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ENERGY PRODUCED BY SOLAR BATTERY AND PERSPECTIVES OF IT'S USAGE IN LATVIA

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Abstract: *Many alternative energy sources can be used instead of fossil fuels. The decision as to what type of energy source shoud be utilized in each case must be made based on economic, environmental, and safety considerations. Because of the desired environmental and safety aspects it is widely believed that solar energy should be utilized instead of other alternative energy forms it can be used sustainably without harming the environment. The paper deals with the solar photovoltaic module capacity recording device whose load characteristic is similar battery charging load characteristic. As a result, the device will record the amount of energy retrieved from the module battery. In 2009th with this device was recorded solar module PVM10/12PF power and charged batteries are retrieved energy levels in the months and year as a whole.*

Keywords: *Solar electricity, photo-electric modules, batteries, system.*

Introduction

Currently there are three known methods for direct conversion of solar electric energy: photo-electric, thermo-electric and thermo-electronic.

Thermoelectric converter (generator), works on the Zeebeka effect, as follows: the electrical circuit, which consists of various materials managers, resulting electromotive force (EDS), on the condition of the driver circuit contact points are at various temperatures. Usually thermoelectric generators consists of a thermo battery, consisting of in series and parallel closed thermopile and thermocouple of a high and the hot end heat exchanger. In order to further exploit the opportunities for thermocouple, thermoelectric generators equipped with solar energy concentrators and sun trackers. Thermoelectric generators have an efficiency of around 15% and power some hundreds of kW [1].

Heat can directly convert in electrical using thermionic converters, which operate on termoelectron emission effect. It is known that a vacuum heated surfaces (cathode) emits electrons that are going through interelectrode room into the anode, creating a current of the external circuit. Saturation current density down converter Richardson equation. Good termoemission material is coated with tungsten cesium. Power production is not required external EDS, where the heated metal surface apply with a lower electron leaving the necessary work. Such a system can generate electricity like a semiconductor p-n junction. From the energy point of view, such devices are ineffective.

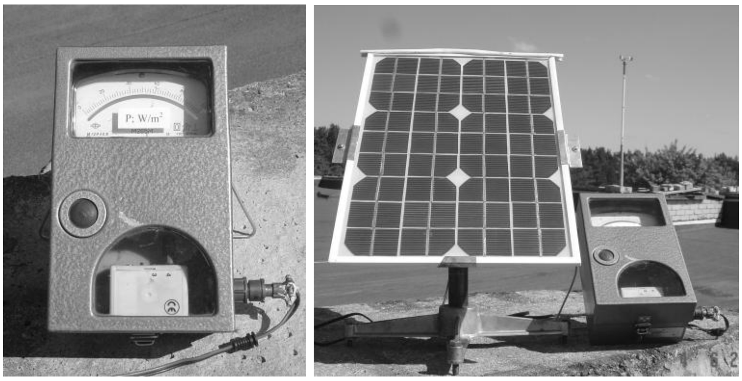
The most widely used photo-electric converters [2] – photo-electric modules (Module), which consists of individual, usually in series of semiconductor photo-electric elements (Cell) The size and number determine currents and voltage value, which provides the module. Connecting in series and parallel photo-electric modules, a photo-electric modules, solar cells (Array).

The most common in the world is silicon (Si) solar cells, which, depending on the technologies of production (depending on the arrangement of silicon atoms in crystal), can be a mono-crystalline, poly-crystalline and amorphous. The corresponding solar energy conversion factors to these elements are as follows: [3]: (12 – 15); (11 – 14); (6 – 7). At the poly-crystal group usually are added (thin film) solar cells, the structure consists of glass, silicium precipitation from the gaseous materials.

To determine and compare the installed capacity of solar cells and modules, during testing the output power measured at the standardized test conditions: the intensity of radiation - 1000 W/m^2, radiation spectrum - AM 1.5 (shown light type and color), the temperature + 25 ºC . AM 1.5 corresponds to solar radiation spectrum, if the beam angle to the horizon is 45°. Power, the battery produced under these conditions denoted by Wp (peak power) and it is the power of the solar battery produced in optimum conditions.
Solar cells produced power is measured in W/m^2 and it depends on the type of radiation (the spectrum) the intensity of radiation and module temperature. More power solar battery produced when irradiated direct, cell surface being perpendicular to the sun's rays, minimum – from reflections (diffuse radiation) and the electric light, it is a vivid impression of light, solar cell produces more electricity than in the shade and the electric lighting.
Designing and implementing the autonomous solar power system, the question arises as solar electric power capacity operating conditions in a given area, it is necessary to know the data on the solar power produced in the nature, characteristics and long term (per year) of the battery load the electric power generated Wh. To develop this challenge, a photo-electric solar power module recorder was made and in 2009 was registered produced power of module PVM10/12PF.

