ENERGY MANAGEMENT SYSTEM FOR RESIDENTIAL SOLAR HOME SYSTEM THROUGH LOAD SHIFTING

UMMI AISYAH BINTI MOHAMAD ZAHIAR

UNIVERSITI TEKNOLOGI MALAYSIA

DEVELOPMENT OF INTEGRATED RENEWABLE ENERGY SYSTEM FOR SUSTAINABLE ENERGY SUPPLY AT MAI FARM KALUMPANG SELANGOR

UMMI AISYAH BINTI MOHAMAD ZAHIAR

A project report submitted in fulfilment of the
requirements for the award of the degree of
Master of Philosophy

Faculty of Chemical and Energy Engineering
Universiti Teknologi Malaysia

FEBRUARY 2023

ACKNOWLEDGEMENT

In preparing this master project, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my supervisor, Associate Professor Ts. Dr. Norzanah Binti Rosmin, for encouragement, guidance, critics and friendship. Without her continued support and interest, this thesis would not have been the same as presented here.

Besides that, I would also like to express my gratitude to all my friends who gave a lot of encouragement during my studies in Universiti Teknologi Malaysia. Thanks to those who involved directly and indirectly throughout this project development. I really appreciated all the corporations from School of Chemical and Energy Engineering UTM.

Finally, I must express my very profound gratitude to my parents and my husband for providing me with unfailing support and continuous encouragement throughout my studies and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

ABSTRACT

Energy Management System (EMS) is a framework that allows energy consumers, such as industrial, commercial, residential and public sector organizations, to better control their energy consumption. It assists businesses in identifying and improving energy-saving technology, particularly those that may not necessitate a large upfront expenditure. This project proposes a EMS in residential solar home system (SHS) through load shifting method. This approach has been established to reduce the energy consumption during peak hours, by shifting away the demands during peak-time to the off-peak time. The decision on the switching algorithm is depending on the time-of-use tariff and electricity pricing. Therefore, each house load has been categorized into fix and transferable load which will be undergo in process of load shifting in order to reach a target of reducing daily electricity bill. Through this method, a modified load profile will be generated and this profile will be analyse further with each solar home system power generation of each house . Through this implementation of load shifting approach, major daily cost reduction of electricity could be achieve and it make the house residential less dependent towards the national power grid. Therefore, the objective of this project is met and EMS using load shifting method is carried out successfully.

ABSTRAK

Sistem Pengurusan Tenaga (EMS) adalah kerangka yang membolehkan pengguna tenaga, seperti organisasi industri, komersial, kediaman dan sektor awam, untuk mengawal penggunaan tenaga mereka dengan lebih baik. Ini membantu perniagaan dalam mengenal pasti dan meningkatkan teknologi penjimatan tenaga, terutama yang mungkin tidak memerlukan perbelanjaan awal yang besar. Projek ini mencadangkan EMS dalam sistem rumah suria kediaman (SHS) melalui kaedah peralihan beban. Pendekatan ini telah dibuat untuk mengurangi penggunaan tenaga pada waktu puncak, dengan mengalihkan permintaan pada waktu puncak ke waktu puncak. Keputusan mengenai algoritma beralih bergantung pada tarif penggunaan dan harga elektrik. Oleh itu, setiap beban rumah telah dikategorikan menjadi beban tetap dan dapat dipindahtangankan yang akan dilalui dalam proses peralihan beban untuk mencapai sasaran pengurangan bil elektrik harian. Melalui kaedah ini, profil beban yang diubah akan dihasilkan dan profil ini akan dianalisis lebih lanjut dengan setiap penjanaan tenaga sistem rumah suria setiap rumah . Melalui pelaksanaan pendekatan peralihan beban ini, pengurangan kos elektrik harian yang besar dapat dicapai dan menjadikan kediaman rumah kurang bergantung pada grid kuasa nasional. Oleh itu, objektif projek ini tercapai dan EMS menggunaka kaedah peralihan beban dijalankan dengan jayanya

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LIST OF ABBREVIATIONS

SHS	-	Solar Home System
EMS	-	Energy Management System
DR	-	Demand response
DSM	-	Demand Side Management
RE	-	Renewable Energy
PV	-	Photovoltaic
SOC	-	State of charge
PSO	-	Particle Swarm Optimization
TOU	-	Time-of-use
PEV	-	Plug-in electric vehicle

LIST OF SYMBOLS

$P_{L,n}(t)$	-	Daily total household power consumption
$P_{L1,n}(t)$	-	Modified load profile
$P_{avg,n}(t)$	-	Average load power
$Price_{peak}$	-	Electricity price during peak hour
$\sum P_{trans\text{-}tot,n}(t)$	-	Total transferable load power
ΔP	-	Operational power variation margin
$P_{avg,n}(t)+\Delta P$	-	Maximum allowable power variation
$P_{avg,n}(t)-\Delta P$	-	Minimum allowable power variation
$P_{s,hour}(t)$	-	The hourly surplus power
$P_{i,hour}(t)$	-	The hourly insufficient power
$P_{g,hour}(t)$	-	The hourly power generated
$P_{d,hour}(t)$	-	The hourly power demand
W/m^2	-	Watt per meter square

