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Стаття рекомендована до
публікації 29.11.2018 р.

UDC 005.8:005.59

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THE STUDY OF RELEVANCE FOR THE PROJECT OF DEVELOPING HYBRID SOLAR ELECTRICITY SYSTEMS IN URBAN AREAS IN NAMIBIA

The purpose of this article looks at the development of solar energy in Namibia based on project approach and how it can be utilized to lower electricity bills of the house owners in urban areas. The author analyzes the relevance of developing a hybrid solar electricity system in urban areas for example, Windhoek which have the highest electricity cost in the country. Fig. 1, tabl.2, ref. 27.

Keywords: solar energy, hybrid solar electricity system, technological advancement of solar energy, alternative energy solution, developing countries, urban areas, smart system.

Historical overview and modern state of Solar Energy in Namibia. The first historical development of solar technology occurred during the period of the 7th century to the 1200c AD. Its start with the magnifying glass that was used to concentrate the sun's light to make fire and light torches by the Greek and Romans [1]. Over the decades, technological advancement on solar energy have been evolving in many developed countries. Such advancement can be easily noticed in developed countries such as Australia, where residential houses are now moving to

smart system such as the solar energy battery houses which is fully supported by the government [2]. This is not the same for developing countries like Namibia.

Namibia is among the sunniest countries in the world with an estimated of 300 days of sunshine annually. There is an average of 3605 hours of sunlight per year (of a possible 4383) with an average of 9:52 of sunlight per day. It is sunny 82.2% of daylight hours. The remaining 17.8% of daylight hours are likely cloudy or with shade, haze or low sun intensity [3]. Even though the country has a favorable weather condition for solar energy, the country is still behind with the development of solar energy as an alternative energy source in the country.

The development of solar energy and policies in Namibia are based on the White Paper on Energy Policy of 1998 by the Energy Policy Committee of the Ministry of Mines and Energy [4]. The White Paper sets six strategic goals; effective governance, security of supply, social upliftment, investment and growth, economic competitiveness and efficiency and sustainability. Even though the development of solar energy was well developed in the White Paper, the usage of solar energy in Namibia dates back to 1993 when the first solar programmes was established when the Ministry of Mines and Energy (MME) launched a programme called the "Promotion of the Renewable Energy Source in Namibia", that was supported by the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH [5].

To stimulate the use of renewable energy technology, the government launched the first Solar Revolving Fund (SRF) under the Home Power Project [6]. This was a partnership programme between the Namibian government and the US Renewable Energy for African Development (REFAD). Now under the Ministry of Mines and Energy, individuals can get funding through SRF following renewable technologies [7]:

- Solar Home Systems (SHS);
- Photo-Voltaic Pumps (PVP);
- Solar Water Heaters (SWH);
- Energy Efficient Stoves (EES).

Off-grid solar system where established with the help of Rural Electricity Distribution Master Plan (REDMP), developed by the Ministry of Mines and Energy in 2000. In 2004, the Namibia Renewable Energy Programme (NAMREP) was launched to address the barriers experienced in the dissemination of renewable energy technologies [8]. The programme was divided into two phases;

1. Phase 1, was designed to address policy and regulations governing renewable energy;

2. Phase 2, was aimed to speeding the implementation of solar energy activities in the country.

To fast track, the off-grid solar system by the REDMP, in 2007, the Ministry of Mines and Energy launched the Off-grid Energisation Master Plan (OGEMP) [9]. This ensured that those areas where grid electrification is unfeasible will be appropriately developed based on solar energy technologies. Through the harmonization of the OGEMP, energy shops were opened through the Energy Shops Concept in 2011. This concept helped to establish energy shops from existing businesses with reasonable distance and also bring the services close to community members to access solar energies.

