New Priorities in Solar Photovoltaic Applications

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Abstract This paper deals with the new priorities and application possibilities of the photovoltaic technology. No doubt that the photovoltaic (PV) technologies will show their significance for longer period. The most important standpoints characterising the PV industry are to be discussed. The new features of the PV technology and the applications are also studied in a great extent. It includes new type of modules along with their colouring, extra size and the fixation system. Examples are shown for such application possibilities.

Keywords Thin film · Colouring · Transparency · New fixation system · Applications

1 Introduction

Within the use of solar energy the solar thermal field identified at a lower innovation potential however their application shows large varieties. Especially the production of electricity from solar thermal is a preferred solution.

In spite of the recent economic situation all over the world a significant yearly increase of photovoltaic module production and their installation were performed in last couple of year period. However it can be observed sensitivity of the market change on the photovoltaic industry, the PV technologies still show increasingly high priority.

At the same time, there are some very important features which are characterising and influencing the PV manufacturing and applications industry. The most important standpoints could be summarized as follows:

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- 20–30 % of the part of renewables in the energy mix,
- at around 30–40 % yearly decrease of the PV cell and module prises,
- the cell efficiency in market products does not increase in a great extent as expected,
- strong competition between the crystalline and the thin film technologies,
- multi-Gigawatts applications are getting into the practice,
- widening the feed-in tariff system in several countries in worldwide,
- presence of the Chinese PV products in worldwide and especially in the European Union market.

Due to the growing market demand of the solar photovoltaic applications several new specific issues came to the light. These factors include new type of modules along with their colouring and extra size, wide range application of thin film technologies, colouring of the modules, transparency of the modules, extra size of modules and new type of fixation systems.

At the Department of Physics and Process Control at Szent István University (SIU) Gödöllő, Hungary as a part of research activities there were performed several solar installations. Among them the largest solar photovoltaic application is a 10 kWp capacity grid-connected system including two different module technologies as polycrystalline and amorphous silicon ones. During the new photovoltaic installation plans at the campus the above mentioned factors are also taking seriously consideration.

2 Recent PV Installation at the Campus Area

In the framework of the PV Enlargement Project of the European Union, a 10 kWp photovoltaic system was constructed (Fig. 1) in the central campus of the SIU. This set-up was the largest grid-connected PV installation in Hungary that time, and beside of the energy production it serves demonstrational, educational and research purposes, too. For the PV modules two different options were proposed as polycrystalline and amorphous silicon technologies. The reason for the use of different technologies is the comparison of the different technologies at the same location under the same operating conditions [1].

The system is installed on the flat roof of a student hostel building of the campus. The azimuth angle is 5° to East and the tilt angle is 30°, which is a good yearly average value for the site. The system consists of three different subsystems, having an own inverter, the same type for each. The PV system is structured into 3 subsystems. One subsystem has 32 pieces of ASE-100 type modules, and the remaining two identical subsystems are planned for using 77 pieces of DS40 type of modules each. The total power of the system is 9.5 kWp.

The main variables measured by the data logging system can be seen in the operational scheme in Fig. 2 as:

Fig. 1 The existing grid-connected PV installation

- Irradiation (in the panel plane by a silicon reference sensor, and the total radiation by a pyranometer),
- Temperature (environmental and module temperature for each type, measured by Pt100 sensors),
- PV array (DC) voltage, current and power,
- AC voltage, current and power supplied to the electrical grid.

Beside an installed PC based data logger, an authorized two way electrical meter was also installed as a control unit for the energy data. The metering unit can store the measured data of a 3 month period and the data can be read out through a telephone modem.

3 New Plans for PV Application Possibilities

Beside the 10 kWp capacity of grid-connected PV plan several new installation plans of about 50 kWp capacity each were considered at the campus of the SIU [2]. Among them four important building were identified showing a kind of priority among the sites of applications:

Laboratory building,
Dormitory building,
Knowledge Transfer Centre building,
Aula building.

The roof area and structure of the selected building were analysed taking into consideration of the size, orientation and tilt. After that preliminary design installation plans were performed along with the energetic estimations. During the calculations the internet-based PVGIS [3] simulation software was applied.

