Electrify Heartland Plan

Section 9: Utility Grid

electrify HEARTLAND

Project title: Kansas – Missouri
Community Readiness for EV and EVSE

Funded by: US DOE DE-EE0005551

By: Metropolitan Energy Center

and Kansas City Regional Clean Cities Coalition

With: Black & Veatch

Metropolitan ENERGY CENTER

Kansas City Regional Clean Cities

BLACK & VEATCH

U.S. Department of Energy Acknowledgement and Disclaimer:

This material is based upon work supported by the Department of Energy under Award Number DE-EE0005551. This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This work was developed in response to the federal funding opportunity announcement titled Clean Cities Community Readiness and Planning for Plug-in Electric Vehicles and Charging Infrastructure. FOA: DE-FOA-0000451

CFDA Number 81.086

Electrify Heartland Plan

Electrify Heartland Project Abstract

Electrify Heartland is an electric vehicle planning project managed by Metropolitan Energy Center. It is a product of the Greater Kansas City Plug-In Readiness Initiative, co-chaired by Kansas City Regional Clean Cities Coalition. Our goal is to produce a regional plan to prepare public resources and secure the economic and environmental benefits of plug-in vehicles within targeted metro areas with estimated 2.7M population. The targeted metro areas include Kansas City, MO & KS; Jefferson City, MO, Wichita, KS; Salina, KS; Lawrence, KS; and Topeka, KS. (14 Counties: Cass, Clay, Cole, Douglas, Jackson, Johnson, Leavenworth, Miami, Platte, Ray, Saline, Sedgwick, Shawnee, Wyandotte).

Electrify Heartland Steering Committee

Team	Organization	Name
Charging Stations	Initiatives	Troy Carlson
Charging Stations	LilyPadEV	Larry Kinder
Charging Stations	Logios	Gustavo Collantes
Government Policy	Polsinelli Shughart PC	Alan Anderson
Government Policy	Black & Veatch	Bill Roush
Project Administration	Metropolitan Energy Center	Ruth Redenbaugh
Project Administration	Metropolitan Energy Center	Kelly Gilbert
Public Education	Nation Ranch Marketing, Inc.	Bill Patterson
Training	Kansas City Kansas Community College	Bob McGowan
Training	National Electrical Contractors Association	Jim Cianciolo
Utility Grid	Black & Veatch	Sam Scupham
Vehicle & Fleet	University of Missouri at Kansas City	Henry Marsh

Exhibit i-i. Electrify Heartland Steering Committee Members

Section 9: Utility Grid

Section Abstract

Electrify Heartland proposed to identify and analyze barriers to the implementation of plug-in electric vehicles (EV) and infrastructure in the proposed area and discuss steps to reduce or eliminate the identified barriers.

The Utility Sub Team identified several potential barriers to increased EV penetration in the region:

- EV impacts on the area electrical distribution system.
- EV/electric vehicle supply equipment (EVSE)/grid communications.
- Area utility rates for EVSE.
- Net metering plan and EVSE.
- EV road tax issues.
- Utility smart grid plans.
- Cost recovery allowed to utilities for EVSE.

In examining these potential barriers to EV development in the region, the Utility Sub Team (UST) found some areas for development, but no insurmountable barriers.

Section Authors:

Bill Roush, and Sam Scupham, Black & Veatch

Contributors:

Chad Mazurek, Lucas Oehlerking, Black & Veatch

Table of Contents

Table of Appendices

The following appendices are in separate files on www.ElectrifyHeartland.org

9 Utility Grid

9.1 EV impacts on the area electrical distribution system

Three representative electric utility distribution feeders were examined: a likely-adopter residential, a mixed use residential and commercial, and an industrial fleet area.

The study findings indicate that for the probable level of electric vehicle deployment within a reasonable utility planning time horizon, there is little concern regarding electrical distribution impacts. This level of vehicle market penetration is far less than 1 percent of current gasoline fueled vehicles. A "one percent case" of EV penetration was modeled and no impact was found on the distribution grid parameters examined. The Black & Veatch distribution study analyzed much higher levels of EV penetration (20 to 100 percent) and was intended to indicate which components of the distribution grid might benefit from additional planning studies if EV penetration were to reach higher percentages.

Even under the most optimistic forecasts for EV market penetration, converting significant portions of the vehicle fleet to EVs would take years. There are currently more than 230 million light duty vehicles in the U.S.[1] This planning effort focuses on deployment of 1 million U.S. EVs by 2015. This utility distribution study considered penetration levels of 20 percent and higher, which equates to 50 million or more EVs in the U.S. These penetration levels were used to provide perspective on the utility planning horizon, rather than to focus on short-term needs. Annual sales of new passenger vehicles are approximately 10 million per year,[2] so it would take years or even decades of high EV sales levels to reach 20 percent or higher penetrations.

Little EV impact is expected on the distribution system in the near future. If mainstream levels of 20 to 100 percent of EV penetration should occur, the highest reliability risk would be to the primarily residential feeders. The residential feeders would most likely have the largest amount of constant EV load (i.e., daily chargers), especially during the work week. In addition, as the system exists today, residential load is typically smaller than that of commercial and industrial establishments. Consequently, the equipment on the residential

---

[1]U.S. BUREAU OF TRANSPORTATION STATISTICS FOR 2010. "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances." *Bureau of Tranportation Statistics*. Research and Innovative Technology Administration (RITA) • U.S. Department of Transportation (US DOT), n.d. Web. 10 Dec. 2012. <http://www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html>.

2U.S. BUREAU OF TRANSPORTATION STATISTICS FOR 2010. "National Transportation Statistics." *Bureau of Tranportation Statistics*. Research and Innovative Technology Administration (RITA) • U.S. Department of Transportation (US DOT), n.d. Web. 10 Dec. 2012. <http://www.bts.gov/publications/national_transportation_statistics/pdf/entire.pdf>.

feeders has lower ratings than that of mixed residential and commercial or industrial feeders.

9.1.1 Residential Area Concerns

The main concerns for residential areas with increased EV use include the following:

- Potential phase imbalances where this problem already exists.
- Over and under voltages.
- Transformer overloads.
- Main feeder thermal overloads.

These areas of concern may appear at levels of EV penetration far higher than what is seen today. Black & Veatch's study reviewed various scenarios with penetrations of 20, 40, 60 and higher percents. The study goal was to determine what areas need to be monitored first so that planning could be focused in those areas.

9.1.2 Mixed Residential and Commercial

In the mixed residential and commercial scenario, minimal impacts were identified on the commercial side for public charging stations sized for up to 100 EVs. Most of the impacts were isolated to the residential portion of the feeder at very high penetration levels.

9.1.3 Industrial Fleet

No reliability impacts were identified for the fleet scenario.

9.1.4 EV/EVSE/GRID Communications

The advanced batteries in electric cars have charging procedures that need to be followed to maintain longevity, safety, and warranties. This is especially true when charging rates increase. In addition, the Society of Automotive Engineers (SAE) defines different levels of charging with varying rates. (Refer to Section 9.4.3, Current Standards.)

Communications between the EVSE and the battery pack in the vehicle regarding data on such things as battery temperature, ambient temperature, state of charge, and charge rate are needed to ensure rapid, safe, and reliable charging and battery condition. Communications and standards issues relating to "overnight" duration charging are largely settled and are not a problem in planning for higher EV penetration levels.

The situation regarding "fast charging," the kind of "15 minute or less" charging that can enable long trips with daytime on-the-road recharging, is not a settled matter. There are multiple potential standards and compatibility issues that, if not resolved, could hamper EV adoption in areas of the country where long trips are common and range anxiety is a concern for EV owners. Making sure that these public, fast charging EVSE can "talk" to the EVs that drive up to them is important for long-term EV adoption.

At lower levels of penetration, when the EVs purchased are self-selected for commuting and are charged at home at night and/or in an employee parking lot, the fast-charging standards are less important.

9.1.5 Area utility rates for EVSE

Some concepts for rate structures for EV charging can involve high rates at certain times and, perhaps more importantly, require the vehicle owner to install expensive equipment. These types of rate structures could create a barrier to EV penetration if they are perceived by the public to remove the economic advantages of EV ownership or to create an installation inconvenience.

Currently, neither Missouri nor Kansas has a utility rate structure that would create a barrier to the adoption of EVs. See Section 3.6 for discussion of rate structures being used elsewhere in the U.S. and Section 9.5 for a more complete discussion of rates in Kansas and Missouri. There is some consideration by utility regulatory staff of possible studies or pilot programs that could involve higher rates in peak demand times. These studies may lead to increased management of EV charging times, but do not, in the near term, seem likely to create a barrier to EV adoption.

9.1.6 Net metering rules in Missouri and Kansas for EVSE

Net metering is one method of allowing and setting the value of electricity sold by a customer-producer to the utility. Usually this occurs when a customer-producer generates electricity from an on-site solar array, wind generator, or other distributed generation device. In the case of an EV, the customer controls electricity stored in a battery in a vehicle which could, theoretically, be sold to a utility. Net metering rules become important to EV penetration only when there are vehicles and EVSE capable of vehicle-to-grid (V2G) charging and selling of electricity to and from the grid. For the most part, neither EVSE nor EVs are now capable of this kind of two-way transaction, in large part because communication and related standards have not been set for such activity.

Currently, neither Missouri nor Kansas net metering laws directly address sales of electricity from an EV to a utility. This absence of metering rules does not create a direct barrier to EV penetration, nor does it create a clear legal path for such transactions.

9.1.7 EV Road Taxes Issues

Several states have proposed methods to replace road tax revenue that is not paid by vehicles using alternative fuels. While some states are further along in pursuing a legislative remedy for this matter, and there is no consensus solution, there is, however, a focus on a fee per miles driven.

In Kansas, a complex proposal specifically aimed at EVs was introduced, but was delayed for further study. Missouri is actually ahead of other states and has already enacted a $75 annual fee on “alternative fueled vehicles,” including EVs.

While state road taxes have come largely from gas taxes, local streets are largely paid for by local communities with other local taxes. The local taxes in place now include utility franchise taxes that are paid on a per kilowatt-hour (kWh) basis by electricity users, including EV owners.

While action regarding these tax issues in the Kansas legislature bears watching, currently there are no significant tax barriers to higher penetrations of EVs in the two-state region.

9.1.8 Utility Smart Grid Plans

There has been much discussion and effort put into making the U.S. utility grid smarter, which generally means adding controls and communication aspects at various points in the transmission and distribution system. If these controls and communication protocols conflict with EVSE, causing malfunctions or poor operation, it may create a barrier to EV penetration.

Both Westar Energy (Westar) and Kansas City Power & Light (KCP&L) have smart grid demonstration projects. Westar’s SmartStar program covers 39,000 residential meters and 4,000 commercial meters in Lawrence, KS. KCP&L’s project in what is called the Green Impact Zone in central Kansas City, MO, includes 14,000 commercial and residential customers. Neither project has an exceptionally large EV charging component. Both smart grid projects allow for and have encouraged EV participation.

9.1.9 PV and EVSE for daytime charging

The potential for daytime EV charging raised initial concern that, in general, adding to peak utility demand could cause cost or reliability issues and create a barrier to increased levels of EV penetration. This study investigated levels of EV penetration that are far lower than 1 percent of load. While adding to peak demand at the expected levels of EVs (approximately 7,000 vehicles by 2015) in the study region will not create grid reliability issues, there was an interest in exploring solar photo voltaic (PV) as an option for serving a part of the peak.

Black & Veatch’s study team did not do a technical study of the potential for PV to shave peak or allow for increased EV charging. However, the team did survey commercial efforts to combine daytime generated solar power with EV charging. Black & Veatch’s survey of activities in this area found several national and regional examples of businesses active in some aspect of combining EV charging with solar power. PV used in a duel role as covered parking and power producer was a common way to make the solar and EV charging connection. University research efforts are being pursued in the region to study other managing elements such as energy storage and power electronics. See section 11 for a longer discussion of PV.

9.1.10 Cost Recovery Allowed to Utilities for EVSE

The Kansas Corporation Commission (KCC) has not issued any rulings directly relating to cost recovery for EV programs by utilities. One method they could use to give guidance in this area would be through a predetermination docket.[3] The KCC did commission a study, *Electric Vehicle Rate Issues*, issued in April 2012 which addresses topics like the key ratemaking issues related to EVs, an overview of current utility EV ratemaking practice (from other states), and some observations about EV activity in Kansas.

9.2 Electric Vehicle Impacts on the Area Electricity Distribution System

This section of the report outlines the Edison Electric Institute (EEI) guide to EV readiness, previous EV grid impact studies, and the Black & Veatch study assessing potential EV impacts on the electricity grid in the study area.

9.2.1 Introduction

According to a report issued by the Union of Concerned Scientists (UCS), regardless of where EVs are charged, the greenhouse gases (GHGs) associated with using EVs are less than those emitted by vehicles powered by internal combustion engines. In the Kansas City area, the emissions associated with EV charging, according to the recent generation profile data used in the study, are similar to the most efficient conventional vehicles and some hybrid electric vehicles.[4] For example, EV emissions in Kansas City are estimated to be equivalent to a car getting 35 miles per gallon (mpg), which is above the compact vehicle national average of 27 mpg.

The UCS report was based on power plant production and emissions data for the region in 2009. It is important to note that a utility generation profile changes over time and that some utilities in the region have lower GHG emissions than the average. For instance, Westar Energy submitted a greenhouse report and control plan to the Kansas Department of Health

---

[3] Fry, Andrew. 8 Oct. 2012. E-mail.

[4] Anair, Don, and Amine Mahmassani. "State of CHARGE:Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States." *Union of Concerned Scientists and Citizens for Environmental Solutions*. Union of Concerned Scientists, June 2012. Web. 10 Dec. 2012. <http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf>.

and Environment in April 2009 that shows their CO_2 emissions to be lower than the regional profile used by UCS.[5]

Regardless, according to the UCS report, almost half of all Americans live in areas where the GHGs associated with driving EVs are less than the most efficient hybrids available today.

Additionally, depending on the cost of electricity in a particular region of the United States, EV use could result in fuel savings of up to $1,200 per year over a gasoline powered car.[6]

With these environmental and operation cost benefits, some predict EVs will gain higher levels of market penetration. A 2011 study by the Center for Automotive Research estimated that U.S. sales for electric vehicles will increase to 140,000 vehicles sold in 2015. The study takes into consideration such factors as previous nationwide hybrid registrations and forecasts by J.D. Power.[7] The predictions of EV penetration vary widely; a report issued by the Electric Power Research Institute (EPRI) assumed 100 million EVs by 2030 when analyzing the possible emissions reductions from EV adoption.[8] While the estimates of future EV deployment vary from source to source, President Obama's administration is helping drive these projected EV levels by setting a goal of 1 million EVs on the road by 2015.[9]

9.2.1.1 Edison Electric Institute

To help utilities get ready for these levels of deployment, the EEI produced "The Utility Guide to Plug-In Electric Vehicle Readiness." The EEI is "the association of U.S. shareholder-owned electric companies," according to the EEI Plug-In Readiness Guide.[10] The guide references a study that EEI conducted in 2010. According to the study:

---

[5] Kansas Department of Health and Environment. "KDHE Greenhouse Gas Report." *Westar Energy*. Westar Energy, n.d. 10. Web. 10 Dec. 2012. <http://www.westarenergy.com/WCM.NSF/CONTENT/KDHE%20GHG%20REPORT>.

[6] Ibid

[7] Center for Automotive Research (CAR). "Deployment Rollout Estimate of Electric Vehicles 2011-2015." *Car Group*. N.p., Jan. 2011. Web. 10 Dec. 2012. <http://www.cargroup.org/assets/files/deployment.pdf>.

[8] Electric Power Research Institute. "2009 Portfolio: Electric Transportation - Program Overview." *Electric Power Research Institute*. N.p., 2009. Web. 10 Dec. 2012. <http://mydocs.epri.com/docs/Portfolio/PDF/2009_P018.pdf>.

[9] "Vice President Biden Announces Plan to Put One Million Advanced Technology Vehicles on the Road by 2015." *Energy.gov*. US Dep of Energy, 26 Jan. 2011. Web. 10 Dec. 2012. <http://energy.gov/articles/vice-president-biden-announces-plan-put-one-million-advanced-technology-vehicles-road-2015>.

[10] Edison Electric Institute, and Electric Drive Transportation Association. "The Utility Guide to Plug-In Electric Vehicle Readiness." *Edison Electric Institute*. N.p., Nov. 2011. Web. 10 Dec. 2012. <http://www.eei.org/ourissues/EnergyEfficiency/Documents/EVReadinessGuide_web_final.pdf>.

> "… almost three in four (71 percent) residential customers feel that electric utilities should [be] working and investing now to assure that proper infrastructure [is] in place for convenient recharging of electric vehicles. Furthermore, almost two-thirds (61 percent) wanted their utility [to] take a leadership role in encouraging a shift toward electric transportation."[11]

The guide breaks down preparing for EVs into the following four areas:

Getting Your Company Up to Speed
Topics to consider when preparing various departments within a utility for EV deployment.

Enhancing the Customer Experience
Making sure customers have a positive experience with EV deployment where "education and outreach will be essential."

VIPs (Very Important Passengers) to Include
Engaging other groups and stakeholders when utilities develop EV plans.

Plugging into the Grid
Items to consider for distribution system impacts.

According to the guide, various utilities are already showing substantial progress toward EV readiness. Southern California Edison has a mature plug-in EV (PEV) Readiness Program with 25 full-time employees working in "four parallel workstreams: Operations, Infrastructure, Customer Education & Outreach, and External Engagement." Other utilities that are also showing significant EV activity include DTE Energy, Hawaiian Electric Company (HECO), Indianapolis Power & Light (IPL), San Diego Gas & Electric (SDG&E) and Southern Company. Some of the items being addressed include the following:

- Modeling PEV loads on their distribution system.
- Conducting surveys to monitor penetration rates.
- Conducting processes for PEV use notifications.
- Conducting employee training and preparedness.

The EEI guide also includes an easy to review checklist that can aid a utility in understanding where it is in the process of becoming "EV Ready" and what some of the next steps might be. The checklist offers many suggestions for actions that can be scaled to any size utility.

---

[11] Edison Electric Institute, and Electric Drive Transportation Association. "Power Poll, Quarter 4, 2010." *Edison Electric Institute*. Web. 10 Dec. 2012.

9.2.1.2 Past EV Grid-Impact Studies

Studies predicting the impacts of a significant number of EVs charging on the electricity grid have been around for some time. This subsection does not contain a complete list of the plug-in hybrid EV (PHEV) grid-impact studies, but it outlines the evolution of the previous studies and provides a background for the Black & Veatch modeling methodology.

Lemoine, Kammen, and Farrell (2006) studied the projected impact of 1, 5, and 10 million PHEVs on an area served by the California Independent System Operator (CAISO) with three charging scenarios: optimal charging (from a grid-operator standpoint), evening charging, and twice per day charging. The study showed that 1 million EVs probably do not produce a significant problem for any charging scenario, but system generation capacity upgrades in the CAISO area may be necessary if large PHEV fleets (several million) were allowed to charge during peak times.[12]

In 2007, Kintner-Meyer, Schneider, and Pratt at Pacific Northwest National Laboratory (PNNL Generation) and Parks, Denholm, and Markel at the National Renewable Energy Laboratory (NREL) were also studying EV grid impacts at about the same time as Lemoine et al. The PNNL generation study showed that the national grid could support the changing energy requirements of up to 73 percent of the U.S. light-duty vehicle (LDV) fleet, although this percentage varies by region of interest. This would require many power plants to operate at near capacity during most of the day.[13]

NREL studied an Excel Energy Colorado service territory using public and “proprietary system data.” The study looked at summer and winter load impacts and used four charging scenarios: (1) uncontrolled charging, (2) delayed charging, (3) off-peak charging, and (4) continuous charging. Continuous charging, where the vehicle charges wherever it is parked continuously throughout the day, resulted in the worst-case scenario and increased the load total and peak demand. However, most load impacts were minimal, and even problems

---

[12]Lemoine, Derek, Daniel M. Kammen, and Alexander E. Farrell. "Effects of Plug-In Hybrid Electric Vehicles in California Energy Markets." University of Vermont. N.p., 15 Nov. 2006. Web. 10 Dec. 2012. <http://www.uvm.edu/~transctr/pdf/email/LemoineArticle.pdf>.

