A Model to Study the Energy Balance and Energy System with Customized Software

Silvija Letskovska and Kamen Seymenliyski
Silvija Letskovska - Burgas Free University
San Stefano 62
8000 Burgas, Bulgaria
silvia@bfu.bg

Kamen Seimenliyski –Burgas Free University
San Stefano 62, 8000 Burgas, Bulgaria
kdimitrov@bfu.bg

ABSTRACT: *The energy production following strong system rules is required for supporting the energy balance. In the time of production, transport, transformation and consumption of energy the lows, methods and principles of technique are considered. In this paper, the authors have offered description of the energy system and the use of renewable energy system with the help of customized software.*

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1. Introduction

The common rules for price forming for the industry are valid in determining the price of electrical energy. It is necessary to take in mind the specific particularities of energy production as well as these of the consumers of electrical energy. The main particularity of the electrical energy is the electrical energy is the limited possibility of keeping and charging. It mast be consumed in the moment of its production following strong system rules for supporting of energy balance. In the time of production, transport, transformation and consumption of electrical energy the lows, methods and princips of electro technique are in fact. All economical statistical, political and social aspects and methods used in the energetic serve for more effective and correct applying.

Every deviation from them destroys normal function of the energy system. In this connection – the base task of different system for price forming in energetic is regulating using economical methods the balance between production and consuming. In Bulgaria work many thermal electrical centrals, with dive more than 80% of the necessary electrical energy. In the future this percent will increase permanently.

The bigger part in these centrals have high technical minimum – 70 to 75% from nominal power. In the same time parameter β in the energy system is very low:

$$\beta = P_{min} / P_{max} = 0.58 \div 0.60 \quad (1)$$

where: P_{min} – minimum loads; P_{max} – maximum loads.

This leads to difficultness in the work of electrical centrals in night minimum loads of the system. To be excluded, arrised as a result of high operating difficultness and connected with them significant economical losses is necessary to act in two main direction [1, 2].

In the first place – to reach methods for increasing of night loads of the consumers of the electrical energy, and in the second place – to decrease the maximum loads of energy system or to search for cheap fast acting generating sources.

Excluding of these problems is getting mainly using: introducing in the energy system of flexible production powers based on small renewable system (SRS), introduction in exploitation of pump-accumulating hydro electrical centrals (like PAHEC Chaira); regulating of consumption with economic methods, for supporting of the energy balance of the country with comparable constant load diagram.

The other trend in the last years is a seasoning transfer of high energy flows to the big sea truistic complexes. It due to intensive building of houses which are used only seasoning. For example, in the last several years only in complex Sunny Beach are connected about 70 new transformers stations and as result the installation power has been increasing with over 30%. In the summer truistic season the consumption of electrical energy only in the complex is significant higher (about 120 MW) compared with this of whole Stara Zagora region (about 80 MW). Burgas region (about 370 MW) during summer season consumes more than Jambol, Sliven and Stara Zagora regions taken together.

The distance of the consumers of the electric energy from the centrals influences significantly on the volume of losses. As a result of this the consumers situated close to the electric centrals (connected in the generated voltage) are in better situation. The consumers far way, consuming energy via several steps of transformation, increased losses for the transfer and transformation.

Power factor (on a practice – cosines f of the consumers) also influences significantly in the transfer and transformation of the electrical energy.

