Impact Factor:					
	ISRA (India) = **3.117**	**SIS** (USA) = **0.912**	**ICV** (Poland) = **6.630**
	ISI (Dubai, UAE) = **0.829**	**РИНЦ** (Russia) = **0.156**	**PIF** (India) = **1.940**
	GIF (Australia) = **0.564**	**ESJI** (KZ) = **8.716**	**IBI** (India) = **4.260**
	JIF = **1.500**	**SJIF** (Morocco) = **5.667**	**OAJI** (USA) = **0.350**

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2019 **Issue:** 07 **Volume:** 75

Published: 27.07.2019 **http://T-Science.org**

QR – Issue **QR – Article**

Kamil Ibrahimov
Dokuz Eylul Üniversity
İzmir, Türkey

Özlem Öztürk
Dokuz Eylul Üniversity
İzmir, Türkey,
kerem_shixaliyev@mail.ru

DESIGN OF RENEWABLE ENERGY SOURCE FOR EMBEDDED SYSTEMS AND IMPLEMENTATION ON COMPLEMENTARY SENSOR STRUCTURES

Abstract: *This article covers the topic of alternative renewable energy sources such as wind and solar energy. As a result of scientific researches the concerns related to use of solar and wind energy as a hybrid form have been solved. In the project where hybrid system developed, summer and winter energy demand and energy shortage is covered. Obtained energy is rechargeable and stored in rechargeable lipo batteries.*

Key words: *Renewable energies, solar cell, wind turbine, hybrid systems, arduino, Electronic key sensors, electric power generation.*

Language: *English*

Citation: Ibrahimov, K., & Öztürk, Ö. (2019). Design of renewable energy source for embedded systems and implementation on complementary sensor structures. *ISJ Theoretical & Applied Science, 07 (75),* 322-328.

Soi: http://s-o-i.org/1.1/TAS-07-75-50 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2019.07.75.50

Classifiers: *energy.*

Introduction

The geriatric population is increasing day by day as Turkey as well as all over the world. With the increase in population, energy is needed in all fields of activity especially in developed countries all over the world. The growing population needed because Turkey is a developing country and in parallel in the growing economy lacks the energy sources consumption continues to increase day by day. Today, Turkey's foreign dependency rate is 72% in the energy field [1,2,5]. For these reasons, Turkey is carrying out studies on fossil energy resources exploration work on the one hand and the other hand to determine the potential of renewable energy sources and use to reduce this rate. In our country, the use of renewable energy sources other than our hydraulic resources was also insufficient (Figure 1). Our energy potential, especially wind and sun, should be determined in a healthy manner and parallel to this, the share of our clean and renewable resources in total energy consumption should be increased and used on the technology devices used in our daily lives [3,4,6]. In the study we propose, to create methods that use renewable energy sources for embedded systems, which are present in most of the smart devices we use today, and to save energy by applying them on these operating systems.

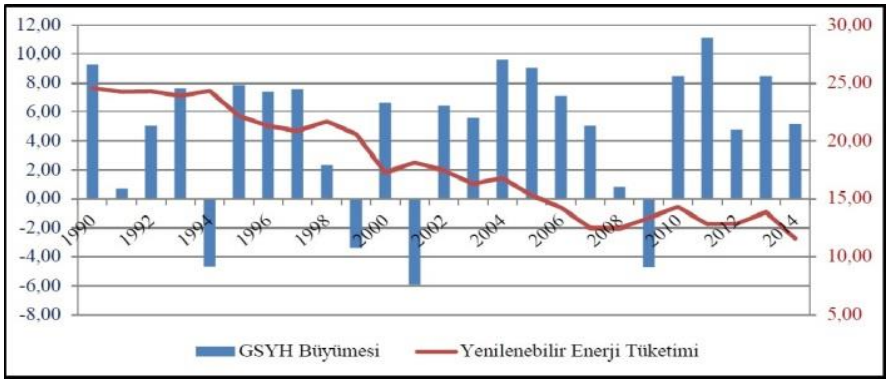

Figure 1. Renewable Energy Consumption and Economic Growth Relationship in Turkey (%)

To design the proposed system, we should examine the solar and wind energies separately. After investigating these energy systems, both of these systems work together as a hybrid system and are applied to embedded systems. In the third stage, the embedded systems used for the project are investigated and the business principles are examined. The prototype and the electronic circuit diagram of the project to be designed are shown in Figure 2. As seen in Figure 2, the energy obtained from the system meets the energy requirements of the lipo battery, Arduino Uno and sensors mounted on the Arduino. Arduino is mounted on three sensors that measure the temperature and humidity of the air. The data obtained from this sensor is displayed on the LCD screen mounted on the Arduino and recorded on the micro SD card. Also, it is sent to the central computer via the Bluetooth Module to ensure that the data is protected and stored in a secure manner.

