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9. ABSTRACT This staff report of the workshop on solar energy for the villages of Tanzania discusses the possibility of using solar energy as an alternative to fossil fuel. The potential value of solar energy was considered for Tanzanian villages as well as the significance of solar energy for an environmentally sound design for Dodoma, the proposed capital of Tanzania. The report describes the workshop's background, organization, conclusions and recommendations, concluding resolution, highlights, working sessions, and follow-up activities. The appendices include the workshop program, a list of participants, conclusions and recommendations, opening address, and several commentaries. Participants at the workshop recommended that attention be focused on technologies having the greatest potential in terms of cost-effectiveness, availability of resources, and long-range power requirements as follows: photovoltaic electricity generation, solar drying and cooling for food and crop preservation, and solar stills for water purification. It is also recommended that solar energy projects be initiated in three villages in each agro-economic zone of Tanzania. Criteria for the selection of the villages would include the village's energy/power needs, availability of renewable energy resources, human skills, the economic viability of the project, village enthusiasm and interest in participation, and social utility of the project. The provision of an adequate supply of clean water should receive top priority in Tanzania. Other suggestions were that reforestation programs should be implemented at the village level and that a limited program for training village technicians should be created. The solar energy forms discussed were direct sunlight, wind, falling water, and photosynthesis.			
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STAFF SUMMARY REPORT:

WORKSHOP ON SOLAR ENERGY FOR THE VILLAGES OF TANZANIA

Held in Dar es Salaam, Tanzania

August 11 - 19, 1977

Jointly sponsored by

Tanzania National Scientific Research Council
United Republic of Tanzania

Board on Science and Technology for International Development
Commission on International Relations
National Academy of Sciences - National Research Council
United States of America

1977

This report is a staff-prepared summary of the Workshop on Solar Energy for the Villages of Tanzania. The workshop was held in Dar es Salaam, August 11 - 19, 1977, under the joint sponsorship of the Tanzania National Scientific Research Council and the Board on Science and Technology for International Development of the U.S. National Academy of Sciences. Participation by the National Academy of Sciences was made possible through funds provided by the Office of Science and Technology, Bureau for Technical Assistance, Agency for International Development, under contract AID/csd-2584, Task Order No. 1.

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I

INTRODUCTION AND BACKGROUND

This joint workshop is the first that the U.S. National Academy of Sciences' Board on Science and Technology for International Development (BOSTID) has held on the subject of solar energy. The workshop followed publication of a recent BOSTID study, Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries, and used the section of that report dealing with solar energy as the main background document.

The seminar and workshop also represents the first collaborative activity between the Tanzania National Scientific Research Council (UTAFITI) and the U.S. National Academy of Sciences (NAS).

In response to an inquiry about BOSTID from Dr. Wilbert K. Chagula, then President of the Tanzania National Scientific Research Council and Minister of Economic Planning, Dr. Carl Djerassi (then Chairman of BOSTID) visited Dar es Salaam in early 1974 to discuss the possibility of a collaborative program. In October 1975, Mr. B. K. Wesley Copeland, a BOSTID staff officer visited Dr. Chagula and USAID officials in Dar es Salaam to continue the discussions and assess the areas of interest of the Tanzanians. Dr. Chagula again expressed his interest in cooperating with BOSTID and suggested a seminar/workshop on solar energy.

Tanzania made a formal request for a seminar and workshop on solar energy in April 1975; however, it was not until early 1977 that funds to support BOSTID's participation became available. Included in the Tanzanian request for the workshop were the following terms of reference.

1. To survey and review the latest state of knowledge of both the technical and economic aspects of the utilization of solar energy for space cooling and heating, for boiling water for human dwellings, especially institutions, and for the generation of electricity;
2. To select the technologies for solar energy utilization which would be most appropriate for Tanzanian economic and social conditions; and
3. To design one or more pilot projects in this general area and to recommend on how the pilot project or projects should be implemented.

II

ORGANIZATION OF THE SEMINAR/WORKSHOP

The seminar/workshop was organized as a three-phase activity designed to bring together Tanzanian and North American scientists, engineers, sociologists, administrators, and planners to assess the potential of solar energy for the villages of Tanzania.

Phase I consisted of a two-day seminar on the state-of-the-art of solar energy technology, which included both the technical and economic aspects of using solar energy for space cooling and heating...for generating electricity as well as for drying fish, seeds, and hides, and for food preservation and salt extraction.

Phase II included visits to Tanzanian villages to assess the possibility of using various types of energy sources in specific social settings

Phase III constituted intensive, informal workshop discussions to select the appropriate technologies for using solar energy consistent with Tanzanian economic and social conditions and to design pilot projects and recommend methods for implementation.

Two background documents, Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries, published by the NAS, and Energy for the Villages of Africa, published by the Overseas Development Council, were distributed to all participants.

III

CONCLUSIONS AND RECOMMENDATIONS*

Mr. Jeremy E. Duwe, Assistant Commissioner for Ujamaa and Cooperative Development in the Prime Minister's Office, summed up the points that his Government views as vital to the success of the discussions on solar energy applications in Tanzania:

1. Energy questions are central to the attempt to improve the quality of people's life anywhere in the world.
2. Conventional fossil fuel resources are rapidly being exhausted and are not easily replaceable.
3. Tanzania does not have sufficient financial and manpower resources to harness the limited conventional fossil fuel sources they have.
4. There is an abundant supply of solar energy which, through sophisticated research, could be tapped for human use.
5. Nations such as Tanzania, which are limited in financial and manpower resources to undertake sophisticated research on solar energy, could use the research findings from more technically advanced nations with modifications to meet local requirements.

*See Appendix C for more detailed conclusions and recommendations.