Matherials and methods

Set up solar photo-electric power modules recorder is given on Fig.1 a). The device work with the photo-electric module PVM10/12PF see Fig.1 b). Photo-electric module PVM10/12PF technical data aggregated into Table 1.



a) b)

Fig.1. **a) The overview of solar photo-electric power modules manufactured by a recording device; b) Capacity recording devices into the photo-electric module PVM10/12PF**

Photo-electric power module registration principal scheme shown on Fig.2. It consists of the capacity of a recording device 2 which is connected to the photo-electric module and a data recorder 3 (Hobo module). Capacity recording device based on the equivalent battery, it is a load, the curve similar to the battery charging power curve. Therefore Hobo registered capacity and the amount of energy can be considered as a battery charger and rechargeable battery power you have downloaded the amount of energy. Device battery equivalent of a DC parametric stabilizer 4 with a series of switch current limiting ballast resistance R1, which is removed from the data recorder and the supply voltage to be proportional to the photo-electric power module manufacturers. To increase the power stabilizer, it created a transistor-based VT, which collector-base circuit dissconect stabilitrons, but the base-emitter circuit - resistance R3.

Table 2 gives the device electrical characteristics. Figures columns of U and I obtained experimentally, it is the replacement of photovoltaic modules with a variable DC voltage source and measuring the corresponding voltage to the circuit. The figures in other columns of the table have been calculated mathematically. Table with the P_b has identified capacity, which is recorded HOBO and measured mikroammeter PA (Fig.2). The Fig.3 shows the device VA curve obtained using the column I, and U numbers of Table 1.

Table 1.

Technical data of Mono-crystal photo-electric module PVM10/12PF

Nr	Parameter	Symbol	Dimension	Value
1st	The peak power	W_p	W	10
2nd	Nominal voltage	U	V	12
3rd	Wp point voltage	U_{Wp}	V	17
4th	Wp point current	I_{Wp}	A	0.6
5th	A short-circuit current	$I_{\bar{I}s}$	A	0.8
6th	The surface area	L	m^2	0.1
7th	Transformation factor	K_p	%	12 – 15
8th	Size	depth*height*depth	mm	280*365*6
9th	Mass	M	kg	0.4

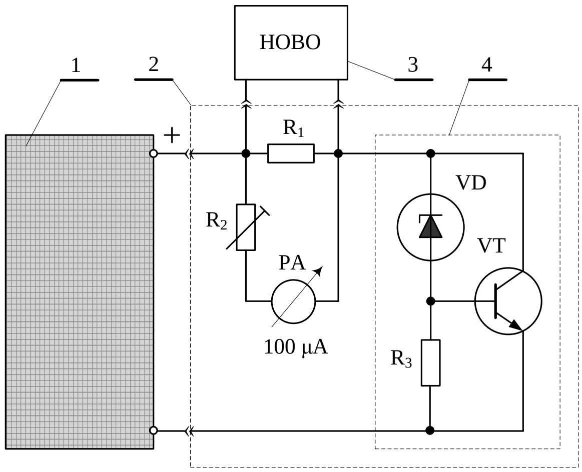


Fig.2. **Principal scheme of photo-electric power module registration process**

R_1 = 1,45 Ω; R_2 = 12 k Ω; R_3 = 240 Ω; VD – Д814Д; VT – KT808

Table 2.

