

Renewable energy education in Botswana: needs, status and proposed training programs

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Received 1 July 2000; accepted 19 December 2000

Abstract

Lack of trained manpower for repair and maintenance of solar energy devices in Botswana has resulted in failure of devices, loss of revenue, and dwindling of consumer faith in solar technologies. The government of Botswana commissioned a study to assess the needs for trained manpower in New and Renewable Sources of Energy (NRSE) technologies, to identify the required training programs and their levels, and the facilities that need to be upgraded and/or created for the implementation of such training programs at the existing technical and educational institutions within the country. The paper presents the findings of the study, and the recommendations made. The study proposed seven training programs at progressively increasing skills and expertise levels that include two certificate courses in each of the solar water heating and photovoltaic technologies for maintenance personnel, a national craft certificate program in solar energy technologies, a higher diploma in energy technologies for supervisory personnel, and a short course for upper management personnel in decision-making positions in order to raise their skills in the procurement of equipment and services, and to provide overall effective leadership. A short course to upgrade the skills of the present maintenance personnel to alleviate the immediate problems is also proposed. Required upgrading of existing technical training facilities, the creation of new facilities and estimated budgetary requirements constitute some of the recommendations. The recommendations have gone through various channels of discussions, and have been accepted in principle. The report is currently under consideration for implementation by relevant government departments. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The Republic of Botswana in Southern Africa, lying between the latitudes 17°S and 27°S and longitudes 20°E and 30°E, is a landlocked country covering an area of 581,730 km². The country has vast reserves of coal, which are used for the generation of electricity. Refined petroleum products are imported. Woodfuel contributes about 70% to the net energy supply, and is the main source of energy for 75% of the population in the rural areas that are far from the national electricity grid and do not have ready access to other commercial energy resources because of insufficiently developed ground transport links and the high cost of transportation. The country receives an abundant amount of sunshine throughout the year. There are on average 3100 to 3500 hours of sunshine and 280 to 330 sunny days per year across the country. The average insolation on a horizontal surface is 21 MJ m⁻² per day. Cloudy days (insolation less than 10 MJ m⁻² per day) are uncommon and far-between. The use of solar energy, mainly for water heating, lighting and refrigeration, holds vast potential, particularly in the rural areas, and its exploitation could ease the pressure on the use of woodfuel. However, its use has not been free from problems. There have been large-scale failures of devices resulting in loss of revenue and loss of consumer faith in the solar energy technologies due to lack of trained manpower for the repair and maintenance of the solar systems, lack of consumer education, and inappropriate systems being installed.

To alleviate the problem and to boost the usage of solar energy, the government of Botswana through the Energy Affairs Division (EAD), Ministry of Minerals, Energy and Water Affairs (MMEWA), commissioned a “Study to assess New and Renewable Sources of Energy (NRSE) training in technical schools in Botswana”. The purpose of the study, amongst other things, was to: (i) assess the training needs for Botswana in the area of NRSE, (ii) evaluate the existing training facilities within the country, and (iii) make recommendations with respect to desired training programs, and the creation of facilities to meet training needs. The study was contracted to Jain and Lungu [1] (Consultants) through a tendering procedure, and was monitored by a reference group chaired by the EAD (Client) and comprising 17 members drawn from all sectors of NRSE, namely technologies, application, maintenance and training. Interim reports that included an Inception Report [2], a Progress Report [3], a Draft Report [4], and a Final Report [5] were submitted to the reference group at progressive stages of the study.

2. Methodology

Information for the study was collected through personal interviews and discussions with stakeholders in NRSE technologies and training that included commercial organisations which manufacture, supply, install and maintain the devices, major/institutional consumers with or without in-house maintenance, technical training and educational institutions, institutions of higher learning, and Research and Development (R&D) organisations. Questionnaires for each of the three major categ-

ories—the commercial sector, consumers and training institutes—were developed to facilitate the interviews and discussions. The questionnaires were not served on the interviewees except in some cases where advance copies were provided on demand to prepare responses. A total of 47 organisations throughout the country from Gaborone in the South to Maun in the North were interviewed. Findings and conclusions from the interviews are summarised in the following section.

