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Witness: Douglas Jester
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Case No. ER-2016-0285
Date testimony prepared: Nov. 30, 2016

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Kansas City Power & Light Company's Request for Authority to Implement a General Rate Increase for Electric Service	) **Case No. ER-2016-0285**

DIRECT TESTIMONY OF DOUGLAS JESTER

ON BEHALF OF SIERRA CLUB

NOVEMBER 30, 2016

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County of Carson City)

State of Nevada)

AFFIDAVIT OF DOUGLAS B. JESTER

Douglas B. Jester, of lawful age, on his oath states: that he has participated in the preparation of the following rebuttal testimony in question and answer form, which is attached hereto and made a part hereof for all purposes, and is to be presented in the above case; that the answers in the following rebuttal testimony were given by him; that he has knowledge of the matters set forth in such answers; and that such answers are true to the best of his knowledge and belief.

Douglas B. Jester

In witness whereof I have hereunto subscribed my name and affixed my official seal this 30 day of November, 2016.

JANO BARNHURST
NOTARY PUBLIC
STATE OF NEVADA
My Appt. Exp. Oct. 15, 2018
No. 93-0121-3

NOTARY PUBLIC

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DIRECT TESTIMONY OF DOUGLAS JESTER

QUALIFICATIONS AND PURPOSE OF TESTIMONY

Q. State your name, business name and address.

A. My name is Douglas B. Jester. I am a principal of 5 Lakes Energy LLC, a Michigan limited liability corporation, located at Suite 710, 115 W Allegan Street, Lansing, Michigan 48933.

Q. What is the purpose of your testimony?

A. In its Application in this case, Kansas City Power & Light (KCP&L) requested approval from this Commission to recover its costs for the Missouri portions of its Clean Charge Network, consisting of infrastructure for electric vehicle charging in its service territory and for a tariff for recovery of some of those costs from those who use the Clean Charge Network. I am testifying today that the Commission should authorize cost recovery for the Clean Charge Network as requested, subject to recommendations in future testimony on rate design. In that future testimony, I will address KCPL&L's proposed tariff for the Clean Charge Network, as well as questions regarding time-of-use electricity rates posed by the Commission in its 24 August 2016 Order.[1] In doing so, I will urge that in setting a tariff for electric vehicle charging:

- The Commission should take steps to ensure that vehicle charging will be well integrated with the electric power system in order to maximize grid-wide benefits

[1] *Order Directing Consideration of Certain Questions in Testimony*, Case No. ER-2016-0285 (filed August 24, 2016).

and in line with the recommendations made by Staff in its Final Report in EW-2016-0123, the *Working Case Regarding Electric Charging Facilities*[2];

- The Commission should seek in the long-term to achieve fair and equitable recovery of electric vehicle charging costs from the drivers of such electric vehicles or the host sites for electric vehicle charging, and
- The Commission should take steps to enable development of a competitive vehicle charging market, while supporting utility engagement in this market.
- The Commission should require regular reporting by KCP&L on its Clean Charge Network to ensure that the program results in "learning by doing" for KCP&L, the Commission and interested stakeholders.

Q. On whose behalf are you appearing in this case?

A. I am testifying on behalf of the Sierra Club.

Q. Summarize your experience in the field of electric utility regulation.

A. I have worked for more than 20 years in regulating the electricity industry and in related fields. My work experience is summarized in my resume, attached as Schedule SC-1.

Q. Have you testified before this Commission or as an expert in any other proceeding?

A. I recently filed testimony before this Commission in Case No. ET-2016-0246, concerning Ameren Missouri's proposal to deploy electric vehicle charging stations in its service territory.

I have testified before the Michigan Public Service Commission in

[2] *Corrected Staff Report* at 30, File No. EW-2016-0123 (filed August 9, 2016) ("If ratepayer recovery of network implementation, operation and maintenance costs is considered: IOUs consider mandatory TOU rates for all public charging stations and for EV owners"; "IOUs explore various emerging technologies and their impact on the areas of demand-response, supply-side resourcing and second battery life programs.").

