Minister for Energy, Water Resources and Development, and Mr.J.J.Chitauro, Permanent Secretary of this Ministry for fruitful exchange of ideas on renewable energy.

Mr.H.S.Makina, Director, T.W.Samunyal, Assistant Director, Mr.G.Manavaniyka , Acting Assistant Director (R and D), Mr.J.T.Chigwada, SRO, and other officials of DOE, provided the facilities, suggestions and data in their respective capacities. Their contribution and assistance is thankfully acknowledged.

Numerous meetings were arranged by DOE with officials of various government, parastatal, NGO and private organisations. Their willingness to meet and information provided them about their respective activities were indeed very useful and their co-operation is duly acknowledged.

The officials of DOE, who undertook the tiring trips with the consultant to the distant villages of Masvingo (S.E.), Marymount (N.E.) and Mutare (E), are thanked for their sincere efforts to acquaint him with life style and problems being faced by rural masses of Zimbabwe and also showing the demonstration projects installed by DOE in these remote areas.

The author is indeed grateful to Dr.S.G.Gata, General Manager, Zimbabwe Electric Supply Authority (ZESA) and Chairman of Zimbabwe Council of Science for taking keen interest in this mission and showing the facilities at their unique and modern ZESA training centre and making an offer of providing infrastructure facilities for the proposed Prototype Testing and Training Centre (Renewable Energy) in their premises.

The author had useful discussions with Ms.J.Chadzingwa,, Under Secretary, Energy Planning, Conservation and Coordination (MEWRD) and Mr.C.E.Chimombe, Regional Coordinator, Biomass Users Network and their contribution are duly acknowledged.

The author is thankful to Mr.D.H.Patel for providing the office facilities and Mrs.Mandakini Patel for her untiring efforts to type and compile the draft report during the holidays. Later the final report was typed in Delhi by Mr.K.K.Nagarajan whose efforts are duly acknowledged.

## 1.0 BACKGROUND

Zimbabwe is relatively industrialised landlocked country in the centre of the Southern part of Africa with an area of about 3,90,000 Sq.km having a population of about 10 million and growing at the present rate of 3 percent. One significant aspect of the population pattern is that over 50 percent is under 15 with an average life expectancy of 57. The per capita income is about Z $ 800 (US $ 356)*.

In 1965, the white-dominated colonial government unilaterally declared independence (UDI) from Britain which resulted in imposition of economic sanctions by U.N. The fallouts of UDI were the rapid development of infrastructure, marked increase in agriculture and industrial outputs and evolving close trade links with RSA(a). Between 1965 and 1974, the GDP grew at an average rate of 7.5 percent a year(1) but due to intensification of political and military struggle for independence, it declined to an average rate of 3 percent per year between 1974 to 1979.

Zimbabwe gained full independence under African leadership on 17th April 1980, resulting in the lifting of economic sanctions.

The major activity in the country is agriculture and about 80 percent of the population depends on it which accounts for 20 percent of GDP. The rural areas are distinguished between commercial farming and communal lands.

Commercial farming generally occupies more fertile land, has greater productivity and constitutes about 43 percent of the total land area. There are about 5,000 farms, almost all owned by European settlers with an average size of about 2,500 ha(2). Some of these farms process and pack their farm produce and are effectively agro-industrial centres.

On the other hand, the majority of rural population (4.6m) live in communal areas which cover a total area of 16.35 mha. (42 percent of total land). These communal areas were created during the colonial era, when the European settlers moved the local population from their chosen fertile lands to less favourable areas, not ideal for agricultural production. The frequent occurance of drought is a problem for farmers who have to depend on intensive water conservation measures. Further the holdings are small, averaging 3 ha per family of 5-6 persons. The overall income varies from average Z $ 700 per family to the poorest (comprising 25 percent of population) with Z $ 225(2).

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(*) Current exchange rate: 1 US $ = Z $ 2.25 (Zimbabwean dollar)

(1) UNDP/World Bank: Zimbabwe Issues and Options in energy sector, Report 3765 - ZIM. June 1982.
(2) D.Hancock, Y.Katerere and S.Maya: Rural Electrification in Zimbabwe, The Panos Institute; London 1988.
(a) RSA Republic of South Africa

The major resources are from the agriculture and mining sectors. The present exports are about Z $ 2.5 billion and its sectorial break-up is presented in Fig. 1.1. The manufacturing sector is mostly geared to provide inputs to mining and agro-processing commercial ventures. About 50 percent of industry is concentrated in Harare and 25 percent in Bulawayo. After RSA, Zimbabwe's manufacturing industry is the largest in Sub-Saharan Africa.

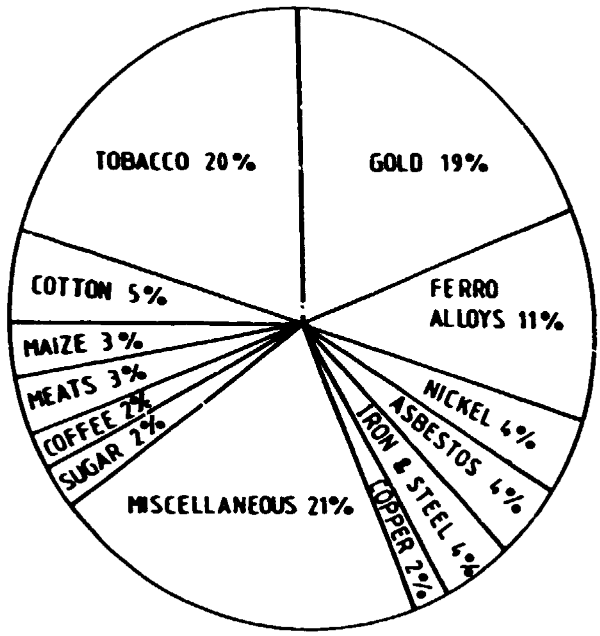


FIG. 1.1 COMMODITY - WISE EXPORT CONTRIBUTION ( 1987 ).

With bulk of the industries, businesses and commercial farming owned by European settlers, the independent nation inherited a heavily skewed distribution of wealth among its people. In 1978 (2), the average income among black African was Z $ 105 compared to Z $ 5,500 for European settlers.

However, forgetting the past differences, all the sections of society are now collaborating amicably and are engaged in the development activities of the country. Accordingly, in November 1982, Government of Zimbabwe brought out its First Transitional National Development Plan Document for the period 1982-83 to 1984-85, highlighting the problems facing the country and aimed at mobilising the human and material resources for self reliant economy, investments promotive of the growth and development and equity objectives of the government. In this plan an average of 7 percent growth rate was envisaged with an investment of Z $ 6,096m out of which 41 percent was designated for private sector. The plan was hailed as neo-second socio-economic revolution designated to give greater meaning to the independence to the people of Zimbabwe. But due to severe droughts and world economic recession, the GDP fell far below the expected growth rate.

During the implementation of transitional development plan, many problems related to organisation of planning and implementation of its programmes, notably shortages of skilled and experienced personnels and inadequacy of authentic statistical information were experienced.

These issues were addressed and government took up the task and incorporated these in First Five Year National Development Plan Document (1986-90) released in April 1986. The plan aimed at an average growth rate of 5.1 percent per year in real terms with overall growth of 28 percent over the plan period. Allocations with respect to energy coupled with water resources were of the order of Z $ 541 million, amounting to 12 percent of the total outlay of Z $ 4,513 million in public sector. The total plan outlay was Z $7,176 million. The purpose of presenting this data is to indicate the extent of the priority accorded to energy sector which was mainly directed towards generation of power and its distribution to rural areas and growth points.

During this period, about 15,000 landless and poor families with about 1,00,000 dependents were expected to be resettled each year.

Accordingly, the Government has established many settlement areas and growth centres in the country. With due a.d desired emphasis provided by creating facilities for imparting education and primary health care has resulted in the establishment of numerous primary and secondary schools, health centres, clinics and rural hospitals even in remote rural areas.

Most of these centres are remote from grid power and due to acute shortage of foreign exchange resources, these are likely to remain without any access to commercial energy for many more years. While schools are basically without electricity, some clinics have been provided with diesel generating sets to meet basic requirement of power.

Apart from mineral resources the country is surplus and net exporter of food, meat and dairy products. In addition to tobacco, the other leading crops are maize, cotton, wheat, soyabean, sorghum, coffee and groundnuts.

In term of energy resources, the country has very good potentials for hydro and coal but these are insufficiently exploited. There is an urgent need to develop indigenous expertise in application of available technologies to exploit these two resources.

Presently, national deposits of petroleum are non-existant and the entire consumption is being met through imports. However, steps have been initiated to carry out exploration of possible petroleum deposits in Zambezi valley. Also about 36 million liters of ethanol is being produced which is being blended with petrol.

Regarding new and renewable sources of energy, the major and potential resources are solar and biomass including biogas. Considering the present shortages of power production and with many constraints for its future availability for rural centres, there is an urgent need to introduce and popularise appropriate technologies to harness these resources. The Government is fully aware of these constraints for providing commercial energy to rural population and important role these renewable energy technolgies can play in overall economic and social development of Zimbabwe.