3. Findings

The majority of the population of Botswana live in thinly populated remote rural areas where conventional sources of energy such as electricity, coal and petroleum products are not readily accessible. Use of NRSE devices is considered to be a feasible solution. Among the various options, the usage of wind and biogas has been very limited due to the limitations presented by the resources themselves. Solar energy is the most significant NRSE for Botswana. This is demonstrated from widespread use of solar energy devices throughout the country and planned expansion of their implementation by most Rural District Councils to rural areas under their jurisdiction. Communication already relies heavily on solar power.

3.1. Training needs

1. There is a severe lack of trained manpower for maintenance, repair, system design, sizing, product evaluation and specification in the area of NRSE, and specifically so in solar energy technology which represents the bulk of NRSE usage in the country. The lack of trained manpower is experienced by all sectors: the manufacturers, suppliers and installers, the consumers, and the maintenance departments. This has led to large-scale failure and malfunction of the devices, resulting in large monetary losses in repair and replacements. The usage of devices is also restricted, and some organisations, for example the Botswana Housing Corporation (BHC), have been forced to abandon their use.
2. In order to minimise losses due to failure and malfunction of the NRSE devices currently in use, to support the envisaged expansion of their usage, and to support the commercial sector, there is a need for trained manpower at the following levels of responsibilities: (i) technicians and artisans for maintenance, repair and upkeep of the systems, (ii) professional/supervisors for design and sizing of the systems and to provide effective leadership, and (iii) decision makers for product evaluation and specification. The minimum levels of training needed for these categories were identified as: (i) Trade Certificates B or C, (ii) National Craft Certificate (NCC) or a diploma, and (iii) a diploma or specialised short-term course, respectively.
3. Although the R&D organisations such as the Botswana Technology Center (BOTECH) and the Rural Industries Innovation Center (RIIC) were considered to be capable of providing support for practical training, the Consultants concluded that these organisations together with the manufacturing sector also require trained

manpower at a professional level with research and development capabilities who can innovate/adapt available NRSE devices for specific applications and develop new devices/systems. Since NRSE technologies are engineering-based specialisations, the professional staff with R&D capabilities in NRSE are visualised to be holding higher degrees in appropriate engineering disciplines with a strong component of NRSE technologies, materials and devices.

4. The Energy Affairs Division by the nature of its responsibilities has varied training requirements. The skills needed range from maintenance to professional capabilities in NRSE on the technical side, and statistical, financial and legal skills, resource projection and planning, and policy formulation, etc., on the administrative side.
5. The countrywide requirements of trained manpower at the present level of usage is estimated to be: 200 artisans/technicians; 40 supervisory staff; 30 decision-making staff; and 10 R&D staff. The envisaged expansion requires an equal number of additional manpower. Projected manpower required to provide for the loss of staff resulting from promotions, career changes, retirement and death is 3 to 5% of the total requirement.
6. There is need for the training of trainers/educators at the level of Higher National Diploma (HND) and degree programs. The estimated number of such staff is 40 and this could go a long way to support the envisaged expansion. In addition, there is also a need to include a component of NRSE in curricula for secondary school teachers.
7. There is also a need for consumer education and training in the usage and routine maintenance of NRSE devices, and general public awareness about the potential of these devices.

3.2. Present status of training

1. The plumbing trade is closest to the solar water heater (SWH) technology so far as the supply of hot and cold water is concerned, and the electrical trade is closest to photovoltaic (PV) technology; they both deal with the supply of power for lighting, household appliances such as refrigerators, fans, TVs, radios, music systems, etc., and power appliances such as water pumps. Apart from a few exceptions listed below, NRSE technologies as they relate to solar energy devices are not covered by any courses and programs currently offered by Brigades and Vocational Training Centers (VTCs). Principles of passive solar architecture are not covered by any of the building trades offered either by Brigades or VTCs. In the NCC program in building, various building materials and their characteristics are discussed in some detail, but there is no reference to passive solar architecture. Wind and biogas technologies are not covered by any of the technical programs available in the country, although Palapye VTC has a windmill which is used for demonstration purposes only. Some aspects of wind and biogas technology are still at the research and development stage. More work is needed to establish their potential.

