INSTITUTE FOR ENERGY TECHNOLOGY, UNIVERSITY OF MALTA

RENEWABLE ENERGIES IN MALTA AND BEYOND

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CONTRIBUTION OF SOLAR APPLICATIONS TOWARDS ACHIEVING A RENEWABLE ENERGY TARGET FOR MALTA

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ABSTRACT: Based on applied research and demonstration activities carried out during the past decade at the Institute for Energy Technology, solar photovoltaic applications offer a good prospective towards achieving a significant percentage of Malta's electricity needs. This paper summarises the most important conclusions reached, describes the current installed systems in Malta, sets the achievable targets and discusses the challenges that face the widespread applications of this technology. Moreover, consideration is given to the widespread applications of solar water heating systems and their contribution towards lowering electricity consumption.

Keywords: solar, photovoltaic, solar heating, potential

1. THE SOLAR DILEMMA

Malta places first in Europe in terms of the availability of solar energy with the least annual variations [1], as shown in Figure 1 and specifically described in Table 1 [2].

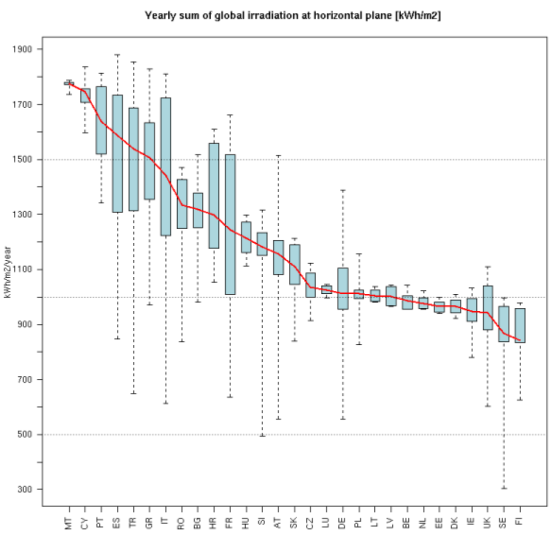

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Figure 1: Annual total horizontal global irradiation in European countries [kWh/m²]. The values show: maximum of 90% occurrence, maximum of the 90% occurrence in residential areas, average, minimum of the 90% occurrence in residential areas, and minimum of 90% occurrence.

Table 1: Summary description of the Clearness Index of the sky conditions over Malta.

Sky Description	Range	Occurrence (%)
Cloudy	$G/H_0<0.2$	2.9
Partly Cloudy	$0.2<G/H_0< 0.6$	34.5
Clear	$0.6<G/H_0<0.75$	61.9
Very Clear	$G/H_0>0.75$	0.7

where,

G = Global horizontal solar radiation;
H_0 = Extraterrestrial radiation;
G/H_0 = Clearness Index.

It follows that more than 62% of the year enjoys an abundance of sunshine, while only 11 days (3%) may be considered as very cloudy days.

However, Malta places 7th from the bottom among EU member states, in connection with the widespread applications of solar grid-connected photovoltaic systems, with a total installed capacity of 15 kWp up to 2005 or a mere 0.03 Wp per capita, based on real data collected by the Author and communicated to the European PV Barometer [3]. Table 2 shows most of the PV grid-connected systems that were installed in Malta up to August 2005 [15]. This table is not exhaustive and there may be other systems that the Author was not aware of.

Table 2: Installed PV grid-connected systems in Malta.

Type	Rating (kWp)	Year (Start-End)	Location	Remarks
Fixed, c-Si, roof-top	1.8	1996-2003	Marsaxlokk	First demo for Malta. Discontinued in Jan. 2004
Tracking, c-Si, roof-top	0.36	2001	Marsaxlokk	First tracker in Malta
Fixed, c-Si, wall-mounted	1.5	2002	Madliena	First private-home owner
Fixed, c-Si, roof-top	3	2002	Marsa	First Installation in an industrial (factory) area
Fixed, a.c. modules, roof-top	0.14	2003-2004	Marsaxlokk	First ac module system in Malta. Discontinued in 2004.
Fixed, c-Si, roof-top	2.3	2003	Madliena	Extension to first private-home owner
Tracking on two-axis	0.55	2003	Attard	Manual Tracking
Fixed, c-Si, roof-top	1.5	2004	Tal-Ftieh, B'Kara	First installation in a communal housing project
Fixed, c-Si, roof-top	1	2005	Xaghra	First grid-connected installation in Gozo
Seasonal Tracking c-Si, roof-top	2.5	2005	Fgura	First on a commercial building. Manual 1-axis seasonal tracking
Fixed, c-Si, roof-top	2.3	2005	Kappara San Gwann	Launched Sep 2005

On the other hand, Malta is placed in the 19th ranking among the 25 EU member states, in terms of the widespread applications of solar water heating systems, with only 0.038 m² of solar collector area per capita or a total of 15,360 m², equivalent to about 8% of the total potential of domestic solar heating systems [6].

