COST ANALYSIS OF SOLAR HOME SYSTEM FOR RURAL AREA OF MOGDISHU USING HOMER SOFTWARE

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To my beloved parents, thank you.

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ABSTRACT

This project discusses the cost analysis of solar home system that will be used by the village located in rural area Mogadishu, Somalia. Energy is a basic need for the overall growth and improvements of people's living standard. But around 2 to 3 billion people in the world have no access to electric lighting. Like other developing countries, the rural electrification in Somalia is very low and government takes some actions to promote the investment in these areas but due to economic constraints and low level of technological advancement the growth is very low. This study focuses on solar PV based rural electrification, its impact on environment and socio-economic development in rural areas of the capital city of Somalia using HOMER software to calculate energy demand and cost of electrification. The data required for solar sunshine hours were obtained from NASA surface meteorology and solar energy database. The study was conducted for 50 typical medium houses in rural areas in Mogadishu. The simulations result has shown that it is more advantageous to use a 70.92 kW solar home system for 50 family homes electrification, although the initial capital investment is higher and cheaper than the connected system. The cost of energy in $/KWh is 0.203. Therefore, the optimal solution was considered in terms of cost and system size of the 330W system which fulfils the electricity demand in rural and urban areas. Finally, In Mogadishu, this project's work serves as a foundation for conducting the research for the long-term viability of this solution, not only in the city, but also throughout the country where the sun shines brightly and where simulations' findings are essential.

ABSTRAK

Projek ini membincangkan analisis kos sistem rumah suria yang akan digunakan oleh kampung yang terletak di luar bandar Mogadishu, Somalia. Tenaga adalah keperluan asas untuk pertumbuhan keseluruhan dan peningkatan taraf hidup manusia. Tetapi sekitar 2 hingga 3 bilion orang di dunia tidak mempunyai akses kepada pencahayaan elektrik. Seperti negara-negara membangun yang lain, elektrik elektrik luar bandar di Somalia sangat rendah dan pemerintah mengambil beberapa tindakan untuk mempromosikan pelaburan di kawasan-kawasan ini tetapi disebabkan oleh kekangan ekonomi dan tahap kemajuan teknologi yang rendah, pertumbuhannya sangat rendah Kajian ini memberi tumpuan kepada elektrik elektrik luar bandar berasaskan PV solar, kesannya terhadap persekitaran dan pembangunan sosio-ekonomi di kawasan luar bandar ibu kota Somalia menggunakan perisian HOMER untuk mengira permintaan tenaga dan kos elektrik. Data yang diperlukan untuk jam sinar matahari suria diperoleh dari pangkalan data meteorologi permukaan dan tenaga suria NASA. Kajian ini dilakukan untuk 50 rumah sederhana khas di kawasan luar bandar di Mogadishu. Hasil simulasi telah menunjukkan bahawa lebih menguntungkan untuk menggunakan sistem rumah suria 70.92 kW bagi 50 elektrik rumah keluarga, walaupun pelaburan modal awal lebih tinggi dan lebih murah daripada sistem yang bersambung, Kos tenaga dalam $ / KWh adalah 0.203. Oleh itu, penyelesaian optimum dipertimbangkan dari segi kos dan ukuran sistem 330W yang memenuhi permintaan elektrik di kawasan luar bandar dan bandar. Akhirnya, Di Mogadishu, kerja projek ini berfungsi sebagai landasan untuk menjalankan penyelidikan untuk jangka masa panjang penyelesaian ini, tidak hanya di kota, tetapi juga di seluruh negara di mana matahari bersinar terang dan di mana penemuan simulasi sangat penting.

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LIST OF SYMBOLS AND ABBREVIATIONS

Ah	-	Ampere hour
AC	-	Alternative current
COE	-	Cost of energy
DC	-	Direct current
DG	-	Diesel generator
DOD	-	Depth of Discharge
E	-	Energy
FGS	-	Federal Government of Somalia
GDP	-	Gross Domestic product
GHI	-	global horizontal irradiance
HOMER	-	Hybrid Optimization Model for Electric Renewables
KVA	-	Kilovolt ampere
kW/h	-	Kilowatt hour
LCOE	-	Levelized cost of energy
M	-	Mogadishu
MW	-	Mega watt
NREL	-	National renewable energy laboratory
NPC	-	Net Present Cost
NPV	-	Net present Value
O&M	-	Operating and Maintenance
P	-	Power
RA	-	Rural Area
RE	-	Renewable Energy
SHS	-	Solar Home System
SND	-	Somali National Development
V	-	Voltage
W	-	Watt

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Renewable energy has attracted a lot of attention because of the increased energy demand, increased environmental sustainability concerns, and the scarcity of fossil fuels, and because of these increased prices, renewable energy is becoming increasingly cost-effective. In most renewable energy options, solar energy has the most appeal because it is an inexhaustible and clean source of energy, as well as being environmentally friendly to utilise. It's estimated that the current worldwide energy demands are considerably less than the amount of solar energy that is available [1].

