Review on Smart Micro Grid Power Management For Multi Renewable Energy Sources

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Abstract- *The world is facing an energy crisis, with limited fossil fuel resources and increasing energy demand. As a result, there is a growing focus on renewable energy sources that are both eco-friendly and sustainable for the environment. Solar energy has emerged as one of the most promising sources of renewable energy due to its unlimited availability and zero cost. However, while the potential of solar energy is immense, there are several challenges associated with its implementation on land. Land availability, land development, land acquisition, substation capacities, evacuation, and timely clearances are some of the hurdles that must be overcome for the successful completion of a solar project on land. Floating solar power plants involve solar panels and other components that are fitted onto a platform with hollow plastic or tin drums that enable it to float on water. This solution has several benefits. Firstly, it addresses the issue of land availability by utilizing water bodies that are often owned by the government. This makes it easier to acquire the necessary land for the project, and eliminates the need for land development. Secondly, floating solar power plants have a higher efficiency compared to land-based systems as they are not subject to overheating. The water provides a natural cooling effect, which improves the efficiency of the solar panels and increases the energy yield of the system. Thirdly, floating solar power plants also help to reduce water evaporation from water bodies, which can help to conserve precious water resources. In addition to these benefits, floating solar power plants also have a low impact on the environment.*

Keywords- Power Generation, Photovoltaic Cells, Floating Solar, power plant etc

I. INTRODUCTION

The exponential demand for energy has led to the depletion of fossil fuels such as petroleum, oil, and carbon. This, in turn, increases the greenhouse effect gases. Energy systems have incorporated small-scale and large-scale renewable sources such as solar, wind, biomass, and tidal energy to mitigate the fore mentioned problems on a global scale. Global energy demand will grow by more than a quarter to 2040, when renewable sources are expected to represent 40 percent of the global energy mix. The reliability of the renewable sources is a major challenge due mainly to mismatch between energy demand and supply. Renewable energy resources, distributed generation (DG), energy storage systems, and microgrids (MG) are the common concepts. The increase in the demand for energy and the rethinking of power systems has led to energy being generated near the places of consumption. In many cases these hybrid systems imply the highest reliability and lowest costs compared to systems with only one energy source. A microgrid consists of a set of loads, energy storage equipment, and small-scale generation systems. It can be defined in a broader sense as a medium or low distribution grid, which has distributed generation including renewable and conventional sources (hybrid systems) with storage units that supply electrical energy to the end users. The reliability of the microgrid is improved by the storage and it is used to complement the intermittency of the PV and wind output power. These microgrids have communication systems that are necessary for real time management. microgrids can also operate either in isolation.

Necessity

Electrical energy plays very important role in day-to-day life. Power management is a continuous improvement process for measuring, monitoring and improving electrical energy. The purpose of power management is to save energy, reduce the chance of outages and limit maintenance costs. This is not possible by only managing consumption (kWh). The quality of voltage and current is just as important here. Harmonic pollution, resonances and voltage dips significantly increase the costs in the modern installation. Discover what the four aspects of power management are.

Objectives

- Understanding The Global Energy Supply Systems and Their Interrelationship with the Environmental Problems.
- Evaluating The Renewable Energy Resource Potential for Different Resources and Sites.
- Analyzing The Current Technologies Used for These Resources Conversion to Useful Energy.

- Analyzing The Economics of These Conversion Methods at Micro- and Macro- Economic Levels.
- Evaluating The Environmental Impact of Current and Future Renewable Energy Systems.
- Planning And Managing of Renewable Energy Projects.