These results were based on 50% available data that was obtained directly from local suppliers, while the remaining 50% was extrapolated based on correlations of different models of solar systems that were collected during a recent survey carried out on domestic solar heating systems [6]. The results have been communicated to the European Solar Thermal Industry Federation and were published in the recent European Solar Thermal Conference (ESTEC 2005) and the European Solar Thermal Barometer [7, 8].

2. PERFORMANCE OF PV SYSTEMS

2.1 Stand-alone PV Systems with Battery Storage

Throughout these past ten years, it was noted that there was some scope for providing results on the performance of stand-alone PV systems with battery storage, mainly to support enquiries for designs of solar PV systems for specific independent lighting projects and more frequently to provide power for off-grid buildings. As time passes by, the cost of extending the grid to these individual houses is constantly increasing, which would make a PV system economically feasible.

A two-year research project that was carried out showed that the long-term electric energy yield of stand-alone systems with battery storage would be 1.9 kWh/kWp/day, peaking in spring at 2.5 kWh/kWp/day and dropping in winter to a minimum output of 1.5 kWh/kWp/day [9, 10]. Other results are shown in Table 3.

Table 3: Performance of stand-alone PV systems.

Inplane solar radiation (kWh/m^2/day)	5.3
Array Output (kWh/kWp/day)	3.0
Final Output (kWh/kWp/day)	1.9
Array efficiency	6.3%
System efficiency	3.9%
Combined battery and battery control unit energy efficiency	62.6%
Performance Ratio	0.37

It is clear that the low efficiency caused by charging and discharging the batteries favours grid-connected systems whenever possible.

2.2 Grid-connected PV Systems

In comparison to stand-alone systems, grid-connected systems perform almost twice as good, with a long-term final output of 3.6 kWh/kWp/day and peaking at 4.6 kWh/kWp/day during spring. The performance ratio was also found to be 0.63 with peaks reaching the 0.8 mark especially in spring [11, 12]. These results include averaging of data collected from a number of systems such as a stationary system and a one-axis tracking demonstration project besides privately owned systems that included the largest system currently installed with a capacity of 3 kWp.

2.3 Hybrid Systems

Although no field tests were carried out on such systems, a hypothetical study was carried out on a hybrid PV/wind system for supplying power to a reverse osmosis desalination plant. By taking advantage of the fact that the solar and wind potential compliment one another over a year, it was deduced that a system could provide an overall uniform monthly output with some peaks during spring and a maximum deficiency between the demand and the supply in October [13].

3. THE SOLAR PV POTENTIAL

There are three potential categories of buildings that may offer rooftop space for installations of solar PV systems namely, domestic rooftops, industrial estates and public buildings. The major potential lies in the domestic sector and reaching up to 165,000 MWh per year or about 7.5% of the total electricity generated in 2003 [4]. This is followed by the industrial estates that form 1.5% and finally the public buildings including hotels, schools, hospitals, etc, which would be capable of producing 0.15%, thus bringing the total potential to 9.1% [5].

This a conservative approach based on the following considerations:

- Use of PV module efficiency of 12% instead of the more advanced 15%;
- An average rooftop area of 80 m^2 for each potential domestic rooftop;
- Deduction of space that may be required for installing solar heating systems, satellite antennas, water storage tanks, potential shading from perimeter walls and washrooms and some space for drying clothes that would further reduce the 80 m^2 to 24 m^2 of flat roof area;
- All apartment buildings assumed to have 3 storeys;
- Although the available area on domestic buildings could accommodate 2 kWp systems, a conservative system of 1.2 kWp was chosen instead to reduce the impact of high capital costs;
- Only half of the roofs in the industrial zones were deemed available;
- A maximum of 5 kWp systems were allocated to each hotel or school. Smaller schools had a share of 2 kWp each.

There could be some hybrid PV/Wind Potential whereby PV systems would be installed beside wind farms. However, due to space limitations this may not possibly be extended to all wind farms. Three centralised PV systems could be realistic reaching a total of 3 MWp that would produce an annual electricity production of 3,950 MWh, or 0.17% of the total electricity produced in 2003.

