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PROSPECTS OF PHOTOVOLTAIC APPLICATIONS IN EGYPT AND INDIA

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INTRODUCTION

All the developing countries of the world, whether they are rich in oil or not, are faced with the same delemma; they have the firm will to improve the life-style of their country-men, but do not have sufficient energy resources which will be necessary to sustain the continued growth for many decades to come - utilizing the available energy technologies from the developed nations. There are two options, One: for those countries which have sufficient oil, coal or hydro power, they should divert reasonable quantity of these resources for the manufacture of the equipment for harnessing the renewable forms of energy. Second: for those countries which do not have sufficient natural energy resources, they should immediately divert all their efforts to developing renewable energy systems and should even seek possible assistance from other nations if need arises. Fortunately for the developing nations, the world realization of the fact that the natural resources are fast dwindling and will eventually peak - out in the next few decades, came at the right moment in the history of man-kind in the form of oil crisis in early seventies. By then most of the developing nations of the world had already prepared long range plans for improving the social and economic conditions of their country-men and were ready to launch massive programmes based on the available energy technologies. However, this sudden realization of depleting energy resources, made them wise and most of the developing nations started searching various other alternatives. In the following two to three years, after the energy crisis, most of these countries initiated or renewed their efforts for the Research and Development programmes in various areas of solar and other renewable forms of energy. Presently, most of the nations have development programmes for the introduction of renewable energy technologies to

meet the demand of various energy sectors, and many of them have already made remarkable progress in this direction. The importance of renewable energy technologies for the developing nations has been now fully recongnized by all the countries and assistance in various forms has started forthcoming from the national governments and United Nations. The USAID programme on Training in Alternative Energy Technologies (TAET) at the University of Florida for the participants of developing countries, the technical and finanicial assistance of the World Bank for the development of Alcohol Power in Brazil and ICTP in Italy under United Nations are best illustrative examples of such assistances. In addition, cooperation amongst the developing nations in the area of alternative energy technologies is gathering momentum. While the assistance from the developed nations to the developing countries, in this area, is expected to provide an over-all understanding of the basic and methodology, necessary for development; the cooperation among the developing nations specially those having similar enviromental conditions will eventually help them to accelerate the process of strategy formation and to exchange information of each other experience in these areas which is likely to provide guilance for the speedy implementation of their programmes.

The present study, concerning the prospects of the application of Photovoltaics in the two countries!VI2: Egypt and India, encompasses the various socio-techno-ecomonic- aspects of the two countries. Such socio-techno-economic- aspects form basic factors which need be investigated in a country. The present section and the following two sections provide an overview of the progress made by these two countries in technology and also various possible routs of solving the energy problems. Chapter IV provides an account of the Present-State- of -Art of photovoltaics in the two countries. In the last chapter the

need for cooperation between the two countries has been outlined and possible areas of cooperation in the field of photovoltaics have been discussed.

Insolation Conditions

Both Egypt and India have abundent sunlight as they happen to be located in the sunshine belt of the world. The insolation level in Central and Southern parts of India during the summer season often exceed 100 milliwatt per centimeter square, while in the north the sunshine levels during sunny days range between 75 - 95 milliwatt per centimeter square - through-out the year. The sunshine conditions of Egypt largely correspond to that of North-West India - having many sunshine days 94,000 hours/year). However, the direct insolation in North-West India and in Egypt constitutes only 60 to 70 % of total insolation; the remaining being diffused radiation. This particular sunshine composition makes the use of fixed orientation non concentrating solar devices more appropriate to these regions. The added advantage of such combination of direct and diffuse radiation is that the flat plate fixed orientation solar devices start delivering sufficient amount of energy earlier in the morning and will continue to do so for longer period in the afternoon hours compared to the locations where the sky is relatively clear and direct radiation forms most portion of total insolation.

