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ASSESSING FEASIBILITY STUDIES ON SMART MICROGRID SYSTEMS: A GLOBAL REVIEW AND METHODOLOGICAL COMPARISON FOR IMPLEMENTING MICROGRIDS IN MALAYSIA

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Abstract:

This paper serves as a comprehensive review of past feasibility studies conducted worldwide on smart microgrid systems. The primary focus of microgrids lies in the generation of electricity using micro sources, such as micro-hydro, photovoltaic, or biomass gasifiers. These generated power is then distributed through low voltage networks, catering to a relatively small number of consumers. Malaysia, owing to its geographical location, possesses abundant renewable resources, making it highly suitable for the implementation of microgrids. The adoption of microgrids in Malaysia holds significant potential, offering numerous benefits to the nation and its residents. Prior to initiating a feasibility study within Malaysia, it is crucial to conduct a preliminary study to gain insights into the methodologies employed in previous studies. This review paper concentrates on comparing the methodologies utilized in various studies, including the feasibility study of microgrid installation in an educational institution with grid uncertainty, the feasibility study for 100% renewable energy microgrids in Switzerland, the feasibility study of a microgrid village employing renewable energy sources, the feasibility study for a solar PV microgrid in Malawi, and the feasibility study of microgrid applications in Langkawi and Socotra Islands. By thoroughly examining these studies, this review paper aims to identify the most optimal methodology for conducting feasibility studies on microgrids.

Keywords:

Microgrid System, Renewable Energy, Load Demand

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Introduction

The history of microgrids date back to the 1882s, where the first power plant constructed in the year at the Manhattan Pearl Street Station can be categorised as a microgrid since a centralised grid was yet to be established But the revolution of the electric service industry to a state-controlled monopoly market, incentives for microgrids were removed to power the nation with a more centralised energy system. As time passed on, there has been a positive trend around the world where the market for microgrids have risen tremendously. The industry players are coming to think that the microgrids or smart grids are more efficient than the existing centralised power grids around the world (Asmus, Cornelius & Wheelock, 2009).

The fundamental concept of microgrid is to generate electricity through micro sources such as micro-hydro, photovoltaic or biomass gasifiers and supply it through low voltage distribution networks to relatively small number of consumers. In any circumstances, a microgrid is very much capable to generate electricity locally and supply to a small community of people through a shared network distribution. This means the microgrid is completely independent from the national power grid network which is a centralised system to a nation. We can also say that the microgrid as a smaller version of traditional centralized electric grids.

The application of microgrid can be classified to two, either operates independently without the aid of central grid or operates parallel with the central grid. Both types of microgrids can cater people from small communities, individual buildings, manufacturing centres or military applications around the world. Microgrids are being used independently specifically in rural areas where the local communities do not have the privilege of the national grid supplying electricity to them. It is also the most cost-efficient way and energy efficient way to bring electricity to a small number of people in rural areas.

However, when connected with the main grid, microgrids serve different type of applications. Since there are frequent shutdowns of electricity or electricity disruption, microgrids are being used parallel with the central grid for energy security and reliability. Many industries require 24/7 electricity supply of electricity to operate efficiently and without any problem. If there is an electricity disruption, microgrids acts as a backup to supply the demand required (Schnitzer et al., 2014). Moreover, a microgrid serves as grid reinforcement when working with the national grid. It benefits the national grid by supporting supply during peak demand, local power quality enhancement by supporting voltage and reduce voltage dips, voltage regulation and power correction. Therefore, microgrid system can be used to solve the irregularity an uncertainty in the main grid to cater good electricity in terms of quality and quantity (A. H. Kasem Alaboundy, 2012).

Application of microgrids may aid us to tackle current issues in the electricity production system like the increasing electricity costs, the need for replacement of aging infrastructure, the improvement to the resilience and reliability, CO2 gas emission problem and rural electrification. Eventhough different nations focus on different issues of modern electrification system, microgrids are flexible and have the potential to tackle these issues and cater cleaner, a more efficient and cheaper electricity to consumer market (Hirsch, Parag & Guerrero, 2018).

