OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

20560

Consultant Bernard McNelis

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

Denpasar, Bali, Indonesia

12 - 17 July 1993

Proceedings of the Expert Group Meeting on the Application of Solar Energy for Electricity Generation for Domestic and Commercial use

PREFACE

As stated in the Constitution* the objectives of the United Nations Industrial Development Organisation, are the following: The primary objective of the Organisation shall be the promotion and acceleration of industrial development in the developing countries with a view to assisting the establishment of a new international economic order. The Organisation shall also promote industrial development and co-operation on global, regional and national, as well as on sectoral levels.

In fulfilment of its foregoing objectives, the Organisation shall generally take all necessary and appropriate action, and in particular shall:

Provide a forum and act as an instrument to serve the developing countries and the industrialised countries in their contacts, consultations and, at the request of the countries concerned, negotiations directed towards the industrialisation of the developing countries;

Serve as a clearing-house for industrial information and accordingly collect and monitor on a selective basis, analyse and generate for the purpose of dissemination on all aspects of industrial development on global, regional and national, as well as on sectoral levels including the exchange of experience and technological achievements of the industrially developed and the developing countries with different social and economic systems;

Promote, encourage and assist in the development, selection, adaptation, transfer and use of industrial technology, with due regard for the Socio-economic conditions and the specific requirements of the industry concerned, with special reference to the transfer of technology from the industrialised to the developing countries as well as among the developing countries themselves;

Develop pilot special measures designed to promote co-operation in the industrial field among developing countries and between the developed and developing countries.

Aware of the energy shortages in the developing countries and the lack of knowledge and skills in the application of renewable energy sources, UNIDO in its Programme and Budget 1992/1993, has planned to convene an expert group meeting on the application of solar energy for electricity generation for domestic and commercial use, with the emphasis on the intensive information and knowledge exchange among the participants from the developing and developed countries, and encourage, as appropriate, transfer of know-how in this field.

---

*) The text of this Constitution was adopted by the United Nations Conference on the Establishment of the United Nations Industrial Development Organisation as Specialised Agency on 8 April 1979 at Vienna.

CONTENTS

INTRODUCTION

Nearly two thousand million people in the developing world do not have electricity. But electricity is the *commodity* which can transform the way people live and work, and is a major key to economic development and physical well-being. In towns and cities electricity provides light and power at home, in the school and in the office; it powers industry, communications and hospitals; and allows entertainment from film, television and radio. In rural areas which are widely scattered and generally not connected to the electricity grid, the standard of living and economic advancement is severely curtailed, and there is a general movement of the population towards the cities and towns.

Rural electrification programmes in developing countries have been an important part of national economic planning. Electricity brings the enhanced conditions of towns to the villages providing education and allowing cottage industries to develop. But the high cost of installing new generating capacity and extending the grid is often prohibitively expensive. In addition, steadily increasing world energy consumption and electricity generation has created a series of problems jeopardising the world and mankind in the following aspects:

- Increasing scarcity of fossil fuel resources (with an energy consumption growth rate of 2% yearly, the oil and gas resources currently known will have been exhausted before the end of next century).

- Increased greenhouse effect and air pollution caused by combustion of fossil fuel for electricity generation, domestic heating and industrial applications, as well as of increased emission of industries, which causes global warming, will endanger the environment.

The amount of energy radiated by the sun is unimaginably large. Solar radiation is absorbed in the atmosphere and at the earth's surface at a rate of around 10^{17}W. The global rate of energy consumption is approximately 10^{13}W, so the sun provides 1000 times more energy than the world consumes! Sunlight is ubiquitous and everlasting. It is clean and in abundant supply, especially in countries within the latitudes 40° N & S, in which most developing countries lie. As sunlight is available to the villages and rural areas, there should be scope for its use to meet basic human needs.

Photovoltaic (PV) cells and modules convert sunlight directly into electricity. This is an extremely attractive electricity production technology, because photovoltaic modules emit no pollution, have a life of at least 20 years, and require little maintenance. Photovoltaic systems of less than a few kilowatts are ideally suited to conditions that prevail in the rural areas of developing countries. Their only drawbacks is their relatively high capital cost, which makes them difficult to purchase by rural and village people.

The Expert Group Meeting, sponsored by UNIDO and the Government of Indonesia, brought together participants with various interests and experiences in the field of solar electricity, from 13 countries in Asia and Europe, to examine the status of the technology and ways in which it can be deployed and used on a wide scale.

The relatively high cost of photovoltaic electricity is well known, but there are many application and occasions when it is the least-cost option and is economically viable. But there is often a lack of information available to potential users and decision makers. The necessary financing mechanisms are often not available to enable potential users to acquire the technology.

This meeting sought to compile experiences in countries represented and to develop a consensus on the status of solar electricity and the nature of problems associated with the technology and hence to draw conclusions and make recommendations.

I CONCLUSIONS AND PROBLEMS

The Export Group Meeting has reached the following conclusions concerning the application of solar energy for electricity generation for domestic and commercial use:

1. In industrialised countries, the public and governmental consensus on PV has been mainly driven by environmental considerations. i.e. the concerns about effects of fossil fuel combustion on climate and overall worries about nuclear power. PV is not yet cost-effective, but there are long-term plans to utilise PV on a large scale, both by centralised grid-feeding MW sized plant and through small distributed building-integrated, grid-connected systems.

2. In developing countries the main motivation for using PV is to supply electricity, for the purpose of improving living standards to the many millions of people in rural areas which are not connected to the electricity grid. There are also he environmental benefits.

3. PV systems are generally accepted as being technically proven. In particular, PV modules are adequate and reliable although there is a need for manufacturers' rated performance to be verified. The few remaining technical problems relate to the balance-of-system components such as batteries and charge controllers. But for properly specified, designed, installed and maintained systems the performance achieved is good.

4. PV is generally cost-effective for small loads, such as lighting, radio/TV, water pumping, when compared on a life-cycle basis with grid extension or use of diesel generators. However PV systems are very expensive on a first-cost basis.

5. It is generally accepted that there will be further cost reductions for PV, although there is some uncertainty about what current 'real' costs are. The typical selling price on the world market is around $5/Wp. The main manufacturers are unprofitable due to the relatively small size of the market for the number of manufacturers but this price is seen as reasonable. Expansion of the market is seen as the main means of reducing costs through scale of production.

6. Relatively small-scale PV module production, as has been undertaken in several developing countries, leads to costs of more than around $5/Wp. There are widely different experiences in different countries. For example Thailand has three manufacturers with a combined capacity greater than the national market and prices in the range $ 7-9/Wp. Korea established a target price of $ 4-5/Wp within its national PV programme but the single manufacturer requires $ 6/Wp and produces only to order. India has a large market, indigenous manufacturers which have supplied almost all of this, and regards the business as sustainable. China has invested in a production capacity of 4.5 MWp/annum in 17 manufacturers, but only utilises 10 percent of this.

7. Local industry involvement in developing and servicing the PV market is clearly desirable. This should involve manufacture of components, including PV cells and modules as appropriate, in addition to systems. Decisions on investments in manufacturing should be made on economic and commercial grounds. A logical sequence of events would be to build up the marketing and infrastructure requirements first of all, followed by systems engineering, ultimately leading to PV cell manufacture, i.e. a 'bottom up' approach.

8. It is agreed that the expanded use of PV in the unelectrified areas of developing countries should be encouraged and supported by all means available. Government policies to this effect need to be encouraged.

9. The main barrier to expanding the market relates to financing. The initial capital costs of PV systems are too high for the majority of potential users to buy them. Therefore mechanisms must be established for the systems to be purchased and the users to pay in line with the cash available to them. This generally requires that Governments and/or financial institutions must be involved in programmes to expand the PV market.

II RECOMMENDATIONS AND PLAN FOR ACTION

The participants recommend that the following actions should be undertaken:

1. Optimum path for development of PV

Given the variety of experiences with PV manufacture and dissemination, these experiences should be compiled and analysed and lessons drawn from them. Key factors effecting market development should be quantified and the relationship and sensitivity of these to market penetration established. This will provide guidance as to the optimal path for expanding the use of PV in different countries.

2. Promote utility support for solar electricity

Utilities should be encouraged to support PV, and other solar-electric technologies, if shown to be cost effective without subsidy on a life-cycle basis. Utilities should finance the purchase and installation of PV systems in non-grid areas and charge consumers on a monthly basis, as is normal with grid-connected consumers.

3. Workshop on PV policy and financing in Indonesia

Indonesia has a large PV potential market and a lot of activity. Developing the potential market requires the co-operation of Government, financing institutions, utility and commercial companies. A workshop involving participants from all these groups should be convened to address the issues, determine the needs for any changes in government policy (and legislation if necessary), and prepare a strategy. UNIDO should assist Indonesia to plan and implement this.

4. National Co-ordination for Renewable Energy

For each country there should be close co-ordination of activities on renewable energy, so that there will not be duplication of effort.

5. Regional Training Programme

There should be a regional training programme for practitioners of PV (and also other renewable energy technologies). This should be organised by UNIDO with the first course being developed in association with CASE-Perth.

III ORGANISATION OF THE EXPERT GROUP MEETING

ELECTION OF OFFICERS

The following officers were unanimously elected:

Chairman:	Dr Lolo M Panggabbean (Indonesia) Head of Laboratory BPP Technology
Vice Chairman:	Mr Malek A Kabariti (Jordan) Renewable Energy Research Centre
Rapporteur:	Mr Bernard McNelis (United Kingdom) Managing Director of IT Power Ltd

ADOPTION TO THE AGENDA

The Expert Group Meeting adopted the following agenda:

1. Opening Ceremony of the Expert Group Meeting
2. Election of Chairman, Vice-Chairman and Rapporteur
3. Adoption of the agenda and the organisation of session
4. Presentation of country/technical papers
5. Discussion on the subjects of the country/technical papers
6. Drawing up of conclusions and recommendations
7. Adoption of the final report.

ADOPTION OF THE REPORT

The final report of the Expert Group Meeting on Solar Energy for Electricity Generation for Domestic and Commercial Use was adopted by consensus at the final plenary session on 17 July 1993.

THE DETAILED AGENDA OF THE EXPERT GROUP MEETING:

FIRST DAY, MONDAY 12 JULY 1993

08.30 - 10.00	:	Registration
10.00 - 10.30	:	Opening Session
		- Introductory Speech by the National Co-ordinator Ms Nenny Sri Utami
		- Opening Address of UNIDO Resident Representative - Mr Fernando Vicente
		- Inauguration of the Meeting by the Director General of Electricity and Energy Development. Ministry of Mines and Energy, Government of Indonesia.
10.30 - 11.00		*Coffee Break*
11.00 - 12.00	:	**SESSION I**
11.00 - 11.30	:	Election of Chairman, Vice Chairman and Rapporteur of the Meeting : Adoption of the Agenda of the Meeting (Chairman - Australia)
11.30 - 12.00	:	Presentation of UNIDO Position Paper Mr Rainer Kaulfersch
12.00 - 12.30		Presentation of Status Report, commissioned by UNIDO Mr Bernard McNelis
12.30 - 13.30	:	*Lunch Break*
13.30 - 15.00		**SESSION II** (Chairman : UK)
13.30 - 14.00	:	Presentation of Country Paper of Indonesia
14.00 - 14.30	:	Presentation of Country Paper of Germany

14.30 - 15.00	:	Discussion Summary and Closing Remarks by the Session Chairman
15.00 - 15.15	:	*Coffee Break*
15.15 - 16.45		**SESSION III** (Chairman - India)
15.15 - 15.45	:	Presentation of First Country Paper of Australia
15.45 - 16.15	:	Presentation of First Country Paper of Korea
16.14 - 16.45	:	Discussion Summary and Closing Remarks by the Session's Chairman

SECOND DAY, TUESDAY 13 JULY 1993

09.00 - 10.30	:	**SESSION IV** (Chairman : United Kingdom
09.00 - 09.30	:	Presentation of Second Country Paper of Australia
09.30 - 10.00	:	Presentation of Country Paper of Thailand
10.00 - 10.30	:	Discussion Summary and Closing Remarks by the Session Chairman
10.30 - 10.45	:	*Coffee Break*
10.45 - 12.15	:	**SESSION V** (Chairman : Switzerland)
10.45 - 11.15	:	Presentation of Country Paper of Philippines
11.15 - 11.45	:	Presentation of Country Paper of Jordan
11.45 - 12.15	:	*Lunch Break*
13.30 - 15.00	:	**SESSION VI** (Chairman : Philippines)
13.30 - 14.00	:	Presentation of Third Country Paper of Australia
14.00 - 14.30	:	Presentation of Country Paper of Vietnam
14.30 - 15.00	:	Discussion Summary and Closing Remarks by the Session's Chairman

15.00 - 15.15	:	*Coffee Break*
15.15 - 16.45	:	**SESSION VII** (Chairman : Jordan)
15.15 - 15.45	:	Presentation of Second Country Paper of Korea
15.45 - 16.15	:	Presentation of Country Paper of India
16.15 - 16.45	:	Discussion Summary and Closing Remarks by the Session Chairman

THIRD DAY, WEDNESDAY 14 JULY 1993

Site Visit to Lombok, West Nusa Tenggara.