2. Solar water heating is covered in the second and third years of NCC in plumbing by the Palapye VTC. It includes installation and maintenance of SWHs. PV–solar technologies are introduced very briefly in the electrical trade at C and B certificate levels. The contents covered are no more than one to two class lectures, with no practical exposure. At NCC level in electrical, PV is covered for about three weeks in the first year, taken along with other courses. The coverage is theoretical, as none of the VTC, except for the Palapye VTC, had laboratory/workshop facilities in PV. The PV facilities at Palapye are adequate, and can easily be expanded to launch the envisaged training programs in PV technology. The Madiba Brigade in Mahalapye offers short courses in PV technology, and has adequate laboratory/workshop facilities to support such programs. It is also a potential candidate for the initial launching of training programs in PV technology. Some Brigades undertake installation, maintenance, and repair of SWHs and/or PV systems as a part of their production activity to generate income for the organisation. In such cases, employees are assisted by students who get some informal exposure to solar energy technologies although no training is provided.
3. The commercial sector has been meeting its manpower requirements through on-the-job training. Some staff have also been trained through short courses within the country whenever available and/or abroad. In the maintenance sector some staff have gained basic skills in the maintenance of solar devices through on-the-job experience. Botswana Telecommunications Corporation invests heavily to train their staff (in-house or otherwise). Their training requirements extend beyond the maintenance of the PV systems, which are but a small component of the complete communication system.
4. The Brigades and VTCs lack formal staff development programs. This has resulted in serious shortages of trained staff. At primary and secondary levels of education, NRSE technologies and their applications are not covered, except that they are introduced as alternative sources of energy. At the tertiary level of education only a few short elective courses are available within the country. The courses are broad-based, some purely theoretical with no practical component, while others are still being planned.

4. Recommendations

From the above findings, the following recommendations are made. The main recommendations are shown in Fig. 1.

4.1. Training programs

1. Technical training programs for SWH technology should be linked with the plumbing trade, and training programs for PV technology should be linked with the electrical trade at Brigades and VTCs. An NCC program with specialisation in solar energy technologies should be launched. A diploma program leading to

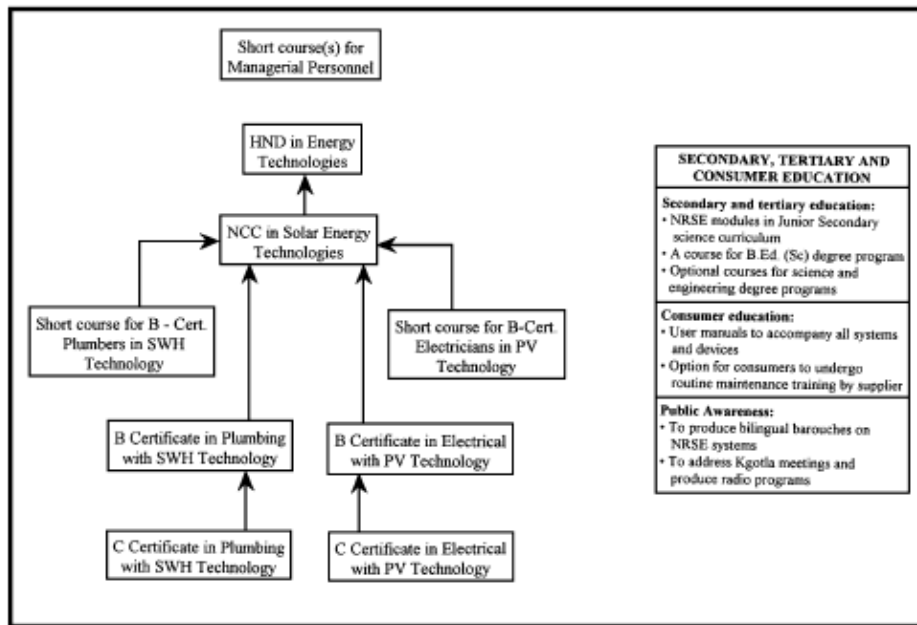


Fig. 1. Main recommendations and their linkages for technical training programs in NRSE technologies.

