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Research Paper

Development of Feasibility Software for Solar Energy Systems Using Solar Radiation

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Abstract— People are prefering to renewable energy sources, due to the rapidly increasing demand for energy today. The most basic renewable energy source is sun. Basically, photovoltaic systems, thermal systems and concentrated solar power systems generate energy from the sun. The efficiency and output potential of these technologies are computed based on the solar radiation values, despite the fact that their operating principles differ from one another. For this reason, it's critical to have accurate knowledge about solar radiation while designing solar energy systems. Solar radiation varies depending on date, location, time of day and climate. By using measuring equipment, meteorology stations instantly, hourly, and daily record these variables. But not all places have measurement stations because the equipment is expensive. Utilizing the chosen parameters, solar radiation values are calculated. There are variety of mathematical methods used to calculate solar radiation values. The determination of the region-specific equation coefficients is necessary to improve the accuracy of the results. Long-time meteorological and geographical data of the region are used in the calculation of these coefficients. Scientific research is used to support the precision of these calculations. All commercial and academic inquiries use data on solar radiation in order to take use of solar energy in the field of renewable energy. The information about the region's solar radiation must be understood before a solar power plant may be erected there. Using solar radiation information, the energy production potential can be determined. With the software developed within the content of this study, radiation values of the selected region are calculated and visual outputs of these values are presented. In addition, with the solar power plant feasibility report, design parameters, characteristics of materials, site information, company information, system cost, return on investment, energy production of the system and losses in the system can be calculated. In this manner, the user can assess the area's solar radiation values and decide whether it is suitable for using solar energy.

Keywords— Solar Radiation Modeling, Solar Positioning, Data Visualization, Solar Power Plant Feasibility, Renewable Energy

1. Introduction

People's needs for energy consumption have grown as a result of the world population's rapid growth and technological advancements. The environmental damage of fossil fuels, which are traditional energy sources, and the gradual decrease of fossil fuel sources in the world have led people to renewable energy sources. Researchers have begun to conduct research in this area [1-3].

Energy is one of the indispensable needs of our daily life. Energy consumption is now recognized as a reliable measure of a nation's degree of development. It is known that countries with high energy production and consumption show economic development [1,4]. Around 90% of the energy used worldwide is derived from fossil fuels. It is estimated that fossil fuels will run out in the near future. A greenhouse effect is caused by the gases released during the burning of fossil fuels. This results global warming. In order to prevent these damages, it is must be used green and renewable sources of energy. Today, thanks to the developments in energy technologies, solar energy has found a wide research and application area [5].

The primary renewable energy source is sunlight. In terms of renewable energy methods, solar energy is the fundamental part of energy generation. The sun is the primary generator of both traditional and renewable energy sources [2, 6].

The main reasons why solar energy has become more attractive in the energy sector of late years are the rice in the efficiency of solar cells, their high reliability and the gradual decrease in their costs after the researches. The advantages of solar energy over other types of energy can be listed as follows.

- It is an abundant and inexhaustible source of energy.

- It is a clean and sustainable type of energy. There are no wastes such as gas, smoke, carbon monoxide polluting the environment.
- Suitable for local applications.
- Since it is not dependent on foreign sources, it is independent of the economic crisis that may arise.
- No need for mixed technologies.
- The operating cost is very low.

Despite these advantages of solar energy, the reasons why it is still scarce in the field of application;

- Large areas are required since the amount of solar energy reaching the unit surface is little.
- Requires storage as solar radiation is not continuous.
- The amount of solar radiation in winter is low and it is absent at night.
- The initial investment cost of many system elements that generate energy from solar radiation is high. The amortization period is long [7, 8, 9].

The two primary categories of solar energy usage technologies are "Photovoltaic Technologies" and "Thermal Technologies". Thermal technologies generate thermal energy by utilizing incoming sunlight. Photovoltaic technologies convert solar radiation falling on it into electrical energy thanks to solar cells made of semiconductor material [17, 18]. Solar radiation values are used to calculate efficiency and production potential despite the fact that the functioning principles and types of energy these technologies produce vary. The amount of solar radiation is the most important element in the design and performance evaluation of solar energy systems. Thus, it is critical to know the solar radiation information accurately in solar energy system design [1, 10, 16].

A pyranometer, which is an expensive instrument, is used to detect solar radiation. Because of the cost of the device, solar radiation measurements are made only in certain centers. In our country, these measurements are made by the Electrical Works Survey Administration, the General Directorate of Meteorology, some universities and research centers. However, there are not many of these stations in either our nation or the rest of the world. Solar radiation models are frequently used to approximate the data needed for solar power systems in places without access to measured meteorological data [10,11, 20].

For the purpose of calculating solar radiation, some parameters are employed to build distinct empirical models. Solar radiation modeling takes into account extraterrestrial radiation, sunshine length, average temperature, evaporation, cloudiness, relative humidity, number of days, latitude, longitude, altitude, date and time [12, 15, 19].

In general, it has been observed that there is an approximate value between the meteorological data calculated with mathematical models. A region-specific model should be created or the model's used coefficients should be chosen based on the region in order to improve the accuracy of the derived results. These parameters vary according to the actual geographical and meteorological data of the region to be calculated. Many researchers in this field have produced new mathematical models using different parameters. The accuracy of these calculations is seen as a result of scientific studies [13, 14, 21].

In this study, a software was developed to calculate the performance and cost of solar power plants using solar radiation models and to create a feasibility report. The following steps were followed in this study.

- As a result of the literature review, mathematical models were examined. The most suitable mathematical model for Türkiye conditions was determined.
- A database containing meteorological data was created. Calculations were made in the most appropriate radiation ranges, taking into account the mathematical model selected with the database created.
- The user will select a desired region from the world map and the solar radiation value of this region will be calculated hourly, daily, monthly.
- System design will be created by considering the number of photovoltaic panels, number of inverters and connection configurations according to the power of the plant to be installed.
- System installation cost and amortization period will be calculated.
- The results of all calculations will be reported to the user with graphs and tables. The user will be able to assess a region's viability for solar energy use by looking at its solar radiation values in this way.

