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Kernforschungsanlage Jülich GmbH

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Report

on the

Status of Solar Energy Research

in

MOROCCO, TUNISIA AND ALGERIA

Itinerary

Morocco

April 19 - 20, 1988

-

Rabat

April 21 - 24, 1988

-

Marrakech

Tunisia

April 25 - 29, 1988

-

Tunis

Algeria

April 30 - May 4, 1988

-

Alger

UNIDO-Mission to Morocco, Tunisia and Algeria

April 19, 1988 - May 4, 1988

MOROCCO - April 19 - 24, 1988

Contacts:

1. United Nations Development Program RABAT

Miss Silvana Rimoldi, Junior Professional Officer

Miss *Rimoldi* had taken care of the hotel reservation and sent a car to the airport to pick me up. Beyond this no preparations had been made for my visit. As office hours because of Ramadan were restricted to 09.30 a.m. to 02.30 p.m. it was not possible to arrange all useful visits within the two days foreseen for my stay in Rabat.

... Ecole Mohammadia d'Ingénieurs, RABAT-ADAL

Prof. M. Trabi was not available, as he was invited to stay for one year in Paris. His temporary successor, *Mohammed Boudida*, Department of Genie Mecanique (tel.: 71905) kindly showed the laboratories and gave valuable informations concerning the status of solar activities in Morocco.

In his laboratory (and in most of the others) some work was done in the field of solar water heaters, but only copies of older systems were to be seen. *Mr. Boudida* explained, that years ago some private companies had started to produce waterheaters in

Morocco, mostly under license of French companies, but all of them had given up again, as there was no market. Today they import some from Tunisia or France and sell installations of family size (60-l-storage) for prices between 7000 and 10000 DH (800 - 1200 US-Dollars). Very few installations of bigger size were put up on hotels.

The laboratory has started the development of a solar cooling house for crops with an absorption cooling system (5 kW) with flat collectors. The very preliminary work did not look promising.

There was as well a modest experiment being prepared for solar water-desalination by distillation.

The laboratory as a whole seems not sufficiently advanced to do substantial project work in the solar field without intensive assistance of some stronger partner.

3. Institut Agronomique et Vétérinaire Hassan II. Département de Génie Industriel Alimentaire, Rabat

In this institute Mr. *Senhaji* (tel.: 70793) is doing work in the field of solar drying. Unfortunately, he was not present, but paid a visit to the Office Regional de Mise en Valeur Agricole du HAOUZ, Marrakech, where his dryers are being tested. His co-worker however, *Jean Baranger*, Ingénieur ENSIA, showed me round the laboratory in Rabat. All work being done here concerns solar dryers with natural convection, which have been tested up to now mainly for apricots, one of the main products of the Marrakech region.

In Rabat there was a smaller dryer with about 3 m² flat collector and the standard drying box on top. During the harvest of apricots in May/June, temperatures of 60 - 80° C are reached in these dryers. It has not been measured, how much air is flowing through the system.

One day later I could see a big dryer of 60 - 80 m² collector size, which had been tested in the JAV in Marrakech. Both systems looked simple enough but too primitive; in the local climate (high insolation, air temperatures in harvest time around 40° C) they seem to be good enough, - at least for one season (about three weeks). I found it remarkable, that in the Rabat Institute different treatments of apricots before the drying process - which are as well used in the traditional non-solar drying processes - had been tested and analysis made. If a good partner is found for this group, it should be able to do good project work.

4. Within the JAV there is more solar development being done in the Département de Machinisme Agricole. The department head, M. Dahman, was not present; I was shown round by Mr. Boulghallat.

There is work going on in the fields of solar water heaters and desalination by distillation, but all subcritical.

I was recommended to visit as well the ECOLE NATIONALE d'INDUSTRIE MINERALE, Département Génie Chimique et Energétique in RABAT, where under Mr. Fassi Fihri work on solar water heaters and applications of fotovoltaic systems is going on; but there was no time left for such a visit.