The following recommendations were made by the workshop participants:

1. A Solar Energy for Villages Pilot Project (SEVIPP) should be established as soon as possible under the Tanzania National Scientific Research Council.
2. Attention should be focused on those technologies having the greatest potential in terms of cost-effectiveness, availability of resources, and long-range power requirements as follows:
 - photovoltaic electricity generation;
 - biogas generation;
 - small-scale hydroelectricity generation;
 - solar drying and cooling for food and crop preservation; and
 - solar stills for water purification.
3. The Tanzania Research Council should work in consultation with other organizations in Tanzania (See Appendix C for specific organizations).
4. A Solar Energy Promotion Committee should be established under the Tanzania National Scientific Research Council.
5. Demonstration solar energy projects in three villages in each agro-economic zone of Tanzania should be initiated.
6. Criteria for the selection of villages for the demonstration projects should include:
 - the village's energy/power needs;
 - availability of renewable energy resources (e.g., water, wind, and sun);

human skills;

the economic viability of the project;

village enthusiasm and interest in participating; and

social utility of the project.

7. The demonstration projects should make use of existing research data in local organizations before initiating long-term research.
8. A limited program for training village technicians should be created.
9. Reforestation programs should be implemented at the village level.
10. The feasibility of collecting and storing rainwater from roofs should be assessed before funds are expended on solar pumping of potable water.
11. The establishment of Dodoma as the new capital of Tanzania should be seen as a unique opportunity to utilize renewable energy in Tanzania.

IV

CONCLUDING RESOLUTION

The seminar expressed great appreciation to the Government of Tanzania, the Tanzanian National Scientific Research Council, and the U.S. National Academy of Sciences for the cooperation that enabled the seminar to take place. The Tanzanian workshop participants elected nine of their colleagues to form the Provisional Solar Energy Promotion Committee, pursuant to recommendation 4. There was general agreement that more members should be co-opted by the Committee as and when appropriate, particularly including a Tanzanian agricultural economist, sociologist, and nutrition expert.

Provisional Solar Energy Promotion Committee

P. Mwombela, Chairman (Tanzania National Scientific Research Council)

S. R. Nkonoki, Vice Chairman (Institute of Development Studies, University of Dar es Salaam)

A. Mzee (Ministry of Water, Energy and Minerals, Dar es Salaam)

D. J. Kavishe (Ministry of Natural Resources and Tourism, Dar es Salaam)

P. A. Msafiri (Meteorological Department)

P. T. Pallangyo (Small Industries Development Organization)

J. S. Nkoma (Physics Department, University of Dar es Salaam)

R. Reichel (Department of Electrical Engineering, University
of Dar es Salaam)

J. Duwe (Prime Minister's Office, Dodoma)

Ex-officio S. J. Asman (Secretary of Committee, Tanzania National
Scientific Research Council).

HIGHLIGHTS AND OBSERVATIONS

Prior to the workshop, the Honorable Al Noor Kassum, Minister for Water, Energy and Minerals, met with the NAS panelists and Dr. Peter Mwombela, of the Tanzanian National Scientific Research Council, to express his concerns and desires. Minister Kassum gave the opening address at the seminar, and also met with the co-chairman, Dr. James Howe and Dr. Peter Mwombela, on the concluding day to receive a report on the results of the workshop.

The Tanzanian National Scientific Research Council arranged for the workshop participants to visit three coastal villages, Kimbigi, Chemgeni, and Kerege, to observe village life and village tasks firsthand. At each village, the participants were greeted by the village chairman and members of the village council. At Kimbigi, the visitors participated in a number of the daily activities of the village. These included carrying water from the well to the village; chopping and carrying firewood from the forest to the villages; cutting and threshing rice; and fishing. This enabled the workshop participants to experience personally the drudgery of village life that could be eliminated by the introduction of alternative forms of energy such as solar energy. The villagers were extremely gracious, while at the same time expressing their concern that the visits result in some concrete programs.

USAID contributed most effectively to the success of the workshop. The USAID Director, Dr. Vernon Johnson, joined the NAS participants for the initial meeting with Minister Kassum and gave a welcoming address at the beginning of the seminar and workshop. USAID also provided local transportation and other logistical support. The U.S. Information Service was kind enough to supply the use of visual equipment during the seminar.

In addition to the program of activities, receptions were given for the participants. A dinner was arranged by Dr. Peter Mwombela on the opening evening of the seminar/workshop. On Saturday, Dr. Mwombela and the Tanzanian National Scientific Research Council hosted a cocktail party. Dr. Johnson also very kindly entertained workshop participants and other members of the U.S. and Tanzanian communities the following week. These events provided an opportunity for informal consultation and discussion with a wider group of people than was possible at working sessions.

VI

WORKING SESSIONS

The working sessions were marked by a high degree of informality, thereby enhancing purposeful, effective discussion. The NAS seminar on the state-of-the-art of solar energy technology was well received, bringing a wide range of the latest concepts and research findings to an enthusiastic audience. The initial commentaries on energy in Tanzania, specifically with regard to the villages, provided an excellent perspective for the whole exercise.

During the workshop, four working groups were established to examine the following areas:

Current Energy Needs and Availability in Tanzanian Villages;

Institutional Factors;

Methodology and Possible Projects for Early Application; and

Short- and Long-term Potential of Solar Energy for Tanzanian Villages.

All the working groups were well attended and their members worked long and hard to produce their reports.

VII

FOLLOW-UP ACTIVITIES

The interest and participation of senior government officials in the workshop and their obvious enthusiasm and receptivity to the potential use of solar energy in Tanzanian villages leaves little doubt that the Tanzanian government will assist appropriately in the implementation of the workshop recommendations.

Indeed on September 3, 1977 the Tanzanians convened the Provisional Solar Energy Committee to consider next steps.

NAS staff conveyed both personally and by communication to the USAID Director and the members of the Tanzanian National Scientific Research Council their willingness to assist the Tanzanians in carrying out the recommendations.

