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Renewable energy homes generating as a sustainable solution to meet Libya's household energy needs

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Abstract

This study provides an overview of surplus energy-generating homes for integration with the public electricity grid and its potential for spatial development in Libya. With a special focus on the idea of a surplus energy-generating home, in addition to the study, the basic components of a solar home system are solar panels and the conversion of building glass panels into solar power generators. The performance of housing and its occupants, especially the sustainable development aspects. Then, research and present the most important proposals for the installation of home photovoltaic roofs that generate surplus energy as a guaranteed way to meet the home's energy needs, achieve economic and environmental gains for its occupants, and contribute to sustainable development.

Keywords: Solar system, grid integration, sustainable development, home photovoltaic roofs, Smart homes.

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منازل تولد الطاقة المتجددة كحل مستدام لتلبية احتياجات الطاقة المنزلية في ليبيا

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الملخص

تهدف هذه الدراسة إلى تقديم لمحة عامة عن مفهوم المنازل المولدة لفائض من الطاقة من أجل التكامل مع شبكة العامة للكهرباء، وإمكانية لتحقيق التنمية المستدامة في ليبيا. مع التركيز بشكل خاص على مفهوم المنزل المنتج لطاقة الذي يولد الطاقة الفائضة، بالإضافة إلى الدراسة، المكونات الأساسية لصنع النظام الشمسي في المنزل فان الجزء الأساسي من النظام الشمسي المنزلي هو الألواح الشمسية وتحويل ألواح زجاج المباني إلى مولدات للطاقة الشمسية. ودراسة أداء المساكن وشاغليها وخاصة الجوانب التنمية المستدامة، من ثم البحث وتقديم أهم المقترحات المقترحة لتركيب الأسقف الكهروضوئية المنزلية تولد فائض الطاقة كوسيلة مضمونة لتلبية احتياجات الطاقة في المنزل، وتحقيق مكاسب اقتصادية وبيئية لشاغليه والمساهمة في التنمية المستدامة.

الكلمات المفتاحية: النظام الشمسي، تكامل الشبكة، التنمية المستدامة، أسطح المنازل الكهروضوئية، المنازل الذكية.

INTRODUCTION

The residential sector is considered the largest sector consuming electrical energy, and despite the large variation in the rates of electrical energy consumption in the residential sector, an official in the Ministry of Electricity stated to the Libyan economic newspaper Sada that 51% of electrical energy is consumed in the residential sector according to 2022 statistics. The annual household consumption for the year 2023 is estimated at 41,430 terajoules, and the consumption of petroleum derivatives is estimated at approximately 331 thousand tons of liquefied gas, and 161 thousand tons of kerosene [1].

Libya is gradually moving towards clean energy sources and adopting renewable energies to reduce carbon emissions and meet the demand for electricity from sustainable, emission-free sources. In this regard, the country is reviewing its efforts on renewable energy projects within the Libyan Renewable Energy Committee. Libya uses different sources of renewable energy, which allows it to diversify the types of energy generated locally and provide decentralized electricity. The North African country aims to produce 22% of its electricity from renewable energy sources by 2030.

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Libya's reliance on fossil fuels for energy generation and its antiquated infrastructure make it difficult for the country to meet the rising demand for domestic electricity. The study looks at the possible role of renewable energy homes, or dwellings integrated with on-site renewable power generation and storage. A decentralized method of power generation is provided by renewable energy homes, which can improve household energy availability and security. They produce electricity locally by utilizing renewable resources like solar and wind, which lowers transmission and distribution losses. They also offer dependable backup power during grid outages when combined with battery storage. To meet Libya's growing demand for electricity, the energy sector needs to open the door to investment by local and foreign companies and tighten government procurement policies and long-term power purchase agreements for renewable energy developers. The Libyan government is discussing several projects with promoters aimed at reducing hydrocarbon demand and carbon emissions.
The government's plan for these projects goes hand in hand with developing access to electricity in remote areas of Libya. A small solar photovoltaic system, allows the consumer to produce energy from their home, and connect it to the public electricity distribution network so that they can export the surplus energy in their home to the public electricity grid. In Libya, the average daily solar radiation is relatively high, about 7.1 $kWh/m^2/day$ in the coastal plain region, and about 8.1 $kWh/m^2/day$ in the southern region. [2] [3]. Also, many local studies confirm the possibility of covering approximately 80% of hot water and heating loads using solar heating systems [4] [5] [6] [7].
The cost of a solar PV system in homes ranges from a minimum of 10,000 dinars up to 20,000 dinars, for homes ranging in size from 200 square meters to 300 square meters. These high costs that have not recovered for many years invite us to ask what incentive entices a citizen to pay between 10 and 20 thousand dinars to install solar panels in his home, and he does not expect to recoup these costs before 15 years at the very least. Domestic solar energy refers to all methods of converting solar energy into whatever form of energy we need to meet our daily needs inside the home. These applications can be solar photovoltaic (PV) systems, solar water heaters, or even solar cooling or heating systems, or even cooking or other systems .The essential part of a home solar system is the solar panels first, solar panels are panels that can convert light energy into electricity, and these panels come in different shapes and types, considering that they can be 6V, 12, or 24 [8].
Expanding the economic benefits of the God-given nature in Libya, expanding solar home projects, providing the necessary equipment for these stations, and trying to manufacture them locally to reduce the cost of building the stations, which are characterized by their high efficiency. Efforts should also be made to raise community awareness of the use of solar cells through various media outlets. Building a solar power plant, whether for investment or to serve projects and homes, can save a lot of money in the long run. The importance of establishing solar power plants is increasing due to the need for safe energy, especially in remote, mountainous, and desert areas of Libyan cities.