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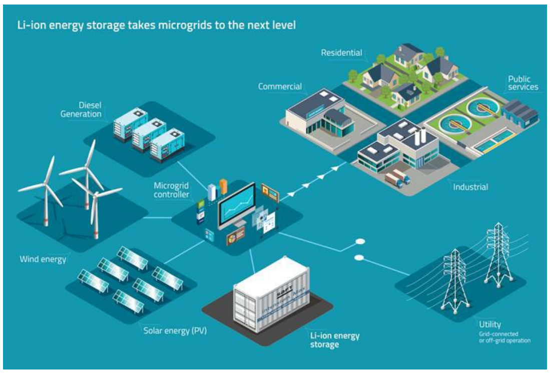

Figure 2.1: A Simple Microgrid Model

Source: Alternative Energy Stories, Videos, Articles, Interviews, Reviews & News | AltEnergyMag.com

Research Method

Feasibility Study of Microgrid Application in Langkawi and Socotra Islands

In the previous study named 'Feasibility study of microgrid application in Langkawi and Socotra Island' by Ahmed Haidar from University of Wollongong, the effects of using hybrid microgrid system in the stated places are being investigated. To select the best system that can be used in the locations in terms of efficiency, reliability and cost effectiveness, configuration of the best hybrid system is done by selecting based on best components and sizing with appropriate operation strategy. Both the islands data were used to determine the total net present cost for both the islands.

The load demand of both the islands were determined and was used as the main factor to calculate appropriate energy needed to be supplied. To achieve this the Homer program software was used. Using the software, different types of components such as solar PV panels(75W), wind turbine (0.6Kw), diesel generator(1kW), inverter or converter(45Kw) and a battery (2V, 600Ah) were mixed in different configurations to find the best system that can be compatible in the islands. 2 case studies were carried out, one with different loads and the second with same load to find optimal systems for both islands.

As a result, the optimal system in terms of total net present cost was selected for both islands. When similar loads are used, for Langkawi island, the optimal system would be wind-diesel generator hybrid system and for Socotra island, the optimal system would be the PV-diesel generator hybrid system. However, when different loads are considered, the optimal hybrid system for both the islands was the PV-diesel generator.

The results of this feasibility study will help in the future installations of renewable energy sources in the respective places with a best performance of hybrid systems and low cost. Moreover, a comparison was carried out on the annual yield of renewable energy with the cost of production by taking in to account the pollution caused by the system (Haidar, 2011).

Feasibility Study for a Solar PV Microgrid in Malawi

In this study named 'Feasibility study for a solar PV microgrid in Malawi' by Aran Eales, Lloyd Archer, Hannah Buckland, Damien Frame and Stuart Galloway discusses on the technical and financial feasibility of a solar microgrid in Malawi. The current electricity usage of Malawi is analysed first. The electricity use per capita of Malawi is 85kWh with a poor access rate of only 11.9% in 2014.Then site selection is carried out where factors such as

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distance to grid, population density, accessibility and economic activities are considered. From this, key inputs for system designing such as expected energy use estimation or load, ability, and willingness to pay, existing businesses activity and other informative social and demographic points can be identified.

Load profiles are for the expected energy usage is analysed. Then the solar resource data from NASA is used to investigate seasonal solar variation. This data is used to determine component specifications (size and cost) and helps in financial viability study. For this study a PV array, battery storage, inverter and auxiliary components are being used. Three case studies are done between small grid (2.5kWp) , medium grid (4.5kWp) and large grid (10kWp). An estimative distribution and supply network were mapped to obtain cable lengths and sizes for allowable voltage drop. The software Homer program is used to do a quantitative review of financial and technical ability. Through this, an optimal solution for local electrification is designed.