VIII

ENVIRONMENTAL IMPLICATIONS

The prospect of using solar energy as an alternative to fossil fuels was the major environmental consideration of the workshop. The value of the solar energy resource was considered not only in terms of its potential for Tanzanian villages, but also in terms of its possible significance to an environmentally sound design for Dodoma, the proposed new capital city of Tanzania.

SEMINAR AND WORKSHOP PROGRAM

August 11 - 19, 1977

Schedule of ActivitiesThursday, August 11, 1977

8:30 a.m.	Opening Remarks - Dr. Peter Mwombela, Tanzanian National Scientific Research Council
	Welcome Address - Hon. Al Noor Kassum, M.P., Minister for Water, Energy and Minerals
	Response -- Dr. Vernon Johnson, USAID Director/Tanzania
	- Mr. James W. Howe, Chairman, NAS Panel
	Commentary - Energy Needs in the Villages - Dr. S. Nkonoki, University of Dar es Salaam
	Commentary - Villages in Tanzania - Dr. Priscilla Reining
12:00 Noon	Lunch
2:00 p.m.	Commentary - Energy Needs in Tanzania - Dr. J. Duwe, Assistant Commissioner, Prime Minister's Office, Dodoma
Phase I. Seminar: State of the Art of Solar Energy--Potential Applications at the Village Level	
2:30 p.m.	Space Heating and Cooling and Water Heating - Presentation by Dr. J. Richard Williams
	Distillation and Desalination of Water - Presentation by Dr. Thomas Lawand
7:30 p.m.	Dinner at Agip Hotel hosted by Dr. Peter Mwombela

3:30 p.m. Working Group Sessions - Current Energy Needs and Availability in Tanzanian Villages

- Institutional Factors
- Methodology and Possible Projects for Early Application
- Long-term Potential of Solar Energy for Tanzanian Villages

7:00 p.m. Reception hosted by Dr. Vernon Johnson at his residence.

Tuesday, August 16, through Thursday, August 18, 1977

8:00 a.m. Working Group Sessions

Friday, August 19, 1977

8:00 a.m. Plenary Session

Reports by Working Groups

12:00 Noon Lunch

2:00 p.m. Closing Remarks - Dr. Peter Mwombela, Tanzanian National Scientific Research Council

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CONCLUSIONS AND RECOMMENDATIONS

During the initial plenary session, it was decided to divide the participants into four working groups in order to come up with specific conclusions and recommendations. These working groups focused on:

(1) Current Energy Needs and Availability in Tanzanian Villages; (2) Institutional Factors; (3) Methodology and Possible Projects for Early Application; and (4) Short- and Long-term Potential of Solar Energy for Tanzanian Villages. The recommendations of these groups were presented for discussion at the final plenary session.

After appropriate amendments and additions, the following recommendations and conclusions were adopted:

1. There are some solar energy technologies that could be installed and made operational in some Tanzanian villages within a period of three months to nine months from the time a decision is made to utilize such technologies and it is recommended that a Solar Energy for Villages Pilot Project (SEVI PP) be launched/established as soon as possible, under the Tanzanian National Scientific Research Council (UTAFITI).

2. There are several solar energy technologies currently used elsewhere in developed and developing countries that have great potential for application in some Tanzanian villages. The technologies recommended, principally on the basis of cost-effectiveness, availability of resources,

and long-range power requirements of villagers, are photovoltaic electricity generation, biogas generation, small-scale hydroelectric generation, and solar cooling and drying for food and/or crop preservation.

3. In the process of planning, implementing, and evaluating the proposed Solar Energy for Villages Pilot Project, the Tanzania National Scientific Research Council should work in consultation and cooperation with the Ministry of Water, Energy and Minerals, the Prime Minister's Office, Regional and District Authorities, and any other relevant institutions such as the University of Dar es Salaam, the Small Industries Development Organization, the Tanzania Electric Supply Company, and the Capital Development Authority. Further, an inventory should be made of the institutions and individuals having particular interest in and/or related to solar energy and other alternative energy systems.

4. A Solar Energy Promotion Committee should be established under the direction of UTAFITI to take appropriate steps to ensure that the recommendations of the seminar are brought before the Government of Tanzania and to prepare for the launching and operation of the proposed Solar Energy for Villages Pilot Project, if the government endorses such a project.

5. The proposed Solar Energy for Villages Pilot Project should be implemented in three selected villages in as many agro-economic zones of Tanzania as resources and environmental factors will permit. Tanzania has seven agro-economic zones.

6. There is a scientific methodological approach to any technological analysis that should be followed in the evaluation and assessment of any conventional and/or renewable energy technique(s) before a final decision is made to adopt or choose a technology.

The following criteria should be considered in the selection of villages to be included in the proposed Solar Energy for Villages Pilot Project (SEVIPP)

- The village's energy/power needs;
- Availability of renewable energy resources (e.g., wind water, and sun);
- Human skills;
- The economic viability of the project;
- Village enthusiasm and interest in participating in nation-building activities; and
- Social utility of the project.

7. To shorten periods of research before installation of equipment, such as windmills, the project participants should first make use of any relevant research data which may be available from the government or other organizations. Where data are not available, or are inadequate, research should be conducted in the shortest time possible.

8. A training program for village technicians and for some specialist staff should be included in the proposed Pilot Project, but a fully fledged, formal training unit or institute within the project is not thought necessary for the Pilot project.

9. Current Tanzania afforestation programs should be implemented at the village level to ensure that the supply of wood fuel is not depleted. Wood fuel is still a main source of domestic purposes as well as for curing tobacco and baking bricks.

10. The provision of an adequate supply of reasonably clean water should be given top priority in Tanzania villages. One method that

should be tried is the collection and storage of rainwater from clean roofs, as well as using solar systems.