In addition to being a clean source that does not pollute the desert environment, it is known for its clean air. Considering the high prices of oil and gas, solar energy is cheaper than other energy sources such as oil compared to solar cells, which are known to last for 30 years.

In summary, the study also advises the necessary legislative and policy framework to encourage the use of renewable energy in homes in Libya. It investigates ways to encourage homeowners and deal with funding issues. It analyzes case studies of households that use renewable energy in other countries.

Libya's Electrical energy consumption

The electrical consumption in all sectors as shown in Fig.1 about 36% of Libya's total electricity production is used in the residential sector, with about 11%for hot water supply, about 8% for lighting air conditioning units use about 6% for the electricity generated 2.22% used for heating and 3.78% for cooling, and the retreat about 10% for driving other electrical devices.

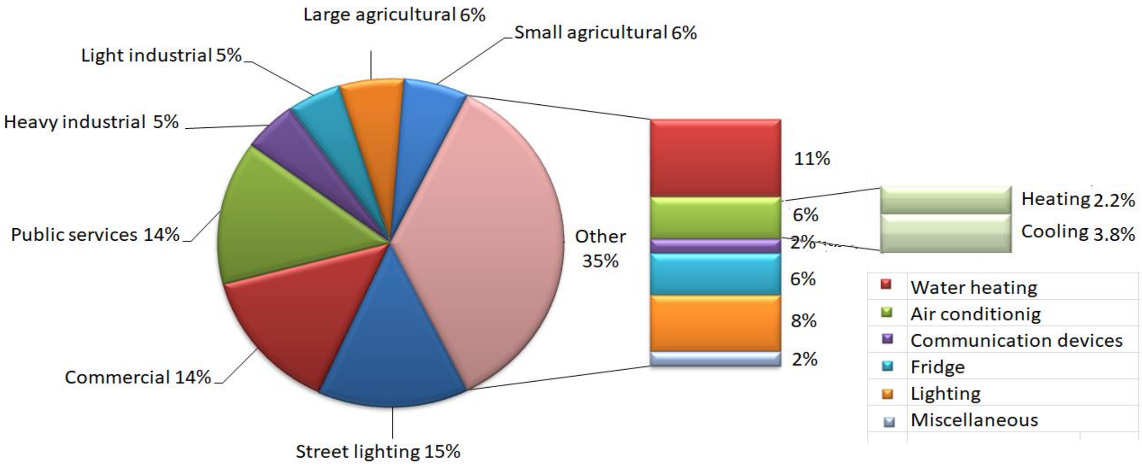

Figure 1 Electrical energy consumption breakdown in Libya [1]

Solar - Renewable Energy Libya's goal of generating 22% of clean electricity by 2030 is in line with the vision of the General Company for Electricity and Renewable Energy. Libya is working to optimize clean energy opportunities, especially solar and wind energy, with Libya currently producing 33 terawatt-hours of electricity. If Libya uses PV systems to harvest only 0.1% of the land area, it is possible to increase the output of its PV system by more than five times. However, it is difficult to change the structure of Libya's economy because it is built on oil and gas production. The country's government can increase its current revenue base with sustainable and renewable energy through proper investment and training. Using the renewable energy available in the oil-rich country region, Libya could meet all of its electricity needs and export most of its southern European neighbors' electricity needs if it builds solar power plants as in Figure 2 Libya can supply all of its electricity demands using solar power.