During my two days in RABAT it was not possible to arrange a visit in the Ministry of Energy and Mines, which I considered important. But finally I could at least get hold of Mr. *Mohamed Srifi*, chief of the Renewable Energy Service, by phone. He declared, that all information he could give me I would get during my foreseen visit in the "Centre de Développement des Energies Renouvelables (CDER)" in Marrakech, as this centre is working exactly along the lines of the Government's philosophy.

5. Centre de Développement des Energies Renouvelables - CDER - in Marrakech

This center, which is (with a staff of about 50 persons) by far the biggest organisation in the field of Renewable Energies in Morocco, was created by law in 1982 and started its activities in 1983. It is not intended to do research, but to analyse the potential of Solar Energy, Wind Energy and Energy produced from Biomass for Morocco. It assists the implementation of promising systems, is expected to adapt them to the specific conditions prevailing in this country, and to train personnel necessary to run such systems.

At the moment the center has only preliminary offices and experimental sites around. The final building is under construction and might be ready beginning of 1989. I was shown the existing experimental facilities in Marrakech: One conventional waterheater, one of own design (not looking very promising) and two bigger units, given by USAID. One of them - a collector test unit - was dismantled. As flat collector development work seems not to be going on, it might not be needed. The second one was operational: Three fotovoltaic panels - each of 1,44 kW_{peak} - with three pumps mounted in one well.

Mr. *Abdelhaq Fakihani*, Director General of CDER, whom I had met before in solar conferences in Bahrein and Jordan, certainly is a very dynamic manager. He gave me some informative papers which are attached as annexes 1 - 3. As I understand them, they present as well existing reality as future plans without making always recognizable which is which. He underlined in the long and intensive discussion the need to start industrial activities in Morocco in the thermo-solar field as well as in fotovoltaics (here starting with the assembly of panels). To promote this development three industrial associations were founded:

AMISOL (Association Marocaine de l'Industrie Solaire)
AMEOL (" " de l'Industrie Solienne)
AMPER (" " de Promotion des Energies Renouv.)

They should not only be considered as lobbies, as they are expected to start a system of quality-self-control of products coming on the market.

Mr. *Fakihani* expressed his strong interest in any activity of UNIDO in Morocco assisting the efforts of CDER.

CONCLUSIONS

As Morocco has to spend about 50 % of its export revenues for the import of oil and as it has all over the country a high insolation the government is highly interested in the use of solar energy in order to reduce the heavy dependence of oil imports. In addition, the government wants to develop the rural areas, especially to

bring electric power to the remote villages not being connected to the electric grid.

R & D, going on in different institutes and laboratories, has not yet reached a level high enough to reach good scientific and technological efficiency without close contacts to stronger partners.

In some fields - like solar water heating and small fotovoltaic systems - the main effort needed is not R & D, but to assist local industry to enter these fields.

For the introduction of solar water heaters a first step could be the creation of a test station for integrated solar water heating systems, which should be selected under the aspects of Morocco's needs and industrial potential. With the existing favourable climatic conditions not only household sizes should be considered, but as well bigger units for hotels, schools, hospitals and industrial use. The main outcome of such an effort should be the information of the national industry concerning different existing technologies and the possibility to choose the most adequate foreign industrial partners. The design of such a test station should as well be assisted by some experienced foreign partner.

For such a test station CDER would certainly be the most adequate national partner. The inclusion of Moroccan industry from the very beginning might be a necessity.

Testing and demonstrating small fotovoltaic units does not need a central station: ongoing activities of CDER in connection with USAID might fully cover the needs.

An interesting start has been made in Morocco to apply solar drying for apricots and some other fruits. Seen the importance of fruit production for agriculture and fruit-industry, it would be worthwhile to start a project of this kind on a somewhat broader basis. An adequate partner would be the JAV in Rabat, where Mr. *Senhaji* has started such work in the Département de Génie Industriel Alimentaire. As well the Office Regional de Mise en Valeur Agricole in Marrakech, which has already been cooperating with Mr. *Senhaji*, should be partner in this project.

