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A SURVEY ON PHOTOVOLTAIC ACTIVITIES IN ALGERIA

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Abstract

This paper summarises the activities in photovoltaics (PV) in Algeria for the last fifteen years. The main activities which are reported are related to PV power systems programs, research, education and market penetration. Concluding remarks recommend the transition from demonstrating small projects to large scale ones in order to promote and develop PV technology in Algeria.

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1. INTRODUCTION

Solar energy represents a significant potential in Algeria. Indeed, the country receives more than 3000 hours of sunshine per year with a high level of radiation and the yearly average of daily solar irradiation ranges from 5 kWh/m².day to 7 kWh/m².day as far as tilted surfaces at optimum angles are considered [1].

In order to take full advantage of these natural resources, the public authorities are conducting investigations in the field of solar energy and its applications. In fact, the research and development in the field of solar energy has existed since 1962, but photovoltaic (PV) applications in situ were initiated in 1985. Also, technical and economical studies are carried out by the scientific commission for research in close collaboration with the universities for the last fifteen years.

The aim of this paper is to summarise the national programs related to PV power systems and research [2-4]. Other aspects of PV development linked to education, market penetration and manufacturing of PV modules are also reported [5]. Thus, this paper gathers technical information concerning PV activities in Algeria, not available yet in the international literature.

2. SOLAR RESOURCES

To give at glance an idea of solar energy potential available in Algeria, two iso-radiation maps respectively of global irradiation and sunshine hours are presented [1]. The first one (fig.1) shows the yearly average map of daily global irradiation received over the country on tilted surfaces. The tilts considered have the same angles as those of latitudes. In this map, the lower the latitude, the higher the yearly average of daily global irradiation. Indeed, a north-south gradient ranges from a minimum of about 5 kWh/m².day at latitude 36° to a maximum of about 7 kWh/m².day at latitude 22°. The second map (fig.2) shows spatial variations of the yearly average of daily sunshine duration fractions which are also characterized by a north-south gradient. The latter ranges from a low of about 0.60 at latitude 36° to a high of about 0.90 at latitude 22°. These two maps give an idea of solar resources potential in Algeria which are more important in the south of the country than in its north.

3. PV POWER SYSTEMS PROGRAMS

As mentioned above, the dissemination of PV systems is due to national programs which have been undertaken and funded by the government. The first program which was initiated in 1985 and finished in 1989 is called "the solar energy great south program" [2]. The second one which started in 1995 and still in progress, is "the south rural electrification program" [3].

3.1. *The solar energy great south program*

This program covered five year period (1985/89). Its purpose was to install stand alone PV plants for different applications.This program was achieved by the Center of Development of Renewable Energies (CDER). The fulfillment of this program has allowed the following :

- The electrification of small isolated villages located in the Sahara desert. The total power expected to be installed was 94 kWp. But, only 67 kWp were effectively installed which represents 70 % of the whole program.
- Photovoltaïc systems for water pumping, with a total power of 85 kWp, were installed.
- A power of 30 kWp was used for lighting in rural houses.
- Telecommunication repeaters were also supplied by PV modules in remote sites. The total power involved is 80 kWp.
- The signaling for 2000 km of pathway in the Sahara desert.
- Thirty refrigeration plants were supplied with PV modules.

Note that the total power which has been installed in the scope of this program is about 300 kWp.

3.2. *The south rural electrification program*

The second program which has been undertaken by the government is the south rural electrification program. It is part of the national electrification program which covered the period of 1995/98 and mobilized 24 billion Algerian Dinars (US$ 1 $\approx$ DA 60) . The aim of this program was to supply 216 000 rural houses gathered in 4000 centers. Also, this program aimed to supply more than 300 agricultural sites located near the considered centers. Furthermore, it was expected to introduce significantly the solar energy in the national energetic consumption model. The achievement of this program was assigned to the National Company of Electricity and Gas (SONELGAZ).