FOURTH DAY, THURSDAY 15 JULY 1993

09.00 - 10.30	:	**SESSION VIII** (Chairman - Germany)
09.00 - 09.30	:	Presentation of Country Paper of China
09.30 - 10.00	:	Presentation of Country Paper of Italy
10.00 - 10.30	:	Discussion Summary and Closing Remarks by the Session Chairman
10.30 - 10.45	:	*Coffee Break*
10.45 - 12.15	:	**SESSION IX** (Chairman - Italy)
10.45 - 11.15	:	Presentation of Country paper of Switzerland
11.15 - 11.45	:	Presentation of technical paper "Notes on Solar Home System Commercial Opportunities in Indonesia" Mr Vcok Siagian
11.45 - 12.15	:	Presentation of technical paper " PV Design Using Loss of Energy Probability " Mr Immanuel Tarigan

12.15 - 12.45	:	Discussions Summary and Closing Remarks by the Session Chairman
12.45 - 14.15	:	*Lunch Break*
14.15 - 17.15	:	**SESSION X**
14.15 0 17.15	:	Formulation of the draft final report and recommendation by the Rapporteur in co-operation with all Session Chairmen.

FIFTH DAY, FRIDAY 16 JULY 1993

08.30 - 12.00	:	**SESSION XI**
08.30 - 09.30	:	Review of the Draft Final Report and Recommendation by the Plenum
09.30 - 09.45	:	*Coffee*
09.45 - 11.00	:	Adoption of the Final Report and Recommendation of the Meeting
11.00 - 12.00	:	Closing Session
11.10 - 11.30	:	Closing Remarks by UNIDO Resident Representative Jakarta
11.30 - 12.00	:	Closing Remarks by Director for Energy Development, Directorate General of Electricity and Energy Development, Ministry of Mines and Energy, Government of Indonesia.

IV REPORT ON THE DISCUSSIONS ON COUNTRY PAPERS

1. UNIDO POSITION PAPER (Mr Rainer Kaulfersch)

Energy, together with the environment, has been identified as one of the five priorities set for the 1990s in the UNIDO medium-term plan, 1990 - 1995. The energy programme now adopted takes into account UNIDO's experience in he field of energy, based on many years of direct involvement in projects in developing countries, and reflects the particular needs for assistance in energy supply and energy conservation in these countries.

Over the next 25 years, the developing countries have the greatest potential to contribute to world-wide energy growth but also have the potential to be the largest polluters. With the proper application of advanced energy technologies adapted for developing country resources, the environmental impact of this rapid growth can be mitigated. Recognising the critical nature of combining the environmental concerns with the need of developing nations to expand their energy production, UNIDO has developed a programme that incorporates energy growth with environmental concern. The programme involves factoring energy systems using environmentally clean technologies and pollution control into all UNIDO projects. A major focus will be the application of technologies with higher efficiencies and emissions control to new and ongoing projects.

UNIDO has carried out a large number of technical co-operation projects on solar energy exploitation, mainly related to solar thermal applications. A major project was carried out in Jordan on the establishment of solar energy testing facilities and the local manufacture of solar thermal collectors. As part of its promotional programme, UNIDO has established the Consultative Group for Solar Energy Research and Application (COSERA). COSERA is a high-level forum for identifying, through collective interaction of its members, the priority needs in research and application to promote the widespread use of solar energy, as well as indicating possible donor sources for financing such activities. it thus acts as a catalyst to achieve optimum results from the multitude of efforts in many organisations in different countries.

2. UNIDO COMMISSIONED PAPER "Solar-Photovoltaic Electricity Generation" (Mr B McNelis, United Kingdom)

Photovoltaic modules convert solar radiation directly into electricity. PV modules are produced by a number of manufacturers, and stand-alone photovoltaic systems, for electricity generation in remote locations are well documented and understood. PV systems are frequently used where connection to the nearest electric grid is prohibited either by expense or technical difficulties.

There have been dramatic improvements in the efficiency coupled with reductions in cost of PV systems. However they are generally too expensive to be purchased by the people who could gain the most benefit from them. The advantage and disadvantages of PV modules are summarised in Table 1.

It is considered that the main barriers to the widespread use of PV, are the lack of information and experience among potential users, governments and financing agencies, and the lack of financing mechanisms for rural and village people.

DISCUSSION

Questions and discussion followed on the current conversion efficiency of commercial PV modules. It was noted that the most efficient modules has an efficiency of about 17% and available from only one manufacturer. Higher efficiencies have been obtained with cells in the laboratory. These were also questions about the measured performance compared with manufacturers claims. It was generally agreed that in the past there have been cases of some products not providing their rated output, but that this is not a general problem.

3. INDONESIA COUNTRY PAPER (Dr L M Panggabean)

Indonesia started to officially pursue the development and application of PV technology in 1979, through the activities of the Agency for the Assessment and Application of Technology, BPP Teknologi, which is an R & D institution belonging to the Government.

Prior to this time many applications of PV technology were found in the country without a special objective other than services, such as navigation signals. From 1979, however, BPP Teknologi embarked in the assessment of PV technology through field testing with the aim of assessing the possibility of its application that could be large enough that it becomes a national industrial activity.

Applications of PV systems covers a wide range, from 50 Wp to several kWp in capacity. There are systems used in sea communications, coastal radios, TV repeater stations, earth stations for telecommunications, medical boxes, incubators in hospitals, drinking water pumping, individual lighting systems as well semi-centralised PV generators.

Three areas of application seem to be very promising today, i.e. Solar Home Systems for individual home lighting, PV powered TV repeater and water pumping both for communal services. The primary reason for this is the low rate of electrification especially in rural areas coupled with the fact that home distribution in rural areas is so scattered that establishment of grid system would not be economical.

Table 1
Relative merits of photovoltaic modules

Advantages

- generate electricity without moving parts, and produce no noise, smoke or fumes
- allow independent power to be generated when no mains power is available
- can withstand short circuits or open circuits under most conditions
- are light, easily installed and readily adjustable for maximum output
- are robust, reliable, durable and weatherproof, and so have long lifetimes
- require insignificant maintenance work apart from occasional cleaning
- have no fuel costs and virtually no maintenance costs; once installed produce virtually 'free' electricity
- can reduce running times and fuel and maintenance costs of petrol or diesel generators used in conjunction with them
- produce direct current (DC) electricity, which can directly charge storage batteries
- are modular units, so extra PV modules can be readily added to suit electricity and budget requirements

Disadvantages

- are relatively expensive compared with many other types of generation, costing about $4.5 per peak Watt (1992) for the larger modules (although the real cost is falling)
- produce a direct current DC output and therefore require additional equipment (i.e. regulator, batteries, inverter) to produce 'mains equivalent' 240V alternating current (AC) output
- have a lower energy output in winter and during wet and cloudy weather, and so may need the assistance of a petrol or diesel generator at these times, depending on the load

According to information from the Indonesian Photovoltaic Association, there are over 16,000 units of Solar Home Systems now installed and in operation in Indonesia. In addition to this the Department of Health is now installing 270 locations of Solar Home System and cool boxes using 75,000 photovoltaic modules.

This situation is expected to grow due to both the availability of the hardware at a lower price, though gradually, the dissemination of information through local Government and Social Institutions.

Problems encountered with PV technology are dependent on the application. For small power applications for lighting, radios, televisions and the like, no major problems are found any longer in all systems installed and monitored by BPPT.

For large systems of several kWp, controlling the charging and discharging of batteries used as energy storage device is still a problem, in that controllers are not made in every size required and availability is often not satisfactory.

A new programme is being developed which will lead to the installation of 50 MWp of other home systems. This includes financing from the World Bank.

DISCUSSION

The extensive experience with PV in Indonesia was discussed. It was concluded that with the large installation programme which will start, local assembly and manufacturing should be seriously considered.

4. GERMANY COUNTRY PAPER (Professor Dr A Götzberger)

Germany has a very large photovoltaic R & D programme. This covers small and compact appliances, autonomous systems. grid-connected domestic power supplies, centralised power systems, and systems for use in developing countries.

Autonomous power supplies are developed for isolated buildings, which always include a storage unit, often also an additional generator. By now there is quite a number of such systems also in Germany. Most of them are for farmhouses or inns which are so far from the grid that a connection is not viable for economic reasons. In addition, these buildings are often situated in nature reserves with strict regulations concerning the landscape, as is the case for the hikers huts belonging to the Mountaineering Association.

A series of buildings has been selected for future installations, in which not only the PV power supply will be important, but also the aspect of energy management in order e.g. to minimise the operating time of a diesel generator.

There are extensive investigations of grid-connected domestic power supplies which use the house roof as the mounting area. These systems could contribute noticeably to Germany's energy supply in future. Thus the preparation of effective solutions, which also include the safety aspects associated with connection to the public grid, has high priority. In a large scale project, the "Federal and Lander 1000 Roofs Photovoltaic Programme", numerous free-standing and semi-detached houses in all states will be equipped with PV systems. 2250 have already been completed.

Valuable experience is being gained on centralised PV systems exceeding the requirements of a single household, in numerous installations. The systems are designed for widely differing needs. They range from the development of autonomous power supplies for agriculture over the demonstration of power station operation to investigations of the combined effect of photovoltaics and hydrogen technology. Installation of systems range in size from 100 kWp to 600 kWp.

The application of autonomous PV systems is particularly attractive in developing countries with little electrical infrastructure. However, if they are to be used there to their full potential, the systems must satisfy very stringent requirements. On the one hand, they must be of very simple construction so that untrained personnel can install and maintain them: on the other hand, they must be extremely robust in order to have along lifetime even under unfavourable climatic conditions such as in the tropics. Comprehensive tests even before export are absolutely essential.

The most important application areas today for photovoltaics in developing countries are telecommunications, water pumps, water purification systems, cooling systems from refrigerators to cooled warehouses, and decentralised village power supplies. Photovoltaically powered refrigerators are used e.g. to cool medicines and are bought for this purpose by aid organisations.

