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# Energy savings approach to optimal location of EV charging stations in microgrids

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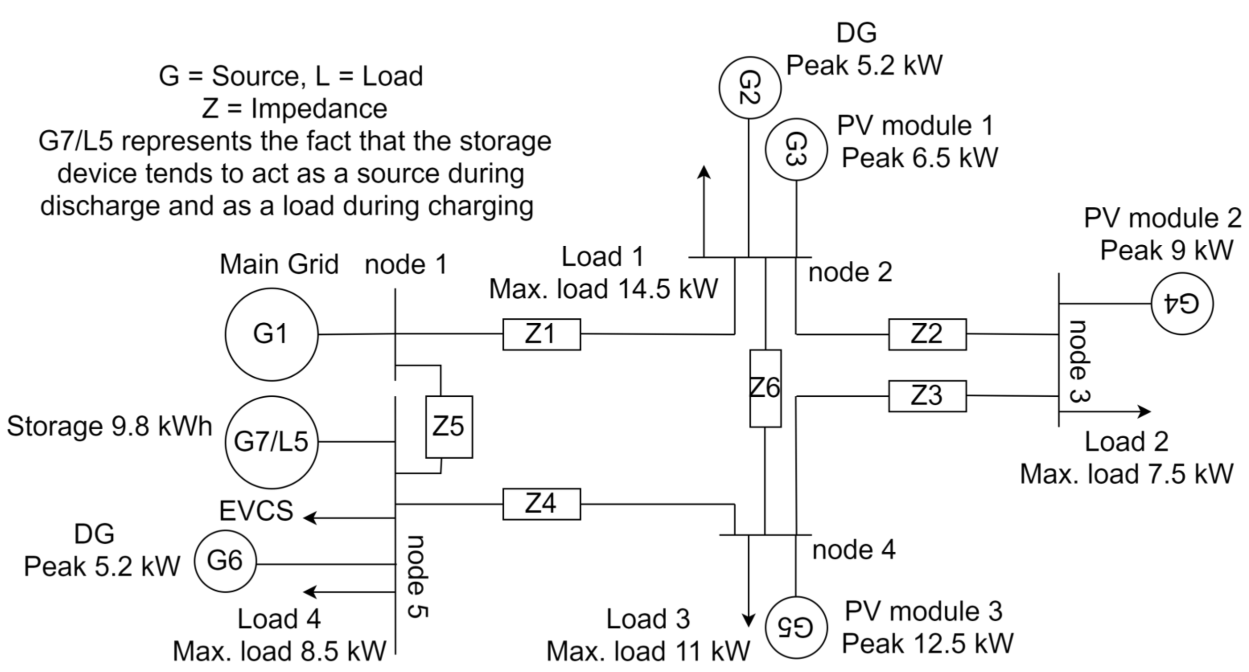
This paper presents an analytical approach to finding an optimal location for an EV charging station based on energy savings in a local microgrid. The analysis is carried out on days obtained by clustering yearly load data and by running an energy management system that runs on MATLAB interior point method. The microgrid is composed of both renewable and non-renewable energy sources. The charging station is equipped with a controlled charging feature and this study considers 2 EV charging strategies out of which the one benefitting the power system is adopted.

The layout of the microgrid.