## 2.0 ENERGY SCENARIO

Zimbabwe is relatively well endowed with conventional energy sources in term of coal, hydropower and fuelwood. But there are extensive regional imbalances in supply and demand. Due to financial constraints and shortage of trained manpower, the first two resources are inadequately utilised. A well developed power system with an installed capacity of 1,631 MW and current coal production of 4.5 million tonnes have been basically developed to meet the requirements of mining, manufacturing industries and commercial farms/agro processing centres. The regions covered by power distribution are shown in Map 2.1.

Due to well developed industries and commercial farming, the current annual per capita energy consumption amounting to about 30 GJ is high by African standard. Yet 80 percent(4) of the population still depends on traditional woodfuel. This amounts to about 58 percent of country's primary energy consumption amounting to 6.46 m tonnes of air dried wood in 1984*.

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* 1 kg of air dried wood = 15 MJ

(4) A.G.Zieroth and R.S.Maya, 'Zimbabwe Charcoal Utilisation and Marketing Study'. Report by Institute of Development Studies, P.O. Box 880, Harare. Sept 88.

(5) R.H.Hosier, Zimbabwe: Industrial and Commercial Energy use. Beijer Institute, Stockholm.

# MAP 2.1 ELECTRICITY SUPPLY AND DISTRIBUTION[2] IN ZIMBABWE, 1986

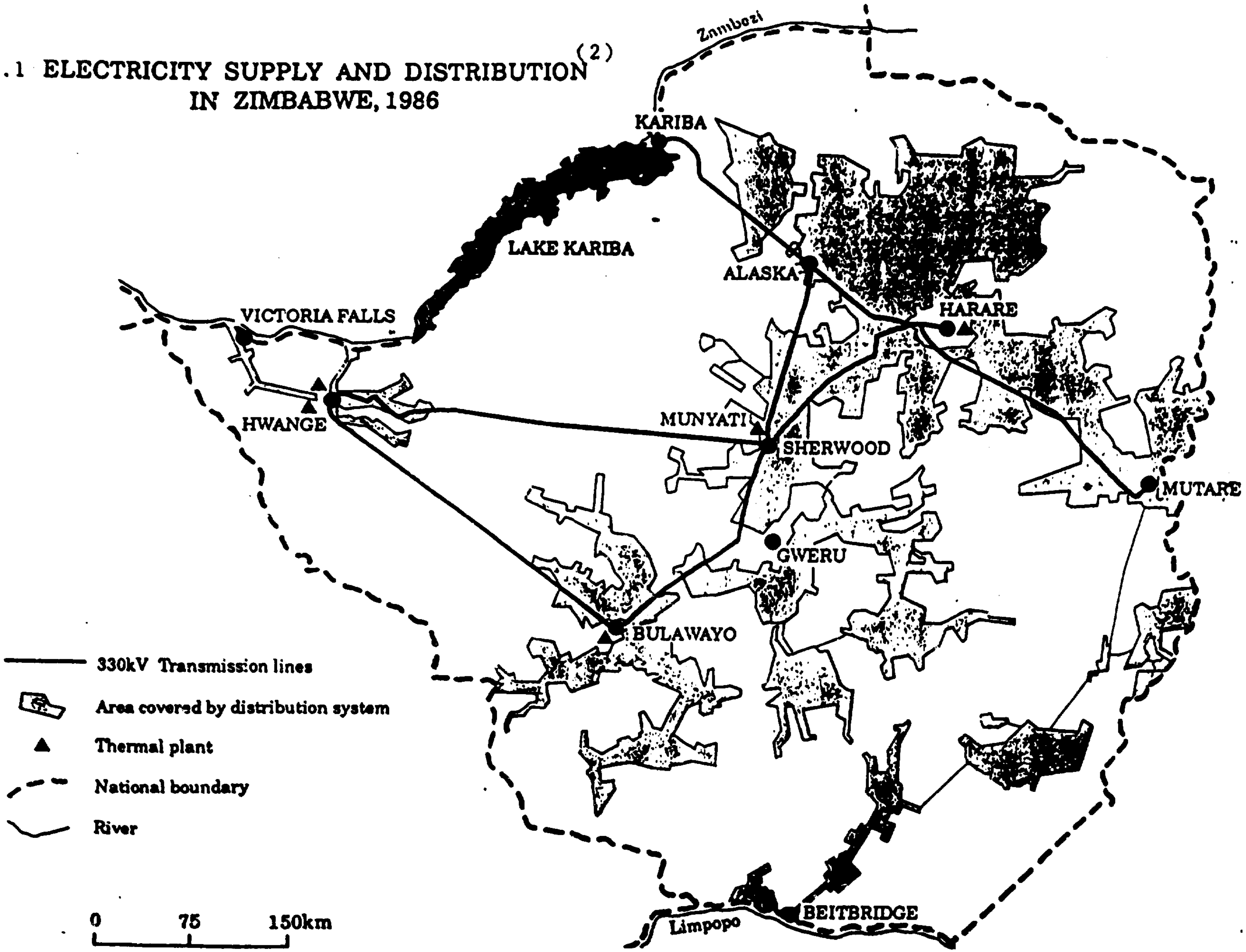

Table 2.1 gives the consumption of energy in different sections as compiled by Beijer/Zeap projects(5) for 1983. Though the sectorial absolute values may have changed, the data still provide the trend of energy consumption. The current prices of different forms of energy are given in Table 2.2.

Table 2.1 - Sectorial Fuel and Power Consumption

| Sector | Liquid Fuels | Coal/ Coke | Electricity | Commercial wood | Fuel wood |
|---|---|---|---|---|---|
| Household | 5.1 | - | 13.6 | 91.7 | 93.2 |
| Agriculture | 10.4 | 18.3 | 7.3 | -- | 6.6 |
| Industry | 4.4 | 58.9 | 65.6 | 3.8 | - |
| Transport | 76.8 | 15.7 | - | - | - |
| Construction | 3.3 | - | 0.6 | 4.5 | - |
| Others | - | 7.1 | 12.9 | - | 0.2 |
| Total | 100 | 100 | 100 | 100 | 100 |

Table 2.2 - Current Energy Supply in Zimbabwe (4)

| FUEL | $/UNIT |
|---|---|
| Coal | 32/Ton washed F.O.R. |
| Diesel/paraffin | 0.6/litre ex pump |
| Electricity | 0.0715 kWh household tariff |
| Firewood | 70/Ton ex depot Harare |

The price structure has resulted in the progressive use of coal products on a large scale in the industry and agro industrial sectors due to least cost option to consumers.

## 2.1 ENERGY RESOURCES

The present energy situation can be summarised as follows:

As mentioned earlier, there are adequate potentials for conventional energy, yet 80 percent of the population still depend on traditional woodfuel leading to extensive deforestation in densely populated communal areas. One of the goals of development policy is to achieve self sufficiency and security in energy supply and eliminate regional imbalances and prevent environmental degradation. The current energy supply pattern is presented in Table 2.3.

Table 2.3 - Energy Supply Pattern

| Form | | Percentage |
|---|---|---|
| Woodfuel | ..... | 58 |
| Coal | ..... | 20 |
| Liquid fuels | ..... | 11 |
| Electricity | ..... | 11 |

## (A) COAL ENERGY

Coal resources are estimated to be 29.2 billion tonnes out of[1] which 2.19 billion tonnes can be classified as reserves which have been fully evaluated with respect to quality and quantity. The present rate of consumption is 4.5 million tonnes out of which 2.2 million tonnes are consumed by thermal power stations at Hwange and 2 percent is presently used by domestic sector. Transportation of coal is one of the biggest constraints being faced at present. In the context of Zimbabwe's relatively large coal reserves and present low rate of consumption, the coal can be equated with other renewable forms of energy. The coal deposits are low in sulphur and the ash content varies from 7 to 40%.

## (B) PETROLEUM PRODUCTS

There are no known deposits of petroleum and the entire consumption is being met through imports. The present quantum of import is about 6 million barrels and with conservative growth rate it is likely go up to 11 million barrels by turn of this century. In 1985, the oil import bill amounted to Z $ 275 millions accounting for 19 percent of all imports.

The major consumption of petroleum products being in transport sector, the Government has already taken steps to conserve their consumption by blending petrol with ethanol. At present, 36 million litres of ethanol is produced from sugarcane. Studies are also being conducted to mix diesel with butanol.

## (C) POWER PRODUCTION

According to UNDP report[1], the hydropower potentials are 5,030 MW mainly on Zambezi and some on Sabi rivers. The present installed capacity at Kariba on Zambezi river is 1,266 MW, of which 50 percent has to be shared with Zambia. The major projects under construction are Kariba South extension (300 MW) expected in 1995-96 and Baktoka Gorge (800 MW) likely to be commissioned by year 2003.

The installed thermal power capacity is 920 MW at Hwange-I and II and 375 MW at other small power stations at Harare (135 MW), Munyati (120 MW) and Bulawayo (120 MW). The performance of some of the plants at Hwange-II is not satisfactory with the result that they are operating at about 50% of their rated capacity. Therefore, to meet the existing demand, power is being imported from Zambia.

Lack of spare parts and skilled man power are some of the major constraints for achieving higher load factors for thermal plants. Presently the Government has therefore decided not to proceed further with expansion of thermal power.

