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STATE OF THE ART OF SOLAR ENERGY R & D IN SOME LATINAMERICAN INSTITUTIONS

Report on mission, Prof. I. Chambouleyron, Ref. UNIDO 452/45

Institutions visited during the mission and staff personnel met for discussions.

MEXICO

a) Instituto de Ingenieria, Universidad Nacional Autonoma de Mexico (UNAM), Mexico City.

Dr. Luis Esteva Maraboto - Director
Ing. Luis Palacios Hammeken - Associate Director
Dr. Ricardo Chicurel - Researcher
Ing. J. L. Fernandez - Researcher
Ing. Alejandro Rodriguez - Researcher
M.Sc. Rafael Almanza - Researcher

b) Instituto de Investigacion en Materiales, Universidad Nacional Autonoma de Mexico, Mexico City.

Dr. Rafael Barrio Paredes - Researcher
Dr. William Pickin -Researcher

c) Centro de Investigacion y Estudios Avanzados, Instituto Politecnico Nacional, Mexico City.

c.1) Departamento de Fisica - Dr. F. Sanchez S., Researcher
c.2) Departamento de Ingenieria Electrica - Dr. J. L. del Valle, Head.

d) Centro de Energia Solar, Universidad Nacional Autonoma de Mexico, Temixco, Morelos.

Dr. Manuel Martinez - Researcher
Dr. Julia Taguena - Researcher

e) Secretaria de Energia, Minas e Industria Paraestatal (SEMIP), Subsecretaria de Energia, Direccion General de Investigacion y Desarrollo, Mexico City.

Dr. Edmundo de Alba - Director General
Dr. Hernando Guerrero - Director, Alternative Sources of Energy
Ing. Alberto Munguia - Associate Director, Alt. Sources Energy.

f) United Nations, Economic Commission for Latinamerica (CEPAL), Mexico City.

Ing. Roberto Gomelsky - Energy Division
Ing. Yves Chevalier - New and Renewable Sources of Energy

CUBA

a) Academia de Ciencias, La Habana.

Dr. Edgardo Gonzalez Alonso - Energy Sector
Mr. Manuel Roldan Barranco - International Cooperation

b) Facultad de Fisica, Universidad de La Habana, La Habana.

Prof. A. A. Martell - Head, Photovoltaic Group
Prof. Osvaldo Vigil Galan - Photovoltaic Group

c) Instituto de Materiales y Reactivos para la Industria Electronica, Universidad de La Habana, La Habana.

Dr. Elena Vigil Santos - Associate Director

ARGENTINA

a) Instituto de Investigaciones en Energia No-Convencional (INENCO), Universidad Nacional de Salta, Salta.

Dr. Luis Saravia - Director
Dr. Graciela Lesino - Associate Director

b) Secretaria de Energia, Direccion Nacional de Conservacion y Nuevas Fuentes de Energia, Buenos Aires.

Dr. Jaime Moragues - Director
Ing. Alfredo Rapallini - Consultant

BRAZIL

a) Laboratory of Photovoltaic Conversion, Institute of Physics, Universidade Estadual de Campinas (UNICAMP), Campinas, S.P.

Prof. Dr. I. Chambouleyron - Head

MEXICO

INTRODUCTION

Mexico is an oil exporting country with large amounts of oil and natural gas proven reserves. As a consequence fossil fuels contribute with a large fraction of the total energy consumed. The mexican Secretaria de Energia (SEMIP) however, is well aware of the finite nature of these resources and in the last years several actions concerning the use of new and renewable sources of energy were undertaken. The thrust of this effort is mainly done in the areas of geothermal energy, biomass (solid fuels) and minihydroelectricity. To a lesser extent, the use of direct solar energy has also been considered. It is important to note that Mexico is located in the world's maximum radiation belt, the annual average radiation being 2000 kWh/m2.