Photovoltaic is the direct conversion of sunlight to electricity, it is a suitable alternative power source since it is safe, silent, and non-polluting, as well as being environmentally friendly It is extremely modular in that its capacity may be progressively raised in response to fast demand growth; and it is efficient, with low failure rates and a 20 to 30 year expected service life. Renewable energy is growing more popular, especially when oil prices fluctuate, due to the great potential for solar energy and inexpensive conversion technology. Solar photovoltaic systems have several advantages, particularly in rural areas [2].

Photovoltaic (PV) energy generation is an excellent source of energy for many applications, particularly in rural and remote areas of eastern Africa. Due to the year-round availability of solar radiation, Somalia benefits from an abundance of solar energy. The amount of potential output and the range of solar energy-based thermal applications are significantly different. Renewable energy accuracy is determined by the region's climate and atmospheric conditions, as well as the infrastructure available

and the power grid's economics [3]. Somalia is in a great location to harness solar energy, with daily sunlight approaching 10 hours. Furthermore, the temperature is moderate, with an annual average of 30°C, which extends the operating life of solar PV systems in Somalia. However, it is unclear why the critical grid link was not created. Photovoltaic cells, when connected to a battery, convert energy into sunlight, which can then be used by a stand-alone photovoltaic system in Somalia. The fundamental component of the PV system is the PV (or solar cells). PV cells are coupled together to form a larger unit called a module, which can be connected in a succession of outstanding component name arrays.

To satisfy simple power requirements, these arrays are connected in parallel and sequence. Although the solar array is only lighted once to create power, it is generally equipped with an outstanding energy storage system. The most common being a series of rechargeable batteries. Charging controls and converters must be introduced to prevent overcharging and over-discharging of hazardous batteries and to drive AC loads. The significant aspect of the system configuration is the PV collection of stand-alone photovoltaic devices, the scale of the inverter, and the battery. Solar radiation data is necessary for the predicted location of the installation site, load needs, photovoltaic modules, inverters, batteries, and their operational efficiency [4].

Variables that offer feedback on the degree of reliability assumed by limitless system load, as well as control techniques built based on power supply across a range of autonomous days, are often used in these primary techniques. These methods are simple and ensure the PV system's required efficiency through autonomous days when the storage system encounters load demand in these activities. The level of stability of the PV system is viewed as the storage system's capabilities, therefore the dependability is strong influenced by the autonomous days [5]. In most cases, the resulting PV array and battery bank arrangement does not meet expectations. If the project is still under research, then the size of the stand-alone PV system is of critical importance. Increasing renewable energy consumption through cost-effective and professional means is critical [6].

Utilizing size optimization, it will be possible to minimize the PV device installation investment cost while still maintaining the amount of electricity that the project generates daily. The project's is cost analysis of solar home system for rural area in Mogadishu system scaling strategy could be costlier than the project itself.

1.2 Problem Statement

Electric power in Mogadishu is generated by imported diesel. Diesel generators are generally across the country at extreme price electric rates for their customers. Additionally, diesel generators often run at part load, low-efficiency conditions due to variable electrical demand coupled with low local knowledge, and sometimes participate in environmental pollution. On the other hand, renewable resources like wind and solar can provide clean, abundant, affordable, and easily accessible alternatives to fossil fuels throughout Mogadishu. The use of non-traditional sources of electricity, such as renewable energy, has been in demand due to the lack of fossil fuels and the steady increase in fuel prices in recent years. To minimize global air pollution and to control climate change, reliance on renewable energy sources should also be encouraged [7]. Access to electrical electricity plays a critical role in accelerating cost-effective development by humanizing the values of wellbeing and the life cycle. Significant investment in the energy sector has been completed-also other combat needed to be completed by resident engineers in partnership with private sectors to achieve the defined objectives of electrifying households to advance electricity entry in homes [7].