11. The development of the new national capital in Dodoma should be seen as a unique opportunity to utilize renewable energy in Tanzania, and UTAFITI should provide information, advice, and encouragement to the Capital Development Authority for such utilization within the urban and village areas of the capital.

OPENING ADDRESS
Hon. Al Noor Kassum
Minister for Water, Energy and Minerals

Mr. Chairman, Distinguished Guests, Participants, and Friends, on behalf of the Chairman of the Tanzania National Scientific Research Council, who is unavoidably absent today, I should like to welcome you all on the occasion of the opening of this historic Seminar/Workshop on Solar Energy Utilization in Tanzania. I call it historic because it is the first seminar/workshop of its kind to be held in Tanzania. I therefore consider it a great privilege to have been invited to open the meeting.

Mr. Chairman, before I make any observations on your seminar/workshop, I should like to seize this opportunity to take your minds back a little and give some background information on this seminar/workshop. The National Scientific Research Council, under whose auspices this seminar/workshop is being held, has eight specialist working committees from which the Council gets its expert advice. The terms of reference of these committees include the acquisition of knowledge from all sources, which is necessary for the effective implementation of their functions. One of these committees, the Committee on Natural Sciences and Natural Resources, had discussed the overall energy problem in this country, particularly in the rural areas. After a lengthy debate on the subject, it was finally agreed that a seminar/workshop on alternative sources of energy for the rural population be convened. On the basis of these

proceedings, the Chairman of the Council, Dr. W. K. Chagula, took the initiative to approach some international organizations which might co-sponsor an appropriate workshop in Tanzania. I am glad to note that the U.S. Agency for International Development (USAID) agreed to provide funds to cover the costs of experts to participate in the seminar/workshop and the National Academy of Sciences (NAS) agreed to make the services of sixty qualified experts available. Today we are witnessing the results of these commendable efforts.

With that brief background, I should like to take this opportunity to thank and express my sincere appreciation to both USAID, for providing the financial support, and the NAS for making available their very able staff to come over to Tanzania and participate in this seminar/workshop. I also wish to pay special tribute to Dr. W. K. Chagula, without whose initiative this seminar/workshop would perhaps not have materialized.

This seminar/workshop is particularly important, as it deals with the burning question of energy. Energy, as you all know, is a central issue today, since practically all activities are dependent in some way on one form of energy or another. Tanzania is a young and developing nation and needs to have access to various forms of inexpensive energy. She lacks the technical know-how for harnessing such energy and their effective usage.

In the report on Energy for Rural Development prepared for the National Academy of Sciences the first paragraph of the introduction reads as follows:

Energy plays a larger role in man's struggle with the vagaries of nature than merely sustaining life. In The Economic History of World Population, Cipolla has said that the more successfully man can use his own energy output to control and put to use other forms of energy, "the more he acquires control over his environment and

achieves goals other than those strictly related to animal existence." He then adds what is certainly obvious, but does not suffer from repetition—that fundamental to the utilization of nonmuscular energy is the problem of transforming it into the needed form "at a selected time and place and at convenient cost."

And the overview of the same report reads:

The relationship between energy and economic development is as crucial in the less-developed countries (LDCs) as it was and continues to be in the industrialized nations. The process of economic growth is traceable in large part to the substitution of energy for muscle in the performance of every type of agricultural, industrial, and domestic task. Moreover, many of the pesticides, herbicides, and fertilizers on which successful agriculture in industrialized nations traditionally depends are also derived from energy (fossil fuel) sources. It is hardly surprising, then, that prospects for growth in critical sectors of the less-developed economies are linked, at least in part, to the development and exploitation of energy resources available to them.

I have deliberately quoted this because within two paragraphs you have a complete philosophy ably and aptly stated.

Mr. Chairman, it is historical knowledge that man has for centuries been harnessing all sorts of energy and power. It will also be appreciated that most of the energy resources, apart from being a source of pollution, are also finite. Because of this, it is considered appropriate to investigate other means of direct harnessing of solar energy. Our country is not very rich in energy resources, but the solar intensity which it receives is comparatively high. This form of energy could be used on a small scale in villages where it can be put to various uses. The sun effect on this country produces a variety of topographical features resulting in winds which can be harnessed and used for pumping water for domestic use and irrigation in the villages. It is clear, therefore, that the impact on the rural areas of our country, as a result of the availability of a less expensive and easily accessible form of energy can be quite profound.

Mr. Chairman, I have gone through the programme of your nine-day seminar/workshop. I see that you are going to cover three important phases, which are necessary before any concrete proposals are made on the utilization of solar energy radiation. These are:

1. The state-of-the-art of solar energy and the application of the technology.
2. Energy consumption and requirements in selected villages.
3. Project design and follow-up activities.

I have also noted that in one of your reading documents titled, "Energy for the Villages of Africa" you have appended bibliographic titles to the tune of a hundred. It is really amazing, the amount of documented literature that is available on the subject, and yet there is a very wide gap between what is already known and what is actually applied. I do hope that this seminar/workshop will primarily look into this considerable wealth of knowledge and suggest ways of matching the known technology with the prevailing problems of the majority of our people.

Your program also includes visits to some villages during the weekend. There you will be able to see and feel the magnitude of the problems which we face, some of which can perhaps be tackled by the use of solar energy. I should perhaps caution our visitors that this country has a wide range of diversified geographical regions, and therefore, the villages you are going to visit may not always be representative of the rest of the country.

After your visit to the villages I note that you intend to spend a good part of your time designing projects. Here, of course, you will

enter into the complex subject of the choice of appropriate technology. It is complex because virtually all the technology we depend upon is imported from countries where capital is plentiful and labor scarce. In any case, besides the fact that we live in an entirely different environment, we have to import expensive equipment which we can ill afford. I am confident that with the panelists' wealth of experience, coupled with the participation of local counterparts, this subject will be discussed thoroughly and meaningful conclusions will be drawn.