Water pumping systems belong to the most significant applications of photovoltaic power supplies. They always include mechanical components, which are particularly prone to failure in practice. There is still a clear need for development not only towards improved reliability, but also towards improved efficiency values, in order to make the most effective use of the expensive PV electricity. PV powered water pumps have been tested for many years in demonstration projects in several sunny countries (Jordan, Egypt, Indonesia). A fairly large (about 26 million DM) project between the BMFT and the Society for Technical Co-operation (GTZ/GATE) has recently been installed. The goal is the testing of water pumps in eight countries to prove the reliability of systems build in Germany under different climatic conditions. Tests have been proposed in Brazil, Indonesia, and the Philippines.

DISCUSSION

The first part of the discussion focused on the amount of subsidies provided by the 1000 Roof Programme. This amounts to 18 to 27 DM/Wp. There were questions about the efficiency of electrical appliances and it was concluded that a lot can be achieved through selection of the best appliances. Some participants thought that even the subsidised installations would be too expensive for Indonesia. There was further discussion on electricity prices in cities and rural areas of Indonesia.

5. AUSTRALIA COUNTRY PAPER #1 - Photovoltaics (Prof. M A Green)

Australia is a large country with vast expanses in the arid "outback" region remote from an electricity supply network. These same areas are exposed to very high annual solar insulation levels, with most receiving average daily global radiation in excess of 6 kWh/m^2 Even in the areas serviced by the grid network, connections to the grid in non-urban areas may require several kilometres of grid extension and generally are quite expensive as a consequence. These circumstances have conspired to make Australia a large commercial user and manufacturer of photovoltaic modules, possibly the largest per capita worldwide in both categories.

Australia has two local manufacturers of cells and modules; BP Solar and Solarex. There is no local silicon wafer manufacturing capability so that both manufacturers import the starting wafer material. Approximately 50% of the photovoltaic product produced in the country is exported. Additional to these two companies, a number of other companies are involved in the manufacture of other photovoltaic system components, primarily inverters and regulators, with an additional group of companies also involved in the supply of integrated photovoltaic systems.

Applications in telecommunications have formed the backbone of the market in Australia. Navigational aids and other small supplies for lighting and electronic equipment for remote homes are other market areas. PV systems are also used for battery charging in yachts and other applications such as powering electric fences. Water pumping in remote areas is an application which continues to grow rapidly.

Telecommunication applications in Australia have been spearheaded by the work of Telecom Australia, which now has over two decades of experience with photovoltaics technology. Telecom began experimenting with photovoltaic installations in 1972. By 1976, it had developed a transportable solar power supply based on the use of a standard shipping container to house the storage battery, to provide facilities for maintenance crews, and to house the array during shipment. This formed the basis of the power supply designed for the first major telecommunications trunk link in the world, between Alice Springs and Tenant Creek, to be powered entirely by solar energy. A large number of similar microwave repeater substations have subsequently been deployed in the more remote regions of the country. These applications make Telecom the largest single user of cells in Australia. With demand peaking at about 350kW per annum during the 1987/88 financial year.

One feature of Australian activity in the photovoltaic systems area has been development of power packages, known as Remote Area Power Supplies (RAPS), suitable for electricity generation for remote homesteads, settlements and towns in Australia's "outback". There are estimated to be about 10,000 homes not connected to the electricity supply grid, either in the "outback" or in sectors of grid service areas which are difficult to access. Diesel or gasoline generators would be the normal method of generating electricity for such homes at present. There are also about 300 remote communities in the "outback" which are also dependent upon diesel generated electricity. The total installed diesel capacity is estimated at 250 MW with an annual diesel fuel use of 330 million litres.

The RAPS industry has now grown to the size where Australian standards and codes of practice relevant to the installation of RAPS systems are being proposed. One factor which has mitigated against the more widespread use of RAPS system has been the tendency for Australian electricity power supply authorities in the past to invest in grid extension to remote households, even when not economically competitive with a RAPS system alternative. From the customer's perspective, such grid extension is often the more favoured alternative, given that the costs of such systems are heavily subsidised by the electricity supply authorities and the full maintenance costs of such extension are not paid by the customer.

Water in the Australian outback has traditionally been pumped using windmills, several hundreds of thousands of which are installed. Rising capital costs and high maintenance requirements are causing these to fall out of favour. PV is well suited to water pumping because of the simplicity of the overall system, the fact that storage batteries are not required, and the generally good match between water requirements and sunshine availability. Water pumping is consequently a rapidly expanding sector of the Australian photovoltaic market.

Australia does not have a formalised national photovoltaic programme such as the United States or Japan. Two key Australian university based research centres are the Centre for Photovoltaic Devices and Systems at the University of New South Wales and the Murdoch University Energy Research Institute (MUERI) in Western Australia. The former Centre is known internationally for its work on improving the performance of conventional silicon cells. In 1985 it produced the first 20% efficient silicon laboratory cell followed by the first 20% efficient photovoltaic module in 1933. Considerable government support has been generated For a proposed UNIDO Centre for Application of Solar Energy involving MUERI. This centre will address photovoltaic and other solar applications relevant to neighbouring areas of the globe.

DISCUSSION

There was discussion on the achievable conversion efficiency of PV cells in the laboratory and production modules. This resulted in the suggestion that a module efficiency of 20% is a realistic target. There was also a lot of discussion concerning battery research. Redox batteries are under development in Australia. Total PV module production is around 3MWp annually.

6. KOREA COUNTRY PAPER #1 - (Bu Ho Kim)

In Korea, priority is given to the development of PV systems, with special reference to low cost, efficiency and technology transfer of the systems. The national programme identifies photovoltaics as one of the most promising renewable energy sources. In order to achieve the economic competitiveness, R & D and demonstration activities are defined in the programme.

The government established goals to be achieved by 2001 in an effort to support PAN-National Plan, and to determine the related plan for 1992-1996. They include 18% for conversion efficiency and 3 $/Wp for the market price of PV modules. About half of the solar budget, amounting to US$ 8.4 million-equivalent, went to PV projects for 3 years until 1991.

The National Project Promotion Committee of experts provides technical guidance and project priorities for planning and operation, regularly do review and evaluation and responds to requests from MOTIR and KEMCO. KIER is responsible for photovoltaic research activities and also for performance tests and evaluation of solar cells and modules developed. The Korea Electric Power Corporation (KEPCO) also provides direct financial support for KIER-KEPCO joint PV system R&D and demonstration.

The present applications of photovoltaic systems in Korea are limited to stand-alone systems for lighthouses, telecommunication, telemetry and electrification of remote islands, where electric power is not available from the existing electric power grid. The number of PV applications installed as of the end of 1991 is about 3,231, with an installed PV capacity of about 1,245 kWp.

Since the Maritime and Port Administration started installation of small photovoltaic systems for unmanned lighthouses in 1972, the lighthouse has become one of the most enthusiastic areas of photovoltaic applications in Korea. The total number of lighthouses in Korea is 656. As of December 1991, 497 unmanned lighthouses of small capacity and 14 manned lighthouses, of 6-8kWp capacity have been replaced with photovoltaic systems with the total capacity of 120 kWp.

Photovoltaic systems for telecommunication are the largest application area, because the Korea Telecommunication Corporation employs a aggressive plan to construct Direct Distance Dialling systems all over the country and broadcasting companies also install photovoltaic systems for relay stations at remote islands, with the total capacity of 820 kWp.

Korea is surrounded by the sea on its three sides and has about 4,000 islands along its coastline, of which 518 are inhabited. Of these 248 islands are provided with a grid network that enables to supply them with 24 hour electricity. Islands far from the coast use diesel power systems for electricity or remain unelectrified. The Government is currently proceeding with projects to use PV power systems in the supply of electricity to 206 islands each with households under 50.

The expected PV market is estimated about 10MWp for the rural electrification, 1 MWp for a photovoltaic power generation plant and about 1 MWp for manned lighthouses telecommunication and telemetry by the early 2000's.

7. AUSTRALIA COUNTRY PAPER # 2 - CASE (Mr G Eley)

Australia is immediately adjacent to South East Asia and the South West Pacific and is in close proximity to the countries facing the Indian Ocean. Many of the world's developing countries are in these areas. Australia has developed strong links with research and commercial organisation concerned with solar energy in these regions and enjoys good relations with all respective governments. The climate in Australia is also conductive to solar technology research and utilisation. The country is unusual in that it has the combination of the industrial and research infrastructure of a developed country with some of the problems of developing countries. These occur in many of the isolated Aboriginal settlements in the interior of Australia. To meet the energy needs of these communities, Australia has had to develop mature solar research development, testing and manufacturing infrastructure.

UNIDO has proposed the establishment of several international Centres for Applications of Solar Energy (CASE) as a means to accelerate the adoption of solar energy technologies, particularly within the developing countries of the world. Australia has been chose as the site for the first CASE facility with the Centre to be located in Perth, Western Australia. The mission of the Perth Centre for Applications of Solar Energy is to bridge the gap between research and development organisations, innovative enterprises and the market place within developing countries to stimulate appropriate application of solar energy technologies and solar energy-related industrial development within developing countries. "Solar Energy" in the Perth CASE context, is the general term for a range of renewable energy forms which use the energy inherent in sunlight and the direct and indirect results of its impact on the Earth.

The objectives of the Perth CASE will be to:

* facilitate the development and application of solar energy technologies which are appropriate to the needs of developing countries;

* support the commercialisation of solar energy technologies and facilitate the transfer of the associated production technology to developing countries;

* advocate the adoption of solar energy technologies, particularly within the developing countries, and support policy measures which lower existing barriers to adoption;

* promote international collaboration between institutions, energy agencies and commercial entities operating in the field of solar energy; and

* act as a catalyst to support the establishment of other regional CASE facilities preferably within the developing countries in other regions of the world.

The Australian Federal Government and the Government of Western Australia will provide funding amounting to A$5 million over five years. The Perth CASE will be a "flat" organisation for which administration overheads and core salary costs will be provided by Australian Governments. The financial structure is designed to limit expenditure on administrative activities so as to maximise funds for operational activities. This is to encourage project funding by multilateral development financing organisations. The CASE will place a high priority on training and on facilitating and funding the establishment of testing and manufacturing expertise within developing countries which it seeks to assist.

DISCUSSION

There was a question about the development of PV water purification. A U.V. system has been tested in Australia.

8. THAILAND COUNTRY PAPER (Mr Amnvay Thongsathitya)

The power sector of Thailand consists of three enterprises: the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA). In addition, the Department of Energy Development and Promotion (DEDP), a government agency, is responsible for energy exploration, planning, promotion, regulation and development of all forms of energy.

At the end of the 6th NESDP (September 30, 1991), out of 61,205 rural villages in PEA's service areas, 58,334 villages or 95 percent of total villages were electrified. By the end of fiscal year 1992, 60,718 villages or about 98 percent of the total 62,262 villages in the PEA's service areas have already been supplied with electricity. Under the 7th NESDP 1991-1996, PEA has planned to continue extending the service supply to rural villages which will rise the percentage of rural electrification to saturated rate of 98%. However, approximately 25 percent of scattered households in rural electrified villages are not connected to the supply.

Most PV projects in Thailand are independently conducted in governmental organisations with its own objectives, application and policy. The main users with substantial PV installations are; DEDP, PEA, EGA, Telephone Organisation of Thailand (TOT), Public Works Department (PWD), Ministry of Education (ME), Ministry of Public Health (MPH).

The PEA owns and generates 3 stand-alone PV power plants donated by the government of Japan under a co-operation programme. There is no indication that PEA would continue to expand its PV activity in the near future.

EGAT has included PV in its renewable programme since the late 1970's. According to EGAT's inventory, about 50 kW of PV modules for various technologies are procured from more than 10 different manufacturers. The applications are; warning lights, camp lighting and communications, microwave repeaters and grid connected demonstration plants. EGAT has been collecting all technical data on PV performance.