[13]Kintner-Meyer, Michael, Kevine Schneider, and Robert Pratt. "IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS PART 1: TECHNICAL ANALYSIS." *Federal Energy Regulatory Comission*. N.p., 24 May 2007. Web. 10 Dec. 2012. <http://www.ferc.gov/ABOUT/COM-MEM/WELLINGHOFF/5-24-07-TECHNICAL-ANALY-WELLINGHOFF.PDF>.

with high penetration rates could be avoided by charging constraints such as delayed charging mechanisms.[14]

9.2.1.3 Recent EV Grid Impact Studies

Among the more recent studies is a study by Letendre and Watts[15] and a study by Sioshansi, Fagiani and Marano.[16] Letendre et al. reported on the impacts of PHEVs on the Vermont power system. They report that even a small amount (50,000) of uncontrolled charging PHEV penetration could increase peak demand. Delayed night-time charging could allow more than 100,000 PHEVs without adding to peak demand, and complete utility control could enable about one-third (200,000) of Vermont's LDVs to charge on the grid without adding to peak electricity demands. Sioshansi et al. reported that a 5 percent penetration level on the Ohio power grid has a "negligible impact;" however, 30 percent LDVs with uncontrolled charging could result in a summer peak load increase of over 3 percent.

9.2.1.3.1 2010 PNNL Distribution System Analysis

Gerkensmeyer, Kintner-Meyer, and DeSteese (PNNL Distribution) published a detailed report, "Technical Challenges of Plug-In Hybrid Electric Vehicles and Impacts to the US Power System: Distribution System Analysis," that studied PHEV impacts on the residential distribution systems of three utilities: Franklin Public Utility District (PUD), Snohomish PUD, and Puget Sound Energy (PSE). The study focuses on the impacts to the entire distribution system as well as the impacts on transformers serving each load. The charging cases include Level 1 and 50/50 mix of Level 1 and Level 2 charging. These different charging levels were coupled with different charge times to make up six different charge cases. Given the lack of information about work charging, the work charging was modified to include only the home charging component (Case 2M and 5M). The charge scenarios are as follows:

- Case 1 – 120 V charging at home.
- Case 2M – 120 V charging at home and work – home only.
- Case 3 – 120 V charging at home delayed until after 10 p.m.
- Case 4 – 50/50 120 V/ 240 V charging at home.

---

[14]Parks, K., P. Denholm, and T. Markel. "Costs and Emissions Associated with Plug-In Hybrid Electric Vehicle Charging in the Xcel Energy Colorado

[15]Letendre, Steven. "Effects of Plug-In Hybrid Electric Vehicles on the Vermont Electric Transmission System." *University of Vermont*. N.p., n.d. Web. 10 Dec. 2012. <http://www.uvm.edu/~transctr/trbpapers/Effects_of_PHEVs_on_the_Vermont_Electric_Transmission_System.pdf>.

[16] Sioshansi, Ramteen, Riccardo Fagiani, and Vincenzo Marano. "Cost and Emissions Impacts of Plug-In Hybrid Vehicles on the Ohio Power System." *Ohio State University*. N.p., 7 July 2010. Web. 10 Dec. 2012. <http://www.ise.osu.edu/ISEFaculty/sioshansi/papers/PHEV_ohio.pdf>.

- Case 5M – 50/50 120 V/ 240 V charging at home and work – home only.
- Case 6 – 50/50 120 V/ 240 V charging at home delayed until after 10 p.m.

The number of feeders studied varied from eight for Snohomish PUD and PSE to 34 for Franklin PUD. The feeders were composed of various amounts of residential, commercial, and industrial loads. The load curves for Franklin PUD and Snohomish PUD were verified by engineers at both utilities and were exported using SynerGEE Electric 2009 (SynerGEE). The levels of penetration considered were 50 percent and 100 percent. A penetration of 100 percent means that each residential customer owns one PHEV. The study evenly distributed these PHEVs throughout the residential-only distribution system. Each residential customer was allotted 7.5 kilovolt-ampere (kVA) and, given the transformer capacity, the number of customers on each transformer was calculated. Analyses were performed in 1 hour increments throughout the day for each of the six charge cases using two levels of penetration (50 percent and 100 percent).[17]

For Franklin PUD, charge Case 3 resulted in all 34 feeders being able to handle even 100 percent (one car per house) PHEV penetration. However, Case 6 resulted in only 19 feeders that could tolerate 100 percent PHEV penetration. Equipment failure for Case 6 included fuses, lines, and switches. The worst case scenario for PSE feeders appears to include Case 6 as well (Cases 4 through 6 were the same), with four feeders' fuses being affected at 100 percent penetration. A 50 percent penetration would cause failures on at least one feeder for all cases. For Snohomish PUD, Case 6 was again the worst, with six feeders showing some kind of failure; 100 percent penetration did not affect Cases 1 through 3. The equipment failing in Case 6 were lines and regulators.[18]

Fast charging was considered for each of the utility's systems as well. This new scenario consisted of three hours of nominal (3.5 kW) charging, from 5 p.m. to 8 p.m. For Franklin PUD, 100 percent penetration caused failures on more than 20 feeders, which included fuses, lines, switches, and reclosers. Fuses were the primary mode of failure for 100 percent penetration for both PSE and Snohomish PUD, with four and seven feeders showing failures at 100 percent penetration, respectively.[19]

---

[17] Gerkensmeyer, C., MCW Kintner-Meyer, and JG DeSteese. Technical Challenges of Plug-In Hybrid electric Vehicles and Impacts to the US Power System: Distribution System Analysis. Rept. no. PNNL-19165. N.p.: PACIFIC NORTHWEST NATIONAL LABORATORY, 2010. SmartGrid. Web. 10 Dec. 2012. <http://www.smartgrid.gov/sites/default/files/resources/phev_distribution.pdf>

[18] IBID.

[19] IBID.

Finally, the 2010 PNNL Distribution study analyzed secondary transformer impacts for each utility for each of the six charge cases. The study presented the number of transformers that were at various levels of capacity for each scenario. For Franklin PUD, charge Case 6 produced a significant number of transformers operating with 70 percent to 100 percent of capacity. For example, the number of transformers operating at 70 percent capacity went up from less than 500 for Case 5 to more than 1,500 for Case 6 at 100 percent penetration. PSE showed many transformers already operating above 100 percent capacity, and this number appeared to increase in the worst Case 6. Snohomish PUD did not show any transformers operating above 100 percent, even for 100 percent PHEV penetration.[20]

In summary, Level 1 charging is generally not a concern to the distribution system but could cause fuses to fail at high levels of PHEV penetration. However, if Level 2 charging is used, fuses, lines, switches, and reclosers can fail at higher levels of PHEV penetration. Making matters worse in this study is delaying the charging until 10 p.m., since the charging is allowed to naturally distribute over several hours. According to the study, of particular concern are older residential transformers that are already operating above their nameplate capacity and have been in use for quite some time.[21]

9.2.1.3.2 2010 ISO/RTO Report

The grid impact section of a report, “Assessment of Plug-In Electric Vehicle Integration with ISO/RTO Systems,” by the Independent Systems Operator and Regional Transmission Organizations (ISO/RTO) Council and DNV KEMA Energy & Sustainability (KEMA) projected PEV penetration rates in regions of the North American ISOs and RTOs. Each region gets its share of the Obama administration’s goal of 1 million PEVs. A “fast” scenario would achieve this goal by 2015, while a “target” penetration would achieve this by 2017. Finally, a “slow” case would not hit this level of penetration until 2019. The study covered other aspects associated with PEV deployment, but the PEV grid impact is of interest to this report.[22]

Two charging scenarios were examined: charging in a 12-hour time frame and charging in an 8-hour time frame. Also, as a worst case scenario, charging happening in a 1-hour time frame was considered. The report assumed that advantages to Level 2 charging would likely

---

[20] IBID.

[21] IBID.

[22] Fell, Ken, et al. "Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems." *ISO/RTO Council*. N.p., Mar. 2010. Web. 10 Dec. 2012. <http://www.isorto.org/ATF/CF/%7B5B4E85C6-7EAC-40A0-8DC3003829518EBD%7D/IRC_REPORT_ASSESSMENT_OF_PLUGIN_ELECTRIC_VEHICLE_INTEGRATION_WITH_ISO-RTO_SYSTEMS_03232010.PDF>.

result in 80 percent of the overall charging, leaving Level 1 charging to cover the remaining 20 percent of PEVs.

The report predicted that Los Angeles will have the most PEVs of the target 1 million, resulting in 119,069 PEVs. San Francisco is close behind at 91,005 PEVs, while the Kansas City metro area comes in at 5,000 PEVs. The report predicted the load "based on the portion of the load within their primary ISO/RTO." The load produced in Los Angeles and San Francisco if everyone charged in the same 1-hour window would be 658 megawatts (MW) and 503 MW, respectively. Scaling this load according to the number of PEVs in the Kansas City metro area, the metro area would see an increase in load of about 27.5 MW.

In summary, PEV adoption modeled after Prius adoption profiles in this report will most likely be focused in the West Coast and Northeast regions.

9.2.1.3.3 2011 Janigian Study

A detailed analysis of a specific residential feeder in California was outlined by Darren Janigian at California Polytechnic State University in 2011. The study, "Plug-In Hybrid Electric Vehicle Impacts on a Central California Residential Distribution Circuit," created a generalized model in Electronic Transmitter Analyzer Program (ETAP) for an actual system in central California and considered only residential components. The study assumed a Chevy Volt battery and included both Level 1 and Level 2 charging. The study examined PHEV levels of deployment from 0 percent (baseline) to 100 percent in 20 percent increments. 100 percent penetration means one PHEV per household.[23]

The study loaded the PHEVs on the feeder in a way to emphasize sequential end-of-line to substation (EOL-sub) loading, sub-EOL loading, and "cluster" loading. EOL-sub loading means that EVs were added near the end of the feeder first. The analysis looked at voltage levels on the main bus, as well as overall feeder load for peak and off-peak times.

The worst-case charging scenario was charging during peak hours of operation with Level 2 charging. The loading arrangement that puts the most stress on the system is EOL-sub PHEV deployment. At 15.3 percent penetration, or 264 of the 1,722 possible total PHEVs, a 64 percent circuit breaker will trip, followed by an 80 percent circuit breaker trip at 33.2 percent penetration. The main 12 kV overhead feeder overload occurs at 37.6 percent, and the final circuit breaker will trip at 54.8 percent penetration. For reference, switching to off-

[23] Janigian, Darren. "Plug-In Hybrid Electric Vehicle Impacts on a Central California Residential Distribution Circuit." Caly Poly San Luis Obispo. California Polytechnic State University, June 2011. Web. 10 Dec. 2012. <http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1543&context=theses>.

peak charging for this scenario allows for 50 percent penetration before the 64 percent circuit breaker trips.

Full capacitor support was required because of sagging voltages at 60 percent penetration for Level 2 charging. For 100 percent penetration, the voltage dropped to 96.5 percent at the end of the distribution line. Increased wear on service transformers could cause a drop below 95 percent. At 100 percent penetration and Level 2 charging, all transformers will be overloaded beyond the 130 percent.

The first circuit breaker trip will only require “switching operations” to be changed, and no equipment will be damaged. However, the report stated that details on circuit breaker settings were beyond the scope of the study.

9.2.2 Black & Veatch Distribution Planning Study

For the EV impact modeling study, Black & Veatch used a distribution planning software called SynerGEE Electric.

9.2.2.1 Distribution Impact Modeling

Black & Veatch developed a framework for modeling EV grid impacts that was based on past EV grid-impact studies and modified to fit regions in the Kansas City metropolitan area.

To gain insights into EV use demographics and transportation-based information, Black & Veatch collaborated with the Mid-America Regional Council (MARC). MARC assessed extensive EV user demographics in the Kansas City metropolitan area in the past for the Greater Kansas City Plug-In Readiness Initiative.[24] These demographics were updated for this study to validate the characteristics of feeders to be modeled in the study. Discussions with the participating utilities also validated the selection of feeders to be studied. Details about the feeder selection and how they relate to Black & Veatch’s modeling efforts are discussed in the following sections.

The intent of this study is to explore the limits of the distribution system to see what, if any, impacts would arise from higher penetrations of EVs into the Kansas City metropolitan area. With that in mind, Black & Veatch looked at three scenarios: a residential scenario, a mixed use residential and commercial scenario, and an industrial fleet scenario. Each of these scenarios was then divided into different EV penetration scenarios to explore unique

[24] Greater Kansas City Plug-in Readiness Iniative, Mid-America Regional Council, and Kansas City Regional Clean Cities. "Greater Kansas City Plug-in Readiness Strategy." *Mid-America Regional Council*. N.p., 16 Feb. 2011. Web. 10 Dec. 2012. <http://www.marc.org/assets/GreaterKansasCityPlug-InReadinessStrategy.pdf>.

loading schemes relevant to EV impacts on the distribution grid. The scenarios and assumptions for each are described in detail in the following sections.

9.2.2.2 Selecting Feeders of Interest

To further refine which areas within the utility service area would be relevant to EV penetration; Black & Veatch collaborated with MARC to update EV user demographics from MARC's previous work on the Greater Kansas City Plug-In Readiness Initiative. The EV user demographics that are used to validate feeder selection for this EV grid-impact study include an Electric Vehicle Driver Residence Analysis and an Electric Vehicle Driver Destination Analysis that were initially created by MARC. These analyses were updated with more current American Community Survey (ACS) census data that are a 5-year average from 2005 to 2009.

The residence analysis uses ACS census data to predict the most likely areas of high EV concentrations in the Kansas City metro. Multiple ACS census datasets and an anonymous EV-owner hand-raisers dataset were weighted together to form the residence analysis. The methodology that MARC used in this analysis was similar to other studies around the nation. According to the Greater Kansas City Plug-In Readiness Strategy, census datasets were selected to meet the following criteria: households with higher income, households with higher education, older population (likely disposable income), and households with 2 or more vehicles. The updated residence analysis created by MARC is shown on Exhibit 9-1.

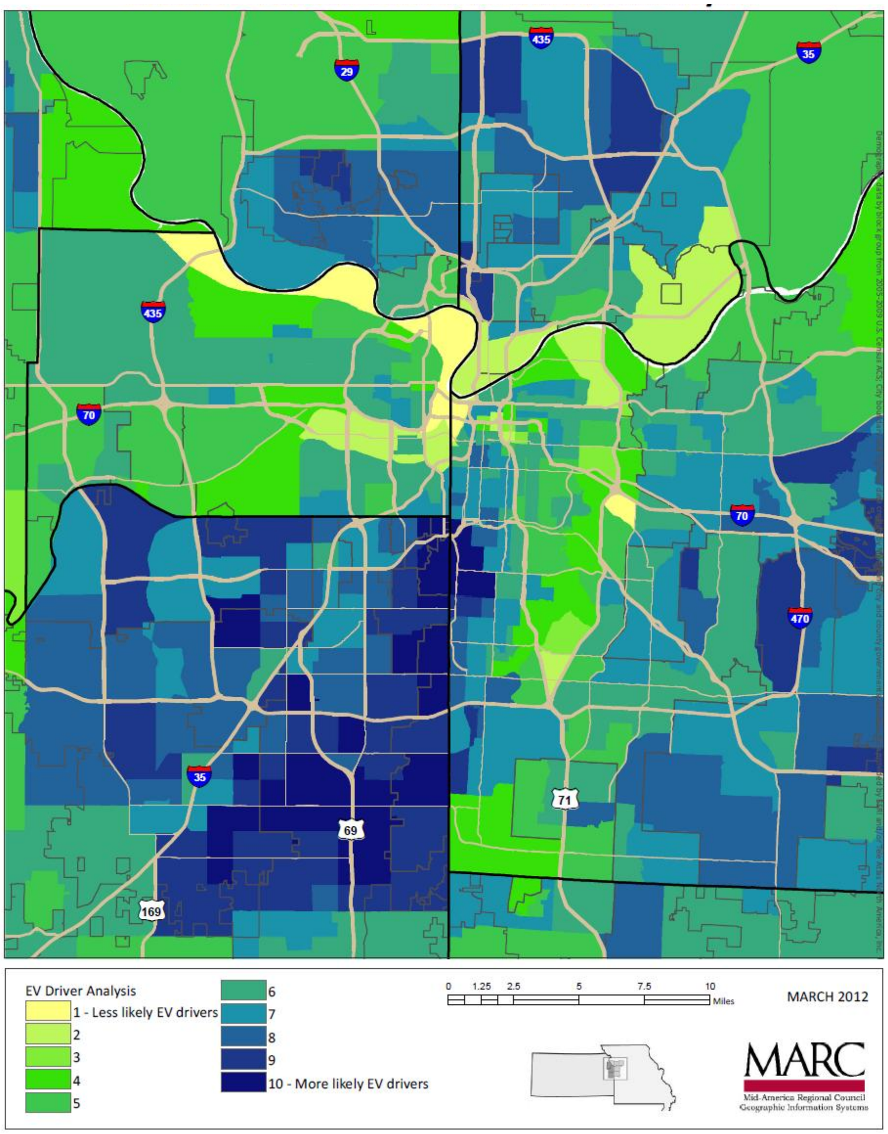

Exhibit 9-1 Electric Vehicle Driver Residence Analysis

The destination analysis estimates the destination of EV drivers with trips originating from the most likely regions of high EV concentration from the residence analysis. In addition to factoring in the residence analysis as areas of origin, the destination analysis also takes into consideration census employment data such as density of high income workers by workplace and information about planned and current activity and employment centers. The destination analysis created by MARC is shown on Exhibit 9-2.