The main solar activities refer to flat plate collectors and optical concentration, solar dryers, photovoltaic cells and modules and a small activity in solar ponds and solar stills. The only activity that has already attained an industrial level is the fabrication of flat plate collectors. There are some 25 local manufacturers producing and commercializing around 30,000 m2/year. Some prototypes of solar dryers have been built and tested and this application seems extremely promising in Mexico where considerable fractions of the grain crops are lost every year because of moisture. A recent study shows that in some rural communities the losses may attain 70% of the total production.

Mexico was the first latinamerican country to start an independent photovoltaic activity. As a result of this action a PV cell manufacturing plant with a production capacity of nearly 20 kWp was installed at the National Polytechnic Institute (IPN). The modules produced at IPN were used to energize rural schools and communities. As a consequence of the absence of a national PV

program the pilot plant production was discontinued. At present the country needs are satisfied with imported modules.

INSTITUTO DE INGENIERIA - UNAM

The Instituto de Ingenieria was visited twice. During the first visit a general exchange of views was held with the directors of the institution. The mission objectives as well as the criteria to be followed in writing project proposals were explained. Useful information concerning the Instituto's R & D programs was in turn conveyed by the staff personnel, a particular emphasis being given to solar energy activities. During the second visit technical discussions where held on the different aspects of the research being done as well as an inspection to the experimental facilities. Before going into technicallyties it is useful to give an overview of the Instituto activities.

The Instituto exists since 1956, its main objective being to contribute to the development of advanced engineering in Mexico. Both basic and applied research projects are actually performed and the majority of the research areas derive from a strong interaction between the Instituto and private or public institutions. The personnel working at the Instituto is composed by:

Technical staff	Ph. D.	29
	M. Sc.	22
	Engineers	67
	Without diploma	16
Technicians and manual labor		100
Administrative employees		120
	total	384

The main R&D areas, as well as the number of projects being developed are listed in Table I. It can be seen that the majority of the projects refers to civil engineering and seismology, a reasonable choice in view of the permanent earthquake risks of the region.

TABLE I

R & D AREA	# of Projects
Automation	29
Building Materials & Structures	37
Soil Mechanics	21
Hydraulics	26
Environmental Engn.	40
Mechanical Engn., Fluid Mechanics and Thermal Engn.	30
Instrumentation	13
Seismology	38
Roads & Bridges	9
Total	268

The ten projects related to solar energy are included in the area of thermal engineering :

	# of Projects
Flat plate collectors	1
Optical concentration	2
Solar ponds	2
Solar dryers	2
Solar stills	1
Solar systems	2

In 1986 the Instituto produced:

91 communications to engineering conferences (out of which 7 refer to solar energy),

19 papers published in scientific journals (2 refer to solar energy), and

5 books (none of which refer to solar energy).

The analysis of the publication list shows that the aim of the Instituto is not merely academic. The Instituto research work is diffused through three series of publications:

1) tecnical works (in spanish),
2) research works (in english or french), and
3) review papers on special subjects aimed at lecturers (in spanish).

The solar thermal plant

The most important solar project done at the Instituto is a solar thermal electric plant that uses cylindro-parabolic concentrating mirrors to heat oil up to a temperature of nearly 300 C. The initial project considered the building of a generating capacity of 60 kWe but up to now only a 35 kWe fraction has been completed. It seems that the original project will never

eventuate because of the following reasons. The plant is located in the fields of the University in Mexico City. The air pollution is so severe in the valley of the City that there are no radiation conditions any more for a satisfactory operation. Finally, among the staff personnel nobody seems interested in this undertaking and the plant looks almost abandoned. The total investement in this project is of the order of 3 to 4 million U$ dollars. It is important to note that, according to some staff members the plant never worked satisfactorily. It is the consultant's feeling that this project was undertaken prior to having the expertise necessary to guarantee its success.