Mr. Chairman, it will be seen that the Government is very anxiously waiting for the outcome of this workshop. We look forward to collaborating with all of you in achieving the expectations of the Council. I am certain that the Tanzania National Scientific Research Council will, as usual, give high priority to those activities designed to promote the standard of living of our people and also benefit the other Third World countries which have similar problems.

Ladies and Gentlemen, it is my great pleasure to formally open this workshop. Thank you.

RESPONSE TO OPENING ADDRESS

James W. Howe
Chairman, NAS Panel

Honorable Minister Kassum, Mr. Chairman, and Members of the Joint Workshop Group on Solar Energy for Rural Tanzania, I would like to talk about three things: first, a brief discussion of the interaction between energy and development; second, a sketch of the topic to be addressed in the next two days by the members of the NAS panel; and third, an identification of the panel members.

I. Energy and Development

Current consumption of energy in the world is very uneven, with the lion's share being used by the industrialized countries of the northern hemisphere. For example, the average citizen of the United States consumes sixty times as much as the average citizen of India; in the case of Bangladesh and Mali, the ratios are 370 to 1 and 700 to 1. Now these comparisons, of course, are overstated because they leave out of account all of the traditional or non-commercial sources of energy such as firewood. These sources provide an estimated fifty percent of all the energy consumed in the developing countries. Moreover, they supply virtually all of the energy available to the people in the rural areas of those countries. This is an important part of the world, amounting to fifty percent of the people in Latin America, about seventy percent of those in Asia, and eighty-five percent of the African population. Thus, it is evident that developing countries in general need to increase sharply their consumption of energy.

Of course, styles of development vary. A country may achieve its goals with an exceptionally wasteful pattern of energy consumption, such as those in the United States or Canada, or it may adopt techniques that are designed to conserve energy, such as in China, Taiwan, and Sri Lanka. Dr. Harrison Brown has calculated that an individual in the rural areas of a very poor country may not use more than 15,000 calories per day for all purposes, including food, firewood, animal traction, etc. That is only about one-third as much as a suburban North American might use driving to and from work. At that low level, it is probably not possible to make much progress toward development.

At the village level, some of the tasks now performed in large measure by human energy or traditional sources include clearing, planting, weeding, irrigating (or watering livestock), harvesting, threshing (or decorticating, shelling, or husking), drying—which is important to avoid spoilage—transporting, grinding, cooking, heating (in cool areas), lighting, and (for certain purposes) refrigerating. In many cases there are shortages of labor during critical times in the crop cycle, which limit the crop area or the yield per acre or both. Hence, helping villages develop better energy sources is not only a matter of reducing human drudgery but also of increasing economic production.

Unfortunately, almost all calculations of future supply and demand of oil—the most widely used commercial fuel—show that between 1985 and 1995 world demand for oil imports will exceed the ability of OPEC countries to export and prices will likely explode again as they did in 1973-74. The Third World already has serious problems meeting its requirements for oil, even at present prices and with the present sharply

limited imports. Yet, unlike the industrialized countries, its consumption of energy should be expanding rapidly. Under these circumstances, the importance of developing the potential of solar energy is clear.

II. Solar Energy as Used in this Workshop

In one sense, all energy is based on the sun, except geothermal, nuclear, and a part of tidal energy. For example, oil, gas, and coal are the residue of solar photosynthetic energy stored by organisms millions of years ago. More commonly, solar energy has come to mean the energy coming in currently to the earth from the sun, energy which warms water and air and sustains all plants (and therefore all animals), feeds the rivers and streams, and causes the wind to blow.

In this workshop we will be prepared to discuss a number of solar energy forms:

1. Direct sunlight, which works in several ways to produce energy:
 - (a) Unconcentrated heat can be collected for space or water heating, to distill water, or to dry food;
 - (b) Unconcentrated heat can also vaporize gas to drive an engine (e.g., for pumping, grinding, or refrigerating);
 - (c) Concentrated sunlight (collected with mirrors or magnifying glasses) can produce high heat for steam to turn a turbine; and
 - (d) Sunlight can excite the atomic particles in a solar cell (such as a silicon strip), creating electric charges that can be collected as direct electrical current.

2. Wind is caused by the differences in amounts of sun that fall on different parts of the earth. It may be used to turn a shaft that can pump or grind or turn a turbine to generate electricity.

3. Falling water is made possible by the heat of the sun, which evaporates water from the seas and other bodies of water, forming the clouds that carry water to elevations on land where it can feed the streams that again descent to the oceans. It may be used to turn a shaft that can grind grain or generate electricity.

4. Photosynthesis stores the sun's energy in plants which may be burned, as in the case of wood or charcoal, fed to animals or people, or converted into gas or alcohol through the action of bacteria.

III. The National Academy of Sciences

Mr. Chairman, the National Academy panel here to discuss these topics consists of six persons drawn from outside the staff of the Academy from throughout North America, all but one working in the private sector. None of them is paid by the Academy for this service, but rather all have responded out of a sense of professional interest and a desire to be of public service. Brief descriptions of their experience are available. As you can see, they represent the academic fields of physical chemistry, chemical engineering, social anthropology, mechanical engineering, and solid state physics. Their experience has covered village studies in East Africa, solar collectors, wind energy, bioconversion, photovoltaics, and a variety of work at the village level with small-scale renewable energy. They have written authoritatively in these fields and were selected by the Academy because they were held in high regard by their professional associates.