Similar to statements found in other EV grid-impact studies outlined in previous sections, participating utility professionals believe that as issues arise with EV adoption, they are likely to occur in feeders in older, more established residential neighborhoods. Correspondingly, the residential feeder for the study was an older, established

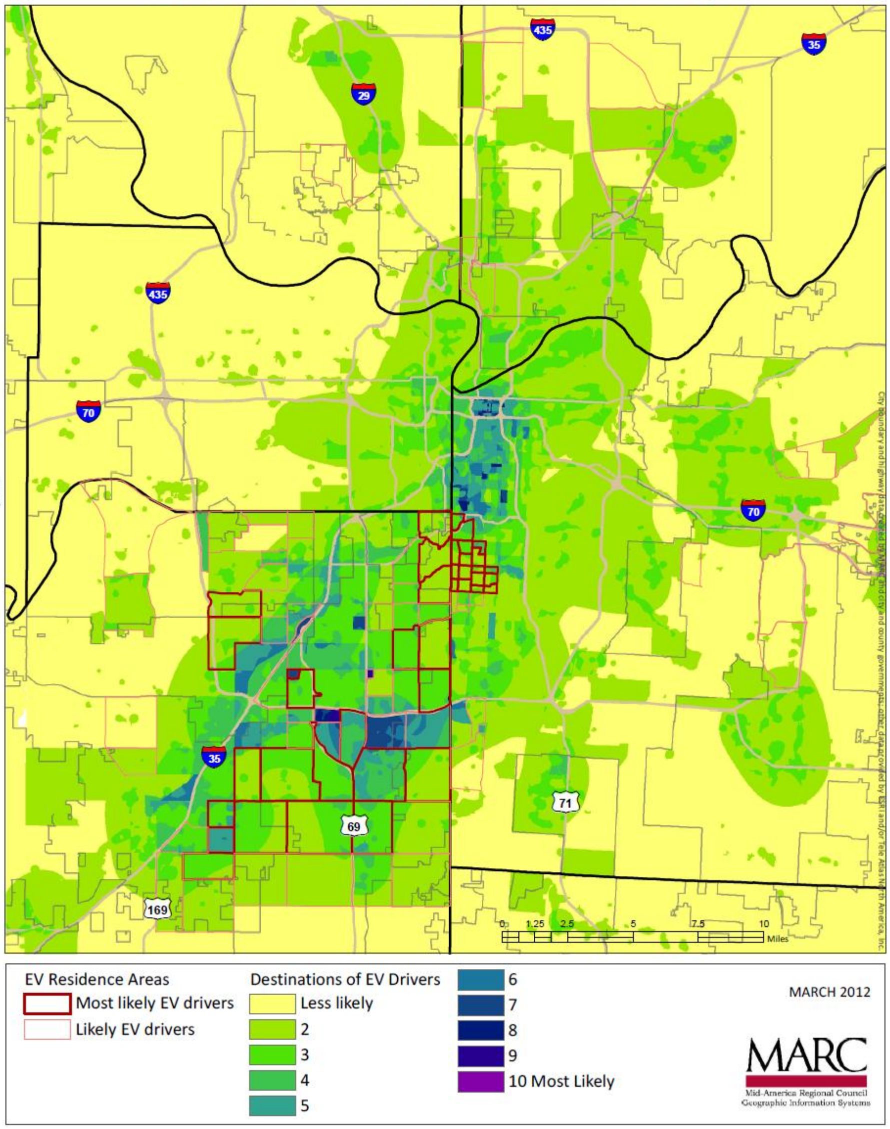

Exhibit 9-2 Electric Vehicle Driver Destination Analysis

neighborhood selected from the most likely regions of EV driver residence from the residence analysis.

Additionally, the destination analysis was used to validate selecting a feeder to explore the effects on the distribution system of EV penetration in a region with mixed commercial and residential loads. The destination analysis was used to select a feeder in a region of most likely EV driver destinations. This destination region was called mixed-use. Finally, the selection of a feeder to be used for modeling the fleet scenario was based on the location of existing distribution centers such as a delivery fleet distribution center.

9.2.2.3 Modeling Methodology and Assumptions

To assess the steady-state reliability impacts on the local distribution system from increased EV penetration, Black & Veatch performed a distribution planning study of three unique distribution feeders. Those feeders included (1) a typical residential feeder, (2) a mixed residential/ commercial feeder, and (3) an industrial feeder where an EV delivery fleet might be feasible. The study consisted of three separate analyses:

- Residential Feeder Analysis:
  - Balanced Penetration: Assumes EVs are distributed evenly across all distribution customers (i.e., no particular distribution customer is more likely to purchase an EV than another customer).
  - Front-of-Line Penetration (FOL): Assumes more EVs tend to congregate on the feeder sections closest to the distribution substation. Load pockets can lead to significant voltage sags. Since distribution feeders are typically operated in radial patterns, a considerable voltage drop near the source (distribution substation) would mean the voltage sags would only get worse further from the substation because of conductor voltage drop (losses) and downstream loads.
  - End-of-Line Penetration (EOL): Assumes more EVs tend to congregate on the feeder sections farthest from the distribution substation. Higher concentration of load can lead to significant voltage sags and thermal overloads, especially if the system is operated in radial patterns and there is a large load pocket downstream.
  - Phase-Imbalanced Penetration: Assumes EVs tend to congregate more to a particular phase than others, creating a load imbalance. This is perhaps one of the most realistic scenarios that could create impacts; despite distribution planning engineers' best efforts, phase imbalances do exist on the system. It is common for much of a neighborhood to be served on a particular phase; therefore, it is not unreasonable to predict that increased EV penetration in such neighborhoods could lead to phase imbalances.
- Mixed Residential/Commercial Analysis
  - Assesses the impact of public charging stations at commercial establishments coupled with residential EV penetration on a feeder with roughly even distribution of residential and commercial load.

- Industrial Fleet Analysis
    - Addresses the impact of a large industrial, manufacturing, or shipping center adopting an appreciably sized EV fleet for delivery vehicles (such as a FedEx, Frito-Lay, or UPS).

The study was performed using the steady-state power flow analysis feature of SynerGEE 4.0.1, a distribution system engineering software suite used by many utilities to design and plan their distribution system. Black & Veatch obtained base case models for each of the three aforementioned types of feeders from an existing utility system. Black & Veatch modified those models to create the following study models based on references to similar studies and good engineering judgment. However, the identities of those feeders were kept confidential, and results are presented as representative of systems throughout the planning area.

SynerGEE models loads on the primary side of the service transformer as distributed loads on the circuits themselves. The service transformers are not modeled. SynerGEE uses two methods for modeling loads:

- Distributed Loads on Feeder Section
    - The entire load on a particular feeder section is distributed uniformly throughout the section. This method is preferred by distribution planners and is defined by the following parameters:
        - kW Demand
        - Kilovar (kvar) Demand
        - Connected kVA – Total kVA capacity available on transformers on each phase for the section, excluding spot loads.
        - Connected kWh – Total peak-month kWh energy usage in each phase of the section.
        - Customers – Number of customers per phase of the section.
        - Capacity Factor
        - Load Composition – The user must specify what percentage of the load is constant current (%I), constant impedance (%Z), and constant megavolt-ampere (MVA) (%PQ). This defines not only the behavior of the load, but also the boundary conditions used in the power flow solution.
- Spot Loads on Feeder Section

- All of the load is concentrated either at the beginning, middle, or end of the section. This method is defined by the following parameters:
  - kW Demand
  - kVAR Demand
  - Connected kVA – Total kVA capacity available on transformers on each phase for the section, excluding spot loads.
  - Customers – Number of customers per phase of the section.
  - Capacity Factor
  - Load Composition – The user must specify what percentage of the load is constant current (%I), constant impedance (%Z), and constant MVA (%PQ). This defines not only the behavior of the load, but also the boundary conditions used in the power flow solution.
- Capable of using "time-of-day analysis" with the use of "customer class" curves.
- Not included in SynerGEE's load-balancing functions.

A customer class can have up to 72 individual load curves associated with it, including peak day, weekday, and weekend curves for each month for both kW and kVAR. An alternative to defining kVAR curves is to define a constant power factor for each of the 36 respective kW curves. Refer to Exhibit 9-3 for a visual representation for a customer class curve.

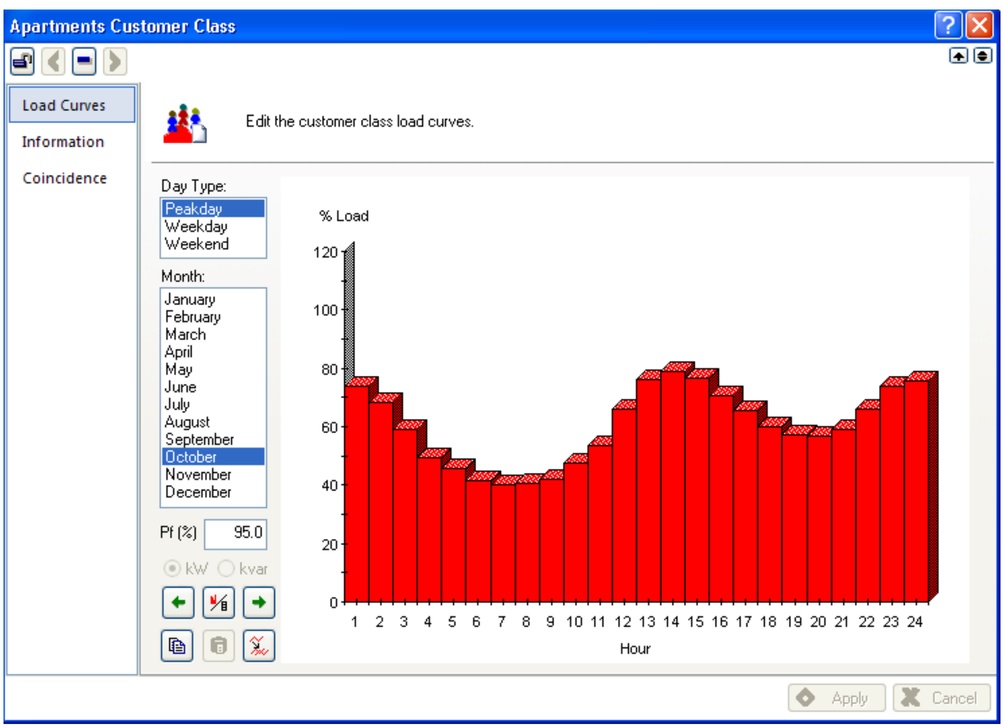

Exhibit 9-3 Customer Class Curves in SynerGEE

The user can set up several customer classes to represent different load types in the model; Exhibit 9-3 is an example of apartment load. After the users have set up various customer classes, they must then define a "customer zone." Customer zones are essentially a mixture of up to three customer classes in specified proportions that determine how much a feeder section's spot and/or distributed load pertains to each class.

Customer zones serve as the intermediary between the raw load data and the model. This intermediate step is necessary to avoid detailed and granular curve data at the section level (models can easily have thousands of sections, even for a small system). It is not feasible to apply customer classes and percentages at the section level for an entire model, because that would require section-specific curves, depending on the load composition. The basic assumption of customer zones is that all loads within a specific zone behave the same way (i.e., have the same composition).

After careful review of the merits of both types of modeling techniques, Black & Veatch determined that the best approach for this study was to model all of the EVs as separate spot loads. Spot loads are simple to implement in SynerGEE and are decoupled from the distributed loads. They can have different load compositions, customer numbers, demand, customer zones, etc., than the distributed loads. This allows the EV loads to have their own separate set of customer zone curves that could be used for all EV loads, eliminating the need to create a composite customer zone curve. Lastly, all customer zones have an assumed load composition (percent constant current, impedance, and MVA) associated with them. EV loads most generally behave as constant impedance loads To obtain the correct power flow on the feeders with EV loads, it is important to ensure that the constant impedance nature of the EV loads is realized in the models; otherwise, the boundary condition used to determine the power flow will be incorrect and could provide misleading results.

9.2.2.3.1 Residential Scenario Modeling

The residential feeder provided by the participating utility was divided into four sections (north, south, east, and west) because the feeder embodied a fairly symmetrical shape, and customer distribution was fairly uniform across each section.

The following sections describe how each sub scenario was modeled on the basis of the physical characteristics of the feeder provided.

9.2.2.3.1.1 Balanced Scenario

The balanced scenario studied up to 100 percent EV penetration in 20 percent increments. The EV placement for this scenario is straightforward. The number of EVs added is a result of the product of the penetration level and the existing customer number as shown below:

$$\boldsymbol{EV\ Load} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)$$

Each distributed load has a defined customer number. This number is understood to present single households. The above calculation assumes two vehicles per household. There is no weighted placement for this scenario; it is strictly driven by the number and location of existing customers. This scenario was also used to benchmark the remaining residential scenarios to ensure that generally the same amount of load was being added at each penetration level to avoid biased results.

9.2.2.3.1.2 End-of-Line Scenario

The end-of-line (EOL) scenario studied up to 60 percent EV penetration in 20 percent increments. The source (distribution substation) is located on the north section of the feeder. Therefore, the south section was selected for the EOL scenario. The equation used in Subsection 9.3.2.3.1.1 for the balanced scenario was modified for the south section, and for the north, east, and west sections as the following equations:

$$\boldsymbol{EV\ Load_S} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{2})$$

$$\boldsymbol{EV\ Load_{N,E,W}} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{0.5})$$

This provided a total EV load similar to the balanced scenario, but with the higher concentration desired on the south section.

9.2.2.3.1.3 Front-of-Line Scenario

The front-of-line (FOL) scenario studied up to 60 percent EV penetration in 20 percent increments. Similarly, as the north section is the closest to the distribution substation, it was selected for the FOL scenario. The equation used in Subsection 9.3.2.3.1.1 for the balanced scenario was modified for the north section, and for the south, east, and west sections as the following equations:

$$\boldsymbol{EV\ Load_N} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{2})$$

$$\boldsymbol{EV\ Load_{S,E,W}} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{0.5})$$

This provided a total EV load similar to the balanced scenario, but with the higher concentration desired on the north section.

9.2.2.3.1.4 Phase Imbalance Scenario

The phase imbalance scenario studied up to 60 percent EV penetration in 20 percent increments. The particular feeder modeled has a partial phase imbalance on the C phase. To be conservative, this was the phase chosen for the phase imbalance scenario. The equation in Subsection 9.3.2.3.1.1 for the balanced scenario was modified for the three phases of the alternating current known as A, B, and C in the following equations:

$$[1].\ \boldsymbol{EV\ Load_C} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{1.5})$$

$$[2].\ \boldsymbol{EV\ Load_{A,B}} = \left(\frac{\boldsymbol{Customers}}{\boldsymbol{Section}}\right)\left(\frac{\boldsymbol{Vehicles}}{\boldsymbol{Customer}}\right)(\%\ \boldsymbol{Penetration})\left(\frac{\boldsymbol{6.6\ kW}}{\boldsymbol{Vehicle}}\right)(\boldsymbol{0.5})$$

This provided a total EV load similar to the balanced scenario, but with the higher concentration desired on the C phase. Per equation [1], all EV loads were assumed to have a power factor of 99 percent. The residential and commercial EVs assumed the charging characteristics of the 2012 Ford Focus EV.

9.2.2.3.2 Mixed Residential and Commercial Scenario Modeling

The mixed residential and commercial feeder represents a feeder with approximately 50/50 distribution of commercial and residential load. This scenario embodies the same practices adopted for the balanced residential scenario with the addition of a public charging station, for example, a parking garage with multiple charging ports. On the basis of the location of the various commercial establishments, Black & Veatch developed five cases. The following is a more detailed description of how each subscenario was modeled on the basis of the physical characteristics of the feeder provided:

1. 20 EV public charging station, 20 percent balanced EV penetrations for residential loads.
2. 40 EV public charging station, 40 percent balanced EV penetration for residential loads.
3. 60 EV public charging station, 60 percent balanced EV penetration for residential loads.
4. 80 EV public charging station, 80 percent balanced EV penetration for residential loads.
5. 100 EV public charging station, 100 percent balanced EV penetration for residential loads.

All EV loads were assumed to have a power factor of 99 percent in accordance with equation [1]. The residential and commercial EVs assumed the charging characteristics of the 2012 Ford Focus EV.

9.2.2.3.3 Fleet Scenario Modeling

The fleet EVs assumed the charging characteristics of the Smith Electric Vehicles Newton EV equipped 120 kWh battery modules. The following equation defines the EV load per vehicle:

$$\boldsymbol{P = \sqrt{3}(21.5\ A)(208\ V)(3)\cos(.098) = 23.233\ kW}$$
$$\boldsymbol{Q = \sqrt{3}(21.5\ A)(208\ V)(3)\sin(.098) = 0.397\ kVAR}$$

Black & Veatch chose one location and studied 20, 40, and 60 percent EV penetration at that location.

9.2.2.3.4 Reliability Criteria

The models used are non-coincident peak models that assume all distribution load peaks at once; this is a conservative industry standard used in distribution and transmission planning. Reliability impacts were assessed in accordance with utility distribution planning criteria.

Voltage Criteria

No load voltages shall exceed 126 V (105 percent of nominal) or fall below 114 V (95 percent) of nominal during system intact conditions.

Thermal Overload Criteria

All conductors and protection equipment (fuses, switches, etc.) shall not be loaded more than 100 percent of their nameplate rating.

Transformer Overloads Criteria

Transformers will be allowed to exceed 140 percent of their nameplate rating for no longer than 24 hours.

9.2.2.4 Comparison of 2010 PNNL Distribution Study to Black & Veatch Study

Black & Veatch reviewed several published studies on the impact of EVs on the distribution system. As previously described, Black & Veatch's methodology and assumptions were based both on previous studies and good engineering judgment. Of all the studies reviewed by Black & Veatch, the study that is the most similar to its study was the 2010 "Technical Challenges of Plug-In Hybrid Electric Vehicles and Impacts to the U.S. Power System:

Distribution System Analysis," performed by PNNL. The table in Exhibit 9-4 shows a comparison of the two. The Black & Veatch study examined, among other issues, where the stress points might be in older feeders that are presumably susceptible to failure.

STUDY ASPECTS	BLACK & VEATCH	PNNL
SynerGEE Electric	Yes	Yes
Steady-State Power Flow Analysis	Yes	Yes
Residential Analysis	Yes	Yes
Mixed Residential and Commercial Analysis	Yes	No
Industrial Fleet Analysis	Yes	No
Time-of-Day Analysis	No (non-coincident peak)	Yes
Mixture of Level 1 and Level 2 Charging	No (assumed all Level 2)	Yes
Balanced EV Penetration Scenario	Yes	Yes
End-of-Line Penetration Scenario	Yes	No
Front-of-Line Penetration Scenario	Yes	No
Phase Imbalance Scenario	Yes	No
Studied Equipment Loading (Lines, Transformers, Fuses, Switches)	Yes	Yes
Multiple Charging Scenarios (charging at home, work, delayed charging, etc).	No	Yes
Effects of Quick Charging	No	Yes

Exhibit 9-4 Comparison of Black & Veatch Study to 2010 PNNL Distribution Study

9.2.2.5 Study Results and Discussion

The Black & Veatch study addressed the following three aspects of reliability with regard to increased EV penetration against the aforementioned criteria:

1. Voltage Criteria – Monitored load side voltages to over and under voltages.
2. Thermal Criteria – Monitored conductor and transformer loadings.
3. Protection Criteria – Monitored the loading of switches, fuses, and fuse pickups settings.

Study results are reported in the following subsections. The residential and mixed use (residential and commercial) feeders are discussed in separate subsections. Because such limited impacts were identified in the industrial/fleet scenario, those results are discussed in the conclusions and outlook sections 9.3.2.6 and 9.3.2.7.

9.2.2.5.1 Residential Scenario Results

While the purpose of the modeling study was to determine stress points in the distribution system due to high levels of EV penetration, these levels of penetration are not expected for several years. Our guidelines for the Electrify Heartland planning effort were to plan for our share of EVs in 2015 based on national EVs sales cumulatively totaling to 1,000,000 vehicles by that time. As stated elsewhere in this report, that level of EV use would result in approximately 7,000 EVs in the Electrify Heartland study area. That number of EVs is much, much lower than the 20 percent and higher cases that were used in the modeling effort to learn what parts of the distribution system might experience stress at high levels of EV penetration.

9.2.2.5.1.1 Residential One Percent Case

As part of our distribution modeling study we ran a "base case" using one percent penetration of EVs. Our planning effort used 1,774,575 as the total number of vehicles in the Greater Kansas City (GKC) study area.[25] One percent of that number of vehicles would be 17,746 EVs in GKC, which is approximately 2 ½ times the 7,000 EVs we were to plan for by 2015.

Exhibit 9-5, below shows that there are no impacts on either the feeder line or the distribution lines regarding voltage at the one percent level of EV penetration on a phase-balanced feeder.

