ELECTRIFICATION OF SMALL CAPACITY CONSUMERS USING SOLAR ENERGY IN GEORGIA

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In the developed countries of the world are received considerable results in business of working out of converters of a solar energy in electric energy.
World leading firms "Splar Liting International", "Sharp", "Conchiglia" make semi-conductor solar modules and panels with efficiency 10-12%.
Solar modules apply to construction of photo-electric systems of an electrical supply.
Photo-electric electrical supply systems happen two types: independent and attached to an Electrical power system.
We have counted up a total area of solar modules for the average consumer consuming 8350 wh.
Key words: *Solar energy, energy converter, accumulator, solar panel, radiation.*

As it is known, Georgia is the mountainous country with many populated points with the small amount of population, with summer and winter pastures, agricultural farms, preserves, tourists' infrastructure, transport and communication systems located far enough from power distribution network. Their supply with reliable power from the network is associated with significant costs and technical problems. The supply of reliable power is extremely difficult in the mountainous regions due to naturally hard meteo conditions. The same can be said about the power supply of force bodies, environment protection and other units functioning in the mountainous regions.

At the same time significant results are achieved in almost all the countries with respect to the development of the converters of the renewable energy sources into the solar energy, in particular into the power. Very effective semiconductor photovoltage converters, accumulators, control and monitor systems allowing to establish reliable small capacity autonomous power systems are produced in the USA, Japan, China and other countries. Solar energy will convert into the power with solar batteries. The solar battery is ecologically clean and reliable source of energy and can operate during 25 years, even for longer time, without any operation costs.

The problem is especially topical today when the world is facing global heating problems, when during generating the power with heat and diesel power plants, with the generators run by internal combustion engines, the environment is polluted by fuel burning products. At the same time, under Agreement of Kyoto between the leading industrial countries, the companies eliminating CO^2 emission during generating the power provided that 0.39kgCO^2 corresponds to 1 kW/h will be stimulated. In this respect, photovoltage converters of the solar energy is ecologically absolutely clean source of energy and its large distribution will help to positively solve the above mentioned global problem.

Main Part

The photovoltage converter of the solar energy together with the consumers is the microenergy system with all the functions characteristic to the power system such as power generation, power transfer and distribution between the consumers. The photovoltage converters, i.e. the solar battery, have all the properties characteristic to the power generator: energy conversion coefficient (coefficient of efficiency), installed or peak capacity, average capacity value during the day time, generation of daily, seasonal and annual power, rated voltage and current, internal resistance, mass-dimensioning specifications, first price of the generated power, reliability, validity term, etc. Elaboration

of the methods and options of determination of these characteristics positive solution of which significantly conditions successful spreading and introduction of this progressive power technology is very urgent scientific and technical task.

Solar modules made of silicium of crystal structure produced by the leading companies throughout the world (Solar Liting International, Sharp, Conchiglia, etc.) have high coefficient of efficiency ranging within 10-12% [1]. Lower efficiency is characteristic to the modules made of silicium of amorphous structure. There are the modules made from plastic material and the coefficient of efficiency compared to the existing one is improved by 7% and this figure may increase to 45% [2] in future. Works resulting in the increase of the coefficient of efficiency to 80% are being performed at the national laboratory of Idaho State, USA [3].

Solar panels are used as the source of power in photoelectric power systems. There are two types of photoelectric systems: autonomous and non-autonomous.

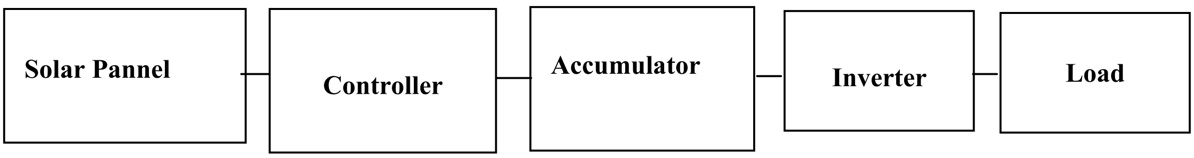


Figure 1.