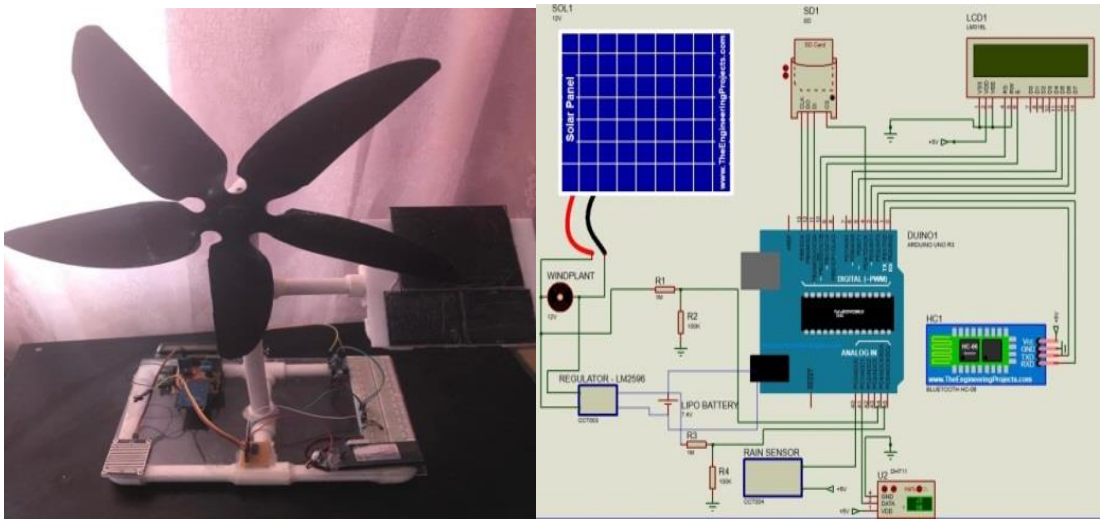

Figure 2. Designed demo model and electronic circuit diagram.

Previous studies.

Machines that are used in the field and which are not easy tmaintain or which have embedded systems such as safety types of equipment, automatic filling devices, which are located at long distances to be maintained, should also work in case of power failure. Any power outage to be experienced is a big problem for the software flow of embedded electronic systems and unexpected situations are encountered. Data losses are experienced, causing designer companie user companies to suffer financial losses.

Many projects have been realized by using solar, wind, hybrid energy systems and different energy sources and researches have been realized. Most of the projects have been developed by using different systems and different methods. In some of the studies, the design of the hybrid system is changed, in the other part of the project, the intelligent charge control unit is designed for the application and storage of the energy obtained from the hybrid system and many similar projects have been realized. However, most of the work is usually done and designed on the battery charging circuit of hybrid and embedded systems. There are several books, doctoral theses, master's theses, papers and articles that can be used to design the Renewable Energy Source for Embedded Systems and their Application on Complementary Sensor Structures in the literature:

In one of the researches, the system is designed to consume low power or energy. While charging the

battery group with the energy it receives from a wind turbine and solar panel, energy is supplied to the load utilizing an inverter from the same battery group [7]. The Intelligent Charge Controller for Wind and Solar Power operates with a microcontroller and PWM (Pulse Width Modulation) technique. The system displays the voltage and temperature information of the batteries, the charge and load current information of the wind turbine and the solar panel voltage values on an LCD screen as well as can be accessed from anywhere in the world via an internet site. The site has analysis and graphs of these values and can be monitored by panel and turbine cameras [7].

In another project, only one renewable energy source is used. In this study, the parking lighting system was designed by using the solar energy system [4]. Also, wireless cameras were used in the project not only to illuminate the park but also to ensure its safety. All types of equipment can make instant and retrospective monitoring with the web-based control system (Data Logger) designed by Mikrodizayn, lighting power can be adjusted gradually and maximum power saving can be achieved [4].

