



MATLAB GUI Model for PV System Feasibility of a House Electricity Consumption in Turkey

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Abstract

In this study, feasibility analysis was done with a program that created a simulation model in the MATLAB GUI environment for the PV system installation in the production of electricity requirement of a house in Turkey conditions. The energy consumption is calculated through the data of the operating hours in a day and the number of running days in a year which entered by user. Once the panel and zone selection options have been specified, the program calculates the annual energy need for the house, the energy generated, the number of panels required to produce this energy, and the area required for system. Monthly energy distribution is shown graphically. Calculations are being revised for different panel number usage. In the economic analysis part, system cost, payback period and annual earnings are determined. PV system model, consumers will invest in renewable energy that will help to make the pre-feasibility and can be used as a decision-making mechanism.

Key words

Feasibility analysis, MATLAB GUI, Payback Period, Photovoltaic System, Renewable Energy

1. INTRODUCTION

According to the definition of the International Energy Agency (IEA), renewable energy is defined as a type of energy that is constantly renewed and obtained from natural processes. According to this; solar energy, wind, biomass, biofuels, geothermal, hydraulic power, ocean resources and hydrogen energy obtained from natural sources are the energy sources that make up this concept [1]. Reducing foreign dependency since it is obtained from countries' own natural resources, being continuous as long as natural resources exist, lack of harms against the environment unlike fossil resources and the fact that it is safe are the reasons of preference of renewable energy. It helps economic development by creating new business areas in the country with the decrease of energy import [2].

In order to increase the use of our country's high renewable energy potential, green energy investments are being developed under the Renewable Energy Laws (REN). Wind and solar energy investments come to the forefront, based on the incentives and practices of these laws [2]. While wind energy is preferred for systems with great power, individuals throughout the world and especially in Germany produce their own energy by using solar energy without harming the environment by integrating PV panels into the roofs which are one of the smallest energy systems. Since this solar-generated energy has wave characteristic, it can be connected to the grid at times

when the sun is insufficient and can take electricity from the interconnected system or use storage tools such as accumulator, battery, etc.

In this study, the feasibility of integrating the PV system into the dwellings of a 4-member family, like in many other developed countries, was realized with the MATLAB GUI program.

2. MATERIALS AND METHODS

In the created model, it is waited from the user to enter the data of electrical devices powers, operating hours of them in a day and number of day in a year to calculate the total energy need in a year. If user need more devices to specify the power that undefined in the program, he/she can use the option "other" labeled.

After the entering power of devices, the next step of the program is PV panel and location choices. User selects one of the PV panels from the popup menu to install the system with, then chooses the location where it will be installed. Yingli Solar PV panels were used for the program as panel options and three districts from Izmir; Cigli, Dikili and Menderes as location examples in this study. Later on, exchange rate of dollar/Turkish liras is defined with the value of the day, to calculate the sale price of the surplus energy.

Then the run button is clicked and the program shows the results. It calculates the annual energy need and, required area, setup cost, installed power, panel number required of the suitable PV system according to the energy need, and annual energy production, annual earning, depreciation time of the system and the graph of generated energy by month. If the user has a thought to install the system with different panel number from calculated by program, he/can specify a new one. The screen of the program as shown below (Figure 1), without entering any data.