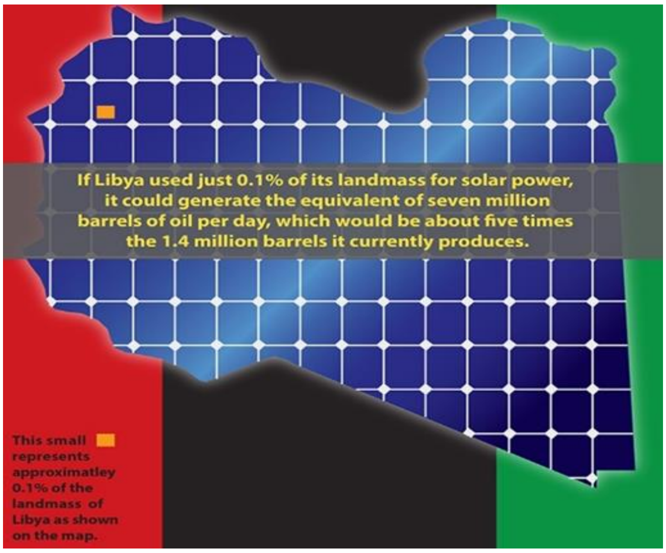

Figure 2 Libya can supply all of its electricity demands using solar power.

Solar central heating system, solar boiler, and solar water heating. Utilizing solar energy technology, thermal energy is produced from the sun's rays and utilized to heat water in solar tubes. Water vapor is produced by heating water in a solar boiler using solar energy. Thermal energy from the sun is used by a solar central heating system to heat water that travels via solar tubes and is then distributed throughout the house to give warmth as shown in Figure 3.

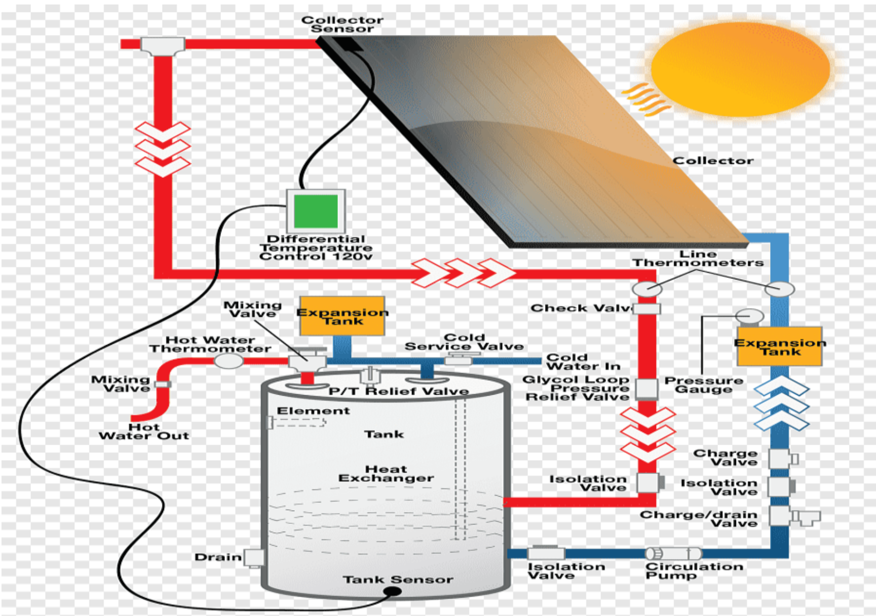

Figure 3 The solar power central heating.

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CONVERTING GLASS ON BUILDINGS INTO SOLAR POWER GENERATORS

PV panels can be installed into a building that has previously been constructed without PV integration, or they can be integrated into the upper façade of the building. It involves hanging or installing PV panels at various building locations. When photovoltaic panels are integrated into a building, they are used as building materials, which eliminates the need for additional space for installation while also producing the necessary quantity of energy from free solar radiation for the building's occupants [9].