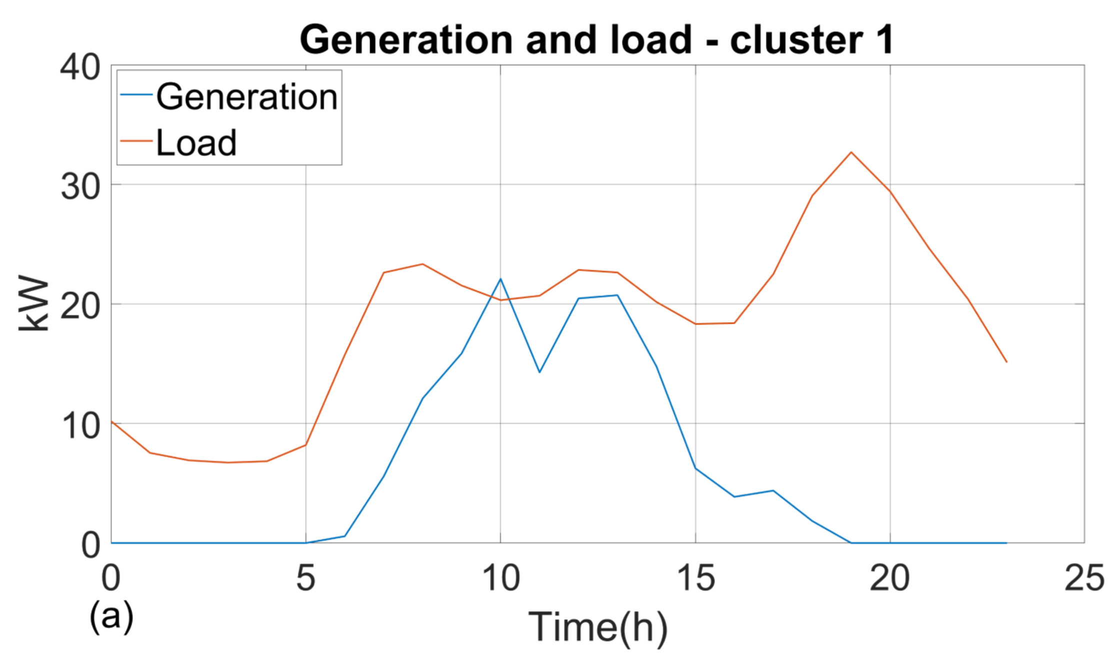

Firstly, the objective function of the Energy Management System (EMS), equality and inequality constraints are defined after which the mathematical model of the EVCS is defined.

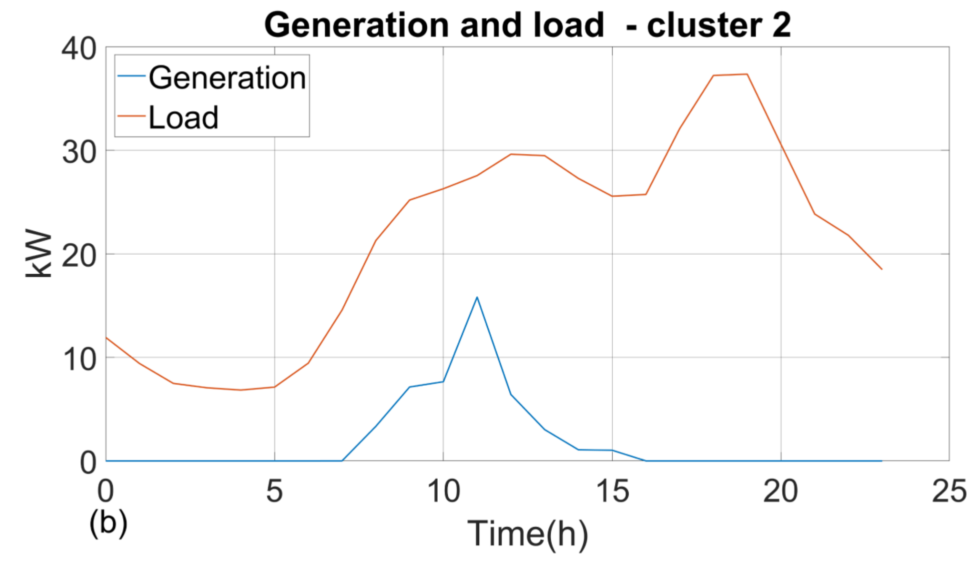
The objective function of the study is to minimize the import of power from the main grid.

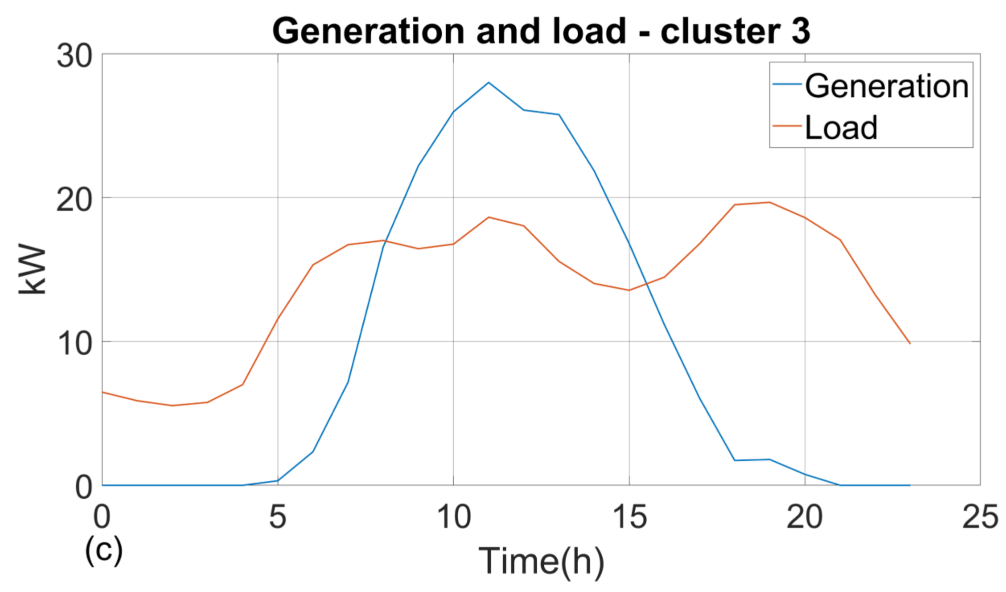
This particular objective function was chosen in order to study the dynamics of the system when all sources of energy in the microgrid are used at their maximum capacity. This is important because the university eventually plans to move to a microgrid that is stand-alone and not grid connected.