The parameter table of recording device of the photo-electric power module

U, V	I, A	P=I*U ($L=0,1m^2$)	P=10IU, W/m^2	U=I*R (HOBO)	P_b=100*U W/m^2
13.03	0.002	0.026	0.26	0.0029	0.29
13.32	0.011	0.146	1.46	0.0159	1.59
13.5	0.021	0.28	2.8	0.0304	3.04
13.88	0.1	1.4	14	0.145	14.5
14.23	0.24	3.41	34.1	0.348	34.8
14.8	0.5	7.4	74.0	0.725	72.5
15.2	0.7	10.64	106.4	1.015	101.5

Using the considered device, photo-electric module output recorded throughout 2009. year. The data recorder used to record two channels of HOBO device, one power and one to record temperature. Therefore, in order to restart HOBO (the data from HOBO are removed) only once a month, registration of data taken at intervals of 12 min. To obtain the photo-electric module power Pb W/m^2 (see Table 2) the processing of data in Excel, Hobo registered voltage value multiplied by 100.

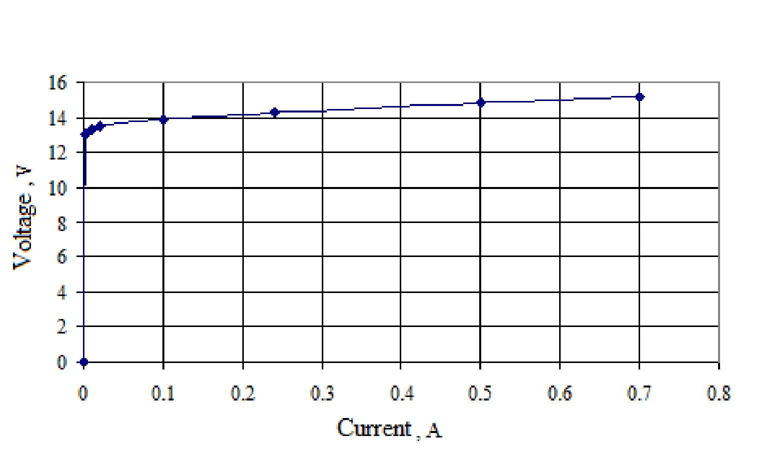


Fig.3. **Photo-electric module, power recorders Volt-Ampere characteristic**

Results and discussion

With Hobo data recorder data from the photo-electric module PVM10/12PF capacity shown with chart tables. Processing data in Excel, we can get power in the form of a chart graphic to any period: hourly, daily, weekly, etc.

On Fig.4. given the photo-electric module, power diagram, 2009 21st April, when, as seen in day has been entirely free of clouds and photo-electric module PVM10/12PF, the day has produced 0.67 kWh/m^2. Found that in April there have been the most favorable weather conditions for the solar cells produce electrical energy module PVM10/12PF in April (see Fig.6) has produced 16.1 kWh/m^2, which is the best indicator of the entire 2009th during the year. Relatively favorable conditions for electric energy production remained until October, because even in September (see Fig.7) obtained 11.79 kWh/m^2 per month. Inimic weather adverse conditions have been during the winter months, for example, in January (Fig.5) and November (Fig.8) is 18 days and more, the power module was less than 10 W/m^2.

In general, the module per year (see Fig.9, converted to 1 m^2 surface with W_p = 100 W) has produced 101.9 kWh/m^2 power, of which 82.63 kWh/m^2, or 81.1% produced by April till September.

In assessing the results of the reliability of the data point of view, it should be noted that the resulting amount of energy should be regarded as the batteries are not downloaded, but no battery is connected directly to the module.

On real working conditions will be energy losses [4] on the battery to 25%, as well as pipelines and the rest of the solar equipment as a result, the resulting amount of energy will be lower.

According to [5], photo-electric module energy output:

$$E = k \cdot W_p \frac{E_g}{1000} \tag{1}$$

where: k – the coefficient, in summer k = 0.5, in winter k = 0.7;

E_g – Global output energy under consideration period;

W_p – peak power of the used photo-electric module.

In our case, assuming full-year k = 0.6; E = 0.6*10*1040000*1000^{-1} = 6240 Wh = 6.24 kWh. Since our module has an area of 0.1 m^2, then the 1 m^2 (Wp = 100 W) energy produced expected will be 62.4 kWh per year (if Wp = 1 kW), the 624 kWh per year which is significantly lower than that recorded by the device.
In [6] at the factors "k" is the numerical value of 0.75. In this case, from 1 m^2 (Wp = 100W) actually get the amount of energy will be around 78 kWh per year, but from Wp = 1 kW of power is expected to be around 780 kWh per year, which could be regarded as a reliable, if due allowance for the above energy loss.