TOT has already powered more than 50 microwave repeaters with about 100 kW/PV modules. All are poly-crystalline silicon modules supplied by Solarex, ME has introduced 20 kW PV modules for remote primary schools. They use this solar electricity for a programme on "Education by Radio". All PV modules are single crystalline silicon supplied by local manufacturers.

There are three local manufacturers of PV modules in Thailand; BP - Thai solar, Solartron and Pan-Siam Engineering. These are joint venture/technology companies with back-up from foreign companies. They import ready-made soiar cells from various sources in world market for panel assembly. The annual production capacity is several hundred kW and exceed the local demand, because of small PV market in Thailand. The production of PV modules is, therefore, not constant but depends on block buying from time to time. The typical price for locally PV produced modules is approximately 7-9 US$/Wp, depend on the order quantity.

In order to promote the realisation of PV technology in Thailand, a PV working group was established in 1987 under sub-committee on Energy Research and Development Coordination (SERDC), National Research Council (NRC), Ministry of Science, Technology and Environmental (MOSTE).

Under the 7th NESDP 1992-1996 the number of electrified villages will be 98%, consequently, more than 1,000 scattered rural villages are still non-electrified because of construction problems and unfeasible considerations. The government has set up a clear policy on rural development, that these villages must be electrified. This provides the main potential for the PV market to develop.

DISCUSSION

The discussion centred on the fact that there are three PV manufacturers in Thailand, but their prices are higher than the general world market price, and their production capacity is greater than the market demand.

9. PHILIPPINES COUNTRY PAPER (Dr C G Zamora)

The Philippine Department of Energy (DOE) was created in January 1993, in response to worsening energy problems. The Non-Conventional Energy Bureau (EUMB) is mandated to accelerate the development, promotion and commercialisation of renewable energy technologies. PV is considered on a first priority technology in the present 1993 - 1996 medium-term Non-Conventional Energy Programme.

A Philippine-German co-operation programme was commenced in 1981 - this introduced R&D in PV technology in the Philippines. The main component of then was the installation of a 13.3kWp grid-connected village central power plant. This was used for testing and training purposes. It was shown that this was an uneconomic option for rural electrification. The second phase of work moved towards small scale individual applications. These have been shown to be commercially viable.

The third phase of work was to demonstrate the commercial viability of introducing PV house systems in unelectrified areas through co-operatives. Local co-operatives were established to market, finance, install and maintain PV systems. The technology and concept is promoted through word-of-mouth advertising. Finance has been provided by the Development Bank of the Philippines (DBP). DBP loans money to the co-operatives to purchase the systems from a supplier. Interest charged is 13% lower than the normal lending rate of 25%. The co-operative in turn provides financing to consumers who make a 25% down payment and equal monthly payments over three years.

Many practical lessons have been learned from the commercialisation experiences. These include choice of PV applications, and quality of product , consideration of rural electrification policy, choice of organisation to co-operate with and development of sound financing.

At present in the Philippines there are at least seven active suppliers of PV systems. The government plans to pursue a comprehensive non-conventional energy programme. Plans for PV include:

* Development of measures for the improvement of the supply of solar technologies or rural areas (improvement of the general conditions, systems, and marketing)

* Development of measures to intensify the acceptance and demand for solar technologies for rural areas (demand analysis, demonstrations, maintenance services, financial instruments)

* Development and identification of a strategy for the dessimination and commercialisation of solar energy technology

* Development of requirements for advanced training related to solar energy.

International collaboration, such as the FINESSE Programme, is an important aspect of the Philippine activities:

DISCUSSION

There was discussion about the prices paid for PV Systems. A single PV module with two lamps but without battery costs around $720 - $1,000. Import tax should be 40%, but this is not included in the prices charged.

10. JORDAN COUNTRY PAPER (Mr M A Kabariti)

Water Pumping in remote and isolated areas in Jordan, is achieved by diesel power engines. Utilisation of such systems is associated with high running cost, maintenance problems and pollution. A study showed that the substitution by PV of the normally oversized diesel powered engines will be cost effective especially because the pattern of consumption coincide with the availability of solar radiation when a PV system gives its maximum power.

Co-operation projects with Germany, Egypt and Iraq has led to the projects to install 15 PV pumps. These range in PV power from 1.3 to 5.5 kWp.

Other parts of the paper dealt with solar water heating and wind energy.

DISCUSSION

Questions were asked about the total amount of PV installed in Jordan, but this was unknown.

11. AUSTRALIA COUNTRY PAPER #3 - Solar Thermal Power (Dr D R Mills)

Solar Thermal Electricity (STE) can be generated on a large multi-MW scale, as demonstrated by Luz. The current Luz STE plants in California achieve an annual average of 15.5-17% net conversion of solar radiation to electricity, far higher than the average efficiency of current large PV plants, and at a far lower cost. The STE technologies currently under development in Australia should result in annual conversion efficiencies in excess of 20%, equal to the long term goal of the low-cost polycrystalline PV industry, and much above that of amorphous technology. STE efficiencies in exceptional solar climates may substantially exceed 20%.

More important than a discussion of efficiency is an estimate of cost. Cost projections of the Sydney University STE technology (about US$1.20/Wp) are similar to long term goals for PV, but STE will be available much sooner at this price. This is a critical issue with regard to carbon pollution amelioration, since it is necessary to have technologies in place before the rapid development cycle anticipated for developing countries during the coming decades. PV has the great disadvantage in that either electrical storage or a full backup system must be provided at considerable extra cost. This limits the economic advantage of even a very low-cost photovoltaic array. It now appears that STE plants with storage will not cost more than daytime-only plants per kWh(e) of electricity produced, and because a steam turbine is used, only backup fuel is required, not an additional backup system.

Globally, the quantity of solar electricity currently produced by STE substantially exceeds that of PV, and it is likely that this gap will substantially grow in the next decade after 'second generation' STE technology arrives. While PV has undeniable advantages in certain markets, any rapidly industrialising country must now look to both technologies for future generating requirements, with STE being preferred for grid-based applications.

The paper presented a detailed review of STE technologies, especially those under development in Australia.

DISCUSSION

There was discussion of PV in comparison with STE. The claims that STE is less expensive for very large (multi-MW) plants was generally accepted, but several participants pointed out that electric utilities had experimented with STE technologies and now lost interest, prefering PV. But it was also claimed that utilities are more 'comfortable' with thermal power generation.

12. VIETNAM COUNTRY PAPER - (Nguyen Van Le)

Silicon PV cell fabrication has been investigated in Vietnam since the 1970's at the Polytechnic University of Hanoi. A variety of samples including cells, modules, sub-modules were obtained. Test data showed that the performance of these samples were poor in comparison with those imported from abroad. The main reason for poor performance is the technology for making monocrystaline silicon, wafers, ohmic contact and encapsulant material. Because of poor performance of cells and unavailability of encapsulation technology, the fabrication of PV cells was not technically and economically viable and was abandoned until recently.

Although the rural electrification is being continued at intensive level in Vietnam, vast areas of the country will remain unelectrified in several decades. Central generation and distribution systems are very expensive and time consuming to implement. Like most rural areas in developing countries, the need for electricity utilisation by the rural people in Vietnam is limited to lighting, running radio/TV and some other small appliances. In locations not connected to the utility grid, if every house were provided with a 60 - 80 Wp panel, the standard of living of rural people would be increased appreciably.

During the last few years more than 100 small stand-alone photovoltaic systems ranging from 50 Wp to 500 Wp each, have been installed for various purposes in Vietnam. Among them, about 30 are used for "buoy aqua sign", located close to Hai Phong port, for warning lights and some 50 research - cum - demonstration systems are installed for domestic uses, several systems are mounted in village authority offices and cultural houses, while others are for communication purposes.

In 1993 - 1994 around 300 of stand-alone PV systems are planned to be installed aiming at improvement of cultural life of people living in mountainous and remote areas of the country. This programme will be financed by "National programme for Socio-economic Development in Mountainous Regions". Electricity supply network extension is one of the maim objectives of the programme, in which photovoltaic application is an important component.

The high price of PV panels is a major problem in realisation of these projects. Vietnam, at present, is not capable to produce PV cells indigenously. There are several research centres making monocrystalline solar cells but only at laboratory scale. In such a situation, the supply of photovoltaic panels is highly dependent on import policy.

13. KOREA COUNTRY PAPER # 2 (Dr Tai Kyu Lee)

The mission of Korea's National Photovoltaic Programme is to help industry develop photovoltaic technology for generation of economically competitive electric power in Korea, making PV a significant part of the national energy mix. This programme emphasises its role in supporting research to bring the cost of photovoltaics technology to compete with conventional electricity generation early in the next century.

Key technologies in the long-term programme are:

Phase I (1989 - 1991): - Development of mass production technology for low cost and high efficiency crystalline Si solar cells; - Performance improvement of inverters and lead-acid batteries for PV systems; - Field experience and standardisation of stand-alone systems for remote islands.

Phase II (1992 - 1996): - Development of production technologies for large area, high efficiency, and high reliability amorphous Si solar cells; - Development of advanced batteries for photovoltaic systems; - Establishment and standardisation of three technologies for test and evaluation systems.

Phase III (1997 - 2001): - Development of production technologies for low cost and high efficiency thin film PV cells; - Field experience and standardisation of grid-connected systems.

In order to validate results of the first phase and for demonstration and testing a 90 kWp photovoltaic system was constructed at Hodo island in April 1993.

The current status of applications of photovoltaic systems is reported that the number of PV applications installed as of the end of 1991 is about 3,231 with an installed PV capacity of about 1,245kWp.

Since there are about 4,000 islands in Korea, electrification of remote islands utilising PV electricity generation system is most attractive approach. Government starts to provide PV power system for supplying electricity at the unelectrified islands under 50 households. There are four application of PV system as a power source to supply electricity for the remote islands.

The first 35 residential-scale (25 kWp) PV system has been installed and in operation since 1988 at 0.56 km^2 Hawado island. The next PV system for demonstration test constructed was on 0.3 km^2 Maradi island is 22 household-scale (about 30 kWp). This PV system has been designed and generation system supplies electricity for 24 hours.

With domestic technologies and instruments government continue to put an effort for the electrification of the remote islands. As a part of this programme, 30 kWp photovoltaics and 2 kW wind hybrid system is being constructed at Wangdeung island in Chillabukdo since March 1993. Since the first step of the PV programme's strategy is to improve the cost effectiveness of PV devices and modules including subsystems for PV electricity network, this program supports promising concepts using a variety of material and different designs and production methods that can meet the programme's goal. The future goals will be examined with respect to present materials and process cost and achieved efficiency results. In order to achieve future goals many PV projects will have government support, so reported costs may include subsidies or tax credits.

DISCUSSION

There was discussion about PV manufacture in Korea. Output is about 300kWp/year at a selling price of $6/Wp.

14. INDIA COUNTRY PAPER (Mr R C Gupta)

In India, Central Electronics Limited (CEL) has pioneered the development and commercial production of PV cells, modules and systems. CEL uses state-of-the-art single crystal silicon technology developed completely in-house, with a product profile catering for small rural to large industrial applications. CEL is strong in all aspects of PV including R & D on cells, system design, manufacturing and support capabilities built and nurtured over more than a decade. The thrust at CEL is in two directions; (i) To bring down PV cost by improvements in manufacturing methods and increase in production volumes, (ii) To develop innovative and cost effective applications both for individuals and community use.

Power plants being one of the major segments of PV business for CEL, there is an ongoing programme for their development. Experience has shown that for a power plant providing AC output, power conditioning unit (PCU) is the most critical equipment influencing the performance and cost of the plant.