2. Related Work

To determine the amount of solar radiation that will hit a specific area of the globe, there are numerous different solar radiation models available. Since the amount of solar radiation at the surface is unknown, researchers have developed a variety of solar radiation models that are appropriate for the location and take into consideration local variables.

With the work of Angström and Prescott in 1924, the first mathematical solar radiation model was created for the monthly average daily solar radiation estimation. The most prevalent model used in solar radiation estimations is this one. In many subsequent studies, new models were derived based on this model created by Angström and Prescott [11].

Calculations were made by including the latitude information of the region in the solar radiation model developed by Glover and McCulloch in 1958. In this model created, the latitude should be less than 60^{o}.

Page made improvements on the model created by Angström and Prescott in 1961 and produced a general equation. He suggested that the equation he produced could be applied to every region in the world.

After the studies of Kılıç and Öztürk in 1983, the daily total radiation falling on the horizontal plane, the instantaneous radiation values and the instantaneous solar radiation on the inclined plane were found. The Angström and Prescott model served as the basis for the creation of this mathematical model. Kılıç and Öztürk model is a model created especially for Türkiye[3].

As a result of the research carried out in 1984 led by Olegman, quadratic polynomial functions were used for calculating the solar radiation falling on the horizontal axis. Thus, it brought a new perspective to the calculation of mathematical models.

The Benson model is a mathematical model created in 1984 for the calculation of total solar radiation, including climatic parameters. It consists of two different equations as October-March period and April-September period [22].

The Zabara model calculates the solar radiation angles and the daily total and instantaneous radiation amounts using the a and b coefficients using the polynomial regression method in 1986. Based on the Prescott-Page model, a mathematical model was created with a and b empirical connections [23].

Taşdemiroğlu and Sever, in their study in 1991, created the solar radiation model with the data they received from five different stations in Türkiye [24].

To calculate the amount of radiation reaching the horizontal surface in his model he developed in 1998, Said used data gathered for Libya between the years 1986 and 1990. He performed a statistical model.

In the 1999 work by Bulut et al., trigonometric equations were developed to determine the horizontal solar radiation intensity and sunshine duration in certain Turkish areas. For the study, meteorological information between the years 1990-1996 obtained from the State Meteorological Affairs was used [4].

In their investigation in the Elazig region, Torul and his associates employed the Angstrom model to determine the monthly solar radiation falling on the horizontal plane. They worked on the constants in the Angstrom equation [25].

In the study conducted by Bulut and Büyükalaca together in 2007, a solar radiation model was designed for Turkey. For this model, a model was created to calculate the daily total radiation by taking 10 years of data from 68 measurement stations in Turkey. The results of the created model were compared with real-time measurements and other results in the literature, and it was observed that appropriate values were obtained [5].

In their study in Tibet in 2010, Li and his colleagues tested eight different models using data from stations located in different cities. The results were compared statistically. As a result of the study, the calculations in the Angström-Prescott model for Tibet were deemed sufficient due to their closeness to the real values [11,19].

The Angström-Prescott model was used in the study they conducted in Van in 2012 to arrange the solar radiation that reached the horizontal surface along with the data they got from 7 separate stations. Data were compared using statistical methods. In this way, the model suitable for Van and its surroundings was determined.

As a result, the first study was the Angström-Prescott model in 1924. In later studies, researchers developed a regional and international solar radiation model by adding new perspectives, mathematical methods and parameters to the model. The aim of all studies is to determine the most accurate solar values of the researched geography. In this direction, many solar radiation models have been created by using different mathematical, statistical and meteorological parameters [11].

3. Solar Energy

The largest energy source on Earth is the sun. In order to better understand solar energy, we need to know the properties of the sun and solar radiation. Thus, we can use solar energy more efficiently in a particular region.

The amount of energy coming from the sun's rays to a perpendicular surface outside the atmosphere per second is called solar radiation. Since the distance between the Earth and the Sun changes, the solar radiation is not constant. Therefore, using an average solar radiation value between the Earth and the Sun provides convenience in calculations. Under ideal conditions, this solar radiation value outside the atmosphere is called the solar constant. The solar constant is called "I_{sco}" and as a result of the studies it has been calculated as 1367 W/m2 with 1% margin of error.

The amount of solar radiation coming to the earth is calculated by considering the amount of solar radiation outside the atmosphere. Due to the variability of the distance between the earth and the sun and seasonal effects, there are slight variations in the solar constant compared to the days. Correction factor (f), and the number of days from January 1 in the year (n);

$$f = 1 + 0{,}033\cos\left(\frac{360 * n}{365}\right), \quad (1)$$

it is calculated with the equation. Table 1 is used to calculate the number of days from 1 January. What is required to calculate the "n" value is to write the day value of the determined month in place of the "i" value in the corresponding month in the table.

Table 1. Calculating the number of days from January 1.

MONTHS	NUMBER OF DAYS OF THE YEAR(n)
January	i
February	i+31
March	i+59
April	i+90
May	i+120

June	i+151
July	i+181
August	i+212
September	İ+243
October	i+273
November	i+304
December	i+334

The value of the solar constant is calculated using the correction factor in equation (1);

$$\text{Isc} = \text{Isco} * \text{f}, \tag{2}$$

it is found by equation.

Radiation is the transfer of energy from a source to the environment in the form of electromagnetic waves or particles. Substances that break down and emit radiation in this way are called radioactive substances. Rays such as alpha, beta and gamma scattered from radioactive materials to the environment are also called radiation. Radiation emitted by the sun and reaching the atmosphere is called solar radiation. While finding solar radiation, we encounter five different concepts. These;

Direct Radiation: It is the solar radiation reaching vertically from the open sky to the earth without being reflected or scattered.

Diffuse Radiation: It is solar radiation that reaches the earth by scattering and scattering. Diffuse radiation is dispersed in the atmosphere due to the effect of particles such as clouds, air molecules, aerosols and water droplets in the atmosphere. The solar radiation reaching the earth by scattering in this way, on the other hand, hits the earth and is redistributed.