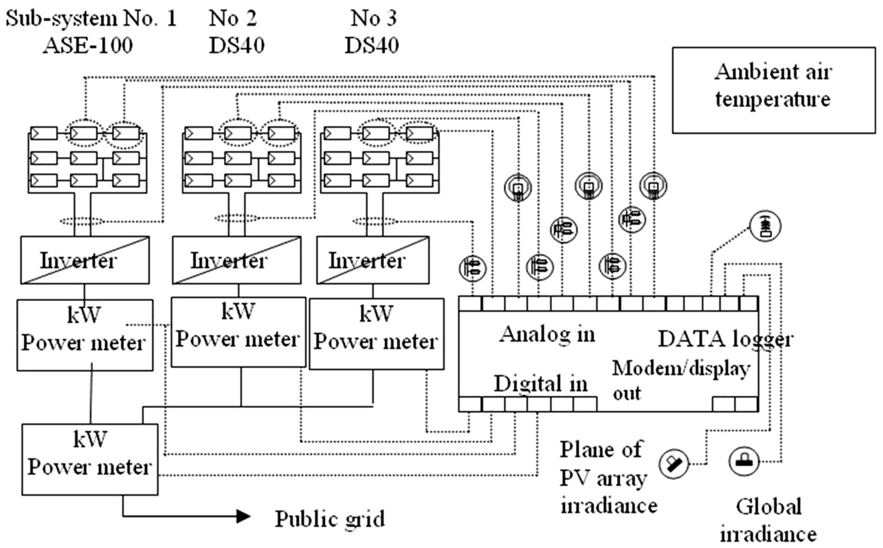

Fig. 2 Operational scheme and data acquisition system of the PV installation

Fig. 3 Picture of the laboratory building

Laboratory Building

The roof structure of the Laboratory building has got a very special shape as it can be seen in Fig. 3.

Table 1 Possible area for PV installation in laboratory building

Notation	Number of roofs (db)	Roof size	Total area (m^2)
North wing	5	19 m × 2 m	190
South wing	6	13 m × 2 m	156
Total			346

The freely available are for the location of the photovoltaic modules is given in Table 1.

The main data of the grid-connected installation are as follows:

Number of modules: 168 pcs (90 for North and 78 for South building)
Capacity of one crystalline module: 265 Wp
Total capacity: 44.52 kWp

Based on the PVGIS [3] simulation the specific energy production of the system is around 1,110 kWh/kWp.

Dormitory Building

The picture of the Dormitory building consisting of two parts (D1 and D2) can be seen in Fig. 4.

Fig. 4 Picture of the dormitory building

Table 2 Possible area for PV installation in dormitory building

Notation	Direction of the roof to south degree	Tilt angle degree	Specific energy production kWh/kWp	Area m^2
D1 east	−105	8	951	150
D1 west	75	8	987	150
D2 north	165	10	882	180
D2 west	75	10	988	220

The freely available are for the location of the photovoltaic modules avoiding the shaded parts is given in Table 2.

The main data of the grid-connected installation are as follows:

Number of modules: 138 pcs (69 for D1 East, 69 D1 West and 62 for D2 building)
Capacity of one crystalline module: 240 Wp
Total capacity: 48 kWp

Knowledge Transfer Centre Building

The front side picture of the Knowledge Transfer Centre building can be seen in Fig. 5.

This building has recently been reconstructed and having a quite large flat roof area of about 3,000 m^2 which is available are for the location of the photovoltaic modules. Furthermore, it is beneficial that the modules can be positioned ideally at 33–35° of tilt angle along with South facing orientation.

Fig. 5 Picture of the knowledge transfer centre building

Fig. 6 Tectum flat roof system

In return the roof is covered with a special plastic cover which causes some difficulty in the fixation of the support for the modules. For such a purposes, for example, it can be used the solution of Tectum flat roof system [4], which has a feature of quick installation, lightweight ($\sim$12 kg/m^2) and high yields (Fig. 6).

The main data of the grid-connected installation are as follows:

Number of modules: 200 pcs
Capacity of one crystalline module: 256 Wp
Total capacity: 53 kWp

Based on the PVGIS [3] simulation the specific energy production of the system is around 1,200 kWh/kWp.

Aula Building

The picture of the Aula building can be seen in Fig. 7.

For the location of the PV modules the following solutions can be considered:

(a) Changing glass surfaces with transparent thin film modules,
(b) Installing green colour PV modules in front of the green building plastic elements,
(c) Installing modules with low tilt on the flat roof area just above the office rooms.