Hybrid Solar Energy System for Urban areas in Namibia as an alternative solution. To reduce the cost of electricity in urban area, this article introduces the development of Hybrid Solar Electricity System (HSES) integrated to the on-grid system. This means the system will interpedently work together with the on-grid electrical system provided by the City of Windhoek (municipality). We want to create a system whereby, the HSES will be deemed as the primary source of electricity in household, with the municipality grid used as secondary source when the solar panels

batteries are on low voltage. As a hybrid system connected to central monitoring system, the switch between the solar electricity and the on-grid system will automatically switch between each other depending on the availability of energy from solar system.

The current funding programmes available in this area of technology in the Namibia are such as the Solar Revolving Fund and Off-Grid Energisation Master Plan which both focused in rural areas for off-grid electrifications. The problem is they don't pay attention to the sky rocking prices of electricity cost in urban areas and the course of the price inflations. The influx of people to urban city in search of employment means the usage of electricity increases in these areas, meaning that NamPower the national organization mandated to provide electricity in the country needs to increase the importation of electricity from neighboring country and this increases the price to final consumers [10]. Implementing the Hybrid Solar Electricity System in urban area could be just the technological advancement which the country needs to reduce the importation of electricity.

Such technological advancements are vividly observed in Australia whereby they have transformed the system in Home Battery Houses powered by Hybrid Solar Electricity System [11]. According to the Clean Energy Australia reports, there are more than 2 million homes with rooftop solar panels and enhancing the cost saving of using solar electricity in the home as an alternative solution. More people are moving to hybrid system because they are tired of the high electricity charge from their utilities companies, and the environmental awareness they have about the clean energy that solar energy produces. But, just how does this system work, let's take a look how does the Hybrid Solar Electricity System work in practice. The diagram below illustrates the visual representation of hybrid system.

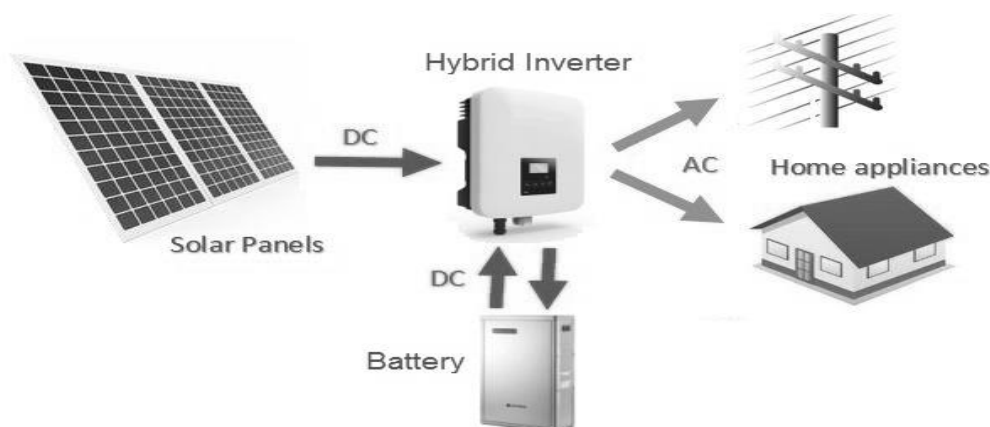


Fig. 1. Hybrid Solar Electricity System [12]

The system is designed to be able to use both electricity source, solar and utility company on-grid, which consist of the following components:

- Solar Panels: used to generate sunlight to solar energy through the use of Photovoltaic (PV).
- Hybrid Inverter: the heart of the system, which convert the DC energy to usable AC energy for home appliances; this also include a monitoring system.
- Battery system: this were the excess electricity is stored for use when there is no sunlight;

- Electricity grid: this is the wire which connects the household to the on-grid system of the utility company.

The work process of the system works that during the day, solar energy produced is simultaneously used in the house and also being saved into the battery system of the house. Once the batteries are at full capacity, the excess electricity is pumped into the national on-grid. Depending on the agreement between electricity provider, the excess electricity could be sold for a credit on the household electricity bill at the end of the month. This process is controlled through the hybrid inverter which has monitoring system software to monitor the inflows and outflows of electricity from both sources. If during the night the battery system is depleted, the system will automatically switch to the on-grid system which will supply electricity to the household appliance and will also charge the battery system, and will calculate the cost of inflows from the on-grid system. Those inflows and outflows of electricity from the on-grid system are reconciled at the end of the billing period to determine the electricity bill for the household.