Intense developmental efforts have been put on the power plants up to 25kWp capacity. Keeping in view the reliability and standardisation of BOS equipment's, a modular approach has been the central idea for such plants. Recently a 10 kWp power plant has been set-up at Madras, where the PV Array has been divided into three sub-arrays, each feeding into a corresponding Power Conditioning Unit (PCU). The battery is common to the three sub-arrays and PCUs. The AC power requirement is fully met by two PCUs, hence for the AC output, always 50% spare capacity is available ensuring no power outage.

CEL has attained maturity in the large power plant technology. Already under execution are two 100 kWp power plants. Each power plant is made up of two phases (i) Stand-alone (ii) grid interactive.

Stand-alone mode utilises three quarters of the PV power which in conjunction with battery bank and three PCUs (each 25 kWp/25kVA) supplies power to the whole village meeting lighting and water pumping needs of the village. This is another example of CEL's strong conviction about modular approach. 25kWp array and a grid interactive PCU without battery storage, form phase-2 of each power plant. DC electricity from the array is inverted into 50Hz, 3PhAC compatible with the 11kV grid to which the power is fed. Phase-1 for one of the plants is already operational since May 1993. For the second plant, Phase-1 is almost complete and likely to illuminate the village in a few weeks time.

Technical aspects of PCU's were described in detail.

DISCUSSION

Questions were asked about India's national PV programme. This includes a project aimed at installing 50,000 PV pumps.

15. CHINA COUNTRY PAPER - (Mr Xu Yong Hou)

In China, PV technology research was started in 1958. Over the past 30 years the Chinese Government has made an investment of more than RMB 40,000,000 yuan to this field for R & D. At present in China the number of institutes, universities and factories which are engaged in PV R&D totals more than 40.

PV technology was started for space applications and at first used in this field. During the period of 1970 - 1991 China launched 28 man-made satellites successfully, the satellites were for scientific experiment, communications, and meteorological research.

Over the past 10 years Chinese research centres have studied crystalline and amorphous silicon. At present there are 20 state standards and 6 ministry standards for PV cells and standard PV cells have been developed.

In order to help China to develop the solar thermal applications in western China, in 1981 UNDP provided Natural Energy Research Institute of Gansu Academy of Sciences financial aid to build up the Solar Heating and Cooling Technology Experiment and Demonstration Centre. Based on this project, the Institute has started a new project "UNCPR 88/00 2 Project Development of Application Technology of PV in Western China". In 1988 the main outputs of this project are: (1) 11 different kinds of demonstration systems for PV; (2) Training PV technical personnel; (3) Preparing the key technology and laboratory for popularising PV application systems. At present the Project is well established and a PV laboratory has been set up at the largest demonstration centre which located at Lanzhou City, Gansu Province.

At present there are 7 production plants for PV cells in China. Among them five lines are for single crystalline Si, two for a-Si. Three pilot production lines for solar cell have been established using home technology. There are 17 manufacturers of solar cells in China. The total capacity of them is 4.5MWp/year. The volume of sales of the module of single crystalline Si and the module of the polycrystalline Si was 15 kW in 1981, and up to 450 kW in 1989, and the production level attained the international level of the early middle years of the 1980's. The accumulation amount of applications was 1MW by the end of 1981. In 1990 the selling price is reduced down to RMB 35-45 yuan/Wp from that of 1981 RMB 75-80 yuan/Wp.

By the end of 1989 the cumulative total amount of PV applications amounted to 12.5 MWp. The amount of output of electricity is 400,000 kWh/year. PV is commonly used in agriculture, transportation, communication, weather stations, seismic stations, medical and health establishment, defence, space and other fields. The scale of the system used is from a few watts, ten watts to several thousand watts. There are 4 power stations with capacity of 5 - 10 kW throughout the country. There are 12 series, about 100 varieties of PV systems used in railway signals, communication and other fields of industries and defence. Only the Si solar cell generating devices the total amount is more than 10,000 sets and the capacity is 400 kw.

Although the capacity of production lines of solar cells in China is 4.5MWp/year the output of them is only about 400 - 500 kWp/year, the utilisation of capacity is only 10% so the market for PV must be developed and the utilisation of capacity must be raised. The problems of product quality and price for the enterprises must also be solved.

DISCUSSION

There was extensive discussion on costs of PV in China and the appropriate exchange rates to use. It was noted that the 12.5 MWp installed is high compared to the small annual production. This was suggested to be accounted for by space applications. The point of production capacity being ten times demand was debated. It was concluded that markets should be developed before investing in production.

16. ITALY COUNTRY PAPER - (Dr C Messana)

In Italy, environmental concerns add up to the need for diversifying energy sources and exploiting, as much as possible, national resources. Italy's energy structure is characterised by an abnormally high dependence on energy imports (more than 80% of primary energy needs) and, in particular, oil imports, which constitute at present about 55% of the total energy budget. Electricity generation relies almost solely on oil and gas fired power plants; and a significant fraction of electricity needs (about 15%) has to be imported.

On the other hand, the options available to change this situation appear very limited. As a consequence of a popular referendum, Italy has shut down operating nuclear power plants and has decided to stop the construction of new plants, until intrinsically safe nuclear technologies become available. Also, the construction of coal fired power stations is becoming increasingly difficult, or impossible, due to environmental concerns of population and local authorities. In this frame, the development of renewable energy sources acquires a strategic importance that is greater, possibly than in other industrial countries. In the Italian programme on renewables, the highest priority is given to photovoltaics. In Italy, the energy potential of photovoltaics is very high, due to the favourable climatic conditions.

In the southern regions of the country and in the islands, there are large extensions of land which are not suitable for agricultural purposes but are characterised by insolation levels as high as 1600-1800 kWh/m^2/year In a long term perspective, a massive use of photovoltaic plants in these areas could significantly contribute to supply the national electricity demand.

The guidelines of the Italian PV programme have been defined by the National Energy Plan (PEN) approved by the Italian Parliament in 1990. PEN's main strategic objectives are, on one hand, the diversification of energy sources and supplier countries and, on the other hand, the full exploitation of national energy resources, with a specific attention to renewable energies. In the frame of this strategy, the PEN pursues the development of photovoltaics as a national source for large scale electrical power generation. The activities planned by the PEN to achieve this goal regard the development of new materials for photovoltaic use, the development of industrial technologies for module mass production and, finally, the construction and operation of pilot plants for research and demonstration purposes. In particular, in order to sustain market growth, exploit scale economies due to mass production and disseminate the technical know-how about construction and operation of PV plants, the PEN foresees an installed power of 25 MWp by 1995.

the main operators active in the photovoltaic field are: ENEA, the Italian National Agency for New Technology, Energy and the Environment; ENEL S.p.A., the National Electricity Utility; and the photovoltaic companies Anit, Eurosolare and Helios Technology

ENEA has been carrying out for many years a wide ranging programme on photovoltaics. At present, according to PEN guidelines, the program covers all the relevant aspects of photovoltaics technology, from research on materials and devices up to industrial promotion and demonstration of innovative applications. ENEA activities have been increasingly focusing on power generation by means of small and medium size grid connected plants.

To this purpose, at the Monte Aquilone facility, ENEA has built the Delphos plant (600 kWp) which is currently used to study the operation of medium size grid connected plants. A second testing station, dedicated to small systems (2-3 kWp) for dispersed generation (e.g. roof tops) is under construction. On the whole, up to now ENEA has promoted the construction of pilot plants for about 1 MWp of installed power: other plants for a power of about 0.5 MWp have been already planned and will be completed within 1994.

ENEL is carrying out a multiyear comprehensive programme of research, demonstration and application of PV systems. This is aimed at promoting the achievement of energy significance of the PV source. To this purpose, the programme covers both applications already cost effective or close to the economical competitivity and applications suitable, in the long term, for bulk power generation. The main actions of the programme are:

* continue early uses of photovoltaic in applications already cost effective (power supply to isolated remote users). Today, every time that a new remote house has to be serviced, it is routinely rested the possibility of installing a stand alone PV plant instead of connecting the user to the grid;

* install PV plants to power isolated remote communities (e.g. small islands) or in stand alone configuration or in connection to the local diesel-powered grid (PV as fuel saver); this application can be cost effective depending on local situation;

* install photovoltaic roof-tops for dispersed generation

* design, build and test on the field scalable photovoltaic central power plants suitable for mutimegawatt power stations.

The most important result of ENEL programme has been the 3.3 MWp Serre (Salerno) plant. The plant, at present under construction, will be completed within 1994; at that date, the total PV power installed by ENEL will be about 4 MWp. The new ENEL programmes, at present in course of definition, foresee the construction of other 6MWp of PV plants by 1998.

Anit and Eurocolare are two medium size firms founded by Agip (the Italian state-owned oil company) and Ansaldo (a large state-owned electromechanical company) to operate jointly on the PV market, Anit, owned jointly by Agip and Ansaldo. Eurosolare (60% Agip and 40% Anit) produces cells and modules by using single crystal and polycrystalline silicon. Helios Technology is a private company which operates in the market of cells, modules and small stand-alone systems both in Italy and abroad, by means of joint ventures with Finnish and South-African companies.

DISCUSSION

There were questions about the cost of electricity from the large PV plant. This amounts about US$0.40/kWh. It was suggested that solar-thermal electricity would be less expensive. ENEL is not interested in this technology.

17. SWITZERLAND COUNTRY PAPER - (Dr H Keiss)

Switzerland has shown a new awareness in the ecological aspects of the use of energy. This leads to a willingness to use energy more rationally, and objectiions against the use of conventional energies. This has resulted in significant work on renewable energy technologies and photovoltaics in particular.

There are demonstration projects carried out by industry and supported by the Government. Integration in buildings has been very important and there are demonstrations in the range of 1kWp to 50kWp. There is a large central PV power station of 500kWp at Mont Soleil.

DISCUSSION

There was discussion about incentives for PV. There is a government programme and a lot of public interest in PV. It is normal for domestic electricity meters to be two-way, so that the utility pays for PV electricity at the same price as it charges.

18. NOTES ON SOLAR HOME SYSTEM COMMERCIAL OPPORTUNITIES IN INDONESIA

Presentation by Ucok Siagian, Centre for Research on Energy
Institute Teknologi Bandung.

The use of individual solar photovoltaic panel home system has been introduced in Indonesia through demonstration projects, government grants, or government funded semi commercial schemes. A pilot of rural electrification using PV solar home system (SHS) was implemented in Sukatani Sukabumi in 1988/1991. The project installed around 100 units of SHS (80 Wp/unit). Through a thorough monitoring programme it was found that the technology is technically reliable and socially acceptable.

Following the success of the Sukatani project a number of dissemination programmes have been launched. Presidential aid financed around 3000 units (45 Wp panels) through a revolving fund scheme. Similar schemes are also applied using regional government budgets. In these projects the recipients of solar installations are required to repay the price of the installation in monthly basis scheduled to be completed in 8 - 10 years time. In some projects SHS users are required to provide down payment for the equipment procurement.

In all cases the dissemination programme has not been implemented on a purely commercial basis. A government contribution (subsidy) is provided in the form of grants or specially arranged low interest rate loan scheme for rural cooperatives. in these programmes monthly payments by end-users are in the range of Rp 7500-10,000. In many cases, particularly in remote areas where supply from the national grid can not be accessed, the economics of solar home system has been proven to compare favourably with other power generation technology options. The use of SHS to replace kerosene lighting and re-chargeable batteries of the same output is also found economically feasible.

The presentation suggested that the aggressive promotional activities of photovoltaic system suppliers, some donor countries and government agencies has resulted in the wider belief about the benefits of the application of that technology. In terms of government sponsored programme, there are some truth to that belief. However, at current economic condition and considering the economics of the system, some notes of caution is in order.

Economic calculations were presented.

