Sensor/HAN Laboratory Roadmap

California Smart Grid Center, CSU Sacramento

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The California Energy Commission funded the creation of the California Smart Grid Center (CSGC) in June 2009. The mission of the CSGC is broadly to accomplish research, outreach, and education to assist the implementation of state energy policies. Two key sub-areas of that mission are to develop demonstration test beds for Plug-in-Hybrid and Electric Vehicles (PH&EV) and also for rate payer (both residential and commercial) electrical energy usage issues. This research will foster changes in electrical energy use that help promote electrical grid efficiency, reliability, and flexibility.

Task 4.2 PH&EV

Plug-in-hybrid and electric vehicles are disruptive technology to the existing electrical grid. Disruptive technology when adopted requires a system response that is often very different from the prior business as usual. Paraphrasing San Diego Gas and Electric's (SDG&E) Borrego Springs study, bringing home an electric vehicle is nearly equal to the power requirements of adding a new home to the neighborhood. The neighborhood power distribution system was most likely not designed with this potential increase of load. Whether the existing power system has the needed extra capacity and can handle this increase in load must be determined case by case. But the case is compelling that the nation needs to wean away from fossil fuels for transportation. Electric vehicles clearly break the direct link between fossil fuel and getting to work. Electric vehicles also represent the ability to transport people and goods by carbon friendly methods. However it cannot be assumed that burning fossil fuels in existing power plants that then charge electric vehicles will result in reductions in carbon released to the atmosphere. Hence we engage in one of the numerous inter-related discussions on smart grid efforts. Electric cars are truly green only if charged by green power generation.

All renewable energy sources whether distributed energy resources near the load or large transmission level generation are dependent on some aspect of nature such as the sun shining, the wind blowing, the river flowing, and so on. The balancing act is to match low carbon footprint power generation to the time of day based power needs of the energy consumer. Pun intended, this is where the rubber hits the road.

Research Plan: Assumption: California electric vehicle roll out starts in 2011 with California sales volume estimated to be below 20,000 cars per year through 2015.

1. Discuss PH&EV roll out plans with utilities, automotive manufacturers, governmental agencies and other stake holders. Determine the volume expected, the timing of the electric vehicle sales, and the likely geographic regions expected to adopt these vehicles. Timing: 2011 to 2012
2. Research the proposed and implemented standards (such as SAE J1772) applied to vehicle charging. Timing: 2011 to 2013

3. Determine the local (northern California) and regional (California) impact of vehicle charging. Timing: 2011 through 2015
4. Devise charging strategies and test hardware that minimize the peak power periods. Timing: 2011 to 2015
5. Inform and educate adopters of electric vehicles on how vehicle operation and charging might have significant consequences on the power grid and their power costs. Timing: 2012 to 2015

Work Started: Fall 2010 and Spring 2011.

1. An undergraduate senior design team is incorporating the SAE J1772 standard in a charging monitoring system. Charging in relation to grid status and feedback to vehicle user is part of their design idea. J1772 Charging wand system bought as part of the project for demonstration purposes.

2. Two undergraduate students were hired December 2010 for the purpose gathering, evaluation and disseminating existing research on PH&EV. See the month report for specific activities.

Task 4.3 Residential and Commercial – Home Area Networks (HAN) and Sensor Networks

Despite considerable media attention to energy policies and potential energy shortfalls, the average electrical consumers seem only slightly concerned over their energy future. It is virtually inevitable that all rate payers will see a change to time of day pricing for their electrical energy. The timing of this change will depend on when the political will emerges but definitely when fossil fuel resources reach pricing levels that make renewable energy sources cost competitive. If climate and global environment husbandry issues carry the political tide, the change to time of day billing may occur much sooner. Those unwilling to reduce power usage will most likely see an increase in their utility bill. Others will be enabled to use energy over the daily cycle in ways and manners that minimize the impact on their energy costs. The vision of the sensor lab is then to have strategies and systems available before they are absolutely needed.

Research Plan: Assumptions: Advanced Metering Infrastructure (AMI) will be in place locally (northern California) by 2012. Automated Demand Response will see movement from pilot projects to larger power users by late 2012. Residential demand response is at least three years away.