- Case U-17473 (Consumers Energy Plant Retirement Securitization)
- Case U-17096-R (Indiana Michigan 2013 PSCR Reconciliation)
- Case U-17301 (Consumers Energy Renewable Energy Plan 2013 Biennial Review);
- Case U-17302 (DTE Energy Renewable Energy Plan 2013 Biennial Review);
- Case U-17317 (Consumers Energy 2014 PSCR Plan);
- Case U-17319 (DTE Electric 2014 PSCR Plan);
- Case U-17674 (WEPCO 2015 PSCR Plan);
- Case U-17679 (Indiana-Michigan 2015 PSCR Plan);
- Case U-17689 (DTE Electric Cost of Service and Rate Design);
- Case U-17688 (Consumers Energy Cost of Service and Rate Design);
- Case U-17698 (Indiana-Michigan Cost of Service and Rate Design);
- Case U-17762 (DTE Electric Energy Optimization Plan);
- Case U-17752 (Consumers Energy Community Solar);
- Case U-17735 (Consumers Energy General Rates);
- Case U-17767 (DTE General Rates);
- Case U-17792 (Consumers Energy Renewable Energy Plan Revision);
- Case U-17895 (UPPCO General Rates);
- Case U-17911 (UPPCO 2016 PSCR Plan);
- Case U-17990 (Consumers Energy General Rates); and
- Case U-18014 (DTE General Rates).

I have testified before the Public Utility Commission of Nevada in

- Case 16-07001 (NV Energy 2017-2036 Integrated Resource Plan).

In the past, I have testified as an expert witness on behalf of the State of Michigan before the Federal Energy Regulatory Commission in cases relating to the relicensing of hydro-electric generation. I also have been listed as a witness on behalf of the State of Michigan, prepared case files and submissions, and been deposed in cases before the United States District Court for the Western District of Michigan and the Ingham County Circuit Court of the State of Michigan, concerning electricity generation matters in which the cases were settled before trial.

Q. Do you have specific qualifications in relation to electric vehicle charging infrastructure?

A. In 2010, I served as an active member of the Michigan Public Service Commission's electric vehicle charging collaborative.

In 2012, my colleagues and I at 5 Lakes Energy, on behalf of the Pew Charitable Trusts, engaged stakeholders in a number of States in roundtable discussions about the development of electric vehicle infrastructure and drafted a report about best practices, which informed Pew's subsequent work in this field.

In 2015 and 2016, my colleagues and I at 5 Lakes Energy produced integrated resource planning tools for least-cost compliance with the Clean Power Plan in ten states. These tools incorporate means to model the potential effects of various levels of electric vehicle market penetration on the electricity system.

Most recently, I testified extensively before the Michigan Public Service Commission in Case U-17990, concerning an electric vehicle charging infrastructure proposal by Consumers Energy.

Q. What schedules, if any, are attached to your testimony?

A. SC-1 Resume of Douglas B. Jester

SC-2 NRC on Overcoming Barriers to Deployment of Plugin EVs

Q. What materials have you reviewed in preparation for your testimony?

A. I reviewed KCP&L's application in this case and subsequent submissions to the docket. I also reviewed the Staff report and comments submitted by stakeholders in EW-2016-0123, the *Working Case Regarding Electric Charging Facilities*. In addition, there is a substantial literature on electric vehicles and electrical vehicle charging that I have routinely read over the last several years. I also cite sources from my accumulated personal library on relevant subjects.

KCP&L'S ELECTRIC VEHICLE CHARGING PROPOSAL

Q. Please summarize KCP&L's proposal concerning electric vehicle charging infrastructure?

A. In this case, KCP&L presents its request and justification for electric vehicle charging infrastructure primarily through the testimony of Tim. M. Rush[3]. Mr. Rush describes the proposed tariff, which I will address in future testimony.