Even if the generation capacity is increased, the main constraint for extending power to the remote areas is the heavy cost involved in laying new transmission lines involving foreign exchange as the major component. The extent of expenditure involved can be gauged by the cost estimates given in Table 2.4.

TABLE: 2.4 COST ESTIMATES FOR TRANSMISSION LINES

| Ratings | Costs/km (Z $) |
|---|---|
| 330 kV | 2,22,670 |
| 132 kV | 65,700 |
| 33 kV | 19,000 |
| 11 kV | 10,000 |

Considering the above mentioned developmental plans and the constraints involved, it is envisaged that even after 30 years of sustained progress about 50 percent of the population may not have any access to commercial energy.

The major resources of renewable energy are basically solar, biomass and animal dung.

(D) SOLAR

Zimbabwe lies in one of the high sunshine regions of the world with most parts having 2,800 hours of sunshine per annum. The mean daily radiation is between 470-510 Cal/cm2. The summer radiations are 30% higher than winter.

(E) BIOMASS

Regarding biomass availability, the country is endowed with adequate amount of agro-residues which at present are not being utilised. The notable are: maize cobs, cotton stalk, coffee husk, groundnut shells and straw which are suitable agro-residues to produce domestic fuel and/or used as decentralised energy systems for mechanical (pumping, grain grinding etc.) and electrical applications. As an instance, about 2 million tonnes of maize is produced giving about 0.6 million tonnes of corn cobs per annum. In addition, in timber plantation areas of Eastern Zimbabwe, wood waste is extensively available which is presently being incinerated as a means of disposal.

(F) BIOGAS

The livestock population in Zimbabwe is large enough to justify the acceleration of National Biogas Generation Programme. The cow dung coupled with other wastes could play a major role in providing domestic energy. The distribution of livestock is given Table 2.4.

TABLE 2.4 - LIVESTOCK IN ZIMBABWE IN 1000

| | Cattle | Sheep | Goats | Pigs |
|---|---|---|---|---|
| Commercial farms | 3231 | 164 | 62 | 81 |
| Commercial farms | 4687 | 260 | 1409 | 94 |

(G) WIND

Wind speeds are rather low varying from average 2.0 m/sec for poor stations to 4.4 m/sec going up to 5 m/sec for good stations. About 116 mills of Climax type (3.0-3.7m diameter rotor) have been installed from 1940 to 1987. These have been mainly used for pumping water not for irrigation but for storing domestic water and for cattle drinking.

(H) GEOTHERMAL

Some minor potentials do exist for geothermal energy. So for, 23 thermal springs have been indentified where temperature ranges from 31 to 97°C.

## 3.0 WORK PROGRAMME OF DEPARTMENT OF ENERGY

Based on political and socio-economic directives from the Government, the primary responsibility of energy policy formulation, planning and monitoring the progress including development of NRSE rests with Department of Energy Resources and Development (DOE) under the Ministry of Energy, Water Resources and Development (MEWRD). This ministry is headed by Minister, Mr.K.Kangai with Mr.J.Chitauro as its Permanent Secretary. The other department is for Water Resources and Development. The activities of DOE are co-ordinated by its Director Mr.H.S.Makina.

## 3.1. FUNCTIONS AND ORGANISATION OF DOE

One of the four sections of DOE is Research and Development which is responsible for all aspects of NRSE technologies in addition to those of atomic energy. Some of the major functions are formulation of programmes, sponsoring and/or carrying out R and D activities, collaborating with various international funding agencies sponsoring NRSE projects, implementation of programmes/ projects and interact with Non-Government Organisations (NGO) and local industries involved in manufacturing of NRSE systems/ applications. They are also expected to acquire information and data base for new technologies and carry out specific studies. For these activities the manpower organisational set up of DOE in general and R and D section in particular is given in Fig. 3.1.

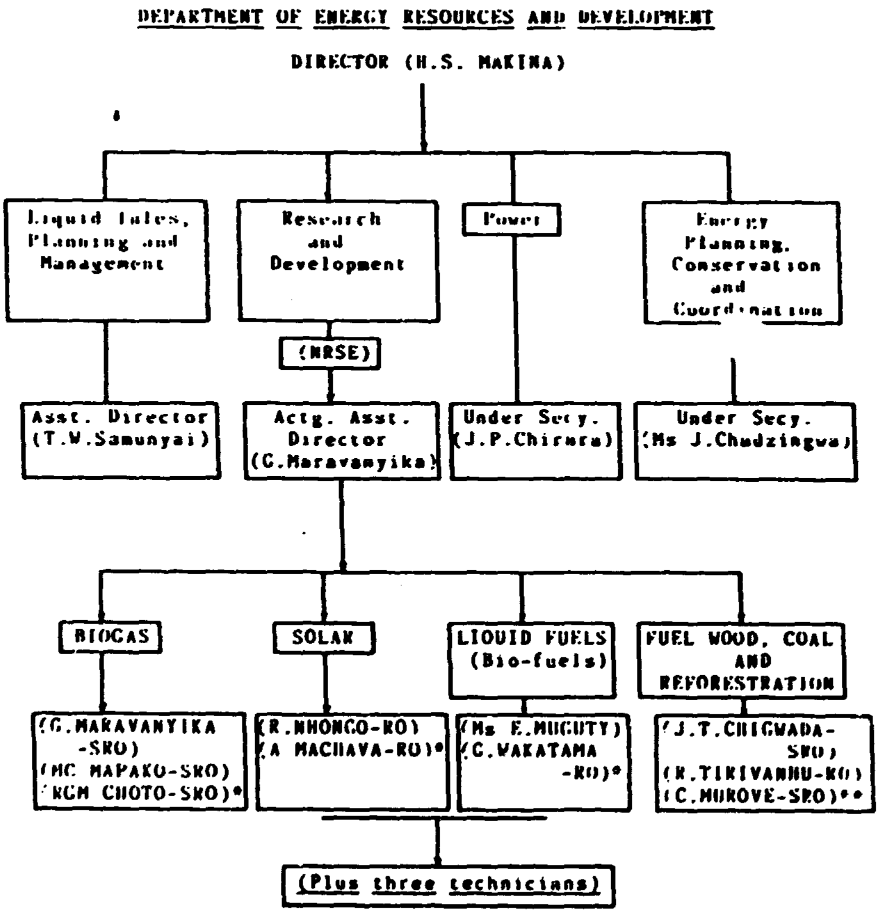


Fig 3.1 ORGANISATIONAL SET-UP OF DOE

(*) Recently appointed.
(**) Seconded to CIDA (Energy Conservation project in SADCC).

Note: 6 positions of scientific staff are vacant against 16 sanctioned positions of Principal Research Officer (PRO) Senior Research Officer (SRO) and Research Officer (RO).

## 3.2 RESOURCES/FACILITIES

As shown in Fig. 3.1, the R and D section is currently short of staff as many technical and scientific staff leave for better working conditions. At present there are three senior research officers who have been working for more than 5 years.

The section does not have any space/laboratory facility for carrying out prototype testing and/or development activities. Further, due to lack of adequate transport facilities, manpower and requisite instruments, a minimum follow up testing activities/feed-back analysis of demonstration systems, already installed in the fields, could not be carried out. These are important activities and imperative for development of these new technologies, not only from technical reliability angle but also from their social acceptability.

Although the department places high exphasis on NRSE, the financial resources available for implementation of demonstration projects are also very limited. A majority of projects are therefore funded by international organisations. Table 3.1 presents the yearly expenditure mainly obtained from Government of Zimbabwe (GOZ).

Table 3.1 EXPENDITURE AND ITS ESTIMATES FOR RENEWABLE ENERGY PROJECTS BY DOE IN Z $

| Financial Year | GOZ | Donors | Total |
|---|---|---|---|
| 1984-85 | 30,304 | NA | 30,304 |
| 1985-86 | 31,963 | NA | 31,963 |
| 1986-87 | 43,346 | NA | 43,346 |
| 1987-88 | 52,992 | NA | 52,992 |
| 1988-89 | 62,000 | 23,000 | 85,000 |
| 1989-90 | 70,000 | NA | 70,000 |
| 1989-91 | 90,000 | NA | 90,000 |

In most of the cases the donor's component for implementation of programme was not available.

## 3.3 ACTIVITIES AND PROGRAMMES OF R & D SECTION

The programmes of this section along with its objectives is formulated each year and its progress is reported to the Government. As an instance, the objectives of this programme given in the Secretary's report for 1987 are as follows:

1. To conserve fuelwood and reduce deforestation by introducing fuel efficient woodstoves, coalstoves and biogas to rural institutions and rural households.

2. To save foreign currency by exploiting non-conventional energy such as:-

   Solar photovoltaics (PV) systems for lighting, water pumping and refrigeration and use of Butanol for blending with diesel.

3. Improve rural life by use of biogas plants as waste (human) disposal units and use of effluent as fertilizer.

The above extract from Secretary's report on NRSE programme indicates that the activities of this section are mainly concentrated in setting up demonstration plants in rural areas. However, due to non-availability of regular feed-back from users and non existance of their time tested monitoring, it is impossible to conclude about the success of these projects. But the general indications are that by and large such systems, like woodstoves, biogas plants, water heating systems and some PV systems are well accepted by individuals and some of the institutions.