For the beyond goals to be accomplished, a combination of several results that focus on the geographical location, revenue, and consumption level is required as a replacement of consuming the traditional connection to the network which is not appropriate in place of rural and remote homes. An off-grid PV system may consider a sustainable solution that can be implemented by simple solar home system generation of technologies that produce electrical power by the primary equipment's of the house to stand-alone systems which can produce high levels of electricity that can be used in homes and other commercial centres. This method can assist a cost-effective and dependable result for the rare growing of power admittance by the entire rural and remote municipal and nation via overall[8].

For the people and the community, the Mogadishu solar home system will help these rural settlements without access to the country or private sector electrical grid.

1.3 Research objectives

The objectives of this project are:

a) To design an off-grid solar PV system based on averaged electrical consumption of the medium household.
b) To simulate the PV system design for homes by using HOMER Software®.
c) To evaluate the cost of stand-alone PV homes system in Mogadishu area by using HOMER Software®.

1.4 Scopes of the Study

The master project's scope of work is limited to the purpose of optimum photovoltaic systems in rural and remote areas of power generation inattentive. In addition, the following constraints are considered to complete the system interprets assessment.

a) The photovoltaic geographic information system in Africa, which is useful for supplying solar energy services, provides significant data on radiation at specified sites. It was used to approximate the budget of the standalone photovoltaic system in the design and simulation of photovoltaic power generation systems in Mogadishu.
b) Calculating or analysing the daily energy usage of 50 household population.
c) Selected Load below 382.00 KWh/day
d) Assuming continuous annual solar energy input and main load curve throughout the project lifespan.
e) This project study is limited to the cost and analysis of solar home systems (SHS) in Mogadishu rural areas.
f) The Hybrid Optimization model will be used in the Electric Renewables (HOMER) software®.

1.5 Report organization

This report is divided into five (5) main chapters. Chapter 1 discusses the introduction, problem statement, objectives, and scope of the project. In Chapter 2, literature review of cost analysis solar home system for rural areas in Mogadishu using homer software. For Chapter 3, the methodology of the project, mathematical formulation of cost analysis solar home system for rural areas in Mogadishu using homer software is discussed. In Chapter 4, the results of using homer software based on cost analysis solar home system for rural areas in Mogadishu. Chapter 5 discusses the conclusion and recommendation of the future work, while the last section highlights the references of this report

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the previous research on solar systems development, as well as ways to incorporate photovoltaic system optimization and reliability. This chapter also contains literature on modelling components in HOMER software and analysing the performance of each paper related to solar system energy.

2.2 Background of Energy in Somalia

Somalia suffers from three major problems related to broad-based electrification lack of access, extremely high costs, and low reliability. Electricity is only available to a limited percentage of the country's households and enterprises. Because few surveys have been done in Somalia in recent years, reliable statistical information concerning the country's energy condition is lacking. While the World Bank says that 29.1% of Somalia's population has access to electricity, a more recent assessment from the 2014 African Energy Outlook suggests that just around a quarter of the population has access to power [9].

These estimates a significant rural-urban gap. Rural communities have almost little access to electricity. It differs substantially across the country in metropolitan areas. According to recent estimates, 60 percent and 68 percent of the population of Mogadishu and Hargeisa are linked to electricity, respectively, whereas smaller cities like Merka have only 23 percent. Estimates of the percent with access to power are

likely inflated in places with greater numbers of internally displaced individuals who are tougher to trace. While these percentages are higher than similar cities in Sub-Saharan Africa, especially in Mogadishu and Hargeisa large cities, the availability of power for companies and homes is a concern. The main issue is that power costs are among the world's highest, ranging from $0.80 to $1.50 per kilowatt-hour, as shown in Figure 2.1.

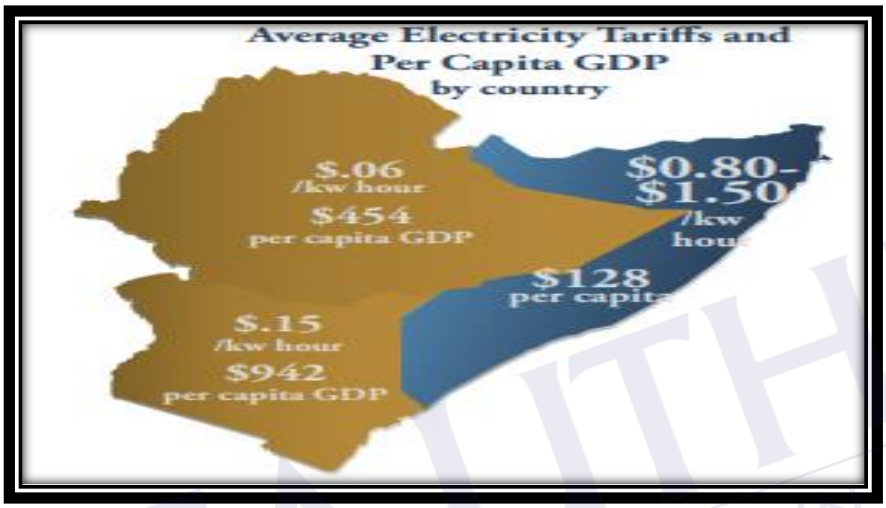


Figure 2.1: Average electricity tariffs and per capita GDP by country [9]

