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PV Stand alone power generation for family house

In this work was designed and optimized photovoltaic systems for standalone operation (off-grid) of a home. Optimized solution would be most appropriate compromise between economy, ecology and user comfort. System design was based on an analysis of solar conditions in Slovakia and energy supply requests at home.

Keywords: Stand- alone photovoltaic system, System design, Family

I. INTRODUCTION

By analyzing and comparing the solar radiation throughout the year and household energy requirements is an obvious two-dimensional disproportion between the production of solar system and household consumption. Photovoltaic panels has its production peak in midday hours in summer, while the maximum household energy needs are during the evening in winter. Solution can be found by different priorities taken into account such as economics, ecology and user comfort. Ecology and economics in this case are in direct contradiction, since one of solutions usage of an auxiliary gasoline generator that is able to significantly mitigate the consequences of that discrepancy. User comfort, in other words, the system reliability means the ability to perform the required functions under all conditions. Lighting conditions cannot be exactly estimated and therefore increasing the reliability of supply of pure photovoltaic system results in overdesign of system, which affects its price. The optimal solution will therefore be a compromise between those factors and this aim is to be accomplished by simulations in Homer Energy software [1,2].

II. CONDITIONAL ANALYSIS

Solar radiation was analyzed using photovoltaic geographic information system PVGIS [3]. Daily radiation in kWh/m2/d used as input data for simulations in Homer depends on the inclination of the panels. The maximum annual income is 1030 kWh/kWp by inclination 35 °. For off-grid systems is priority to maximize solar radiation in the winter months at the expense of the total annual income [4]. Therefore inclination of 60 ° showed to be best solution. Figure 1 presents comparison of average values of daily radiation for both inclinations.

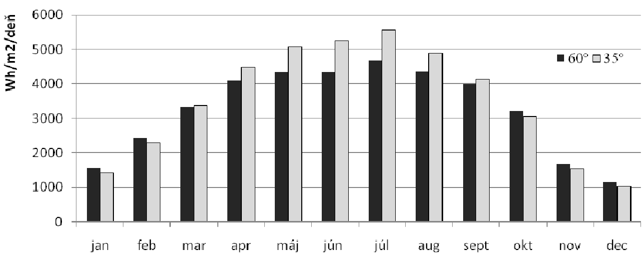

Fig.1 Comparison of average daily radiation by inclination angle.

Household consumption was analyzed based on installed appliances and estimate their use. The daily load curve varies between summer and winter days on the basis of lightning from the earlier hours.The average daily consumption of household was estimated to 7.40 kWh in months from April to October, respectively 8.68 kWh from November to March. The total annual consumption is estimated at 2890 kWh. By modeling the consumption in Homer it was included an additional random day-to-day variability of 30% and 10% time-step-to-time-step. The resulting annual load profile is shown at Fig.2

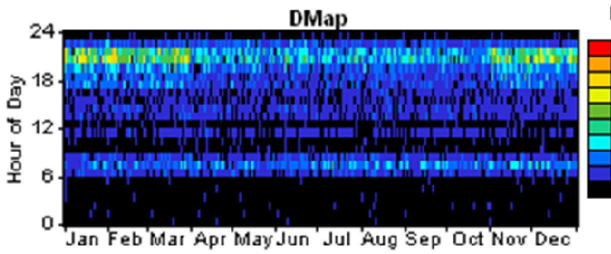

Fig.2 Annual electricity load profile of the household

III. SYSTEM DESIGN

Using Homer software has been evaluated various design options for the system conditions and requirements. Design requirements are represented by its pointers. Economic efficiency is being evaluated by total system cost, or cost per kWh of produced energy, environmental friendliness by released emissions during operation and user comfort by the proportion of unserved electric load per year. To found an optimal solution for pure photovoltaic system (without a secondary source), relation between the cost of the system and proportion of unmet electric load has been analyzed. Analyzed cost curve is presented on figure 3. Two curves were made to compare the impact of panels iclination (35 and 60 degrees). Figure 3 also shows the above-mentioned argument about the advantage to prefer higher income in the winter months before the total annual gain (static panel placement). The most significant decrease of total costs is at 2.1% of unmet electric load per annum. This solution represents a compromise between the price and user comfort, without using gasoline generator.

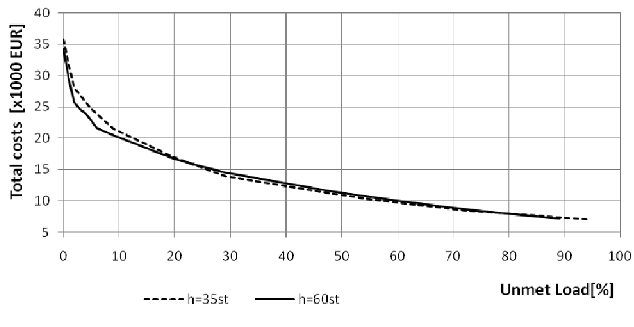

Fig.3 : PV system total price dependence of the non-delivered energy fraction, where parameter is panels inclination

Cost curve of the ratio of energy supplied from photovoltaic panels on energy consumed (Fig.4), has been analyzed to find an optimal solution for a hybrid system with a gasoline generator. Position of minimum of the curve depends on the considered gasoline prices. By increasing reference value of fuel cost, minimum of the curve will move towards the energy supplied purely from photovoltaic panels. When the price 1.6 euro per liter [5], is taken as reference, the minimum of curve is found for 84% of energy delivered from photovoltaic panels. Increasing this value means system costs will be higher due to over sizing, but reduce the fuel consumption and thus decreases emissions.. This solution is most economical while maintaining maximum user comfort (no unmet electric load), bud due to additional emissions from burned fuel is not the most environmentally friendly.