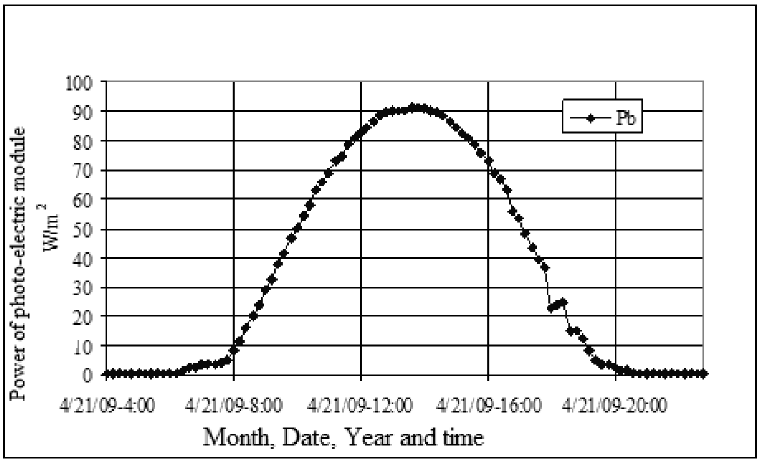


Fig.4. **Photo-electric power module diagram 2009, 21st April**

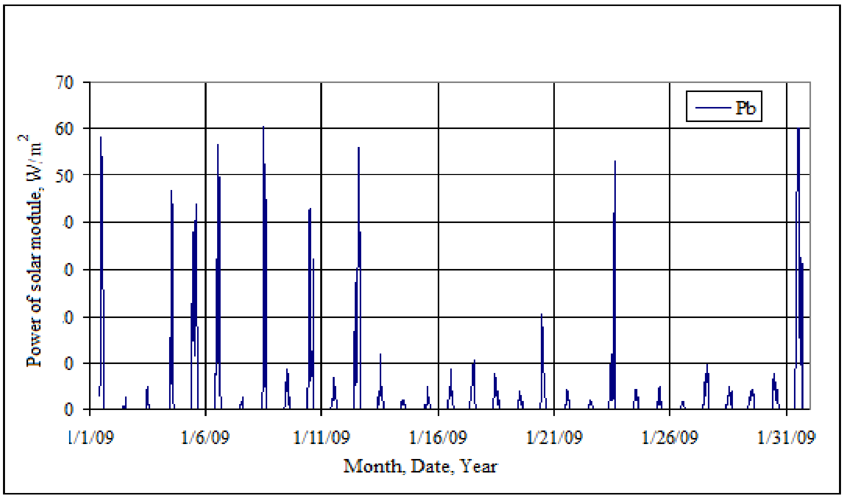


Fig.5. **Photo-electric power module diagram and power diagram energy output in January, 2009th**

Analyzing data from the economic point of view we see that 100 Wp module to the surface of 1 m^2 (per loss) during the year has produced about 78 kWh of electricity and bring in (price 0.073 Ls) 5.7 Ls.
As noted at [7], now cost per kW of installed peak capacity in Latvia are about 5,500 to 6,000 euro (average of 4000 Ls). This price includes all the equipment, the planning and installation. Given that one of the peak power kW our circumstances, can produce around 780 kWh per year in monetary terms corresponds to 57 Ls, the solar installation payback period will be 4000/57 = 70 years. Given that the solar battery life is 30 - 40 years, the state subsidies, such as buying batteries for energy produced at a higher tarif, solar battery for use in Latvia as a realistic basis.

The world's major focus is on reducing the prices of the batteries, which strives for:
Construction of the sun following solar battery [8] equipment; increasing the battery energy conversion factor, using the high-quality, multi-layer GaInP / GaInAs / Ge structure of photo-electric elements, which size 2*2 mm and the Fresnel lens on those, up to 1000 times the solar capacity, thus reducing the cost of equipment installed capacity up to 2 $ per W [9].
Encouraging, photovoltaic main construction material, pure (99.999) silicon extraction technology (chlorine free) [10] by reducing the production cost of silicon 2-fold, thus reducing the silicon and solar batteries on the market price.
Building and developing thin film solar [11] photo-electric modules: the copper-gallium diselenid (CIGS), kp = 20% Cadmium-tellurium (CdTe), kp = 16%, amorphous silicon (a-Si: H), kp = 10%; nanocristalic silicon Si, kp = 10%, and other materials.