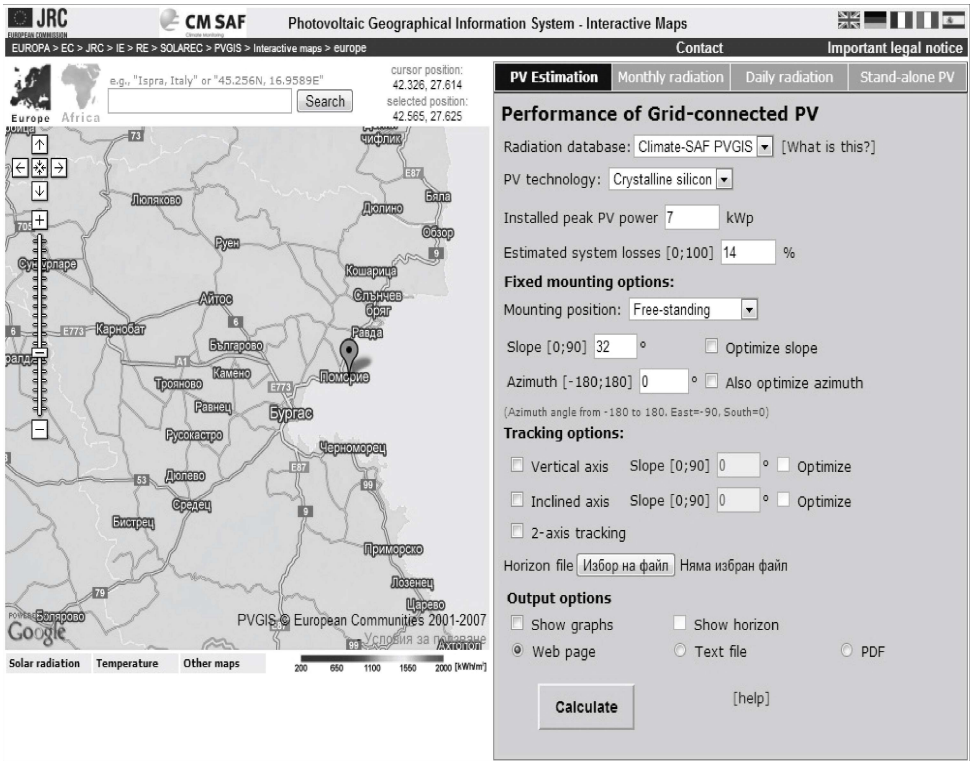

Figure 1. Sun-energy odit of Pomorie

Due to, that the electrical energy can not to be stored but must be immediately to be consumed, consumers, producers and distributors use different capital investments for unit of used energy. For consumer, which work only night time, do not require building of additional generation powers and are favourable for the system.

After performing not in the better way privatization of the electrical distributing companies the price of electrical energy is changed several time with the goal reaching of normatively declared in the privatization contracts of these companies profit. That leaded to disproportion, due to retardation of the price, respectively and the profit of the Common System operator, production powers, producers of the primary energy resources and etc.

Acting at the moment methods for determining price of electrical energy defined by State Commission for Energy and Water regulation tolerates some known possibilities for subjectivity and unambiguous interpretation of output information, as well as and using of prognostic data, which can be manipulated. It reacts and for price of the energy from renewable system.

With their connection into the networks of electrical distributing companies, with goal selling of electrical energy, the additional taxes are counted, which additionally make then expensive.

All these problems increases the actuality of building and connecting of renewable system for domestic consumption. In this connection is important to investigate how much is economically favourably to build small renewable system based on photo-voltaic panels in the truistic regions in Bulgaria.

As an example in this aspect is the town of Pomorie. It is served by the electrical distributing network, owing of EVN – Bulgaria and it has a number of problems of objective and subjective character. The territory of Pomorie town is occupied chiefly by houses - type multifamily homes, populated usually from one to four families. Average every one of these houses has roof space in the range of 100÷300 m^2.

The average usage of electrical energy for one family, data`s from EVN is 115 lv in month. These data are on the base of the consumption of the average – statistical four members family. The consumption of the electrical energy is distributed as follows: 75% for heating; 15% for electrical appliances; 10% - for lighting [3].

Thus, if the initial calculation is done, oven these are the data for the price of electrical energy without transfer taxis and another elements, with form it, the next will appear:

- With price of one kW electrical energy 0.19 lv – average price for 1 kW, the quantity of the used energy for month will be 605 kW;

- Annually for one four members family is such average monthly consumption will be 7260 KWh, wich will form the price about 1400 lv. This means that the daily consumption is about 20 kWh.

2. Building of Autonomous Renewable Energy PV-system on the Territory of Pomorie Town

Assessable potential of sun energy determines after calculating of several base factors: irregular distribution of energy re-sources of sun energy during the separated seasons of the year; physical – geographic particularities of the territory; limitations in building and exploitation of sun system in the specific territories, as nature reservations, military objects and ets.