Socio - Economic Conditions

Both Egypt and India are in the same stage of social and economic development and have similar problems confronting the planners of these countries. Both the countries have over population and have a tedious task of controlling. The percentage of literacy in these two countries is not satisfactory and because of this low level of literacy the participation of general public in the development of the nation is limited. However, in the last few decades concentrated

efforts to educate their respective country-men by both the countries have yielded noticable results. Now people are more aware of the problems facing their own countries and have will to help governments to improve social conditions. Both the countries are faced with the problem of providing adequate health coverage to its countrymen. Presently a large population do not have health centers within reasonable distance. The majority of population in both the countries is concentrated around the rivers and with the continued internal immigration of its population towards the cities is posing difficulties to city planners creating lack of utilities in these areas. The economic conditions of both the countries are also almost similar. The investment in larger industries is not forth coming from private organizations and most of the heavy investment industries are owned and managed by the government with the responsibility of managing such organizations and in future it may over burden the governments leaving less attention to be paid to other welfare programmes. Most of the export items in these two countries are in the form of raw material. There is a great scope for the development of process industries and consumer goods industries in both the countries which are likely to generate good employment potential for their countrymen.

Technological Development

Both Egypt and India are in very good stage of technological development inspite of not so good socio-economic conditions in these countries. Amongst the developing countries both Egypt and India occupy very significant position. Both the countries have large steel industries, make finest textiles, have satisfactory base in the production of machinery and electronic equipment. Both the countries have their own chemical industries and most of the demands for industrial and laboratory chemicals is met within the country. In addition both the countries manufacture their own transportation vehicles. In respect of most of the technological aspects of both the countries are not very much lagging behind and are heading for the modernization of their industries.

THE ENERGY SITUATION

As indicated in the beginning of this report the energy situation in all the developing countries, including Egypt and India is not satisfactory. As reported in the literature * the growth rate of Gross National Production during 1960 - 1972 for lower and middle income group countries was 3.7 and 6.2 percent respectively, which fell down to 2.3 and 5.9 percent during 1972 - 1976. This phenomenen of lowered GNP growth rate can obviously be attributed to the uncertainty condition of energy supply in these countries. If Egypt and India intend to accelerate the growth rate of economic development, the energy consumption which has been doubling every ten years in the last two decades will further go up and is likely to go up to a rate of seven year doubling period.

Inspite of such a rapid industrial growth and the growth in the energy consumption rate in these two countries, the benefits of industrialization have not yet reached their rural masses. In - order to increase the national growth (growth of GNP) and to achieve their social goals, in shortest period of time, both the countries will have to provide tremendous amount of energy to their remote areas and specially to the poor - so that they can also enjoy minimum comfort and may ulitize the available power to improve their productivity and there by improve their family income. This will enable them to contribute productively to the nations economy.

In addition both the countries need energy to improve their agricultural production and aim at creating safe levels of food stocks. In both the countries large areas of land, which are otherwise suitable for agricultural

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* Energy Supply Demand Integrations to the year - 2000, Paul Basile - MIT Press - 1977.

purpose, are not yet connected to any kind of irrigation systems. The power requirements for such irrigation projects are very large.

It is obvious that if these countries want to sustain their industrial growth, improve the transportation facilities, improve the life style of their people, enhance the agricultural production at the desired rate, then all their energy reserves put together will not be sufficient in the long range. Although both the countries, Egypt and India have excellent Hydro potential and while Egypt has comfortable oil reserves and India has comfortable coal reserves - the two countries will have to rely on their capabilities to develop renewable energy sources as they can not afford to exhaust all their reserves in the next few decades.

It may be noted that both Egypt and India have nuclear power stations and plan to further increase the nuclear power generation capability but, based on the world wide fear of radio - active pollution such generation power is not considered safe till clean nuclear technology is developed. Associated political problems make the production of nuclear power more uncertain as they largely depend on outside supply of nuclear fuel.

TABLE I - Some Energy Facts*

Item	Egypt	India
1. Commerical Energy Consumption - 10^6TCE		
- 1960	7	70.8
- 1972	11.2	140.0
2. Crude Oil Reserves - 10^6bbl	2,761	926
3. Solid Fuel Reserves and Resources 10^6MT	25	23,160

* Energy Supply Demand Integration to the Year - 2000, Paul Basile - MIT Press-1977.