In order to assure an effort equivalent to the importance of the topic, a partner from an industrialized country should be included, who could cover both main aspects of the problem: To develop simple and economic dryers of different capacity and to look into the food-technological aspects of the drying process, especially the chemical pretreatment of the fruits and its influence on the aging behaviour (like discolouring) and the influence of drying temperature on the fruit quality.

TUNISIA - April 25 - 29, 1988

Contacts:

1. United Nations Development Program TUNIS

My visit was prepared by Mrs. *Cluckers* in contact with the German Embassy. Mrs. *Cluckers* was active and helpful.

2. Agence de Maitrise de l'Energie - AME

This agency, acting for the Ministry of Economy, has to coordinate all activities in the field of Energy. A long discussion with *Mohamed Sassi Radhouani*, Department of Renewable Energies, (tel.: 787700) showed, that in Tunisia the government is taking much more influence in the overall development than in Morocco. AME is screening all project proposals before they can get public funding, - not only in the field of R & D, but as well all applications expecting any financial help. It has as well influence on import licences.

The main reason for the more advanced use of solar water heaters and small fotovoltaic equipment in this country might be the investment help given by the government to private persons buying such installations. The owner has to take over only 10 % of the cost, the rest being prefinanced by the public utilities and paid off by the owner over a period of seven years.

Mr. *Radhouani* considers new activities necessary in the following areas:

- building up a test station for solar water heaters from household to industrial size being needed for the decisions of AME which products to promote. The test station should be run by some neutral organisation, but have good contact with concerned industries in order to transfer its experience;
- household water heaters of substantially lower price than those being presently on the market having the same construction

principles as those in industrialized countries. In spite of their comparatively low prices and the financial help given by the government they still are too expensive for people in the rural areas. Under the aspect of the firewood problem a cheaper version seems important, not by degrading the construction being on the market, but by developing a much more simple - but not primitive - version, which might have somewhat lower efficiency and smaller storage but which can achieve the water temperature needed in rural households (about 50 - 60° C);

- solar water heaters of bigger size for hotels, schools, hospitals and industrial use;

- advanced solar drying equipment for farmers. There is a bigger project for solar drying underway, initiated by a French company with financial contribution of the EEC, but it is meant only for bigger organizations like cooperatives, as it uses equipment applicable only for big quantities. Mr. Radhouani has seen the development going on at the University of Hohenheim (Prof. Mühlbauer) and would like to have it adapted to Tunisian products and climatic conditions;

- solar desalination units of family size for rural and remote areas. They are needed not only for seawater, but as well for groundwater-desalination, as in many areas the groundwater being used as drinking-water has too high a salt-content (≥ 1000 ppm).

A paper of Mr. Radhouani (annex 4) gives more details.

3. Institut National pour la Recherche Scientifique et Technologique - INRST

This institute has only partly been built up; it was foreseen to have a staff of 500; at the moment there are 70 professional staff and about 100 workers. It seems uncertain, whether the institute might ever reach its originally foreseen size.

Mr. *Mohamed Maalej* is the director of the "Centre de Physique et Energétique (CPE)" within INRST and has some overall influence on R & D-activities in the field of Renewable Energy. He principally agreed with the ideas of Mr. *Radhouani* with some modifications in detail:

- The test station as proposed by AME should include a test banc for fotovoltaic panels and equipment, as it seems necessary for the development of national industrial activities;
- he agrees that simple household water heaters for rural areas would be useful but gives them a lower priority;
- he, too, gives high priority to solar drying (grapes and pimenta) and desalination.

A survey on research going on in Tunisia in the field of Renewable Energy is given in a paper of Mr. *Maalej* (annex 5).

A tour through the institute showed the character of the work going on there. Some bigger units (10 kW thermo solar power station, fotovoltaic power station) given by other countries looked operational: a collector test unit, already two years old,

was brought into operation with the assistance of a German expert. A semi-industrial unit for the encapsulation of silicon wafers of a capacity of about 10 kW_p/a was under preparation but not yet in operation. The equipment was selected with the help of an Italian company.