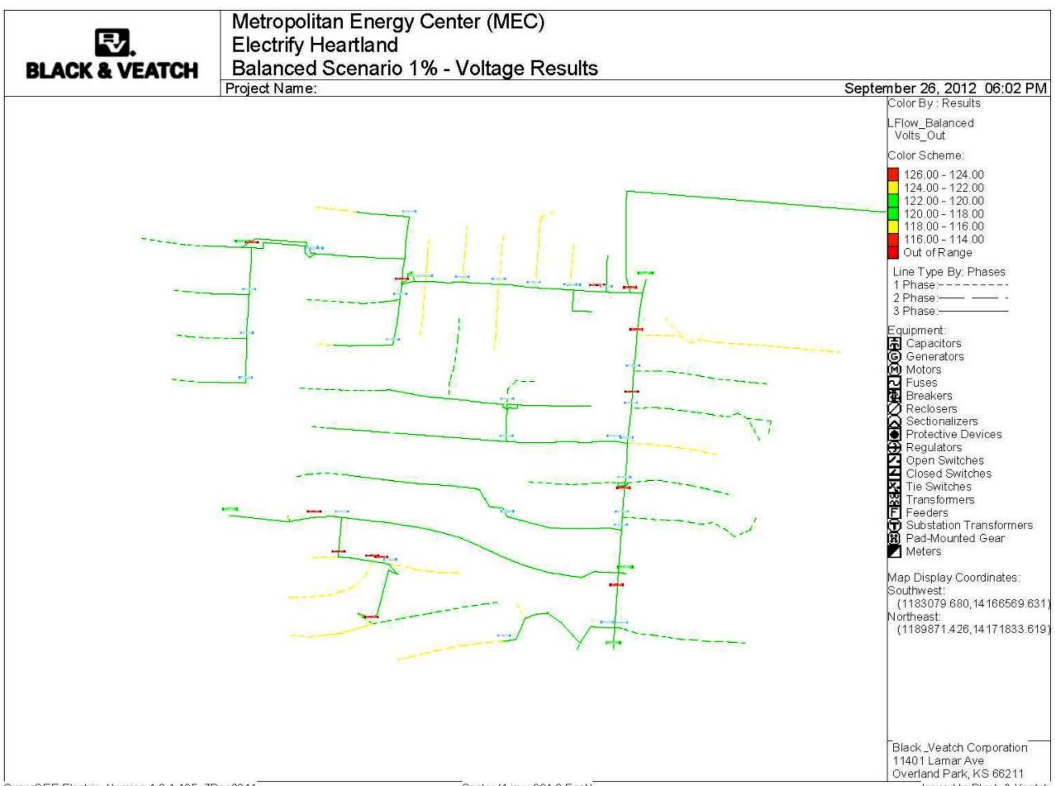

Exhibit 9-5 Balanced Scenario One Percent EV Penetration – Voltage Results

[25] Why EV & EVSE, Ruth Redenbaugh, 12/2011

Exhibit 9-6 below shows that there are no impacts on either the feeder line or the distribution lines regarding thermal overloading at the one percent level of EV penetration on a phase-balanced feeder.

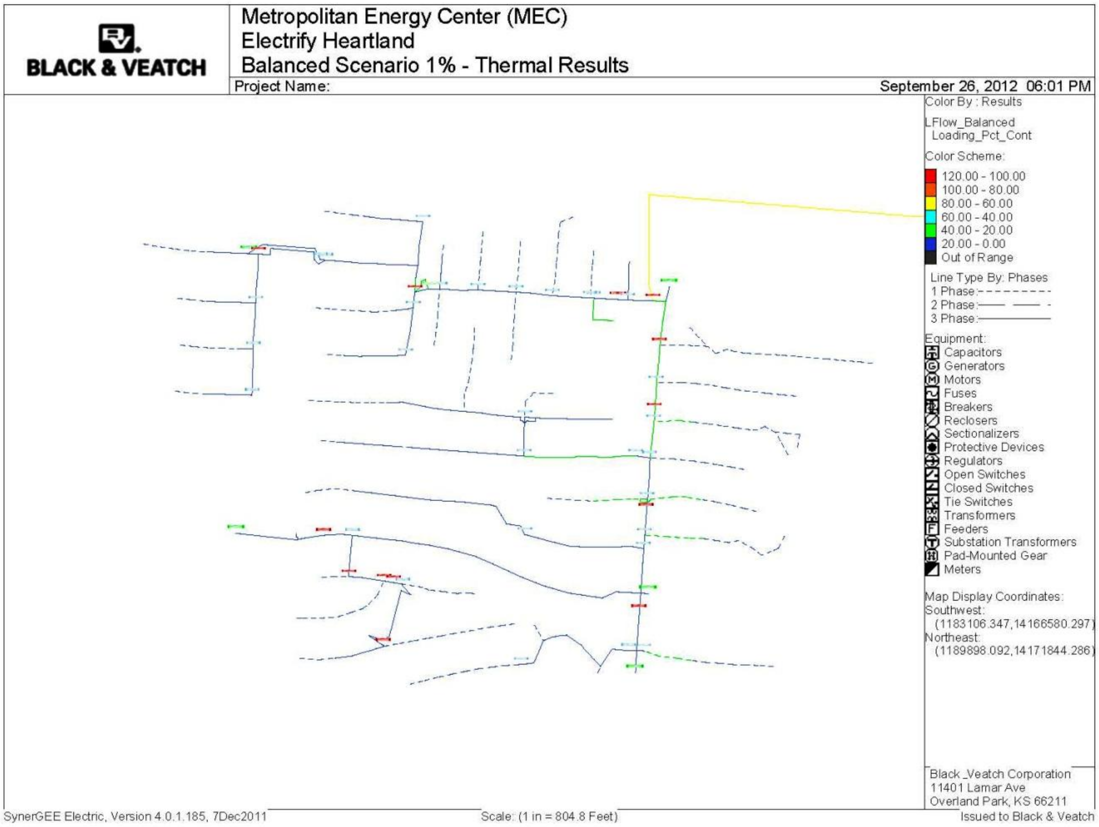

Exhibit 9-6 Balanced Scenario One Percent EV Penetration – Thermal Results

Exhibit 9-7 below shows that there are no impacts on either the feeder line or the distribution lines regarding thermal overloading at the one percent level of EV penetration on a phase-imbalanced feeder.

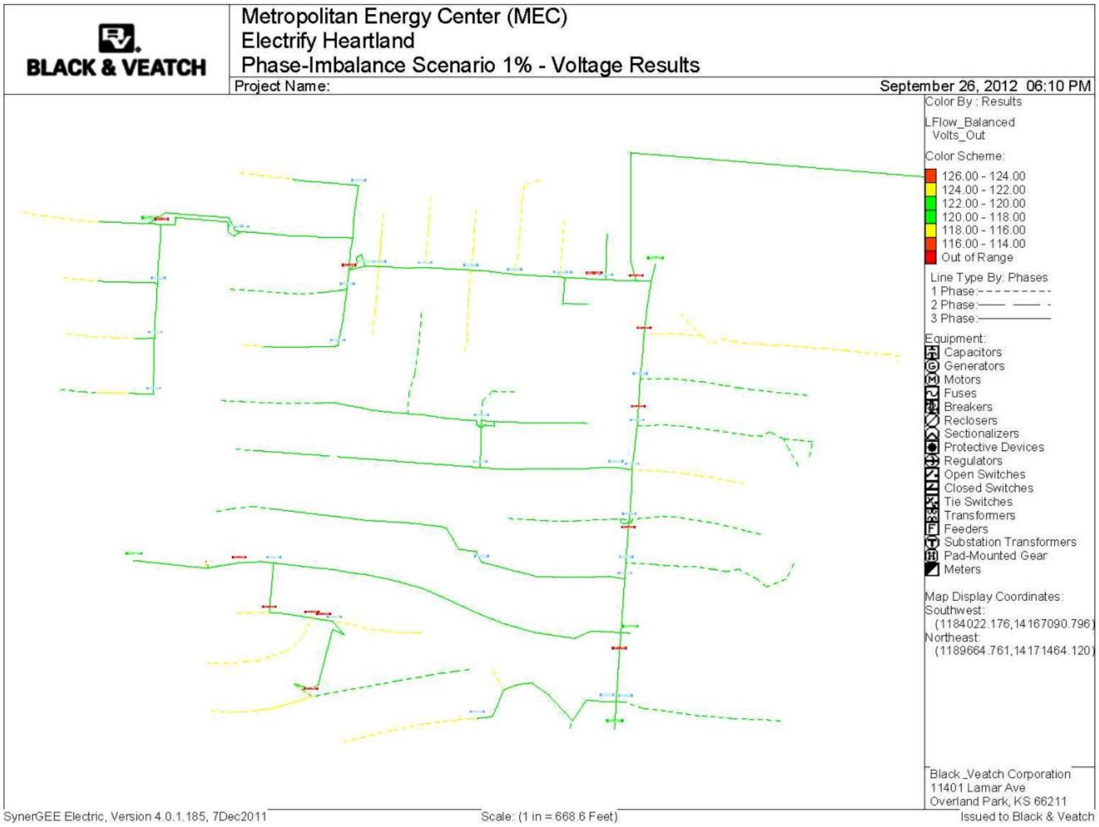

Exhibit 9-7 Phase Imbalanced Scenario at one percent EV penetration – Voltage Results

Exhibit 9-8 below shows that there are no impacts on either the feeder line or the distribution lines regarding thermal overloading at the one percent level of EV penetration on a phase-imbalanced feeder.

For this case of one percent EV penetration, which is more than two times the EV penetration levels planned for in the study, we found no impact on the older, residential distribution feeder modeled. The current distribution system in our area appears to be able to handle EV penetration levels far above the levels expected in the planning study, even using assumptions of charging at relatively high levels at peak times.

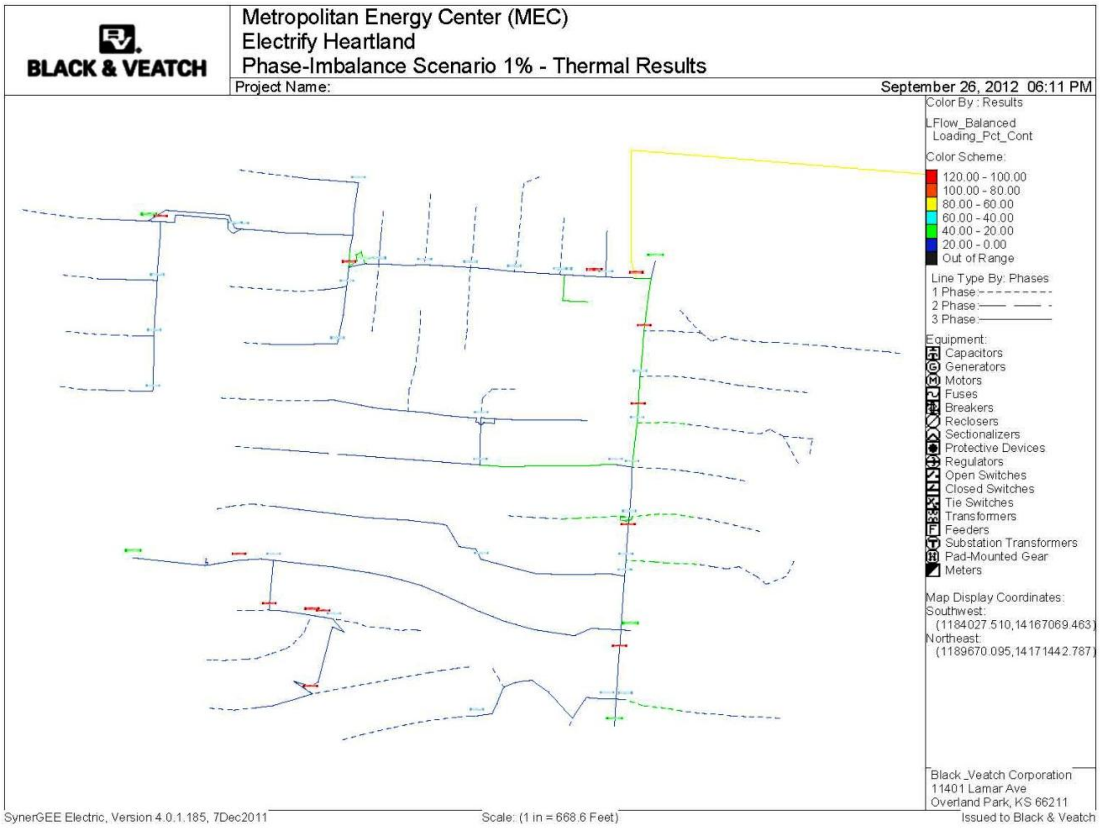

Exhibit 9-8 Phase Imbalanced Scenario at one percent EV penetration – Thermal Results

9.2.2.5.1.2 Higher Levels of EV Penetration

At higher levels of EV penetration, primarily, all of the feeder overloads were limited to the main feed from the distribution substation. This particular feeder under study indicated thermal overloads with EV penetration at 20 percent, with the majority of the overloads present at a 40 percent penetration. While the number of unique overloads did increase slightly as EV penetration increased, most of the overloads were triggered at the lower penetration scenarios. This indicates that a majority of the distribution line upgrades would be prompted by an EV penetration of 40 percent for this particular feeder, as shown on Exhibit 9-9.

Thermal overloads were observed at 20 percent EV penetration, although they were isolated to the main feeder section from the distribution substation. This trend continued as the penetration level was increased up to 100 percent, as shown on Exhibit 9-10.

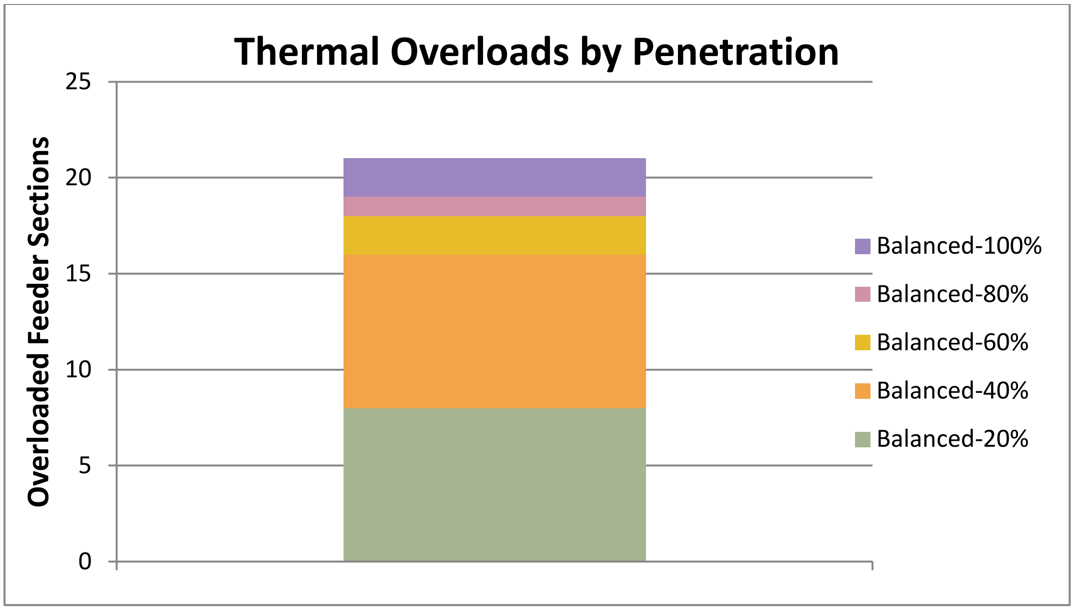

Exhibit 9-9 Balanced Scenario – Conductor Loading

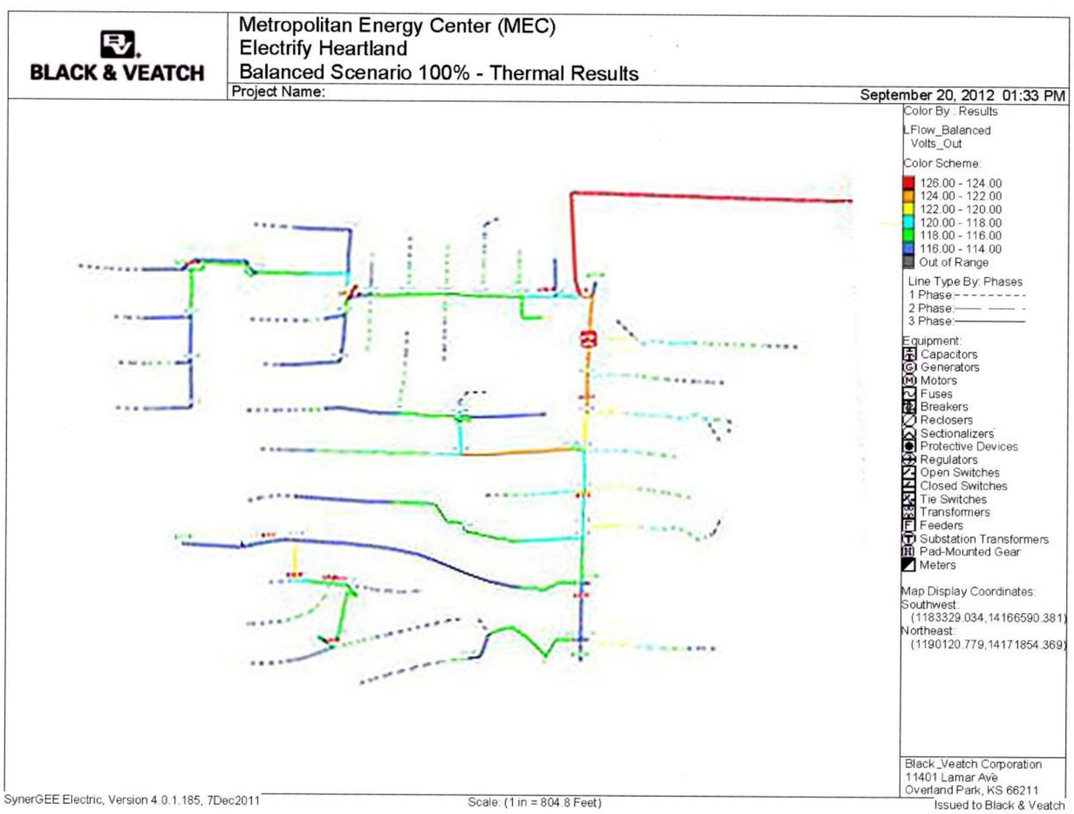

Exhibit 9-10 Balanced EV Scenario 100 Percent - Thermal Results

The number of overloaded feeder sections remained relatively constant at 60 percent and above, with the previous overloads getting worse as more and more EVs were added to the system.

There were minimal voltage violations observed under the balanced scenario. Steady voltage sag was observed as EV penetration was increased, as expected, although no under voltages were observed until the 100 percent scenario, shown on Exhibit 9-11.