Reflected Radiation: Reflected radiation is the radiation that is sent back to the atmosphere by incoming solar radiation in the atmosphere, hitting the clouds, air molecules and the earth. The amount of reflected radiation makes up a small part of the incoming radiation. It is also called local radiation.

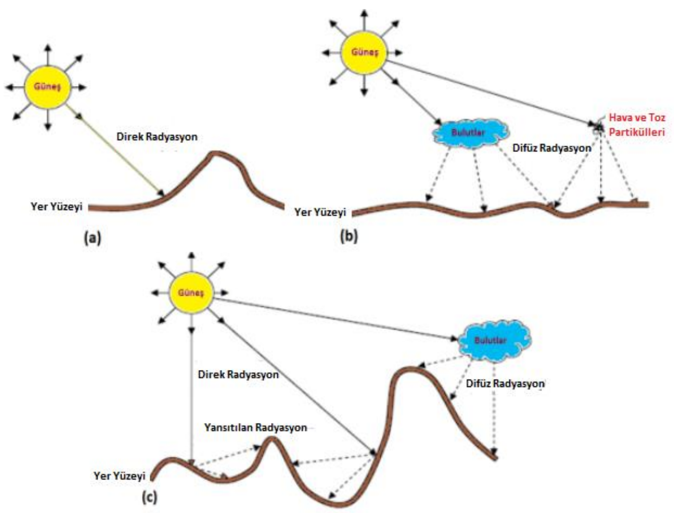


Figure 1. Types of Solar Radiation. a) Direct Radiation b) Diffuse Radiation c) Reflected Radiation

Albedo: It is the rate of reflection of the solar radiation reaching the earth from the ground. The ratio of the radiation reflected from the ground to the total radiation from the sun is equal to the albedo.

Total (Global) Radiation: The sum of direct radiation, diffuse radiation and reflected radiation is called global or total solar radiation.

The following equations, which were created by Angstrom, express the parameters and general equation used in solar radiation calculation.

$$\frac{H}{H_0} = a + b\left(\frac{n}{N}\right), \tag{3}$$

where H is the mean monthly solar radiation; H_0, monthly average atmospheric radiation; n is the average monthly sunshine duration; N is the average monthly day length; a and b are constants calculated by statistical methods. In addition, (H/H_0) represents the cloudiness index. The constants in the equation change depending on the local climate, weather data, topographical features, and vegetation cover.

Declination angle (δ): The sun's angle of incidence with respect to the equatorial plane.

$$\delta = 23{,}45 \text{ x } \sin\left(\left(\frac{360(284+n)}{365}\right)\right). \tag{4}$$

Latitude angle (φ): The angle that the radius connecting a point on the earth to the center of the earth makes with the equatorial plane is called. This angle is taken as 0 degrees at the equator, +90 degrees at the north pole, and -90 degrees at the south pole.

Hour angle (ω_s): It is the angle between the longitude of the sun's rays and the longitude of the place under consideration.

$$\cos\omega_s = -\tan\delta * \tan\varphi, \tag{5}$$

$$\omega_s = \cos^{-1}(-\tan\delta * \tan\varphi). \tag{6}$$

Sunrise hour (S_0): It is the length of the day. Since 15 degrees is 1 hour, we use the following equation to find the full-day sunshine time in hours.

$$S_0 = \frac{2}{15}\cos^{-1}(-\tan\delta * \tan\varphi), \tag{7}$$

$$S_0 = \frac{2}{15}\omega. \tag{8}$$

Zenith angle (z): It is the angle between the sun's ray and the vertical of the horizontal surface.

$$\cos z = (\cos\delta * \cos\varphi * \sin\delta * \sin\varphi), \tag{9}$$

$$z = \cos^{-1}(\cos\delta * \cos\varphi * \sin\delta * \sin\varphi). \tag{10}$$

Elevation angle (y): It is the angle that the sun's rays make with the horizontal surface.

$$y = 90 - z. \tag{11}$$

Solar azimuth angle (sa): It shows the deviation of the sun's rays from the north in a clockwise direction.

$$\cos(sa) = \left(\frac{(\cos\delta * \sin\varphi * \cos\omega_s + \sin\delta * \cos\varphi)}{\cos y}\right), \quad (12)$$

$$sa = \cos^{-1}\left(\frac{(\cos\delta * \sin\varphi * \cos\omega_s + \sin\delta * \cos\varphi)}{\cos y}\right). \quad (13)$$

To calculate the instantaneous radiation (H_0) coming to the horizontal surface outside the atmosphere, we can find it with the help of the following equation.

$$H_0 = \frac{24 * 360 * Isc}{\pi} * f * \left(\cos\varphi * \cos\delta * \sin\omega_s + \frac{\pi\omega_s}{180}\sin\varphi * \sin\delta\right), \quad (14)$$

where, Isc represents the solar constant, f correction coefficient, φ latitude, δ declination angle, ω_s hour angle, π pi number.

To calculate solar radiation, numerous mathematical models have been created. The following Table 2 includes a few of these mathematical models.

Table 2. Some mathematical models

Model	Explanation	a	b
Angstrm, Prescott	It is the first model.	0,307992	0,33741
Page	It is a global model.	0,23	0,48
Bakırcı	It was developed for Türkiye.	0,2786	0,4160
Li	It was developed for China's Tibetan city.	0,2223	0,6529
Aras	It is a model developed for Türkiye.	0,3078	0,4166
Kılıç-Öztürk	Models created for Türkiye	0,103+0,000017z + 0,198cos(φ - δ)	0,533 – 0,165cos(φ - δ).

4. Electricity Generation from the Sun

The sun is the greatest source of energy for all living things. But people also use solar energy in different ways. The sun also plays a major role in the formation of traditional energy sources. Electricity is produced from the sun thanks to solar cells. Semiconductor materials are used in solar cells that convert the sun's rays into electrical energy without the need for any moving parts and without polluting the environment, with the help of the sun's rays (photons) coming to their surfaces. Solar cells work on the photovoltaic principle. The rays falling on the solar cell create electrical voltage at the ends. The source of the energy produced is sunlight.