Solar drying

Mexico produces food for nearly the whole population, whose diet is essentially based on grains. In the last years however the apparent per capita consumption of calories has decreased. This fact is believed to be partially due to the high losses the grain crop experiences in the transportation circuit between the place where the grain is harvested and the consumer. Rough calculations show that these losses amount to the food imported by the country. The problem is the following: the producers do not possess any grain drying infrastructure, the conventional systems being highly expensive. This situation makes that they must either sell the grains in a period when the prices are low, either store them in bad conditions and suffer high production losses. Both situations are unfavorable to the mexican peasant's economy. The government (CONASUPO) has large store buildings where the grain drying is made with oil powered systems. These facilities are however insufficient during the narvest season, creating a bottleneck in the grain reception. As a consequence the gathering centres store the grain in non optimum conditions and the process associated losses are also considerable.

An alternative solution to this problem is the use of low temperature grain drying at the producer level and consequently,

the Secretary of Energy is interested in the development of solar dryers. They must be designed in such a way as tobe economic and locally built with the materials and manpower available in the rural regions. They should also be modular and of size appropriate to the grain quantities normally dried in small community farms. It is believed that the use of solar dryers would result in a 90% economy of conventional fuels, the remaining 10% representing the electric energy (when available) used to power the funs.

At present the Instituto is working in a solar dryer project having a capacity of 30 to 40 tons of grain. The first part of the project has been already achieved. It studies the temperature and humidity of the air coming out of a 160 m2 collector made out of cheap materials like volcanic stones and plastics supported by a light metal structure. According to the staff personnel the results of the measurements made in the experimental field of the Instituto, are highly satisfactory. In a simultaneous operation a computer model describing the grain drying process has been developed and is presently being tested. The second part of the project deals with the building of the grain container and the study of its performance with different grains. It is the consultant's opinion that this is one of the most interesting projects being developed at the Instituto.

Other solar projects

The Instituto also works in the technology of mirror fabrication. This is a more basic research dealing with the minimization of the reflective losses in metal coated glasses. It is at present at a rather preliminary stage. In a similar level of development a project on a solar still is being carried out. It is planned to use it in Baja California where the lack of potable water is dramatic.

OTHER INSTITUTIONS IN MEXICO

Other mexican institutions committed one way or another with the research and development of solar energy were also visited. These visits were highly instructive in providing the consultant a clear picture of all mexican solar activities. However, an important research centre that was not visited is the R&D facility of the Comision Federal de Electricidad (CFE), Palmira, Morelos, where research is being done on wind mills, geothermal energy and solar ponds.

CUBA

INTRODUCTION

The cuban energy panorama is completely different from the mexican one. Cuba is an oil importing country and also lacks all the other conventional sources of energy like coal and hydroelectricity. Nevertheless the electric grid covers the whole country and satisfies the needs of more than 85% of the population. A nucleo-electric plant was projected and is now being built under soviet supervision. It is the result of an energy policy tending towards the diversification of energy sources, the aim being to decrease the country's dependence on imported oil. Within this context a concomitant effort is being made, both in the research level and in the industrial area, regarding the use of the new and renewable sources of energy.

There are two main activities being carried on in the field of solar energy:

a) A flat plate collector factory in Santiago de Cuba. The collectors, made with local technology are mainly used in schools, hospitals and hotels. Other R&D projects refering to solar stills, solar refrigerators and ambient conditioning are also carried out in Santiago de Cuba.

b) Concerning the photovoltaic activity the situation is the following. A P.V. module production factory exists in La Habana having an installed capacity of 150 kWp/year. This key turn factory was bought in Spain and is working at present at one third of its nominal production capacity. The single crystal silicon solar cells are currently imported from Spain or from other countries. The main end uses of the P.V. modules are: TV station repeaters, lighting and communications in fishing gathering centres, rural health facilities, isolated schools, etc. A photovoltaic research group exists at the Instituto de Fisica, Universidad de La Habana, developing the manufacturing

technology of single crystal silicon solar cells. It is important to note that a simultaneous industrial effort is being made concerning electronic devices, a field of activity somehow related to photovoltaics. A factory in Pinar del Rio produces discrete devices like power rectifiers and transistors and integrated circuits of low level of integration.