The energy management strategy algorithm can be found in the paper.

In order to have a wholesome picture of the dynamics of the microgrid in an entire year. The load data was clustered using the k-means clustering algorithm. This resulted in a total of 3 clusters around which all days in a year can be classified on.



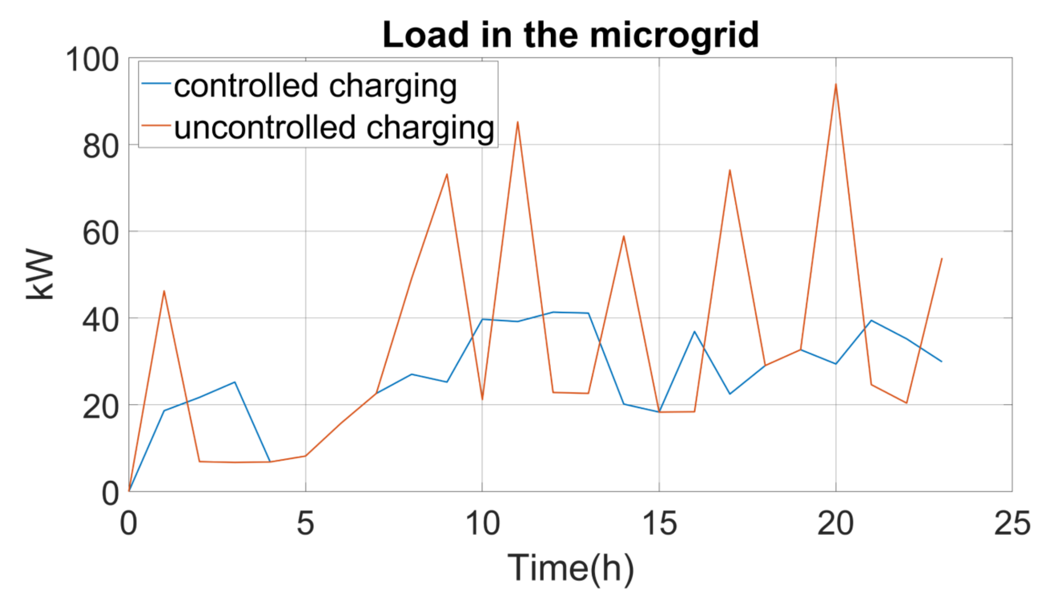




Cluster – 1 is representative of both the spring and autumn when both the power generated withing the microgrid and the load demand are somewhere in between their peak and minimum values.

Cluster – 2 representing the winter is a time period during which the power generated in the microgrid remains very low and the load very high. This is because of low availability of sunlight and the harsh winter during which heating devices are regularly used. During this period reliance on the external grid is high.

Cluster – 3 is typical for the summer wherein the power generated is very high due to high availability of sunlight. Moreover, the summer is quite mild which keeps the load demand quite low. The reliance on the grid during this time period is lower when compared to other time periods.