Comparatively the neighbouring countries of Kenya and Ethiopia enjoy average rates of $0.15 and $0.06, respectively. Somalis not only pay far higher electricity bills, but they also make significantly less money. Somalia's GDP per capita is estimated to be $128, a small fraction of Ethiopia's $454 and Kenya's $942. Somali inhabitants live in one of the world's poorest countries yet pay one of the highest power bills of any country. Location and differential pricing by energy suppliers account for the wide range of power rates in Somalia. Within cities, those who live far from metropolitan centres often pay the highest energy expenses; tariffs vary between providers, and providers do not always utilize a consistent rate among their clients. The lack of transparency and predictability causes issues for both users and suppliers in the industry. The electricity supply's second problem is its extraordinary unreliability. Due to the constraints of the current infrastructure, the networks are plagued with shortages and outages [10].

Somalia is at a threshold. Emerging from a winter of conflict and instability, the country is at a point where security and growth will continue to take root given the

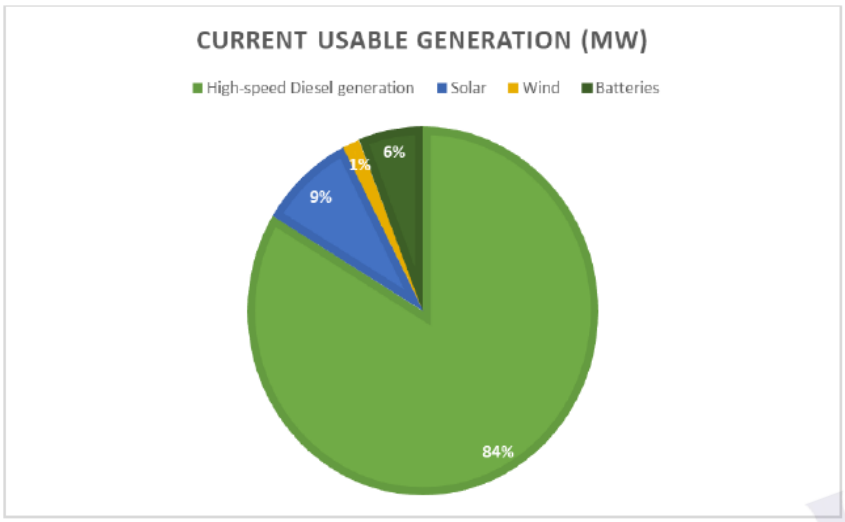
right support for economic recovery and improved governance. To get Somalia over this hump, more inexpensive and dependable power is required. The purpose of this paper is to call attention to the escalating energy challenges in Somalia, where most people living in rural and urban regions lack access to power. Those having access in metropolitan areas pay some of the world's highest rates for restricted and occasionally faulty services. Businesses take the burden of such high expenses, which force them to reduce their output and, in some circumstances, contemplate transferring operations to countries where power is more reasonable. Households, health institutions, and schools all feel the burden of inadequate and expensive electricity. Continued deforestation is a big casualty of the situation, as people continue to utilize charcoal from Somalia woods for cooking. Beyond the turmoil and instability that have dominated headlines in Somalia for decades, the country has remained afloat because of quiet, steady growth led by the private sector. A robust business sector in Somalia is now ready to assist cement political and economic stability if given the proper assistance. The scarcity of inexpensive energy is a stumbling block to such development. Because of Somalia's degraded grid infrastructure as a result of decades of violence and neglect, the country's energy generation is among the least efficient and expensive in the world [11].