This concept is widely being used by major Australia utility companies such as AGL Energy which is providing an inverter and battery package [13] and Ergon Energy is the leasing program [14]. This technological advancement is fully supported by the government and every state in Australia has policies aimed at increasing the usage of solar energy and solar battery. Under the Renewable Energy Target, the Australian government has two policy schemes which are the backbone of the Renewable energy in the country [15]:

- The Large-scale RET - supports the creation and expansion of renewable energy power stations;

- Small-scale RET - creates financial incentives for individual and small business to install eligible small-scale renewable energy sources such as residential solar panels.

Through those schemes the government wants to produce at least 20% of their electricity from renewable energy in the country. State and Australian government policies and programs are implemented in each state, whereby policies and incentives are developed to make sure that Small-scale RET are successful in the areas. Four states which are currently leading in terms of policy support in Australia are ACT, South Australia, Queensland and Victoria [16]. Their support is increasing the solar battery storage technology in the country, which is the part of the component to creating a Hybrid Solar Electricity System which can either be off-grid or on-grid system. As an example, the state of South Australia has an incentive program which provides finance for one of the most expensive components of the hybrid system, the battery. This program is called the South Australia's Home Battery Scheme, which provides a capped amount of \$6000.00 per system installed, and depending on the battery storage capacity [17]. Household owners are also eligible to add solar panels to the funding, if they don't already own a solar system in their house.

Benefits introducing Hybrid Solar Electricity System in urban areas in Namibia. The cost of electricity is one of the most expensive utility bills for urban area residents in Namibia. According to NamPower Namibia, the national power utility company in the country, the country imports 73% of electricity from neighboring countries like South Africa, Zambia and Zimbabwe [18]. The high rate of electricity importation has significantly increased the price for electricity in the urban areas of Namibia. Currently the rate for electricity in urban areas like Windhoek costs N\$1.44 per kWh for domestic consumers with a conventional meter through a circuit breaker capacity up to 20Amps, 25 up to 60Amps, and over 60Amps, while on the other hand, domestic consumers with prepaid meters supporting single phase all circuit breaker sizes cost N\$2.05 per kWh, single phase - pensioners all circuit breaker sizes cost

N\$1.44 per kWh, and 3 phase all circuit breaker sizes cost N\$3.03 per kWh [19]. This is 5% increase from the previous year tariffs.

The average wage income is N\$ 6 626.00 per month for one person, dividing that by two adults gives an average monthly household as N\$13 252.00 [20]. Household in urban areas spend between a maximum N\$1 987.80 of their average income on electricity bills which is about 15% of their total income. A high portion of income goes only on one type of bill while there are other expenses such as water and municipality fees of garbage collections also to be paid. Thus, there is need for alternative affordable electricity source in urban areas especially in urban area such as the introduction Hybrid Solar Electricity System. Even though we have policies and funds such as the Solar Revolving Plan and the Off-Grid Energisation Master Plan, the country is not fully utilizing the programmes and usage of solar energy.

High electricity cost is a depressing essential cost for urban area residents, and to make it worse, residents do not have any alternative energy supply since the provision of electricity is nationalized through national utility company NamPower and reach the final consumer through the City of Windhoek [21]. Since the supply of electricity in the country is nationalized, residents of urban areas have no alternatives source of electricity, and have not choice rather than pay the high tariffs impose by the national company.

Introducing this type of technological advancement does not only have economical benefits but also solve the burden of high tariffs to urban area residents. These benefits are outlined in the table 1 below.

Table 1

Economic and Urban Area resident benefits of introducing Hybrid Solar Electricity System

Government (Economic) Benefits	Urban area Resident Benefits
Increase the production of renewable energy.	Alternative source of electricity.
Reduce the burden of peak hour importation of electricity from neighboring country.	House owner will become both consumers and producers of electricity.
We will become self-sufficient in terms of electricity production.	Reduce electricity bills up to 50%.
Price of electricity will reduce by an estimate of 5%	Total control of their electricity inflows and outflows.
	Protection from sudden blackout and emergencies cut off of the on-grid system - there will always be power in the house.

