Popular Science Summary

Due to the ongoing climate changes, there is a global interest in removing society's dependence on fossil fuels. In Sweden there is a goal to have net zero carbon emissions by 2040. For a private energy consumer this means using more renewable energy to supply electric power and heat to their homes and using electric powered vehicles, instead of gas- or diesel-powered cars etc. In order to accomplish this, many different solutions are being proposed. One interesting proposed solution is to make the consumer become an energy producer by installing solar panels in their homes and buildings. Energy and construction companies have started to investigate and invest in local energy systems (LES) to help utilize the produced solar power within and between buildings, in order to maximize the efficiency of these solar panels and make them a more viable competitor in the energy market.

These LES's create an interesting opportunity, since the buildings share their produced energy between themselves instead of sending it directly to the external AC grid. Since the LES isn't directly connected to the AC grid, it would also be possible to run the LES as DC instead of the standard AC. Using DC in the LES would increase the efficiency since more and more of our daily energy usage and production is DC based, such as battery powered devices, heating and charging electric vehicles. DC devices being used today include adaptors to convert the AC voltage from a wall socket into DC voltage for the device, which causes unnecessary power losses.

These LES's will become more and more common in the coming years, as new residential areas are built with solar power generation in mind. Hence, it is interesting and important to see which type of LES would be best at using solar power. There are three main differentiating factors to look at, one is interconnecting buildings together locally so they can share their solar production between each other. Another area is the batteries, which are used to store excess solar production within the LES and finally, to use low voltage DC (LVDC) instead of low voltage AC (LVAC) to improve the overall efficiency of the LES.

A model of a real case LES has been developed assuming that all buildings in the LES will match their sockets with the LES's voltage (AC for AC and DC for DC) depicted in Figure 1. The model is designed on the information received from an owner of a building within the LES, where they plan to install 160 kW solar production and 45 kWh battery capacity.

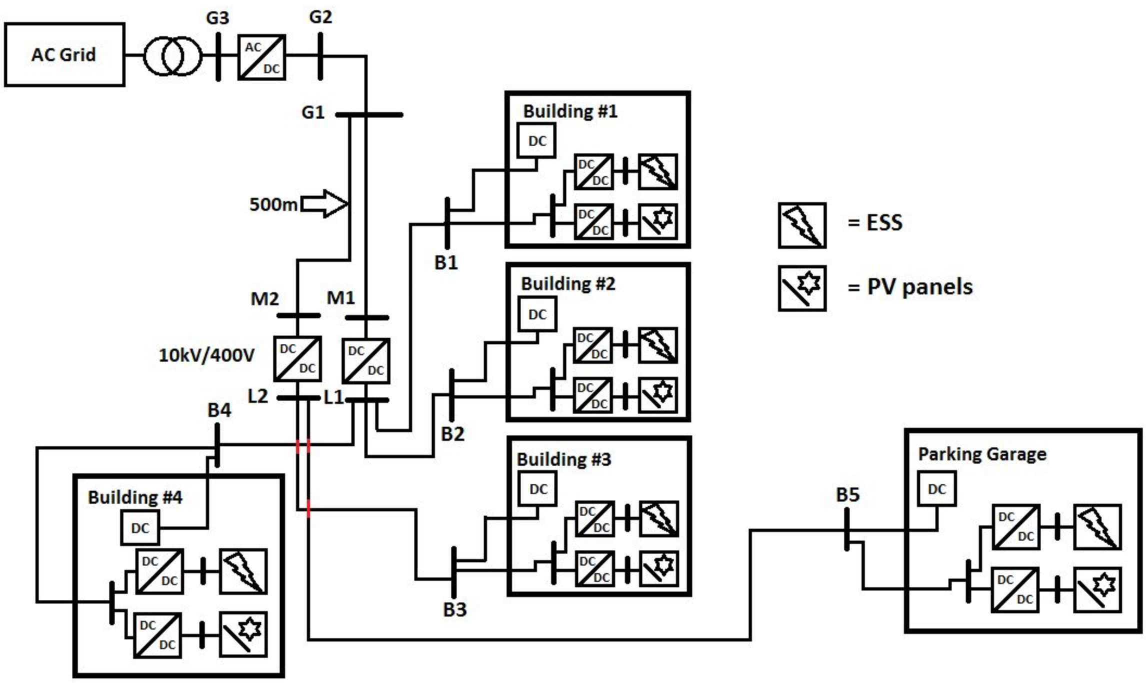

Figure 1: The model for the LVDC LES, including batteries (ESS) and PV panels (Photovoltaic, or solar panels).

The model input data is based on the energy consumption characteristics and solar production for one year. The model includes losses from converters and wires to give an accurate simulation of the power flow in an actual LES. The simulations showed that the LES had a 25% increase in self-sufficiency when switching from LVAC to LVDC and lowered the power demand from the larger AC grid by 1,6%. The self-sufficiency is how much of the LES load demand is covered by self produced solar electricity.

A best-case scenario for solar power usage was created by interconnecting the buildings and adding batteries to an LVDC system. When comparing the results from this case to an LVAC case, where none of these changes were made, showed the following improvements:

- As stated previously the switch from AC to DC increased efficiency by 1,6%.
- The self-sufficiency increased from 8,3% to 11,3%.
- The total yearly power demand from the AC grid was reduced by 3,5%.
- This case also fully charged all its batteries 242 hours per year, using only solar power.

From these results it was concluded that, from a technical perspective and in case of overproduction, using an interconnected LES is preferable compared to letting buildings sell their solar production to an external grid. The results showed an overall increase in efficiency and self-sufficiency when the LES ran on LVDC instead of LVAC and the LVDC LES makes better use of batteries than the LVAC LES. The interconnection of buildings in a LES and the addition of batteries both provided increased self-sufficiency. Hence, from a technical perspective, interconnecting buildings and using batteries is a recommended approach when designing a LES.

The results made it apparent that the solar energy production capacity and battery sizes that were specified for this case study were too conservatively chosen. Therefore, from a technical perspective, it is recommended to increase the solar power-and battery capacity to make the system more capable of covering the LES’s loads and thereby achieve higher self-sufficiency.