The following Table 3.2 gives the consolidated latest position of demonstration/actual commercial systems installed so far in different parts of the country by DOE. In addition, a few local manufactures of solar water heating systems, cookers, PV systems and windmills have sold such systems about which no data were available with DOE.

Table 3.2 NRSE SYSTEMS/GADGETS INSTALLED BY DOE TILL DATE

| No. | Systems | No. | DOE/ Donor | Area/ District | Remarks |
|---|---|---|---|---|---|
| 1 | Solar cookers | 6 | DOE | Chihota | Feed back awaited. |
| 2 | Solar dryers | 6 | DOE | Goromonzi | In addition to 8 installed earlier. |
| 3 | Solar absorption refrigerators | 4 | DANIDA | (a) Parirenyatawa Hospital<br>(b) Gora Clinic (Mhondoro)<br>(c) Zvarota Clinic (Shurugwi)<br>((d) Nemanwa Clinic (Masvingo) | Magnetic values found faulty. Replacements received, yet to be repaired. |
| 4 | Solar water heaters | 8 | DOE | (4) Kuwadzana (Harare)<br>(2) Nkulumane (Bulawago)<br>(2) Rujeko (Masvingo) | 1.Installed in low income area.<br>2.Feed back awaited.<br>3.GOZ intends to install 100 units in 4 urban areas. |

..Contd.

| No | Systems | No. | DOE/ Donor | Area/ District | Remarks |
|---|---|---|---|---|---|
| 5. | PV SYSTEMS: | | | | |
| | Lighting and refrigeration | 1 | French | Marymount | Partially working. |
| | ,, | 1 | USAID | Chikwaka | Working. |
| | ,, | 1 | USAID | Chihota | Not working. |
| | Pumping | 1 | French | Chiweshe | Working. |
| 6. | Woodstoves (including Training) | 1,331 | DOE | 11 out of 55 districts | Feed back awaited. |
| 7. | Coalstoves | 25 | DOE | Murewa | Feed back awaited. |
| | | 20 | DOE | Ntabazinduna | Additional 50 will be made. |
| 8. | Gasifiers | 2 | UNIDO | Nijo Farm (Harare) | Installed testing to be done. |
| 9. | Biogas plants | 16 | DOE | Different locations | Monitoring and feed back |
| | ,, | 5 | Private | ,, | awaited for |
| | ,, | 24 | UNDP | ,, | most plants. |
| | ,, | 10 | CSC (a) | ,, | Cap.4 to 20M3 |
| | ,, | 9 | DOE/SH(b) | ,, | with one of |
| | ,, | 2 | DOE/EEC | ,, | 80M3 commercial unit. |
| 10. | Windmills | 2 | DOE | Chiweshe Masvingo | Donated by Steward & Lloyds a local company. Monitoring constrained by lack of instruments. |

(a) CSC - Commonwealth Science Council
(b) SH - Siveira House (NGO)

Other activities involve testing the vehicles on Butanol/Diesel blend and procuring funds for carrying out feasibility studies for local production of Butanol from maize and cassava. Some pilot work is also initiated by DOE on afforestation by screening plants (theoretical) and providing seeds to district officials who are mainly responsible for national afforestation programme under respective ministries.

## 3.4 TRAINING

The DOE does not offer any training programme except to the builders of cookstoves/biogas units during installation. However, it facilitates the training of personnels in overseas through foreign agreements. There is an immediate need to set up a small and effective training establishment along with testing of prototype systems. This aspect is further discussed under recommendations.

## 3.5 POLICIES FOR PROMOTION OF NRSE

Since 1980, Government has recognised the important role NRSE can play as an instrument for imported petroleum substitution, in reducing deforestation and supplementing the overall energy balance.

The scope for implementing biomass, solar energy and biogas technologies is immense. The Government of Zimbabwe has committed itself by incorporating development and dissemination of NRSE technologies in the Fist Transitional National Development Plan (1982-83 to 1984-85). This is so pertinent that the extract of the policy documented in Vol 1, November 89, section 14.23 page 78 is being reproduced.

"In the medium and long terms new and renewable sources of energy could make a significant impact on the economy's total energy requirements both as subtitutes for imported energy and as compliments in the rural development strategy. In the field of solar energy efforts will be made to improve the performance of collectors, reducing the cost of solar water heating systems, while field testing of photovoltaic systems for isolated points such as schools, clinics and hospitals and work on solar refrigeration will continue. Biogas produced from animal and agricultural wastes under adiabatic conditions can be utilised for cooking, lighting and refrigeration. Research will be undertaken on cost reduction, plant design, feed materials operational parameters, microbiology and fermentation kinetics".

In a recent report published by Dr.S.K.Maya for SADCC on NRSE in Zimbabwe, Sept 1989, the author desired the need to radically reformulate the policy regarding the development of NRSE in Zimbabwe. According to the same author, "The pricing of energy does not reflect any bias towards NRSE, the taxation structure does not give any special consideration for NRSE, the investment and energy funding patterns do not specifically favour NRSE and R and D does not emphasise these forms of energy on their effective dissemination.

Public sector spending in the energy sector for the period 1986-89 and for the period 1989-91 allocates only 0.6 percent of resources to NRSE. This represents a fall in commitment from a 1986 level of Z $ 2.9 million to an expected 1991 level of Z $ 1,26,000.

No financing arrangement has been set up to support the diffusion of NRSE, outside of the funding of those technologies directly disseminated by government. The foreign exchange allocation system also gives no special consideration to NRSE technology.

Solar conversion technology was until recently considered a luxury item and taxed at 23 percent. This taxation level has however, been reduced to 12.5 percent following strong lobbying from the solar energy industry"

Inspite of meagre financial resources provided to DOE and limitations of trained manpower and other infrastructure facilities, it goes to the credit of DOE that its R and D section has made some meaningful progress by introducing various demonstration projects in rural areas which have brought about some sort of awareness amongst the masses.

No doubt, international funding agencies and also local private companies have contributed major share, but the DOE has to collaborate and co-ordinate their activities, especially with the international organisations. The fact that a number of private companies have put in their own resources and started manufacturing/assembling solar water heating systems, PV systems, windmills, stoves and some are going in for latest technologies, show that sufficient market does exist for NRSE systems. However, these units, being expensive are still beyond the reach of rural masses and are being purchased by commercial organisations and urban population.

The need being greatest in the communal areas where in majority of the cases, the electric power cannot be provided in next 20-30 years or more, government should immediately provide some essential fiscal benefits so as to bring down their prices making them affordable to the poor rural masses.

The sale price is one of the major reasons that these technologies have not made any impact in improving the life style in rural areas. For example, a simple wood burning metal stove costs about Z $ 60 which, on an average happens to be more than the monthly income of a rural family.

Therefore, government should immediately initiate a comprehensive study on the price/taxation structure of these technologies with the objective to provide direct/indirect subsidies and tax relief to enable the rural consumers to adopt these systems. These steps are imprative if these technologies have to play their due role in the overall national energy scenario and preserve the environment by reducing ever increasing deforestation. Only large scale dissemination of these appropriate and reliable technologies can make an impact on their living conditions.

However, even before this study is initiated, certain obvious steps which are mutually beneficial to both government and consumers should be immediately implemented. These are:-

(a) Waiving of direct sales tax of 12.5 percent on NRSE systems.

(b) Removel of import duties on selective basis for capital goods and components used for these technologies which cannot be manufactured in Zimbabwe.

(c) Liberal provision of foreign exchange allocations for those machines which are required to manufacture components resulting in import substitution.

These steps are very much needed and desirable due to the fact that firstly the quantum of revenue obtained by their sales is insignificant and secondly these have indirect benefits of reducing the consumption of imported subsidised diesel and paraffin oil used in resettlement areas for grinding mills and by rural/urban low income masses for lighting and cooking respectively.

## 3.6 PROMOTION OF LOCAL MANUFACTURERS

One of the important functions of DOE is to encourage both large and small scale manufacturers of these technolgies. The latter can take up manufacturing of simple systems like small charring units, wood/coal/coke stoves; and small to medium scale decentralised power systems based on biomass, microhydel, solar and windmills can be manufactured by others. It is encouraging that even at this initial stage there are atleast seven prominent companies engaged in manufacturing and sale of water heating, photovoltaic, cookers and windmill systems. Considering the potential their number should be manifold. This is achievable if the quantum of sale is large to make these ventures renumerative enough to sustain the interest of the manufacturers. This would also result in reduction of prices and better follow-up services can be provided.

The above objectives can be achieved by providing due fiscal concessions and expediting the disposal of pending cases submitted to the government for release of foreign exchange and licences for manufacturing. Instead of concentrating these units in Harare or Bulawayo, additional incentives will have to be provided for them to put up their establishments in other provinces.

In the absence of these promotional incentives, which are considered imperative for these technolgoies, the existing manufacturers may even loose interest and diversify their activities. In that eventuality, the development of NRSE technologies will be the main casualty. Zimbabwe, with its lead in this area (except RSA and may be Kenya) and a firm industrial base, has great potentials to export these systems to neighbouring SADCC and later to PTA countries.