While the conventional energy sources are needed more for industrial development and sustaining the economic growth. The only alternative is to develop renewable energy sources in the shortest possible time. In the context of future energy pattern these renewable energy sources can be utilized to meet one or more of the following energy needs:

1. Power to meet the minimum basic needs, like drinking water & cooking and subsequently provide minimum comfort to their people in remote villages. This will improve manpower efficiency.
2. Power to run educational programmes like evening adult education centers, community TV and radio for education and entertainment, to preserve medicines and vaccines in rural health centers in remote villages in India and in Oasis of Egypt.
3. Provision of power for small hill stations to provide hot water, air cooling and heating in hotels, this will tremendously improve tourism in India. Similar provisions of power in hotels in Oasis in Egypt will improve her tourism industry.
4. Finally, if the alternative energy sources could be developed at a faster pace then these sources can be utilized to supplement the energy demand in Industrial sector and will provide on-site power for agricultural farm operations.

FUTURE ROLE OF ALTERNATIVE ENERGIES

Fortunately both India and Egypt have several options, which include solar, wind, biomass, ocean thermal and geothermal energies. It may be noted that there is a very large gap in future energy demands and national reserves of oil/coal and it will not be possible for any single newly developed energy source to bridge this gap alone. Efforts in various areas are needed to develop all forms of alternative energies. In fact both Egypt and India have already started work in many renewable energy areas. Both Egypt and India have done remarkable work in low grade solar thermal systems and photovoltaics mostly using their own know how. Both the countries have already started technical feasibility studies of wind energy systems and high temperture thermal systems. With such an excellent R & D base in renewable energy studies and past few years progress, both the countries have good future provided they can manage the further R & D and Yield Testing programmes, in order to take technology to their masses. This will not only require concentrated efforts of their scientists and engineers but will also need whole hearted support from politicians, administrative machinary, and various social organizations. This kind of support of other organizations than technical is more important to renewable energy technology as these require field assistance to its users unlike coal, oil, hydro, or nuclear power.

Following table gives brief account of the status of renewable energy sources in both the countries.

TABLE-II - RENEWABLE ENERGY SOURCES IN EGYPT & INDIA

Form of Renewable Energy	Possible Areas of Application	Present Status
1. Solar a) Low grade thermal	Home cooking, water heating, refrigeration, water pumping, drying, distillation.	Egypt: Many of the devices developed indegineously are in field use, besides imported ones. Production intended. India: Developed many devices indegineously, few private companies already manufacturing them . Gaining popularity with users. More factories planned.
b) High Temperature	Power generation for small communities or remote area industries, refrigeration.	Egypt & India: In both countries R & D and feasibility studies in progress.
c) Direct conversion (Photovoltaics)	Home lighting, water pumping, electric power to community centers and health units, earth communication in remote areas.	Egypt: Own as well as collaborative R & D testing programmes in progress. Production plans under formulation. India: Excellent R & D results on various kinds of solar cells achieved using own efforts. Production of 50 kw/yr. Many demonstration projects in progress.

2. Wind Energy	Suitable for power generation at the North cost of Egypt and East coast of India to meet agricultural and industrial (small) power demands.	Egypt: Indegineous efforts to develop wind mills in progress. System studies going on application for irrigation. India: Own and collaborative R & D programmes and feasibility studies in progress. Many systems yet to be developed.
3. Bio - Mass a) Methane generation (Biogas)	Domestic cooking and lighting, environmental protection in heavily populated areas, and fertilizers.	Egypt: R & D started and some application for demonstration in villages. India: Developed already using own efforts. Now gaining popularity in villages. Extention planned.
b) Algae Production	Methane production (energy). Environmental control, animal feed (protein productors)	Egypt: Work on Lab scale (pilot Plant) India: Some projects are in progress on R & D scale.
c) Ethanol Production	Fuel (transportation)	India: Good alcohol production facilities already exist-India being a sugar producing country. Scope for improvement. Gasohol vehicles under development using own efforts.

d) Gasification of woody biomass	Industrial power (small) home cooking, lighting, transportation.	India: Great potential exisits, systematic work yet to start.
e) Aforestation & Forest plantation	To renew forest resources in hill areas in India. Possibility to stop the spreading of desert both in Egypt and India	Egypt: Developing Plans India: Government has started plans for aforestation.
4. OTEC/Geothermal	Future application	Both Egypt & India need correct assessment before taking up serious programme. India: Small project on geothernal energy in progress for refrigeration using own efforts.