This program has initiated pilot projects in the sites of Tahifet (latitude 22° 53' north, longitude 6° east and altitude 1400 m) and Imehrou (latitude 26° north, longitude 8° 50' east and altitude 600 m). In

these sites, two PV installations of 720 Wp were built and put into operation in 1992 with the aim of testing and disseminating PV programs [6-7].

Few PV installations have been implemented ever since for providing electricity to rural localities in the south which are respectively composed from 4 to 6, 8 to 10 and 16 to 20 homes. PV electricity was primarily used for lighting, radio and television followed by refrigeration and ventilation. Table 1 shows the peak power to be installed and the expected energy output related to each type of PV installation. The program is still being conducted and it is early now to appreciate its contribution to the quality of life and rural development.

4. RESEARCH AND EDUCATION

4.1. *Research*

The main objective aimed by the research is to acquire the know how needed to cover completely the PV chain from theoretical and experimental studies to full plant implementation. In this context, different research projects including those undertaken in collaboration with foreign partners were carried out by centers for research, universities and companies.

4.1.1. *Research projects*. The research projects which are supported by the ministry for research from 1985 to 1995 are mainly dealing with the following topics :

(I)The development of tools for mastering PV systems.

This topic deals with the development of sizing methods and simulation for PV systems and the use of electronic instrumentation for the experimental analysis of plants performance. The aim of such research is to acquire the whole necessary techniques for an optimal use of PV plants in situ.

(II)The development and optimization of processing systems aimed to manufacture the mono and polycrystalline silicon cells.

For an efficient skill of the technology from the raw materials till the PV generator, it has been agreed to consider the manufacturing process of PV modules from the end and to go up. This is why the encapsulation stage of the cells is operational. The stage of mastering solar cells manufacturing is going on and well advanced while the industrial elaboration of the silicon is still on.

(III)The technical and economical studies of the electrification by using both the conventional and solar energy sources.

The aim of these studies is to determine for each part of the country which needs electrification, the most attractive and economical solution, either by extension of the electrical grid or by PV conversion. The expected results will compare the investment costs of the electrification of a house by using the above approaches and in order to determine the best choice for different regions of the country.

4.1.2. *Research program.* In 1999, the renewable energy national program for research was adopted. The PV energy takes a significant part of this program. The main topics are summarized as follows:

- Crystalline silicon solar cells and technologies
- PV systems and components
- PV applications

In the scope of this program, many scientific projects have to be submitted for agreement to the national commission for scientific research (CNRS). The accepted projects will be funded by the National Agency for the Development of University Research (ANDRU).

4.1.3. *International co-operation program.* Few projects dealing with the topics mentioned above were undertaken in collaboration with foreign partners. One the few projects carried out under an international co-operation program is the intersudmed project. Its main objective is to perform technical and economical studies dealing with the electricity production from renewable energy resources in the southern Mediterranean countries. This work is partially financed through the JOULE and INCO programs of the European Commission Directorate XII [4]. Sonelgaz is the partner representing Algeria. In the case of this country, the location of Djanet (latitude 24°33' north, longitude 9°28' east and altitude 1054 m) was selected for pre-feasibility study related to the installation of medium size PV plants (~ 600 kWp) to support local MV diesel powered grid with high production costs.

In the other hand, in scope of the World Solar Program (1996-2005), two projects of high priority have been agreed by the World Solar Commission in June 23,1997. These projects are :

- Solar photovoltaïc electrification of 20 villages
- Contribution of photovoltaic to the improvement of the environment

4.2. *Education*

There is no graduate studies on photovoltaïcs in Algeria, but post-graduate studies are well developed. Indeed, many courses of post-graduate level are organized each year in many universities and

research centers. A number of lectures dealing with for example, PV conversion, PV systems engineering and semi-conductor thin films are carried out. Besides the theoretical background, the students receive practical training in photovoltaic laboratories.

In the scope of the World Solar Program (1996-2005), the project of creating the International Institute of Renewable Energy is agreed. This institute should be located in Ghardaïa in the south of the country. It should contribute to photovoltaic education effort devoted at local, regional and international scales.

