Smart Grid
Ensuring Robust Operation

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In the next few years, electric vehicles (EV) will be very widely deployed worldwide. In the United States two models have become commercially available within the past few months: Nissan Leaf and Chevrolet Volt. The rate at which these EVs are introduced into the population will have a significant effect on the Grid and by some analyses will absolutely require the resources of the Smart Grid. In December 2009 the Electrification Coalition, an organization led by influential business leaders including John Chambers, CEO of Cisco and Jeffery Immelt, CEO of GE, produced a document "Electrification Roadmap" that has had a significant impact on US policy.

The Roadmap called for 25% of light vehicle miles in the U. S. to be electric by 2020 and 75% by 2040. In order to accomplish this goal the recommendation was that the U. S. Congress pass legislation to have the Department of Energy establish 6 to 8 Electrification Ecosystems in large cities in the 2010-2013 time frame.

The Roadmap surveyed the situation in the world and reported that, at least 10, countries had policies that would support EV deployment. For example, Israel would like to have 10K to 20K vehicles per year starting in 2011, Germany would like 100K by 2020, and China has declared EV manufacturing as a strategic goal. The US Administration has set a goal of 1M EVs on the road by 2015. (This goal was reiterated in the President's State of the Union message on January 25.)

The State of California plans to become a leader in the EV market. Their analysis indicates that at the 1M PEVs would account for less than 1% of the total electricity demand. Although as indicated below local Distribution Transformers could be stressed.

The potential for this substantial amount of EVs coming into the fleet has utilities making preparations to accommodate this impact. Southern California Edison has a number of scenarios under consideration ranging from 200K to 1M EVs in their service area by 2020. Their preparation includes a schedule of increasingly sophisticated approaches to charging the EVs batteries. In the near term, this is primarily preparation. In the 2012-2015 time frame there will be an ability to identify discrete meters dedicated to charging batteries. In future time frames, SCE plans to include public charging with sophisticated methods to enable individual pay methods.

In preparing for the panel I researched in Xplore and the net and could find only one reference to the reliability of the electric grid. The reference was a presentation that analyzed a specific scenario and concluded that the life time of a distribution transformer decreases exponentially as the transformer load increases.

Most analyses of the impact of EVs on the Grid are scenario dependent. As more EVs come on line methods for alleviating the impact become important. One approach is based on local energy control where charging is based on individual residence loads that determines the time for charging. Another strategy is to base the time for charging on the total load by a set of residences e.g. 100-200. Either strategy can be shown to work in this scenario.

One of the most important researchers in this field is Saifur Rahman a leader in the IEEE Power and Energy Society. He and his graduate students at Virginia Tech have examined a number of scenarios with very interesting results. They show, for example, that for Level 1 Charging, a 25kVA transformer and the normal load from 3 houses that up to 3 PHEVs do not overload the transformer but adding on clothes dryer does overload the transformer. For Level 2 charging and the same scenario transformer overload could occur at 2 PHEVs. The conclusion is that Smart Grid strategies will be necessary to prevent catastrophic failure. This could be designed to use Demand Response. A PHEV charging circuit will learn that the transformer is close to threshold. This event will slow charging until another signal allows return to quick charge.

These scenarios indicate that there is a significant role for assessing the reliability of the Smart Grid in the presence of large numbers of PHEVs