2.3 Renewable Energy Status in Somalia

The war-torn energy ecosystems in Somalia are on the verge of collapse. Diesel-powered generators are the most common power source in the country. While electricity is widely available, it is outrageously expensive, as it is almost non-existent. Most people use firewood, charcoal, or animal dung in their cooking. This contributes to indoor air pollution. Somalia has enormous renewable energy resources, including undeveloped hydropower, huge geothermal energy resources, several attractive wind locations, and enough sunlight for solar power generation. The ever-increasing and constantly varying diesel prices that fuel energy generation have a negative influence on the economic climate in a region that is attempting to shift away from coal. from post-conflict recovery to a rather quick economic development [12]. Around 95 percent of Somalia's energy was derived from fossil fuels as recently as the 2000s. Exploring new, cleaner, and more sustainable energy sources is no longer a pipe

dream; it is already a reality. Because it relates to hybridizing with other kinds of electricity generation rather than generating in isolation, energy storage will be explored more thoroughly under the section on generation [13].

This is further fuelled by the fact that capital costs for wind and solar PV generation have continued to fall in recent years and are expected to drop another 15 to 35 percent in the next five to seven years. Currently, there is no national production and exploitation of locally sourced fossil fuels such as coal, natural gas, or liquid petrochemicals in Somalia. Somalia has high winds, 310 sunny days per year, modest hydroelectric potential in the Shebelle and Juba rivers estimated to be approximately 100-120MW, but it remains undeveloped owing to security concerns, and significant potential for wave and tide-based power, which can ultimately be exploited. Once the technologies have been validated [14]. Renewable resources are abundant in the country's northern regions, sections of the middle regions, and along the coasts. It is well acknowledged that the Indian Ocean coastline, as well as areas of the Gulf of Aden region, have unusually powerful wind resources. In addition, large solar PV resources are accessible in the country's northern and central regions, both along the beaches and in the land. A small number of renewable energy projects are being developed or are already operational, thanks to funds provided by Somali businesses both inside and outside the nation. The government had invited businesses and possible international donors and investors to explore how to launch initiatives in a country where there are evident opportunities for growth but also significant obstacles, with the support of the United Nations. Small hybrid grids are likely to expand access to electric power in several places with the help of donor financing. Furthermore, a comparable drop in diesel power output might result in lower prices, making energy more accessible to a wider range of urban users. Somalia is in a better position to investigate newer and cleaner energy sources now that it has experienced notable political stability after decades of warfare [15]. Figure 2.2 below represents the current usable generations installed, expressed in percentage of the total.



Source: Unicon

Figure 2.2: Installed capacity type expressed a percentage of the total [15]

2.4 Potentials of Renewable Energy Somalia

2.4.1 Solar

In Somalia's rural areas, access to modern electricity has been limited. Solar PVs for rural electrification are still prohibitively expensive, even though they are a viable solution with several benefits for rural people and the economy the price of solar panels has been dropping over the last five years due to innovation and market competition. The federal government envisions and indicates to the Somali people and investors its desire to assist and invest in solar energy consumption by homes, enterprises, and the public and private sectors through this strategy. Somalia absorbs a great quantity of energy from the sun each year due to its geographic location and climatic circumstances. Each location receives roughly 20 MJ m-2 of daily insolation and 3000 hours of sunlight on average Somalia receives average solar insolation of 5 m2 per day, resulting in a total energy capacity of 2,163 million MWh per year [16].

2.4.2 Wind

The wind speed ranges from 3 to 11.4 m/s. Mogadishu constructed four 50-kilowatt turbines in 1988, and wind power was also used for pumping. In the 1940s, the UN Trust Fund erected it in Somalia. The country has a wide shallow sea along its coast that is ideal for offshore wind power generation, and it is adjacent to some significant shipping hubs, like Mogadishu and Barbara According to the study, nearly half of the country's land area has sufficient wind speed for power generation, and 95 percent of the country's land area may benefit and gain from replacing diesel-fuelled water pumps with wind systems [17].

2.4.3 Biomass

In 1985, Somalia's forested sector accounted for around 39 million hectares or almost 60% of the country's total land area. These estimates have been significantly inflated because of overexploitation. According to statistics from 2001, forest coverage might be as low as 10%. In Somalia, strong and liquid biomass collection has enormous potential, although largely in the form of crop and animal waste, as well as aquatic biomass. Sustainable charcoal processing technologies will also play an important role in the globe since existing charcoal manufacturing has a considerable impact on the climate [18].

2.4.4 Hydropower

The Fanole Dam in central Jubbah, which was built with Chinese assistance from 1977 to 1982 at a cost of around $50 million, requires repair for irrigation and hydroelectric power generation. There was also a proposal to build the Bardheere Dam upstream of the Fanole Dam, but it was halted due to the civil war. Furthermore, according to a recent analysis by the Federal Government of Somalia (FGS) and the African Development Bank, there is significant potential for renewable energy across Somalia [19].

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