Average annual quantity of sun shining for Bulgaria is about 2150 hours and average annual recourse sun radiation – 1517 kWh/m^2.

As available annual potential for absorbing can be shown approximately 390 ktoe (As official source for evaluation of sun energy potential is used project of the program PHARE BG9307-03-01-L001 – «Technical and economical estimation of Renew-able Energy in Bulgaria ». In the base of the project are data from the Institute for meteorology and hydrology in BAS, taken from all 119 molestations in Bulgaria for the period over 30 years).

After the analyse of data base zoning is done for sun potential and Bulgaria is divided of three regions depending on the

intensity of sun shining.

Pomorie town is situated in the third region – South-East and South West region, in which is situated and southern cost. Average annual duration of sun shining in this region is from 500 h to 1750 kWh/m^2.

With the help of Photovoltaic Geographical Information System (PVGIS) giving the coordinates of Pomorie town sunenergy audit was done on its territory (Figure 1).

PVGIS is WEB-based system for science investigations, demonstrations and geographical evaluation of sun energy resource in the range of integrated ruling of distributed generation of an energy [4].

PVGIS combines data from laboratory investigation, monitoring and testing with geographical know ledges, for analysing technical, ecological and social-economical factors of producing electrical energy from sun energy [4].

With the help of PVGIS the calculation are performed, taking in mind the influence of different parameters which would create losses in functioning of one PV-system (temperature, corner reflection, conductors, invertors and etc.).

From the received result can be accepted, that on the territory of Pomorie town insiste favourable conditions for producing of electrical energy using building PV-systems, as well as building of tracking system is not economically (Figure 2).

Fixed system: inclination=33°, orientation=0°				
Month	E_d	E_m	H_d	H_m
Jan	0.00	0	2.29	71.0
Feb	0.00	0	2.86	80.0
Mar	0.00	0	3.84	119
Apr	0.00	0	4.79	144
May	0.00	0	5.48	170
Jun	0.00	0	5.54	166
Jul	0.00	0	5.83	181
Aug	0.00	0	5.65	175
Sep	0.00	0	4.87	146
Oct	0.00	0	3.94	122
Nov	0.00	0	2.49	74.8
Dec	0.00	0	2.01	62.2
Yearly average	**0**	**0**	**4.14**	**126**
Total for year		**0**		**1510**

Figure 2. The Calculation With PVGIS

Legend: E_g - Average daily electricity production from the given system (kWh); E_m - Average monthly electricity production from the given system (kWh); H_g - Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2); H_m - Average sum of global irradiation per square meter received by the modules of the given system. PVGIS estimated of solar electricity generation The point of chose has insufficient data to calculate the relative efficiency of the PV modules.

The result shown the See the map of relative efficiency for regions with valid data.
Location: 42033'52" North, 27038'59"East.
Elevation: 0m a.s.1, Solar radiation database used: PVGISclassic; Nominal power of the PV system: 0.0kW (crystalline silicon); Estimated losses due to temperature: 8% (generic value for areas without temperature

information or for PV module); Estimated loss due to angular reflectance effects: 3%.

Other losses (cables, inverter etc.):15%. Combined PV system losses: 21.1%.

The technologies for producing of photovoltaic panels develop and improved with very high rate. The variation for increasing of coefficient of useful work (efficiency). During the last years the price of the panels for square meter sensitively drops, in the same time increases output power, in keeping and decreasing of panel sizes. In the present moment on the market offers:

• Single crystal silicon panels (efficiency 13÷18%) with power from several to 300 Wp;

• Polycrystalline silicon photovoltaic panels with low efficiency (10÷14%) and low productivity in temperatures higher 250C. They strongly are influenced by the angle of sun radiation. They have application in building of photovoltaic systems for facade of building and roods of houses;

• Amorphous silicon panels (with lowest efficiency – less 11%), which are not so influenced by high temperatures and more effective in cloudy weather.

The other advantage of thin type of panels is the possibility for producing of big variety of products – thin film photovoltaic modules, flexible photovoltaic modules for glasses, solar chargers for laptops, GSM and etc.