DISCUSSION

There was extensive discussion about the need for subsidy and the need for no subsidies. Subsidies are required to get programmes started, but lending institutions do not approve of subsidies. No consensus emerged.

19. PV DESIGN USING LOSS OF ENERGY PROBABILITY METHOD

Presented by Dr I I Tarigen

Using the loss of Energy Probability (LOEP) method, a computer programme for designing a stand alone Photovoltaic system has been developed. In this programme global solar radiation, latitude of the location, characteristics of the cell and average load per day to be supplied by the PV system, had been used as input data. The output of the programme were peak watt of the system, battery capacity and the total price of the system. This programme had been applied in sizing a PV system to be installed in Wamena, Irian Jaya hinterloand.

Results show that the higher the reliability the lower the value of LOEP.

20. AUSTRIA COUNTRY PAPER (Mr G Shauer and Dr A Szeiess)

The Austria paper was received by fax.

Austria generates 60% of its electricity by hydro-power. In 1978 the use of nuclear energy for electricity generation was prohibited by popular referendum, and already constructed nuclear power plant was never brought into operation. Because of this Austrian utilities looked at alternative - electricity generation technologies, and commenced a programme to construct, test and utilise photovoltaic power stations.

Austria participates in international programmes including the International Energy Agency Solar Heating and Cooling - Task 16, Photovoltaics in Buildings, and the recently launched Photovoltaic Power System Programme. Austria also collaborates in a EUREKA project, with Finland and Germany.

At present the total installed photovoltaic power in Austria amounts to approximately 580 kWp, which is roughly distributed as follows: 150 kWp are installed in small stand-alone systems such as summer cottages, recreation applications, etc; 83 kWp are attributed to larger stand-alone systems like radio transmitters and mountain refuges; 147 kWp are grid-connected PV plants; 100 kWp of which are operated by the utilities; 200 kWp photovoltaic rooftop programme. These small PV plants are grid- coupled and their investment costs are subsidised up to 35% by the electric utilities.

In the past eleven years Austrian electric utilities have been engaged in many photovoltaic projects. Each of these grid-connected PV systems is different in design, size and equipment. Already a wide range of experience and know-how has been acquired.

In May 1992 the Austrian 200 kWp Rooftop Programme was started. The idea was to use existing structures for mounting solar modules more economically without unnecessary land use. The main goal is to demonstrate the feasibility of integration of small scale PV systems into local low voltage grids and to prove their reliable operation with satisfactory availability. Great importance was given to the economic assessment of such systems. Up to now PV rooftop systems of almost 160 kWp were funded by the programme. Meanwhile it is intended to extend the programme.

An interesting project is a 40kWp installation on the sound barriers of a motorway.

The aim of constructing this PV power plant was trying to minimise the costs for supporting structures by using the roof of the already existing sound barriers of the motorway A1 near Seewalchen in Upper Austria. Furthermore, a new type of inverter was tested. There was great interest in testing the behaviour of PV modules in a dirty environment like the motorway.

V LIST OF PARTICIPANTS

No	NAME/POSITION	COUNTRY	ORGANISATION/ADDRESS
1.	Prof. Martin Green Director	Australia	Centre for Photovoltaic Devices & Systems, The University of New South Wales, Electrical Engineering Building, PO Box 1, Kensington NS 2033, Australia, Tel: 02 697 4018, Fax: 61 2 662 4240
2.	Dr David R Mills	Australia	University of Sydney, Department of Applied Physics, NSW 2006 Australia, Fax: 61 2 660 0703
3.	Graham Eley Co-ordinator	Australia	CASE 170 St George's Terrace Perth Western Australia 6850
4.	Xu Yong Hou Director, Senior Engineer	China	GNERI 77 South Dingxi Road, Lanzhou, China, 730000 Tel: 86 931 25211 - 2057 Fax: 86 931 486243, Cable: Lanzhou 2521
5.	A Goetzberger	Germany	Fraunhofer Institute for Solar Energy systems, Oltmannsstrasse 5, D-79100 Freiburg, Germany Tel: 07 61 4588, Fax: 07 61 4588116, Telex: 17 761187
6.	R C Gupta Asst. General manager (Special Projects & Development	India	Central Electronics Limited, 4 Industrial Area, Sahibabad 201 010 (U>P>) India Tel: 8761065 Fax: 091 011 8731843

7.	Dr Rachmat Mulyadi Head of Technology Division	Indonesia	BPP Teknologi, Technology Implementation Unit, Energy Technology Lab., Psspiptek Serpong, Tengerange 15310, Indonesia Tel: 7560133 - 49 Ext 1177
8.	Ababakar Lubis Head of Sub Directorate of Power Plant Safety	Indonesia	Agency for the Assessment & Application of Technology (BPP Teknologi) BPPT Building 14th Floor, JL M H Thamrin No 8 Jakarta 10340, Indonesia Tel: 021 322942 334343 Fax: 62 021 334342 Telex: 61321 BPPT IA
9.	Drs Adjat Sudradjat, MSc Kelmopok Fotovoltaik	Indonesia	BPP Teknologi, Unit Pelaksana Teknis, Laboratorium Sumberdaya Energi, Puspiptek Serpong, Tangerang 15310, Indonesia Tel: 7560133-49 Fax: 7560904
10.	Dr L M Panggabean Head of Laboratory	Indonesia	Agency for the Assessment & Application of Technology, Technical Implementation Unit- Energy Technology Laboratory (UPT-LSDE), Puspiptek-Sepong, Tangeranr 15310, Indonesia Tel: 021 7560904, 7560916 Telex: 45512PPIT IA
11.	Drs Agus Salim Dasuki M.Eng, Director	Indonesia	BPP Teknologi, Gedung BPPT Lantai 14, L M H Thamrin No 8, Jakarta 10340 Indonesia Tel: 62 021 322942, 334342 Fax: 334342 Telex: 61321 BPPT IA

12.	Edy Iskanto High Voltage Department	Indonesia	Perusahaan Umum Listrik Negara, State Electricity Corporation JL Listrik Negara, Duran Tiga, PO Box No 1/KBYT, Jakarta Selatan, Tel: 7992098, 7993908, 7982035 Fax: 021 7991762
13.	Ir. Mega Luminar Msc	Indonesia	Perusahaan Umum Listrik Negara, Pusat Penyelidikan Masalah Kelistrika, Jl Duren Tiga, Jakarta 12760, Tel: 799 2098, 7993908, 7982035
14.	Immanuel Iman Tarigan Senior Research Scientist	Indonesia	Research and Development Centre for Applied Physics, Indonesia Inst. of Sciences, Bandung 40135, Indonesia Tel: 62 022 2503050, 2503052 Fax: 62 022 2503050 Telex: 28491 PPPFT IA,
15.	Roswilman Rusli Photovoltaics Manager	Indonesia	B P Solar, BP South East Asia Ltd Kuningan Plaza, South Tower Suite 401, JL H R Rasuna Sand, Jakarta 12941 Tel: 4200823/4200481 Fax: 4200052 Telex: 4973 PT KMAN IA
16.	Z Harahap President	Indonesia	P T Haras Tantra Dipoda, Prince Centre, 7th Floor Suite 703 JL Jend, Sudirman Kav 3-4 Jakarta Pusat, Indonesia Tel: 5703328-587644 Fax: 5703328 Telex: 62080 GAMMAZ IA

17.	Ir. Ucok Slagian Research Associate	Indonesia	Institut Teeknologi Bandung, Centre for Research on Energy, Jalan Ganesha 10m PO Box 426, Bandung 40001 Indonesia Tel: 022 84252-84258 ex 498 Telex: 28763 LPPITB IA
18.	Ir. Amien Rahardjo DEA Sekretaris Jurusan Elektro	Indonesia	Universitas Indonesia, Teknik, Jl Manggis 11B.4 No 4, Tanjung Duren, Grogof, Jakarta 11470
19.	Ir I Farniwa M Kartadinata Staff Laboratorium	Indonesia	Universitas Indonesia, Kantor Jt Salaba 4, Jakarta Pusal, Tel: 3906969
20.	Rob De Lange	Indonesia	PT R&S Rekadaya, Energie Surya, Jalan Banyumas 4, Jakarta 10310 Tel: 390 4071-3, Fax: 361 639
21.	Nenny Sri Utami	Indonesia	Ministry of Mines & Energy Directorate General of Electric Power and New Energy, J I H R Rasuna Sai Blok X-2, Kav 07-08 Kuningan, Jakarta Seletan, Tel: 021 512108, Fax: 021 516044
22.	Michael Adrian Dipl-Ing Project Leader,	Indonesia	TUV Reinland, Institute for Energy, Technology and Environmental Protection, Renewable Energies Indonesia c/o BPP Teknology, 14th Floor, JI MH Thame, Jakarta 10340 Tel/Fax: 021 321662 Telex: 61331 boot a

23.	Ir Tjahjana Adi, MSME Assistant Director	Indonesia	Gadjah Mada University inter University Centre for Engineering Science, PAU Limu Teknik, JL Teknika Utara, Barek Yogyakarta Tel: 0274 65834 Fax: 0274 64239 Telex: 25135
24.	I Nengah Sumerti	Indonesia	Jurusan Teknik Elektric, Fakultas UGM, EL Grafika No 2, Yogyakarta
25.	Dr Calogero Messana Capo Progetto, Sistemi Fotovoltaici	Italy	ENEA, 00100 Roma, Casaccia SP Anguillarese 301, Tel: 06 3048 4675
26.	Malek A Kabariti	Jordan	Renewable Energy Research Centre The Royal Scientific Society, PO Box 925819 Amman-Jordan Tel: 962 6 844701 Fax: 962 6 844806, Telex: 21276 Ramah Jo
27.	Tai Kyu Lee, Ph.D Senior Researcher, Thermal Research Dept.	Korea	Korea Institute of Energy Research PO Box 5, Taedok Science Town Taejon 305-343, Korea Tel: 042 860 3561-3560 Fax: 042 861 6224 Telex: Kierel K 45507
28.	Bu-Ho Kim	Korea	71-2 Jangdong, Yusongku, Taejon, 305-343, Korea Tel: 042 860 3414 Fax: 042 861 6224 Telex: Kierel K 45507
29.	Christopher G Zamora Supervising Science Research Specialist	Philippines	Department of Energy, Merit Road, Fort Bonifacia, Makati, Philippines

30.	Helmut Keiss Physicist, Senior Scientist - Material Research	Switzerland	Paul Scherrer Institute Zurich Badenerstrasse 569, CH-8048 Zurich, Switzerland Tel: 010 492 6350 Fax: 010 491 0007 Telex: 822 373
31.	Amnuay Thongsathitya Chief, Energy Prototype and Testing Section	Thailand	Department of Energy Development and Promotion, Rama 1 Road, Yodse, Bangkok 10330, Thailand, Tel: 221 1853., 221 1877 Fax: 226 1416
32.	Nguyen Van Le Project Manager Solar & Wind Energy Division	Vietnam	Khuong Thuong, Donga Da, Hanoi, Vietnam, Tel: 84 4 263739 Fax: 84 4 263311 Telex: 412317 insen vt
33.	Bernard McNelis Managing Director	U.K.	I T Power Ltd The Warren, Bramshill Road Eversley, Hampshire RG27 0PR Tel: 0734 730073 Fax: 0734 730820
34.	Fernando Z. Vicente Country Director	UNIDO	UNIDO c/o UNDP PO Box 2338, Jakarta 10001, Tel: 6 221 321308 Fax: 6 221 310251 Telex: 44178
35.	Dr P Prijapratama	UNIDO	UNIDO Headquarters PO Box 300, 1400 Vienna, Austria, Tel: 010 492 6350 Fax: 010 491 0007 Telex: 822 373
36.	Rainer Kaulfersch Industrial Development Officer, Engineering Industries Branch	UNIDO	UNIDO Headquarters Vienna International Centre, PO Box 300 A-1400 Vienna, Austria Tel: 431 211 314586 Fax: Telex: 135612 una-a,

37.	Carola M Piazolo Programme Officer	UNIDO	UNIDO c/o UNDP, JL M H Thamrin 14, PO Box 2338, Jakarta 10001, Indonesia Tel: 021 321308 Ex 603, Fax: 62 21 3907126 or 3105251 Telex: 44178 Undevpro IA

COUNTRY PAPERS

(to be added)

by Rainer Kaulfersch

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO ENERGY PROGRAMME FOR DEVELOPING COUNTRIES

Paper to be presented at the Expert Group Meeting on the Application of Solar Energy for Electricity Generation for Domestic and Commercial Use
12 - 17 July 1993, Denpasar, Bali, Indonesia

1. Over the next 25 years, the developing countries have the greatest potential to contribute to worldwide energy growth but also have the potential to be the largest polluters. With the proper application of advanced energy technologies adapted for developing country resources, the environmental impact of this rapid growth can be mitigated. Recognizing the critical nature of combining the environmental concerns with the need of developing nations to expand their energy production, UNIDO has developed a programme that incorporates energy growth with environmental concern. The programme involves factoring energy systems using environmentally clean technologies and pollution control into all UNIDO projects. A major focus will be the application of technologies with higher efficiencies and emissions control to new and ongoing projects.

