“TOGETHER STRONGER” SMART ENERGY SUPPORT SYSTEM

Yusuf Yasef ÖZŞALOM[1] - Eyal KOHEN[2] – Reha DİRİ[3] – Talha KILIÇ[4]

Abstract

The rapid increase of the world’s population has led to an exponential need for energy. Today, most energy requirements are met by fossil fuels; however, they are hazardous to human health and pollute the environment. Consequently, there has been an enormous increase of studies about alternative energy sources while there is also a general trend towards renewable energy.

Concepts such as Artificial Intelligence and Algorithm, which are becoming increasingly topical in recent years, are the fields which might shape the future, not least through their application towards sources of renewable energy.

Since the existing networks which use renewable energy were not designed to control the different sources of renewable energy, difficulties arise when amalgamating variable energy sources such as solar, wind and wave energy. [1]

In the near future, renewable energy sources will be controlled by the unlimited power of Artificial Intelligence, the application of which will have a significant contribution to the solving of the world’s energy problem.

This study is aimed towards households which use a renewable energy system exclusively (individually) and independently of a network in an off–grid mode in the same region or premises. While the surplus energy can be idle in exclusive (individual) usage, houses can transfer energy to each other with the Smart energy sharing system which this study proposes. The central management system records in real time exactly how much energy is transferred to which house and identifies which house is credited to which.

The demonstration of this method was carried out on a small scale by using photovoltaic solar panels. However, it is also possible to integrate this study with wind turbines and different types of green energy sources.

The energy which each house produces is primarily used to meet the consumption needs of the household itself. However, if a house produces a surplus, the additional energy produced can be used for the consumption needs of other houses either within the regional vicinity or the actual premises.

[1] Student at Bahcesehir University - yusufyasef03@uoml.k12.tr
[2] Student at Ulus Private Jewish High School - eyalkohen04@uoml.k12.tr
[3] Project supervisor at Yildiz Technical University - rehadiri@gmail.com
[4] Project supervisor at Ulus Private Jewish High School – talhakilic@uoml.k12.tr

The proposed shared energy management system demonstrates that the energy management approach is effective in reducing energy costs for the end user and also for limiting the load demand of the distribution system operator.

The most important difference between this study and existing studies is that the system which this paper proposes can be created by using simple algorithms and cost-effective components. It can also be monitored instantly, and the same system can also control different renewable energy sources.

The main software used to control the system and is at the center of this study, is multithreaded. It can collect real-time current and voltage information from houses and switches accordingly.

Key words: Artificial Intelligence, Algorithm, Energy Management, Photovoltaic Systems, Shared Energy Systems.

Aim of the Study

The aim of this study is to develop a system which enables household groups which use off-grid renewable energy systems to transfer energy among themselves independently of the main grid, and also record the data within their environment.

Introduction

In order to reduce our carbon footprint, the use of renewable energy generation systems within households is becoming increasingly common. Many households prefer the use of photo voltaic solar panels over other systems because they are fairly easy to install and also have advantages in terms of energy performance and cost. Such power systems are commonly referred to as microgrids. [2]

It is microgrid automation that enables a group (region, premises, etc.) to have independent renewable energy sources that operate independently from the base network but in a way that is synchronized.

The microgrid group consists of renewable energy sources such as wind, solar, gas turbine, small hydropower, geothermal energy, biomass, biogas and battery. Microgrid technology can operate independently of the network or be connected to the public network.

The microgrid uses scatteredly placed renewable energy sources to generate electricity and to distribute storage energy. Bad weather and power outages can adversely affect the network. In order to avoid being affected by power outages, consumers should ensure that they can also use electricity from the main network. [2]

Method

This study introduces a mechanism which controls the battery level of homes which use renewable energy off-grid but with the capacity to provide energy to each other when needed or switch to the main grid when necessary. The system which was designed for this purpose was implemented on a small scale, and 3.7 Volt Li-Po batteries were used instead of 12 Volt batteries which are usually used in houses.

In the first stage, the system was designed. The model was then conceived under the reasonable assumption that there were three individual users living in the same premises. Representing one battery per house, the model consisted of a 3.7 Volt, 150mA Lithium polymer battery, two 6 Volt mini photovoltaic solar panels 500mA, 3 Volt 1.2 Watt bulb as light source representing the consumption of energy, 5 Volt relays as the energy distribution switch, and a personal computer (PC) that communicates with Arduino uno as the main control center, were positioned as the Main System, as shown in Figure 1.