The solar PV potential on facades has still to be evaluated. High rise buildings would have virtually all the roof space occupied by air-conditioning systems and other service appliances such as dish antennas, water tanks, solar heating systems, etc… However, they would have ample façade surface for solar PV installations. It would therefore be advisable to consider the orientation of buildings and use of glass and PV modules besides other parameters, at the design stage of new projects.

4. THE SOLAR WATER HEATING POTENTIAL

As mentioned above, the current installed solar heating systems account for 8% of the total potential in the domestic sector. It follows that the overall potential would save 4.8% of the total electricity generated in 2003, not including the saving potential from installing solar heating systems in other sectors such as public building, hotels and factories [5].

The recent introduction of direct heating evacuated-tube solar systems would eventually raise the potential, as their efficiencies are 60% higher than the traditional flat-plate solar water heaters. Moreover, the fact that their prices are now comparable to other systems, it is envisaged that they will gain popularity at a faster rate.

5. THE CHALLENGES FOR PV WIDESPREAD APPLICATIONS

The capital costs of PV systems would be the major challenge to overcome. The current life cycle costing of small solar PV systems is close to 13 cents/kWh (30 € cents/kWh) [14]. As Enemalta Corporation is now offering 2.1 cents per kWh there remains another 11 cents to be provided to reach breakeven point. The current capital for installing solar PV systems in Malta is in the region of Lm3,000 per kWp installed. Strong incentives and maximum use of external funding opportunities such as the United Nations Development Programme (UNDP), the Global Environment Facility (GEF), the World Bank's Prototype Carbon Fund (PCF), the Kyoto Clean Development Mechanism (CDM) and INTERREG III of the European Regional Development Fund, coupled with expert advice and supervision, would accelerate the implementation of solar photovoltaics.

Another option for overcoming the capital cost hurdle is to implement the solar PV system at the design stage of new buildings. In that way, costs would be absorbed in the total capital and would only slightly alter the final selling price of apartments, since the investment in the solar system would only be a small fraction of the total capital for the whole project. However, other factors weigh down on this option such as the lack of clear guidelines and legislation from the side of construction and façade integration and weak interest from the side of architects and contractors in general. Besides, the fact that every 1 kWp installed would save the environment 1 tonne of carbon dioxide annually seems to fall on deaf ears.

On the other hand, the solar water heating market has started to flourish but not as much as it should. The increase in electricity rates and the introduction of the fuel surcharge were the major contributors to this development. The current incentives of Enemalta and the Government would together amount to about 30% of the cost of a solar heating system. Nevertheless, it is important to address other issues that may hinder an increasing number of owners from installing systems such as the present scenario that does not recognise solar heating systems as an essential commodity and hence the *right of use* of rooftops in apartments for this purpose.

Social issues also affect the widespread applications of solar systems such as the lack of organised propaganda, shortage of information campaigns, negative experiences of unsatisfied owners of solar heating systems and poor interest in environment issues in general. Most of all, the fact that only few potential users consider solar heating as an essential and secure source of hot water, preferring to indulge in other more trendy appliances such as dish washers, makes it more difficult for solar systems to catch on.

Unlike the scenarios of diffusion of solar systems in Cyprus and Israel, Malta's development of this market would lie in the hands of the private sector. As in the case of other new technologies such as mobile phones, cable television, dish antennas and computers that gained popularity fast, in the same manner solar applications would also be pushed into the market, once their market potential is realised. In fact, one has observed the recent sudden increase in the number of companies that are investing to provide their services in both solar heating and solar photovoltaics.

CONCLUSIONS

The EC Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market, obliges all EU Member States including Malta, to produce bi-annual reports that should include an analysis of success in meeting the national indicative targets for the year 2010, now due by the end of October 2005. To date little has been implemented in terms of actual installations on the ground.

Diversity of renewable energy sources to produce Malta's electricity needs is of paramount importance, as it increases the security of supply and levels off the intrinsic intermittent nature of renewable energy sources. Undoubtedly, all forms of renewable energy systems, whether centralised or decentralised, would require some form of support in the first instance. Careful balancing between the level of support given to each technology would ensure a balanced and impartial introduction of all possible applications into the local scene.

The involvement of the private sector in developing the market of renewables in Malta plays an important role in defining the future of this technology in the local context. This may be encouraged by offering direct and indirect incentives to the use of renewable energy systems in buildings, in industry, and other amenities or applications where these technologies may be put into use.

The market for implementing renewable energy projects together with energy efficiency measures should be fostered and facilitated at all levels. Only then the ever-increasing costs of fuel importation would be eased to some extent, while contributing towards a better environment.

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