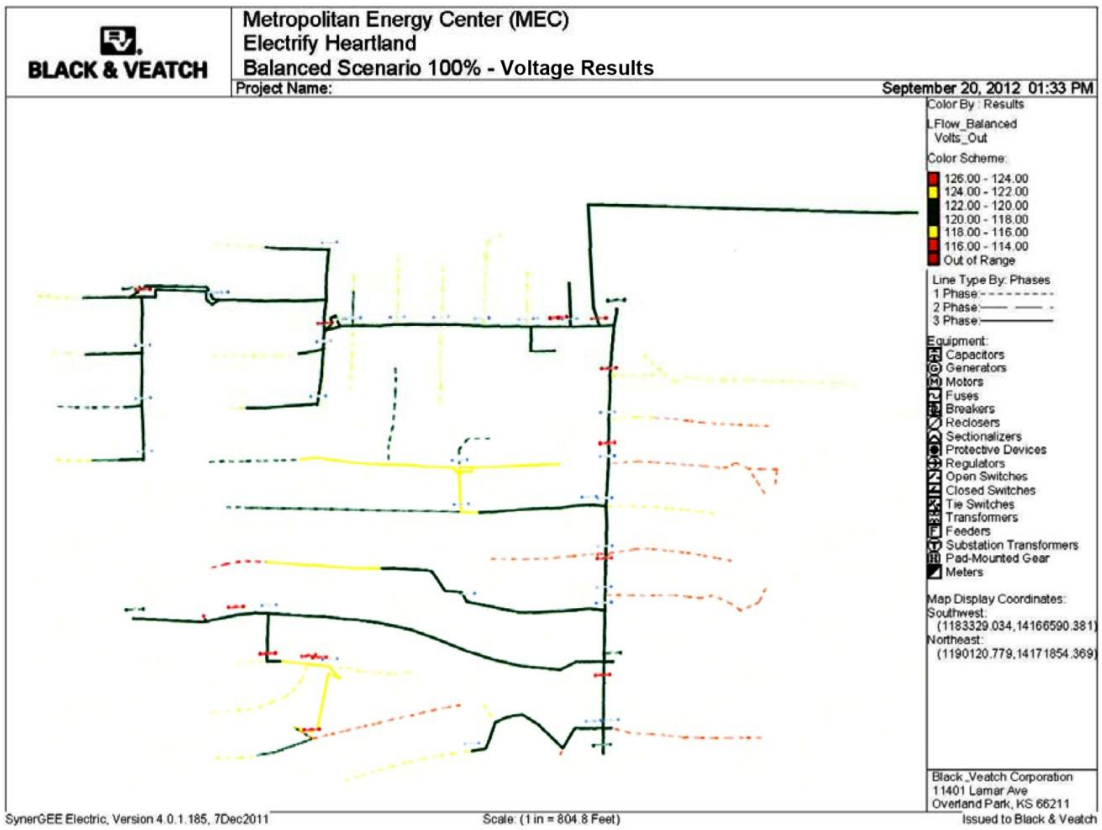

Exhibit 9-11 Balanced EV Scenario 100 Percent - Voltage Results

Distribution transformer overloading was by far the most prominent issue observed under this scenario. Any transformer overloads that existed in the base case condition were omitted from the results because they are not caused by increased EV penetration. There were several distribution transformer overloads observed at 20 percent EV penetration, with the number of transformers overloaded remaining fairly constant throughout the analysis. The number of new and cumulative distribution transformer overloads is shown on Exhibit 9-12.

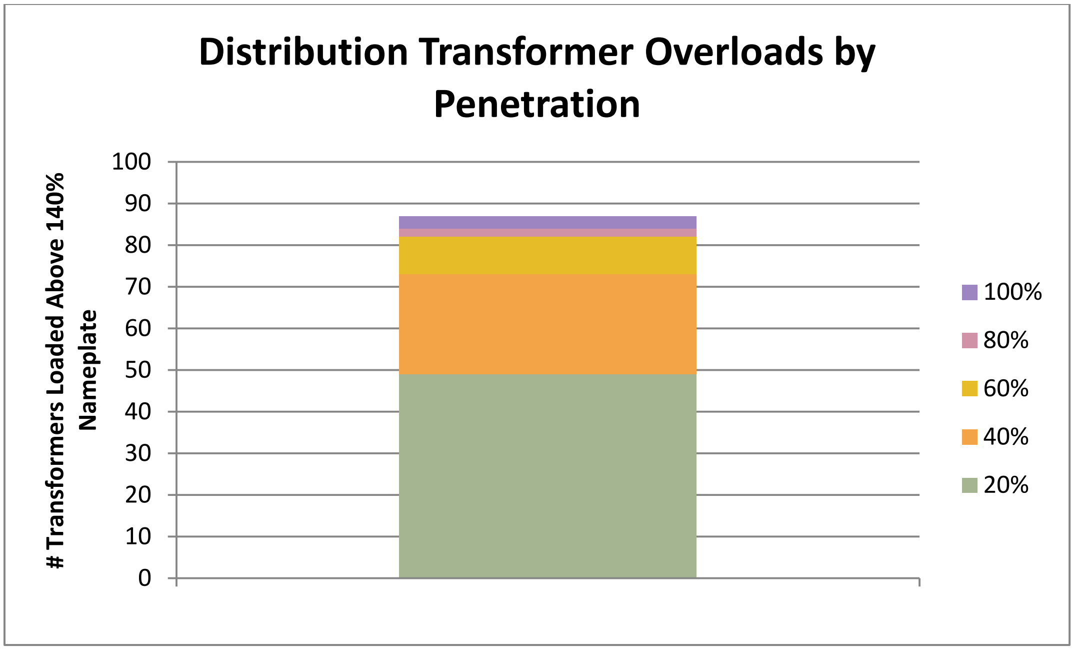

Exhibit 9-12 Balanced Scenario – Transformer Loading

This particular feeder under study indicated thermal overloads with EV penetration at 20 percent, with the majority of the overloads present at a 40 percent penetration. While the number of unique overloads did increase slightly as EV penetration increased, most of the overloads were from the lower penetration scenarios. This indicates that a majority of the distribution transformer upgrades would be prompted by an EV penetration of 40 percent for this particular feeder.

Lastly, the analysis considered the impacts of increased EV penetration on the system protection elements, specifically focusing on switches, fuses, and their associated pickup settings. Although some overloads were observed, they were minor, given the amount of load added to the system. A few switch overloads were observed, as well as some fuse overloads. It can be rationalized that increased EV penetration will require close observance to the loading of system protection elements and protection settings to prevent failures or tripping on load.

Compared to the balanced scenario results, the phase imbalance scenario proved to be much more problematic from a reliability standpoint.

Thermal overloads were observed at 20 percent EV penetration, although they were isolated to the main feeder section from the distribution substation.

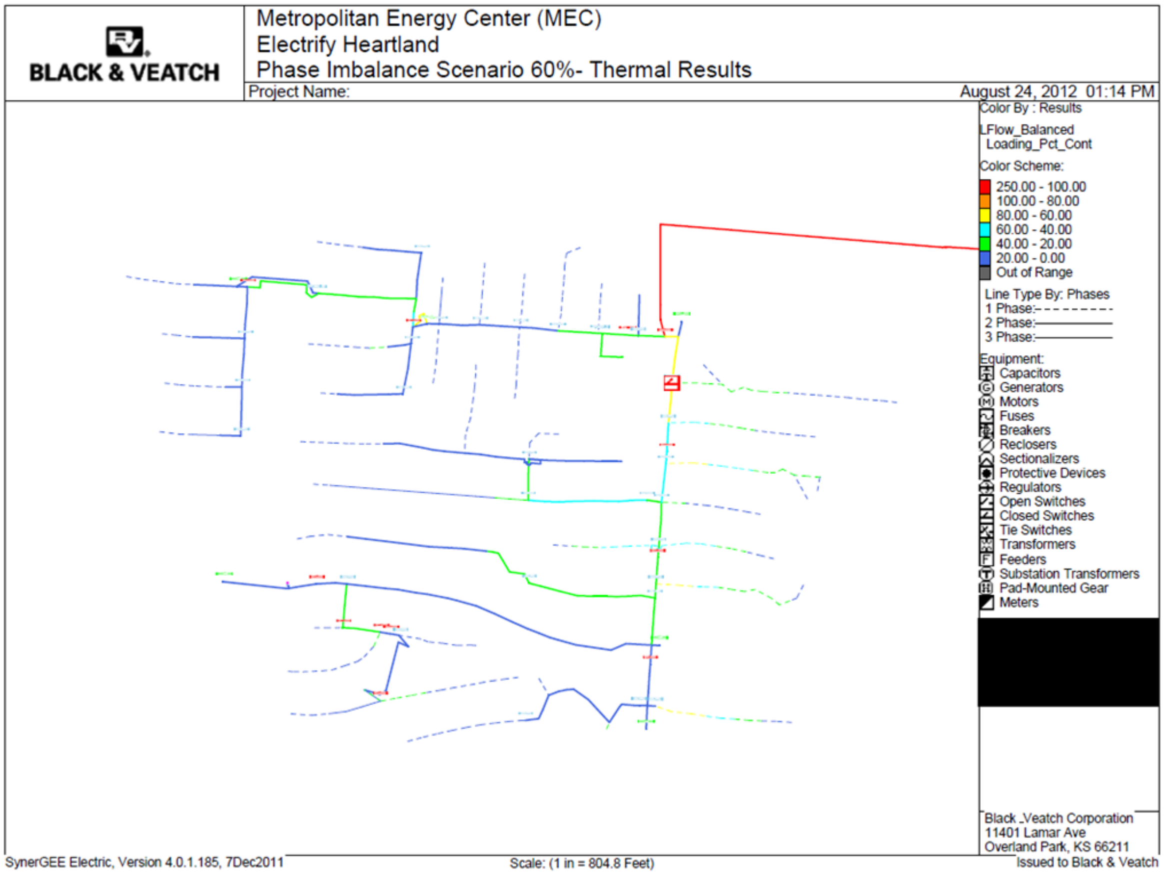

Exhibit 9-13 Phase Imbalance EV Scenario 60 Percent - Thermal Results

This trend continued as the penetration level was increased to 60 percent. The conductor overloads in this scenario continually increased with EV penetration and did not taper off as they did in the balanced scenario. This is shown on Exhibit 9-14.

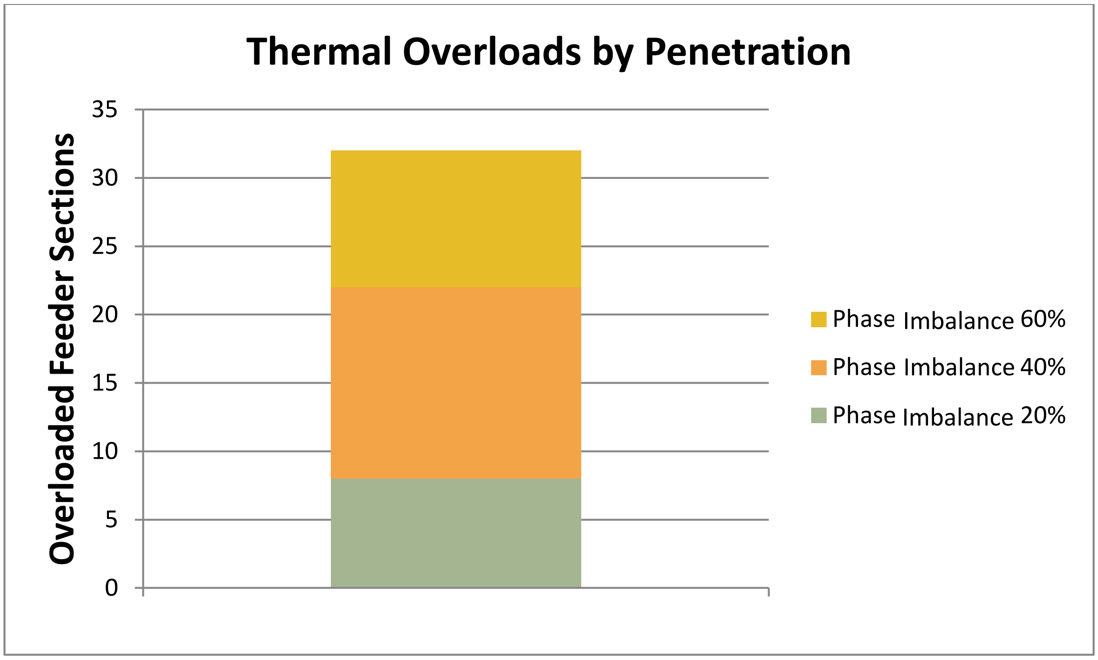

Exhibit 9-14 Phase-Imbalance Conductor Loading

Unlike the balanced scenario, where voltage violations were minimal, significant phase voltage violations were observed in this scenario. Severe under voltages were observed on several C phase sections because of the unbalanced placement of EV load. The voltage sag was large enough in some cases that it resulted in over voltages on the A and B phases. Phase imbalance at the 60 percent penetration level is shown on Exhibit 9-15.

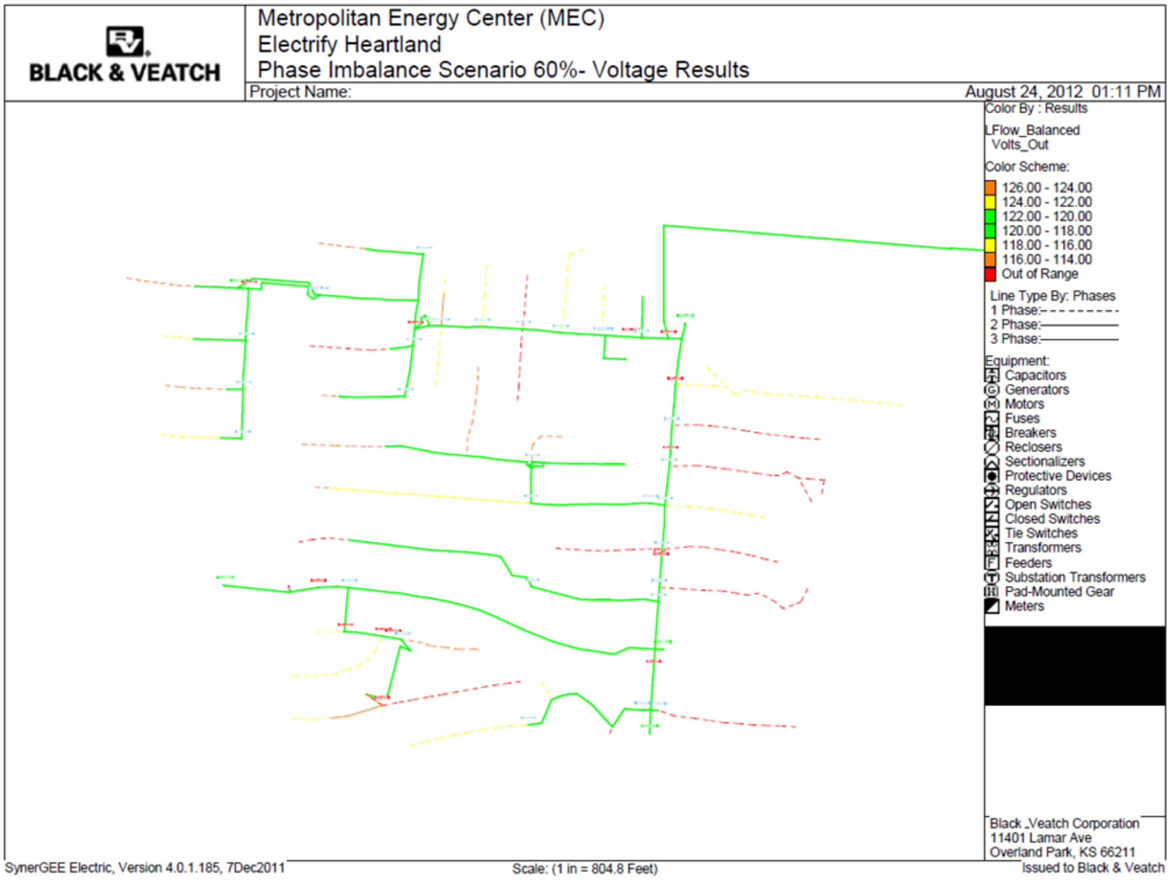

Exhibit 9-15 Residential Scenario, Phase Imbalance Summary 60 Percent, Voltage Results

For the specific feeder under study, a 40 percent penetration with a phase imbalance proved to be the point where the system started to suffer severe voltage sags. Unlike the thermal overloads where the problems leveled out, as EV penetration increases, the issues became much worse, as shown on Exhibit 9-16.

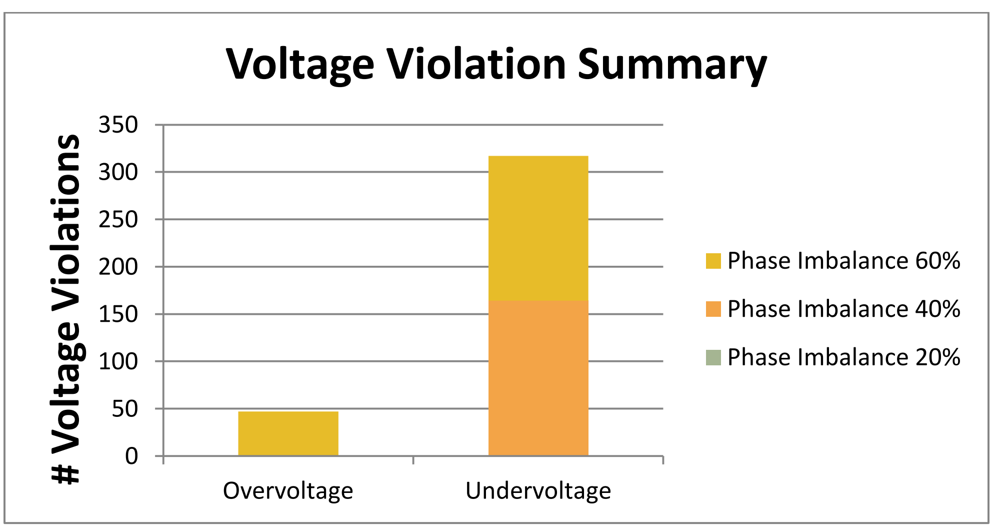

Exhibit 9-16 Phase-Imbalance Voltage Violation Summary

There were several distribution transformer overloads observed at 20 percent EV penetration, with the number of transformers overloaded remaining fairly constant throughout the analysis. Any transformer overloads that existed in the base case condition were omitted from the results because they are not caused by increased EV penetration.

The transformer overloads in this scenario, shown on Exhibit 9-17, continually increased with EV penetration and did not taper off as much as they did in the balanced scenario.

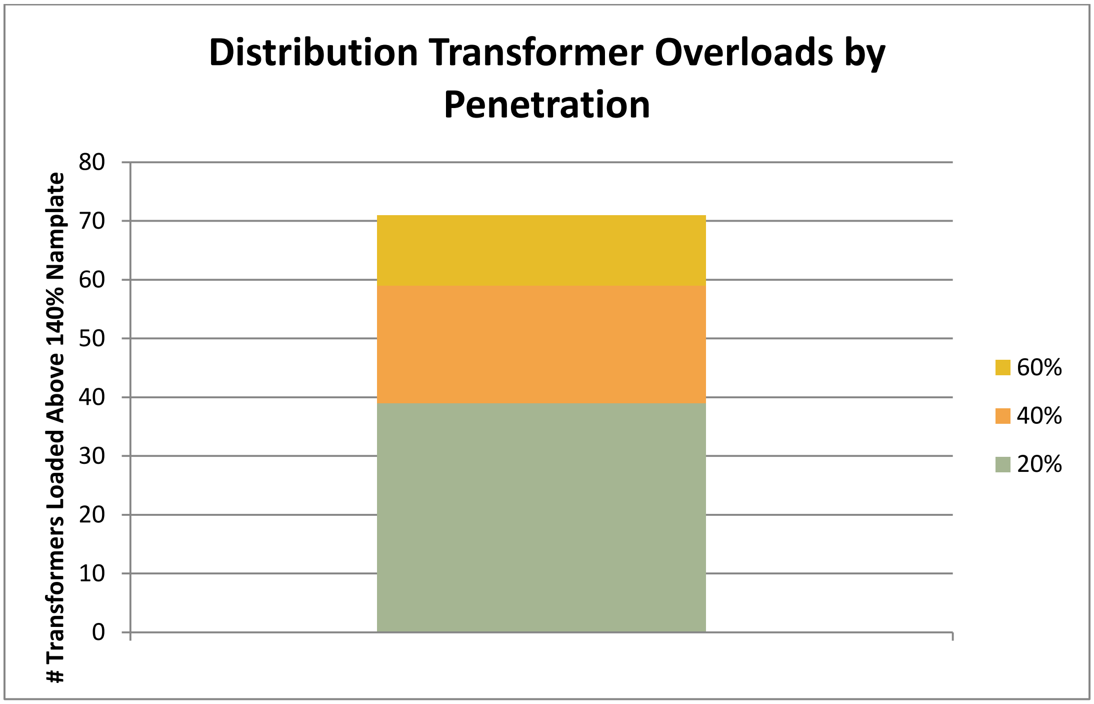

Exhibit 9-17 Phase-Imbalance Distribution Transformer Overloads

Lastly, the analysis considered the impacts of increased EV penetration on the system protection elements, specifically focusing on switches, fuses, and their associated pickup settings. Although there were some overloads observed, they were minor, given the amount of load added to the system. A few switch overloads were observed, as well as some fuse overloads. It can be rationalized that increased EV penetration will require close observance to the loading of system protection elements and protection settings to prevent failures or tripping on load.