In the moment on the market has high number of producers which give different prices and technologies. Available separated as panels, invertors, controllers, batteries as well as finished system and performances [5-7].

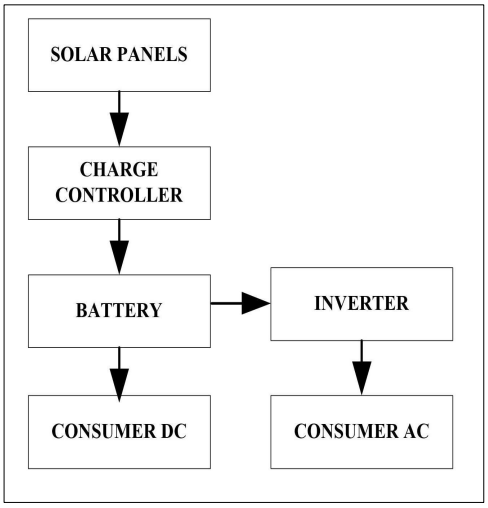

Figure 3. PV-system - example variant

On Figure 3 is shown of an example variant of building of photovoltaic system on the root space for multifamily house on the territory of Pomorie town with power 5000 W. The choice of such system with lowest economical parameters the results are obtained shown on Figure 4. The parameters (coordinates, power, losses and ets.) are given in PVGIS. The final results shows that the system will produce average annual about 6230 kWh.

Location: 42'34'16" North, 27036'41" East. Elevation:2m a.s.1, Solar radiation database used: PVGIS-CMSAF.

Nominal power of the PVsystem:5.0 kW (crystalline silicon); Estimated losses due to temperature and low irradiance: 10.4% (using local ambient temperature).

Other losses (cables, inverter etc.): 14%. Combined PV system losses:25.2%.

Fixed system: inclination=32°, orientation=0°				
Month	E_d	E_m	H_d	H_m
Jan	9.19	285	2.25	69.6
Feb	12.60	352	3.13	87.8
Mar	15.80	489	4.06	126
Apr	19.10	573	5.08	152
May	23.20	718	6.32	196
Jun	23.20	696	6.47	194
Jul	23.90	742	6.73	208
Aug	23.80	737	6.67	207
Sep	19.40	583	5.32	160
Oct	14.40	445	3.80	118
Nov	10.80	325	2.72	81.7
Dec	9.11	282	2.24	69.4
Yearly average	**17.1**	**519**	**4.57**	**139**
Total for year		**6230**		**1670**

Figure 4. PV-system with lowest economical parameters

Prices of the system elements				
Type of element		Number	Price pcs (lv.)	Total (lv.)
1	Single crystal PV module 175 Wp	10	525	5250
2	Charge controller 12/24V, 50A	2	360	720
3	Inverter 2/1500W, 230V/50Hz	2	670	1340
4	Battery 12V, 100Ah	8	350	2800
5.	Other expenses (construction, wiring, documentation)	1	1000	1000
Total value				11110

Table 1. Prices of the Chosen System

In Table 1 the prices of the chosen system are given and in Table 2 – produced energy and cost price of the produced electrical energy for the period of exploitation up to 25 years.

PV-system 5000W	Period of exploitation (years)					
	5	10	15	20	25	Remark
Produced energy (kWh)	31150	60000	88000	104000	118000	Calculated losses from amortization
Price kWh (lv.)	0.353	0.23	0.188	0.184	0.186	

Table 2. Prices of KWH

Conclusion

In so chosen object for investigation – multifamily house in Pomorie town and after calculations on the base of price and conditions, comparable with these of EVN at the moment, the accepted results are the base for next conclusions:

• If the proposed for building PV-system is used over ten years the price of one kWh will appear to be comparable with the price of one kWh electrical energy from EVN. In this moment 88000 kWh from EVN have price about 16720 lv;

• The proposed variant for building of PV-system with choice of firm for delivery and mounting will insure full recreation of the capital for nine years work of the system with present prices of the EVN. After these years the expenses will be only for the maintenance of the system.

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