PROSPECTS OF PHOTOVOLTAICS

The solar cell is basically a p-n junction device such that one of its layer is quite thin and when light is shown to this thin side pairs of charge carriers are generated near the junction and are eventually collected on the opposit sides of the solar cells due to the build in electric field of dissimilar semiconductor layers. This results in a emf called the photo-emf and can be utilized to pass current through a suitable load connected electrically in a circuit to the two opposit sides of the solar cells - like to the two electrodes of a battery. These solar cells form the basic building blocks of photovoltaic energy generating sources. A typical silicon solar cell generates around 0.55 volt emf and can supply 35 ma of current for each aquare centimeter of its area. Thus in order to generate the necessary emf for coupling to a load the solar cells are connected in series and then encapsulated hermatically. These modules in turn can be connected in series and parallel to form solar Photovoltaic energy system. The other two constitnents in PV energy systems control devices and energy storage.

The solar photovoltaic arrays hold promise as future solar energy conversion devices to supplement the specific energy needs in the developing countries. The basic features of Photovoltaic (PV) power not only makes it a good component of future rural energy metrix but, if some of the expected breakthroughs in the area of low cost PV materials and process technologies materialize, then the PV will positively become one of the most important components of future world power. The PV power has following advantages: i) Photovoltaic power arrays are modular in nature implying that the efficiency of PV power systems is not a function of array size and in fact the efficiency of PV arrays remains remarkably

constant from milliwatt size modules (eg in solar watches) through small few-watt modules (eg radio or TV module) to killowatt/megawatt arrays of village powering systems. Such remarkable independance of efficiency is not shown either by conventional power stations or any other alternative energy system. Generally the efficiency of conventional power system based on coal, oil or nuclear reduces to great extent as the size of the system is reduced. In addition fractional watt systems are not possible using most other forms of energy.

The modualr nature of PV power systems will also enable its user to install a small generating set in the beginning and then subsequently add more PV modules from time to time as the energy need grows or as the buying capacity of the user goes up. Such often installation additions in successive steps for many other kinds of power systems are either not possible or are extremely difficult. ii) The photovoltaic power modules are portable. Thus the PV power modules can be manufactured at a central location in a factory and then can be shipped to the place of actual use, like many consumer electrical goods. Unlike many of the coal/Hydro/Nuclear stations unstallation of PV arrays does not require fabrication of on-site massive and tedious structures. However, miminal civil/structural work may be needed to install the array and the other subsystems.

This on-site power generation by PV arrays will also be helpful in climanating the transmission and distribution losses of power and also sizable fraction of investment on transmission and distribution lines can be saved especially in developing countries, where so far most of the areas have not been served by central power grid.

The Portability of PV arrays may also enable us owners to deploy it

for multipurpose utilization. A PV array of suitable size may be used by a farmer on the farm for irrigation purposes and when brought back home and plugged into home electricity system would provide his family minimum comfort and entertainment. The excess power generated by such an array at home may also be used for his own small cottage industry. iii) The photovoltaic systems are the easiest to operate and will need mininal maintenance - occasional cleaning. In case a module breaks, accidently, then that particular module can be sent to repair center. In the mean time the system can be run on slightly less load or can be run on full load by inserting a spare module in place of broken one. iv) Although, so far the reliability of PV systems has been tested on a limited time scale but these systems hold a great promise for high reliabilities as proved by the short test of these modules. In addition terrestrial PV system's life has been estimated over 25 years based on the available results of accelerated environmental life cycle tests - which are routinely conducted by defense organizations for many of their simular electronic products. v) The PV systems hold also the promise of low cost. Unlike space quality solar cells, the technology of terrestrial quality solar cells is relatively simple and its process requirements can be easily complied by many of the developing countries, which have some base of electronic industry. The moduling technology is relatively far more simple and is within the reach of a technically trained small entrepreneur. Thus PV power modules provide scope far indigeneous technology application in many developing countries. vi) Finally, the most important, these system do not incur any fuel expenses and their use is unlikely to create any pollusion problems. This is especially true of silicon based PV modules.