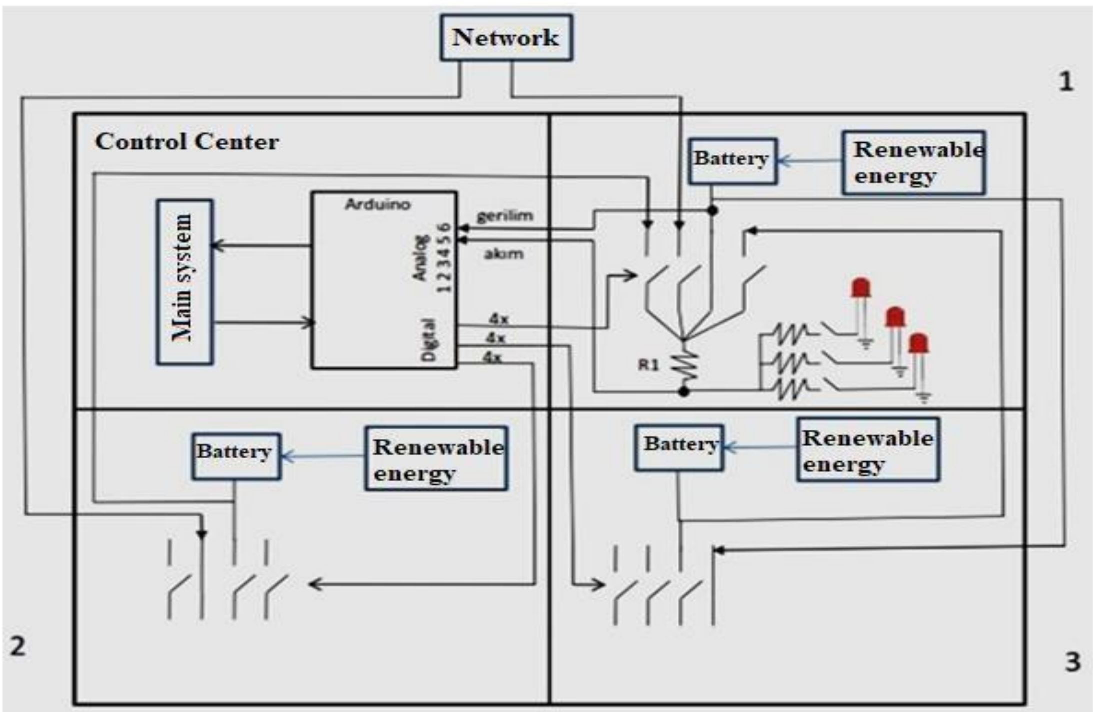


Figure 1: Design of the system

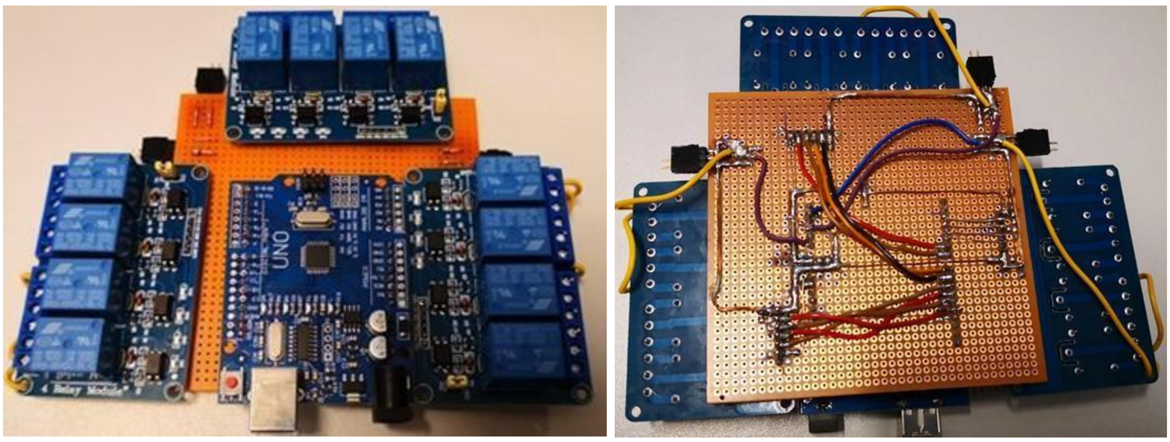
In the second stage, a premises model consisting of three houses was prepared by using 3 mm thick plywood sheets in order to demonstrate and to test the applicability of the system. (Picture1)