HND with specialisation in energy technologies should be launched for the training of supervisors, and teachers at Brigades and VTCs.

2. Short courses of 2 to 3 weeks duration should be launched for managerial staff. Short courses of 3 to 6 months duration should be made available to meet the immediate needs of trained manpower in the installation and maintenance sector, and the teaching needs at Brigades and VTCs.
3. A variety of optional courses in energy technologies should be made available for engineering degree students to train professional staff in NRSE with R&D capabilities. A course in NRSE technologies with appropriate practical component should be made available for secondary school science teachers.
4. Measures should be taken to provide consumer education and training, and public awareness about the use of NRSE.
5. At the present level of usage of wind and biogas energy, the Consultants did not foresee scope for specialised training programs in these areas of NRSE. In view of the low demand within the country, specialised programs leading to bachelor's and master's degrees in energy technologies may not be sustainable.

4.2. Structure for technical training programs

1. An introductory module of 3 weeks duration in solar water heating should be introduced for the trade certificate C program in plumbing. The module should be supported with appropriate practical experience in the laboratory/workshop environment. Similarly, an introductory module in PV should be introduced for the trade certificate C in electrical.

2. An intermediate module of 6 weeks duration in solar water heating should be introduced for the trade certificate B program in plumbing. The module should be supported by appropriate practical experience through field work/industrial attachment. Similarly, an intermediate module in PV should be introduced for the trade certificate B in electrical.
3. The following structure is recommended for the NCC in NRSE. (i) Input to the NCC in NRSE could hold either: (a) a B certificate in plumbing under the new proposed system by those who have covered the basic training in SWH, or (b) a B certificate in electrical under the new proposed system by those who have covered the basic training in PV, or (c) a B certificate from the old system by those who have completed the short training course in NRSE recommended under Section 4.4, item 2. (ii) Students spend two years completing the program and cover the following contents. Year 1: Input from the plumbing stream complete a basic electrical course as may be adequate for PV, the introductory modules of PV which would have been completed by electricians, and a basic course in welding. Input from the electrical stream complete a basic course in plumbing as may be adequate for SWH, the introductory modules of SWH which would have been completed by plumbers, and a basic course in welding. Year 2: Both streams do common advanced modules in SWH and PV. Both years should be supported by adequate practical, workshop and industrial attachment components according to the regulations governing the award of the NCC.

4.3. Tertiary education

1. A program in NRSE technologies leading to HND should be launched to train teachers/trainers for the Brigades, VTCs and supervisors in the manufacturing and maintenance sectors.
2. Optional courses in energy technologies and related areas supported with relevant industrial training should be introduced for mechanical and electrical engineering degree students.
3. A course in NRSE technologies of at least one semester duration with an appropriate practical component should be introduced for secondary science teachers. Such a course could be included as one of the options for the BSc/BEd degree students. Existing courses in energy for BSc/BEd and MSc degree students at the University of Botswana should be strengthened by adding appropriate practical components.

4.4. Short courses

1. Short courses of two to three weeks duration should be made available occasionally for the managerial personnel in decision-making capacities dealing with NRSE. Such courses should aim at imparting the skills of product evaluation, product specification, assessment of tender documents, broad knowledge of system design and sizing, and maintenance problems. Such courses may or may not have

a practical component. The Institute of Developmental Management (IDM), with support from the local industry and R&D organisations, may be considered as a venue for providing the short courses for managerial personnel.

2. To upgrade the skills of those who are currently working in the system, but have no formal training in NRSE, short courses of three to six months duration including industrial attachment should be mounted, so that plumbers could attend to the maintenance of SWHs, and electricians could attend to PV systems. Such courses may also be useful for the initial basic training of teaching staff for Brigades and VTCs.

4.5. Primary and secondary education

1. The energy component covered at the primary level is adequate.
2. Topics in NRSE should be introduced in the junior secondary science curriculum. The modules of one week lecture duration for each of the three years of junior secondary school should cover new and renewable energy sources of relevance to Botswana, the advantages and limitations of NRSE usage, NRSE devices and their applications, principles of the working of these devices, and routine maintenance of the devices.