THE ACADEMIA DE CIENCIAS

This institution plays in Cuba the role of an academy of sciences and a national research council, that is, it establishes the general policies in science and technology for the whole country. It is under the supervision of the Academia that most of the R&D projects on new and renewable sources of energy are developed. This is the reason why the visit to the Academis was highly important and allowed the consultant to have an overview on the activities performed in the country. As a consequence of the cuban centralized administration, the Academia is also the right place where to discuss international cooperation. During the consultant visit an interesting exchange of views occurred with the officials in charge of the solar projects. The aims and objectives of the mission were presented and a detailed survey of the cuban solar projects was undertaken. It appeared that one of the most promising projects is the development of an industrial prototype of a solar-thermal ambient conditioner to be installed in nurseries and low age children keeping houses. Cuba is at present building a large number of such institutions. Because of their social objective and the tropical humid climate of the island, ambient conditioning is an absolute necessity.
The energy needed to power the air conditioners in Cuba is supplied by thermo-electric plants. As already mentioned, there is a general energy policy tending to decrease the use of imported oil. Within this context the possibility of using solar conditioning appears as highly desirable. Once the proposed prototype is developed, the local industry should manufacture it

in large quantities. Cuba will probably submitt to UNIDO a project on solar conditioners design and construction.

THE FACULTAD DE FISICA - UNIVERSIDAD DE LA HABANA

A group of approximately ten researchers is working at the Facultad on single crystal silicon solar cell technology. The head of the group is Prof. A. A. Martell and a strong scientific interaction exists between the cuban group and several laboratories of Eastern Europe countries, particularly the Soviet Union and Poland.

The visit to the laboratories and the discussions held with the group members showed that, on one hand the laboratory lacks modern and sophisticated equipment, most of which is home made. In the consultant's opinion this constitutes a severe limitation to the development of high tech products. On the other hand, and probably because of the abovementioned limitation, the main research subjects, single crystal silicon solar cells and semiconductor- insulator- semiconductor structures (surface barrier solar cells), are developed with a mere technical approach. In other words, the general impression is that little scientific research is being done, although the personnel appear as highly qualified. It was not clear to the consultant how close are the relations between the laboratory and the P.V. module factory.

INSTITUTO DE REFRIGERACION Y CLIMATIZACION

It was not possible to visit this institution although a phone contact was established with its associate director, Mr. Quinteros. This institution works on the many applications of solar energy in ambient conditioning and most probably the abovementioned conditioner prototype will be developed by this Instituto.

ARGENTINA

INTRODUCTION

Argentina is self-sufficient in oil and the country possesses large reserves of natural gas and hydroelectric resources. Notwithstanding, a national program on new and renewable sources of energy has recently been established. The five years plan (1985 - 1989) refers to the use of biomass, wind and direct solar energy, micro and minihydro, tidal energy and geothermal power. Concerning direct solar energy the main activities are solar houses, solar thermal and photovoltaics. The resource is measured through a solarimetric network having at present 42 stations distributed all over the country.

The Secretary of Energy supports several Regional R & D centres which operate in close relation with the Secretary for Science and Technology, the government of the province where the centres are located and local universities. Up to now four such institutions exist: the Regional Centre for Solar in Energy in Salta, the Regional Centre for Geothermal Energy in Neuquen, the Regional Centre for Wind Energy in Chubut and the Regional Centre for Microhydroelectricity Generation in Misiones. In a simultaneous action the type of the most relevant applications is established, as well as the size of the respective market.