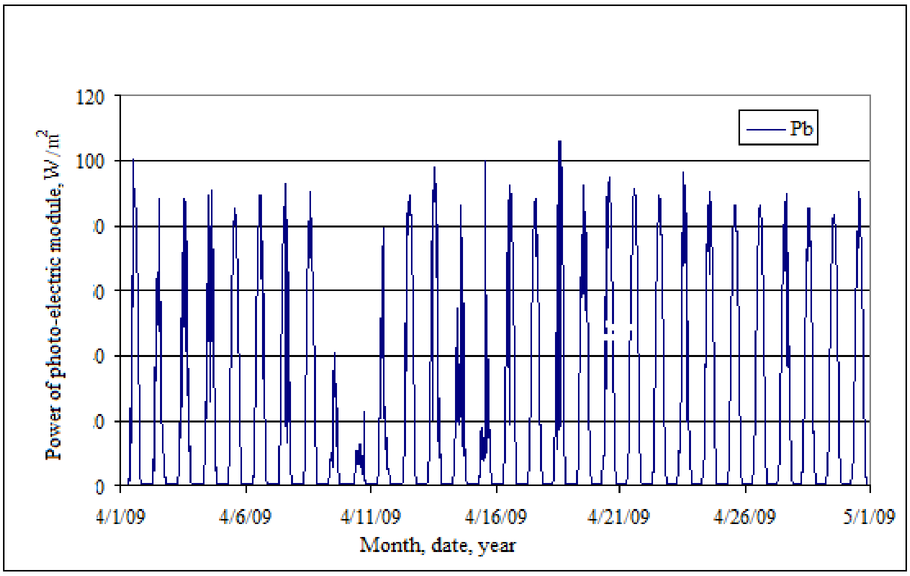


Fig.6. **Photo-electric power module diagram and power diagram energy output in April, 2009th**

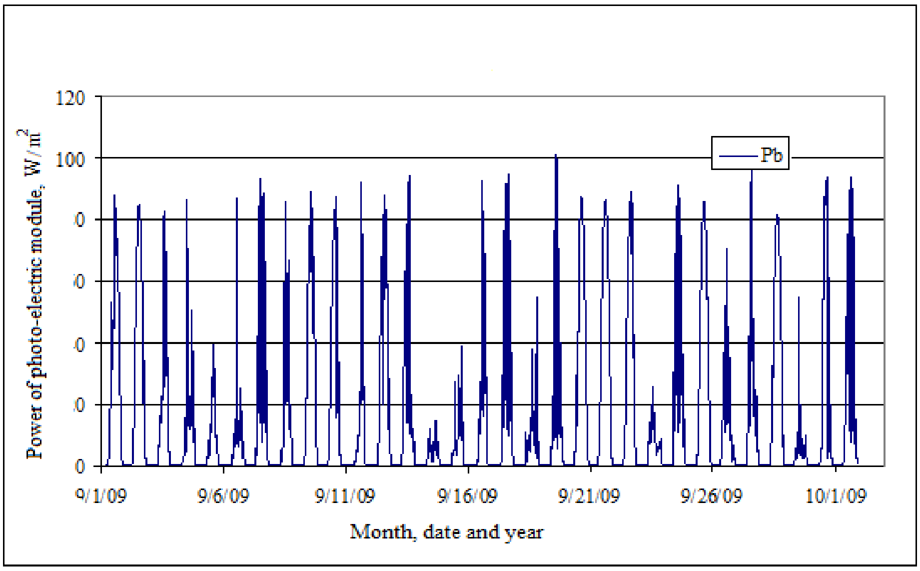


Fig.7. **Photo-electric power module diagram and power diagram energy output in September, 2009th**