Figure 1 shows the autonomous microenergy system consisting of the following elements: solar element, controller, accumulator, inverter and consumer.

The autonomous systems are used for the power supply of the units located far from the mobile and basically power transmission lines.

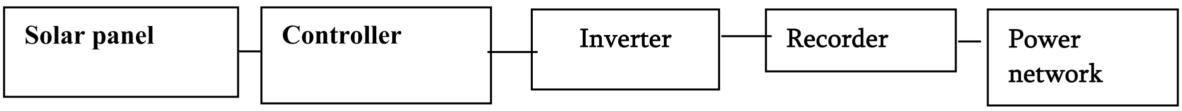


Figure 2.

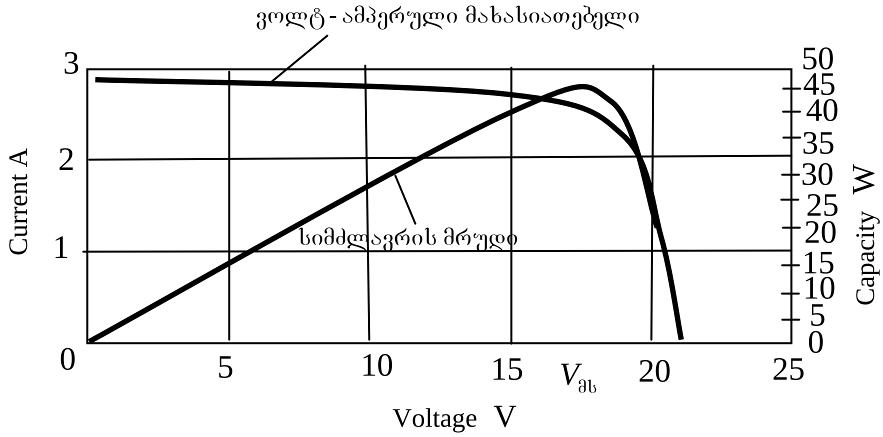
Figure 2 shows the block - diagram of the second system supplying the generated power to the power network.

Let's review separate components of the autonomous system.

The solar panel is obtained by the succession and parallel connection of particular photoelements. Single-crystal and polycrystal silicium photoelements are most widely used. The elements of single-crystal silicium have higher coefficient of efficiency (15-20%). Power parameters of the solar module are defined by their voltage-current characteristics which are taken for standard conditions – STC (Standard Test Condition). STC includes: solar radiation rate – 1000 watt/m^2, solar element temperature – 25^{0}C, solar spectrum – 45^0 on latitude.

The voltage-current characteristics have the following form:

Voltage-Current Characteristics



Intersection point of the voltage-current characteristics curve against the current axis is idle current $V_{უს}$, and current axis intersection point – short circuit current $I_{მგ}$. The same diagram illustrates the capacity curve. Voltage value corresponding to the maximum module capacity is called maximum capacity voltage (working voltage) and the respective current – maximum capacity current (working current). The coefficient of efficiency of the solar element is defined by the dependence of the maximum capacity and radiation capacity of the module.

In order to obtain the required capacity and working voltage, the modules are connected in succession or in parallel way. The photoelectric (panel) generator is obtained in such a way. The generator power is always less than the sum of each module capacity which is caused by the losses.

Table 1 shows key parameters of some solar module types.

Table 1

Type	Mass, kg	Size (length, width and depth), mm	Capacity, W	Idle voltage B	Short circuit current A
PVM-10	1,8	510 234 30	8,5...11	21,6	0,6...0,65
PVM-15	3,5	508 410 30	14...18	21,6	0,9...1,05
PVM-20	4,0	527 450 30	17...22	21,6	1,2...1,3
PVM-30	6,0	975 410 30	28...36	21,6	1,9...2,1
PVM-40	6,5	970 450 30	34...45	21,6	2,4...2,6
PVM-50	7,7	970 595 30	42...55	21,6	2,8...3,2

Quantitative parameters of the voltage-current characteristics will change together with the change of the solar radiation capacity (radiation), in particular the reduction of the radiation capacity results in the reduction of the values of the working current and the short circuit current, and the working voltage and the idle voltage will decrease insignificantly in case the proper operation of the system is ensured.