II. LITERATURE REVIEW

- **Fesli (2002) et. al.** worked on the realization of a hybrid renewable energy system for a domestic application, which ran under a microcontroller to utilize the solar and wind power. the batteries in the system were charged by means of a small alternator or solar power through a maximum power point tracking (MPPT) module. Real time control of the inputs and outputs was carried out by 3 current sensors and 3 voltage sensors in the system.
- **Tina (2006) et. al.** presented a probabilistic approach based on the convolutional technique to access the long-term performance of a hybrid solar-wind power system (HSWPS) for both stand-alone and grid-linked applications. In order to estimate the energy performance of HSWPS, the reliability analysis was performed by the use of the energy index of reliability (EIR) directly related to energy expected not supplied. Analytical expressions were developed to obtain the power generated.
- **Wang and Liu (2007) et. al.** proposed a web-based, real-time, monitoring and control system of a hybrid wind-PV-battery renewable energy system. The proposed hybrid system constituted a supervisory control and data acquisition (SCADA) system that employs campus network of the Cheng Kung University integrated with a programmable logic controller (PLC) and digital power meters. They concluded from their results that the proposed monitoring and control system can be effectively employed to various forms of renewable energy located in remote areas.
- **Ahmed (2007) et. al.** worked on power fluctuations suppression of stand-alone hybrid generation systems. The hybrid energy system they worked on combined variable speed wind turbine, solar photovoltaic and fuel cell generation systems to supply continuous power to residential power applications. The wind and photovoltaic systems were used as the main energy sources while the fuel cell is used as secondary or back-up energy source. Three DCto- DC converters are used to control the power flow to the load. Their results showed that even when the sun and the wind were not available, the system was still very reliable and available and it can supply high-quality power to the load.
- **Diaf (2008) et. al.** carried out a study to estimate the appropriate dimensions of a standalone hybrid PV/wind system that will guarantee the energy autonomy of a typical remote consumer in Corsica Island, with the lowest cost of energy (LCE). They also compared the performance and optimal sizing of two system configurations. From the results of their simulations, they concluded that the hybrid system is the best option for all the sites considered in the study because it yielded a lower LCE and higher system performance than PV or wind systems alone.

III. THEORETICAL DESCRIPTION

A microgrid is a self-contained grid that uses renewable energy, batteries for energy storage and generators to produce power. Microgrids can complement the national grid or work independently from it, providing communities with access to more sustainable and resilient energy supplies. With the latest technology innovations - such as 5G connectivity, IoT systems and AI - we can connect, monitor and manage the renewable sources and ensure a more efficient, reliable and sustainable microgrid infrastructure. The issue of solving climate change in general, is urgent, and it is also urgent that we help end fuel poverty. We have seen that electricity prices skyrocket, so decoupling that economic viability from fossil fuels is core to solving climate change and ending fuel poverty.

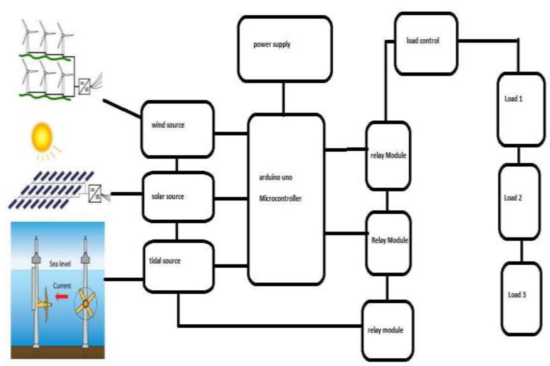

Fig. 1 Block Diagram of Microgrid

Diagram Consist an integrated arduino with a three-power supply Connected with the load Sources and relay unit During the normal operation supply fed to the load. In case of increasing load the relay module Senses increase or decrease in Joad and provide a command signal to the arduino which shift the load from one source to another source for the normal operation of system.

A. Microgrid Energy Management with Renewable Energy Generation

A microgrid is composed of different distributed generation resources that are connected to the utility grid via a common point. Figure 2 shows a microgrid energy management mode along with several features that are modules of human machine interfaces (HMI), control and data acquisition, load forecast, optimization

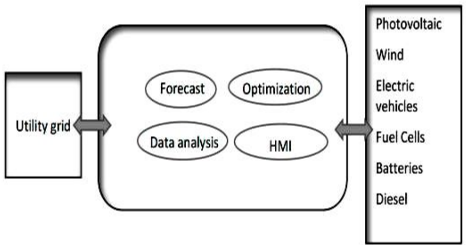

Fig. 2 Microgrid energy management

Many researchers have addressed energy management by implementing different approaches. However, all approaches have focused on determining the most optimal and efficient microgrid operation. The following sub-sections discuss and classify these strategies and solutions.

B. Energy Management Based on Linear and Non-Linear Programming Methods

Ahmad et al. presented a technical and economic method to optimize a MG based on mixed integer linear programming (MILP). This paper presents the advantages of programming the generation of distributed sources, managing the intermittency and volatility of this type of generation, and reducing load peaks. The cost function is solved via linear programming based on a general algebraic modelling system (GAMS). Simulations to optimize MG size are performed via software called HOMER. Taha and Yasser presented a robust algorithm based on a predictive control model for an isolated MG. The model incorporates multi-objective optimization with MILP, which minimizes the cost, energy consumption, and gas emission due to diesel generation in the MG. Sukumar et al. proposed a mixed method for MG energy management.

