NanoGrid – A Path to Energy Efficiency and Renewable Energy

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Abstract

Energy sustainability and the aging grid infrastructure in the United States are two important subjects at the crossroads between politics, economics and technology. One proposed solution to these two issues revolves around the concept of an islanded microgrid. Microgrids are becoming increasingly popular combining multiple energy generation and storage systems to diversify and secure their private energy portfolios. In fact, with prices of consumer photovoltaic (PV) generation systems decreasing, the number of small-scale electricity generating households is growing steadily. Specifically, in California, where the weather is advantageous for solar generation, average citizens are installing PV generation systems at an impressive rate [1]. While this is a positive development that will help migrate energy production away from centralized fossil fuel plants by increasing the customers' control of their own electricity generation, many current household generation systems are not able to take full advantage of the electricity they generate. Households solely equipped with PV systems can only generate electricity when there is sun (daytime) and are forced to purchase electricity from the grid otherwise. Additionally, excess generated energy has to be sent back into the grid, instead of being stored for later use, which may negatively affect grid stability.

To circumvent this set of problems, several energy storage systems have emerged within the market that give households the ability to store self-generated energy for later use. With the increasingly common partnership of PV generation and battery energy storage systems, a household with both can be treated as its own microgrid system, capable of self-generation, storage, and only using a connection to the existing utility network when absolutely necessary. The major component of microgrid energy management systems is an efficient control strategy.

We chose to forgo the connection to the grid and instead utilize a proxy distributed generation source. We focus on small off-the-grid systems; more specifically residential homes. We will call these single home microgrids, *nanogrids* (nGrids). The assumption is that every nGrid will have a Renewable Energy Source (RES) such as rooftop solar panels, storage, and a sustainable clean energy generator such as a fuel cell. We made this decision not out of convenience, but to further support the reduction of fossil fuel consumption. This assumption also brings a few advantages. The control strategy:

- does not need to handle multiple loads and control competition for a shared resource,
- relinquishes power generation and distribution responsibilities from the public grid,

- provides the consumer complete control.

The objective of this work was to build a small prototype that emulate the behavior of the nGrid and test different control strategies. For this prototype, we built an autonomous electric car and used few lights to represent the house load. Two solar panels that can provide enough power during the day to meet the load, a chargeable battery besides the electric car and a DC generator that is representing a fuel cell, representing the generation to satisfy the load demand.

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Reference

[1] Residential Solar Statistics – California Solar Initiative (CSI), www.gosolarcalifornia.ca.gov