The final solution will therefore be a compromise between the total costs and emissions from fuel burned by secondary generator.

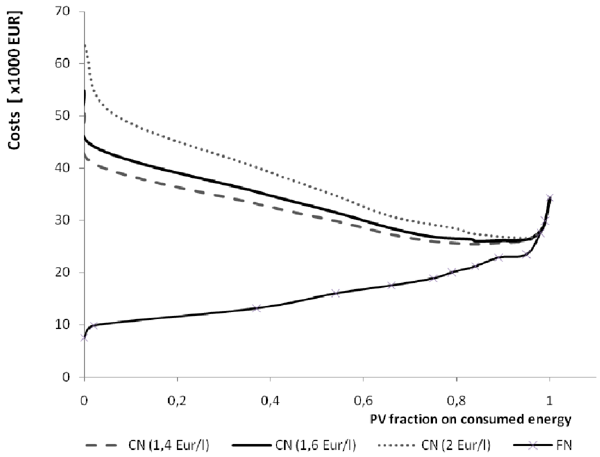

Fig 4: Costs dependence of PV fraction on consumed energy for various fuel price scenarios. CN-Total Costs; FN–Fixed Costs (independend from fuel price)

Table 1 presents parameters of various system options designed by mentioned principles and proposal for a compromise solution, which increases the cost by 1.2%, but reduces CO2 production during the operation by the 68% and at the same time maintain 100% of requirements of electricity supply for home.

Table 1 Parameters of optional systems designs based on various priorities

System Parameters	Economical optimum	Economical/ Ecological optimum	Overall optimum
PV size [kWp]	4,5	6,5	5,64
ACU size [kWh]	24	36	24
Fuel [l/year]	248	0	79
PV energy ratio[%]	84	100	96
Unmet load [%]	0	2,1	0
Emissions CO2 [kg/rok]	575	0	182
Total costs [Eur]	25 930	25 796	26 246
Cost of electricity [eur/kWh]	0.785	0.794	0.795

Every solution mentioned is optimum for specific priorities. The task was to to find the optimal solution in terms of all required parameters. Since these are contradictory, it is necessary to find a compromise. Based on simulations, the best solution seems to be a hybrid system with autonomous secondary source that supplies the missing 4.4% of energy. The remaining 95.6% of energy will be sourced from unconventional source - photovoltaic panels.

Such system consists of photovoltaic array size of 5.64 kWp, which will consists of 24 panels each having peak power 235 Wp connected in parallel up to 5 panels on a charge controller. Accumulation system will comprise in total of 12 units of 1000Ah batteries with a rated voltage of 2 V to connected in series by 6 with a total capacity of 24 kWh. Photovoltaic and battery strings are forming DC side of two parallel connected converters with output 5.2 kW. Gasoline generator with output 2.5 kW will work with the grid voltage in load following mode. Scheme of the proposed solution is in Figure 5

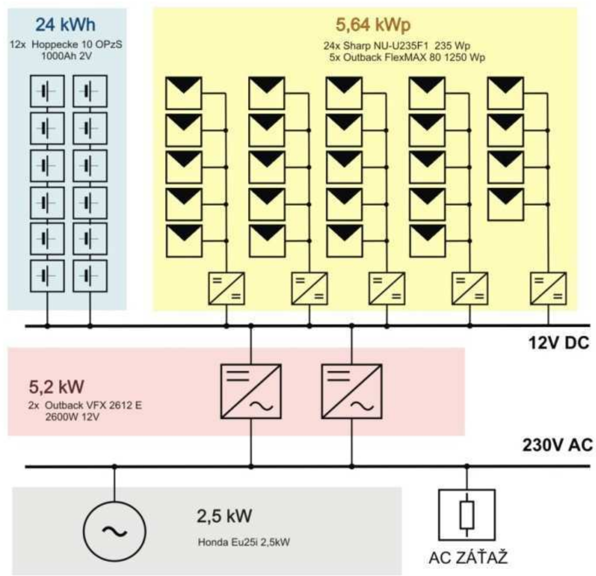

Fig.5 Scheme of the proposed hybrid system.

IV. CONCLUSIONS

The proposed photovoltaic system produces electricity for the needs of households in price approximately 0.8 euro / kWh. In economic terms cannot stand in against to the price of grid electricity, but such a comparison is not correct without considering other factors such as environmental aspects or independence from the electricity supplier. Real justification for such solution is in the case of unavailability of the network. If we consider the price of 6 euros per meter of power cable and its imposition and the average price of electricity for the next 20 years (the planned life of the project) 0.15 euros / kWh, then the distance from the network in which the photovoltaic system is viable is about 3 km. From Figure 4 is clear that the power supply from proposed photovoltaic system is already now half more profitable than power supply purely from petrol generator

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