Proper operation of the system during the radiation change is ensured by the controller (figure 4). It measures discharge voltage and current of the module and regulates the load for it to operate at maximum capacity.

Figure 4.

Maximum capacity controller – Solarix MPPT 2010 is used in both autonomous systems and the systems connected to the network.

Let's provide maximum power supply from the solar panel. The controller provides maximum possible capacity of the system in any natural conditions. Besides, it provides the control of the accumulator condition.

Device peculiarities:

- **regulation of voltage level;**
- **automatic identification of voltage level;**
- **multiple charging technology of the accumulator;**
- **load swith off for maintaining maximum capacity point;**
- **automatic load restart.**

Protection functions:

- **accumulator protection from overcharging;**
- **accumulator protection from deep discharging;**
- **protection from pole displacement in engaging loading, photoelectric module or accumulator;**
- **protection from short circuit on solar element or on load;**
- **protection from circuit disconnection in the absence of the accumulator;**
- **protection from overheating and overloading.**

Indication:

- **multifunctional LED indication;**
- **various LED indicators;**
- **indicators reflect the following modes: operating mode, charging stage, error.**

The accumulator is chemical source of alternative energy and it is the weakest point in the system. The companies producing the accumulator battaries work on improving their operation in order to prolong their service life.

The most important stage of setting up the microenergy system is selection of the accumulator capacity. The capacity is calculated by the relation of the consumed energy to the accumulator current. For instance, if total energy is 1000 watts/h per day and the admittable depth of the 12 watt accumulator discharge – 50%, then the accumulator capacity will make 1000/(12·0,5)=167 a.h.

The energy generated by P_w capacity solar module:

$$W = k P_w E / 1000,$$

where k is coefficient which in summer equals to 0,5 and in winter – to 0,7. This element regulates capacity losses during heating up the panel under the sun; E – solar radiation value which we get from the presented table. If we divide it into 1000, we will get the time during which the sun shines at 1000 watt/m^2 rate; P_w - peak module capacity.

Calculations in table 2 are given in kWh/m^2. The solar radiation in Georgia in July is 206,8

kWh/m^2 meaning that the sun in July shines 206,8:31=6,6 approximately at 1000 watt/m^2 rate for 7 hours during a day.

$$W = k\,P_w\,E / 1000 = 0{,}5 \cdot 120 \cdot 6{,}6 = 396 \quad wt/h,$$

i.e. 396 watt/h energy is in average obtained from 1 m^2 space.
For selecting the module total capacity of the consumer should be estimated first of all. The capacity of each consumer is measured in watts and is given in their passport data.

As an example let's take the average consumer (table 3).

Table 3

Consumer	Capacity, watts	Operation term, h	Consumed power, watts/h
TV	70	10	700
refrigerator	480	10	4800
Bulbs	20X5	6	600
Washing machine	500	0,5	250
Iron	1000	0.5	500
Computer	150	10	1500

Totally we have 700+4800+600+250+500+1500=8350 watt energy.

Month; Georgia; Latitude 43^0	January	February	March	April	May	June	July	August	September	October	November	December	Year
Horizontal panel, kW/h	37.0	55.2	84.0	116.6	167.1	199.0	206.8	185.0	130.1	95.4	54.2	34.7	1365.1

As we calculated already, the panel at 1 m^2 provides 396 watt/h energy. Therefore, the panels located within 21 m^2 will provide 8350 watt/h.

In January when the solar radiation is 37 kW.h/m^2, the sun shines 37:31=1,2 approximately at 1000 watt/m^2 rate for 1,2 h during a day.

$$W = k\,P_w\,E / 1000 = 0{,}5 \cdot 120 \cdot 1{,}2 = 72 \text{ watts/h},$$

i.e. in average we get 72 watt/h energy from 1 m^2 area module.
For the above mentioned consumer requiring 8350 watts/h energy, the panels located at 8350 : 72 = 116 m^2 will be needed.

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