Finally, Mr. Chairman, may I make an observation based on my own work. Small-scale renewable technologies have been tried before in Africa. The failure rate has been high, as may be seen from the skeletons of windmills and the remains of biodigesters in various African nations. Yet, the technology of wind and methane generation is not inherently faulty, but quite the contrary, has been proven in other parts of the world. My hypothesis is that the failure has been due to not involving the people of the village in planning the task to be energized, selecting the device, and installing, operating, and maintaining it. Instead, outside technicians came with pre-selected technology for a pre-selected task. They erected and operated a device and when they left, it soon fell into disuse. The villagers had not been involved in this alien technology and so they rejected it. Hence, in our deliberations, let us insist on relating each technology we discuss to real life in real villages. If we follow this guideline, we may produce something of value.

COMMENTARY ON ENERGY FOR THE VILLAGES OF AFRICA
S. R. Nkonoki
Senior Lecturer in Development Studies
Institute of Development Studies
University of Dar es Salaam

Mr. Chairman and Fellow Seminar Participants, the document/report on Energy for the Villages of Africa in my view is an exciting as well as a highly commendable effort by the authors, Mr. James W. Howe and the staff of the Overseas Development Council. I say this because for too long scholars have been too preoccupied with enumerating causes of underdevelopment and not doing much or proposing concrete steps towards the development of the villages of Africa. It is in this context that I personally have found some consolation in the report and some proposals within this report on Energy for the Villages of Africa because we are now beginning to look seriously at the problems of the producers of wealth who have been neglected and exploited for too long. The electricity wire, "the grid," is passing over the heads and homes of villagers as we travel between Kidatu Hydroelectric Plant in Morogoro and Dar es Salaam or between Nyumba ya Mungu in Kilimanjaro and Dar es Salaam. To the villagers, the telephone lines and the electricity transmission line seem to be decorations running not only more-or-less parallel to our trunk roads and railways, but also parallel to the problems of the villagers. Even if they--the "villagers" know that that line carries "electricity," they often joke to each other, "That is energy for the big people in town. What would you do with it if the power were eventually brought to you village house?"

Mr. Chairman, the peasants of Africa who live in the villages have for too long been fed with promises of this, that, or the other. As a "student" of physics and as a keen student of rural development, particularly in Tanzania, I personally appeal to those of us who can design and develop empirical technology, even if it be on a trial and error basis, let alone systematic technology, to do so for the development of the village people. Let us start to translate our political or even scientific visions, ideas, and goals into specific measures.

Mr. Chairman, in many Tanzanian villages, especially in the districts of Dodoma, Kongwa, Magu, Kwimba, Maswa, Shinyanga, Bariati, Nzega, Igunga, Singida, Kiomboi and Manyoni, housewives sometimes walk as many as three or even more kilometers each day in search of water for domestic consumption, especially during the dry season between July and September/October. A lot of man-hours are wasted in this way, which could be otherwise utilized for production. We should not rely heavily on a theoretical, elaborate, and long sociological research strategy whose preliminary phases may last two or three years in an effort "to help villagers identify tasks they want performed by non-human energy."¹

Mr. Chairman, the villagers may be ignorant about mathematical equations and scientific theories, but they are not fools. They know that their ruling Party and their Government know their most pressing problems. It would be absurd to ask villagers if the task they want performed by non-human energy is to pump water from the nearest river or well to their

¹Overseas Development Council, Energy for the Villages, Conference Paper, 1977, p. v.

village. By the same token, the villagers who are still grinding their grain, using the traditional method involving a big flat stone and a smaller hand-driven stone are more likely to feel cheated should anyone set out to investigate if they would be happy or not to have engine machinery set up in their villages to help them mill their grain within their Kata² area. Mr. Chairman, what I am trying to say is that if we really want to help villagers to develop and utilize non-human energy projects we should emphasize applied or adaptive research, rather than turn villagers into projects—mere sources of statistical, biographical, and other vital information which may be of an economic nature. To accumulate data on yields per acre by peasants in 1977 is not only to do the obvious, but to delay supplying energy to the villagers. Base line studies are very important, especially when large industrial or agricultural projects are involved, but not so important when one is dealing with small-scale, decentralized energy projects. Tanzania has villages whose population is known almost to the nearest one thousand. The average number of homesteads for each village is also known. There are, on the average, between 250 and 300 homesteads per village, following the recent country-wide villagization program which reached its peak in 1974/1975. Now Tanzania has 7684 villages with 13,067,220³ people living in

²Kata is a Swahili word which means ward: - a political as well as administrative area which has between four and six villages on the average. The population of a Kata ranges between 5000 and 10,000 people.

³Tanzania, MIAKA 10 YA AZIMIO LA ARUSHA, Wizara ya Habari na Utangazaji, Dar es Salaam, 1977, pp. 97-98.

them, out of an estimated national population of 15 million. Incidentally, Tanzania is to have a National Census in 1978 and a lot of up-to-date data will be available. The Party (CCM)⁴ has repeatedly stated that the prime purpose of Ujamaa Vilages is to establish a foundation that will help Tanzanians to develop themselves and raise their living standard from the depths of ignorance and poverty to prosperity, democracy and cooperation among villagers. Within these general goals of Tanzania's socialist rural development strategy we find embraced the relevance of the focus of this conference--energy resources for the development of man, energy to free man from boredom and unnecessary toil so that man can have more time to do more creative and more productive tasks in order to improve his standard of living.