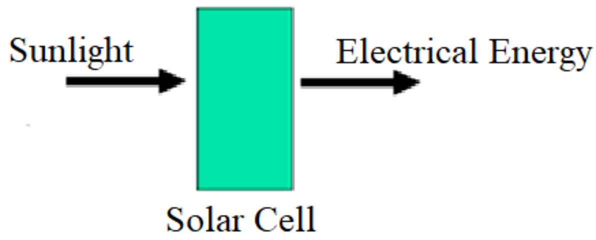


Figure 2. Solar Cell Working Principle

A structure called solar cell module or photovoltaic panel is formed by connecting many solar cells in series or parallel to each other. Depending on the desired power demand, the number of interconnected solar cell modules is increased.

In order to understand the behavior of a photovoltaic cell, it is necessary to construct an electrical equivalent circuit using components with known behaviors. An ideal photovoltaic cell circuit is modeled as in the figure below. It comprises of a parallel current source and a diode as seen in the figure. The current source generates the IPH, which is directly proportional to the sunlight intensity.

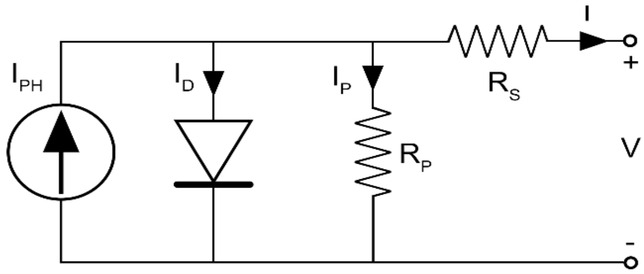


Figure 3. PV cell equivalent circuit model using a typical diode

Kirchhoff's current law can be used to get the current-voltage (I-V) equation of the solar cell's simplified equivalent circuit.

$$I = I_{PH} - I_D[\exp((V + I * R_S) / (a * V_{TH}) - 1] - (V + I * R_S) / R_P \quad (15)$$

In the equation; I_{PH}: the current produced by the PV cell by the photovoltaic effect, I and V: the output current and voltage of the photovoltaic cell, respectively, I_0: the diode reverse saturation current, a: the diode ideality factor, R_S and R_P: the series and parallel resistance of the PV cell, respectively. VTH is the thermal voltage of the cell and is calculated by equation (16).

$$VTH = (k * TC) / q \quad (16)$$

In equation (16); k: Boltzmann constant (1.380×10-23 J/K), TC: cell temperature and q: charge of an electron (1.602×10-19 C)

5. Results and Discussion

Due to the developments and support in the renewable energy sector, the interest of researchers and investors in the field has increased. Before the solar power plant is installed, a preliminary study is required. Preliminary studies, calculations, collection of meteorological data and determination of the land can be long and costly. Instead, computer software coded using scientifically accepted methods can be used for preliminary study.

The application is written using the C# programming language. Project information will be stored via MS SQL Server Management Studio database server. The following steps are carried out for the feasibility analysis.

- Entering the project information that introduces the project
- Determination of the project site via Google Maps
- Manually selecting the project site for situations where there is no internet connection.
- Creation of database record for meteorological data.
- Creating a mathematical model of calculation methods.
- Calculation of values such as solar radiation, sunshine duration, day length, average radiation.
- Determination of the total installed power of the system to be installed and the panel arrangement angle.
- Establishment of a database of system devices required to generate solar energy.
- Selecting the photovoltaic panels used in the system and displaying the catalog information.
- Selecting the inverters to be used in the system and displaying the catalog information.
- Calculating the cost analysis of the project.
- Calculating the return time of investment costs and calculating the profitability analysis.

Solar energy feasibility software flow-chart is given in figure 4.

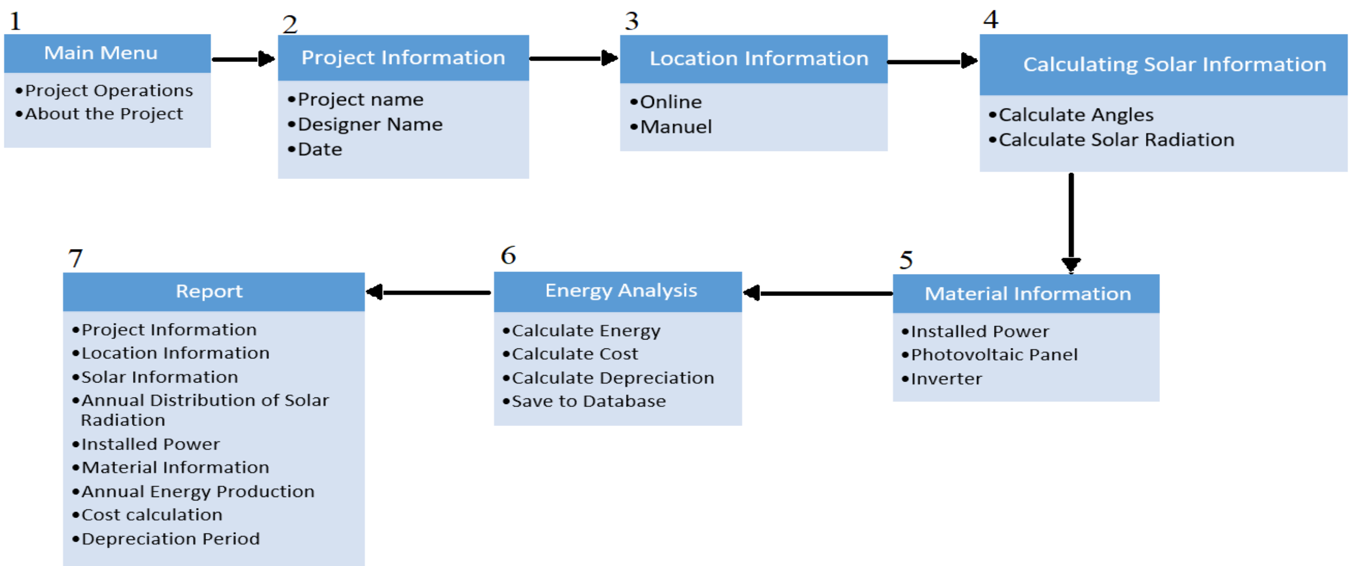


Figure 4. Solar Feasibility Software Flow Chart

Through the main menu, the user will be able to make calculations for the region he wants, access database operations and generate reports for the system. With its simple and understandable design, the main screen allows us to easily open new projects and upload projects. When the operation to be performed is selected from the Options panel, the user is guided to use the program with the information in the description panel about what the selected operation can do.