Unlike other projects, the hybrid system was created by using both wind and solar energy at the same time and applied to embedded systems. Also, although most of the projects generally use solar panels and 5-bladed wind turbines, the solar cell and multi-bladed wind turbines are used in the project we proposed. Unlike other projects, the regulator is used as the energy stabilizer because the energy we want is low. By designing the project, the target is achieved by providing the continuous operation of the embedded systems and the sensors on the system by providing uninterrupted energy needs.

Recommended Design.

Unlike other projects in the design that we propose, the hybrid system was created by using both wind and solar energy at the same time and applied to buried systems. Also, although most of the projects generally use solar panels and 3-bladed wind turbines, the solar cell and multi-bladed wind turbines are used in the project we proposed. Also, a rechargeable lipo battery was preferred instead of a high-cost generator for energy storage. Unlike other projects, the regulator is used as the energy stabilizer because the energy we want is low. By designing the project, the uninterrupted energy requirement of the embedded systems and the sensors on the system is met and the system operates continuously.

The main objective of this project is to provide a more comprehensive, easier use of the embedded systems or sensor modules that are used in the summer and winter or our daily life or the field, to meet the energy demand and not to interrupt the power for a moment. To design solar and wind energy systems and to ensure the installation of the hybrid system, the design shown in Figure 3 was made. Plexi and rubber pipes are used in this design. As shown in Figure 3, a magnetic motor and a wind fairy are used to obtain energy from the wind and a solar cell is used to obtain energy from the sun. The resulting electrical current is directed to a positive and negative fixed point utilizing cables. As shown in Figure 3, rechargeable batteries are used for electrical storage. After the electricity is stored in the battery, it is sent to Arduino and sensors via cables. After the operation of the hardware on Arduino is ensured, the data obtained from the hardware is sent to the central computer via Bluetooth module and communication is provided. Also, the data received from the sensors is displayed on the LCD screen mounted on the Arduino and is recorded on the SD card by the SD card module. The data obtained are known to be read and analyzed on the computer at any time (Figure 3).

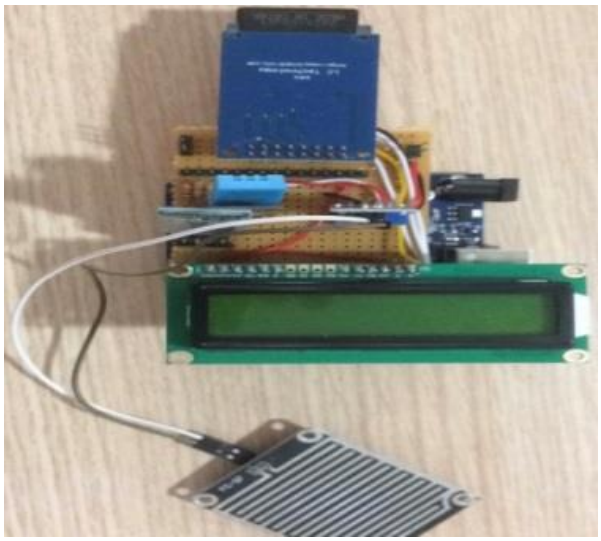

Figure 3. Arduino and Electronic switch sensors installation method

Circuit Design.

The entire system is contoured with Arduino Uno as shown in Figure 4. In solar energy, energy is provided by using solar cells. The metal-geared motor is used to get energy from wind. By installing the wind propeller on the motor, the speed of the wind and the cycle of the propeller will provide energy intake. The hybrid energy system is formed by connecting the energy to be taken from solar cells and wind turbine's in parallel to each other utilizing cables. The circuit board is designed to measure the obtained voltage on the Arduino Uno and display it on the LCD panel (Figure 4). Resistors are used on the card as shown in the figure. By using the resistors on the circuit board, we realize the voltage divider method and make the Arduino Uno and sensors work. Since the embedded systems operate with a maximum of 5 v energy, we have ensured that the whole system operates faultlessly with the circuit board and voltage division method we have designed.