CHAPTER 1

INTRODUCTION

1.1 Background of the research

Energy is often regarded as one of the most critical technological inputs for socioeconomic development and rapid industrial expansion. In the case of developed countries, the energy issue or crisis could be significant obstacle to their future infrastructure growth [1]. Nowadays, fossil fuels have become the primary source of electricity generation in most countries all over the world. However, fuels do not last indefinitely due to high demand in every major sector such as transportation, power generation and others. Renewable energy sources are the perfect alternative choice, given the ever-increasing expense of fossil fuels and their environmental impact. The growing interest of using renewable energy sources to generate electricity has resulted in the creation of a new type of power system network that comprises both renewable and fossil fuel power plants [2]. The major goal of this network is to establish a sustainable energy system, with a focus on lowering gas emissions and increasing energy security and responsibility for all or any users at the lowest possible operational cost.

Solar photovoltaic (PV) is the most prospective, promising, and promising renewable energy source for converting solar energy into electrical energy, with or without battery backup. Most regions in Southeast Asia and Africa receive sufficient sunlight (above 5.5 kWh/m2/day for most regions) [3]. For this reason, solar PV generation can be an attractive alternative to conventional fuel electricity generation. Through a physiochemical mechanism, the photovoltaic cell, also known as the solar cell, turns the sun's light energy into electrical energy. A solar cell's maximum open circuit voltage is roughly 0.5 to 0.7 V [7]. The efficiency of a PV Cell is practically very low due to a variety of factors, the most notable of which is the lack of direct

sunlight impacting the solar panel. The technology of solar panels has advanced dramatically in recent years. Modern solar panels are more efficient and reliable at capturing solar energy, and it had been offered in the lower price.

As a consequence of advanced technologies, Solar Home Systems (SHS) are the dominant decentralized technology used and promoted in developing countries for rural electrification [4]. SHS is by far the most prevalent means of providing energy access to households in places where there is no electricity or where the electricity supply is inconsistent. PV panels are often utilized as a source, batteries are used for storage, and a solar charge controller is used to power appliances like lights, fans, television sets, and refrigerators [5]. Figure 1.1 shows a block diagram of a typical SHS.

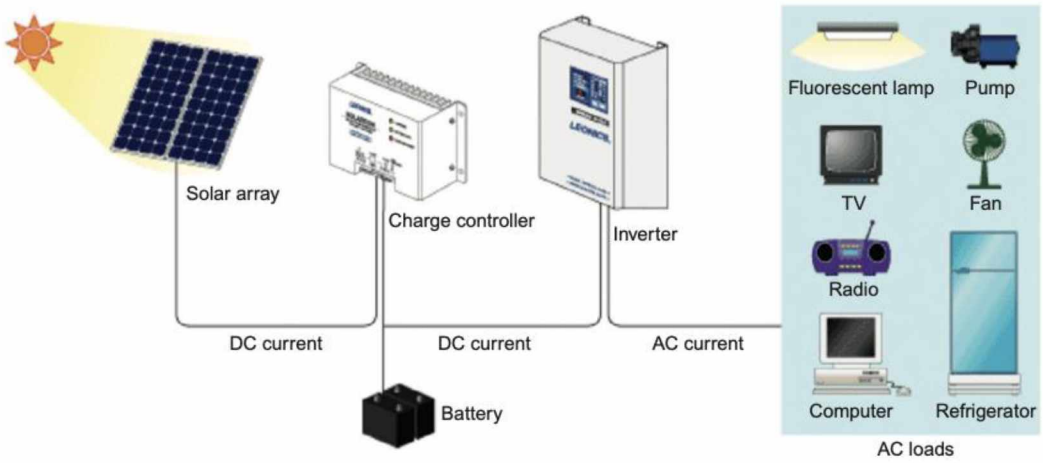

Figure 1.1 Typical configuration of SHS [6]

An Energy Management System (EMS) is a framework that allows energy consumers, such as industrial, commercial, residential and public sector organizations, to better control their energy consumption. It assists businesses in identifying and improving energy-saving technology, particularly those that may not necessitate a large upfront expenditure. EMS is also a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation or transmission system. In the wake of advanced research and technology, EMS has developed into cloud-based energy management systems provide the ability to remotely control and other energy-consuming

equipment, gather detailed, real-time data for each piece of equipment, and generate intelligent, specific, real-time guidance on finding and capturing the most compelling savings opportunities [8].