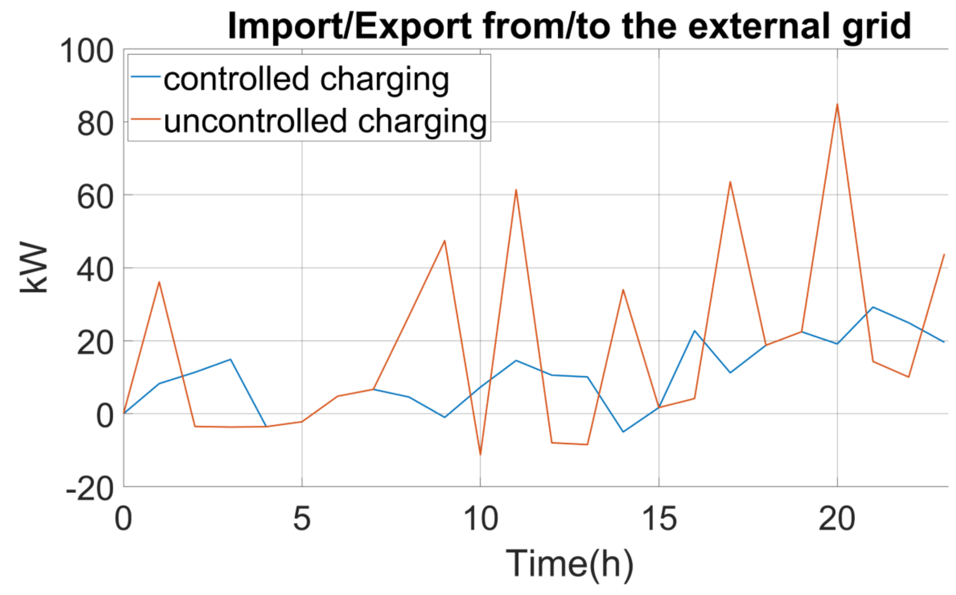
The load characteristic for the day from cluster 1 when controlled charging and uncontrolled charging are applied separately.

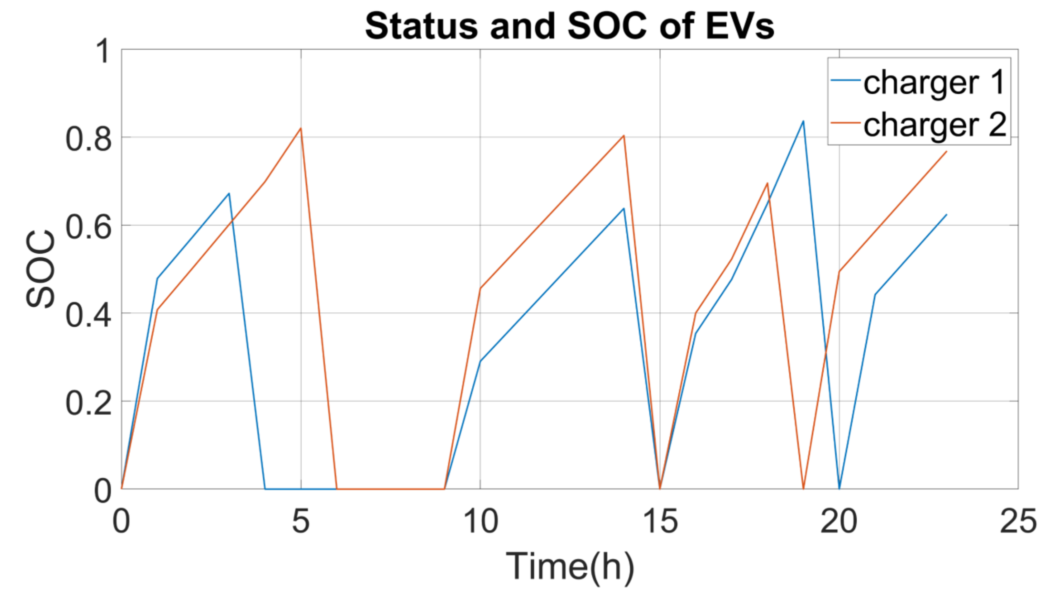



The load characteristic is affected significantly and is very stochastic with high peaks and sharp falls. Moreover, the frequency of such peaks and falls are high indicating that the power system is stressed during such an operation. On the other hand, when the charging is controlled the load curve is smooth which ensures healthy operation of the power system.

The next figure (left) shows the power exchange characteristic during the same time period and it can be seen that much of the power demand due to the uncontrolled charging is met by importing power from the external grid.

It is also possible to track the SOC of the incoming EVs during their charging process . Figure on the right shows the SOCs of different EVs being tracked at chargers 1 and 2 of the EVCS during the controlled charging scenario.




Both chargers were charged up to their desired inputs (maximum waiting time or time taken to reach desired SOC).

This paper presented an approach to optimally locating an EVCS in a local microgrid. The final decision on the location was based on an analysis of the energy savings observed by placing the EVCS on different nodes in the microgrid for days representing the whole year.

The uncontrolled charging strained the functioning of the microgrid. Moreover, it significantly increased the reliance on the main grid.