Integrating solar cells into the building envelope is the process of developing an integrated photovoltaic system. The system is intended to reduce the need for fossil fuels, produce fewer gasses that deplete the ozone layer, save money on roofing materials and electricity, and enhance the building's architectural appeal. Compared to PV systems that need separate rooms and specialized mounting systems, building an integrated PV system is frequently less expensive. A collection of practical parts, including thin-film, crystalline, transparent, semi-transparent, or opaque solar panels, a charge controller, an energy storage system, power conversion devices, a backup power source, appropriate mounting and supporting hardware, wiring, and safety components, are needed to build an integrated PV system. We have made a name for ourselves in the market by combining fantastic features into a single system. If necessary, it can be linked to the national grid in case of inefficiencies, and the general configuration of the system is shown in Figure 4.

Figure 4. Integrating photovoltaics into the building envelope.

HOME PHOTOVOLTAIC ROOF INSTALLATION

The surfaces ought to be clear of obstacles and in good shape. You can check to see if your roof is well-lit and whether there are any obstacles in the way. Solar PV power plants are often better suited for installation on flat or sloped roofs. A flat roof is situated on a horizontal roof, and as Figure 5 illustrates, PV cells can be put at the optimal angle for maximum power generation.

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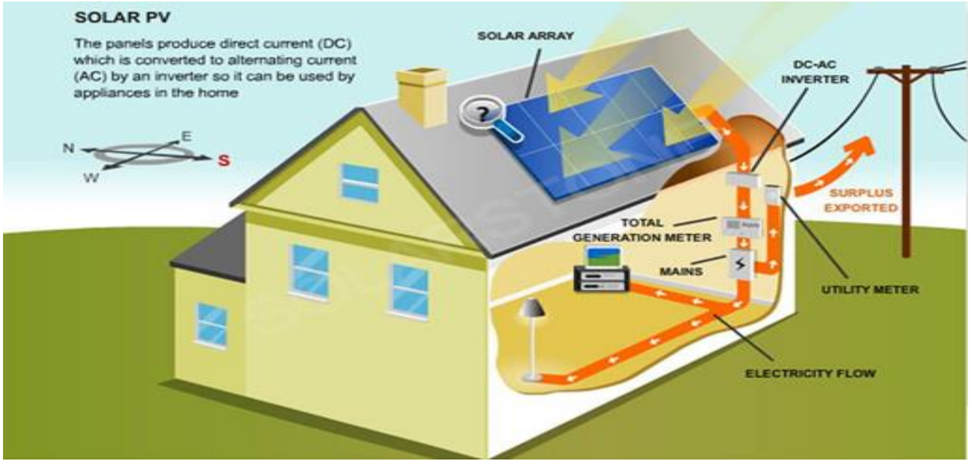

Figure 5. Home PV roof installation.

Thermal insulation and cooling are the main benefits of mounting a PV power plant on a flat roof. The temperature may typically be lowered by five to seven degrees, and it is supported by a photovoltaic system and a cement pavement. Investment costs are not very high:

a) A pitched roof solar PV installation is efficient and visually appealing, benefiting from the roof's natural slope for rainwater drainage and minimal maintenance. The roof's inclination eliminates the need for extra support or angle calculations and even allows for automatic cleaning .

b) PV systems can also be installed on sloped surfaces in homes and buildings, offering an affordable and sustainable energy solution with easy access to installation equipment .

c) For installation, the homeowner must own the roof, making it easier for independent houses than in shared apartment buildings where communal consent is needed for grid connection.

The number of solar panels that can be mounted on a residential building's roof A single-family home's rooftop area will determine how many solar panels can be installed on it for household projects ranging from 3 kW to 10 kW, depending on use. Of course, greater projects can be implemented if the area is larger and powerful solar modules are used. Normally, 3kW may be installed on a roof that is roughly 10 square meters in size. However, by modifying the design and layout and using high-power components, 3kW can produce 7 to 8 square meters of power.

GRID-INTEGRATED SMART HOMES

Smart homes have such substantial positive effects on the environment, society, and economy, that smart houses are now crucial parts of the smart grid in many nations. Smart homes assist consumers optimize energy use to lower costs and improve the dependability and efficiency of the power grid by enabling the scheduling of domestic appliances by

demand response programs implemented by energy suppliers. Additionally, lowering the generation, transmission, and distribution investments necessary to meet future electricity demand is made possible in large part by smart houses [10].
Advanced information and communication technologies, including Internet of Things (IoT) devices, smart appliances, sophisticated measurement infrastructures, and smart sensors, have come together to produce smart houses. The installation of residential energy management systems has made it possible for future smart grids thanks to this expanding trend as shown in Figure 6 [11].

Figure 6 Smart homes advanced information and communication technologies.