Environment and Energy Sector

2. Currently, energy sector demand in developing countries is growing at an unprecedented annual rate, over seven per cent, leading to potentially economically devastating energy shortages. Projections for the rest of this century show that energy consumption will grow most rapidly in developing countries,

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

EXPERT GROUP MEETING ON THE APPLICATION OF SOLAR ENERGY FOR ELECTRICITY GENERATION FOR DOMESTIC AND COMMERCIAL USE

Denpasar, Bali, Indonesia
12 - 17 July 1993

Paper 2

SOLAR-PHOTOVOLTAIC ELECTRICITY GENERATION

Position Paper prepared by
Bernard McNelis

IT Power Ltd
The Warren
Bramshill Road
Eversley RG27 0PR
United Kingdom

ITP 93459

RNSW

(4)

PHOTOVOLTAIC TECHNOLOGY
R & D AND APPLICATION IN INDONESIA

COUNTRY PAPER

INDONESIA

Paper 3

Presented at : Expert Group Meeting on The A
for Electricity Generation for Dor

Denpasar, 12 - 17 July 1993
Bali, Indonesia

Presented by L. M. Panggabean

ISNTN
(5)

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 4

GERMAN EXPERIENCE ON PV APPLICATION

Mainly a technical report on Renewables + PV

1

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 5

PHOTOVOLTAIC RESEARCH AND APPLICATION IN AUSTRALIA

MARTIN A. GREEN

AUSTRALIA

Bmen

(7)

Photovoltaic Research, Development and Practical Application in Korea.

Unido Workshop

12 - 17 JULY 1993

DENPASAR, BALY, INDONESIA

Paper 6

BU-HO KIM

KOREA INSTITUTE OF ENERGY RESEARCH

Photovoltaic Research Lab,

P.O Bax 5, Taedok Science Town

Taejon, Korea

Tel : 042-860-3414

Fax : 042-861-6224

UNIDO Workshop
Bali, Indonesia July 1993 Paper 7

THE PERTH CENTRE FOR APPLICATIONS OF SOLAR ENERGY

Australia

Graeme Eley and Samantha Brennan

CASE

Introduction

It has long been recognised that solar and other renewable energy sources have a vast under utilised potential, particularly in developing countries. However, the renewables have, as yet, contributed very little to the energy needs of developing countries. (1)

Despite fossil fuel price fluctuations, significant progress has been and continues to be made in developing solar-based technologies for a whole range of applications: heating, drying, water treatment, refrigeration and cooling, cooking, water pumping, and particularly in thermal and PV electric power generation. However, while significant niche markets exist such developments have not resulted in any appreciable worldwide utilisation of solar-based applications (1).

The United Nations Industrial Development Organisation (UNIDO) recognises that the solar energy sector requires greater promotion and encouragement of cooperation in research and application. Renewable energy is abundant, clean and widely available both in developed and developing countries (2).

With the growing international concern about the global environmental impact of continued burning of fossil fuels, there is now more reason to place greater emphasis on solar energy applications, particularly in developing countries. This is becoming urgent because many commentators predict that the developing countries will join the industrialised countries in becoming major sources of "greenhouse gases" early next century. If environmental concerns are not to impede development efforts in developing countries, availability of clean energy sources must be a top priority.

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 8

STATE OF THE ART ON RESEARCH DEVELOPMENT AND UTILIZATION OF PHOTOVOLTAIC TECHNOLOGY AND SYSTEM IN THAILAND

PREPARED BY

AMNUAY THONGSATHITYA
CHIEF ENERGY PROTOTYPE AND TESTING SECTION
ENERGY RESEARCH AND DEVELOPMENT DIVISION
DEPARTMENT OF ENERGY DEVELOPMENT AND PROMOTION
MINISTRY OF SCIENCE TECHNOLOGY AND ENVIRONMENT
BANGKOK THAILAND

1993

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 9

9

PHILIPPINE COUNTRY PAPER

RESEARCH AND DEVELOPMENT PROMOTION AND COMMERCIALIZATION OF SOLAR PHOTOVOLTAIC (PV) TECHNOLOGY

by:

Christopher G. Zamora[1]

I. INTRODUCTION

The Philippine Department of Energy (DOE) was formally created last January 1993 by virtue of Republic Act 7638 in response to the deteriorating energy problems. The DOE has been vested with full organizational mandate to carry out its coordination and decision-making functions relative to the overall energy matters. Under the new energy sector structure, the Non-Conventional Energy Division (NCED) under the Energy Utilization and Management Bureau (EUMB), remains mandated to accelerate the development, promotion, and commercialization of non-conventional energy technologies through the formulation and implementation of a national Non-conventional Energy Program (NEP). Consequently, the NCED has now broadened its responsibility taking into effect the coordination, integration, and administrative supervision of non-conventional energy activities of the other energy agencies. "Please refer to Appendix A for the DOE Organizational Structure".

The Philippine Non-Conventional Energy Program (NEP)

The present 1993-1997 Non-Conventional Energy Program (NEP) is now in the process of being formulated. The NEP still includes a Technology Program (TP) which aims to increase the techno-economic efficiency of non-conventional energy systems (NESs), a Promotion and Commercialization Program (PCP) which aims to accelerate the development of a market environment conducive for the commercial use of NESs, and the Affiliated Non-con Energy Center Program (ANEC) which aims to establish an institutional mechanism for the promotion and use of NES. The ANEC program being the centerpiece of the NEP establishes linkages between DOE and provincial universities and agricultural colleges to strengthen and institutionalize current efforts to implement a planning and implementation approach for the commercialization and promotion of use of NES in rural areas.

The major components of the NEP are as follows:

- Renewable Energy Technologies (biomass, solar, wind and micro-hydro
- Rural Energy Plan

---

[1] Supervising Science Research Specialist, Department of Energy, Merritt Road, Fort Bonifacio, Makati, Metro Manila

Papers 10

RENEWABLE ENERGY ACTIVITIES IN JORDAN

by Malek A Kabariti

RENEWABLE ENERGY RESEARCH CENTER - ROYAL SCIENTIFIC SOCIETY
P.O. BOX 925819 - AMMAN - JORDAN

ABSTRACT

This paper presents briefly renewable energy activities in Jordan, in particular the solar and wind energy activities carried out by the Renewable Energy Research Center (RERC) at the Royal Scientific Society (RSS). Basically one might recognize that policy and to some extent promotion related activities are implemented at the Ministry of Energy and Mineral Resources (MEMR). The basic research in this field is carried out by the four Jordanian universities. The Jordan Electricity Authority (JEA), and MEMR installed, and tested the first Jordanian wind farm connecting to the gird and made the primarily contacts with European companies to erect the largest solar thermal power plant (30 MW; PHEBOS Project). The Meteorological Department had started a program to measure solar radiation. The Higher Council for Science and Technology (HCST) was established to take the lead in simulating and coordinating science and technology within the research and development centers.

The RERC concentrated its work, until now, on conducting applied research in the field of solar thermal, wind energy and photovoltaic application. Furthermore, solar and wind energy technology commercialization and the transfer of the Jordanian gained knowledge to other developing countries are also considered.

References missing

Very little on PV!! - cobbled together from some old papers

SOLAR THERMAL ELECTRICITY

Dr. D.R. Mills
Department of Applied Physics
University of Sydney
NSW 2006
AUSTRALIA

I. OVERVIEW OF CURRENT SOLAR THERMAL ELECTRICITY (STE) DEVELOPMENT

Solar Electricity Technology vs Developing Country Needs

As we move rapidly toward an energy future based upon renewable energy, it is necessary that priorities be set as to which renewable technologies can realistically contribute to global emissions reduction in the desired time frame to achieve atmospheric stabilisation. In the context of developing countries, additional social development goals must also be a part of the evaluation process. We must be aware of the reasons why we invoke new technology, and the effects of any choice made. For example, thousands of small PV (photovoltaic solar) installations may contribute immensely to the lives of rural farmers in a social and economic sense, but may contribute little to Greenhouse effect reduction. Larger solar thermal electricity plants may allow enormous reductions in emissions for supply of urban and industrial electricity, and may substantially reduce imported fuel requirements, but may not directly socially benefit those living away from the electricity grid.

In the descriptive material supplied prior the workshop, a statement was made that solar thermal electricity (STE) was less efficient than photovoltaic power for the production of electricity. In fact, the opposite is the case. The current Luz STE plants in California achieve an annual average of 15.5-17% net conversion of solar radiation to electricity, far higher than the average efficiency of current full PV plants, and they do it at a far lower cost. The STE technologies currently under development in Australia should result in annual conversion efficiencies in excess of 20%, equal to the long term goal of the low cost polycrystalline PV industry, and much above that of amorphous technology. STE efficiencies in exceptional solar climates may substantially exceed 20%.

More important than a discussion of efficiency is a an estimate of cost. Cost projections of the Sydney University STE technology (about US$1.20 per peak watt) are similar to long term goals for PV, but STE will be available much sooner at this price. This is a critical issue with regard to carbon pollution amelioration, since it is necessary to have technologies in place before the rapid development cycle anticipated for developing countries during the coming decades. PV has the great disadvantage in that either electrical storage or a full backup system must be provided at considerable extra cost. This limits the economic advantage of even a very low cost photovoltaic array. It now appears that STE plants with storage will not cost more than daytime-only plants per kWh(e) of electricity produced, and because a steam turbine is used, only backup fuel is required, not an additional backup system.

APPLICATION OF SOLAR ENERGY FOR ELECTRICITY GENERATION IN VIETNAM

Expert group meeting on the application of solar energy for electricity generation for domestic and commercial use
Bali, **Indonesia 12 :- 17 July, 1993**

Paper 2

by: **Nguyen Van Le*** and **Le Van Khanh+**

I. Introduction:

Located in the Indochinese peninsula in Southeast Asia, Vietnam is surrounded by the East Sea, border with China, Laos and Cambodia. The total land area is 331,032.7 square kilometers. According to the 1991 census, the population stood at 67.7 million with average population density of 200 persons per square kilometer.