STATUS OF PHOTOVOLTAIC TECHNOLOGY

A. World: Many of the developed nations have been working on PV power modules since late fifties in order to provide reliable power to space crafts and light buoys. USA, France, Germany, and Japan have done pioneering work in this area. However, PV power for terrestrial use was sincerely considered after the energy crisis. Since that these countries have been working on various low cost techniques to bring down the cost of PV modules to a reasonably low level say $0.50 per peak watt to enable them to compete with the conventional power. Since then the cost of PV modules has come down from $500 per peak watt to about the latest quoted price of $6 per peak watt. This reduction of cost has been possible by using low grade silicon material, improving the process technology & engineering development. Even at this cost PV power is cost effective for many remote application in developing countries. In fact such an opportinity has already been realized by some of the private companies in developed nations and they have plans to export PV modules at the present cost and if possible set up factories in developing countries.

B. Egypt: Photovoltaic device is a typical semiconductor device and its manufacture or R & D needs a basic facility of electronic component manufactoring. The electronics industry in Egypt is not in an advanced stage. Most of the electronic equipment are imported or only assemble in the country (eg radio TV, and land communication sets). However there are small private industries in the area of electronic components production but the quantities produced do not satisfy the international market. The only serious governmental attempt to build electronic industry was more than 10 years ago, when Benha Electronic Factory was established. This factory imported silicon single crystals, from

which diodes and transistors were prepared to meet some of the national needs. Egyptian National Strategy for establishing PV production is not finalized yet. The only activities in this area concern laboratory scale preparation of solar grade silicon and other materials. Testing and utilization of imported silicon cells and panels. Many research efforts are also devoted to materials science of solar cells. Such types of R & D activities are mainly conducted at Universities and Ministry of Electricity and Energy (Committee of Renewable Energy). Thin film solar cells of semiconductor compounds (CuS/cds - cds/cdTe) are mainly studied at National Research Center (NRC) under the different international contracts (USA & France). Single crystal silicon solar cells are prepared and studied at Alexandria University under the contract with UN and Holland (Institute of Higher Studies). Field studies of PV systems are conducted by the American University in Cairo for social development programmes of devert areas, and also by the Ministry of Electricity. A Laboratory for single crystal silicon growth has been established at the Cairo University, which has already started its programme. The large number of scientists and specialists in solid state physics, chemistry and technology, and technological background no doubt allows for the establishment of PV industry in the country as soon as national strategy is formed.

C. India: The research and development work on space and terrestrial quality solar cells started in India in late sixties and early seventies at Indian Institute of Technology Delhi, Solidstate Physics Laboratory Delhi and Bhabha Atomic Research Center Bombay. However, terrestrial quality solar cells did not receive much attention till 1975, when the government of India decided to launch a systematic long range programme for research, Development and Demonstration of PV devices, modules, systems and materials. The detailed programme was prepared in 1975 and initial steps were taken to start R & D work in various areas of

PV technology at institutes of higher education and national laboratories. Simultaneously Central Electronics limited (A Government of India Undertaking in the field of electronic componemts and systems manufacture) was given the responsiblity to carry on engineering development based on the most technology (viz-silicon) and draw out a plan for pilot production of PV modules and systems.

To date most of the organizations engaged in the various areas of PV have made remarkable progress in their respective areas. The most important areas of PV devices include R & D on silicon solar cells, silicon naterial other process materials and system studies. Following are some of the highlights:

* Using its own completely indigenous know how central electronics sheild (Government owned) has established production facilities of 50 KW/yr using imported silicon wafers. Now on its way to use its own crystal growth and slicing . By 1984 plans to achieve 1000 KW/yr production using indigeneous silicon. Most of the process equipments are made in India.
* Another company Continental Devices India Ltd (Private) has shown its capability to fabricate silicon cell modules and likely to go in PV production in the near future.
* Indigeneous effort to produce solar grade silicon in India show good promise. Good results already shown by IIT-Kharapper (silicon from rice husk) National Physical Lab (Trichloro Silane -of less purity- process) and Regional Research Lab - Bhurneswar.
* National Physical Lab has used its own silicon material to make single crystal silicon solar cells (low cost - 10% efficiency) and Polysilicon solar cells (8-9% efficiency)
* Four private companies have already attained manufacturing license for silicon. One of them M/S Mettur Chemicals using know-how from Indian Institute of Science is in the final stage of plant set up.