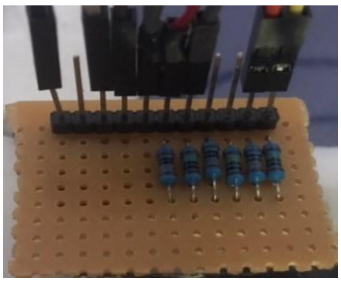

Figure 4. Voltage dividing board

The storage of the energy obtained from the hybrid system we designed is provided by 7.4 V 2 S lipo battery as shown in Figure 4. The battery that we use to store energy works with a maximum of 7.4 V. In case of energization of more than 7.4 V, the voltage regulator is used between the battery and the hybrid system as the battery breaks down. The purpose of using the voltage regulator is to provide a constant charge of 7 V energy to the battery and to ensure the long-term operation of the battery. As shown in Figure 3, more than one hardware is used on the Arduino to perform some operations. It is impossible to install all the equipment used on the Arduino Uno due to an insufficient number of cable inputs and outputs on the Arduino. The circuit board is designed to eliminate this problem. The designed circuit board is mounted on the Arduino Uno, increasing the number of cable entry and output sockets on the Arduino, allowing all hardware to be mounted on the Arduino Uno. Arduino Uno is designed identical to one-to-one with the circuit board, providing only the principle of increasing the number of inputs and outputs. The designed circuit board are shown in Figure 3

As shown in Figure 3, all the sensors used on the Arduino are installed and operated one to one with the circuit board designed for the Arduino. Also, sensors are used to measure the humidity, temperature, and temperature of the air on the Arduino. The data obtained from the sensors are monitored on the LCD screen at the same time, the HC-06 Bluetooth module sends the data to the computer and provides communication and data monitoring between the computer and the Arduino, as well as the 8 Gb SD card installed on the system to ensure the safe protection of the data content. The data obtained from the sensors appear on the LCD panel as shown in Figure 3. Except for communication and data transfer, the HC-06 module can control the flow and storage of data obtained from the entire circuit via the computer, and it is known to be switched on and off at any time.

Hardware Components.

The designed system consists of two parts as described above. It consists of another part where the hybrid energy system is designed and consists of the Arduino platform. Device Arduino UNO, HC-06 Bluetooth Module, DHT11 Humidity and Temperature sensor, Mini adjustable 3A LM2569-ADJ Voltage regulator, Rain sensor, SD card module, 2GB micro SD card, 7.4v 2S 1750 mAh lipo battery, LCD display, 12 V 150 mA solar cell and N20 12 v DC 500 micro metal-geared motor consists of.

Metal reducer motor which provides energy from wind and solar cell which provides energy from solar is connected to the voltage regulator and the regulator on the battery in the same way, and the battery is charged and the Arduino platform meets the energy demand of the battery. Mini adjustable 3A LM2569-ADJ Voltage regulator includes dividing the voltage obtained from the hybrid system and transferring it to the battery and Arduino as 7 V. Humidity and Temperature sensor, Rain sensor, SD card module, and LCD are placed on Arduino UNO. After the raw data obtained by the sensors are evaluated using a complementary filter on the Arduino UNO, the data is sent to a computer that collects information via the Bluetooth module. Also, the same data obtained is displayed on the LCD screen mounted on the Arduino and saved to the 8 GB SD card content via the card module.

Performance Results and Evaluation.

The system, which is designed as mentioned in the previous sections, consists of two parts. In the first

part, the hybrid system is designed and energy production is provided. In another part, the design of the embedded systems was realized by mounting them to the hybrid system and working as a single system. To control the data recording of the designed system on the computer, an interface was created on the program using the Matlab program. With the designed interface, functions such as stopping and recording the data of the system can be realized with the computer at any time. This process is done with the Hc-06 Bluetooth module. We manage the operation of the Bluetooth module on the computer and control the components and record the data.

In the designed project, it is possible for me to provide energy intake from hybrid system in maximum 7-9 V range and 2 A power. The energy obtained is fixed on the regulator to 7 V power and ensures that the lipo battery is supplied and charged. In addition, this energy is applied to the arduino by applying 5.5 - 6 V voltage arduino system and voltage divider system provides the operation of arduino and sensors. The data obtained from the components that are designed over the system that we have designed are recorded on the computer with 10 seconds interval and kept in memory. As a result of continuous operation from the designed system, 360 data in 1 hour and 8640 data in 24 hours are recorded separately from each component. In order to check whether the designed project is working properly, 120 data were run at a height of 10 m and 720 data were obtained.