The benefits of this system does not necessary means there are not downside of implementing the Hybrid Solar Electricity System. This technological advancement does not come cheap and its both an expensive investment for the government as well as the residents in urban areas. The intial cost of the system is high compared to the benefits. Even the current funding program within the Ministry of Mines and Energy the Solar Revolving Fund (SRF) will not be able to cover 50% of the initial cost of investment which only fund a maximum N\$50 000.00 [22]. Thus, new policies and funding schemes needs research by the governing body of the Ministry of Mines and Energy. The hybrid inverter and the battery system are the most expensive components of the system which makes up 60% of the total cost of the system [23].

From a global point of view, the production and disposal of batteries has an effect to both the environment and human. The manufacturing process goes through

photochemical reaction as they decompose in landfills which gives harmful greenhouse effect dangerous to the climate. On the other hand lead used in the batteries is harmful to human through inhalation and ingestion [24]. Thus, there is a need to install the battery system in a secured container and out of reach of children. And a recycle program should be implemented to make sure that proper disposal of batteries which has exceeded their lifespan is disposed in manner that it does not harm the environment.

Project Business Idea and SMART-Goal. Having describe the project and its benefits to the development of urban areas, with those information the author created the project idea and the SMART-goal as project instrument implementation tools for the Hybrid Solar Electricity System. As we all know, every project starts with an idea which is meant to solve a particular problem experience by people living in that environment. According to the Business Dictionary an idea is thought or collection of thought that generate in the mind, which is usually is usually generated with intent, but can also be created unintentionally [25]. In order to execute an idea, it is important to define the project idea correctly and outline the idea into solving the problem in the certain area [26]. In our case, the environmental problem experienced in urban areas is the high cost of electricity for household owners. The reason being that the country imports about 73% of electricity consumption from neighboring countries. The following statements outline the project idea of the introduction of the Hybrid Solar Electricity System in Windhoek.

1.Reasons of project initialization. Urban areas has sky rocking utilities bills, especially for electricity. Homeowner spend over 15% of their income on utilities bills and the biggest portion is electricity. This project is being created because the we want to help resident in Urban save their money by spending less on utilities bills.

2.The essence of innovative idea and method of a specific organizational problem solving. We have to create a hybrid system combining renewable solar energy with the municipal electricity grid. The innovativeness of the idea for this project is that, the controlling of the inflows and outflows of electricity between the solar electricity and the on-grid system is controlled by the hybrid inverter that is connected to the monitoring system. During the day, the system will allow the use of solar electricity in the house and to charge the battery system. Once there is excess electricity, the system will export this to the on-grid system as a credit to the house owner. During the night, if the battery system goes on low voltage, the system will automatically switch to the on-grid system to supply electricity in the house and will calculate the inflows from the grid. Those inflows and outflows of electricity from the on-grid system are reconciled at the end of the billing period to determine the electricity bill for the household. This system is estimate saving cost to house owners in urban area up to 50% of the bills

3.Project goal. To install a hybrid electricity system that uses solar energy in residential houses in urban areas.

4.Expected benefits from the project: lower the utilities bills of residential house in Urban area, especially the electricity bills; help low income homeowners save their money from paying expensive electricity bills; help the government to lower their importation of electricity from neighboring countries and save money.

5.Limitations of the project: government interventions; not having the financial investment to initiate the project; not creating a cost effective product that will be affordable to low income earners.

6.Assumptions and risks of the project: when the is not sun for a long time, people will use on-grid electricity which which will increase their bills at the end of the month; theft of solar panels residential houses; malfunctions of the hybrid electricity system.

The SMART-goal is used to give clear representation about the relevance of the project idea in urban areas [27] and is described below in table 2.