Finally, let us notice that very few conferences dedicated to solar energy, including photovoltaics and their impact on the environment were held in Algeria.

5. MARKET PENETRATION

5.1. *Potential market*

The main sectors which need PV power for the development of their activities in remote areas are as follows :

- Energy
- Agriculture
- Telecommunications
- Transport
- Health
- Defense

The PV power is particularly used for rural electrification, pumping, telecommunication repeaters, cathodic protection, refrigeration and ventilation.

Taking into account these demands and many other specific consumptions, the potential PV power demand has been evaluated as
2 MWp per year and it may remain for at least, the ten next years.

5.2. *Commercialization and industry*

The PV modules are available in the national market but their prices are very high. This is mainly due to the following reasons [5] :

- The first reason is that these modules are not manufactured in Algeria but imported from abroad.
- The second one is the devaluation of the local currency.
- The third reason is the taxes and duties for the PV panel.

The metallic support structures for ground or roof installation, the stationary batteries and many electronic and electrical devices for PV systems are produced or assembled locally.

Many efforts have been devoted to set up an industry for manufacturing PV modules. For this purpose, economical and engineering studies have been performed but the achievement of such project is still difficult because of the lack of investment. Only, one unit of encapsulation of PV modules came into operation in 1985. The PV modules produced by this unit were the equivalent of 250 kWp. Most of this production has been used exclusively by the CDER for the realization of one part of the solar energy great south program [2].

The new laws related to the international trade which has been recently applied in Algeria, encouraged the emergence of many kind of private companies. The main activities of these firms are the trade and the installation of PV equipments. Moreover, within the framework of partnership, many operations of investment for the establishment of PV industry for MW scale production are yet to be materialized.

6. CONCLUDING REMARKS

Despite the competition of the conventional energy sources, the solar energy is very attractive economically. A recent assessment of installed PV power in Algeria since 1985 shows that the estimated installed capacity of PV systems is about 1 MWp. Table 2 gives an idea of the PV power which has been installed in some provinces of Algeria from 1985 to 1993. These data shows clearly that the installed PV power is far away from a fully exploitation of the solar resources which are very significant as shown above.

PV power systems implemented in Algeria until now, demonstrate the feasibility of PV technology. The promotion and development of PV in Algeria requires the transition from demonstrating small projects to large scale projects like those aimed to the south rural electrification program and the intersudmed project. This requires the best assessment of the PV power demand, the fully exploitation of solar resources by mastering the technology and the installation of plants for manufacturing locally PV modules.

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Peak-power of PV systems (kWp)	0.75	1.5	3	6
Expected energy output (kWh / day)	2.5	5	10	20

Table 1 : Peak power and expected energy output of installed PV power systems (South rural electrification program)

province	Latitude	Installed Power (kWp)
Alger	36° N	30.00
Bejaia	-	1.60
Blida	-	1.00
Bordj Bou Areridj	-	2.80
Boumerdes	-	1.80
Guelma	-	1.50
Medea	-	8.00
Tipaza	-	4.20
Tizi Ouzou	-	0.80
Batna	35° N	32.80
Khenchela	-	4.20
Mostaganem	-	1.20
M'sila	-	4.60
Sidi Bel Abbes	-	0.20
Tebessa	-	0.80
Tiaret	-	5.30
Tissemsilt	-	1.20
Oum El Bouaghi	-	8.80
Oran	-	0.80
Biskra	34° N	1.00
Djelfa	-	1.70
Tlemcen	-	0.60
El Oued	33° N	1.40
Laghouat	-	0.40
Ghardaia	32° N	5.40
Bechar	31° N	14.80
Ourgla	-	5.00
Adrar	27° N	74.00
Tindouf	-	19.20
Illizi	26° N	9.10
Tamanrasset	22° N	30.00