## 3.7 STRENGTHENING THE PROGRAMME OF DOE

Inspite of many constraints, DOE has done commendable work in installing a number of these systems. (summarised in Table 3.2). However, there is inadequate follow-up action and systematic feed back methodology is not developed. It is counter productive for the dissemination programme to have even a small fraction of these systems unattended and non-operational in the field.

Further, feed-back information analysis and its diagonostic studies are essential to progressively upgrade these systems.

It is understandable that with existing resources of manpower and facilities it is difficult to have continuous monitoring of systems installed at different distant locations. To strengthen this important aspect, it is suggested that DOE should initiate steps to establish nodal agencies for these activities in each of the eight provinces. Later these can be expanded to 55 districts and ultimately to the ward levels. As there is general restriction on recruitment of staff in public sector, initially this programme could be implemented by collaborating with various ministries involved in land agriculture and rural resettlement and/or local government, rural and urban development or any other agency which has nationwide network.

The personnel so engaged to work at nodal agencies and grassroot levels need extensive training both in theory and more so in practice. DOE should initiate effective and intensive training programme at all levels: such as at technician, supervisors, nodal officials and even refresher courses at planner's level. Accordingly, there is an urgent need to set up a Prototype Testing and Training Centre (P.T.T.C.) under DOE. The major outcome of the present mission is to recommend to GOZ and UNIDO to establish such a centre on priority basis. During the series of meetings, this particular suggestion had received unconditional support from all officials of DOE, organisations like NGOs, international funding agencies, private manufacturers, users and above all from the Minister, Mr.K.Kangai, himself. According to him, the establishment of such a training centre was long overdue. The details of setting up P.T.T.C. and its mode of funding from UNIDO and GOZ is discussed in subsequent section.

## 4.0 NATIONAL STOVE DISSEMINATION PROGRAMME

At present, in addition to DOE, there are a number of organisations including NGOs, international funding agencies like GTZ, many women organisations and Institutes which are engaged in efficient woodstove dissemination programme. But presently their activities are not properly co-ordinated. There is a need to start a National Programme for Propagation of Cookstoves under a separate section of DOE. This section should have separate budget and well formulated programme for dissemination of cookstoves on large scale by collaborating with various organisations. Presently, there is no consolidated data about the number and type of stoves so far disseminated. Regular workshops and meetings with implementing agencies, users and promoters should be organised to make this programme more effective.

Further, the cost of these stoves is in the range of Z $ 40 to 60. This is rather too high and steps need to be taken to reduce their prices by using local materials. Stoves costing 5 to 10 dollars can be manufactured by adopting some of the designs developed in Ethiopia, Sri Lanka, India and other countries.

At the moment, agricultural residues not used as fodder are being wasted by incineration. The typical materials are coffee waste, saw-dust, groundnut shell and straw (surplus from thatching of roof). Therefore, efficient stoves using agro-residues need to be introduced. During the present mission, a biomass gas stove (PARU stove) was got fabricated (courtesy of private company, M/s.Ecological Designs, P.O.Box 780, Masvingo) and it was demonstrated to the officals of DOE, using coffee husk. Such stoves and others working on agro-residues need to be incorporated in this programme. This would compliment the national reforestation programme which is formally strengthened every year on 2nd December as National Tree Planting Day. A part of the budget from this programme can be allocated to that programme.

Further, coal is not an ideal fuel for cooking due to emittance of unburnt obnoxious volatiles. Coke can be made by individuals near coal fields and its production further supplemented by production of same by low temperature carbonisation beehive/ recovery coking plants. Apart from being clean fuel, the cost of cokestoves in very low. In fact these can be made out of old tins and buckets by local artisans and even housewives. These can be made in different sizes and can be used effectively for domestic, sweet-meat shops, restaurants and for making local beer both in rural and urban areas. Because of higher heating value and high bulk density, the cost of transporting energy by coke is much lower than that for wood.

## 5.0 RECOMMENDATIONS FOR PROTOTYPE TESTING AND TRAINING CENTRE (P.T.T.C.)

As elaborated in Section 3 of this report, it is impossible to accelerate the present programme of NRSE technologies dissemination without removing some of the constraints being faced by all promotional organisations in general and DOE in particular.

The major constraints are:

(a) Non-availability of space and instruments with DOE for testing prototype systems.

(b) Non-availability of trained manpower at all levels.

(c) Lack of awareness amongst the potential users and promoters at grassroot level.

(d) Lack of information about technologies and data with the planners to appreciate the advantages and limitations of NRSE systems.

(e) Lack of co-ordination between various agencies involved in promotion of NRSE.

(f) Lack , of fiscal incentives and testing facility to manufacturers and users of these technologies.

(g) Inadequancy of funds with R and D section of DOE for implementation programme.

At least constraints (a) to (e) above can be progressively eliminated directly and (f) indirectly by establishing a Prototype Testing and Training Centre for NRSE technologies under the overall charge of DOE. UNIDO can actively participate in providing technical assistance and funds for procurement of testing instruments, imported appliances and prototype systems.

### 5.1 FUNCTIONS OF P.T.T.C. (Renewable energy)

There shall be three major functions of this centre. These are:

(1) To test, monitor and upgrade the performance of NRSE systems and develop standard testing procedures for their evaluation.

These test facilities shall be made available to all interested organisations including private manufacturers. The objective shall be to increase their efficiency and more so, the reliability of the systems.

(2) To conduct continuous training programmes and refresher courses.

The training programmes are expected to be at the following levels:

(a) Technician level

(b) Supervisory level - for those with 'O' or 'A' level education

(c) Orientation training programmes - for graduates in science and engineering

(d) Refresher courses at planners and executive levels.

Later it is also intended to introduce a one year Post-Graduate Diploma programme in Renewable Energy in collaboration with and affiliated to the University of Zimbabwe.

(3) To inculcate awareness about the potentials of NRSE technologies among the general public.

This can be acheived by having a miniature version of Technology Park attached to P.T.T.C.. The park would have relevant NRSE prototype systems coupled with utilities which would be kept open as working exhibits to the general public for particular periods on regualr basis. This park can also be used for training programmes.

5.2 INFRASTRUCTURE OF P.T.T.C. (Renewable energy)

Scientific/Engineering staff:

The centre should have only a minimum number of well qualified and experienced staff, preferable on secondment/deputation from DOE and other organisations. At any time the number should not be more than six, preferably with the following background. By rotation, one of them can be the head of the centre for three years.

| | | |
|---|---|---|
| 1. | Biomass Conversion | : Chemical/process engineering. |
| 2. | Biogas | : Experienced Biologist / Agricultural Engineer/Environmentalist/Biochemical Engineer/ Bio-Chemist. |
| 3. | Solar/Wind/ Microhydel | : Experienced Physical Scientist/ Mechanical Engineer |
| 4. | Electrical/ Electronics | : Electrical/Electronic Instrument Engineer |
| 5. | Economist/Social Scientist | : Degree in Economics/Sociology |
| 6. | Energy modelling and planning | : Degree in Engineering/Physical Sciences |

In addition to faculty, the centre would also have trained technicians one each in Electronic/Electrical instruments and chemical analysis and three in mechanical trades including machining, welding and fabrication work.

Administrative support should be in the form of one office superintendant, one accountant and a secretary with 2-3 laboratory/office attendants. The objective is to have a functional centre with minimum number of regular staff.

In addition there shall be one draftsman and one EDP operator also looking after documentation centre.

For refresher/training courses, invited speakers/lecturers may be inducted on payment of honorarium.

## 5.3 SPACE

Initially the space should comprise of the followings:

1. Functional office rooms.
2. Seminar/lecture room and documentation/computer room.
3. One main instrument/chemical laboratory.
4. Maintenance workshop with store.
5. Open space (about 1000 sq meters) for Technology Park.
6. Covered shed area of about 200 sq meter for testing/training of prototypes.

## 5.4 LOCATION

The Government of Zimbabwe has already initiated steps for the establishment of a Scientific Industrial Research Centre (SIRDC) which would undertake R and D work in collaboration with manufacturing industries. In the first phase, areas pertaining to micro-electronics, mechanical engineering, building engineering and energy have been included by a team of experts from the Commonwealth Science Council in their report of August 1989 (6). The proposed P.T.T.C. could be an extension station of SIRDC with pseudo autonomous status under DOE. As per discussions with officials of Research Council of Zimbabwe the establishment of SIRDC may take about four years to establish. To expedite, it is recommended that the P.T.T.C. be immediately established in the premises of ZESA training centre in Harare. The General Manager of ZESA has agreed in principle to provide basic infrastructure facilities and space for Technology Park and prototype testing. However, it is strongly recommended that the staff attached to P.T.T.C. should have similar status and prerequisites being offered to the staff at ZESA training centre so as to attract competent and committed personnels. As both the organisations are responsible to DOE, there should not be any delay in working out the administrative and financial arrangement based on mutuality of interest.

## 5.5 PROPOSED TRAINING PROGRAMME

The outline of the training programmes (Table 5.1) are being proposed. The details can however be worked out by the DOE staff with assistance from experts sponsored by UNIDO. These experts are also expected to initiate and take active part in these training programmes and procurement of identified NRSE systems.