For some non solar purposes a wind-channel is being constructed, which can as well be used for investigating the kinetics of fruit drying.

No other endogenous developments were to be seen. Parts of the fotovoltaic activities however are going on in other institutes, especially in the faculty of science of the Tunis University under the guidance of *Prof. Bennaceur*.

4. Ecole Nationale d'Ingenieurs de Tunis - ENIT

The work of this organisation within the field of Renewable Energies has been going on for some years in cooperation with a German governmental Agency represented by two German specialists integrated into the staff ENIT. Focal points of the activities are thin layer fotovoltaic systems, thermosolar water heaters, collector testing and the development of computer programs for passive use of solar energy. The group has good contact with the thermo-solar industry.

5. Société Tunisienne d'Electricité et de Gaz - STEG

Mr. Khéreddine Guellouz, director of the department of R and D (tel.: 341383), explained that the main interest of his group was the diagnosis, under which boundary conditions fotovoltaic energy

can become economic and in which way the government should give financial help in order to achieve optimal use of solar energy in the fotovoltaic and thermosolar field.

Fotovoltaic units were found to be competitive in sizes up to 1 kWh/d power production. As there exists a considerable market the national production of such units is considered to be necessary. A special laboratory to assist industry to enter this field is under consideration. Financial assistance of UNIDO to buy the laboratory equipment would be very welcome.

Solar water heaters produced by three companies (SEREPT, SIAME and SACEM) are being sold in Tunis for about 550,- DM/m² (including storage, not including alternative electric water heater). Standard sizes of 2 - 4 m². The 90 % of the investment cost, prefinanced by the government, are paid back over 7 years (for a 2 m² unit about 26,- DM every two months included in the regular bills of STEG). Expected life time of the waterheaters about ten years. For a private household connected to the grid the price of one kWh_e is 0,14 DM.

6. SEREPT Energies Nouvelles S.E.N.

Following a recommendation of STEG out of the three industrial companies producing solar water heaters, S.E.N. was visited. Mr. *Slah Djebali*, "President Director General", who made the impression of being very competent, gave all needed informations:

S.E.N. has taken over the technology of a French company (Alf Aquitaine) and is producing the French type of water heater for about 60 % of the French production costs. In 1987 7000 m² of water heater collectors were sold; in 1988 a production of 9000 - 9500 m² is expected. The export to Morocco is growing; Mr. *Djebali* was astonished to learn, that they are sold there for about the double price.

The majority of the company is hold by the government. It imposes to the company to sell the water heaters to the lowest possible price without making profit, which explains the low specific price of the heaters (about 550,- DM/m²). It also explains the substantially higher selling prices in Morocco, where private companies prepare the production of such equipment and certainly want to prepare the market for their future prices.

S.E.N. is already entering the market of bigger units for hotels. A first big installation of 450 m² of collectors (being made up of the small collectors used in household units) on a hotel ("SULTAN") in Hammamet will be inaugurated within short. For such bigger units S.E.N. concludes a service-contract over the first years for a fee of about 2,- DM/m²/a to make sure that they will lead to good experience.

On invitation of Mr. *Djebali* I could visit the production line of these units. It made a well organized impression and showed at the same time that a very simple collector design (1 glass-cover, no selective layer, aluminium absorber sheets black painted, mechanically fixed to Cu-tubes, nearly no thermal insulation at the sides, 3 cm of mineral wool and 3 cm of styropor as back side insolation) can do the job under climatic conditions as prevailing in North Africa.

CONCLUSIONS

Tunisia still is an oil exporting country but it is expected that in the beginning of the nineties the national oil-production will be fully used within the country in spite of substantial efforts to find new oil resources. As a consequence the government is strongly promoting the use of renewable, especially solar energy. The prefinancing of solar water heaters which is being expanded to small fotovoltaic units has created a market for national industry, which is actively entering it.