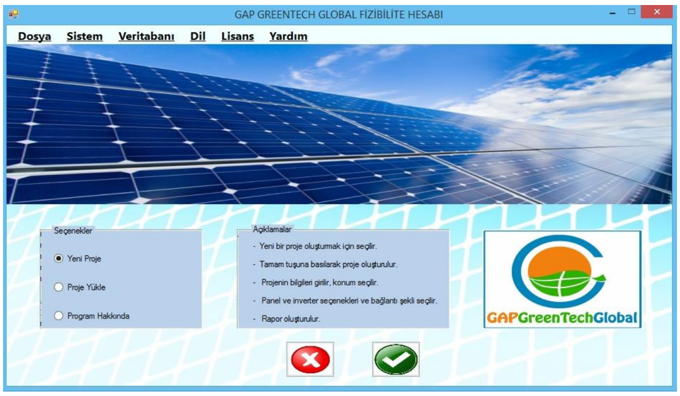


Figure 5. The main menu screen of the program

After selecting the Create new project option in the main menu and pressing the confirmation button, the new project screen opens. The information that will introduce our project is completed by filling in the appropriate places on the screen. If the fields to be filled in the information are blank, the program will warn and ask for the empty fields to be filled.

Figure 6. New project open screen

After entering and confirming our project information, we need to determine the solar power plant project site. For selection, the user can follow three different paths. An internet connection is required for two of these selections. The first option is to determine the project location by pointing to the desired area via Google Maps and clicking with the mouse. As the second option, the name of the project site can be written in the search box and selected via Google Maps. When searching for locations, it is possible to search as desired without case sensitivity. When the search box is left blank, the user is warned and asked to fill in this field. After specifying the location, the selected city is shown on the screen. The third option is that in cases where there is no internet connection, the project site can be selected manually. When this option is selected, the information of the selected city from the database can be accessed. At this stage, the map of the selected city is displayed.

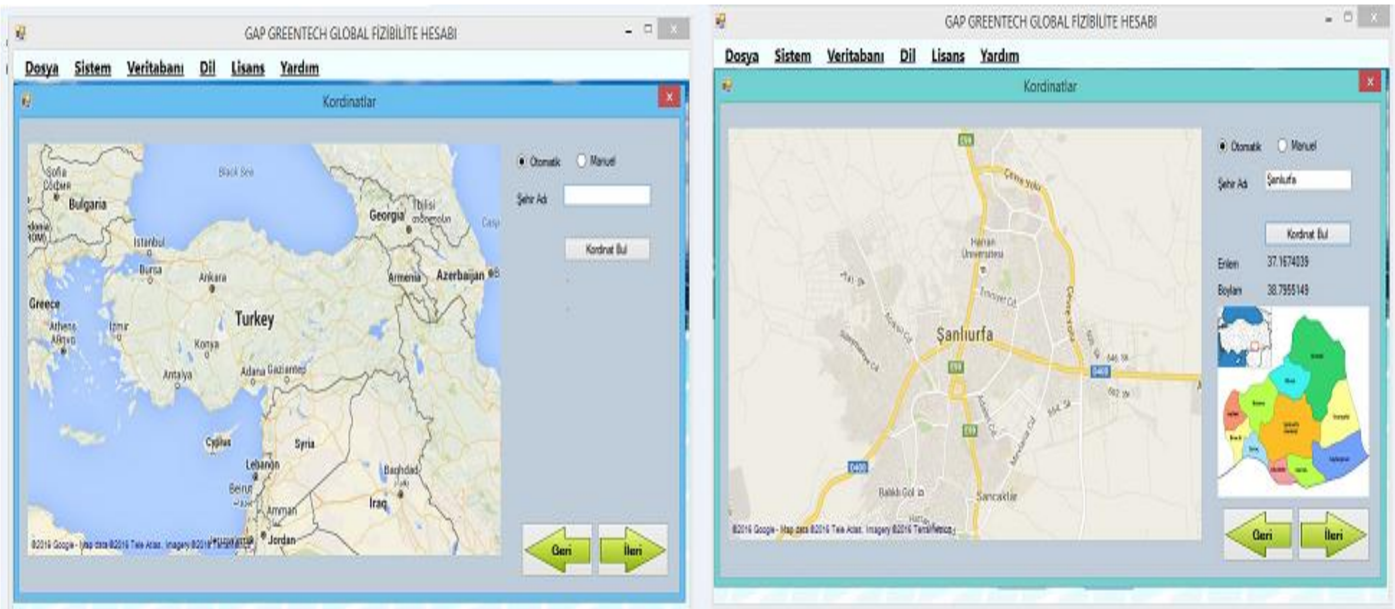


Figure 7. Project location screen with Google Maps

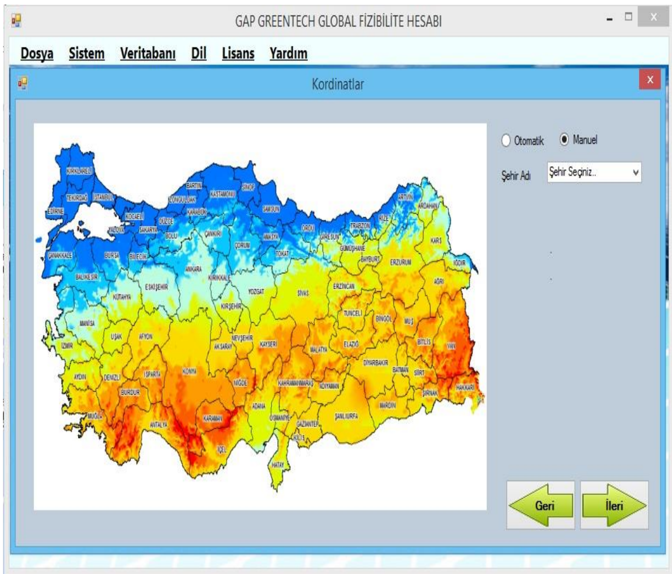


Figure 8. Manual project location display when there is no internet connection

Figure 9. Solar and solar values calculation screen for the project area

After determining our project site, we move to the solar radiation calculation screen to learn these solar values. Here some angular and conceptual calculations about the sun are made. The most important values calculated at this stage are the solar radiation values. It gives us solar radiation instantaneously, daily and annually, and the values are transferred to the graph.