He also summarizes KCP&L's proposed cost recovery of its investments and expenses for installing, operating, and maintaining the Clean Charge Network, with 400 of 1000

[3] Direct Testimony of Tim. M. Rush, page 20, line 15 through page 32, line 9.

charging stations located in Missouri jurisdictional service territory. He represents that KCP&L's capital budget for the Clean Charge Network is about $16.6 million, of which approximately $6 million should be allocated to Missouri jurisdiction sites. He also estimates that Missouri jurisdictional share of operations and maintenance costs will be approximately $250,000 per year. Any offsetting tax credits will be a reduction to revenue requirement.

THE COMMISSION SHOULD ACT TO ACCELERATE EV ADOPTION

Q. Why should the Commission act to accelerate electric vehicle adoption?

A. Vehicle electrification will produce a number of general societal benefits, including reductions in air pollution that will benefit public health, mitigation of climate change, improvements in national energy security, and increases in macroeconomic stability. In addition to these general societal benefits, accelerating electric vehicle adoption in Missouri will potentially provide substantial benefits to all electric utility customers of KCP&L, whether or not they own electric vehicles.

Reliable access to electric vehicle charging infrastructure is critical to the growth of the electric vehicle market.[4] However, electric vehicle adoption and electric vehicle charging infrastructure suffer a "chicken-or-egg" market coordination problem that is best addressed through utility engagement in accelerated development of charging infrastructure. Missouri utility engagement can only occur with the support of the Commission, so the Commission should act in this case to accelerate electric vehicle adoption.

[4] National Research Council, 2015. Overcoming Barriers to Deployment of Plug-In Electric Vehicles. Available from http://www.nap.edu/catalog/21725/overcoming-barriers-to-deployment-of-plug-in-electric-vehicles

Q. How does vehicle electrification reduce air pollution and benefit public health?

A. US EPA estimates that mobile sources (principally on-road vehicles) are the source of more than 84% of anthropogenic carbon monoxide emissions[5], and over 50% of nitrous oxide emissions, over 30% of volatile organic compounds, and over 20% of fine particulate matter ($PM_{2.5}$) emissions[6]. Carbon monoxide interferes with oxygen uptake and transport in all animals and can impair vision, motor function, mental acuity, and work performance. Nitrous oxide is the primary precursor of ozone—also known as smog—which causes respiratory distress including asthma exacerbations, may cause structural alteration of lungs, and is increasingly understood to cause premature death. Missouri is currently violating the 2008 and 2015 National Ambient Air Quality Standards ("NAAQS") for ozone.[7]

Fine particulate matter, another pollutant for which Missouri is in nonattainment[8], aggravates respiratory and cardiovascular problems and has been implicated in heart disease, lung disease, and miscarriages. National studies[9] suggest that these are substantial, with premature deaths due to vehicle emissions exceeding those due to vehicle crashes by more than 50%. Caiazzo et al.[10] estimate that Missouri annually suffers 1,192 premature deaths due to PM2.5 and ozone from vehicles. Vehicle electrification along with cleaner electricity generation can clearly reduce these emissions and their health effects.

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[5] https://cfpub.epa.gov/roe/indicator.cfm?i=10#1
[6] https://www.epa.gov/air-pollution-transportation/smog-soot-and-local-air-pollution
[7] St. Louis, in particular, has struggled to meet the 2008 and 2015 ozone standards. In the St. Louis area, the "design value" for ozone levels from 2012-2014 was 78 parts per billion ("ppb"), and from 2013-2015 was 71 ppb, compared to 75 ppb for the 2008 standard and 70 ppb for the 2015 standard, respectively.
[8] U.S. EPA. (2015). Current Nonattainment Counties for All Criteria Pollutants. http://www.epa.gov/airquality/greenbook/ancl.html
[9] See Caiazzo, Fabio et al. 2013. Air Pollution and Early Deaths in the United States. Atmospheric Environment 79: 198-208.
[10] Ibid., Table 5.