Picture 1: Model of system application

In the third stage, the system designed using the elements in Table 1 was created and the circuit assemblies were made. (Picture 2)

No	**Material**	**Quantity**
1	Laptop Pentium I5	1
2	Arduino Uno	1
3	5 Volt relays	12
4	3 Watts 0.33 ohm resistance	3
5	On/off switch	3
6	6 Volt mini solar panel 500mA	6
7	4.5 V – 6 V solar charger	3
8	150 mah 1s 3.7 Volt Li-Po battery	3
9	3 amper step down buc converter	2
10	0.25 att 9k resistance	3
11	3 Volt, 1.2 Watts bulb	3

Table 1: Materials used in the study



Picture 2: The Main Control System made by using Arduino Uno and relays

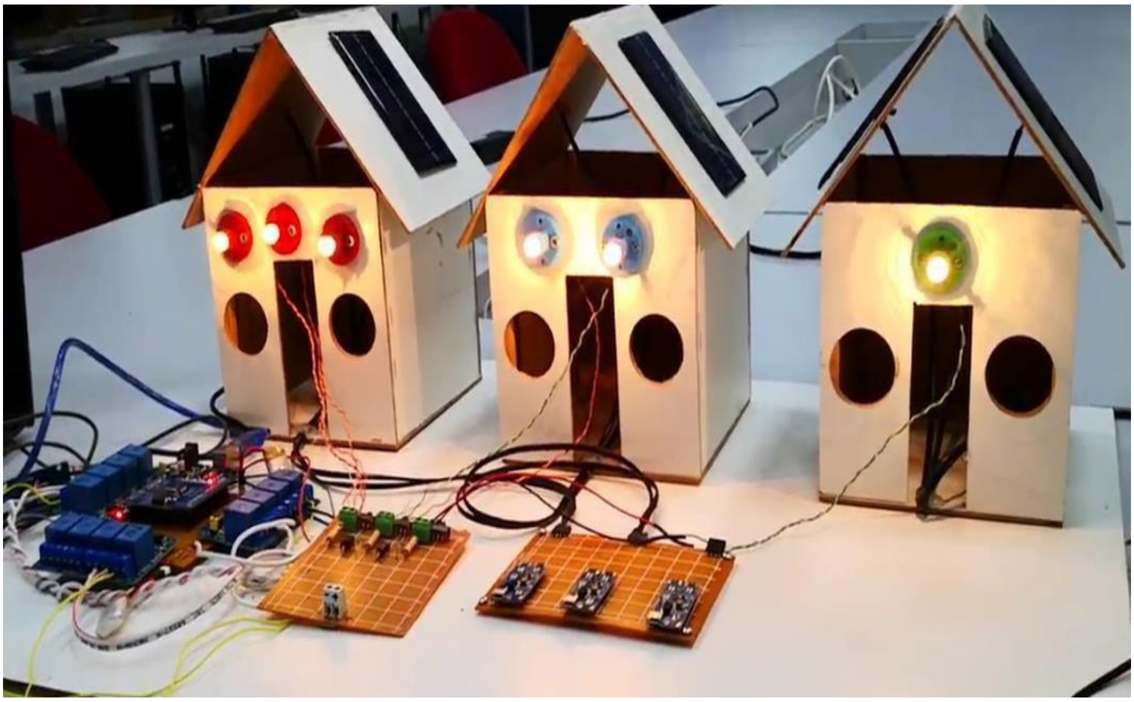
In the fourth stage, coding was completed by using Python on the PC and by using C languages on the Arduino (Appendix 1).

The Arduino is used to enable the PC's software to communicate with the hardware connected to the house. Arduino transfers current and voltage information to the PC and also performs the PC's switching orders which are transmitted via relays. Therefore, all of the controls in the Python software is on the PC.

Python software works as a multithread. A thread that operates independently receives continuous current and voltage values from houses and calculates instantaneous power values while saving them. In the other sections, switching and screen displays were performed.