At this stage, the selection of the materials required for the system and the determination of the installed power are carried out. The person who will design the system determines the installed power of the solar power plant to be installed on this screen.

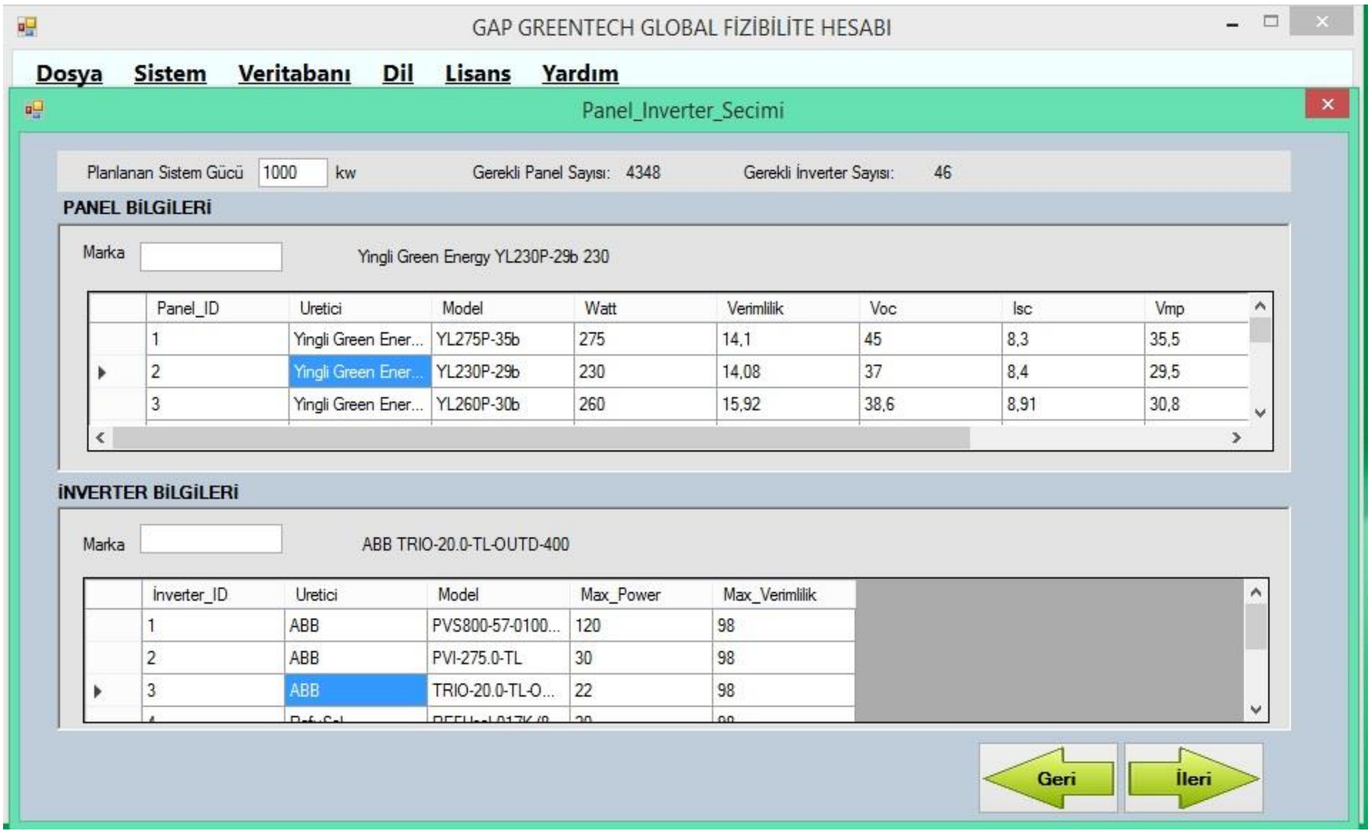


Figure 10. Screen for selecting components of the system

The photovoltaic panels and inverters to be used in the system can be selected from this screen. Based on the installed power value, the program can automatically calculate the required number of photovoltaic panels and the number of inverters.

In this screenshot, reporting can be done and the designed system can be saved. In the reporting phase, information such as solar power plant information, annual energy production, installation cost analysis of the system, depreciation period, material information used, return on investment time are included.

Figure 11. Reporting and recording screen

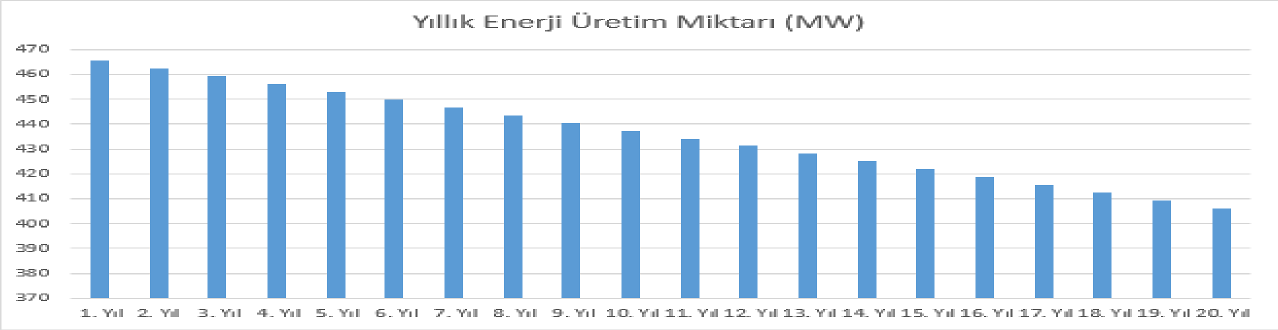
The basic parameters to be presented to the user in the solar power plant feasibility report can be listed as follows.