4.6. User education and training

1. Manufacturers and suppliers should provide a user's manual with every NRSE device sold in a similar way to those provided by manufacturers for equipment ranging from small items such as radios to large items like videos and air conditioners. Such manuals should be in at least two languages with one being the local language. The user's manual should include, among other information, system specifications/technical information, dos and don'ts of the device/system, how to take care of your system, routine maintenance procedures, simple problem hunting and their remedies, and terms and conditions of guarantee, etc.
2. Supplier/installer may offer an option to individual buyers to provide short basic training on how to take care of the system. In the case of institutional users, where bulk purchasing of systems is involved, the supplier/installer may offer the buyer an option on mutually agreed terms to conduct a formal training of one to two weeks duration for the specified number of their maintenance staff. Such training may cover amongst other contents the basic principles of the working of the systems, different components and their functions, routine maintenance procedures, problem hunting and remedies, and replacement of faulty components.

4.7. Public awareness

1. The Energy Affairs Division should produce brochures on each NRSE device,

particularly on SWHs, PV-lighting and PV-water pumping. Such brochures should be published in as many local languages as possible, and should include, amongst other information: the basic principle of the operation of the device/system, different types of systems available, for example in the case of SWHs with or without electrical back-up, and direct and indirect water heating type, their advantages, their limitations, precautions/discipline needed for their use.

2. In rural areas, where there is large usage of NRSE devices, EAD may consider holding occasional Kgotla meetings to brief the users on the proper use and care of their devices and systems. This may be supplemented with radio programs.

4.8. *Incidental matters*

The following matters did not fall within the terms of reference of the commissioned study, but they were raised at the time of the visits and interviews, and are considered to be peripherals to the study.

1. Some measures need be taken to minimise losses resulting from theft and vandalism.
2. All new products or models introduced in the market should be tested, approved and certified by an appropriate monitoring agency. Standards and specifications should be defined and implemented for all types of NRSE equipment and devices. Basic terms and conditions of guarantee should be set for all types of NRSE systems and components. A code of practice for SWHs and PV should be strictly adhered to.
3. The staff development program for the Brigades and VTCs should be strengthened.
4. Elements of passive solar architecture should be introduced in the B level certificate in the building/bricklaying trade.
5. Guidelines for rental structure and value of property with NRSE devices should be set by an appropriate agency.

5. Structure and contents for the proposed courses

5.1. *C and B trade certificates in plumbing with SWH technology*

C certificate in plumbing with SWH component

Duration: 3 weeks, comprising 2 weeks of class lectures+1 week of practical work.

Objectives: Students should be able to understand the basics of the solar energy usage, and the principles of solar water heating.

Contents: Nature and components of solar radiation; Measurement of duration of sunshine and components of solar radiation; Types of solar energy devices—ther-

mal devices and PV devices; Advantages, disadvantages and limitations of solar energy applications; Principles of solar water heating; Types of solar water heaters and different components of a solar water heater.

Practical component: Exposure to solar radiation measurements as it is done in Botswana; Exposure to different types of solar water heaters, and their construction either in a laboratory/workshop or through attachment with a manufacturer/supplier.

B certificate in plumbing with SWH component

Duration: 6 weeks, comprising 2 weeks of class work+4 weeks of industrial attachment.

Objectives: Student should be able to install SWH, and attend to simple faults.

Contents: Different components of a solar water heater and their functions; SWH code of practice; Installation of solar water heaters; Basic fault finding and their remedies.

Practical component: Four weeks of industrial attachment with installers/maintenance units of SWH; Participate in the production activities of the Brigades in the maintenance/installations of SWH where available.

Possible venue for the courses: Brigades and/or VTCs.

5.2. C and B trade certificates in electrical with PV technology

C certificate in electrical with PV component

Duration: 3 weeks comprising 2 weeks of class lectures+1 week of practical work.

Objectives: Students should be able to understand the basics of the solar energy usage, and the principles of photovoltaic devices.

Contents: Nature and components of solar radiation; Measurement of duration of sunshine and components of solar radiation; Types of solar energy devices—thermal devices and PV devices; Advantages, disadvantages and limitations of solar energy applications; Principles of photovoltaic energy conversion and applications of PV technology; Types of solar PV panels and different components of PV systems.