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(6) - Com Man Sat "making it happen". Establishment of Scientific Industrial Research Centre (SIRDC) Commonwealth Secretariat.

ZESA - Zimbabwe Electricity Supply Authority: a parastatal organisation

TABLE 5.1 OUTLINE OF TRAINING PROGRAMMES

| Level | Duration (in weeks) | Frequency per year | Target group/Remarks |
|---|---|---|---|
| I | 3-4 | 4-6 | Technicians: Incorporating more practical component and hand on experience with specialisation in one of the main NRSE systems |
| II | 3-4 | 2-3 | Supervisory staff: General theory and practicals |
| III | 10-12 | 2 | Orientation programme in theory and practice of NRSE. |
| IV | 2-3 days | 3 | Refresher course for planners and executives |
| Post-graduate Diploma | 1 year (3 Semesters) | 1 | Graduates in Science and Engineering |

The desired curriculum for post-graduate diploma programme incorporating the outlines of course content is given in section six. This also encompasses the subject matter suitable for training programmes of Level I to IV. The relevant subject matter can be extracted from these syllabi and curriculum developed for a specific programme depending upon the nature of participants, their background qualifications and experience.

## 5.6 INPUTS FOR P.T.T.C.

The establishment of P.T.T.C. would need inputs both from UNIDO and GOZ.

It is proposed that the UNIDO should meet the costs of technical assistance, study tour for a senior executive official of DOE as national coordinator, purchase of prototype systems and importation of monitoring instruments.

The tentative inputs envisaged during the 3 years duration of project are:

| | | |
|---|---|---|
| 1. | Study tour for National Coordinator | 1 m/m |
| 2. | Specialised training-staff of P.T.T.C for six persons for 3 months each | 18 m/m |
| 3. | Expert technical assistance - one CTA and 4 to 5 experts | 20 m/m |
| 4. | Purchase of prototype systems out of list given in section 6 | US $ 0.25 m (items 4 and 5) |
| 5. | Monitoring instruments | |

The details for P.T.T.C. including the nature of expert inputs, type of prototype systems and related instruments should be formulated by CTA in collaboration with National Coordinator. The systems selected should be reliable and appropriate for Zimbabwean conditions which can be progressively manufactured in the country. The total UNIDO financial input is estimated to in the range of US $ 0.65 m.

The Government should meet the local cost of infrastructure and also the recurring expenditure.

## 6.0 CURRICULUM FOR TRAINING PROGRAMMES:

The scheme of courses for one year post-graduate training is presented which can be used for developing the curricula for other training programmes. This scheme is based on experience gained from an existing international programme on NRSE technologies being offered in India for participants from developing countries on behalf of United Nations University, Tokyo.

For Post-Graduate Diploma, the year's programme is divided into 3 semesters, each with a duration of 15-16 weeks. First two semesters are utilised for theory and practicals, while the final semester is devoted to a comprehensive project work, preferably undertaken in the field.

The proposed scheme of courses is given in Table 6.1 which may be modified in accordance with the approved credit requirement of the University of Zimbabwe awarding the P.G. Diploma. While the compulsory courses should remain as proposed, the optional courses may be altered to suit the specific requirements of the participants.

### TABLE 6.1 SCHEME OF COURSES FOR POST-GRADUATE DIPLOMA

**FIRST SEMESTER**

| (1) No. | Courses | (2) L - T - P | Hours/ Week | Credits |
|---|---|---|---|---|
| T-11 | Energy Conversion Processes | 3 - 1 - 0 | 4 | 4 |
| T-21 | Chemical Energy Systems | 3 - 1 - 0 | 4 | 4 |
| T-31 | Fluid Energy System | 3 - 1 - 0 | 4 | 4 |
| T-41 | Energy Analysis/ Socio-Economics | 3 - 1 - 0 | 4 | 4 |
| P-11 | Practicals | 0 - 0 - 12 | 12 | 4 |
| | Total | 12 - 4 - 12 | 28 | 20 |

**SECOND SEMESTER**

| | | | | |
|---|---|---|---|---|
| T-52 | Energy Conservation | 3 - 1 - 0 | 4 | 4 |
| T-62 | Integrated Energy Systems | 3 - 0 - 0 | 3 | 3 |
| T-72 | Solar Energy Systems | 3 - 1 - 0 | 4 | 4 |
| P-12 | Practicals | 0 - 0 - 12 | 12 | 6 |

..Contd.

| | | | | |
|---|---|---|---|---|
| E-12 / E-22 (3) | Elective Subject | 3 - 0 - 0 | 3 | 3 |
| E-02 (4) | Optionals (Audit Course) | 2 - 0 - 0 | 2 | - |
| | Total | 14 - 2 - 12 | 28 | 20 |

## THIRD SEMESTER

| | | | | |
|---|---|---|---|---|
| P-23 | Specific Project | 0 - 0 - 25 | 25 | 12 |

(1) Note: T-Theory, P-Practical, O-Optional Subject, E-Elective followed by first letter giving course No. and second letter the semester in which offered.
(2) L - T - P denotes Number of hours per week for Lectures, Tutorials and Practicals respectively.
(3) One subject only out of E -12 and E-22
(4) Any optional course. Computer Techniques/Mathematics etc.

## 6.1 COURSE CONTENTS

### T-11 PRINCIPLES OF ENERGY CONVERSION PROCESSES:
3 - 1 - 0 - First Semester

Concepts of Thermodynamics - Important uses. Thermodynamic properties. Thermodynamic laws. Material and energy balances, Conversion efficiencies, Various power cycles and their applications in internal and external combustion engines. Refrigeration, Heat pumps, Sterling cycles - Thermal power. Basis of heat transfer in heat exchange equipment. Applications in OTEC and Geothermal systems. Economic evaluation.

Thermoelectric, Thermoionic, and Photovolataic Conversion. Fuel cells. Electrochemical energy conversion systems. Solar hydrogen energy conversion.

### T-21 CHEMICAL ENERGY SYSTEMS: BIOMASS ENERGY
3-1-0 - 1st Semester

Production and classification of biomass. Biomass potential as source of Energy and Chemicals - Integrated systems. (agro and forest based industries). Biomass Characterisation. Comparision with fossil fuels. Thermochemical Conversion: Principles and appliances, Combustion, Gasification, Pyrolysis and liquification systems. Utilisation of various end products, briquetting of char and densification methods. Cookstoves: principles and applications. Biochemical conversion of biomass - Biogas, principles and design of reactors. Conversion to alcohol and other useful products, Economic evaluation of comparative processes, Environmental and pollution aspects.

T-31 FLUID ENERGY SYSTEMS - WIND AND MICROHYDEL ENERGY:
3-1-0 - 1st Semester

Aerodynamic principles, Machine design options, Performance characteristics, Applications: water pumping, motive power for other end uses and power generation. System design and economics, Case studies.

Assessment of hydro resources. Low and medium head turbines. Stability and efficiency. Microgenerators: Characteristics, S-control, stability and reliability. Criteria for selection of subsidiary systems. Energy utilisation and storage systems.

Introduction to tidal energy.

Environmental aspects of Wind, Microhydel and Tidal Energy systems.

T-41 ENERGY ANALYSIS AND SOCIO-ECONOMICS OF RENEWABLE ENERGY TECHNOLOGIES:
3-1-0 - 1st Semester

Energy measurement, Energy costs of goods, services, fuels and food. Methods of energy analysis. Energy analysis and Thermodynamics. Energy analysis of renewable energy systems and industrial systems. Computer aided analysis and design.

Social values and traditions. Energy profiles in different societies. Behavioural studies. Acceptability of innovations. Economic perspective, Cost-benefit analysis. Inflation, uncertainty, and sesitivity analysis.

T-52 ENERGY CONSERVATION: 3-0-0 - 2nd Semester

Thermodynamic aspects of energy conservation. Energy conservation through controls. Energy Auditing. Process heat and steam management. Waste-heat recovery and energy cascading. Energy flow in buildings. Thermal insulation in energy conservation. Solar passive architecture. Electrical energy conservation in buildings and industries. economics of energy conservation.

T-62 INTEGRATED ENERGY SYSTEMS: 3-0-0 - 2nd Semester

Past practices and futuristic demand of energy for selected regions of Zimbabwe and the world. Energy surveys. Modes of integration. End use matching. Optimal mix of energy technologies. Selected tools from operations research. Total energy concept. Waste heat utilisation. Case studies.

T-72 SOLAR ENERGY SYSTEMS - PRINCIPLES AND APPLICATIONS
3-1-0 - 2nd Semester

Solar radiation and its characteristics. Basic Principles of heat transfer. Selective coatings. Design and performance of flat plate collectors. Types of solar concentrators: design and characteristics, Tracking, Testing of collectors. Solar stills. Solar drying, Cooling and Cooking. Conversion to mechanical energy, Stirling engine, Water pumping. Thermal energy storage. Fundamentals of semiconductors and solar cells. Types of solar cells, Fabrication, Photovoltaic panels, PV pumps, PV lighting systems, with electronic components and storage.