It is important to note that the main objectives behind the governmental effort to increase the use of the new and renewable sources of energy in Argentina are: to satisfy actual energy needs of the population living in isolated regions, to promote the local industry through the manufacturing of mature tecnology equipment, and to preserve the environment with the use of benign energy technologies.

It is the consultant's opinion that most probably Argentina is the only latinamerican country where the promotion of the new and renewable sources of energy is clearly programmed in a National

Plan. Other countries experience great difficulties in establishing such programs and many actions, as important as they might be, are more the result of isolated and individual undertaking than the result of planned and coordinated activities at an official level.

THE INSTITUTO DE INVESTIGACIONES EN ENERGIA NO-CONVENTIONAL (INENCO), UNIVERSIDAD NACIONAL DE SALTA.

As its name clearly indicates all INENCO activites refer to the use of non-conventional energy sources. Established in 1981 on the grounds of some research groups existing at the University of Salta, INENCO possesses R & D projects related to solar, geothermal, and other non-pollutant sources of energy. This program is established in close contact with public and private institutions of the region. The methodology has proven to be very succesful and rich in results, in the sense that it allowed to tackle actual energy problems existing in the northwestern provinces of Argentina. Three years ago a small research team working at the University of Catamarca was associated to INENCO. The main R & D activities however, still remain in the province of Salta (25 staff members, 10 technicians and 3 administrative employees). The facilities at INENCO comprise three indoor laboratories and two outdoor field test laboratories. These are: laboratory for small solar ponds, for thermal measurements, and for thermodynamics of solutions; and fields for solar pond testing and for the solar drying of agricultural products, respectively. Two workshops for electronics and mechanics, a library and a computer centre complete the infrastructure.

Main solar projects under development:

1.- Rural applications of the solar energy:
The objective of this project is the development of solar systems allowing to solve some energy problems of the northwest rural

areas, in particular those of isolated human settlements. Some detailed information follows.

a) The solar drying of agricultural products:

This subject is developed in two levels: systems working at a family scale and at large or industrial scale, respectively. In the northwestern argentine provinces the drying of grains, fruits, pepper, tobacco leaves and coffee is of paramount importance. Besides the succesful development of small scale solar dryers, INENCO has also developed two large scale systems. The first one is mostly to dry pepper (capsicum) in the Calchaqui valleys. The solar energy collector covers an area of 400 m2 and provide hot air at 52 C, eliminating the chronic problem of dust contamination always present in the open air drying systems. The second one addresses the problem of the drying of tobacco leaves, Salta being one of the big producers in Argentina. At present the installed equipment covers 700 m2 of collectors and works with 3 stoves, each one able to dry 6000 Kg of humid tobacco. The dryer includes a heat storage system of 250 tons of stone, the drying systems working also at night time.

b) Greenhouses for arid zones:

In the arid zones of the "Puna" (H 3000 m above sea level, andean region), the population suffer a chronic deficit of vegetables and fruits in their diet. The shortage of green products derive from the impossibility of growing plants in such an arid and cold climate. At present a greenhouse prototype is being installed in a "escuela-hogar", i.e. a primary school where the children live. The idea behind the project is to nourrish the school children with the products they help to grow. The benefits and the limitations of the system under construction will be establishe within a couple of years.

c) Solar stills:

In many zones of the Andes there is a problem with brackish and arsenic contaminated water. Small units producing potable water

at a family level would greatly contribute to increase the quality of life. For that purpose a small (15 m2) but highly performant solar still is at present under test.

d) Photovoltaic systems:

An effort is being made in the design of small P.V. systems for lighting and water pumping applications. Some P.V. systems are already installed and their performance is continuously monitored. In the province of Catamarca 22 rural primary schools are being energized with P.V. systems (200 Wp/school).