9.2.2.5.2 Mixed Residential and Commercial Scenario Results

No switch overloads were identified for this scenario.

Results of the mixed residential and commercial scenario proved to be quite favorable from a reliability standpoint.

A minimal number of thermal overloads were observed, and those were present only in the 100 percent case (100 EV public charging station and 100 percent balanced residential penetration). The thermal overloads were limited to the residential portions of the feeder. These 100 percent penetration level thermal overloads are shown on Exhibit 9-18.

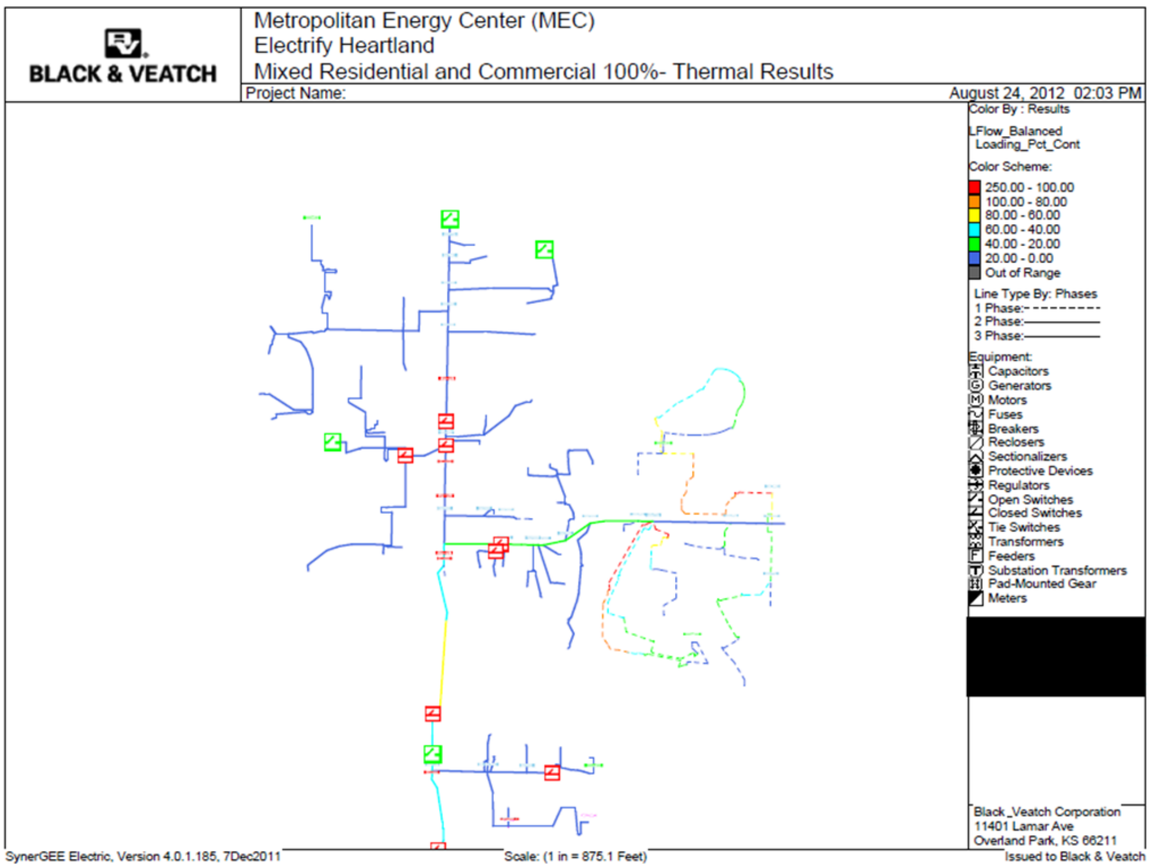

Exhibit 9-18 Mixed Residential and Commercial Balanced EV Scenario 100 Percent - Thermal Results

There were several over voltages observed in this scenario, although they were minimal and could most likely be mitigated by adjusting distribution transformer tap settings. The over voltages were isolated primarily to the A phase because of high voltage sag on the B phase. It is evident that load balancing is just as important for this scenario as it was for the residential scenario. These voltage results are shown on Exhibit 9-19.

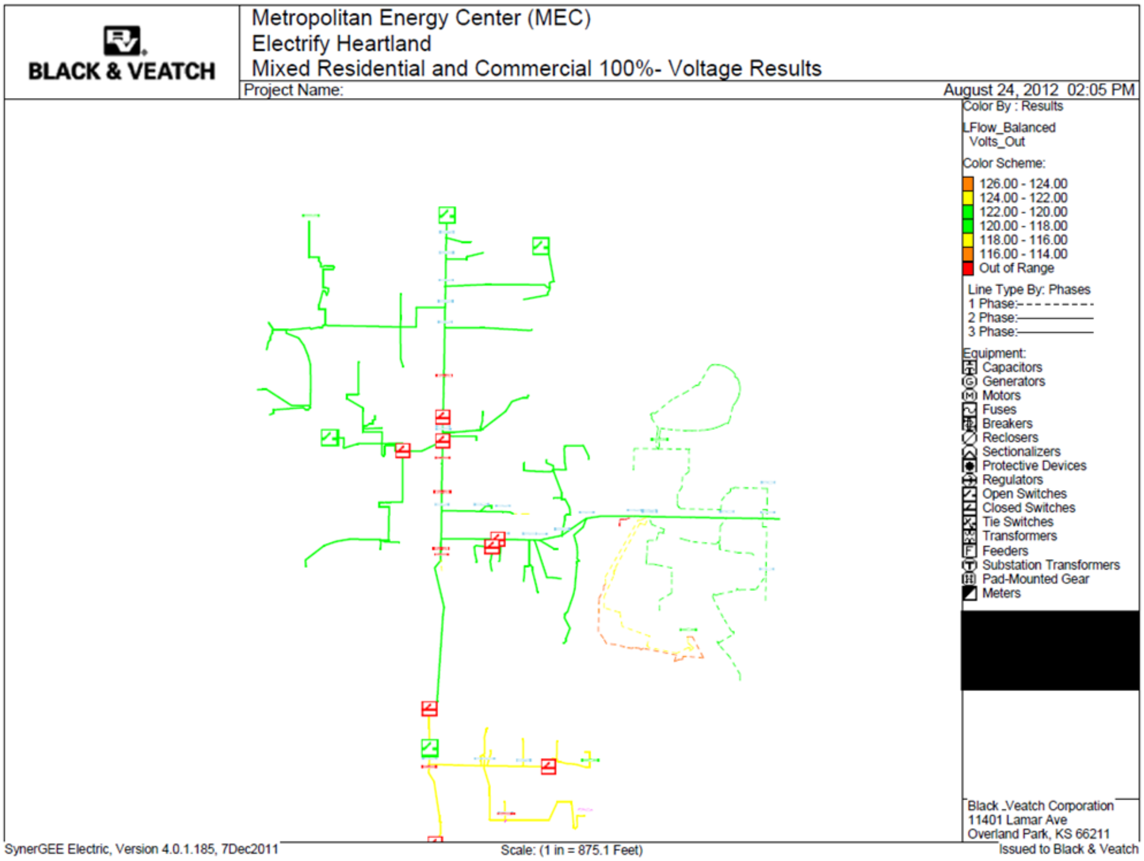

Exhibit 9-19 Balanced EV Scenario 100 Percent - Voltage Results

There were several distribution transformer overloads observed, although not nearly as many as in the residential scenarios. Any transformer overloads that existed in the zero-EV case condition were omitted from the results because they are not caused by increased EV penetration. Distribution transformer overloads by penetration in the mixed-use area are shown on Exhibit 9-20.

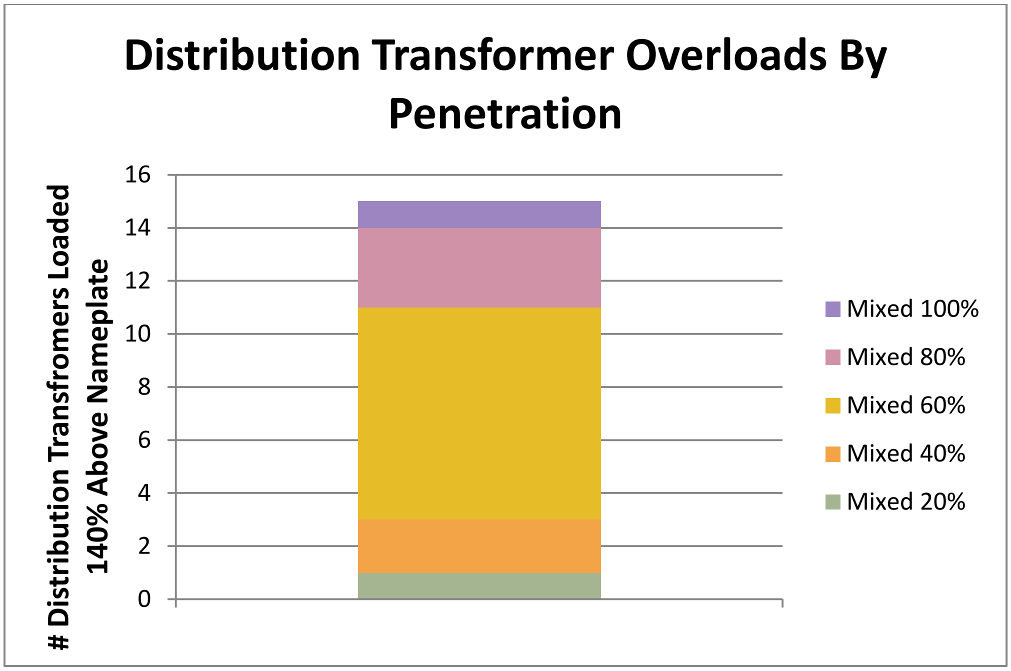

Exhibit 9-20 Mixed Scenario – Distribution Transformer Overloads

Lastly, the analysis considered the impacts of increased EV penetration on the system protection elements, specifically focusing on switches, fuses, and their associated pickup settings. Although some overloads were observed, they were minor, given the amount of load added to the system. No switch overloads were observed. It can be rationalized that increased EV penetration will require close observance to the loading of system protection elements and protection settings to prevent failures or tripping on load.

9.2.2.6 Overall Distribution Level Planning Study Conclusions

Each of the scenarios studied provided valuable insight into the potential reliability impacts on the distribution system associated with increased EV penetration. The following summarizes the above findings and discusses how these impacts will potentially affect the distribution system as a whole for the study area.

The study findings indicate that mainstream EV penetration poses the highest reliability risk to the primarily residential feeders. The residential feeders will most likely have the largest amount of constant EV load (i.e., daily chargers), especially during the work week. In addition, as the system exists today, residential load is typically smaller than that of commercial and industrial establishments. Consequently, the equipment on the residential feeders has lower ratings than that of a mixed residential and commercial or industrial feeder.

Specifically with regard to the residential feeders, the largest reliability implications appear to be caused by potential phase imbalances. The most prominent issues were over- and under-voltage and distribution transformer overloads. For the feeders provided by the utility, the feeder conductors for the most part appear to have adequate thermal capacity to serve this extra load, although there were overloads observed on the main feeder section from the distribution substation. This implies that as significant EV penetrations come to fruition, there may be some upgrades required for the main feeder sections, although this will depend on the feeder and how dense the EV load is.

The issues for the EOL and FOL scenarios were minimal compared to the balanced and phase imbalance scenarios and, therefore, were not covered in this report.

The mixed residential and commercial scenario indicated minimal impacts on the commercial side for public charging stations sized for up to 100 EVs. Most of the impacts were isolated to the residential portion of the feeder.

The fleet scenario indicated no reliability impacts. The feeder provided by the utility for this analysis was a robust feeder with a large amount of industrial load. There are several existing loads that were larger than the total EV load even in the 60 EVs case. EVs also have a high power factor that is important for industrial applications.

It is important to note that this study was performed on a non-coincident peak basis. Therefore, the impacts observed may be more severe than they would be under typical peak loading conditions. The study also assumed that all residential and commercial EVs utilized Level 2 charging. In addition, the results of this study are limited to the steady-state time frame. This study does not assess the impacts with regard to transient stability.

9.2.2.7 Outlook for the Study Area

The most limiting factor to high EV penetration for the study area lies with the residential feeders, because they appear to be more susceptible to reliability impacts. This study presented an aggressive approach to EV penetration in an attempt to bring to light the worst-case barrier to high EV penetration. That being said, the following types of issues were observed and can potentially come to fruition, depending on the location and density of the EV load(s):

- Distribution transformer overloads.
- Conductor overloads.
- Voltage violations.
- Minimal system protection equipment overloads.

The conductor overloads appear to be mostly isolated to the main feed from the distribution substation. Voltage violations are largely dependent on the location of the EV load pockets. Careful consideration should be given to system phase loadings as more EVs come to market. Distribution transformer overloads were one of the most constant violations witnessed across all residential scenarios and one of the most costly, although they were mostly prominent at higher penetration levels.

The use of public charging stations appears to be feasible in centralized locations. Keep in mind that even though this study analyzed a public charging station with up to 100 EVs, only one station at a centralized location was studied. The impacts of multiple 100 unit, or similar, charging locations have yet to be seen.

The use of EVs in industrial applications looks promising based on the results of this study, keeping in mind that only one feeder was studied. Industrial feeders are typically much more robust than a typical residential feeder because of the amount of load being served and the sensitivity of those loads, with some demanding a high degree of reliability to function properly. EVs also have a high power factor, which is particularly important because they do not add to power factor issues caused by motor startup, which is common in industrial areas.

As previously noted, this study does not assess the impacts with regard to transient stability. There are many aspects of reliability that steady-state analysis cannot answer and that can only be addressed by further studies.

9.3 EV/EVSE/Grid Communications

9.3.1 Introduction

Various types of communication are available with EVSE. At an advanced level, sophisticated communications may be possible for power-use monitoring and control, financial transactions, and marketing statistics on vehicle use. There are several parties, perhaps with varied interests, that could be potentially involved in EVSE communications. The parties involved could include the vehicle owner, the vehicle manufacturer, the EVSE owner, a third-party financial transaction manager, the electric utility, and/or a third-party demand side management aggregator. The type of communication system involved can determine how and what data flows to whom and who is in control of the EVSE power. If prospective PEV buyers do not see EVSE that match the cars they are considering, it could be a barrier to EV adoption. Electric vehicles without an EVSE infrastructure have a limited value for purchase and resale. Electric vehicles that "can be plugged in anywhere" have more utility and value. Standards tend to lower costs of manufactured goods such as EVSE by creating a competitive marketplace of suppliers. Standards also can make manufacturing decisions easier and cheaper as suppliers vie for that segment of the auto supply chain market.

Utilities would like to know how much power is being used for EV charging and where those vehicles are charging.

9.3.2 Background

9.3.2.1 Standards History

Several international standards and industry organizations are involved in EVSE communications. In the U.S. market, principal among these are the SAE, the Institute of Electrical and Electronics Engineers (IEEE), and EPRI. Consideration of standards for EVSE communications began many years ago, but standard setting is still ongoing. For instance, SAE recently moved to focus Level 1 and Level 2 charging on the European-based ISO/International Electro technical Commission (IEC) 15118 standard. Chinese interests have limited activity in the American standard setting discussions.[26]

9.3.2.2 Utility Communication Standard

EPRI is working toward a common standard for utility communications and is involved in setting standards, along with IEEE and SAE. EPRI established an Infrastructure Working Council to provide a forum for utilities, automotive manufacturers, suppliers, and other stakeholders to address issues regarding electric infrastructure for PHEVs and EVs.[27]

9.3.3 Current Standards

The anticipated increase in electric-powered vehicles has prompted many efforts, both domestic and international, to standardize aspects of the industry. One useful and widely used model is the Open System Interconnection (OSI) model (ISO/IEC 7498-1), which defines the following seven layers of a communication system: [28]

1. Physical
2. Data link
3. Network
4. Transport
5. Session

[26] Lawler, Tim. EPRI. Interview by Bill Roush. 26 Mar. 2012.

[27] Electric Power Research Institute. "2009 Portfolio: Electric Transportation - Program Overview." *Electric Power Research Institute*. N.p., 2009. Web. 10 Dec. 2012. <http://mydocs.epri.com/docs/Portfolio/PDF/2009_P018.pdf

[28] SAE International. "Charging – What Can Be More Simple?" *SAE International*. N.p., n.d. Web. 28 Sept. 2012. <http://www.sae.org/smartgrid/chargingprimer.pdf>.

6. Presentation
7. Application

SAE standards have been developed to address some of the layers defined in the OSI model: SAE 2931 (OSI link layer) establishes the type of technology used, and SAE 2847 (OSI application layer) establishes how data are presented.

The SAE standard J1772 defines two levels of EV power charging:

- Level 1—120 V AC charging from standard 15 or 20 amp NEMA outlet, on-board vehicle charger (approximately 1.9 kW).
- Level 2—208–240 V AC charging up to 80 amps, on-board vehicle charger (approximately 19 kW).

~A definition for DC charging levels (fast charging) is currently under development.[29]

Other organizations and companies are collaborating to find workable standards for the industry. One such group, the Smart Energy Initiative, which consists of American Electric Power, Consumers Energy, Pacific Gas and Electric Company, Reliant Energy, Sempra, and Southern California Edison and ZigBee and HomePlug alliances, is working on advanced metering infrastructure (AMI) and home area networks (HANs). EPRI is also collaborating to standardize communications and certification processes to improve the efficiency of the smart grid.

9.3.3.1 Establishing a DC Fast Charging Standard

Currently, there is no single "breakout" vehicle with enough sales to drive the development of standards. Absent international standards from traditional organizations, Nissan is actively working with a Japanese group called CHAdeMO[30] (which stands for charge and move) for its DC fast charging equipment. The Nissan Leaf uses a CHAdeMO plug and is a leading production non-hybrid EV. The DC fast charging system is optional on the Leaf (50 kW), so only a limited number of Leafs have the feature. The system is used in Japan, Norway, and parts of the United States. ABB is currently introducing Terra Smart Connect in Europe using CHAdeMO connectors. The Chinese are not participating fully with either the CHAdeMO or SAE/European Automobile Manufacturers' Association (EU ACEA) international standard setting group.