- Project site information
- Project owner / company information
- Total installed system power
- Total required space
- Monthly and annual solar radiation power table
- Total electrical energy produced
- Photovoltaic panel characteristics
- Inverter characteristics
- Losses in the system
- System installation cost
- Monthly/annual return of the system
- Return on investment of the system
- Profit transition point and 20-year income statement

In the light of the information contained in the report, researchers and investors will have preliminary information about the installation of solar power plants. With the feasibility report, information will be given about the correct site selection and the use of materials in solar power plant installations. In this way, necessary methods will be applied to produce electricity with the highest efficiency by minimizing losses. A sample report produced within the scope of the software is shown in figures 12 and 13.

Yıllık Radyasyon Değerleri (MW) :

Ocak	Şubat	Mart	Nisan	Mayıs	Haziran	Temmuz	Ağustos	Eylül	Ekim	Kasım	Aralık
1,96	2,7	3,73	4,88	6,29	7,17	7,09	6,38	5,26	3,87	2,43	1,79



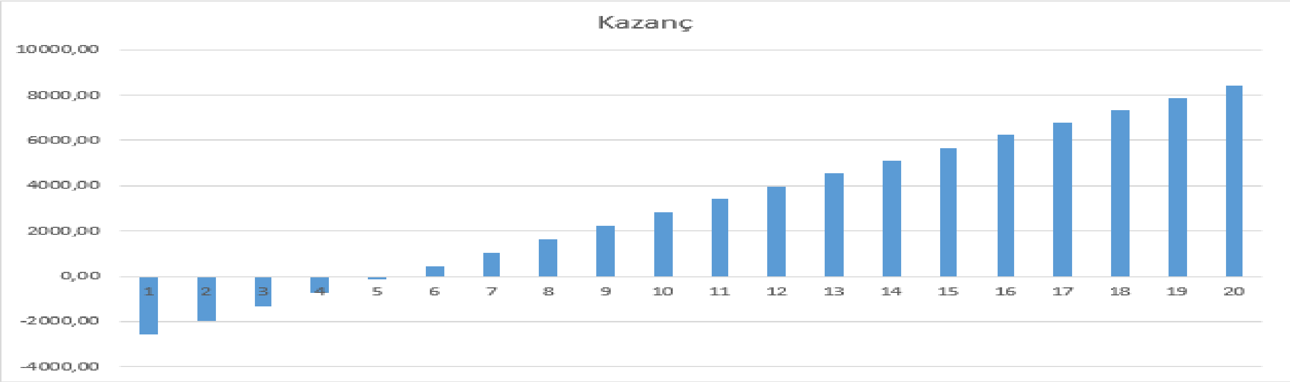


Figure 12. Report 1

Maliyet Bilgileri :

Sistem Maliyeti 3200

Yıllık Gelir :

Yıl	Yıllık Üretim(MW)	Yıllık Kazanç (TL)	Net Kazanç (TL)
1	1,55	619,85 ₺	-2.580,16 ₺
2	1,54	615,85 ₺	-1.964,31 ₺
3	1,53	611,85 ₺	-1.352,46 ₺
4	1,52	607,85 ₺	-744,61 ₺
5	1,51	603,85 ₺	-140,77 ₺
6	1,5	599,85 ₺	459,09 ₺
7	1,49	595,85 ₺	1.054,94 ₺
8	1,48	591,85 ₺	1.646,79 ₺
9	1,47	587,85 ₺	2.234,64 ₺
10	1,46	583,85 ₺	2.818,50 ₺
11	1,45	579,86 ₺	3.398,35 ₺
12	1,44	575,86 ₺	3.974,21 ₺
13	1,43	563,86 ₺	4.546,06 ₺
14	1,41	563,86 ₺	5.109,92 ₺
15	1,4	559,86 ₺	5.669,78 ₺
16	1,39	555,86 ₺	6.225,64 ₺
17	1,38	551,86 ₺	6.777,51 ₺
18	1,37	547,86 ₺	7.325,37 ₺
19	1,36	543,86 ₺	7.869,23 ₺
20	1,35	539,87 ₺	8.409,10 ₺

Figure 13. Report 2

6. Conclusion and Future Scope

The design of solar energy systems requires the use of solar radiation models. The local solar radiation levels are the first factor that engineers, researchers, and investors take into account while designing solar power plants. While creating the models, meteorological and atmospheric data were appropriately adapted to the region using mathematical functions.Since solar power plant installation requires high cost, it is common to use credit. A reliable feasibility study is an important element in finding the appropriate loan. For this, the correct calculation of the preliminary analysis of the performance and efficiency values of the system provides an advantage for the designer and the investor.In our study, 15 mathematical models were compared for 8 cities selected from different regions in Turkey. As a result of the calculations, Kılıç-Öztürk model was used, which gives the closest results for Turkey in general. Site selection, materials used, required area calculation, shading factor, energy production, energy losses, sun position and sun angles are calculated and reported in the solar power plant feasibility software. It has been observed that the feasibility report we received as the output of the program gave results in line with other accepted software and calculations made on real data. Unlike other software, it provides a feasibility report in Turkey, in which models closest to regional data are used and in accordance with the principles specified in the regulations. In addition, the program interface is in Turkish, allowing easy use of the program. In future studies, it is considered to estimate solar radiation using deep learning.