Table 2

SMART-Goal of the Hybrid Solar Electricity System in Urban Areas

Hybrid Solar Electricity System SMART-Goal
<p>Initial Goal: The goal of the project is to create a hybrid solar electricity system that uses hybrid solar inverter with a monitoring system connected to the solar panels and battery system to produce electricity in urban areas to reduce the cost of electricity in residential houses to less than 10% of household incomes. As a hybrid system, it will be connected to the on-grid system and house owners through the monitoring system can be able to inspect the inflows and outflows of electricity from solar panels and on-grid system. When there is excess electricity, the system will export this to the on-grid system as a credit to the house owner. The goal is to reduce cost of electricity to less than 10% of household incomes through the reconciliation of the outflows and inflows from the on-grid system. The global goal is to help the government with excess electricity into the national grid, which in return lowers the importation of electricity from neighboring countries.</p>
<p>Specific: The project is aimed at reducing the cost of electricity in urban areas, example residents of Windhoek. By the end of 2020, we want to launch the project into urban areas after a trial period of three (3) months on selected beneficial houses in Windhoek.</p>
<p>Measurable: The hybrid inverter and the monitoring system measure the inflows from the solar panels and inflows from the on-grid system. The excess electricity from the solar system is exported to the national on-grid system as a credit to the houseowner. At the end of the month, the inflows and outflows from the national on-grid system is reconcile to calculate the electricity bill of the household. Thus, urban area houseowners are expected to spend less than 10% of the household income.</p>
<p>Achievable: Solar electricity is a renewable energy free from the sun. The current solar system available in the market are off-grid system which are mostly in rural areas. All the materials for building the system are available in the market. We only need to add the hybrid inverter with the monitoring system, which will allow to manage the system and calculate the inflows and outflows from both the solar system and national on-grid system.</p>
<p>Relevant: The project is relevant in the market as it will significantly help urban area residents to lower their cost of electricity bills and its promoting the use of renewable energy in the country. This will also help the country to be self-sufficient as the excess electricity exported into the national grid, means the government will reduce the importation of electricity.</p>
<p>Time-bound: The first half of the year 2020, we need to create a piloting system to install the system into urban area, example in Windhoek in low-income houseowners. The information obtained from the piloting project will be used to get government support and get approval for mass installation in municipal house in urban areas.</p>

To conclude the SMART-Goal, we formulate it as following: To develop a Hybrid Solar Electricity SYstem using solar panels and a battery system connected to the national grid and used as an alternative electricity source for residents in urban area, example Windhoek. The excess electricity from the solar system is exported to the national on-grid system. Using the management monitoring system, the system will manage the proces of inflows and outflows from the solar system and the national grid system whereby at the end of the month - the system reconcile the two parameters to calculate the household electricity bills. Thus, we expect to reduce the urban area resident bills to less than 10% of their income. The piloting project will start in mid 2020 in urban areas of Windhoek to test the efficiency of the project idea into the market before the mass installation of the system. Milestone: Have a piloting project system by mid 2020. Deadline: End of 2020.

Conclusion. The development of solar energy and other renewable energy technologies in Namibia are well established in the White Paper of Energy Policy, but the uses of solar energy is not yet utilized to its maximum. Namibia has the potential to be self-sufficient in energy production if a large investment is put into renewable energy solution such as solar energy.

To implement the Hybrid Solar Energy System into urban area, government support and approval is needed. Currently our policies on renewable resource are aimed at off-grid system, but if we want to be energy efficient nations, we need to take a closer look to on-grid and hybrid systems. This research does not have a deep find on the cost of implementing such system in the country. Thus, research and development on hybrid system and on-grid system compiled and presented to the government in order to influence the finance of such system.

There certain barriers that will need to be addressed by both the government along with the private sector, which include public awareness institutional framework and financing. The successful use of solar energy will be based on elements such as financing, capacity building, and quality standards that are under threat from the absence of obligatory policies such as renewable energy regulations and the national integrated resource plan.

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Стаття рекомендована до
публікації 06.12.2018р.