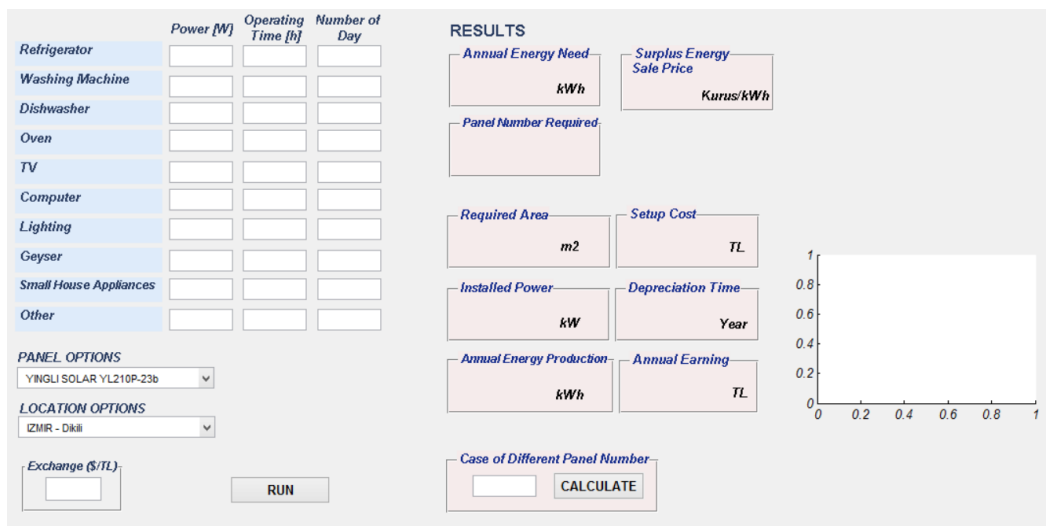


Figure 1. First screen of the program

Solar energy data are taken from SEPA (Solar Energy Potential Atlas) for selected regions. In this study, by using the global radiation values of the Dikili district of İzmir province, energy reaching a house in that area were calculated. When we look at the one-year radiation distribution in the SEPA radiation bar graph Figure 2, it appears that the selected zone is suitable for solar energy investment.

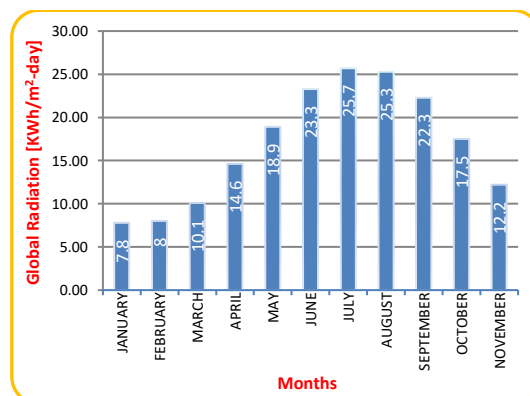


Figure 2: Izmir - Dikili Global Radiation Values [3]

Figure 3 shows air temperature data for selected regions, taken from the RETScreen program. RETScreen is a renewable energy feasibility program used by the Canadian government that supplies all atmospheric data from NASA. Detailed atmospheric solar data from the RETScreen program was also used in calculations to support global radiation data from SEPA for the selected region.

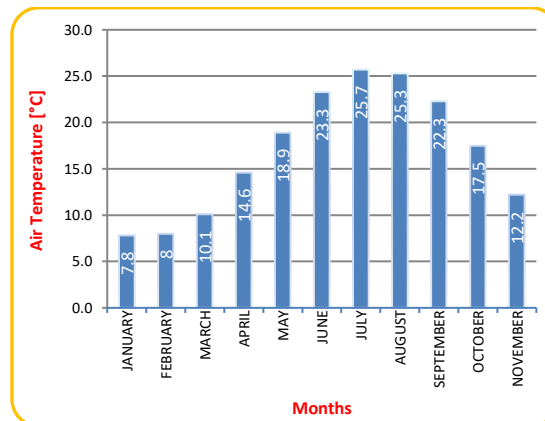


Figure 3: Air Temperature of Dikili [4]

3. MATHEMATICAL BACKGROUND

After providing the potential of solar energy and weather temperature data, the total solar energy, the required number of panels and the panel area is calculated. After the power of the annual energy requirement devices and the annual working hours are entered into the program as hours and days, with the multiplication and subsequent collection of the data of each device in itself, the number of panels required, is calculated by dividing the calculated energy requirement by the energy generated by one of the selected panels on the program in the selected region. The required space for the system setup is obtained by multiplying the selected panel by the required number of panels [5].