As a result, the net present cost of the proposed system is determined along with the levelized cost of energy for all three sizes of grids. With this, the project lifetime sensitivity, solar resource and temperature sensitivity and load growth sensitivity are determined. As a conclusion, the medium grid (4.5kWp) and large grid(10kWp) are found to be feasible in terms of affordability and cash flow. With this study, progress is expected to be made in the potential solar microgrid system in Malawi which could benefit and transform the lifestyles of rural communities (Eales, Archer, Buckland, Frame & Galloway, 2018).

Feasibility Study of Microgrid Village with Renewable Energy Sources

In the previous study named 'Feasibility study of microgrid village with renewable energy sources' by Emmanuel Loukakis and Emmanuel Karapidakis, an evaluation is carried on a remoted microgrid of Vorias village in the Crete island. First of all, a meteorological study was carried out to obtain the data of speed and direction of wind in m/s, the air temperature in °C and solar radiation in kWh/m2. This data was obtained from the RETScreen4 software and Hellenic National Meteorological Service (HNMS) and processed in Microsoft excel document.

Next, the Geographical Information System (GIS) was used to map potential wind and solar maps in order to maintain the reliability and security of the operating system. The ArcGIS 10.1 software was used for mapping purposes under linear and logistic functions. Through this process they were able to obtain information on geomorphology (relief and slopes) and elevation in order to meet the engineering and infrastructure design requirements.

Then, the load of the village mainly consists of household loads, industrial loads and agricultural loads were obtained through the Hellenic Electricity Distribution Network Operator (HEDNO). The renewable energy sources they focus on this study are wind turbines, photovoltaic panels and biomass generators are integrated with a storage system to store excess energy produced. Calculations were made by keeping in mind all the aspects that were gathered above.

This study aims to produce 100% independent renewable energy by considering the economic and environmental factors. With the calculations done, the design of the renewable sources was planned, and size of the operating system is determined (Loukakis & Karapidakis, 2017).

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Feasibility Study for 100 % Renewable Energy Microgrids in Switzerland

In the previous study 'Feasibility study for 100% renewable energy microgrids in Switzerland' by Sarah Barber, Simon Boller and Henrik Nordborg, twelve sites in Switzerland were chosen for a feasibility study of microgrid. This study is only done by involving 100% renewable energy which is the wind energy and solar energy (PV). This is due to the fact that the combination of each energy makes the system more constant in terms of coverage of energy production and more efficient.

For this study, the HOMER Pro software was used for technical and financial study of the project. A total of six steps were carried out to complete this study. Firstly, the site is chose based on wind speed, terrain, and nearby villages. Secondly, an analysis of resources was done by obtaining the solar radiation and wind distribution data for each site. Thirdly, the microgrid layout was done by designing the setup of microgrid and selection of components was done. Fourthly, the range of suitable load profiles for the selected sites were chosen. Fifthly, the most suitable optimisation algorithm can choose. Finally, the optimisation algorithm is run to calculate the optimal amount of PV, wind, and storage.

In this study, five sites out of twelve sites were found to be potentially economical for installation. The self-sufficient ratio (SSR) was found to be between 1 and 2 for all the sites, stating that extra installed capacity is required to supply electricity demand constantly in islanded operations. By halving battery capital for the combination of wind and PV, the Cost of Electricity (COE) can be reduced by 11%, number of wind turbines can be decreased by 1% and SSR can be reduced by 1%. However, by halving the wind turbine capital cost, the COE can be reduced by 30%, the number of wind turbines can be increased by 16% and the SSR can be increased by 16%. Not forgetting the capital cost of PV if halved, the COE reduces by 8%, number of wind turbines will decrease by 39% and SSR will decrease by 19%.

From this study, it can be found that the implementation of 100% renewable energy microgrid involving medium sized wind turbines is limited by the area required by the infrastructure of turbine and the total number of turbines that can be realistically installed. A feasible solution was found by undertaking a case study for an extension to a High-Performance Computing centre in Canton Glarus (Barber, Boller & Nordborg, 2019).