2.- Solar ponds

The northwestern provinces of Argentina possess several open sky salt mines which appear to be appropriate for solar pond applications. Several years ago INENCO undertook R & D projects related to the use of the solar energy captured by solar ponds in the industrial purification process of non-metallic minerals. Since 1981 an industrial unit operates in the region. The system produces sodium sulphate at a rate of 130 tons/month. It is useful to note that this is probably the only succesful experience in the use of solar ponds in an industrial process. Nowadays the research team in Salta is working in a project aiming at the industrial production of boric acid and aluminum sulphate. A second project contemplates the possibility of using the heat extracted from solar ponds to condition houses, public buildings or greenhouses.

3.- Temperature conditioning in houses and buildings

One important item of energy consumption in Argentina is the indoor conditioning, heating in winter time and cooling during summer. It is relevant then to study building materials that together with helio architectural design minimizes the expenditures in oil and electricity. INENCO possesses several projects in this area. The most important one is the study of a house specially designed for the arid and cool climate of the

Puna. The house was finished in 1986 and more than a year indoor conditions monitoring exists today. The house does not possess any ambient conditioning system other than solar. The results of the study show that the in-house temperature conditions are remarkably stable (around 20 C) in spite of the large outdoor temperature variations. A second stage of the project that is now being developed considers the possibility of using cheaper materials for school building. It is interesting to note that these results with ambient conditioning are highly relevant not only for Argentina but also for other countries having the same climate, like Chile, Bolivia, Peru and Ecuador. The discussions with INENCO officials showed that a project in this area may make a lot of sense for the Region. The help of UNIDO will probably be required.

Another couple of research projects refering to indoor cooling are under development. They address the problem of temperature control in hot-dry and hot-humid climates respectively. Passive evaporating systems and dehumidifiers (using special salts) followed by evaporation are under test.

BRAZIL

INTRODUCTION

It has been correctly stated that Brazil more than a country is a continent. That also means that the energy panorama is not unique in Brazil and changes from state to state, in particular with reference to the R & D in the field of new and renewable sources of energy. The most famous achievement in the area is the brazilian alcohol program that feeds today hundreds of thousands cars accross the country.

A rough estimate of the strictly solar direct activities shows four interesting spots: Paraiba, in the northeastern region where a lot of research on solar thermal systems has been done and continue to be made; Rio de Janeiro and Sao Paulo states where most of the research, development and industrialization of solar materials and devices is located, and Rio Grande do Sul where some work is also done on solar thermal systems. Brazil manufactures flat plate collectors, a well established industrial activity with a moderate private market. It also manufactures silicon solar cells (Heliodinamica S.A.), an industrial activity that only exists in the three Third World giants, China, India and Brazil. It is important to note however that Brazil imports the polysilicon. Single crystal silicon ingots are locally grown, sawed and the wafers are processed to solar cells out of which P.V. modules and systems (mainly for communications and water pumping purposes) are locally manufactured. At present the industrial capacity of Heliodinamica S.A. is:

1.- Single crystal silicon ingots, Czochralski method, up to 8" diameter, production capacity: 34 tons/year.

2.- Silicon wafers, unpolished, up to 8" diameter, production capacity: 1.2 million wafers/year.

3.- Silicon wafers, polished, up to 6" diameter, production capacity: 150.000 wafers/year.

4.- Photovoltaic cells and modules, 4" diameter cells, production capacity: 1 Mwp/year.
The company exports silicon wafers (U.S.A., India, Argentina, etc.) and to a lesser extent solar cells, P.V. modules and systems.

It is not possible to give here a full account of all brazilian activities in solar energy. The consultant had no occasion to visit all the groups nor to review the official plans concerning the use of new and renewable sources of energy. It is relevant to note however that in Brazil there is not a unique governmental agency dealing with the problem. In fact no less than a dozen secretaries of state, federal financing agencies and research councils at a federal or state level, promote and support these activities through programs that, most of the time ignore each other. In spite of this apparent chaotic situation much has been done and Brazil is today the leading latinamerican country in the majority of solar technologies.