P-1 PRACTICALS/FIELD EXPERIMENTS ON PROTOTYPES
0-0-12 - 1st Semester and 0-0-15 - 2nd Semester

Demonstration: Operation, data acquisition and analysis. Calculation of material/energy balances and efficiency at varying operating and environmental conditions. Hand-on experience on both preventive and breakdown maintenance. Preparation of design, operational, maintenance and safety manuals for one/two system (s).

Prototype systems for practical:

A. SOLAR: Cooker, water heater, PV for lighting, refrigeration and water pumping including electronic components and storage.

B. BIOMASS: Biomass Characterisation, Biomass gas stoves, gasifiers for mechanical and electrical modes. Testing of wood stoves, charcoaling with recovery of products and briquetting

C. COAL: Testing the performance of coke and coal stoves.

D. BIOGAS: Both Chinese and Indian models. Effect of gas production as function of feed quality and quantity. PH and C/N ratio. Analysis of Gases.

E. FLUID ENERGY: Microhydel simulated system - performance evaluation.
Windmill simulated system - performance evaluation.

P-23 PROJECT: 0-0-20 - 3rd Semester (for specialisation)

Complete erection, operation and performance evaluation of one NRSE system/Technology in the field (with the help of field staff and instructors). Cost/benefit analysis and socio-economic studies. Operation manual.

## ELECTIVE SUBJECTS

E-12 POWER PLANT ENGINEERING: 3-0-0

Types of thermal power stations. Steam power stations based on fossil fuels. Economy and thermal scheme of the steam power stations. Thermal power plant equipment: boilers, superheaters, economizers, condensers, combustion chamber and gas loop, turbines etc. Gas turbine power stations, steam gas power stations, peak load generating sets. Elements of hydropower generation. Recent advances in power plants. Elements of nuclear power plants. Nuclear reactors and fuels. Hazards due to nuclear power plant. Instrumentation.

E-22 POWER SYSTEMS: GENERATION, TRANSMISSION AND DISTRIBUTION 3-0-0

Introduction to Electrical Energy Systems. Generation: Synchronous generator operation. Excitation and governing systems. Synchronisation. Parallel operation, load sharing, efficiency, temperature rise and cooling. Auxiliaries in power stations. Transmission: Overhead lines and cables. Insulators. Transmission line equations. Single line diagram and per unit system. Distribution. Economic operation: Co-ordination of incremental production cost and transmission loss. Hydro-thermal co-ordination.

## 7.0 RESEARCH AND DEVELOPMENT WORK IN ZIMBABWE

The systematic R and D work in the area of NRSE technologies is rather very limited and a few institutions are actually involved in their specific areas. Some of these are Institute of Agricultural Engineering at Borrowdale, Technology Centre at University of Harare, Siveira House and one or two private manufacturing organisations. There is also a professional Solar Society which organises lectures and workshops on solar energy.

The research by private companies is limited to system adoption and performance testing of equipment manufactured/assembled by them. They rely on foreign R and D support and make use of published materials in professional and trade journal/documents.

So far, there has been some success only in developing cookstoves by various organisations which are being sold or disseminated by NGO's, DOE and international funding agencies. However, field evaluation methods and mechanism for feed back analysis need strengthening.

In view of the limited R and D work the establishment of proposed P.T.T.C. and SIRDC assumes special importance.

## 8.0 IDENTIFICATION OF RELEVANT TECHNOLOGIES

In Zimbabwe the main renewable resources of energy are solar and biomass including biogas resources. Wind power has inadequate potentials while microhydel resources are limited. The latter when coupled with water resource management, assumes prominent position and is worthy of its exploitation. Windmills have been installed in the country for over forty years in commercial farms for pumping and storing water for cattle.

Most of the decentralised technologies based on solar energy have already been installed. However, these have not been fully modified/altered to suit the local environments. Firstly, most of these are relatively new and have not been time tested and secondly, in the absence of feed-back the most suitable models and their requisite capacities have not been identified. Cookstoves and Biogas dissemination programmes also suffer from these constraints. Most of these technologies are site specific and locational primary data about resources versus energy demand are rather limited and need to be updated.

### 8.1 SOLAR ENERGY TECHNOLOGIES

The common solar energy technologies on water heating, PV units for lighting and refrigeration for clinics/hospitals and beer stores (common in Zimbabwe) have been introduced. PV pumping system are being introduced with aid from GTZ. In addition to thorough field testing of these technologies, there is need to introduce and test the following technologies/concepts in Zimbabwe.

(a) Large crop drying systmes for cereal and cash crops in specific locations. Such systems have been developed in Germany and India and model systems can be trial tested.

(b) Steps should be initiated to bring in the concept of solar passive housing in order to increase the comfort level at reduced building costs. DOE can collaborate with Physics and Civil Engineering Departments of University of Zimbabwe and this programme may be initiated with assistance from West Germany.

### 8.2 BIOMASS CONVERSION SYSTEMS

Except for two 40 KVA gasifiers, most of the biomass conversion technologies have not been introduced in Zimbabwe. With adequate availability of low ash agro-residues as suitable feed stock for gasification, this technology preferably at small scale level has great potentials. In the absence of of any experience with biomass gasifiers, it is recommended that initially application oriented, simple, cheap and reliable gasifiers suitable for village level uses, such as maize grinding, water pumping for drinking and irrigation and power generation for hospitals/ clinics and schools in rural areas should be introduced. However, care should be taken to have diesel engines of the same type and make already being used so that procurement of spare parts does not pose problems. Due to acute shortage of foreign exchange, steps may be taken to progressively manufacture these engines in Zimbabwe. The technology of manufacturing diesel engines in some of the developing countries is now well established. For example, in India these engines are manufactured in small scale sector and competing with organised sector in quality and prices. Probably the same situation exists in Pakistan and other developing countries such as Thailand, China and Bangaladesh.

(A) GASIFIER TECHNOLOGIES

Although large gasifiers are being manufactured and used in Zimbabwe by industrial sector, these are basically updraft gasifiers working on coke/charcoal and accordingly used for industrial thermal applications.

The need is to introduce small scale agro-waste based gasifiers specially suitable for corn cob, cotton stalk, and small twigs and branches which are not used as domestic fuel. Since these gasifiers are required in rural areas, these have to be cheap, reliable and maintenance free and suitable for working in mechanical and electrical modes.

To meet the above objectives it is desirable to have these systems suitable for charred biomass, should be downdraft type and capable of operation without constant attention.

These type of gasifiers are available and one such system has been developed under U.S.AID assisted project at I.I.T. Delhi and now manufactured by a commercial firm in Bombay. The present cost of a 5 H.P. system complete with charring unit, gasifier and standard Kirlosker (Cummins) diesel engine - pump set is $ 2,000 ex India. Out of four models being marketed in India, this is the only one based on carbonised maize and other biomass species while remaining three models are based on wood, including ANKUR model purchased by UNIDO for Nijo farm near Harare.

It is recommended that under U.S. AID assisted programme or UNIDO sponsored programme six complete models along with utility systems should be purchased and introduced in Zimbabwe and later more in SADCC countries, initially for the following applications:

(a) Gasifier-engine set up with maize grinding mill (2 Nos), for maize grinder run with diesel engine is a common activity in rural wards.

(b) Gasifier-engine set up for irrigation in selected areas (2 Nos).

(c) Gasifier-engine set up for power generation for rural schools/clinics in maize/cotton stalk/timber growing areas. GOZ has given top priority to setting up schools and clinics in rural areas and large number of these have been constructed. Most of these institutions have no hope of getting power in next 20-30 years. Later these gasifiers can be manufactured in Zimbabwe.

## (B) SMALL SCALE CHARCOALING AND BRIQUETTING SYSTEMS FROM BIOMASS

The above systems have great potentials in Zimbabwe and other African countries where presently biomass residues are being wasted. Excellent charcoal can be produced from maize cobs which can be used for domestic and metal purification/reduction processes. Powdered charcoal from other biomass can be briquetted.

Further recovery of by-products from small charcoaling units can be introduced at village levels by adopting simple techniques. The insoluble tar obtained can be used for preservation of wood which is extensively used in Zimbabwe for constructing village houses, fencing for commercial farms and also pens for cattle. The other by-product, aqueous tar also known as Pyrolignious acid (PLA) can be used for protection of thatched roofs from environmental deterioation due to attack of termite and other insects.

## (C) CO-GENERATION SYSTEMS

Systems based on controlled pyrolysis of biomass for generation of valuable products and power generation can be introduced as demonstration units as model for decentralised power systems.

Coffee husk and groundnut shells which are presently being burnt to facilitate disposal can produce excellent industrial carbon or activated carbon along with production of power. 250 kg per hour of these materials can give about 60 kg of good quality carbon and 37 KW of surplus power. Depending upon the sale price of carbon, the cost of power production can be competitive to the cost of commercial energy.

Such systems can be employed as decentralised power cum industrial units. The power can be supplied to the neighbouring rural areas by installing groundnut/coffee shelling plants in remote areas growing these products. Further, the cost of transportation of groundnut can be reduced by transporting shelled groundnuts rather than whole nuts. Being economical, these can attract private investments. Feasibility studies should be carried out for such systems in Zimbabwe and other PTA countries.