---

[29] *MindDrive*. Tangient, n.d. Web. 10 Dec. 2012. <http://minddrive.wikispaces.com/EPK>. This is a wikispace that contains information about the MindDrive project objectives, educational objectives,mentor educational process and project bios.

[30] "Hydro-Quebec Joins CHAdeMO Association." *CHAdeMO*. N.p., n.d. Web. 10 Dec. 2012. <http://www.chademo.com/pdf/pressrelease.pdf>.

NRG Energy and the California Public Utilities Commission have entered into an agreement that includes deploying a minimum of 200 DC fast charging EVSE sites in the state. The agreement was part of a settlement stemming from the legal actions taken as a result of the 2001 California energy crisis. NRG's subsidiary produces eVgo charge stations that convert 480 V AC to DC. Past NRG DC charging projects have used a CHAdeMO-compliant charger, but it is unclear what the plans are for these new California DC chargers.

9.3.4 Recent Standards Developments

There is progress from conventional standard setting organizations in establishing standards for EVSE fast charging and communications. SAE narrowed Levels 1 and 2 charging to ISO/IEC 15118 in late March 2012.[31] This decision anticipated fast DC charging, but did not set a standard.

The International SAE has chosen the "combined charging system," as has the ACEA, the European association of vehicle manufacturers. This is an AC/DC system that builds on the SAE J1772–type connectors. It includes single and faster three-phase AC charging, DC charging at home, and ultra-fast public DC charging.[32] For this combined charging system agreed to by SAE and ACEA, member vehicle manufacturers Audi, General Motors, BMW, Chrysler, Daimler, Ford, Porsche, and Volkswagen are set to have vehicles fully using the system by 2017.

9.3.5 Alternative Communications and Control Methods

In addition to the EVSE through network via smart grid communications discussed here, there are other communications avenues to control charge patterns that may help address EV adoption barriers. These forms of communication may also be used to help address the multiple issues of safe battery charging, cost allocation and efficient infrastructure use.

For example, a utility could potentially communicate with the EV, rather than the EVSE, through onboard telematics, such as GM OnStar®, to control charging. A signal sent directly to the EV from the utility could allow the car to accept or decline charging.

Also, utilities can already communicate directly with ratepayers to convey information regarding the costs and benefits of various charging scenarios. This communication could be targeted to EV owners. It could come in the forms of informational campaigns such as fact sheets, information tied to billing (via paper or on the Web), and special EV rate structures.

---

[31] Lawler, Tim. EPRI. Interview by Bill Roush. 26 Mar. 2012

[32] REVE. "Universal Charger for Electric Vehicles." *REVE*. N.p., 5 July 2012. Web. 7 May 2012 <http://www.evwind.es/2012/05/07/universal-charger-for-electric-vehicles/18350/>.

9.3.6 EVSE Communications and Smart Grids

Because EVSE communications would interface with smart grid communications planned by many utilities, there is an effort to coordinate these systems. Smart Energy Profile 2.0 is being moved forward by the ZigBee® Alliance (a group of vendors using the proprietary Zigbee low-power wireless sensor and control networks) and includes the following development partners.[33]

- HomeGrid
- HomePlug Powerline Alliance
- SAE International
- IPSO (Internet Protocol Smart Object) Alliance
- SunSpec Alliance
- Wi-Fi Alliance

Smart Energy Profile 2.0, which includes EVSE EV communications, is not universally agreed upon but is in the process of developing standards. The capabilities of this communication could include commands to provide information such as location, battery capacity, charge cycles, and how much energy an EV could use versus how much it is actually using. At this point, this Smart Energy area is limited to proprietary services. In this scenario, ZigBee would be the link layer, and on top, visible to the end user, would be an EV energy management and control application layer.

Smart Energy Profile 2.0 is intended to address such topics as sub-metering, special EV tariffs, demand response, off-peak charging, mitigation of local EV hotspots at distribution transformer level, vehicle to grid, energy storage for grid arbitrage and ancillary services, micro-grid and uninterruptible power supply (UPS) and renewable energy integration (green renewable energy credit [REC] sales, etc.).

9.3.7 Conclusion

While there is considerable progress being made in Level 1 and Level 2 charging standards, there is no universally agreed-upon standard for DC fast charging. This is a barrier to EV adoption because travel by EVs over long distances or extended or unplanned excursions, even close to home, becomes more difficult if “15 minute” recharging is not available for the vehicle model in use.

---

[33]ZigBee Alliance. "Smart Energy Profile 2.0 Documents." *ZigBee Alliance*. N.p., 30 Mar. 2012. Web. 10 Dec. 2012. <http://www.zigbee.org/Standards/ZigBeeSmartEnergy/Version20Documents.aspx>.

Fast charging requires powerful electrical infrastructure, possibly in a somewhat remote location, such as a refueling station in a rural area of a heavily traveled interstate or state highway. Demand for EVSE stations like this may require planning by electric utilities; such planning is complicated when EVSE fast charging standards are not set. Further, some of these locations may be in the service territory of smaller electric utilities, rural electric cooperatives, or municipal utilities who have not previously planned for high EV penetration levels. The transient nature of the EV fast charging load may be of concern to utilities.

Communications with EVSE can aid utilities in managing EV charging load to off-peak times, lessening the impact on stressed distribution infrastructure. This communication can come in forms such as onboard telemetric (GM OnStar), networked EVSE, and direct smart metering to vehicle communication.

9.4 Kansas and Missouri Utility Rates for EVSE

9.4.1 Kansas and Missouri Public Utility Commission Activity

It is possible that the Kansas Corporation Commission (KCC) and Missouri Public Service Commission (MPSC) could incorporate rate tariffs that would affect EV use and development. However, there is currently little activity at the KCC or MPSC that could be construed as a barrier to EV development. The current activities being pursued by the two commissions are summarized in the following subsections.

9.4.1.1 Kansas Corporation Commission Electric Vehicle Activity

A pilot program for real-time electricity pricing filed by Westar Energy in January 2009 (effective February 2010) could affect EV development in Westar's North Rate Area (roughly northeast Kansas). It was a small pilot program, limited to five customers. While the tariff structure is complex, the "Energywise Adjustment" is essentially weighted by the customer's actual kWh energy metered, minus the customer's baseline load (CBL).[34] This adjustment could effectively increase or reduce the customer's bill, depending on how much the customer's usage differs from the customer's CBL. The results of this study are not currently available.

[34] *Westar Energy*. Ed. Westar Energy and State Corporation Commission of Kansas. N.p., 2009. Web. 10 Dec. 2012.<http://www.westarenergy.com/wcm.nsf/publishedtariffs/57B82FE1CAD08EFA8625770C0067622C/$file/EHLF-RTP.pdf>.

In the spring of 2012, the KCC approved a pilot program for up to 1,000 Westar customers, anywhere on the system, to opt for a time-of-use rate program.[35]

Additionally, Kansas City Power & Light (KCP&L) has suggested a series of informal collaborative workshops to discuss rate design issues with broad implications, such as exploration of the best method to encourage off-peak charging of PHEVs.[36]

9.4.1.2 Missouri Public Service Commission Electric Vehicle Activity

The MPSC was awarded an American Recovery and Reinvestment Act (ARRA) grant of $900,000. The goal of the project, as stated in the MPSC 2010 Report[37], is as follows:

> The Commission applied for and was awarded an ARRA grant of $900,000 to be spent over a four year period to help facilitate timely consideration of dockets, demand-side management tariff filings, notices of inquiry, integrated resource plans, rulemakings and other regulatory actions pertaining to the ARRA electricity-related topical areas of: renewable energy, energy efficiency, demand response, energy storage, Smart Grid, plug-in hybrid electric vehicles, coal and carbon capture and storage, transmission and distribution.

As the grant indicates, this money is to be allocated, in part, for topics relating to PHEVs. The MPSC has hired an engineer and a policy analyst to work on this project full-time. A 2010 Missouri Department of Economic Development ARRA Dashboard Report indicated that there will be future work targeted at streamlining policy decisions related to "modernizing" and maintaining Missouri's "electric system."[38]

The MPSC also received a real-time electricity pricing program filing from KCP&L. This filing, which applies to industrial and commercial customers, was effective May 14, 2006, and may be relevant to EV development in the area.[39]

---

[35] LEHRMAN, MATT. INTERVIEW BY BILL ROUSH. 26 APR. 2012. REGARDING WESTAR SMARTSTAR PROGRAM.

[36] "KCC Docket No. 09-GIME-360-GIE (27 June 2009 Order, ¶127)," *Kansas Corporation Commission*. N.p., n.d. Web. 10 Dec. 2012. <http://estar.kcc.ks.gov/estar/ViewFile.aspx/20090727082750.pdf?Id=3ed8929d-f080-4577-9041-9317d657dd09>.

[37] "Missouri Public Service Commission 2011 Annual Report." *Missouri Public Service Commission*. N.p., 2011. Web. 10 Dec. 2012. <http://psc.mo.gov/CMSInternetData/Annual%20Reports/PSC%20Annual%20Reports/2011%20Annual%20Report.pdf>.

[38] *Transportation*. N.p., 14 Apr. 2010. Web. 10 Dec. 2012. <http://library.modot.mo.gov/RDT/ARRA/TEMP/DED%20ARRA%20DASHBOARD,%20APRIL%205,%202010.PDF>.

[39] "KCP&L Real Time Pricing." *Kansas City Power & Light*. N.p., 13 Apr. 2006. Web. 10 Dec. 2012. <http://www.kcpl.com/ABOUT/MORATES/SCHED26.PDF>.

9.4.2 Resale of Electricity through EVSE

Kansas and Missouri laws prohibit the resale of electricity to a consumer via a third party. Laws similar to ones in Kansas and Missouri are common in the United States. However, several states are considering allowing resale of electricity through EVSE. Colorado passed a law that, effective August 2012, would allow the resale of electricity through EVSE.[40]

9.4.3 Conclusion

Policy and infrastructure will evolve in the coming years to adapt to increased EV market penetration. For example, to handle possible increased peaks on local grids, utility companies could request the implementation of EV-targeted tariffs. Potentially, these changes could serve as barriers to EV deployment. To the extent that those legislative or regulatory actions seek to add additional costs to or restrictions on EVSE service to EVs, such as requiring separate customer-purchased meters, prohibiting charging at certain times of the day, or prohibiting third-party resale of electricity through EVSE, those actions could dampen EV market penetration.

Currently in Missouri and Kansas, utility regulators have not systematically addressed EV issues or created new barriers to EVSE adoption. However, both states do have regulations and utility tariffs that prohibit the resale of electricity by a third-party, which effectively prevents the development of third-party EVSE deployment in both states.

9.5 Net Metering Plan and Electric Vehicles

9.5.1 Kansas and Missouri Net Metering Laws

In Kansas, net metering is limited to 200 kW for nonresidential utility customers and 25 kW for utility customers. The rule applies only to investor-owned utilities. Meter aggregation and V2G issues are not specifically addressed. A bidirectional meter must be supplied at no cost to the customer. There is a capacity limit to net metering set at 1 percent of a utility's retail peak demand for the previous year.[41] A bill was introduced in the Kansas Senate that could raise the 200 kW nonresidential limit to 3 MW; but as of November 2012, no further action had been taken.[42]

---

[40] Finley, Bruce. "Electric-Vehicle Drivers in Colorado to Get a Charge Out of New Law." *Denver Post*. N.p., 24 June 2012. Web. 10 Dec. 2012. <http://www.denverpost.com/recommended/ci_20926269>.
[41] "Kansas Incentives/Policies for Solar." *Database of State Incentives for Renewables & Efficiency*. North Carolina State University, 28 June 2012. Web. 10 Dec. 2012. <http://www.dsireusa.org/SOLAR/INCENTIVES/INCENTIVE.CFM?INCENTIVE_CODE=KS08R&RE=1&EE=1>.
[42] "Senate Bill No. 383 by Committee on Utilities." *Kansas Legislature*. N.p., 1 June 2012. Web. 10 Apr. 2012. <http://www.kslegislature.org/li/b2011_12/measures/sb383/>.

In Missouri, net metering has a system capacity limit of 100 kW and an aggregate cap of 5 percent of the utility's single-hour peak load. The rule applies to all utilities in Missouri. REC ownership, V2G, and meter aggregation issues are not addressed. The customer must pay for any additional metering hardware required.[43]

9.5.2 Regulatory Status of EV Charging/Discharging into Grid

This issue does not appear to be addressed in either Missouri or Kansas.

9.6 Electric Vehicle Tax Legislation

EVs are becoming increasingly available as an option for transportation. However, the EV market is still relatively small. According to the 2011 U.S. Energy Information Outlook, only about 20,000 electric cars existed in 2011 compared to more than 225 million total vehicles on the road in the U.S.[44] This number will likely increase with President Obama's goal of 1 million EVs nationwide by the year 2015 and the administration's 2012 budget that proposes increasing the existing EV tax credit from $7,500 to $10,000.[45] When broken down into a local 14 county region, this 2015 goal would result in about 7,000 EVs on the road in Kansas and Missouri (exclusive of the St. Louis and Cape Girardeau metros).

With this background in mind, this section examines potential legislative and regulatory barriers to achieving the EV adoption rates described above. If the current fuel tax policy remains as these electric vehicles enter the market, state fuel tax revenues will be affected. It is possible that state legislators will respond to this potential impact on revenue by enacting EV use taxes. If implemented, such taxes could serve as a barrier to EV deployment.

9.6.1 Potential Electric Vehicle Use Tax Issues

Currently, both Kansas and Missouri use fuel tax revenues for maintaining and constructing highways and roads. A substantial growth in EV use could slow the growth of or reduce federal and state fuel tax revenues, and this is a concern as governments consider changes to infrastructure and policy to allow for EV deployment.

---

[43]"Kansas Incentives/Policies for Solar." *Database of State Incentives for Renewables & Efficiency*. North Carolina State University, 28 June 2012. Web. 10 Dec. 2012. <http://www.dsireusa.org/SOLAR/INCENTIVES/INCENTIVE.CFM?INCENTIVE_CODE=KS08R&RE=1&EE=1>.

[44]Energy Information Administration. "Light Duty Vehicle Stock by Technology Type, Reference Case." *US Energy Information Administration*. US Department of Energy, n.d. Web. <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=49-AEO2011®ion=0-0&cases=ref2011-d020911a>.

[45]Voelcker, John. "Obama 2012 Budget Proposes Higher Tax Credit For Plug-In Cars." *The Washington Post*. N.p., 15 Feb. 2012. Web. 10 Dec. 2012. <http://www.washingtonpost.com/cars/obama-2012-budget-proposes-higher-tax-credit-for-plug-in-cars/2012/02/15/gIQAPuKgFR_story.html>.

Several states have proposed plans to resolve this decrease in fuel tax revenue and to ensure that EV owners pay a fair share of transportation costs. The Washington State Senate recently passed legislation that requires owners of electric vehicles to pay a $100 fee when they register their cars each year in order to make up for lost gas tax revenue.[46] Similar legislation currently being considered in Oregon would charge registered owners or lessees of electric vehicles 1.43 cents per mile.[47] In both bills, revenues would be distributed to state and local transportation projects in a similar way to fuel tax revenues.

Legislative efforts of this type are not new occurrences. Over the past few years, Arizona, California, Colorado, Mississippi, Texas, and Utah have all either unsuccessfully introduced legislation or had indications that this type of legislation may be proposed.

In early 2012, legislation was introduced in Kansas that proposed taxing the amount of electricity used to charge EVs.[48] Although it was recently heavily modified and tabled, as proposed, the legislation would have required EV owners to maintain two electricity meters: one to record traditional power consumption, and one to record EV power consumption. Electricity used to charge EVs would then have been taxed at a higher rate by the utility companies, with the proceeds passed back to the state.

Missouri has imposed an annual fee on “alternative fueled vehicles,” including EVs. The Missouri fee imposes an “alternative fuel decal fee in lieu of tax” on “vehicles powered by alternative fuel.”[49] For passenger motor vehicles, the decal fee is $75 per year. The Missouri Department of Revenue says the Chevy Volt does not need a decal because it also uses gasoline, but the (all-electric) Nissan Leaf does require one.[50]

In addition to the gas tax substitute issues described above, another tax issue that factors into EV adoption is a utility franchise tax. A utility franchise tax is a tax that cities impose on utilities providing service within the city limits. This tax is important because it shows consumers that the city has a revenue stream directly from their use of electricity for EV charging as well as other uses. Additional information regarding the electric utility franchise

---

[46]Haugen, et al. "Senate Bill 5251." *Washington State Legislature*. N.p., 19 Jan. 2011. Web. 10 Dec. 2012. <http://apps.leg.wa.gov/documents/billdocs/2011-12/Pdf/Bills/Senate%20Bills/5251.pdf>.

[47]"House Bill 2328." *The Oregonian*. N.p., n.d. Web. 10 Dec. 2012. <http://gov.oregonlive.com/BILL/2011/HB2328/>.

[48]Committee on Energy and Utilities. "House Bill No. 2455." *Kansas Legislature*. N.p., 2012. Web. 10 Dec. 2012. <http://www.kslegislature.org/li/b2011_12/measures/documents/hb2455_00_0000.pdf>. Session of 2012.

[49]"Missouri Revised Statutes." *Missouri General Assembly*. 2012 Committee on Legislative Research, 28 Aug. 2012. Web. 10 Dec. 2012. <http://www.moga.mo.gov/STATUTES/C100-199/1420000869.HTM>.

[50]Russel, Linda. "Missouri's alternative fuel fee surprises electric car driver." *KY3 Article Collections*. KY3-TV, 23 Feb. 2011. Web. 10 Dec. 2012. <HTTP://ARTICLES.KY3.COM/2011-02-23/ELECTRIC-CAR_28623140>.

tax for Kansas City, Missouri; Overland Park, Kansas; and Lawrence, Kansas, is provided in a following section.

9.6.2 Electric Vehicle Tax Legislation at the State Level

Recently, the U.S. Congressional Budget Office (CBO) released a report stating that "a consensus view of many transportation experts and economists is that a system of taxes on vehicle-miles traveled should be viewed as the leading alternative to fuel taxes as a source of funding for highways."[51]

Oregon, Washington, and Kansas are among the states that have recently attempted to proactively address this revenue replacement issue through proposed legislation aimed at generating revenue from EV use. The bills are designed to either accrue on a per-mile basis or collect a fee at the time of the yearly vehicle registration. The legislation considered in Kansas proposed to tax the amount of electricity used in charging at a level similar to a per-mile basis on gas taxes. Additional information about state-level initiatives to address the gas tax issue is provided in the following subsections.

9.6.2.1 Oregon Legislation

In 2006, Oregon Department of Transportation (ODOT) carried out an extensive pilot program that showed promising enough results to warrant state legislation.[52] Specifically, ODOT launched a pilot program in the Portland area that addressed an EV "mileage fee" and possible issues surrounding its implementation. The study found that the concept was a viable alternative to the gas tax in Oregon.[53]

The pilot program findings materialized in early 2011 as House Bill 2328.[54] The legislation was introduced to the House of Representatives on January 11, 2011, and passed the Transportation and Economic Development Committee as well as the Revenue Committee.[55]

The fee is now called a "vehicle road usage charge" in House Bill 2328. The bill applies to "electric motor vehicles," or EVs, and "plug-in hybrid electric motor vehicles," or PHEVs. A

---

[51] The Congress of the United States. "Alternative Approaches to Funding Highways." *The Hill*. Capitol Hill, Mar. 2011. Web. 10 Dec. 2012. <http://thehill.com/images/stories/blogs/flooraction/Jan2011/cboreport.pdf>.