THE LABORATORIO DE CONVERSAO FOTOVOLTAICA - INSTITUTO DE FISICA UNIVERSIDADE ESTADUAL DE CAMPINAS, (UNICAMP), CAMPINAS, S.P.

The laboratory started its activities in 1979. At that time there was no photovoltaic activity in Brazil. In 1980 a course on Solar Energy Conversion at a post-graduate level was offered and attended by 25 researchers coming from UNICAMP, the University of Sao Paulo, the University of Sao Carlos and the National Institute for Space Research in Sao Jose dos Campos. This pioneering effort produced most of today's P.V. group leaders in Brazil, including the industrial sector.
By its size and experience the Laboratory is, in the field of P.V. materials and devices, the most important research place in Latinamerica. At present it attracts students and specialists of all countries of the Region and joint research programs exist already with Argentina, Colombia and Mexico. Staffed with four senior researchers, the Laboratory will incorporate in 1988 other

two well known latinamerican specialists in amorphous semiconductors and devices. Six M.Sc. and Ph.D. thesis in Physics have been already completed and six more are under completion. In the last years the Laboratory produced more than 40 scientific international publications, 50 communications and a dozen technical reports. In 1987 Prof. I. Chambouleyron, head of the Laboratory, receive the Energy for Mankind award, given by the Global Energy Society, USA.

The group perform both basic and applied research and is supported by the University, financing agencies at a federal and at a state level and by research contracts established with public and private companies. The Laboratory developed the manufacturing technology of single crystal silicon solar cells and is currently working in the fabrication processes of up-graded metallurgical silicon devices (solar grade silicon). In relation with these developments some research was also done on basic and applied aspects of transparent electrodes, in particular the oxides of tin and indium. This last research subject led to a project on optical memories of high storage capacity. An international patent was issued on the fabrication process of the optimized material.

Besides the above mentioned technological developments it is important to mention the research being done on amorphous semiconductors. Hydrogenated amorphous silicon films have been produced by the glow discharge of silane gas and by the so called R.F. sputtering method. The material properties were optimized and p-i-n a-Si:H solar cells having 7% conversion efficiency were produced. In parallel with this development a lot of research on a-Ge:H films, as well as in silicon and germanium alloys has been made. These variable band-gap amorphous semiconductors, like Si (Ge) nitrides and carbides and Si-Ge alloys are very promising materials in photovoltaics, their use being foreseen in multijunction solar cells.

Some relevant work is also done in the computer modeling of crystalline and amorphous solar cells and on the socio-economic

impacts of the use of photovoltaic systems in the Third World. The research group possesses three reasonably well equiped laboratories and benefits from the scientific infrastructure of the Institute of Physics at Unicamp (X-rays, low temperatures, visible, infrared and Raman spectroscopy, surface and interface analysis, high speed electronics, magnetic ressonance, etc, etc.)

Considering the role this Laboratory may play in the latinamerican region a few remarks apply. During the last decade major areas of concentration of the government R & D programs in both developed market economy countries and socialists countries of Eastern Europe have been photovoltaics and biomass technologies. In the Third World the need to establish a policy in these area has led in many countries to three different types of strategies: a) monitoring strategy, b) application-oriented strategy, and c) indigenous technology development strategy.
It is the consultant's opinion that, taking into account its relative degree of development, the latinamerican region should adopt the last strategy for photovoltaics. This entails the assimilation and eventual mastery of a wide spectrum of photovoltaic technologies and the need to build up domestic capabilities to generate new technologies as well as to reproduce them. The human and financial resources needed to meet these goals preclude individual countries to perform such a task. The need appears then to establish for the Region "centres of excellence" where researchers and students of all countries could perform advanced research, work on specific energy technologies or obtain higher degrees in the subject. Within the present latinamerican context the Laboratory of Photovoltaic Conversion - UNICAMP can play such a role if appropriate funding is available. A project proposal in such direction will be submitted to UNIDO.