The Python software switches in accordance with the voltage value of the Arduino. Threshold levels were determined for the switches. For example, if the battery level of a house dropped below the 3.3 Volt threshold, switching is required in order to obtain energy from another house that is able to provide energy. Also, if the battery level of a house drops below the 3.5 Volt threshold, a necessary block is enacted because a house with such a battery level would be unable to transfer energy to other homes. These threshold levels and related actions are provided in Table 2.

The coding file was added to the APPENDIX section at the end of the study.



Picture 3: View of the system in operation

The working principle of the Smart Energy Support System is shown in Table 2.

BATTERY VOLTAGE RANGE	ENERGY USE OF HOUSE	SUPPLY of ENERGY TO OTHER HOUSES
IF LESS THAN 3,3 VOLT	Energy is taken from the house with the highest voltage level among suitable houses where energy can be received. If there is no house where energy can be supplied, energy is supplied from the network.	Does not distribute energy outside.
IF IN BETWEEN 3,3 VOLT – 3,5 VOLT	If there is a battery condition that goes below 3.3 Volts and recharging, energy is taken from outside until it reaches 3.5 Volts, else it would consume its own battery.	Does not distribute energy outside.
IF IN BETWEEEN 3,5 VOLT – 3,7 VOLT	It receives energy from its own battery.	If there is a battery condition below 3.5 Volts and is recharging, it does not distribute energy outside until it reaches 3.7 Volts, otherwise it can give energy to the outside.
IF MORE THAN 3,7 VOLT	It receives energy from its own battery.	Distributes energy outside.

Table 2: Working principle of the Smart Energy Support System

MONTHS										
Job Description	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dic.**	**January**
Literature Search	X	X	X	X	X	X	X	X		
System design			X	X						
Material purchases				X	X	X	X			
Project installation							X	X	X	
Software developmen							X	X	X	
Experiments							X	X	X	
Project report writing									X	X

Table 3: Project Work-Time Schedule

Findings

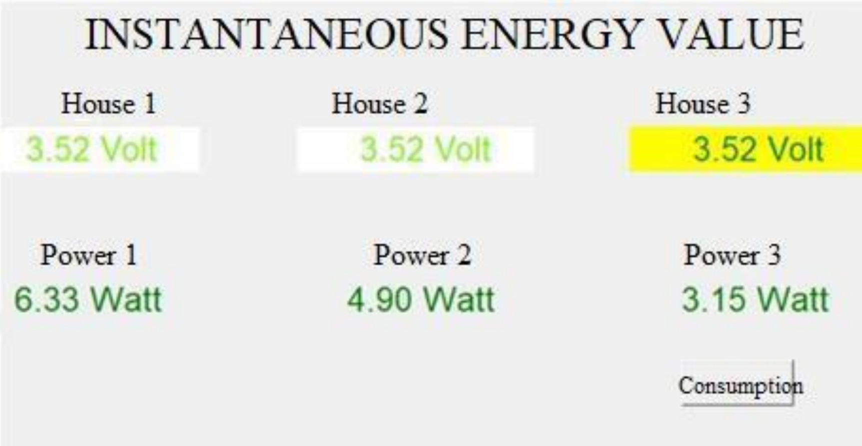


Table 4: Screen while House 1 and House 2 are being supported by the battery of House 3