However, it required massive amount of expenses in order to establish the communication network between smart grid, smart meter and the smart house itself. Therefore, the real application of the cloud-based EMS still at shallow. Figure 1.2 below show an example of smart home EMS.

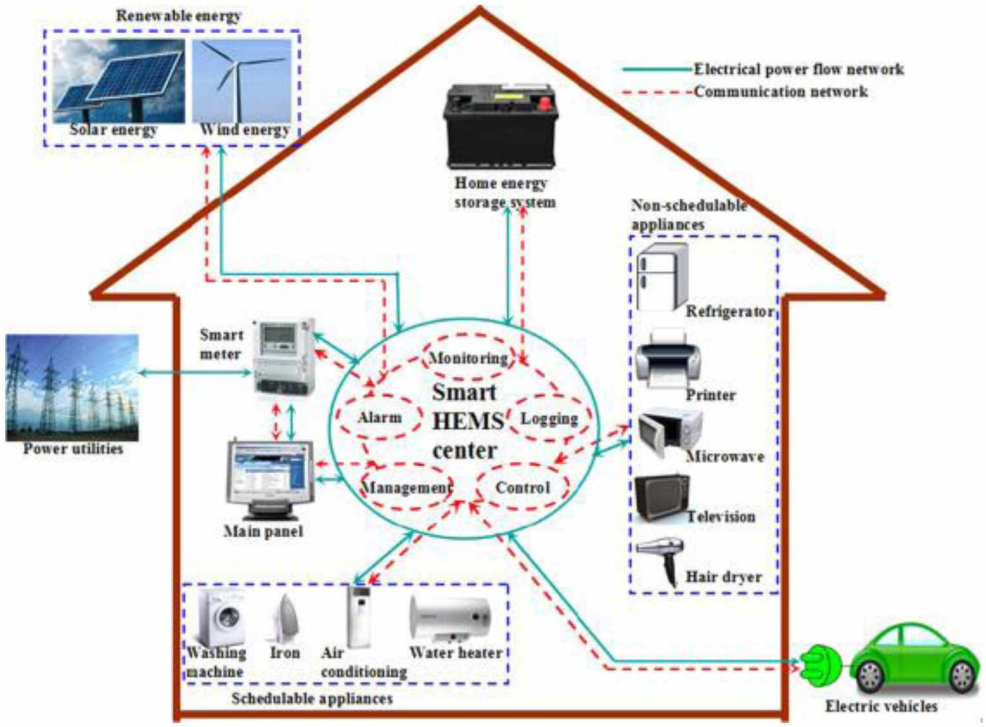

Figure 1.2 Smart Home EMS.[8]

1.2 Problem Statement

Households that have their own solar home system (SHS) which are located at places where solar radiations are abundant could have potential of underutilized the solar power, especially during the day time where nobody at home. During sunny day, solar home system generating the most electricity and the surplus power from the generation will charge the battery storage after supplying the load demand. This battery storage is important in order to provides a reliable power backup option when

the sun goes down. Usually, household requires more energy in the morning when people are getting ready, and at night when more appliances and electronics are in use. However, there are also a house that having high load demand during the day time compared at night. Therefore, to fully utilize the battery storage, it is crucial to have an efficient load usage. It will help the house owner to maximize its daily solar power generation and reducing the electricity cost buying from the grid. Hence, it is important to look into the selection of efficient control tools for home energy management systems that can offer optimization alternatives of load usage.

1.3 Objectives of the research

Followings are the objectives proposed for this research:

1. To propose a EMS approach for residential solar home system through load shifting method by using Rule Based Algorithm.
2. To analyse the energy consumption pattern during the implementation of EMS in each house.
3. To compare the electricity cost of each house before and after the implementation of the EMS.

1.4 Scope of the Study

In this research, EMS for SHS is studied and a method control EMS approach is applied by using rule-based algorithm. The proposed EMS has considered 5 houses in the residential area with different energy demand. Each house has installed solar photovoltaic panels as renewable energy sources and battery storage as a backup power. All SHS is connected to the grid line system. The load of the residential will be classified into fix load and transferable load. The proposed EMS will be analyzed in MATLAB/Simulink software.

1.5 Significance of the Study

The main contribution of this research is the implementation of a load shifting method as an EMS approach in residential SHS. Using this approach, the generation cost can be minimized while enhancing the system reliability and stability by considering customer's demand response scheme. Through this approach, energy consumption during peak hour can be clipped and transferred to the valley curve side. This also enables optimization of the battery storage of each house. The diversity of generation costs also can be demonstrated for the proposed SHS system through the fixed and variable loads test.

1.6 Report outline

There are five chapters in this report, and details of this work are given in these chapters. Literature reviews related to this study are described in Chapter 2. The research framework and proposed methodologies are explained in detail in Chapter 3. In the next chapter, the preliminary results based on the proposed method will be presented and discussed in Chapter 4.

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