**3 Description of the Model**

**3.1 Background**

In an electrical grid system, power generation and consumption should be balanced at all times because an imbalance between them may lead to problems such as voltage fluctuation and power outage. Therefore, a grid system has been designed to have generation capacity greater than the maximum peak demand, which occurs no more than a few times a year.[1] The costs of meeting the peak demand have been significant as generators, transmission lines, circuit breakers, and transformers have been largely underutilized during off-peak hours.[2] The daily peak demand usually occurs around 5:30 PM, due to office use, domestic demand, and, in certain seasons, the fall of darkness.[3]

Our study first started with a conjecture that, along with the already existing factors mentioned above, simultaneous charging of electric vehicles(EVs) during evening hours would further raise the daily peak load. Although EVs only comprise a small portion of the automotive market at the moment, the sales of EVs have surpassed a million since their mass market began only five years ago.[4] Thus, we supposed that, in near future, our grid system will have to either increase its generation capacity or efficiently alleviate the peak demand in order to supply enough power required to charge hundreds of thousands of EVs everyday. The former proposal seems less ideal because it will lead to even more severe underutilization of facilities. The second option—alleviating the peak demand—secures higher grid robustness, the ability of a network to withstand an unexpected event without degradation in performance.[5] In a grid system that supports electric vehicles, a lower peak load induced by EVs directly leads to greater capacity to serve other unexpected demands. Efficient demand management can be achieved in a few different ways.

A smart microgrid, a modern and localized network, has been considered one possible solution because of its active decentralized management of demand. Unlike a traditional, centralized grid (macrogrid), a microgrid actively responds to locally collected demand information. Therefore, in this study, we have modeled a smart microgrid with EVs, which collects local power consumption information and determines when each of its member EVs should be charged.

**3.1 Objectives**

This study uses a mathematical model and simulation to analyze a smart microgrid with EVs. Our study addresses the following questions:

* How does the total power consumption of a smart microgrid change throughout a day? When does the peak demand occur?
* How and how much can this peak demand be alleviated?
* How and how much does the microgrid save total cost?
* How does the microgrid find its optimal solutions for grid robustness and cost reduction?

[1] Alt, Lowell (2006). [*Energy Utility Rate Setting*](http://books.google.com.au/books?id=RW3tycY4TToC). Lulu.com. p. 66. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [1411689593](https://en.wikipedia.org/wiki/Special:BookSources/1411689593). Retrieved 25 June 2013.

[2] Peterson et al., The economics of using plug-in hybrid electric vehicle battery packs for grid storage, Journal of Power Sources, 2010.

[3] Landsberg, Dennis R.; Ronald Stewart (1980). [Improving Energy Efficiency in Buildings: A Management Guide](http://books.google.com.au/books?id=M0EnqtFxW3cC). SUNY Press. p. 456. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [1438409990](https://en.wikipedia.org/wiki/Special:BookSources/1438409990).

[4] Jeff Cobb (2015-09-16). ["One Million Global Plug-In Sales Milestone Reached"](http://www.hybridcars.com/one-million-global-plug-in-sales-milestone-reached/). HybridCars.com. Retrieved 2015-09-16. U.S. cumulative sales since 2008 totaled 363,265 highway legal plug-in electric passenger cars through August 2015.

[5] Kott, A.; Abdelzaher, T. Resiliency and Robustness of Complex Systems and Networks. *Adapt. Dyn. Resilient Syst.* 2014, *67*, 67–86.