3.1. Calculation of Energy from the PV

NOCT (nominal cell operating temperature) is the cell temperature module with solar radiation of 0,8 kW/m², air temperature of 20°C and wind speed of 1 m/s [6]. T_{cell} [°C] is the cell temperature calculated from the air temperature, T_{air} [°C]. S is the solar radiation value [kW/m²]. The cell temperature was calculated under PTC conditions (PVUSA Test Conditions - air temperature = 20°C, radiation $S = 1$ kW/m²). P [kW] is PV panel power calculated using P_{mpp} (maximum power point) and κ [%/°C] (estimated power loss for each temperature value around 25°C) values. Annual solar energy E [MWh] is calculated by adding 10% operational loss, multiplying solar panel power with daily sun peak hour strike (solar peak hour/day).

$$T_{cell} = T_{air} + [(NOCT - 20^{\circ}\text{C})/0,8] \cdot S \quad (1)$$

$$P = P_{mpp} \cdot [1 - \kappa \cdot (T_{cell} - 25^{\circ}\text{C})] \quad (2)$$

$$E = P \cdot (\text{sun peak hour/day}) \cdot 365 \text{ day/year} \cdot 0,9 \quad (3)$$

$$\text{Panel Number} = \frac{\text{Daily Energy Demand}}{(\text{Power of a PV}) \cdot (\text{Sunshine Duration})} \quad (4)$$

3.2. Economic analysis

As a result of calculating the annual energy requirement, the next step is economic analysis. The following formulas are used to calculate the annual earnings and payback period obtained from the PV system.

$$\text{Payback Period} = \frac{\text{CAPEX}[TL]}{\text{Yearly Energy Produced}[kWh] \cdot 0,40[TL/kWh]} \quad (5)$$

The system cost (CAPEX: Capital Expenditure) is calculated by multiplying the system installation cost, which is taken as 4500 TL per kilowatt, with the installed power.

4. CASE STUDY

In this study, the pre-feasibility analysis of a complete house for a four-person household in the case of the complete supply of energy from the PV system was carried out using the MATLAB GUI program. The investor calculates the annual energy consumption by entering the data of the power of each household electrical appliances, the working hours, and the number of days the appliances work for each year into the program. To supply the consumed energy from the PV system, panel options are selected as desired. Region selection is made for the planned system to be established. Finally, the current dollar parity is entered and the results are evaluated.

As an example, required data to calculate annual energy need for a family of four, electrical devices powers was entered by us as shown below (Figure 4), YINGLI SOLAR YL200P-23b named PV model and Izmir-Dikili location was chosen and dollar parity value was typed as 3.7 for that day.

	Power [W]	Operating Time [h]	Number of Day
Refrigerator	1100	24	365
Washing Machine	2000	2	120
Dishwasher	1200	2	120
Oven	2500	1	75
TV	100	5	365
Computer	75	4	365
Lighting	90	5	365
Geyser	2000	1	365
Small House Appliances	500	1	100
Other	1000	2	120

Figure 4: Energy demand chart for each device

As output, the annual energy need and the optimum number of panels (53) required for the system are calculated. Accordingly, the area that needs investor, system installed power, annual generated energy, system cost, payback period, annual earnings and generated energy by month are calculated as shown below (Figure 5). If the person planning to install the system wants to use with different number of panels, he/she can change the panel number (i.e. 70 panels) on the program and accordingly the results on the screen are updated (Figure 6).