C. Energy Management Based on Dynamic Programming Techniques:

An energy management system for a MG based on dynamic programming and mixed-integer non-linear programming optimization. The MG is interconnected to the grid and decisions are made using the Bellman equation. Historical data are used off-line, while considering the power flow and battery storage as constraints. Using the algorithm in multiple MGs simultaneously is a feasible possibility. Almada et al. proposed a centralized system for energy management of a MG either in the stand-alone or interconnected modes. In the standalone mode, the fuel cell only works if the battery is less than 80%. In the interconnected mode, a 60% threshold is required to ensure reliable behavior. Wu et al.proposed an algorithm based on dynamic programming for the management and control of stand-alone MGs. The deep learning algorithm works in real time, which permits intra-day scheduling to obtain a control strategy for MG optimization, while sending information from local controllers within the framework of centralized management. Zhuo proposed an energy management system using dynamic programming to manage a MG with renewable generation sources and batteries. The objective was to maximize the benefits from the sale of renewable energy and minimize the cost required to satisfy the energy demand.

D. Energy Management Based on Artificial Intelligence Techniques

Elseid et al. defined the role of energy management in a MG as a system that autonomously performs the hourly optimal dispatch of the micro and utility grids (when interconnected) to meet the energy demand. In the above study, the authors used a CPLEX algorithm developed by IBM. Mondal et al. proposed an energy management model for a smart MG based on game theory, using a distributed energy management model. In this scheme, the MG selects a strategy to maximize its benefits with respect to the cost and adequate use of energy. Prathyush and Jasmín proposed an energy management system for a MG using a fuzzy logic controller that employs 25 rules. The main objective is to decrease the grid power deviation, while preserving the battery state of charge. Leonori et al. proposed an adaptive neural fuzzy inference system using an echo state network as a predictor. The objective was to maximize the income generated from energy exchange with the grid. The results showed that the energy management performance improved by 30% over a 10 h prediction horizon/period. De Santis et al. introduced an energy management system for an interconnected MG using fuzzy logic based on the Mamdani algorithm. The main objective is to take decisions on the management tasks of the energy flow in the MG model, which is composed of renewable energy sources and energy storage elements. The optimization was realized in a scheme that combines fuzzy logic and generic algorithms. Venayagamoorthym et al. proposed an energy management model for a MG connected to the main power grid. The MG maximizes the use of renewable energies and minimizes carbon emissions, which makes it self-sustainable.

E. Energy Management Based on Other Miscellaneous Techniques

Astaneh et al. proposed an optimization scheme to find the most economic configuration for a stand-alone MG, which has a storage system with lithium batteries, and considered different control strategies for energy management. The lifetime of lithium batteries is estimated using an advanced model based on electrochemistry to evaluate the battery longevity and its lifetime. Neves et al. presented a comparative study on the different objectives of the optimization techniques for the management of stand-alone MGs.

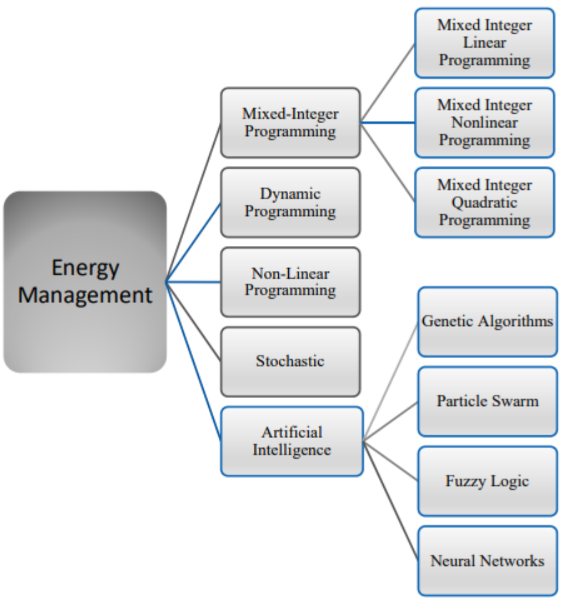

Fig. 3 Energy Management Methodologies In Microgrids

This approach is primarily based on linear programming and genetic algorithms. The results showed that the optimization of the controllable loads could result in an operating cost reduction and inclusion of renewable energies. Wei et al. proposed an iterative and adaptive algorithm based on dynamic programming to enable optimal energy management and control a residential MG. An optimal operating regime is developed for the hybrid system, followed by a study on the levelized cost of electricity (LCOE). Figure presents a summary of the energy management methodologies used for the MGs based on the above-reviewed literature. Different researches have proposed several methodologies related to energy management in MGs. Many methods are based on classical approaches such as mixed integer linear and nonlinear programming. Linear programming can be considered a good approach depending on objective and constraints, while artificial intelligence methods are focused to approach situations where other methods lead to unsatisfactory results, including renewable generation forecasting and optimal operation of energy storage considering battery aging, among others.