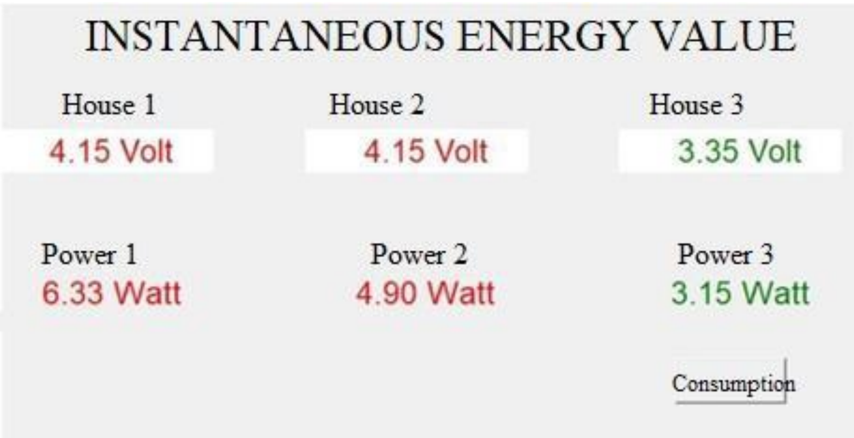
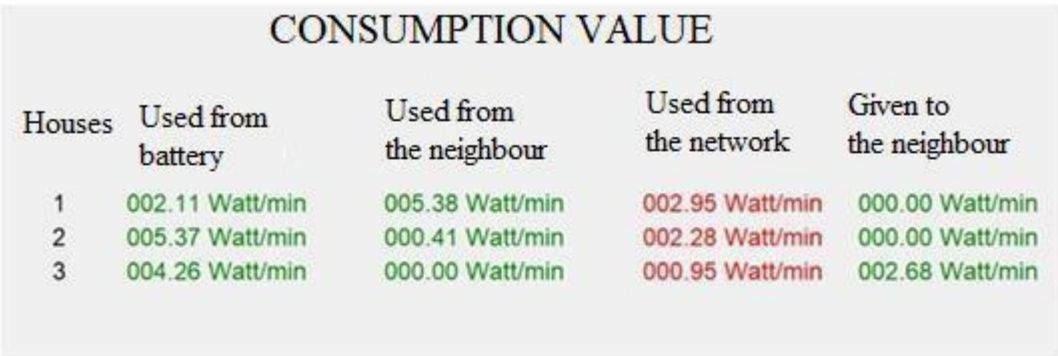


Table 5: House 1 and House 2 feeding from the network while House 3 is supported by its own battery.



CONSUMPTION VALUE

Houses	Used from battery	Used from the neighbour	Used from the network	Given to the neighbour
1	002.11 Watt/min	005.38 Watt/min	002.95 Watt/min	000.00 Watt/min
2	005.37 Watt/min	000.41 Watt/min	002.28 Watt/min	000.00 Watt/min
3	004.26 Watt/min	000.00 Watt/min	000.95 Watt/min	002.68 Watt/min

Table 6: Total expenditure and energy supply values on the basis of resources

Conclusion and Discussion

In this study, an energy management system based on a load demand and power generation algorithm was developed in order to evaluate the benefits of shared batteries for users.

In order to evaluate the effectiveness of the proposed method, a certain number of domestic consumers, each having photovoltaic units and located in the same region, were taken into consideration. The main objective of the proposed approach is to provide the most economical way of exchanging energy between households by using shared batteries and to also limit the amount of energy consumed from the network by domestic consumers, especially during times of high energy prices. For this purpose, it is assumed that consumers earn energy credits as a result of the related energy exchanges and spend these credits during a demand response activity period.

If 12 Volt batteries are used instead of the 3.7 Volt Li-Po batteries used in this designed and carried out system, and also if the threshold parameters are regulated according to 12 Volts, this system is capable of switching to 12 Volt without any further change.

The results stated in this study were obtained by using a limited number of household loads and only one shared storage unit. From this conclusion, it can be stated that in different studies where a wider distribution network and more than one shared storage unit are taken into consideration, the number and variety of consumers (industrial, commercial, etc.) and the benefits that can be offered would significantly increase.

Recommendations

In the future, an investigation is recommended into the technical and financial benefits of energy storage technologies with higher capacities which can be used instead of battery-based shared storage units.

Bibliography

[1] Taşcıkaraoğlu, A., Erdinç, O., (2019) "Paylaşımlı Elektrik Enerjisi Depolama Sisteminin Kullanımına Dayanan Bir Enerji Yönetimi Yaklaşımı", European Journal of Science and Technology No. 16, pp. 589-604,
[2] Zhu,T., Huang, Z., Sharma, A., (2014), "Sharing Renewable Energy in Smart Microgrids", conference paper, (https://www.researchgate.net/publication/261451435)
[3] http://www.emo.org.tr/ekler/39a721e7e13d0df_ek.pdf (Erişim Tarihi: 20/04/2019)
[4] http://www.sbb.gov.tr/wp-content/uploads/2018/11/Seda-Cebeci.pdf (Erişim Tarihi: 24/04/2019)
[5] https://www.intechopen.com/books/smart-microgrids/renewable-energy-microgrid-design-for-shared-loads (Erişim Tarihi: 28/04/2019)
[6] Özen, F., (2019), "Yenilenebilir Enerjide Yapay Zeka Uygulamaları", Haliç Üniversitesi

Appendix

Appendix 1: Together Stronger coding file