Mr. Chairman, we must avoid the mistake of isolating science and technology from ideology. Tanzania is building a socialist society based on self-reliance. Tanzania can attain self-reliance through the application of scientific research and the diffusion of technology in the rural areas as well as in towns. Once you discuss technology in the Third World you inevitably discuss aid. Tanzania will not achieve technological or industrial independence by relying on foreign aid in the form of scientific personnel funds, information systems, or machinery. No country has been able to become technologically independent through begging. What Tanzania needs is not lock-in technology that perpetuates dependence on foreign know-how. Tanzania needs to develop

⁴CCM means Chama Cha Mapinduzi: CCM is Tanzania's only Political Party which was inaugurated on February 5, 1977 after the merger of TANU and Afro Shirazi Party.

and strengthen her own scientific manpower for research activities in industry and agriculture. The process of gasification of rural Tanzania, the electrification of villages, and the provision of solar energy devices for drying crops, fish such as Dagaa, meat, and so on, must enhance Tanzania's policy of self-reliance and hence development of men. If the provision of non-human energy to the villages promotes independence on foreign manufacturers for simple spare parts, or maintenance staff, then such technology will be the further development of underdevelopment. For as President Nyerere has said, "Development brings freedom, provided it is development of people. But people cannot be developed; they can only develop themselves. For while it is possible for an outsider to build a man's house, an outsider cannot give the man pride and self-confidence in himself as a human being."⁵ During his recent tour of the United States, President Nyerere said "The whole idea of aid is wrong because it is both ineffective in dealing with the problem of poverty and humiliating to the receiver."⁶

I would therefore like to propose that, among the projects to be considered in promoting the provision of energy for villagers, there should be a strong training component for middle-level village technicians as well as top-level research scientists in the Institutes, departments or faculties of engineering, agriculture, physics, chemistry and development studies of universities and other research organizations. Short-term and long-term study or research fellowships can be offered

⁵Nyerere, J. K. Freedom and Development, Oxford University Press, Nairobi, 1973, p. 60.

⁶See Sunday News, No. 1283, Dar es Salaam, p. 1.

for postgraduate students to do further research in solar energy devices and techniques, better preparation and utilization of wood-charcoal, development of better designs of gobar gas (methane) plants, small-scale hydroelectricity generation for small-scale industries and domestic consumption by using the waters of village streams and rivers, windmills and so on. In this way, we shall be developing man as well as promoting technical independence and, eventually, economic independence.

A design problem which might be worth mentioning here concerning village-oriented technology, relates to the ownership of devices or design of crop-drying appliances for individual homesteads or for a group of homesteads such as Ubalozo.⁷ Or should we design large solar heat engines to cater to the needs of the whole village, which in Tanzania is a cooperative society anyway? In a capitalist society we may argue that the more the sizes of devices, the better for the consumer, since choice and variety are offered. But the average villager of Africa, at this stage of development, would not like to own and maintain an electricity-generating system on his own. Such a system will be better utilized and cheaper if it is maintained by the village as a whole for providing energy to a small village-based industry, to light the village dispensary, the village's primary school, or welfare center, and so on.

Finally, Mr. Chairman, when we talk of providing developing gas appliances for villagers, we should never lose sight of the explosive dangers of fire. The village houses at present are more often than not

⁷Ubalози is a Swahili word used in Tanzania's political language to mean ten homesteads which are under a CCM Cell Leader.

thatched with grass, except for the houses of Wagogo, which are plastered with mud. The villagers have been using fire for hundreds of years in these grass-thatched houses. It may be over-pessimism on my part to propose that we need to be careful of our design of gas appliances for the villagers because gas, even in modern houses, is extremely dangerous. The answer lies in educating people so that they can cope with technology. Perhaps to suggest that people should cope with technology is to subordinate human beings to technology, rather than vice versa. What I want to say is that people should be educated so that the results of science and technology can serve the cause of man, and in so doing, technology can bring prosperity and happiness in man.

Mr. Chairman, science and technology must be utilized for the liberation of man and not for the enslavement of man or promotion of fear and uncertainty about the future. If we who are gathered here can make concrete proposals and programs of research and development geared towards provision of non-human energy for the villages of Africa, we shall have made a small but important contribution for the liberation of man.

Thank you, Mr. Chairman and fellow participants, for according me this time to make my comments.

COMMENTARY ON ENERGY NEEDS IN TANZANIA
Jeremy Elias Duwe
Assistant Commissioner
Ujamaa and Cooperative Development
Prime Minister's Office

Ndugu Chairman, Fellow Participants, Ladies and Gentlemen, my colleague and I from the Prime Minister's Office regard ourselves more as observers than resource persons at this scientific seminar/workshop.

Because the Prime Minister's Office has, among its responsibilities, the role of coordinating development efforts and of following up the implementation of national development policies, and because this scientific seminar/workshop is a contribution towards Tanzania's development, we feel honored to have been invited to participate in this very important workshop and share its scientific deliberations.

The Prime Minister's Office has been asked to give a commentary on energy needs in Tanzania. Our first reaction to this request was that this topic should have been assigned to the National Scientific Research Council itself or to the Ministry of Water, Energy and Minerals. I hope that the address given by the Hon. Al Noor Kassum, M.P., Minister for Water, Energy and Minerals at the opening session of this seminar/workshop this morning has covered the major aspects of this topic.

Having unfortunately missed the Minister's address, the response by Dr. James Howe, Chairman of the NAS Panel, Washington, and the other commentaries given this morning, I fear that I may bore you with the

repetition of what has already been elaborated by the previous speakers. Should it be so, ladies and gentlemen, you will have to excuse me.

Our commentary is going to be very brief. We should like to share your views on the following points.

1. That energy questions are central to any attempt at improving the quality of people's life everywhere in the world.

2. That the hard fact now is that the conventional fossil fuel resources which have been the main source of energy are fast becoming exhausted, and are not easily replenished.

3. That most of the developing countries like Tanzania do not have enough financial and manpower resources to harness the limited conventional fossil fuel which they may have.

4. That on the other hand, the world, and especially tropical areas like Tanzania, has an abundance of solar energy to turn to.

5. That through sophisticated research, this abundant solar energy could be tapped for better human consumption.

6. That limited as they are in financial and manpower resources for such sophisticated research on solar energy, the poor nations such as Tanzania could utilize the research findings of the abler nations, with minor modifications to suit their requirements.