In order to guide industry there should be installed a test-station for water heaters and as well for fotovoltaic components produced locally. The preconditions for them are given both in ENIT and in INRST.

The development of very simple and cheap water-heaters for rural areas would make a contribution to the improvement of living conditions in remote rural areas. It could be combined with the development of cheap water-heaters of bigger size as needed for industry, schools and hospitals. Such work would fit into the activities of ENIT.

In Tunisia, too, solar drying of different fruits has high priority. The wind channel under construction in INRST could be a helpful instrument for finding optimal parameters for different fruits. This institute would therefore be the best place (under the visited institutions!) for such project, for which the University of Hohenheim would be a welcome partner. As in Rabat

(JAV) and in Marrakech as well substantial work has been started it should be considered to create close contacts between Tunisia and Morocco in this field.

INRST would be open for the exchange of scientists and technicians between both countries.

Small units for the desalination of salt-water of different origine for remote areas would be of importance under medical aspects. As their technology might correspond to that of simple water-heaters the development of both methods at the same institute (ENIT) seems recommendable.

ALGERIA - April 30 - May 4, 1988

Notes:

WIDO, Mr. *Jörg Hake*

Due to the late announcement of my visit to the Ministry of Foreign Affairs, Mr. *Hake* could arrange visits to the most important institutes. Mr. *Hake* was very helpful in every respect.

Centre de Développement des Matériaux, Alger

The most important activity going on in this center and at the same time the only one which was discussed with me, is the production of photovoltaic cells (monocryst. silicon). Mr. *Boudiaf* and the scientific staff, present at the discussion, mentioned that in Algeria priority number 1 is given to the broad

development of fotovoltaic power. The fotovoltaic panels used in the country are nearly exclusively made in this center out of metallic silicon cells bought on the world market.

The production line having a capacity of 60 kW/a was shown to me in operation. It uses square silicon weavers, EVA foils, a non-treated glass pane in front and a Teflon-foil at the back side. It is foreseen to increase the capacity to about 100 kW/a per shift.

In the discussion only one proposal for a UNIDO-assisted project was brought forward: Building up a new laboratory dealing with problems of encapsulation of fotovoltaic cells. Such laboratory would be open to guests from other developing countries in the sense of south-south cooperation. I recommended to think as well of other proposals aiming on the use of new materials or new processes without however finding any positive reaction.

Centre de Développement des Energies Renouvelables - CDER

The center covers a broad field of activities as shown in annex

In the extensive discussion took part:

- Mr. *Chabane Boumeddane*, director of the center
- Mr. *Abderahmane Bairi*, head of the meteorological division and of educational activities,
- Mr. *Ali Malek*, head of the fotovoltaic laboratory,
- Mr. *Amiar Bouhdjar*, head of the thermal laboratory,
- Mr. *Belkacem Bouzisi*, director of the desert test-station in Adrar.

The staff of the whole center amounts to 150 persons out of which 60 are professionals.

The thermal division with about 20 professional co-workers has developed a solar water heater of family size (3,6 m² collector, 200 l storage) which will go into production within the center in September. The collector might not be good enough for the climatic conditions of this country (intrusion of dust to the absorber surface, too low efficiency for the winter period). At present, there exists no production of water-heaters in private industry, but I was informed, that it might come up soon.

Some stills had been built for the desalination of salt-water, but have not reached production standards.

There is a vivid interest in solar drying (and curing) of tobacco. In order to be able to regulate the air temperature as it is necessary for this product, solar air-heaters with an additional electric heater were designed. A first laboratory model shown to be out of function.

There were some small parabolic troughs around which had been used in the laboratory and a non used, very big (18 tons) parabolic "solar furnace", very similar to the old French model.

The photovoltaic division has a staff of 15-18 professionals. It is responsible for the planning and dimensioning of the comparatively big number of units erected in the southern areas of the country. The interests are concentrated in:

- family size units for houselighting, television etc. (200 - 400 Wp),
- central powerstations for villages (2 - 5 kW and as well 30 - 100 kW),
- fotovoltaic pumps (1.5 kW) and
- fotovoltaic flash-lights along the desert-roads, which are being used along 2000 km of such roads.