* On their own efforts IIT-Delhi has developed cadmum slphide solar cells. Better than 8% efficiencies are reported. Work on ternary solar cells in progress. Similarly IIT- Kampur has obtained small area MOS solar cell efficiencies of 9%. Work has been reported in many international journals. In addition, Central Electronics Engineering Research Institute had developed high concentration (up to 40 sun) and has reported better than 8% efficiency.

* About 5 solar Photovoltaic Pump sets - all the components fully developed in India - are in field operation under various enviromental conditions. These are expected to provide good data for future development.

* Two Recon systems for ship navigation are powered by indigeneously made PV modules for more than two years. Working satisfactorly.

* Several other systems eg PV-Radio, TV home lighting (all system components completely indigeneous) are in operation for long time. Good performance reported.

* Two private pump manufacturers have under-taken R & D on high efficiency low - HP,DC pump sets. Their protypes used in conjunction with indigeneous modules have shown satisfactory performance. Production Planned.

After the successful completion of Pre-commerical Pilot plant of PV modules, and systems at Central Electronics Ltd. the Government of India has plans to start several factories in many of her states. These factories will have 10-100 MW/yr production capacity. Other precess materials eg dopents, and reflection coating materials and conducting pastes have been developed by National Physical Laboratory and National Chemical Laboratory and have been successfully tried by Central Electronics Ltd. Government of India has plans to promote/under-take the production of such raw-materials within the country.

PHOTOVOLTAIC STRATEGY STEPS AND POSSIBILITY OF COOPERATION

The important role which photovoltaic technology is expected to play in future in the developing countries and specially in Egypt and India has been described in the preceeding sections. Photovoltaic systems are expected to play vital role in small size power requirements in immediate future, since their introduction in remote areas to power small electrical appliances will save both the countries from large expenses on extending power lines to the areas or from transporting fuels to such locations at an Exorbitant cost. In near future, when the cost of photovoltaic panels comes down to $1.00 to $0.50 per watt, as predicted by several scientists and industrialists working in this area, PV systems may be deployed to provide more power to meet electrical needs of general population in remote areas. This cost reduction according to many developed countries is expected to be realized in the next 3 to 4 years, but systematic establishment of photovoltaic production facilities will take more time. At this stage, when PV power has already shown potential for cost reduction and when the confidance level of Scientists & Technologist working in this area is very high, national governments of developing countries should take immediate steps to explore the possibility of PV production in their own countries in order to avoid future implementation delays. It is expected after 30 years, (PV power is expected to become cheap much earlier) the cost of oil produced energy will be much higher than non-conventional power (PV is good candidate), the oil will be needed for export specially by Egypt to maintain balance of trade and for aviation purposes. It may be noted that price of nuclear power is not cheap and is not expected to come down. If these countries wait for the developing nations to develop photovoltaic power, they will lose time and will be lagging behind in achieving their social & economic goals. It also may

be noted that developed nations have sufficient energy reserves and have developed their industries and power stations based on conventional resources and are not faced with the urgency of developing PV power for electric generation.

It may be noted that PV power when developed is expected to suit the specific social structure of developing nations where the population may be scattered in remote areas and the general public does not have sufficient knowledge of running and maintaining the complicated oil operated power system. Operation of PV power systems will not require good technical skill.

Looking back in the past history of man-kind, it may be seen that when-ever several forms of energies were available for development only those forms of energies got maximun attention of researchers and industrialist which were easy to handle and were neat and clean, eg. electric power in the present context when 4 - 5 good alternatives of renewable energies are available to maintain the most likely candidates will be the alcohol power & photovoltaic power as both of these are easy to handle and are clean in operation. In view of above it is the feeling of the authors of this report that these two forms of energy are likely to get maximum investment from private and government industries once the production technology is fully established. In fact in the area of photovoltaics few enterprising companies and oil companies in developed countries are investing large sums of photovoltaic research development. In India few private companies are keeping close track of photovoltaic device development while others have already ordered the R & D on other systems components. In Egypt the government is keen to develop PV power in shorter time.