Wood gasifiers can be demonstrated in tea/coffee estates which are using wood for drying of these products. By using wood gasifiers the consumption of wood can be reduced by 60 percent. Such systems for tea drying are commercially working in Sri Lanka developed by Engineering Research Station, Colombo.

## (D) BIOMASS DOMESTIC STOVES

As described earlier, agro-residue (Biomass) gas stoves are very relevant for Zimbabwe. One such unit has already been demonstrated during this mission. Taking this as a model, it can be further modified with a view to reduce its metal content and so the cost and taken up actively for popularisation under National Stove Dissemination Programme.

## 8.3 BIO-GAS SYSTEMS

These systems have been already introduced. The need is to simplify these, provide technical back-up facilities to keep them operational and using these as models for popularisation and training.

Steps needs to be taken to install a few bio-gas diesel engines at these sites to use the gas for power generation. Further there is need to incorporate efficient burning and lighting appliances for these bio-gas plants.

## 8.4 OTHER TECHNOLOGIES

For exploitation of microhydel and wind resources it is imperative that studies be initiated to find out suitable sites based on primary data about the resources and local demand for power. In view of their limited potentials and limitations of resources and manpower, their exploitation programme can await so as to give priority to other technologies.

ANNEXURE - I
(Reproduced from Information Sheet provided by ZESA)

# ZIMBABWE ELECTRICITY SUPPLY AUTHORITY NATIONAL TRAINING CENTRE BELVEDERE

## 1.00 Introduction

The Zimbabwe Electricity Supply Authority Training Centre is situated in the City of Harare, the capital of Zimbabwe and has a capacity of 240 trainees at any given time. It is today the largest Electricity Training Centre in the country and was built at a total cost of US $ 10 million

The Centre has laboratories, classrooooms, workshops extensively equipped with modern teaching equipment. The teaching equipment includes a "live" Distribution Network, a Mini-Distribution Simulator, a Mini-Control and Instrumentation Simulator and a Generic Thermal Power Station Simulator.

The National Training Centre is equipped with very sophisticated Pedagogical aids and was designed to cater for all technical training in the field of Generation, Transmission and Distribution from the unskilled worker to the graduate engineer level. Experts from the Electricite de France (EDF) assisted ZESA to design and develop this training centre under the Zimbabwe-Frence Protocol.

## 2.00 In House Courses

ZESA's National Training Centre was designed for technical training and therefore presently their activities are geared towards satisfying technical training requirements of the user departments. Courses range from full training programmes lasting several months to short courses on specific subjects.

## 3.00 Facilities At National Training Centre

In addition to classrooms, laboratories, workshops distribution network for training purposes, the facilities include hostels (for 240 persons), canteen facilities for trainees, and seminar facilities.

Modern recreational facilities are also available on campus.

## 4.00 Power Plant Simulator

One of the special features of this Training Centre is the availability of a generic Thermal Coal Fired Power Plant Simulator for training of Power Plant Operational and Maintenance staff.

5.00 <u>This Simulator will enhance the training of the following categories of staff:</u>

5.1 Initial trainees

5.2 Auxilliary Plant Attendants

5.3 Assistant Unit Operators

5.4 Operations Engineers

5.5 Artisans (Mechanical, Electrical, Control and Instrumentation)

5.6 Design Engineers interested in designing control systems and certain plant modifications, etc.

6.00 <u>Courses Available at the Centre</u>

Courses are available for the following categories of staff:-

6.1 Auxilliary Plant Attendants

6.2 Unit and Assistant Unit Operators

6.3 Control and Instrumentation Technicians

6.4 Distribution Electricians

6.5 Metering and Protection Technicians

6.6 Semi-skilled Upgrading courses in Distribution and Generation

6.7 Post Graduate Engineers training in both Generation and Distribution.

6.8 Other specialised courses related to Power Systems are offered as well. These are for Engineeers/Technicians and non technical staff.

7.00 <u>Non-Technical Courses</u>

The Centre is also geared for non technical courses such as financial, management, administrative, and/or managerial skills as well as supervisory training etc.

8.00 <u>Future Expectations - SADCC and PTA Role</u>

The ZESA National Training Centre can meet the needs of the specialised training in the power industry and is available for the SADCC and PTA countries. It is envisaged that some of the training carried out overseas and involving participants from these countries could be carried out at the ZESA National Training Centre on a joint venture basis with other utilities. The Centre will be able to carry out research requested by the organisations. In addition to the above, training in areas using our expertise and equipment, is offered to government agencies, other parastatals and the private sector within Zimbabwe and the region.

We would be pleased to arrange visitis to the Training Centre on request.

The potential and scope of the ZESA National Training Centre was highlighted in SADCC Energy Sector - Project 3.0.2 - Study of specialised Training in the Electricity Sector in the SADCC Region January 1988/Lahmeyer International which observed:-

> "ZESA has embarked on a very ambitious project and programme in order to satisfy the manpower requirements within a few years. They should be congratulated for their foresight and supported by utilising some of the facilities that have been developed for training"

9.00 A Handbook giving full details of the Courses available including special modules which can be tailored to suit some of the needs of sister utilities is available on request to:-

The General Manager
Zimbabwe Electricity Supply Authority
P O Box 377
HARARE

TELEX NO. 24323 ZW
TELEPHONE 739033 TO 39

## ADDITIONAL VISITS/MEETINGS

In addition to the activities given in the itinerary (Annexure-III) the following meetings/visits were also organised by DOE:T These trips were also made to Masvingo, Manicaland province (Mutare) and Rushinga regions which are shown as shadded portions in the attached map of Zimbabwe.

1. Meetings with Mr.C.E.Chimbobe, Regional Coordinator, Biomass User's Network - Africa Regional Office.

2. Visit to Fallscroft Coffee Estates (Pvt.) Ltd., Essex Road Vumba, Mutare and Meeting with Mr.Hugues, R.G.C.G. Motteux, Director.

3. Meeting with Mr.E.Buwu, Marketing Manager (oilseeds), Grain Marketing Board, Harare.

4. Meeting with W.J.Humphreys - Engineering Consultant, Zimbabwe Tobacco Association, Harare and visit to their training centre.

5. Visit to Aberfoyal Tea Plantations, Juliasdale Mutare and meeting with Mr.G.Sathiagnanam, Manager.

6. Meeting with Mr.Hogler Liptow, GTZ Coordinator, Energy Programme.

7. Meetings with Dr.Gata, General Manager, Zimbabwe Electricity Supply Authority (ZESA) and Acting Chairman of Research Council of Zimbabwe and visit to National Training Centre (ZESA) Beleverde, Harare.

8. Visit to 'Airflo' engineering company and meeting with Mr.Austin Birney, General Manager.

9. Visit to NIJO farms of ARDA - site where two gasifiers are installed under UNIDO project.

10. Visit to NEI, Cochran - Engineering company


ZIMBABWE
ZAMBIA
MOCAMBIQUE
BOTSWANA
BOTSWANA
MOCAMBIQUE
MOCAMBIQUE
SOUTH AFRICA
REFERENCE
GWERU
BULAWAYO
TSHOLOTSHO
ZVISHAVANE
WEST NICHOLSON
MUTARE
KADOMA
DETE
CHIPINGE
HIPPO VALLEY

# MEMORANDUM

To. Act. Director : From. G. Marawanyika

: Tel.

Ref. C/1/43 : Date. 7 - 12 - 89

## Re: Professor Grover's Visit and Itenary

The following is a tentive itenary of meetings and visits for Prof. Grover during his stay in Zimbabwe. Since the Department has no vehicle at the present moment we seek your authority to use own car or the GTZ truck for some of our journeys.

**5 - 12 - 89**

| | | |
|---|---|---|
| Morning | : | Acting Director |
| Afternoon | : | Zero |

**6 - 12 - 89**

| | | |
|---|---|---|
| Morning | : | Siveira House |
| | : | Permanent Secretary |
| | : | Jetmaster |
| Afternoon | : | Forestry Commission |
| | : | Ecological Designs |

**7 - 12 - 89**

| | | |
|---|---|---|
| Morning | : | Scientific Liason Office |
| | : | University of Zimbabwe |
| Afternoon | : | ENDA |
| | : | ZIDS |

**8 - 12 - 89**

| | | |
|---|---|---|
| Morning | : | Agritex |
| | : | Hon. Minister |
| | : | Chishawasha |
| Afternoon | : | Zimbabwe Tobacco |

**10 to 11 - 12 - 89**

Visit projects in Masvingo.

**12 - 12 - 89**

| | | |
|---|---|---|
| Morning | : | Director |
| | : | Jamaica Inn |
| Afternoon | : | Tobacco Research Board |

13 to 15 - 12 - 89
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Visit projects in Manicaland Province

18 - 12 - 89
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Morning : ARDA

: Solamatics

Afternoon : W.S.G. Hitech

19 - 12 - 89
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Visit photovoltaic installation in Rushinga

20 to 22 - 12 - 89
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Discussions with DOE staff on the visits to projects in the rural areas.

27 to 29 - 12 - 89
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Preparation and writing up of report.

G.Marawanyika
Department of Energy Research and Development