[52]Whitty, James M. *Oregon's Mileage Fee Concept and Road User Fee Pilot Program*. Salem: Oregon Department of Transportation, 2007. *State of Oregon*. Web. 10 Dec. 2012. <http://www.oregon.gov/ODOT/HWY/RUFPP/DOCS/RUFPP_FINALREPORT.PDF?GA=T>

[53] IBID.

[54]"B-Engrossed House Bill 2328." *Oregon State Legislature*. N.p., 16 May 2011. Web. 10 Dec. 2012.<http://www.leg.state.or.us/11reg/measpdf/hb2300.dir/hb2328.b.pdf>. 76th OREGONLEGISLATIVE ASSEMBLY--2011 Regular Session.

[55] "House Bill 2328." *The Oregonian*. N.p., n.d. Web. 10 Dec. 2012. <http://gov.oregonlive.com/BILL/2011/HB2328/>.

transition fee of $0.0085/ mile would be in effect on July 1, 2015, as this bill currently stands. During this transition rate period, a driver can opt to pay a yearly $300 fee. On July 1, 2018, a rate of $0.0156/ mile would be charged to all EV and PHEV users.

The mileage reporting method is yet to be determined by this legislation. Electronic location technology could be one of the methods used for reporting miles traveled, but an alternative to location technology could also be made available.

Should it be enacted, the revenues generated from this legislation are predicted to range from $300,000 in 2016 to $12 million in 2021[56]. According to House Bill 2328, the revenue generated is to be distributed as follows:

- 50 percent to the Department of Transportation.
- 30 percent to counties for distribution as provided in ORS 366.762.
- 20 percent to cities for distribution as provided in ORS 366.800.

9.6.2.2 Washington Legislation

Washington's Senate Bill 5251 passed the Senate on April 27, 2011, and again this year on February 11, 2012.[57] The bill targets EVs only and implements a $100 yearly fee due at the time of vehicle registration. As this bill currently stands, the fee will be assessed to registration renewals due on or later than February 1, 2013[58].

If the legislation passes, generated revenues are predicted to range from $56 thousand in FY 2012 to $1.55 million in FY 2021.[59] The revenue generated will go to the Motor Vehicle Fund for "highway purposes" and will be dispersed as follows after the fund reaches $1 million:

- 70 percent to the motor vehicle account.
- 15 percent to the transportation improvement account.
- 15 percent to the rural arterial preservation account.

---

[56] "B-Engrossed House Bill 2328." *Oregon State Legislature*. N.p., 16 May 2011. Web. 10 Dec. 2012.<http://www.leg.state.or.us/11reg/measpdf/hb2300.dir/hb2328.b.pdf>. 76th OREGONLEGISLATIVE ASSEMBLY--2011 Regular Session.

[57] Senate Committee on Transportation. "Senate Bill Report 2SSB 5251." *Washington State Legislature*. N.p., 2012. Web. 10 Dec. 2012. <http://apps.leg.wa.gov/DOCUMENTS/BILLDOCS/2011-12/PDF/BILL%20REPORTS/SENATE/5251-S2%20SBR%20APS%2012.PDF>. As Passed Senate, February 11, 2012.

[58] Senate Transportation. Second Engrossed Substitute Senate Bill 5251. *Washington State Legislature*. N.p., 2011. Web. 10 Dec. 2012. <http://apps.leg.wa.gov/DOCUMENTS/BILLDOCS/2011-12/PDF/BILLS/SENATE%20BILLS/5251-S.E2.PDF>. 2011 first special session.

[59] Transportation Committee. "Washington State Senate." *Washington State Legislature*. N.p., 24 Jan. 2012. Web. 10 Dec. 2012. <http://apps.leg.wa.gov/CMD/default.aspx?AID=17686>.

9.6.2.3 Kansas Legislation

Kansas House Bill 2455 was introduced to the House on January 17, 2012, and, as introduced, proposed imposing a fee on the amount of electricity used when recharging either EVs or PHEVs.[60] However, recently the Kansas Committee on Energy and Utilities adopted a substitute version of the bill that dramatically reduced the potential impact.

As originally proposed, the fee was to be set by the Kansas Department of Transportation and approved by the KCC. The fee was intended to be "comparable to the motor fuel tax established in K.S.A. 79-3401 *et. seq.*, and amendments thereto." Residential charge stations were to be required to have a separate meter to record the amount of electricity being used. This would present significant technical challenges, as well as piracy and privacy concerns in that Level 1 charging can be done at any standard 120 volt power outlet. The fee was to be collected by the utility providing the electricity. Any other public or private recharge station would also have been required to pay a fee to the utility providing the electricity, which would then be collected by the Kansas Department of Revenue and distributed as follows:

- The Motor-Vehicle Fuel Tax Refund Fund for fuel tax refunds.
- The State Highway Fund.
- The Special City and County Highway Fund.
- The Kansas Qualified Agricultural Ethyl Alcohol Producer Incentive Fund.

However, as noted above, the original bill was debated before the Kansas House Committee on Energy and Utilities, and on February 20, 2012; that committee passed a substitute bill which dramatically reduced the impact of the legislation. Specifically, all of the provisions discussed above were deleted from the text of the bill and were replaced, in pertinent part, with the following:

> The Department of Transportation is directed to organize a discussion with the public and all interested stakeholders about the long term feasibility of relying on the motor fuel tax as the primary mechanism of funding the state's highway maintenance and construction program and as the major contributor of state aid to local government transportation budgets. The department is to report its findings and policy recommendations to the governor and the legislature by 1 January 2014.[61]

---

[60]Committee on Energy and Utilities. "House Bill No. 2455." *Kansas Legislature*. N.p., 2012. Web. 10 Dec. 2012. <http://www.kslegislature.org/li/b2011_12/measures/documents/hb2455_00_0000.pdf>. Session of 2012.

[61] Committee on Energy and Utilities. "Substitute for House Bill No. 2455." *Kansas Legislature*. N.p.,2012. Web. 10 Dec. 2012. <http://kslegislature.org/li/b2011_12/measures/documents/hb2455_01_0000.pdf>. session of 2012.

9.6.2.4 Mississippi Legislation

House Bill 796 died in a committee on February 23, 2011, but the bill proposed a $0.005 per mile tax on miles traveled in the previous year for electric vehicles.[62] The Department of Revenue eventually would have obtained the revenue, which then would have been allocated similar to state fuel taxes.

9.6.2.5 Arizona Legislation

In Arizona, House Bill 2257 was proposed on January 17, 2012.[63] This bill proposed to tax EVs $0.01 per mile. However, in recognition of the fact that this area of lawmaking is quite young, it requires the state to "adopt rules necessary to implement this article."

9.6.2.6 California, Colorado, Texas, and Utah Activity

California Assembly member Bonnie Lowenthal authored a resolution recommending that the president and the U.S. Congress study a VMT tax as an acceptable form of transportation revenue.[64] Assembly Joint Resolution 5 (AJR 5) "urges the federal government to study the feasibility of collecting transportation revenues based on vehicle miles traveled (VMT) to create a reliable and steady transportation revenue source." This became law (chaptered) on June 8, 2011.[65]

Colorado plans to run an "electric/alternative fuel vehicle user-based fee program in 2012," according to legislative liaison, Melissa Nelson-Osse.[66]

Texas proposed legislation, HB 1669, aimed at setting up a pilot program to study a VMT tax in Texas. The pilot would include electric, hybrid, and "liquefied fuel" (for example operating on liquefied natural gas or propane) vehicles. It was introduced to the House of Representatives on March 3, 2011.[67]

---

[62] Ellington. "HOUSE BILL NO. 796." *Mississippi State Legislature*. N.p., 2011. Web. 10 Dec. 2012. <http://billstatus.ls.state.ms.us/documents/2011/pdf/HB/0700-0799/HB0796IN.pdf>. Regular Session.

[63] Farley. "Vehicle Mileage Tax; Electric Vehicles." *Arizona State Legislature*. N.p.,2012. Web. 10 Dec. 2012. <http://www.azleg.gov/legtext/50leg/2r/bills/hb2257p.pdf>.

[64] *Official California Legislative Information*. California State Legislature, n.d. Web. 10 Dec. 2012.<HTTP://WWW.LEGINFO.CA.GOV/PUB/11-12/BILL/ASM/AB_0001-0050/AJR_5_CFA_20110505_105552_SEN_COMM.HTML>.

[65] Lowenthal, Bonnie. "Relative to Transportation." *MapLight*. N.p., 8 June 2011. Web. 10 Dec. 2012.<http://maplight.org/california/bill/2011-ajr-5/985345/history>.

[66] Shepherd, Todd. "CDOT exploring tax on electric vehicles, raising gas tax." *Independence Institute*. Independence Investigates, 11 Sept. 2011. Web. 10 Dec. 2012. <HTTP://INVESTIGATES.I2I.ORG/2011/09/11/CDOT-EXPLORING-TAX-ON-ELECTRIC-VEHICLES-RAISING-GAS-TAX/>.

[67] Harper-Brown. "A Bill to Be Entitle an Act." *Open Government*. N.p., May 2011. Web. 10 Dec. 2012. <http://tx.opengovernment.org/system/bill_documents/001/241/873/original/HB01669H.htm?1310512458>.

Finally, the Salt Lake *Tribune* reports Utah has considered an electric vehicle tax, but no bill was found to actually pursue this.[68]

9.6.3 Local Distribution of Kansas and Missouri Fuel Taxes and Utility Franchise Taxes

9.6.3.1 Kansas and Missouri Fuel Taxes

The federal government imposes a tax of $0.184 per gallon for gasoline and $0.244 per gallon for diesel.[69] Additionally, Kansas has a $0.24 per gallon gasoline fuel tax and a $0.26 per gallon diesel fuel tax,[70] and Missouri has a fuel tax of $0.17 per gallon for both gasoline and diesel.[71]

About 7 percent of both Kansas and Missouri's total tax revenues come from motor fuel taxes. This amounts to about $425 million generated from fuel taxes in Kansas[72] and about $722 million in Missouri during fiscal year 2010.[73] This compares equivalently with Oregon's and Washington's fuel tax revenues, which during fiscal year 2010 were about 6 percent or $403 million[74] and about 7 percent or $1.2 billion[75], respectively.

Kansas allocates fuel tax revenues as follows:[76]

- 66.37 percent to the State Highway Fund.
- 33.63 percent to the Special City and County Highway Fund.

---

[68] Gehrke, Robert. "Legislator's plan: Fee for owners of hybrid, electric cars." The Salt Lake Tribune. N.p., 29 Apr. 2011. Web. 10 Dec. 2012. <http://www.sltrib.com/politics/51715747-90/CARS-ELECTRIC-GAS-HYBRID.HTML.CSP>.

[69] Weingroff, Richard. "Highway History." *U.S. Department of Transportation- Federal Highway Administration*. N.p., 7 Apr. 2011. Web. 10 Dec. 2012. <http://www.fhwa.dot.gov/INFRASTRUCTURE/GASTAX.CFM>

[70] "Memorandum- Tax Rates." *Kansas Department of Revenue*. N.p., 16 Aug. 2010. Web. 10 Dec. 2012. <http://rvpolicy.kdor.ks.gov/Pilots/Ntrntpil/IPILv1x0.NSF/ae2ee39f7748055f8625655b004e9335/fa9f71af6ca0cf5786256528006f7006?OpenDocument>.

[71] "Motor Fuel Tax: Frequently Asked Questions." *Missouri Department of Revenue*. N.p., n.d. Web. 10 Dec. 2012. <http://dor.mo.gov/faq/business/fuel.php#q9>.

[72] "State Government Tax Collections." *United States Census Bureau*. N.p., 15 Mar. 2010. Web. 10 Dec. 2012. <http://www.census.gov/govs/statetax/1017ksstax.html>.

[73] "State Government Tax Collections." *United States Census Bureau*. N.p., 15 Mar. 2011. Web. 10 Dec. 2012. <http://www.census.gov/govs/statetax/1026mostax.html>.

[74] "State Government Finances." *United States Census Bureau*. N.p., 14 Dec. 2011. Web. 10 Dec. 2012. <http://www.census.gov/govs/state/1038orst.html>.

[75] http://www.census.gov/govs/statetax/1048wastax.html

[76] Kansas Legislative Research Department. "Transportation and Motor Vehicles." *Kansas Legislative Research Department*. Skyways, 2012. Web. 10 Dec. 2012. <http://skyways.lib.ks.us/KSLEG/KLRD/PUBLICATIONS/2012BRIEFS/Z-1-STATEFUNDINGFORTRANSPORTATION.PDF>.a service of the state library of Kansas.

Missouri allocates fuel tax revenues as follows:[77]

- 10 percent to County Aid Road Trust Fund.
- 15 percent to cities, towns, and villages.
- The remaining revenue goes to "the state road fund" and is to be "expended and used solely as provided in subsection 1 of section 30(b) of Article IV of this Constitution."

9.6.3.2 Kansas and Missouri Utility Franchise Taxes

Another type of tax that exists at the city level that could affect EV development is a utility franchise tax or fee. Cities in both Kansas and Missouri collect utility franchise fees from utilities for doing business within city limits. Functionally, EV owners can view these fees as taxes, as the utilities directly pass the franchise fees collected from their customers to the cities in question.

Kansas City, Missouri, has an electric utility franchise fee of 6 percent. An emergency tax of an additional 4 percent also exists, but it applies only to commercial and industrial customers[78].

Cities in Kansas also charge a utility franchise fee to utilities operating within their city limits. Lawrence, Kansas, has a franchise rate of 5 percent,[79] which in fiscal year 2009 brought in about $5.78 million in revenue.[80] Overland Park, Kansas, has a franchise rate of 3 percent,[81] which in fiscal year 2010 brought in about $9.95 million in revenue.[82]

---

[77] Article IV. Mo. Rev. Stat. Sec. 30. 1962 and Supp. 2012. *Missouri General Assembly*. Web. 10 Dec. 2012. <http://www.moga.mo.gov/const/A04030a.HTM>.

[78] Finace Department. "Utilities Licence Tax." *City of Kansas City Missouri*. N.p., Sept. 2009. Web. 10 Dec. 2012. <http://kcmo.org/idc/groups/finance/documents/finance/rd-util.pdf>.

[79] Wheeler, Toni Ramirez. "Draft Ordinance Amending Provision Related to Franchise Fee." Letter. 20 Nov. 2006. *City of Lawrence Kansas*. Web. 10 Dec. 2012. <http://www.lawrenceks.org/assets/agendas/cc/2006/12-05-06/12-05-06h/cm_report_franchise_fee_kawvalley_letter.html>.

[80] Department of Finance, comp. *Comprehensive Annual Financial Report*. N.p.: n.p., 2009. *City of Lawrence Kansas*. Web. 10 Dec. 2012. <HTTP://WWW.LAWRENCEKS.ORG/FINANCE/SYSTEM/FILES/ CITY+OF+LAWRENCE+CAFR+09.PDF>.

[81] *Adopted 2009 Annual Budget*. Overland Park, Ks.: n.p., n.d. *The City of Overland Park Kansas*. Web. 10 Dec. 2012. <http://www.opkansas.org/wp-content/uploads/downloads/2009-city-budget.pdf?&redir=1>.

[82] Scott, David M. *City of Overland Park, Kansas: Comprehensive Annual Financial Report*. Overland Park,Ks.: n.p., 2010. Print. Financial Report.

9.7 Westar and KCP&L Smart Grid Plans

9.7.1 Westar Energy SmartStar Lawrence Project

The Westar SmartStar project involves 39,000 residential and 4,000 commercial meters in Lawrence, Kansas. The total budget is approximately $40 million. The project goes beyond automated meter reading to include a meter communications network and backhaul communications for a meter data management system (MDMS), enabling improved billing, outage management, and load research. Customers can call Westar and have service started or restored minutes after payment with no expensive or time consuming "truck roll" of Westar service crews.[83] In addition, 15 out of 1,338 distribution circuits received automation equipment.[84]

9.7.2 Kansas City Power & Light Green Impact Zone SmartGrid Demonstration

KCP&L is implementing an end-to-end smart grid demonstration in an older neighborhood of Kansas City, Missouri, as part of a larger project known as the Green Impact Zone. The KCP&L SmartGrid program is an end-to-end demonstration area involving 1 substation, 10 circuits, and 14,000 residential and commercial customers. The full cost of the program is approximately $50 million.[85]

9.8 About the Author

William Roush is a renewable energy specialist in Black & Veatch's Consulting Engineering Services group, providing feasibility studies, due diligence, planning, and project development support for a variety of energy technologies, including wind, biomass, solar, energy storage and electric vehicles. Mr. Roush has nearly 30 years of experience with renewable energy. This includes 10 years as the owner of a solar photovoltaic product manufacturing and system integration company. Mr. Roush is currently the President of the Heartland Chapter of the Solar Energy Industries Association. In addition, he serves on the Solar Electric Power Association's Central Region Advisory Board and was a founding member of the Mid-America Electric Auto Association.

---

[83] Lerhman, Matt. Westar SmartStar Program Analyst. Interview by Bill Roush. 26 Apr. 2012.

[84] U. S. Department of Energy, Office of Electricity Delivery and Energy Reliability, http://www.smartgrid.gov/sites/default/files/09-0249-westar-energy-project-description-06-13-2012.pdf, July 2011, Accessed April 2012.

[85] "Kansas City Power and Light Green Impact Zone SmartGrid Demonstration." Smart Grid. US Department of Energy, n.d. Web. Apr. 2012. <http://www.smartgrid.gov/project/kansas_city_power_and_light_green_impact_zone_smartgrid_demonstration>.

Sam Scupham is the Kansas City Office Manager for Black & Veatch's Renewable Energy services business. The group provides technical assistance for energy companies, investors, governmental agencies, and industrials. Mr. Scupham is actively involved in analyses of commercial and developing renewable and energy storage technologies. These analyses are varied to include studies of technology selection, resource assessment, due diligence, feasibility, screening, supply-side analysis, and site evaluation. These studies frequently include conceptual design and estimates of thermal performance, capital cost, and operations and maintenance costs. Mr. Scupham graduated from the University of Colorado in Boulder with a degree in civil engineering and is a licensed Professional Engineer in Kansas. Mr. Scupham lives in Kansas City with his wife and daughter.

Kansas City Regional Clean Cities Coalition Administered by Metropolitan Energy Center, the coalition is a public-private partnership among fleet managers and manufacturers, vendors and service providers in the alternative fuels and vehicle industries. It works in communities across Kansas and in western Missouri. Kansas City's coalition is a partner since 1998 with the U.S. Department of Energy's Clean Cities Program, whose mission is to advance the energy, economic, and environmental security of the United States by supporting local actions to reduce petroleum use in transportation. The coalition administers more than $40 million in clean transportation projects in Kansas, Missouri, Iowa and Nebraska. For more information visit www.metroenergy.org/kccleancities.aspx.About

Metropolitan Energy Center is a nonprofit organization with a threefold mission to create resource efficiency, environmental health, and economic vitality in the Kansas City region. Over the past three decades, MEC has grown to be a recognized catalyst for regional energy partnerships that satisfy the triple-bottom-line approach. Founded in 1980, MEC is a catalyst for community partnerships focused on energy conservation. It works through a variety of educational and training programs, including Kansas City Regional Clean Cities Coalition, Home Performance, Project Living Proof and EnergyWorks KC. Every energy dollar conserved through MEC's work remains available for investment in the local economy. MEC was awarded more than $17 million in federal funding for transportation projects in recent years and is a partner in other multi-million-dollar projects in Kansas and Missouri. MEC has been the recipient of many awards recognizing its contribution to energy conservation and was host of the national Affordable Comfort Conference in 2003 and 2009