Testing Solar Equipment in Latvian Conditions

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Abstract

Solar energy use technologies are striving to deal with the fast-growing energy demand. Solar thermal systems are particularly important for solar heating, hot water preparing and even cooling that for many countries are very actual now. Solar thermal systems need a solar collector that guarantees substantially safe and effective operation. Besides the specific costs of the collector field also aspects like the resulting collector area and suitable collector technology for a specific system have an influence on the decision for a certain collector types.

To select the suitable solar energy use equipment technology for a specific system properly, the weather conditions and the industrial load profiles or the characteristics of the solar energy use system always have to be taken into account by reliable and cost effective solution for sustainable energy consumption.

For this purpose it was created testing polygon for the solar energy use equipment in Latvian climate conditions, which helps to meet these requirements.

The paper presents the first results of the solar energy use equipment's examination from the testing polygon that was build up on the roof of the Institute of Physical Energetics (IPE) and includes:

- a system for solar collectors testing;
- devices for solar radiation and weather condition parameters measurement.
- an autonomous system for PV elements testing;
- a quasi-autonomous for PV elements testing;

1. Introduction

As concerns solar energy, it could be used for production of thermal energy (by solar collectors) and electric energy (by solar PV batteries). The sunlight duration and intensity depends on the season, weather conditions and geographical position of a country. In the northern Europe the maximum value of solar radiation is 1100 kWst/m^2.

As shown by experimental studies in IPE, the application of solar collectors in Latvia can give good results. The energy of solar radiation can be employed for 1700-1900 hours annually.

The reasons that make the use of solar energy attractive and suitable in Latvian conditions in the last years are as follows:

• High consumption of hot water in summer time (typically taking place in dwelling houses and such public institutions as hospitals, hotels & camps, sportive and summer camps).

• Tendency for energy price increasing.

• Construction of new buildings in which solar collectors and PV could be built-in. Latvian's energy policy now provides use of RES, accordingly to the "Law of Energy Efficiency in Building" article 7 recommends use of RES in the new buildings and renovated buildings. [1]

• Significant advantages for solar energy use for electricity production appeared in this year. The new Regulations "Rules for the generation of electricity from renewable energy resources, and pricing arrangements" was adopted in February 2009. Due to these Regulations transmission grid operator is obliged to pay the feed-in tariff for electricity producers which use solar energy for electricity production (PV) (purchase price of solar power is 427 EUR/MWh). [2]

2. Description of the IPE Solar Energy Testing Polygon

The IPE is the leading institute for solar energy research and development in Latvia.
On the roof of the Institute of Physical Energetics a testing polygon for the devices using solar energy, which consists of the following four large parts (see Figure 1), has been created:

1. A system for testing solar collectors.
2. Sensors of solar parameters and weather conditions.
3. An autonomous system for testing solar photo-voltaic (PV) elements.
4. A quasi-autonomous system for testing PV elements.