Grid-integrated home energy management systems have grown widely accepted in recent years and are now necessary for efficiently controlling electricity consumption in the smart grid. This has allowed for lower electricity prices and increased energy efficiency in both business and residential power systems. Control and communication technologies, which are essential to HEMS, continue to present numerous hurdles. Energy storage, renewable energy, and electronic power converter integration into energy management systems are some of the most urgent problems. These technologies allow for the rapid dispatch of control strategies across the grid and access to energy demand data. The size of coverage of communication networks in smart grid applications can be divided into two categories: three types of networks: wide area, neighborhood, and home a smart electricity meter that links several household appliances, sensors, displays, gas and water meters, renewable energy sources, and electric cars is an example of a typical network. For grid-integrated homes, all of these elements are controlled and monitored by an energy management system that keeps an eye on energy generation, storage, and consumption [12].
Through its smart meter, the centralized controller is linked to the utility network.

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Depending on the coverage region, data is gathered and stored in a database from several networks. The utility administrator receives the data gathered from various networks to assist in making decisions on various system characteristics, such as cost and anticipated load. The communication means used to categorize the communication technologies appropriate for mesh networks[13].

Each network-integrated home communications technology has pros and cons that are proportionate. For instance, power line communications connect customers to utility companies with an equivalent level of security to that of the Internet, but at a lower cost than wireless options. Because information is transmitted via AC power lines between the energy management controller and the connected home devices, it does not offer as high transmission rates as other alternatives. Power line connections perform best at data transmission rates of 4 to 10 Mbps, however wireless alternatives offer better connectivity at similar setup costs. Due to noise concerns, power line communications also have a lower data transmission quality[14].

The operational deployment of energy management systems in smart homes depends on the integration of energy storage systems, hybrid renewable energy sources, and power electronic devices in addition to communication technologies. Energy storage system integration is crucial for managing renewable energy sources in homes with grid connections. Through demand response systems guarantee the stability of intermittent power generation to deliver better power quality and energy efficiency. Currently in use are flow batteries, lead-acid batteries, chemical energy stores, and ultra-capacitors as energy storage system integration technologies [15]. To balance energy supply and demand when imbalances occur, it is vital to identify solutions because renewable energy sources, like wind and solar power, are vulnerable to weather fluctuations. By ensuring power consistency and dependability, intelligent battery charging and discharging systems can mitigate the volatility of renewable energy sources. While renewable energy plants can be used at any time to alleviate supply and demand imbalances and improve power system resilience, they will operate at full capacity to power smart homes during peak load periods [16].

PROPOSED TO INSTALL LARGE-SCALE SOLAR PROJECTS ACROSS LIBYA

In Libya, solar energy is one of the most promising forms of renewable energy. The temperature of the solar photovoltaic cell has a significant impact on how much electricity it produces. Libya's huge territory and diverse topography mean that the country experiences wide regional variations in temperature, wind, precipitation, and humidity. Consequently, rather than extrapolating findings from one area to the entire nation, this variation needs to be considered when evaluating the viability of solar PV systems.

This includes choosing the right PV technology in terms of electrical properties. Based on local climates, the study sought to determine the best places in each Libyan region for solar module installations. Based on meteorological parameters like temperature,

sunshine intensity, and other variables, the image would give a visual depiction of the precise locations that were determined to be the best ideal within each region .
The chosen sites would seek to optimize solar energy generating potential while accounting for local climate variations in each of the country's several regions. As shown in Figure 7, offering optimal installation sites at the regional level enables the planning of solar power development according to the circumstances existing throughout Libya's many geographic areas.

Figure 7 Solar project planning in Libya.

CONCLUSIONS

Utilizing Libya's plentiful solar resource to generate distributed renewable energy at the household level will greatly lessen the country's dependency on the erratic grid electricity and expensive diesel generators that power a large number of households at the moment. Grid-integrated houses maximize appliance consumption and electric car charging in home area networks, allowing users to make energy-efficient decisions without sacrificing comfort. To manage the power grid overall, including electricity prices, utilities can use large-scale networks to monitor high-tech home energy management systems. They can also use these networks to gain situational awareness of the grid and take preventative action when supply and demand imbalances occur. Subsequently, utilities can examine the best possible power flow and stability by using unified monitoring of households connected to the grid to avoid overloading and voltage or frequency instability in changing weather scenarios. Libya stands to gain significantly from a switch to renewable Libya will now be able to meet its future electricity needs through the use of decentralized distributed generating models and locally available renewable resources more sustainably.

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