Practical component: Exposure to solar radiation measurements as it is done in Botswana; Exposure to different types of PV panels, and components of PV systems for different applications either in a laboratory/workshop or through attachment with a manufacturer/supplier.

B certificate in electrical with PV component

Duration: 6 weeks comprising 2 weeks of class work+4 weeks of industrial attachment.

Objectives: Students should be able to install PV systems, and attend to simple faults.

Contents: Different components of a PV system and their functions; PV code of practice; Installation of PV systems for lighting and water pumping; Basic fault finding and remedies.

Practical component: Four weeks of industrial attachment with

installers/maintenance units of PV systems; Participate in the production activities of the Brigades in the maintenance/installations of PV systems where available.
Possible venue for the courses: Brigades and/or VTCs.

5.3. NCC in solar technology

Intake: B certificate in plumbing or electrical trade with the new NRSE components as recommended in subsections 5.1 and 5.2.

Duration: 2 years including industrial attachment.

Objectives: Students should be able to size and design solar thermal and PV systems, specify and assess product and supervise artisans in the maintenance and installation of systems.

Contents—Year 1:

For students with B certificate in plumbing: Components of PV covered in C and B certificates in electrical which are not common to B and C certificates in plumbing; Basics of electrical trade as is adequate for the installation and maintenance of PV systems.

For students with B certificate in electrical: Components of SWH covered in C and B certificates in plumbing which are not common to B and C certificates in electrical; Basics of plumbing trade as is adequate for the installation and maintenance of SWH systems.

Common for both intakes: Basics of welding as is adequate for solar technology; Advanced skills in plumbing directed towards solar technology; Advanced skills in electrical directed towards solar technology.

Practical component: Practical work in the laboratories and workshop to match with the course contents for both intake types; Industrial attachment with PV sector for both groups of intake; Industrial attachment with SWH sector for both groups of intake.

Contents—Year 2 (for all students):

Advanced fault finding, repair and maintenance of SWHs; Advanced fault finding, repair and maintenance of PV systems; Design and sizing of PV and SWH systems; Product specification and assessment.

Practical component: Industrial attachment with both SWH and PV industries and contractors/consultants dealing with system design and sizing.

Possible venue for the course: VTCs.

5.4. HND in energy technologies

Duration: 2 years.

Objectives: To produce professionals in energy technologies with emphasis on NRSE who can participate in research and development.

Contents: New, renewable and conventional energy resources including nuclear energy, and their applications, advantages, disadvantages and limitations; Principles of wind energy technology and applications; Principles of biogas technology and applications; Principles of solar energy technologies and applications; Advanced principles in sizing and designing of a select group of NRSE devices including solar; Installation and maintenance of a select group of NRSE devices and systems including solar; Advanced aspects of problems finding and remedies for a select group of NRSE systems including solar; Industrial applications of NRSE devices and systems; Solar concentrating and non-concentrating devices; Solar tracking—semi-automatic, single axis and double axis tracking; Principles of heliostat tracking, solar power towers and their applications; Economic analysis and costing of NRSE systems; Environmental and legal aspects of NRSE devices applications; Project work and dissertation.

Practical component: The program should be supported with well-equipped laboratories and workshop. There should be a provision for attachments with the industries, and R&D organisations within the country and/or region.

Possible venue for the course: University of Botswana, Faculty of Engineering and Technology and/or Faculty of Science.

5.5. A short course for managers/decision makers

Duration: 2 to 3 weeks.

Objective: To enable the supervisors to take effective decisions when implementing policies relating to the use of NRSE devices.

Contents: May vary depending on special demands from the prospective clients and more than one such course of varied duration may be made available. The following bare minimum is proposed to achieve the objectives. Various forms of NRSE and their applications, with emphasis on major resources of relevance to Botswana; Limitations, advantages and disadvantages of the usage of different sources as they relate to Botswana; Different types of solar energy devices and their applications; Principles of the working of these devices; Code of practice for PV and SWH; General problems, and their remedies; Basic principles of sizing and designing of PV and SWH systems; Product specification, product assessment and tender evaluation; Legal and environmental aspects of solar energy usage.