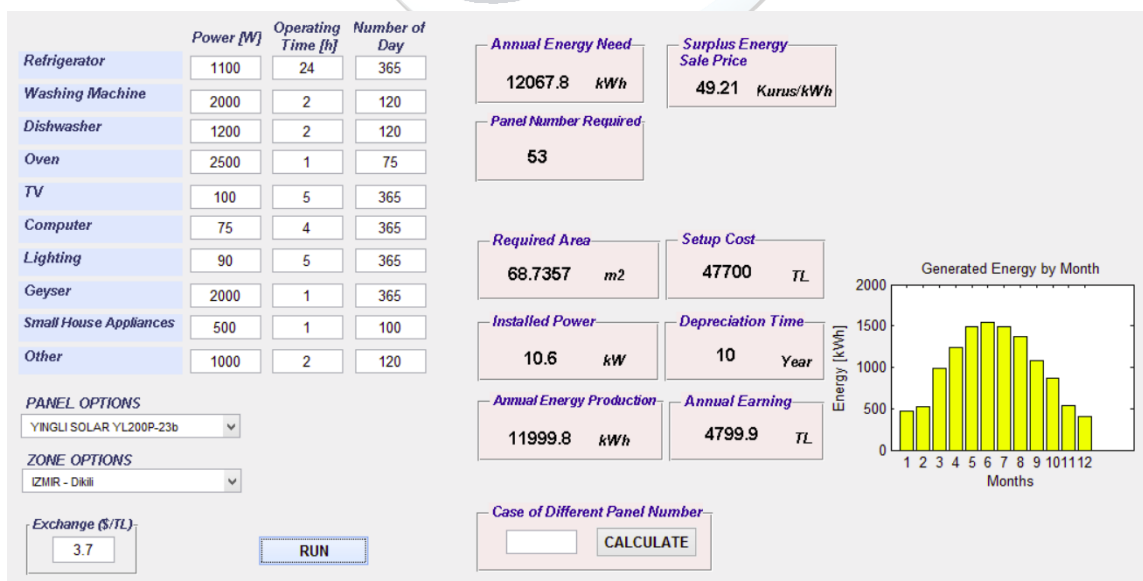


Figure 5: The results of the program according to defined example

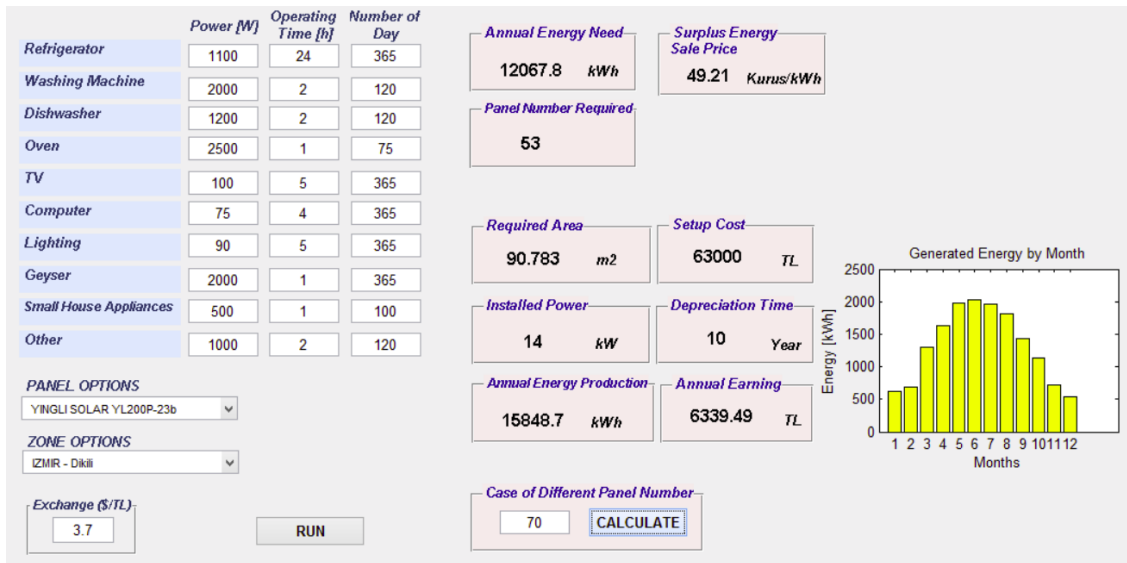


Figure 6: Screenshot of the program for the second case, with different panel number

5. CONCLUSIONS

In this paper, a MATLAB GUI program is created to calculate the annual energy production, component number, required area for producing this energy, payback period and installed power from PV panel. Calculations are based on a four-person household in the case of the complete energy supply from the PV system. Consumed energy is calculated through the data of the operating hours in a day and the number of running days in a year which entered by user. There are various PV panel and region options in the program. Monthly generated energy distribution is shown graphically. System cost, payback period and annual earnings are also calculated in the economic analysis part so that will help to make the pre-feasibility and can be used as a decision-making mechanism for investors.

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