Table 2 : Installed PV peak power in Algeria from 1985 to 1990

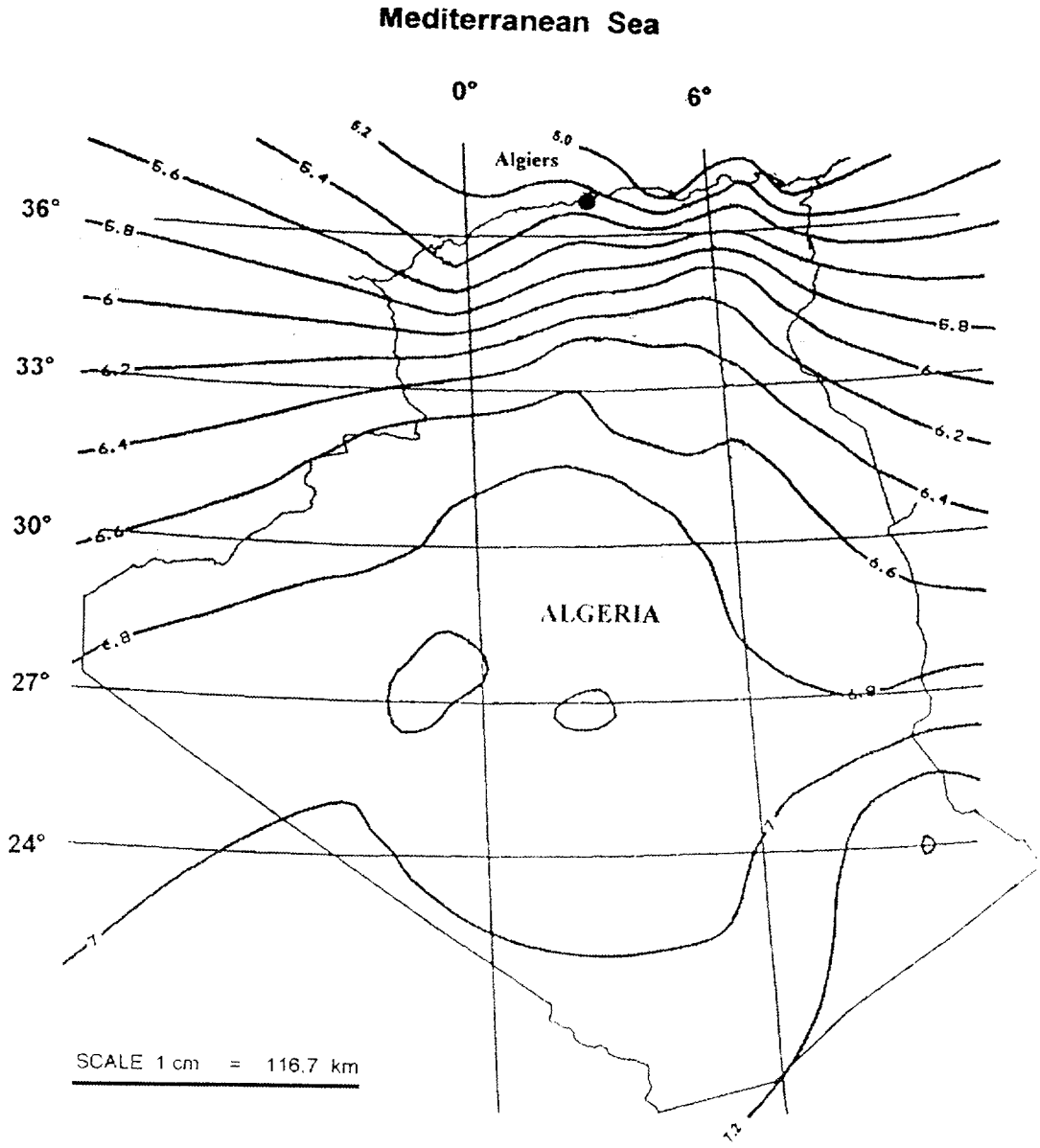

Fig. 1 : Yearly average map of daily global irradiations (kWh/m^2) , received on tilted surfaces (tilts = latitudes)

