Optimal Energy Management of a University Campus Microgrid Integrating Solar Energy, Storage and Fuel Cell

Sowmya Bellam, Johann Espinosa and L. Isaac Marcia
Supervisor: Dr. Maryam Khanbaghi

Abstract

The usage of Renewable Energy (RE) has become a global priority for two major reasons: environmental impact of fossil fuel and its future scarcity. Intense research is being conducted on the integration of Renewable Energy Sources (RES) into existing power generation systems. One proposed solution revolves around the concept of microgrid. Microgrids are becoming increasingly popular combining multiple energy generation and storage systems to diversify and secure their private energy portfolios.

According to the U.S. Department of Energy (DOE) a microgrid is "a group of interconnected loads and Distributed Energy Resources (DER) within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate either in a grid-connected or islanded mode". A microgrid is capable of supporting a predefined number of loads but it is typically not designed to operate indefinitely without being connected to the traditional utility infrastructure.

The new generation of microgrids will not only be used for supplying backup power, but also a more complex configuration that contains all the essential elements of a large-scale grid such as the ability to balance electrical demand with sources, schedule the dispatch of resources and preserve grid reliability. In fact, these new microgrids will enable increased DERs utilization, limit greenhouse emission, improve local grid reliability and reduce operating cost. Moreover, driven by descending cost of DERs, microgrids are becoming more appealing for managing the variability of RE[1].

The objective of this work is to explore optimal energy management of a university campus integrating solar energy and fuel cell. Energy management system (EMS) of the university campus considered here requires to meet three requirements: 1) to satisfy campus load, 2) to use sustainable energy and 3) to minimize electricity costs. The campus electric power is provided by different energy sources. They are comprised of different type of roof-top photovoltaic panels (different size and efficiency), solar thermal systems and a fuel cell. It is connected to the local grid distribution system via two different transformers where each serves half of the campus. One approach for the campus EMS which will allow to meet the three requirements is to use the concept of microgrids. This means to revisit the campus energy sources and it's EMS.

For this work we envisioned the campus as two connected microgrids. Our goal for this two connected microgrids system is, at any point of time, each can be disconnected from the grid or the other microgrid. Managing both microgrids simultaneously by overcoming the intermittent

presence of solar energy and meeting the above-mentioned requirement is a challenging problem[2].

There have been many studies on energy management of smart buildings integrated with renewable energy [3] and EMS of microgrids [3]. Considering commercial spaces such as university/ office campuses are steady loads compared to residential loads, technically load forecasting would be easier in these cases compared to a random residential load.

We have performed load analysis and differentiated load according to the type of building usage. We combined lecture halls and dining halls power consumption since they have comparable load pattern. Similarly, student dorms and libraries load are combined together. Since university has several parking structures, we compared rooftop solar design with carport design. In terms of design, construction cost and efficiency, it was observed that carports would suit the requirements. In the design we therefore used carport design for most of the parking structures.

Using this new design improves usage of parking spots. The examined parking lots have very few shading losses, hence carports can efficiently draw energy. Also, location of examined spots are near to the lecture halls therefore, power can be distributed among the nearby loads. For roofs with good direction and less HVAC disturbances we used rooftop solar as well.

Hence, the focus of this project was on the usage of microgrids, their advantages and promote their usage in commercial spaces. Also, using these spaces can educate young professionals the importance of energy in today's world. The idea of building campus microgrids can improve the duck curve which could be advantageous to the utility and especially with increasing loads, this solution will help in not overloading the transmission lines.

Future work will include testing the analysis by considering the campus as two connected microgrids and can operate in islanded mode, use scheduling to understand the working and efficiency of proposed two microgrids model. Furthermore, analyze different types of fuel cells according to the on-site generation needs and storage. Fuel Cell will be considered as a backup generation source. Another important step in the future of this project would be sizing and integration of battery storage into the buildings on campus.

Reference

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