Data Availability

There are no restrictions in this study.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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Authors' Contributions

All authors contributed an equal amount. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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References

[1]. Emrah Aslan, Mehmet Emin Tenekeci, Nurettin Beşli, Bülent Yeşilata, "Online Solar Radiation Modelling and Visualization Software", SolarTR2014 Conferance, İzmir, Türkiye, pp.**24-27 2014.**

[2]. Emrah Aslan, Mehmet Emin Tenekeci, Nurettin Beşli, Abdulkadir Gümüşçü, "Solar Enerji Sistemleri için Güneş Radyasyon Hesaplama Yazılımı", Akademik Bilişim Konferansı Eskişehir, Türkiye, pp. **11-16, 2015.**

[3]. Aksel Öztürk, Abdurrahman Kiliç, "Güneş Enerjisi", Kipaş Yayıncılık, İstanbul, Türkiye, pp. **1-329, 1983.**

[4]. Hüsamettin Bulut, Asım Fatih Durmaz, Bülent Yeşilata, "Eğik Düzleme Gelen Güneş Işınım Değerlerinin Deneysel Olarak İncelenmesi", I.Ulusal Güneş Ve Hidrojen Enerjisi Kongresi, pp. 143-149, Türkiye, **2006.**

[5]. Hüsamettin Bulut, "Bina Enerji Analizi Ve Güneş Enerji Sistemleri İçin Eğimli Yüzeylere Gelen Toplam Güneş Işınım Şiddeti Değerlerinin Hesaplanması", IX. Ulusal Tesisat Mühendisliği Kongresi, pp. 435-448, Türkiye, **2009.**

[6]. Hüsamettin Bulut, Asım Fatih Durmaz, "Türkiye İçin Pencerelerden Geçen Güneş Işınım Analizi", II.Ulusal Güneş Ve Hidrojen Enerjisi Kongresi, pp. 85-95, Türkiye, **2008.**

[7]. Ertuğrul Yörükoğullari, "Yenilenebilir Enerji Kaynakları", Anadolu Üniversitesi Açık Öğretim Fakültesi Yayınları, Eskişehir, Türkiye, pp.**1-207, 2013.**

[8]. İbrahim Doğan, "Güneş Enerjisi Uygulamaları", Bileşim Yayınları, Türkiye, pp.**1-177, 2006.**

[9]. Bülent Yeşilata, Mehmet Azmi Aktacir, "Fotovoltaik Güç Sistemli Pompaların Dizayn Esasların Araştırılması", Mühendis Ve Makine Dergisi, Vol. **42**, Issue.**493**, pp. **29-34, 2001.**

[10]. Zeynel Abidin Firatoğlu, Bülent Yeşilata, "Bataryalı Ve Direk Akupleli Fotovoltaik Pompa Sistemlerinin Çalışma Karakteristiklerinin Araştırılması", Yıldız Teknik Üniversitesi Dergisi, pp. **1-11, 2003.**

[11]. Angström A,"Solar And Terrestrial Radiation", Quartely Journal Of Royal Meteorological Society, Vol.**50**: pp.**121-125, 1924.**

[12]. Gülfer Vural, "How Do Output, Trade, Renewable Energy and Nonrenewable Energy Impact Carbon Emissions in Selected Sub-Saharan African Countries?" Resources Policy, Vol.**69**, pp.**1-7, 2020.**

[13]. Salim Mudi, "Design and Construction of a Portable Solar Mobile Charger", World Academics Journal of Engineering Sciences, Vol. 7, Issue **1**, pp.**40-44, 2020.**

[14]. Bugatha Ram Vara Prasad, T. Deepthi, N. Satyavathi Varma, R. HemaKumar "A Comprehensive Review on Photovoltaic Charging Station for Electric Vehicles", World Academics Journal of Engineering Sciences, Vol. 8, Issue 2, pp.45-49, 2021.

[15]. Murat Öztürk, Nuri Özbek, Berna Berkama, "Isparta İçin Aylık Ortalama Günlük Global Güneş Radyasyonu Tahmininde Mevcut Olan Bazı Modellerin Karşılaştırılması", Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi, Vol.18, Issue.1, pp.13-27, 2012.

[16].Tuncay Yilmaz, Hüsamettin Bulut, Muammer Özgören, "Isı Kazancı Olarak Camdan Geçen Toplam Güneş Radyasyonu Hesaplanması". Çukurova Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, Vol.11, Issue.2, pp.133-146, 1996.

[17]. Kamil Kaygusuz, "Prospect of Concentrating Solar Power in Turkey: The Sustainable Future", Renewable and Sustainable Energy Reviews, Vol.15, Issue.1, pp.808-14, 2011.

[18]. Bülent Gültekin Akinoglu, Ahmet Ecevit, "A Construction of a Quadratic Model Using Modified Angstrom Coefficients to Estimate Global Solar Radiation", Solar Energy 45, 85- 92, 1990.

[19]. Dany Li, Josheph Lam, Chris Lau, "A New Approach for Predicting Vertical Global Solar Irradiance", Renewable Energy, Vol.25, pp.591-606, 2002.

[20]. Koray Ülgen, Arif Hepbaşli, "Comparison of The Diffuse Fraction of Daily and Monthly Global Radiation for İzmir, Turkey", Energy Sources, Vol.25, Issue.7, pp.637-649, 2003.

[21]. Sefa Tarhan, Ahmet Sari, "Model Selection for Global and Diffuse Radiation Over the Central Black Sea (Cbs) Region of Turkey", Energy Conversion and Management, Vol.46, Issue.4, pp.605-613, 2005.

[22]. R. Benson, M. Paris, J. Sherry, C. Justus, "Estimation of Daily and Monthly Direct, Diffuse and Global Solar Radiation Fron Sunshine Duration Measurements", Solar Energy, Vol.32, ssue.4, pp.523-35, 1984.

[23]. K. Zabara, "Estimation of Global Radiation in Greece", Solar Wind Technology Journal, Vol.3, Issue.4, pp.267-272, 1986.

[24]. Ersoy Tasdemiroglu, Ramazan Sever, "An Improved Correlation for Estimating Solar Radiation from Bright Sunshine Data for Turkey", Energy Conversion and Management, Vol.31, Issue.6 pp.599-600, 1991.

[25]. İnci Türk Togrul, Hasan Togrul, "Global Solar Radiation Over Turkey: Comparison of Predicted and Measured Data", Renewable Energy, Vol.**25**, Issue.**1**, pp.**55-67, 2002.**

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