1. Establish Smart Grid Home laboratory. Room 3001 in Riverside Hall is about 1,100 square feet and, in August 2010, was dedicated to residential and commercial smart grid research. The lab has been outfitted with basic equipment and is currently engaged in preliminary research on building to grid sensors. Research grade power monitoring equipment has been acquired and is expected to be installed in parallel with a revenue

grade AMI meter (SMUD style Landis+Gyr meter) in RVR 3001 by January 2011. AMI meters, provisioning software, data aggregators and wireless equipment will allow the lab to complete a Grid to Home link. Timing: 2010 to 2011

2. Identify the issues associated with HANs and sensor networks and then test systems to give feedback to consumers. The CSGC and SMUD are in the early stages of forming a partnership for the functional testing of home based devices useful in the *Utility HAN* as it is frequently called. This testing is proposed to occur over almost three years during which time vendors should have launched many new products aimed at this market. Thus in cooperation with utilities, vendors and energy policy agencies, the lab will examine the HAN environment and research the interoperability and practicality of wired and wireless systems proposed for residential energy users. Compile a tool set that enables residential consumers utilize energy more efficiently. Where appropriate promote the use of HAN network devices to include Utility HAN aware appliances. Timing: 2011 to 2013
3. Determine and document how to configure, install and commission sensor networks similar to building to grid in both new construction and retrofit applications. Timing: 2012 through 2015
4. Devise sensor, instrumentation and communications strategies that nearly autonomously determine the energy profile of a building. Then apply those strategies to developing control algorithms that can predict energy usage for some hours to days ahead outlook. Integrate some limited capability to communicate with existing SCADA, and energy management systems (EMS) currently in use in commercial buildings. Timing: 2012 to 2014
5. Compile a tool set that enables residential consumers utilize energy more efficiently. Where appropriate promote the use of HAN network devices to include Utility HAN aware appliances. Timing: 2011 to 2013

*Work Started***:**

1. Sensor Lab infrastructure Fall 2010. An existing laboratory was reworked into a sensors and instrumentation lab (Riverside 3001). The lab was equipped with tables, computers and support equipment useful for rapid prototyping and device testing. Five dedicated project work tables were configured with useful test equipment such as power supplies, function generators, multimeters, and oscilloscopes. Four computers were provided by the EEE Dept and the IT group of the ECS College into which were installed data acquisition hardware and LabView software.

2. IT Infrastructure Fall 2010. A research grade local area network was installed that links the sensor lab (RVR 3001), the power lab (SCL 1102) , the energy lab (SCL 1357) and the ECS College data center (RVR 2011A). The LAN hardware will take most research related traffic off the ECS network and also allows for cyber testing of all current protocols. Servers in the data center dedicated to smart grid research received 4 TBytes of hard drive storage.

3. Wireless sensor network Fall 2010. Zigbee wireless sensor nodes were purchased from National Instruments. The NI Zigbee nodes are based on 1.0 of the standard. These sensor nodes permit the development of sensors without a need for integrated wireless components. The sensor nodes themselves permit device characterization to include signal power, propagation characteristics, and hardware layer testing.
4. Sensor data storage was addressed in hardware by the IT infrastructure. Data retrieval and data mining has been initially enabled by the Pi software system donated by OSIsoft.
5. Five undergraduate projects were started in the Fall term that examine some aspect of the sensor and instrumentation goals of Building to Grid (B2G).

Relevant Grant Tasks:

Task 3.3 Ongoing Operations:
The contractor (CSGC) will develop future research plans to ensure continuation of long-term attention to smart grid research and funding partners other than the Energy Commission.
Review of activities (tasks, goals, objectives, research outcomes, deliverables, and status).

Task 4.0 Smart Grid Demonstrations
Develop demonstration test beds in …..
Plug-in-Hybrid and Electric Vehicles (PH&EV)
Residential and Commercial – Home Area Networks and Sensor Networks

Task 4.2 Plug-in-Hybrid and Electric Vehicles (PH&EV)
Conduct literature search on PH&EV issues associated with use [sic] on the distribution system.
Work with the UC Davis PHEV Center and the California Utilities to identify additional issues associated with PH&EV use at the distribution level.
Prepare a report documenting the identified issues.

Task 4.3 Residential and Commercial – Home Area Networks (HAN) and Sensor Networks
The goal of this task is to design and test Home Area Networks (HANs) for residential and sensor networks for residential and commercial buildings.
The Contractor (CSGC) Shall:

- Establish a Smart Grid Home laboratory within existing facilities at CSUS to test smart new and emerging energy devices
- Assess the needs and potential tools for consumers to make intelligent choices to control their energy use with HANs and sensor networks

- Work with Center for Information Technology Research in the Interest of Society (CITRUS), i4Energy Centers, and the California Utilities to identify additional issues associated with HANs and sensor networks
- Survey tools and compile a tool set that enables consumers to conserve energy and reduce their energy bill using Home Area Networking
- Match HAN tools with Utilities Demand Response offerings to design networks that maximize the incentive to use HAN tools and expand the consumer's choices.
- Test, at the Smart Grid Home laboratory, systems that enable a wide range of feedback to consumers on the impact of their behavior on energy consumption
- Test, at the Smart Grid Home laboratory, technologies that provide a bridge between utility advanced metering infrastructure and customer premises networks
- Determine and document how to configure and install sensor netowrks in both new and retrofit applications

Deliverables:

- Subtask report
- Demonstration report
- Behavior report
- Report on the use of HAN tools
- Report on HAN design optimization
- Report on sensor networks