The country is S-shaped, stretching over 15 degrees of latitude. The mainland territory, (excluding offshore islands) extends between $8^{o}10'$ and $23^{o}24'$ North latitude and $102^{o}09'$ and $109^{o}30'$ east longtitude. The mountainous and hill areas account for about 67 per cent of total land area and the rest 33 per cent is occupied by plains. Vietnam has two deltas watered by Red river in the North and Mekong river in the South. The total area of the former is less than onehalf of that of the later.

The topographical features of the country and the monsoons influence directly on climate. There are two climatic zones demarcated by north latitude 16^{o} crossing the Hai Van pass. In the North from the Hai Van pass is the tropical monsoon zone, while the southern part from Hai Van pass down is the zone of sub-equatorial monsoons. Generally speaking, the weather in the South is warmer and more moderate than that in the North.

According to the 1990 statistics, the economy of Vietnam can be divided into three most important sectors: Agriculture, which contributes 38.3 per cent of the Gross National Products (GNP), Industry occupies 35.1 per cent and

---

* : Project manager

+ : Head of Solar and Wind Energy Division - Institute of Energy

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 13

Solar Energy Conversion for Electricity in Korea

Tai K. Lee
Korea Institute of Energy Research

1. Background

Every country faces many difficult challenges in energy supply and use. These challenges involve numerous national issues, including energy security, energy cost, international balance-of-trade, and international competitiveness. Energy use directly affects environmental quality as well. Growing, pervasive problems with atmospheric pollution, water resources, acid rain, and the greenhouse effect may ultimately limit the burning of fossile fuels. We need to find ways to ameliorate these environmental problems while maintaining assured access to the energy resources our country requires.

Solar energy conversion for electricity utilizing solar thermal or/and photovoltaics is one of the most promising source of power since sunlight can help us meet our enrgy needs, and the conversion process technology is well-established. However, there appears to be no single or simple answer to the energy dilemma of developing country: it is likely that a mixture of mutually supporting technical, institutional and developmental approaches will be needed. With regard to technical approaches, one of the most promising one, particularly for rural development, appears to be photovoltaic energy conversion. A PV power system is designed to convert solar energy into electrical energy suitable for connection to an application load. Solar thermal power generation subsystem may be used for application requiring combined PV/thermal modules.

Korea's energy demand has been met mostly by imported oil and natural gas for electricity generation and for transportation. Although some efforts have been made to diversify the sources of energy for the last two decades the fossile fuels have continued to play a major role in the country's power generation and energy needs. But both the oil and gas are not only available in amount, but also causes environmental problems due to the fast growing consumption. Total dependence on oil and gas could lead to serious consequence. With these realities in mind, government, scientists and engineers have paid attention to the research and development on various sustainable and safe renewable energy resources.

Out of wide range of the renewable energy research in progress in Korea, solar energy research stands out as the most active field. Among various solar conversion processes, solar thermal processes for electricity generation has not received much attention seriously, but research on photovoltaic cells has been

by K C Gupta
Asst. General Manager
CEL Sahibabad

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 14

SOLAR PHOTOVOLTAIC POWER PLANTS FOR RURAL INDIA

1. INTRODUCTION:

In India, Central Electronics Limited (CEL) has pioneered the development and commercial production of Solar Cells, modules and systems. CEL uses state-of-the-art single crystal silicon technology developed completely in-house, with a product profile catering for small rural to large industrial applications. CEL has very good strength in all aspects of SPV including R & D on cells, system design, manufacturing and support capabilities built and nurtured over more than a decade. The thrust at CEL is in two directions; (i) To bring down SPV cost by improvements in manufacturing methods and increase in production volumes, (ii) To develop innovative and cost effective applications both for individuals and community use.

This paper aims at sharing with the participants the information about the current developmental activities of CEL and the experiences gained in the field of Solar Photovoltaic power plants essentially for Rural India.

2. Current Developmental Activities:

Power plants being one of the major segments of SPV business for CEL, there is an ongoing programme for their development. Experience has shown that for a power plant providing AC output, power conditioning unit (PCU) is the most critical equipment influencing the performance and

VMBO Workshop
Bali, Indonesia
July 1993

Paper 15

15

THE APPLICATION OF SOLAR PHOTOVOLTAIC IN CHINA

Natural Energy Research Institute of Gansu Academy of Sciences
Lanzhou, Gansu, China

Some nonsense in here.

JUNE 2, 1993

Expert Group Meeting on the Application of Solar Energy for Electricity Generation for Domestic and Commercial Use

Denpasar, Bali, Indonesia - 12/17 July 1993

Pap 16

Electricity Production by Photovoltaics in Italy

Calogero Messana

ENEA, Casaccia . Energy Area, Department of Renewable Energy Sources

Via Anguillarese 301 - 00060 S.Maria di Galeria, Italy

1. Introduction

During the last years, industrial and developing countries have been devoting continuous and growing efforts to the development of renewable energy sources.
In industrialized countries, the public consensus on renewables has been mainly driven by environmental and climatic concerns about the use of fossil and nuclear fuels, while, in developing countries, the interest on renewables has been aroused by the fact that the exploitation of these energy sources looks, very often, as one of the most promising ways to provide energy to villages and isolated communities, especially in rural areas.

In this respect, Italy situation is rather peculiar (1). In Italy, environmental concerns add up to the need of diversifying energy sources and exploiting, as much as possible, national resources. In fact, Italy energy structure is characterized by an abnormally high dependence on energy imports (more than 80% of primary energy needs) and, in particular oil imports, which constitute at present about 55% of the total energy budget. Electricity generation relies almost solely on oil and gas fired power plants; besides, a significant fraction of electricity needs (about 14%) has to be imported.

On the other hand, the options available to change this situation appear very limited. As a consequence of a popular referendum, Italy has shut down operating

UNIDO Workshop, Bali, INDONESIA

July 1993

Paper 17

POWER GENERATION BY PHOTOVOLTAICS IN SWITZERLAND

Helmut Kiess

Paul Scherrer Institut

Villigen, Switzerland

I. GENERAL REMARKS:

ENERGY AND ENERGY RESEARCH:

Science, technology and society are intimately tied

-> they do not act independently

-> interaction shapes the future of society

IMPLICATIONS FOR RESEARCH AND DEVELOPMENT

In order to be viable and optimal for society, energy research and development, R & D has to be

capable to supply solutions, which are based on a high scientific standard and on an assessment of their economic, ecological and political aspects.

UNIDO Workshop
Bali, Indonesia
July 1993

Pop-18

Technical Paper

NOTES ON
SOLAR HOME SYSTEM COMMERCIAL OPPORTUNITIES IN INDONESIA

Ucok Siagian
Center for Research on Energy
Institut Teknologi Bandung

The use of individual solar photovoltaic panel home system has been introduced in Indonesia through demonstration projects, government grants, or government funded semi commercial schemes.

Pilot project of rural electrification using PV solar home system (SHS) was implemented in Sukatani Sukabumi in 1988/91. The project installed around 100 units of SHS (80 Wp/unit). Through a thorough monitoring program it was found that the technology is technically reliable and socially acceptable[1,2].

Following the success of the Sukatani project a number of dissemination program have been launched. Presidential aid financed around 3000 units (45 Wp panels) through a revolving fund scheme. Similar schemes are also applied using regional government budget. In these projects the recipients of solar installations are required to repay the price of the installation in monthly basis scheduled to be completed in 8 - 10 years time. In some projects SHS users are required to provide down payment for the equipment procurement.

In all cases the dissemination program has not been implemented in pure commercial basis. Government contribution (subsidies) are provided in the form of grants or specially arranged low interest rate loan scheme for rural cooperatives. In these programs monthly payments by end-users are in the range of Rp 7500-10,000. In many cases, particularly in remote areas where supply from the national grid can not be accessed, the economic of solar home system has been proven to compare favorably with other power generation technology options. The use of SHS to replace kerosene lighting and rechargeable battery of the same output is also found economically feasible[3].

The aggressive promotional activities of photovoltaic system suppliers, some donor countries and government agencies has resulted in the wider belief about the benefits of the application of that technology. In terms of government sponsored program, there are some truth to that belief. However, at current economic condition and considering the economics of the system, some notes of caution is in order.

The price of an installation of 45 watts peak solar photovoltaic panel and the necessary additional fixtures like batteries, controller, and other items is currently priced at around Rp. 1,000,000 - Rp 1,250,000 (US$ 500-625), depending on the procurement volume. Direct purchase of the equipment is simply beyond the affordability of the majority of rural households. To overcome this high front-end investment barrier, credit schemes for financing the procurement of the installation need to be made available. The mapping between the price of a 45 Wp SHS package against the required monthly repayment of the borrowed credit are presented in Figure 1 and 2 respectively for credit maturity of 5 and 10 years.

UNIDO Workshop
Bali, Indonesia July 1993

Paper 19

TELAAH, JILID XI, NO 1 & 2, 1988

PV DESIGN USING LOSS OF ENERGY PROBABILITY METHOD[1]

I.I. Tarigan and Didi Mulyadi[2]

INDONESIA: Technical Paper

INTISARI

Dengan menggunakan metode Loss of Energy Probability (LOEP), telah dikembangkan suatu program komputer untuk mendisain suatu sistem PV yang berdiri sendiri. Dalam program ini radiasi [illegible] lokasi, karakteristik dari sel surya dan beban rata-rata perhari digunakan sebagai data [illegible] program adalah daya puncak, kapasitas baterai dan harga [illegible] untuk mendisain sistem PV yang akan digunakan di Wamena Irian Jaya.

ABSTRACT.

Using Loss of Energy Probability (L.P) method, a computer program for designing a stand alone Photovoltaic system has been developed. In this program global solar radiation, latitude of the location, characteristics of the cell and average load per day to be supplied by the PV system, had been used as input data. The output of the program were peak watt of the system, battery capacity and the total price of the system. This program had been applied in sizing a PV system to be installed in Wamena, Irian Jaya hinterland.

1. INTRODUCTION

Usually a stand alone PV system comprises of a PV panel, power conditioner, battery storage and load as shown schematically in figure 1.

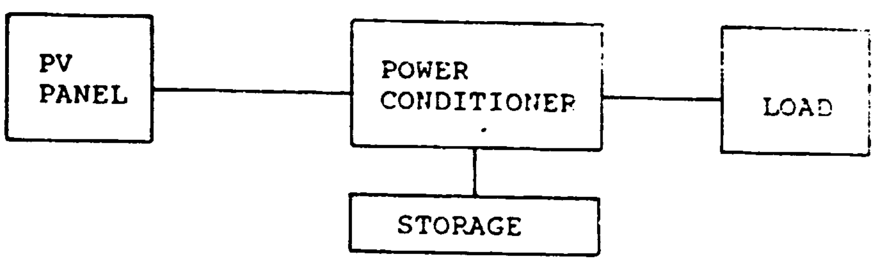

Figure 1. Basic Components of a stand alone PV system

In this program, using global radiation data on the horizontal surface, which is one of the input data, the direct and diffuse radiation on horizontal surface were estimated (1). Then the optimum tilt angle of the panel for the location considered [illegible] calculated. (2) The radiation on the optimum tilt plane [illegible] used as the tilt of the PV panel, was calculated using [illegible] explained in reference (1).

1. Presented at Seminar cum Training Course on Solar PV System in Developing Countries, Islam[illegible] 13-22 March 1988
2. Research and Development Centre for applied Physics-LIPI, Jl. Cisitu, Bandung 40135, Indonesia

4 JUL '93 17:31 VERBUND-WIEN-AE

UNIDO Workshop
Bali, Indonesia
July 1993

Paper 20

Not presented - sent by Fax

Experiences with PV systems in Austria

Gerd Schauer and Andreas Szeless,
Austrian Electricity Board (Verbundgesellschaft)
A-1011 Vienna, Am Hof 6a. T: 0222-53113-2439