Feasibility Study of Microgrid Installation in an Educational Institution with Grid Uncertainty

The study named 'Feasibility study of microgrid installation in an educational institution with grid uncertainty' by Ashwin Kumar Sahoo, K.P. Abhitharan, A. Kalaivani and T.J. Karthik analyses the feasibility of wind and solar PV based microgrid installation in an educational institution in Chennai, India with grid uncertainty. This study is done by implementing a microgrid by involving available renewable sources like solar and wind.

First of all, the load details of the educational institution are obtained from the in-house substation and analysed. Both seasonal and yearly load profiles are obtained and analysed in this study.

Then available energy resources in the educational institution are determined. From the analysis, three energy resources which are solar PV, wind and diesel fuel were identified. A sensitivity study was done involving wind speed data, solar radiation level and diesel price.

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From the demand and resource validations, the suitable components which are 300Kw solar PV, 30Kw wind turbine, 50Kw diesel generator and convertors were selected and the cost of energy production is also calculated.

The software of HOMER Pro was used in this study with a goal to reduce diesel cost, carbon emission and increase the renewable energy usage by 50%. This software was used to do simulation of the system, where the results are helpful in design, analysis, and financial evaluation of a hybrid power system. The most feasible combination of renewable power sources, storage components and power conditioning components were able to be identified through this software.

Finally, an economic validity of the project against conventional power sources were determine d. The cost of energy (COE) was calculated based on the selected 10 wind turbine generators, 50kw diesel generators and 300kw solar PV panels. The percentage of source utilization for each resource were calculated and determined. Through this study, the requirements of design and system for total renewable energy usage to reach 50% is successfully determined (Sahoo, Abhitharan, Kalaivani & Karthik, 2015).

Improvisation and Recommendation

From all the feasibility study papers on microgrid application, we can see different steps are being carried out. To improve this, firstly, the site selection must be done to determine the terrain and topography of the location to ease the engineering and deigning aspect of the infrastructure of the microgrid system. It is also important to consider the renewable source available at the location such as solar, wind or hydro. Secondly, the data of renewable resources such as solar radiation, wind speed and stream flow rate must be analysed. Thirdly, the load demand of the focused location must be determined. The load profile data of peak demand and low demand must be analysed. Fourthly, the design layout of the project such as sizing, and component selection must be done to meet the load demand of the selected area. Fifthly, a suitable optimisation algorithm is selected. Then, we should simulate the efficiency and performance of different renewable sources along with the cost of energy production and compare them to obtain the optimal system for the microgrid.

From the review I have done, I can conclude that most of the studies use HOMER Pro software to do simulation and analytical work to obtain the best system for a preferred location. But some only focus on the technical part and do not focus on the economical part. Improvisation should be made where both technical and economical part should be given same amount of importance. This is because a feasibility report must not just focus on the technical part of the microgrid. The cost of energy production will play a huge role in order to determine the most feasible system that can be fixed in an area.

Other than that, we can see that some of the reports integrate unrenewable sources such as diesel generators in microgrids to obtain constant and reliable power. From my opinion, a microgrid should be run with 100% renewable energy to combat carbon emissions and to obtain clean energy. This will be very important for the far future when the natural resource of fuel becomes depleted, and the cost of fuel will increase. By only integrating renewable sources we can ensure the cost effectiveness of a project and also provide clean energy with minimal carbon emission. The reliability of a microgrid can be improved by increasing the power

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production at a time and by increasing the energy storage capacity of a microgrid for future usage and during peak load demand.

Conclusion

As a summary, microgrid have so many advantages and have high potential to be implemented in Malaysia. However, many aspects must be considered and researched before a microgrid system can be modelled and tested. Information such as the potential of renewable energy sources on a proposed location, load demand of the proposed location and component selection are key elements that are being researched before the design of a microgrid is modelled. Previous feasibility studies also play a role as they provide a guideline for us to model our own system in Malaysia. These studies also facilitate us in the simulation and feasibility analysis aspect of our system using the HOMER Pro software.

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