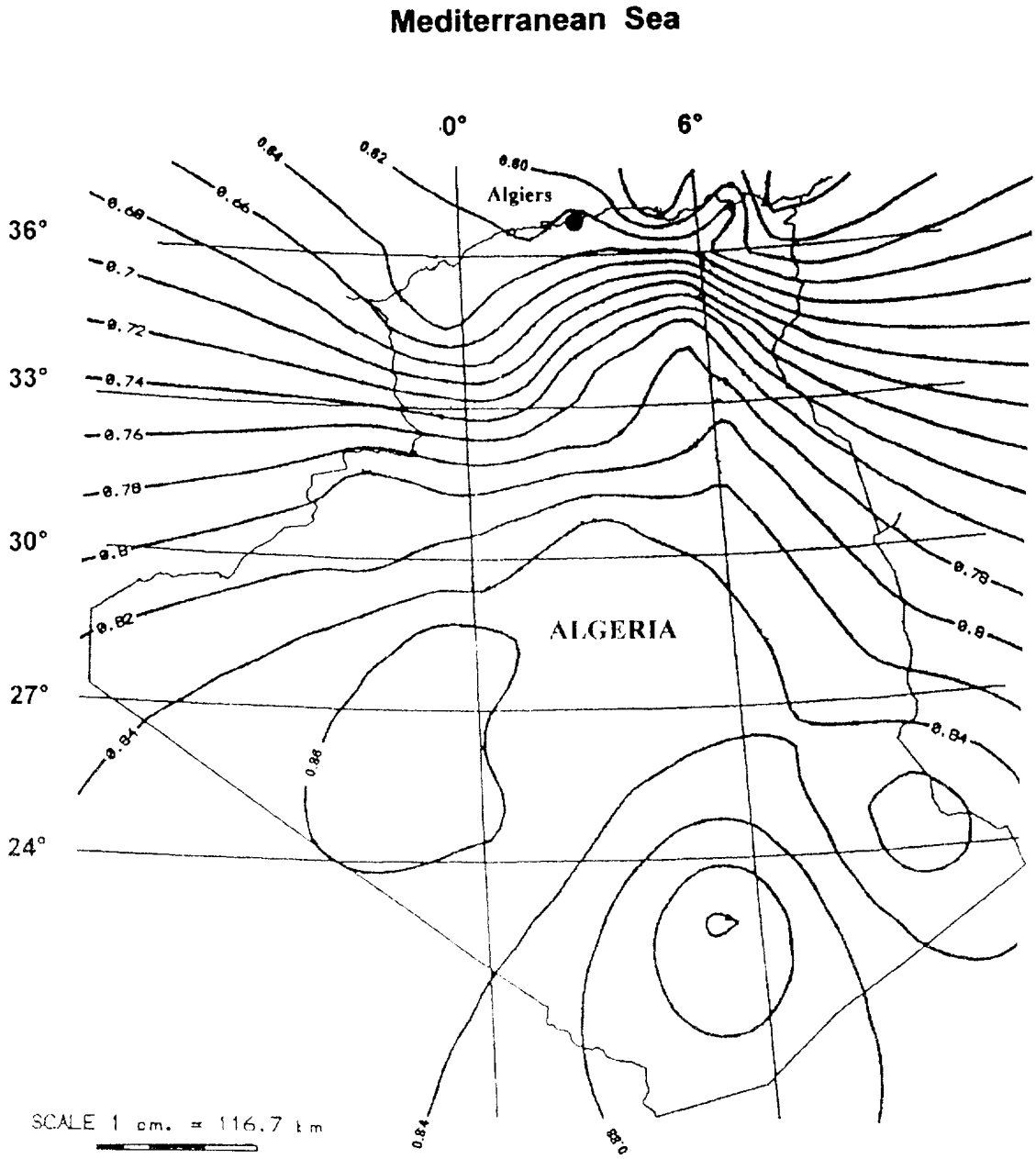

Fig. 2 : Yearly average map of daily sunshine duration fractions