The freely available area for the location of the photovoltaic modules is given in Table 3.

The main data of the grid-connected installation are as follows:

For the vertical arrangement (in front of the green plastic elements):

Number of modules: 78 pcs

Fig. 7 Picture of the dormitory building

Table 3 Possible area for PV installation in aula building

Notation	Direction of the roof to south degree	Tilt angle degree	Specific energy production kWh/kWp	Area m^2
West (entrance)	80	90	586,951	105
South	−10	90	757	30
West (entrance flat)	−10	10	1,050	100
South (entrance flat)	−10	10	1,050	180

Capacity of one crystalline module: 250 Wp
Total capacity: 19.5 kWp

For the low tilted flat arrangement:

Number of modules: 110 pcs
Capacity of one crystalline module: 265 Wp
Total capacity: 29.15 kWp

4 Transparent PV Applications

With the support of the British Council a Climate Office has been established at the campus dealing with all the aspects of the climate change, environmental issues related to the energy consumption.

Fig. 8 Glass PV plan

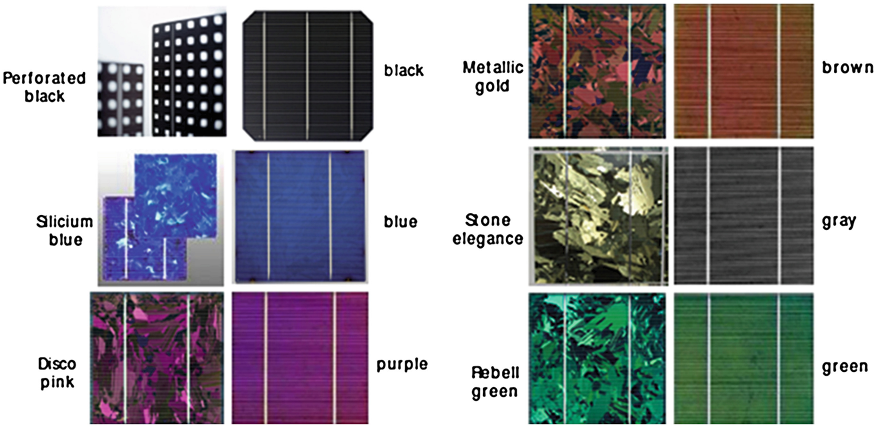

Fig. 9 Suntech glass PV colours

The Climate Office has made several plans for the use of renewable energy resources at the campus including also the solar energy. Among them one important idea was to use semi-shade PV modules located at the corridor of the Climate Office rooms. The preliminary plan of that unit is shown in Fig. 8.

The attractiveness of the applications is increased with the use of the different colours of modules. The possible colours of the planned semi-shade cells [5] can be seen in Fig. 9.

The main features of the Suntech modules are the standard framed unit with a tempered front glass and the durable clear polymer substrate. The module has got 50 % transparency, so it can be used to increase natural light behind the module along with providing energy production and surely some shading.

5 Environmental Influences

The applicability of solar energy is favourable in Hungary especially in the sense of radiation characteristics. The yearly sunny hours varies between 1,990 and 2,200. The average value of solar irradiation is 1,300 kWh/m^2. As a matter of fact, there is a significant difference between the summer and winter radiation conditions. In winter period there are some obstacles which have to be taken seriously into account.

Concerning to the photovoltaic applications the roof integrated and the ground positioned autonomous and grid-connected solutions are the most typical solutions.

The solar photovoltaic potential can be calculated on the basis of the available area all through the country which is estimated as: 4051.48 km^2 including the fields located along with the highways and railways. Considering the tilt angle of the available areas and the efficiency of the solar modules the entire solar photovoltaic potential was estimated as: 1,749 PJ/year.

Beside the energy saving opportunities the environmental impact of the use of photovoltaic technology can also be significant effect. For the estimation of the total reduction of the CO_2 emission the relative value of 0.82 kg/kWh is to be applied.

6 Conclusions

The priority of the use of PV installations at the campus is obvious as electric power generation is basically required.

Preliminary technical design of four typical 50 kWp capacity grid-connected PV system design has been completed along with the energetic and financial calculations.

Additionally some the environmental and social impacts of the plan were also taken into consideration.

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