The electronic workshops in general made a good impression; the solar inverter in its present status still has a too low efficiency.

The meteorological division made a remarkably good impression. It is well equipped and tries to extract from old measurements (covering some decades) reliable information at least about global insolation values. A modest number of modern meteorological stations spread over the southern desert are being run.

Dr. ... , head of this division, made two proposals for UNIDO-aided projects:

- increasing the capacity of his division and make up ...
- "Solar Map" of North Africa,
- scholarships for the formation of technical and scientific staff in countries with advanced solar technology.

Mr. ... , head of "La Centrale Solaire de Melouka" (near Ad... a desert test station, which has been in operation for one year reported of its activities. It is a joint activity of Algeria and Belgium, financed 50/50 by both countries (details see annex ...)

It is ... for accelerator tests under the extreme climatological conditions prevailing there:

very high insolation, very high temperatures in day time, very low ones during the night and heavy sandstorms in spring.

A visit could not be made as it was not foreseen in the program. The use of this station should be of immediate interest to other arid or semiarid countries but as well for developments going on in Europe.

4. Haut Commissariat pour la Recherche - HCR

The meeting in the Haut Commissariat was proposed by the Algerian side to summon up the results of my visits and discussions.

Participants were:

- Mr. *Belkrim Ramtani*, director of external relations of HCR (tel.: 653065),
- Mr. *Radji*, administrator of HCR (tel.: 663325),
- Mr. *Beddane*, director of CDER (tel.: 784220),
- Mr. *Radjar*, head of the solar thermal laboratory of CDER,
- Mr. *Amel*, consultant of HCR,
- Mr. *Hake* of UNIDO.

After a short introduction in which I explained the purpose of my mission, I presented the four potential project-proposals emerging from the laboratory visits:

1. Setting up a laboratory for problems of fotovoltaic cell insulation;
2. Increasing the capacity of the desert test-station in Adrar for the use by other countries;

3. Increasing the capacity of the meteorological division of CDER to create a "Insolation Map" of North Africa;
4. Scholarships for the formation of scientists and engineers in countries with advanced solar technology.

Mr. Ramtani fully agreed with these proposals. In the following discussion two more proposals were put forward by the member of the HCR-staff:

5. Solar desalination.

When starting this topic the member of HCR only proposed to start in cooperation with the Nuclear Center in Cadarache the construction and test of an improved version of the two-stage distillation process developed there some years ago. I recommended to leave it (for the moment at least) to see whether a potential project proposal in the field of desalination should follow this or some other line. I stated that the Cadarache method is not simple enough to use in remote desert areas. I recommended to consider as well other processes which (in contrast to the Cadarache system) are adequate for small family size units. Mr. Ramtani agreed with my proposal.

6. In desert areas it is necessary to humidify the air in living quarters. This humidification, automatically combined with solar air cooling, is being done mostly with none solar standard equipment using high amounts of electric power. There exist some simple methods for humidification being used in several countries, which need however some improvement for extreme desert climates. A project is

therefore proposed aiming at the improvement of existing or the development of new methods based mainly on the use of solar power.

The meeting was concluded with a discussion of the possible next steps of the UNIDO-initiative. The only prediction I made was, that it would certainly need considerable time (more than 6 months) before any reaction could be expected, and that - if any - only a small number of the proposed projects could be taken up.

The atmosphere of the meeting was cooperative and friendly.

PERSONAL REMARKS

The activities going on in Algeria in the different laboratories in the field of photovoltaic use of solar energy in general have reached a level good enough for further promotion. This is not the case with respect to solar thermal work as far as I could see it, - including solar desalination. If a project should be considered in this area it would be advisable to create some link to an advanced group such as the one in Cadarache.

The desert station in Andrar most probably will have a satisfying status as it is being run in cooperation with the Belgian CEN.


(A. Boettger)