IV. PROJECT PROCESS

A. Project Design and System Configuration

As the first effort of its type, this project required more extensive investigation, design, and engineering than will be required in future projects.

- Team formation: At the peak of the process, more than 35 different parties collaborated to develop safe, feasible, and effective designs. Parties included electrical, mechanical, civil, and structural engineers, communication systems designers, fire safety, architects, battery and inverter manufacturers, contractors (general, solar, electrical, concrete, mechanical systems, others), OSHPD specialists, and two distinct university teams to coordinate with the design team for monitoring, communication, and control.
- Site characterization: The team evaluated site energy loads, electrical architecture, operational objectives, physical space constraints, OSHPD and non-OSHPD governed spaces, possible points of interconnection, site geology, structural versus non-structural elements, relevant national, regional, and local ordinances and regulations, and the stipulations of the serving utility, Pacific Gas and Electric Company.
- Design meetings: In addition to several site meetings to evaluate physical systems, the project team held virtual meetings with all stakeholders to ensure project progress, strict adherence to regulatory requirements, and compliance with site tolerances and objectives. A Technical Advisory Committee composed of all technical stakeholders provided additional commentary and recommendations to achieve project success.
- Microgrid engineering: Engineering representatives from the suppliers, contractors, facility, and consultants collaborated to determine systems sizing, controls goals, point(s) of interconnection, monitoring and communications architecture, fire suppression, and other systems. Additionally, the participation of OSHPD representatives resulted in a novel dual interconnection methodology to both the “normal” and life/safety branch of the hospital electrical systems.
- As shown in Figures the addition of microgrid equipment allows for multiple power supply options.
- During normal operation, the diesel generator(s) (“GenSet”) remain idle and disconnected while power is supplied from the utility across the main meter and the microgrid. When the utility energy supply is interrupted and power delivery is initiated from the generator(s), the manual transfer switch (shown as MTS in the figures)

may be repositioned to allow the microgrid to supply the entire life/safety branch load (“islanding” mode).

B. System Installation

Once the project team received approvals from the City of Richmond, Pacific Gas and Electric Company, and OSHPD, project installation proceeded in a mostly linear fashion, including the following key steps:

- Solar canopy: The SunPower solar canopy panels were erected on a steel canopy superstructure atop the hospital parking structure. Solar panels (250 kilowatts) were joined electrically to meet the direct current port voltage requirements of the single, centralized inverter.
- Battery/inverter room: Concrete block wall battery and inverter rooms were constructed for heat isolation and long-term battery performance. The solar panels and Samsung SDI batteries (1 megawatt-hour) were coupled to a Princeton Power Systems BIGI250 inverter.
- Central utility plant: Approved penetrations into the OSHPD-governed central utility plant were made to allow the dual interconnection specified in the design phase. Simultaneously, six specialized data acquisition devices called phasor measurement units were installed at critical monitoring points and connected to a secure, independent communications network to monitor systems performances.
- Microgrid controller: Microgrid controller resides in the computers that are resistant to harsh conditions. These computers were located onsite and at a control design facility for the purpose of systems regulation, remote access, and redundancy.
- Ancillary systems: The team installed fully independent fire suppression, DSL internet service, security, and environmental controls.
- Testing and commissioning: Charge Bliss developed testing and commissioning processes to evaluate the individual systems within the microgrid as well as the microgrid as a whole. As the core item in the direct current-coupled microgrid, the most time was spent on inverter commissioning and tuning.
- First, internal inverter controls were tuned to maximize the amount of solar energy. Second, communications and controls between the battery system and the inverter were verified through serial charging and discharging.

C. Microgrid Controller Design

The Charge Bliss microgrid controller was first remotely tested using real-time controller hardware in the loop simulation by the Nhu Energy, Inc. and Florida State University. Remote, specialized testing allowed the team to virtually eliminate risks inherent in new controller implementation in the real-world microgrid. The process also proved that control could be done locally but supervised and corrected from another location. The microgrid controller provides the external control capabilities for the inverter. The methodology is repeatable for other critical facilities.