Practical component: Whereas the participants need not go through formal practical/field work training, it is recommended that they spend one to two days to visit industry, BOTEC, Gaborone, RIIC, Kanye and the maintenance sector to have a demonstration of some of the principles covered in the course.

Possible venue for the course: IDM to offer such courses for the regional clientele in collaboration with local industry and other stake holders.

5.6. A short course for present B certificate holders in plumbing and electrical trades

Duration: 3 to 6 months.

Objectives: To meet the immediate needs of trained manpower in solar technology at artisans/technicians levels by raising the skills of: (i) present B certificate holders in plumbing to be able to attend to SWHs, and (ii) present B certificate holders in electrical to be able to attend to PV systems, and to provide a starting point for staff training for Brigades and VTCs.

Contents: For B certificate in plumbing:

Same contents as recommended for C and B certificates in plumbing.

For B certificate in electrical:

Same contents as recommended for C and B certificates in electrical.

Practical component: Same components as recommended for C and B certificates in respective trades.

Possible venue for the courses: Brigades and/or VTCs.

6. Resource implications

The recommended training programs will require creation of physical facilities such as classrooms, laboratories, workshops and library facilities, and development of human resources for training. The following assumptions are made in order to project the estimated cost of the proposed training programs.

1. Initially, training programs in both solar water heating and PV systems leading up to B certificate are launched as a pilot project for an intake of 10 students in each program at one of the Brigades. Likewise, a pilot NCC program in NRSE is launched for 10 students at one of the VTCs. Since Madiba Brigades in Mahalapye and Palapye VTC are already equipped with some facilities, and have some experience in this area of training, they are considered as the potential candidates for the pilot project. On successful completion of the pilot training programs, and from the experience gained, the programs can be replicated in as many Brigades and VTCs as are determined by the demand.
2. Although a batch of 10 students is considered for the pilot project, classrooms and workshop/laboratory spaces are created to accommodate a batch of 30 trainees.
3. An annual rate of 10% depreciation is assumed for the up-keep of the workshop/laboratory and library facilities. Financial implications of lost man-hours of work for the trainees released from their jobs are not considered.
4. The cost of short courses for managerial staff is estimated at the current IDM-rate for such courses, and does not include the cost of infrastructure or facilities which may be needed. Likewise, the cost of short courses for technical staff

- includes only the tuition and allowances for the trainees, because they will use the same facilities that have been created for the full training programs.
5. Resource implications for the optional courses in NRSE recommended for the higher degree programs to train professional staff are not projected, as the degree programs are ongoing. However, workshop/laboratory facilities will have to be created for such optional courses.
 6. Completion of the pilot project in training should take 5 years from the time it is launched. This includes the time needed for the creation of facilities. Training of projected 200 technical staff should take 9 years to complete assuming that 40 people are sponsored each year. This includes 4 years that will be taken by the last batch to complete NCC (or 3 years for B the Certificate). During the same period, training of staff in other programs could also be completed. However, it is to be noted that during this period the training needs would have grown as projected, and the programs are anticipated to be sustained.
 7. It is estimated that P2,775,000 is required for physical facilities, P745,000 is needed annually in salaries and benefits for the training staff, and P8,623,000 is required to train the present estimated manpower. (P3.00=US\$1.00 at the time of estimate.)

7. Present status

A one-day national seminar was called by the EAD in June 1998 to disseminate the findings and to discuss the recommendations. The seminar was attended by over 40 representatives of various stakeholders who adopted all the recommendations with minimal amendments [6]. The report is now with the concerned department within the Ministry of Education to budget and identify resources for implementations.

8. Conclusions

The exploitation of solar and other renewable resources of energy, where favorable resource conditions exist, may provide a ready answer to the problems of access to clean, environment-friendly energy for the poor rural populations in developing countries. The infusion of new technologies and devices may be hampered due to the lack of maintenance resulting from the lack of trained manpower. It is more so if the devices and systems are not produced within the country. For countries with socio-economic conditions similar to Botswana, conclusions drawn from our study and recommendations made may be of interest to them to base their training strategy on energy technologies.

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