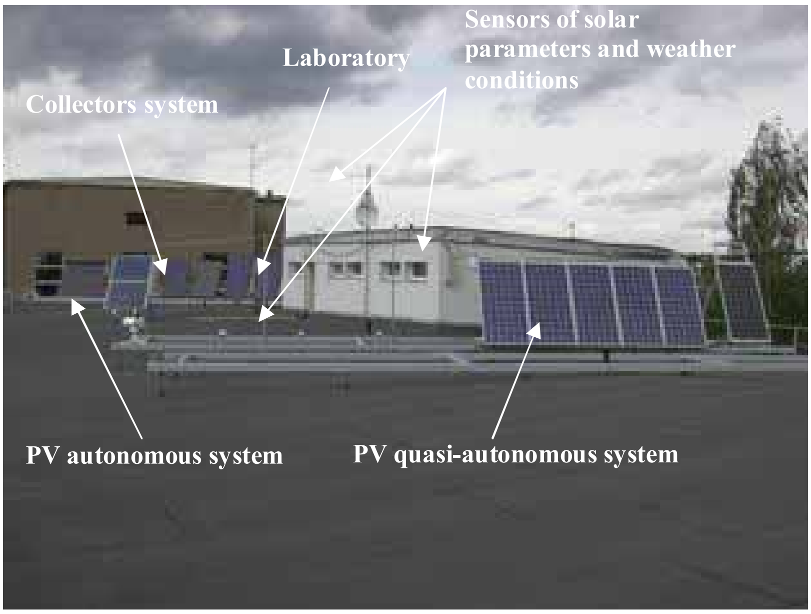

Fig. 1. General view of the polygon

2.1. Solar collectors testing system

The system for testing solar collectors (see Figure 2) consists of seven solar collectors, accessories, monitoring devices, control system's devices, and a heat accumulator. Each solar collector possesses its own separate frame capable of changing its slope to the horizon. The installed collectors are: five collectors of the popular producers and two self-made collectors. From each collector a pair of tubes is extended, which forms for it a separate heat carrying loop. A collector's loop contains a circulating pump, a heat meter, a bidirectional valve with drive, and a balance valve (see Figure 3). For automatic pump operation, in the forward and backward directions of each collector's loop temperature sensors are arranged. Similar arrangement is provided for the meters and driven valves. At the heat accumulator the forward tubes of all the loops meet in one tube. The same occurs with the backward tubes. Near the heat accumulator a common heat meter is installed. From the accumulator a branch diverges at whose end an extension vessel is installed, which occupies 15% of the total collector system's volume. The total volume of the accumulator is 1 m^3 (see Figure 4). The hot water supply system is completely renovated. From the laboratory premises situated on the roof this system supplies hot water to the lavatories (six in total) and the cafe on the first floor. The monitoring and control of the solar collector system is performed automatically with the help of controller.

Fig. 2. Solar collectors

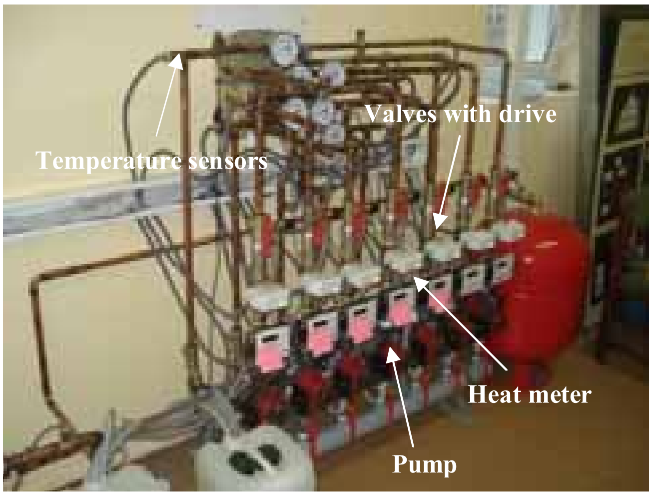

Fig. 3. Fittings of the heat carrying loops of solar collectors

Fig. 4. Hot water accumulator

2.2. PV autonomous system

The autonomous system for testing solar PV elements (see Figure 5) consists of two batteries 145 W_p each, which are positioned on a special frame capable of changing its slope to the horizon. The total power of the batteries at the maximum power point is 290W_p, and the nominal DC voltage is 24V.

In the laboratory premises the system's control automatics and two series-connected 12V 120Ah accumulators are located. The control automatics (see Figure 6) contains a charge regulator, which checks that the accumulators are not under- or over-charged, a PLI interface providing connection to a computer for data registration, a 600W inverter for transforming the DC voltage of 24V into 230V 50Hz AC voltage that is then fed to the load and connection terminals with three switches.

Through the PLI interface the devices are connected to the computer with a special program installed, which reads the data out of the device. The program allows reading out the following data: maximum voltage, minimum voltage, charging charge rate, discharging current, the energy accumulated by solar modules, and the energy consumed to operate the switches. The data are automatically stored in the computer memory after a time interval sets by the operator. The program also allows registration of current values in a real-time.