In addition, the simulation of the proposed project was carried out in order to ensure the control of the system's operating accuracy before the demonstration. The simulation of the project was carried out using the Proteus program. The actual values of the components were used on the program and accurate results were obtained. The control interface and simulation of the system via the computer is shown in Figure 5.

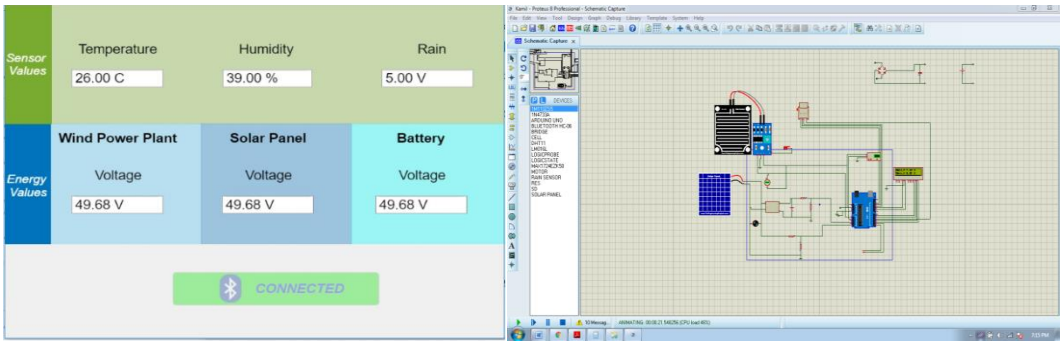

Figure 5 .Control interface and simulation image of the system via computer.

The demo of the project was run within 60 minutes and 360 data obtained from hybrid system, sensors and lipo battery were transferred to excell program and the table was created. Then, the data is drawn by graph analysis. Some of the data obtained and the graphical analysis are shown in Figure 6.

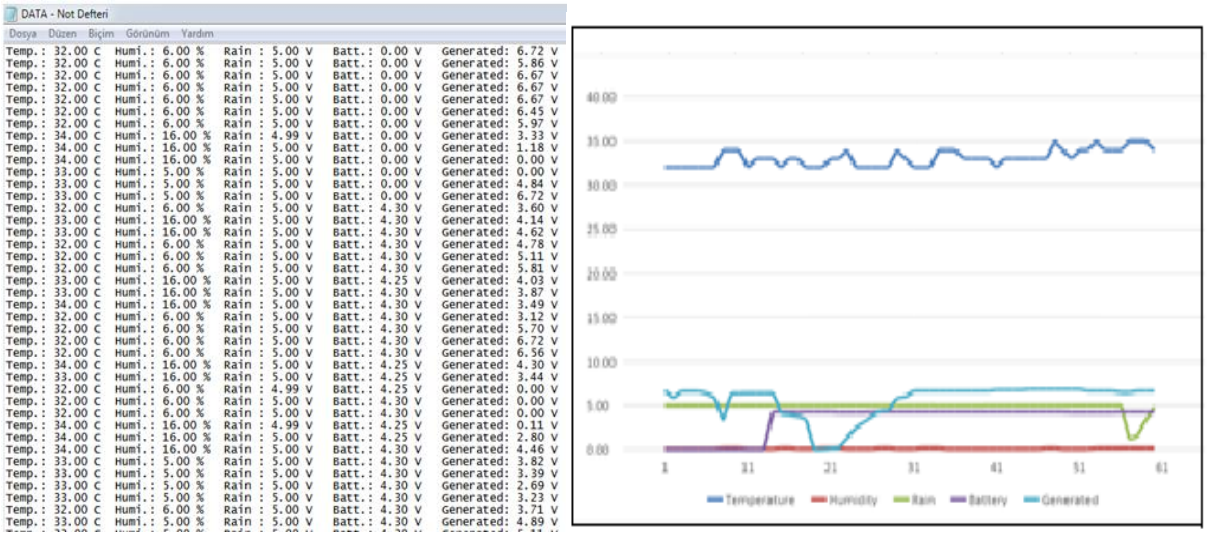

Figure 6.Data list of components and data analysis graph

As shown in the Figure 6 on the simulated project as in the solar cell and wind turbine connected to each other in parallel with the hybrid system was formed and the design of the electronic circuit drawing of the connections between the components are established by connecting the actual values given and separate data obtained on the project by obtaining the results of separate LCD printed on the panel. The data obtained from the sensors and displayed on the LCD panel is shown in Figure 7.