Q. How does vehicle electrification mitigate climate change?

A. Combusting fossil fuels in vehicles produces carbon dioxide and nitrous oxide, two important greenhouse gases. In 2014, the US EPA[11] found that 26.3% of greenhouse gas emissions in the US in 2014 were from transportation fuels.[12] In 2016, the US Energy Information Administration found that found that carbon emissions from the transportation sector exceeded those from the power sector for the first time since 1979.[13] Thus, any comprehensive effort to mitigate climate change requires significant reductions in fossil fuel use in vehicles.

All analyses of strategies to mitigate climate change that I have read conclude that substantial reduction of greenhouse gas emissions from vehicles is a necessary step[14], and that the most likely path to do so is vehicle electrification[15] in combination with reductions in the carbon intensity of electric power production.[16] Moreover, multiple studies have shown that vehicle electrification reduces greenhouse gas emissions even with current generation portfolios. For example, a recent report[17] by the Union of Concerned Scientists illustrates in the following map that electric vehicles charged in KCP&L's service territory produce greenhouse gasses equivalent to those from a

[11] EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014. April 15, 2016, available from https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf

[12] Missouri's own emissions are consistent with this nationwide finding. In 2013, the US Energy Information Administration found that the state's transportation sector accounted for 27% of the state's carbon emissions. See U.S. Energy Information Administration. (2015). State Carbon Dioxide Emissions. http://www.eia.gov/environment/emissions/state/

[13] Energy Information Administration, http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

[14] E.g., Williams, J.H. et al. 2012. The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity. Science 335: no 6064, pp 53-59.

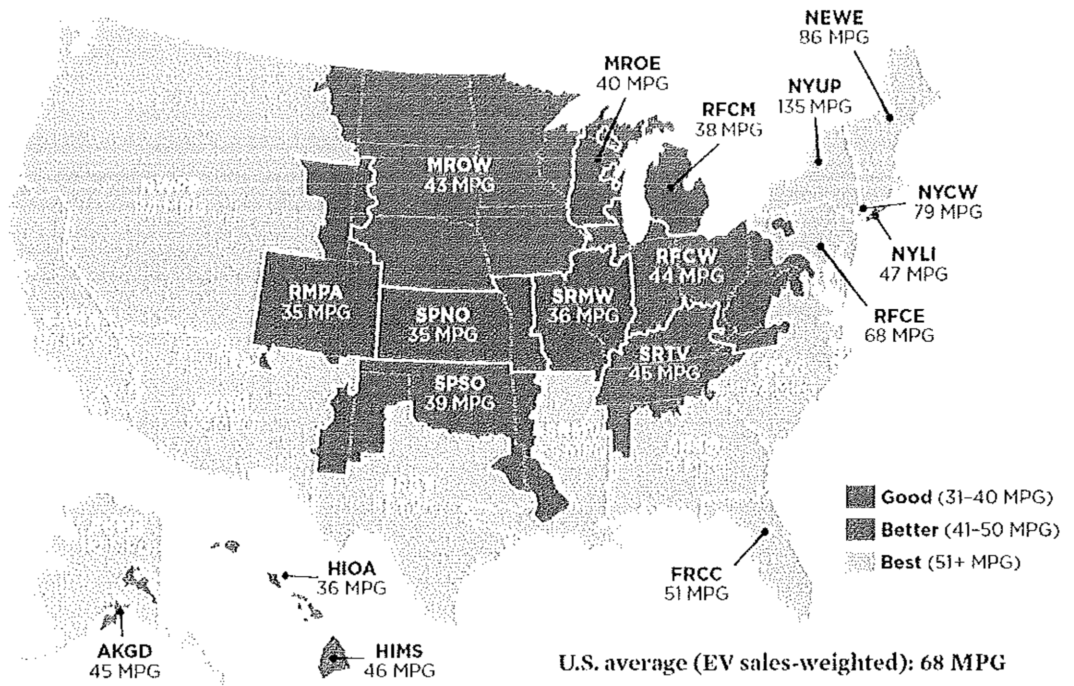
[15] On-board energy storage can be in the form of voltaic energy in batteries or hydrogen for use in fuel cells, either of which would be charged using electric power.

