Solar-Powered Charge Stations: LCA Thinking

E. Chan[1], L.E. Erickson[1], T.K. Boguski[1], B.A. Leven[1], B. Natarajan[1]
[1]Kansas State University

Introduction

Dependency on foreign oil puts the United States economy at risk and fuel combustion for transportation in the country pours an estimated 1,745 million metric tons of carbon dioxide into the air each year, about one-third of total U.S. greenhouse gas (**GHGs**) emissions[2].

Introducing plug-in hybrid electric vehicles (**PHEVs**) and electric vehicles (**EVs**) can potentially reduce dependence on foreign oil, and introducing more charge stations can help them penetrate the automobile market. Sales for hybrid EVs (**HEVs**) rose steadily during the 2000s, then sharply shrank in light of the 2008 economic crisis[6]. Sales numbers are recovering, but 2011 HEV numbers are still below that of 2007. Providing a wide availability of public charging stations for EVs is expected to encourage their market potential, even after the sales numbers recover.

Further, life cycle assessment (**LCA**) shows that drawing energy for the charge station from photovoltaic (**PV**) technology is the most effective option.

Project Plan

A multidisciplinary team of researchers and educators at Kansas State University is embarking on an effort to develop best practices for solar powered charge stations for PHEVs and EVs. The plan is for the team to work cooperatively to develop triple bottom line systems decision support tools.

Life Cycle Assessment
The planned LCA component of the research will advance the science of integrating environmental, economic and social LCA to determine best practices in solving the problem of fueling vehicles of the future. The research results will be useful for communicating and educating students and community members on the different potential impacts related to use of PHEVs and EVs.

LCA Component of Research to Date

- Literature review of LCA studies for PV panels
- Preliminary evaluation of social LCA elements of solar-powered charge stations
- LCA of electricity from different fuels (cradle-to-gate)

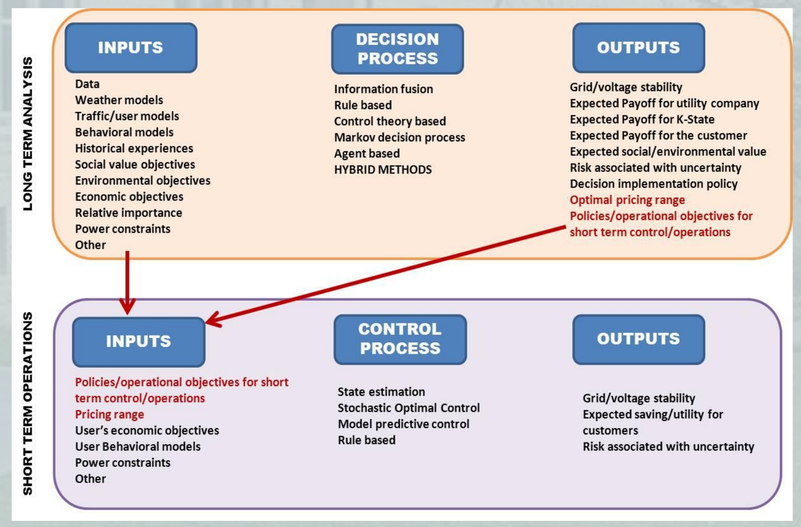
Social LCA Thinking

Solar-powered charge stations may provide local social benefits for consumers, such as shade and convenience. Additionally, a significant increase in solar-powered charge stations should promote more EVs in urban areas to replace gasoline-powered vehicles. The resulting improvement in air quality and subsequent positive impact on consumer health are social benefits that may be evaluated alongside other elements outlined in the UNEP/SETAC Social LCA guidelines.

More typical social impacts of worker safety, child labor, fair wages, etc. may also be evaluated throughout the life cycle of mining raw materials, manufacturing and production of solar powered charge stations.

Decision Tree for Best Practices

- To integrate science and engineering, economics, psychology, public inputs, and life cycle assessment methods for holistic decision-making
- To achieve electrical grid and mini-grid efficiency, voltage stability and reliability in systems as solar power is incorporated at greater levels into the national energy mix
- To advance market penetration of EVs, PHEVs
- To provide multidisciplinary team research experiences for students at Kansas State University



Literature Review: LCAs for PV Panels

Type of Solar Panels (30-yr useful lifespan)	GHG Emissions in CO_2 Equivalents (g CO_2-eq. / kWh)
High-concentration photovoltaic systems (HCPV)[4]	27
Cadmium telluride photovoltaic (CdTe PV)[4]	13
Life-cycle GHG emissions for standard Si-panels[5]…	40 – 55
…and newer thin-film technologies[5]	25 – 32

Energy Source Comparisons

Energy Source	GHG Emissions in CO_2 Equivalents (g CO_2-eq. / kWh)
Natural Gas[7]	585
Coal[3]	823 – 934
Wind[8, 9, 10]	4.6 – 10

Conclusions

Solar-powered charge stations and the electrification of transportation reduce GHGs and improve air quality. They have the potential to positively impact market penetration of EVs.

References

1.Chan, E., Erickson, L.E., Boguski, T.K., Leven, B.A., Natarajan, B. (2012): "Solar Powered Charge Stations: LCA Thinking."
2.Environmental Protection Agency (EPA) (2010): INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS, 1990-2010, p. ES-7.
3.Fthenakis V., Dillon A., Savage N. (2007): Life Cycle Analysis for New Energy Conversion and Storage Systems. Warrendale, PA, Materials Research Society Symposium Proceedings, Vol. 1041, pp. 147-158.
4.Fthenakis V.M., Kim H.C. (2011): Life cycle assessment of high-concentration photovoltaic systems. Prog. Photovolt: Res. Appl. doi: 10.1002/pip.1186.
5.Good Company (2008): Life-Cycle Environmental Performance of Silicon Solar Panels. Rep. Oregon State Government, Aug. 2008. Retrieved from http://www.oregon.gov/ODOT/HWY/OIPP/docs/solar_panel_lifecycle.pdf?ga=t
6.J.D. Power, EDTA, Hybrid Market Dashboard, and Green Car Congress
7.Skone, T.J., Littlefield J., Marriott J. (2011): Life Cycle Greenhouse Gas Inventory of Natural Gas Extraction, Delivery, and Electricity Production. DOE/NETL–2011/1522, National Energy Technology Laboratory. Retrieved from http://www.netl.doc.gov
8.Sovacool, B.K. (2008): Valuing the greenhouse gas emissions from nuclear power: A critical survey. Energy Policy, Vol. 36, p. 2950.
9.Wang, Y., Sun, T. (2012): Life-cycle assessment of CO2 emissions from wind power plants: Methodology and case studies, Renewable Energy, Volume 43, Pages 30-36, ISSN 0960-1481, 10.1016/j.renene.2011.12.017. (http://www.sciencedirect.com/science/article/pii/S0960148112000043)
10.World Steel Association (2008): Case study: Wind energy. Oct. 2008. Retrieved from http://www.worldsteel.org/dms/internetDocumentList/case-studies/Wind-energy-case-study/document/Wind%20energy%20case%20study.pdf

Funding from the "Earth, Wind, and Fire: Sustainable Energy in the 21st Century" REU site (NSF EEC#1156549) is gratefully acknowledged.

September 2012