D. Project Challenges

The first significant project challenge was the venue. The original host hospital declined to participate so Charge Bliss had to identify another suitable host site. The Energy Commission approved substitution of the Kaiser Permanente facility in Richmond, California with the other design parameters remaining the same. Interconnection is generally considered to be a major obstacle to microgrid development. In this case, well-engineered designs which sought to interconnect a system that was highly unlikely to export power, limited the requirements for utility investigation, systems upgrades, or other expensive or time-consuming processes. While pre-engineered, containerized battery-plus-inverter-plus-control systems are increasingly desirable, there may be no reasonable location for their construction at many facilities. In the case of Kaiser Permanente Richmond, none of the open parking lots, spaces next to buildings, or other areas were available for use. Moreover, bringing electrical lines above- or below-ground to the main power plant would have required complex, expensive, and potentially dangerous crossing of transportation routes and utility easements. Like many hospitals, the Kaiser Permanente facility has a multi-story parking structure which is owned by the facility and appeared to have adequate space for location of microgrid systems. However, the entry height of the main parking structure was too low to permit placing a shipping container within it. Therefore, the team had to design an entirely new block wall room for both the inverters and batteries as well as the fire suppression, heating, ventilation, and air conditioning, internet communications, and security systems that would otherwise have been included in a containerized system. Future deployments in the built environment will need to consider available space, height, depth, and weight allowances, and complexities of electrical connections to facility electrical systems. The design with a canopy array on top of the parking structure required additional structural and civil engineering to ensure that weight, wind shear, anchoring points, and other elements could be rendered safe to build such an array. The same design also allowed the microgrid systems to be located in proximity to the central utility plant for the shortest distances for electrical lines, which help balance additional expenditure for unexpected structural requirements.

V. BENEFITS OF MICROGRIDS

- Provide efficient, low-cost, clean energy
- Improve the operation and stability of the regional electric grid
- Critical infrastructure that increases reliability and resilience
- Reduce grid "congestion" and peak loads
- Enable highly-efficient CHP, reducing fuel use, line losses, and carbon footprint
- Integrate CHP, renewable, thermal and electric storage, and advanced system and building controls
- Make RTO markets more competitive
- Offer grid services including: energy, capacity, and ancillary services
- Support places of refuge in regional crises and first responders
- Use local energy resources and jobs
- Diversified risk rather than concentrated risk
- Using electric and thermal storage capabilities, a microgrid can provide local management of variable renewable generation, particularly on-site solar
- When properly designed, a regional power grid that combines both large central plants and distributed microgrids can be built with: less total capital cost, less installed generation, higher capacity factor on all assets, and higher reliability.

A. Microgrid Features

Microgrids are a growing segment of the energy industry, representing a paradigm shift from remote central station power plants toward more localized, distributed generation especially in cities, communities and campuses. The power to isolate from the larger grid makes microgrids resilient, and the ability to conduct flexible, parallel operations permits delivery of services that make the grid more competitive. By "islanding" from the grid in emergencies, a microgrid can both continue serving its included load when the grid is down and serve its surrounding community by providing a platform to support critical services from hosting first responders and governmental functions to providing key services and emergency shelter. Microgrids provide efficient, low-cost, clean energy, enhance local resiliency, and improve the operation and stability of the regional electric grid. They provide dynamic responsiveness unprecedented for an energy resource.

VI. CONCLUSIONS

As proposed, a smart microgrid test bed has been successfully designed, built, tested and installed in the UTA campus. Different technologies for future microgrid development have been identified, tested, validated and demonstrated based on this smart microgrid test bed. Different operation and control schemes to improve the reliability, efficiency and robustness has been verified and utilized based on this smart microgrid. An advanced control and operation system based on NI Compact RIO has been designed and installed for this smart microgrid test bed. Advanced protection system and operation schemes have been integrated into the control system. Further applications, such as high pulse power testing, have also been implemented using this microgrid test bed. This smart microgrid has already achieved most of the original goals for the DOE funded project 'Development of a Smart MicroGrid Tested'. Our group in UTA will keep exploring the microgrid related technologies utilizing this smart microgrid test bed to find a better solution for distributed renewable energy integration with microgrid to support future smart electricity infrastructure.

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