Figure 7. Simulation of sensors and hybrid system on the data display.

The data obtained from the hybrid system was evaluated according to the results obtained from the project's demo. Firstly, the average value of the data obtained within 60 minutes was calculated with the formula shown below**.**

$$H_{or} = \frac{h1+h2+h3+h4+\cdots\ldots\ldots hn.}{N}$$

According to the obtained value, accuracy and absolute error of the data were calculated with the following formula. The absolute error of the data is calculated by the difference between the maximum value of the system and the measured value.

$$H_{mutlak\ hata} = H_{max} - H_{or}$$

Percent relative error of the data is calculated according to the absolute value. The relative error of the data is equal to the ratio of the absolute value to the actual value. The calculation of the relative error is made by the following formula.

$$E_{bağıl\ hata} = \frac{Xmax - Xor}{x_{or}} \text{ x \%100}$$

As a result of all calculations, the accuracy and accuracy of the system is shown in Table 1.

Table 1

Operating energy of the system	Production energy of the system	Accuracy	
		Absolute error	Percent relative error
5-7 V	5,23 V	1,77 V	33,84 %

The results of the proposed project were first simulated on the proteus program and then a demo was obtained and the working accuracy of the project was proved. As seen in the table, 5-7V energy is needed for the operation of the embedded systems. With this system, we propose an average of 5.23 V energy production. This is enough to make it work in energ

Conclusion.

The most important objective of the study is to create a design that uses a renewable energy source for embedded operating systems and to use this design on the system. The second objective is to ensure energy production continuity for the system that we use by saving energy and to obtain exact results from the sensors and modules we use on the system. In this project, the hybrid energy system was established by using more than one energy source. Furthermore, the energy obtained from this system and Arduino Uno and the moisture, temperature sensor were installed and the data obtained from the sensor were sent to the central system via the Bluetooth module placed on the Arduino and the determinations were made by communicating. To make these determinations, different methods have been combined and used as a single system. It has been proposed to use the Hybrid System, which is designed to ensure accurate, reliable and continuous operation continuity of embedded systems and to obtain precise results from the sensors being used. The demo of the proposed system was designed and run and the data obtained from all components were proved and the graphical analysis of the data was performed by proving that the system was operating correctly. Also, the proposed system was simulated and the way of working was followed and tested. By designing this method, firstly energy saving and then the embedded systems are provided to work continuously in all areas and all climates. By developing this design in the future, it is planned to realize the intelligent system installation following the sun and wind on the hybrid system and to control the entire system and to monitor and monitor the data obtained from all of the components that connect with it.

References:

1. Mustafa, E., & Metin, Ç. (2005). "Güneş-Rüzgar Hibrid Enerji Üretim sisteminin İncelenmesi", *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi , sayı 2, cilt 11*, pp.225-230.
2. Roth, P., Georgiev, A., & Boudinov, H. (2004). "Design and Construction of a System For Sun-Tracking", *Renewable Energy, 29*, pp. 393-402.
3. Demirtaş, M., Sefa, İ., Irmak, E., & Çolak, İ. (2008). Güneş Enerjili Sistemler İçin Mikrodenetleyici Tabanlı DA/DA Yükselten Dönüştürücü. *Gazi Üniv. Müh. Mim. Fak. Der. Cilt 23, No. 3*, pp.719-728.
4. Cheng, H. H., Huang, D., & Lin, M. (2012). Heat dissipation design and analysis of high power LED array using the finite element method. *Microelectronics Reliability, 5*, pp.905-911.
5. (2018). TÜİK. "ElektrikİstatistikleriI." *Erişim tarihi: 2 Haziran 2018*.
6. Uslu, M. F., Barış, S., & Tansel, T. (2013). *"Türkiye Aylık Elektrik Talep Modeli."* Erişim tarihi: Retrieved March 15, 2016, from http://www.barissanli.com/calismalar/2013/mfuslu-bsanli-ttemur-AETM.pdf
7. (n.d.). Erişim Tarihi. Retrieved July 31, 2018, from http://databank.worldbank.org
8. (n.d.). Retrieved 2019, from http://www.saviorsolar.com.tr/?p=b8na