For those developing countries which intend to enter the area of Photovoltaics the authors of this report suggest following strategy steps. Many

of the steps suggested below are interlinked to each other and have complicated inter-relationship and hence the strict sequence of steps could not be maintained.

1. Study various alternative photovoltaic technologies in the world and consider these interms of raw material availability, technological back-ground and scientific manpower available in the country.
2. Based on step 1, decide if PV power module/system production will be feasible, the what process steps are possible within the country.
3. Formulate immediate longrange PV programme in the country.
4. Initiative or put more efforts immediately on the PV - R & D programmes in the country. There is a certain probability that few other types of solar cells eg. Cds, A-Si, GaAs may become cost competitive in future.
5. Study the possibility of cooperation with other countries, which have played leading role. This will save tremendous time. It may be noted present PV status in the developed/developing countries is an out come of more than two decades of R & D work. Developing countries, if possible, should not start from beginning and wait for their own results. This may take a long time.
6. Interface with other industries and reaccess the availability of raw materials on large scale needed for future PV expansion. Redraw the plan if necessary.
7. Explore the possibility of producing high purity raw materials, within the country. If needed start programmes in those areas too.
8. Explore the possibility of producing other system components within the country if needed start the programmes in those areas.
9. Obtain the necessary scientific & technical man power within the country and start setting up production facilities of PV modules and raw materials. If needed send them for training in the specific areas.

10. It will be better to have an experience on the PV power systems and how they operate under the enviromental condition of the country. This experience will be necessary to develope countries own technology. If possible, few PV panels available in world market may be procured and systems be fabricated using local components.
11. Start the programme of educating the students at various levels so that manpower with proper back grown is available in future for specific training in various areas of Photovoltaics.
12. Have a feeling how the PV panels are going to be deployed in the field. What banking faciilities or technical assistance will be needed by the users. Look into the possibility of starting activity in this direction.

Both Egypt and India have been working in the area of Photovoltaics for (Tab.III) the last many years. The results have been very exciting. In addition, both Egypt and India have vast lands which contain high purity quartz sand and crystals. White Sinai sand in Egypt and crystalline deposits of quartz in Orissa in India open good possibility of production of high purity silicon. As mentioned above the possibility of cooperation between these two countries is likely to save time and effort. It may also help in supplementing each others efforts and may consider combined economic priorities. While formulating the cooperative ventures strong areas of each of the two countries will have to be looked into separately.

The present project report, has given brief account of the technology and research status of PV in Egypt and India and emphasises that there is a strong possiblity of cooperation between Egypt and India depending on the willingness of the respective governments to do so.

TABLE III
LIST OF ORGANIZATIONS WORKING IN PHOTOVOLTAICS IN EGYPT AND INDIA

AREA OF ACTIVITY	EGYPT	INDIA
1. Research and Development (Devices)		
(a) Silicon Cells (non-concentrating)	National Research Centre (NRC) Alexandria University Ein-Shams University (Cairo) Cairo University	M/S Central Electronics Limited (CEL) National Physical Lab. (NPL) Bhaba Atomic Rsch Centre (BARC) Solid State Physics Lab. (SPL) Indian Inst. of Tech. (IIT) Kanpur Indian Assoc. For The Cultivation of Sciences-Calcutta
(b) Others	NCR Ein-Shams Univeristy Assiut University	IIT - Delhi, NPL Jadavpur University Electronics Corp. of India Ltd (ECIL) Central Electronics Engring. Research Institute (CEERI)
2. Materials	NCR American Univeristy in Cairo Cairo University Ein-Shams University (Cairo)	National Chemical Laboratory, Poona NPL, Indian Inst. of Sci.-Bangalore, Regional Research Laboratory Bhurneswar, IIT-Madras, M/S Mettur Chemicals Ltd.
3. Production and System Studies	American Univ. (Cairo) NRC Ministry of Electricity and Energy	M/S CEL M/S Continental Devices of India Ltd. (CDIL) Dept. of Science & Tech. Min. of Agriculture, and many universities

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Note: The views expressed in this report are those of authors as participants of the TAET programme and do not necessarily represent the views of either government of Egypt or India.