In diffusing these technical innovations to the developing nations, especially to the villagers, we should like to remind the technical innovators to bear in mind the right approaches for affecting change and development. People have to be involved so that they will be able to understand, appreciate, and adapt the innovations as part and parcel of their integral development.

For example, in this aspect of solar energy usage, it should be borne in mind that raw solar energy has been used in different forms in Tanzania from time immemorial. Just to mention a few common usages:

- It has been used for heating; people have warmed themselves with sun's heat, acquiring what you scientists call Vitamin D, without their knowing it.

- It has been used for heating, bathing, and washing water.

- It has been used for drying wet clothes and for domestic utensils in order to destroy pathogenic bacteria acclimatized to damp or wet surroundings.

- It has been used for the preservation and storage of foodstuffs such as meat, fish, green vegetables, beans, grains, maize, sorghum, cassava, etc.

- It has been used for fermenting local beer and other drinks.

- And so on and so forth.

Of late, much effort has been made by domestic and international institutions such as the Ministries of Health, Agriculture, Water Energy and Minerals, FAO, UNICEF, etc., to improve the utilization of solar energy in the country, especially in the rural areas.

These institutions have contributed in finances and in expertise to helping and advising villagers to build better food-preservation facilities through solar energy.

The efforts of institutions like these and others cannot be appreciated enough. Your research findings on the usage of solar energy and its practical application will surely help the whole of mankind in this critical shortage of conventional fossil energy.

Your efforts need, therefore, to be appreciated and encouraged. In Bob Kennedy's words, "Come friends, it is never too late to build a better world." Ladies and Gentlemen, thank you.

CLOSING REMARKS
Dr. Peter Mwombela
Chairman,
Tanzania National Scientific Research Council

Fellow Workshop Participants, Ladies and Gentlemen, we have now come to the end of our workshop, but only the beginning of the tasks ahead. In the first two days we had the opportunity to have an overview of the development of solar energy technologies at the international level. This opportunity has enabled us to realize that the use of solar energy technologies is a reality and not a dream, as people apparently seem to believe. The experiences gained in the U.S.A., Europe, China, and other parts of the world, which have been demonstrated in the seminar, were very inspiring to us all.

I would first like to take this opportunity to express our most sincere gratitude to our colleagues from North America (U.S.A. and Canada) and particularly to the U.S. National Academy of Sciences (NAS) for having made available these experts who have made a very significant contribution in sharing their knowledge and experience with us in this important field. I have no doubt in my mind that our fellow colleagues from Tanzania have found this opportunity both an enrichment to their technical know-how and challenging during the consideration of its application in Tanzania. I also believe that our colleagues from North America have had something to take from this seminar/workshop, at least an insight into the type of problems encountered by Third World countries like Tanzania.

This is the first attempt in which NAS and the Tanzania National Scientific Research Council have jointly organized an activity of mutual interest. This should be a beginning and not an end of such collaboration. We should look forward to future collaboration not only between these two institutions, but also with organization of similar interest with NAS so that, in our joint ventures, we may be in better position to tackle the serious technical problems that face us in Tanzania. It is therefore very important that the recommendations and projects that are the results of this workshop ending today are followed up with vigor and commitment so that we may look forward to seeing the application of these technologies both in those villages we have visited and in others where these technologies are appropriate. This will be in line with the Government and Party policy which aims to improve the conditions of the masses living in villages, so that their lives may be more enjoyable and fulfilling.

It was obvious throughout the five-day workshop that there is a great need for gathering relevant data necessary for planning and implementation of these technologies, e.g., data on availability of direct sunshine, rainfall, wind, etc. I also realized that the methodology to be adopted before the application of these technologies is very important. Nonetheless, even under present conditions where adequate data is not available, it was observed that certain technologies which could be put to use on a small scale, can immediately be applied. It is to the interest of the Tanzania National Scientific Research Council to see to it that whatever can be applied to the villages, a follow-up action should be immediately taken. In this connection, I would like

to appeal to the U.S. NAS, the University of Dar es Salaam and the Ministry of Water, Energy and Minerals to make available both the human and binancial resources required for the implementation of these projects. As you will recall, the villages we had visited have some expectation, and it is therefore important that we mobilize all our energies and resources to make their expectations a reality. It is only when we can demonstrate our commitment to solving their problems that the villagers will, in future, have more confidence and pride in our technicians. This is consistent with the call made by our Honorable Prime Minister, who has directed that experts and technicians spend most of their time with villagers so that solutions could be found to solve their problems.

This is not the time to make a lengthy speech. I would like to end by first paying a special tribute to all participants who have shown keen interest in the proceedings of this seminar and workshop. I feel very gratified to state this is the first seminar/workshop in which I have found almost one hundred percent attendance. This is indicative of your devoted interest in solar energy technologies, and we from the Tanzania National Scientific Research Council will take all necessary steps to see that this interest is kept alive and transformed into real activities.

I am sure you also wish me, on your behalf, to thank the Building Research Unit and particularly the Institute for Finance Management who have provided excellent facilities for our seminar/workshop. Last, but not least, I would like to thank our supporting staff—typist, drivers, etc.; without them our activities would not have been possible.

Finally, I would like to apologize to our visitors for having kept them so busy that they had no time to relax and make use of some of our attractive beaches and game reserves--not to mention sunshine, which is plentiful here on the coast. This means that our visitors should be encouraged to come back again to see what they have missed. We hope, therefore, to have another opportunity to welcome you here in a more humane and relaxing mood than we have done this time. Please remember, if you ever manage to come again, don't plan to leave immediately after the official engagements because it does not permit us to show you what we would have liked to do outside the conference room.

With these remarks, I wish to thank you all for your indulgence in listening to me and wish our visitors a safe and enjoyable journey home. We look forward to seeing you in the not too distant future. Kwa herini!