Fig. 5. PV batteries of the autonomous system

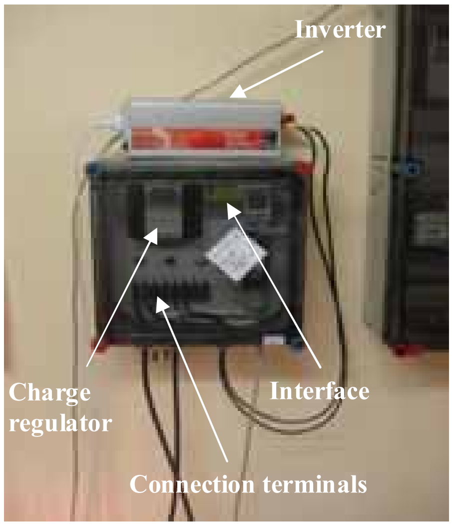

Fig. 6. Control device of the autonomous system

2.3. PV quasi-autonomous system

The quasi-autonomous system (see Figure 7) for testing PV elements consists of five solar batteries 170 W_p and one solar battery 150 W_p. The batteries are arranged on paired rails, for which a self-made design has been worked out and which is capable of changing its slope to the horizon. The total power of the six PV batteries at the maximum power point reaches 1025W_p. The system's voltage is 24V. In the laboratory premises the system's control automatics is set out, which contains network inverters (Sunny Boy, UPS), and four 6V accumulator batteries (connected in series to give 24V).

The control system (see Figure 8) is conditionally divided into three parts – those of regulation, UPS, and network. The regulation part contains a charging regulator, which ensures that the accumulators are not under- or over-charged. This part has also a PLI interface for connection to the computer. The UPS part contains an electricity meter, which measures the energy consumed by it. Besides, this part contains a relay and a pin jack for direct connection of the load. In the network part the same elements are set out: an electricity meter and a pin jack for direct load connection. This last part contains a switch that could be set to the UPS mode or to the network mode. One more switch is meant for establishing the automatic mode or the manual mode. The network Sunny Boy inverters, which serve for connecting the system to the network, are located outside the installation box.

The described system made it possible to use at the testing polygon a worldwide adopted scheme, which consists in connection of solar batteries to the network, and, in the cases when after consumption there is a solar energy surplus, this surplus could be given up to the network; if otherwise, the energy is taken from there. The UPS presents here an autonomous part with electric energy stored in accumulators; so, if the load is large, then the energy is taken from them, and this process is controlled by UPS. The system is called therefore quasi-autonomous, since there are both the network and the autonomous accumulation parts. All data on the system's operation through the PLI interface can be entered into computer using the program that is employed in the autonomous system – here only the COM port names should be changed to watch either the autonomous or the quasi-autonomous system or both of them simultaneously. It is possible to perform monitoring of the network part using the Sunny Boy controllers, or, using computer, to control automatically the installation itself and read out its operation data.

Fig. 7. PV batteries of the quasi-autonomous system

Fig. 8. The control system of the quasi-autonomous system

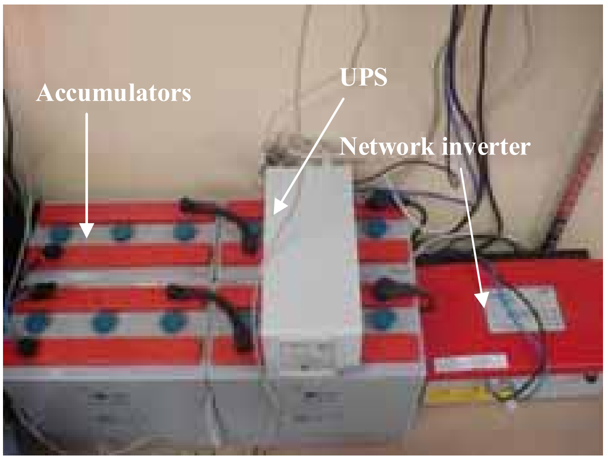

Fig. 9. Accumulators, network inverter and UPS of the quasi-autonomous system

2.4. Measuring equipments for solar parameters and weather conditions

The following measuring equipments for solar radiation parameters and weather conditions are installed:

- CM21 Pyranometer, which is intended for measuring the density of radiation (W/m^2) consisting of the direct solar irradiation and the diffuse atmosphere radiation.
- CMP3 Pyranometer, for the same measurements. At the polygon two pyranometers of the kind are installed, one of them oriented at a 45^o angle to the horizon and the other is set horizontally. Such installation scheme makes it possible to observe differing densities of solar radiation at the angular and the horizontal orientations of the device. The sloped pyranometer controls the circulating pump for the solar collector system.
- NR-Lite net radiometer – intended for measuring the difference between solar and far-infrared radiation (usually called the net (total) radiation).
- CH1 normal radiation pyrheliometer – at its orientation to the sun the density of direct solar radiation is measured. This sensor is installed at the polygon on a STR-21 sun tracker that follows the sun with sensibility $< 0.01^0$. Apart from that, the sensor allows indirect measurements of the solar irradiation time when it is set in such a way that at a definite value of the radiation density (approximately 20klux) it starts measuring the time of solar radiation.
- CGR3 pyrgiometrs measures the density of the descending component of long-wave atmospheric radiation. The sensor makes it possible to measure also the ascending radiation component – for example, heat losses through windows and from a collector's surface, the temperature of protection glass of the solar batteries, etc. To each of the mentioned sensors a specially calibrated signal amplifier is connected, from which the signal is further fed into the laboratory premises where a data logger is located. The data are then stored in the computer memory.
- At the polygon, a WS2500 station for observation of weather conditions is installed. It contains the following sensors of weather conditions: WS2500-15 wind sensor for measuring the direction and velocity/speed of the wind; WS2500-16 sensor for measuring precipitation quantity; WS2500-19 radiation density sensor for measuring the density of atmosphere radiation; at 20klux it starts measuring the duration of solar irradiation; WS2500-27 temperature/humidity sensor measures the temperature and humidity indoors; WS2500-25 temperature/humidity sensor for measuring the air

temperature and humidity outdoors; apart from that, it is a barometer (measures the atmospheric pressure).

All the sensors are wireless, and in the laboratory premises a special data logger is disposed that receives the data from the sensors and, with the help of special program sends them to the computer memory.

3. Conclusion

Different solar collectors of different solar collector's producers and with the different technical characteristics are installed in IPE polygon. The materials of absorbers of collectors are different – aluminum, copper and even steel and a thermal conductivity from absorber to heat carrier changes remarkable accordingly to the absorber's materials and those thickness.

The correct data on solar collectors' effective use does not exist in Latvia now. Producers published only theoretical data of technical parameters for solar energy equipments and the IPE testing polygon allows getting realistic data of the solar collectors and PV use in Latvian conditions. The first measurements in real meteorological conditions already showed that the theoretical parameters differ from the measured.

IPE studies showed that, that flat plate solar collectors can give from 600 kWh/m^2 to 800 kWh/m^2 per year and the vacuum tube collectors - till 1000 kWh/m^2 per year in the Baltic States region.

It is possible to state that the tube collectors are more effective than the flat plate collectors already now after comparisons of initial experimental results.

Solar energy use polygon could be used also as an education and training place for the new specialists - students, PhD students, etc.

References

[1] "Law of Energy Efficiency in Building" (13.03.2008.)

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[3] Shipkovs P., Esbensen T., Kashkarova G., Lebedeva K., Shipkovs J. „Solar energy use in Latvian conditions". Journal of applied research official journal of Lithuanian Applied Sciences Academy, Lithuania, Nr. 2 (2005) 68-73.