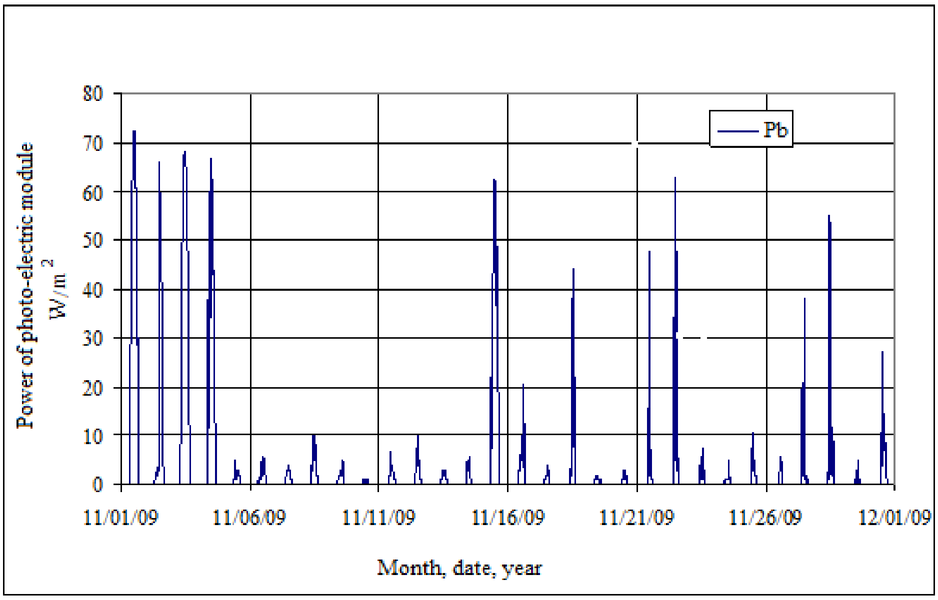


Fig.8. **Photo-electric power module diagram and power diagram energy output in November, 2009th**

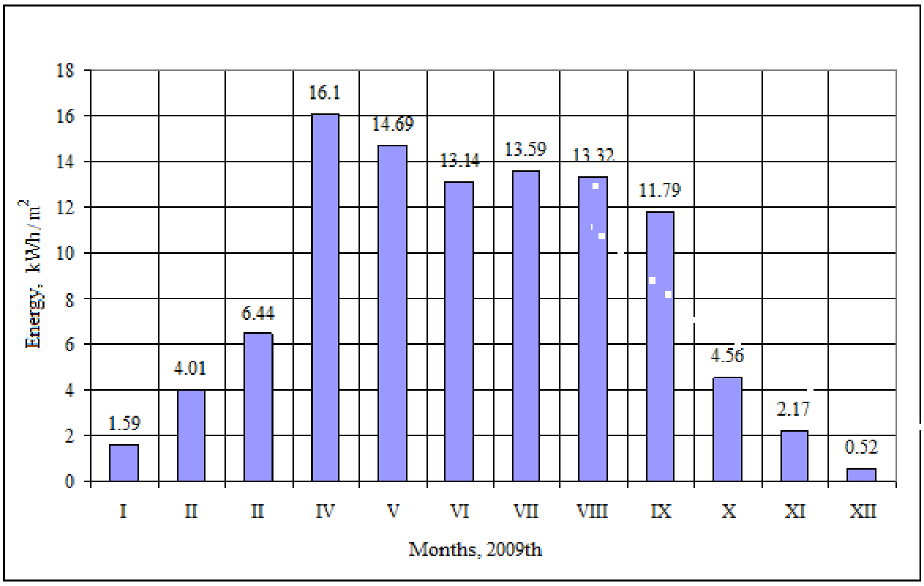


Fig.9. **The recorded output (the batteries are not loaded) energy levelsin 2009th, Total 101.9 kWh/m^2**

Conclusion

1. Solar photo-electric power modules used for recording solar power recorder, which is similar to the load curve (equivalent to) the battery charging load curve, as a result, the device will record the battery retrieved the amount of energy.
2. Connected to a single crystal photo-electric module PVM10/12PF, solar power recorder, in 2009th year, calculated on a peak power of one kilowatt (kW_p), has registered 1,019 kWh of electricity, of which 826.3 kWh, or 81.1% recorded from April till November.
3. Taking into account the energy loss of battery and pieces of equipment to the consumer of energy for the amount assessed around 780 kWh of peak power per kilowatt.
4. If the solar plant with a peak power in kW installation costs 4000 EUR, then the cost of the pay back period, at constant electricity tariff, may be 70 years long.

5. Same unit price of solar cells can be up around 40% of the total project cost, therefore the world, emphasis is placed on battery to reduce the price by trying to reach: the sun using the following equipment with energy concentrators up to 1000 times, improving the production of silicon technology to reduce its prices in developing and the construction of thin film photoelectric cells and modules.

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