[16] See for example, http://unsdsn.org/wp-content/uploads/2014/09/US-Deep-Decarbonization-Report.pdf, which concludes that, in concert with other power sector trends, 80-95% of all passenger vehicle miles traveled must come from vehicles that use primarily electricity.

[17] Union of Concerned Scientists, 2015. Cleaner Cars from Cradle to Grave. Available from http://www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycle-ev-emissions#.V4vXA1-cFJ8.

gasoline vehicle that averages 35 miles per gallon, which is higher than the vast majority of gasoline-powered vehicles[18]:

Electric Vehicle Global Warming Pollution Ratings and Gasoline Vehicle Emissions Equivalents by Electricity Grid Region



Note: The MPG (miles per gallon) value listed for each region is the combined city/highway fuel economy rating of a gasoline vehicle that would have global warming emissions equivalent to driving an EV. Regional global warming emissions ratings are based on 2012 power plant data in the EPA's eGRID 2015 database (the most recent version). Comparisons include gasoline and electricity fuel production emissions. The 68 MPG U.S. average is a sales-weighted average based on where EVs were sold in 2014.

With announced coal plant retirements and replacement generation coming from a mixture of renewable and natural gas generation, the benefits of vehicle electrification in Missouri will accelerate.

Because only 15 to 17 million passenger vehicles are sold each year nationally, it will take about 15 years of exclusively electric vehicle purchases to largely replace the fleet with electric vehicles. Ramping electric vehicle penetration of new sales to 100% by

[18] DOE also has a calculator at http://www.afdc.energy.gov/vehicles/electric_emissions.php that compares emissions from powering an electric vehicle to emissions from a comparable internal combustion vehicle. For Missouri, this calculator shows that EVs pollute about 28% less CO_2.

2035 will require that the annual increment of electric vehicle share of sales average almost 5% per year beginning immediately. Thus, if vehicle electrification is necessary for mitigating climate change, then near-term acceleration of electric vehicle adoption is necessary.

Q. How does vehicle electrification improve energy security?

A. Despite the effects of fuel efficiency standards and recent increases in US oil production, the United States still imports approximately 25% of our oil consumption and is not currently projected to ever reach oil self-sufficiency.[19] Because of the potential disruption to the US economy due to international oil supply interruptions, the US invests substantially in a strategic oil reserve and large military presence in oil-producing regions.[20]

Since electricity can be produced using a wide variety of technologies and fuels, and in practice all of these are largely domestic, vehicle electrification will reduce the United States' exposure to oil-related risks. As a result, the US Department of Energy found[21] that "reliance on oil is the greatest immediate threat to US economic and national security.... Vehicle efficiency has the greatest short- to mid-term impact on oil consumption. Electrification will play a growing role in both efficiency and fuel diversification."[22]

Q. How does vehicle electrification positively impact local and regional economies and

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[19] EIA, 2016. Annual Energy Outlook 2016. Available from http://www.eia.gov/forecasts/aeo/.

[20] DOD, 2014. 2014 Quadrennial Defense Review. Available from http://archive.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf.

[21] DOE, 2011. Report on the First Quadrennial Technology Review. Available from http://cms.doe.gov/sites/prod/files/ReportOnTheFirstQTR.pdf.

[22] M.R. Copulos, *and* A.J. *Liska & R.K. Perrin (2010) The Hidden Cost of Oil* Securing Foreign Oil: A Case for Including Military Operations in the Climate Change Impact of Fuels

increase macroeconomic stability?

A. Transportation is the single largest energy use sector in the state of Missouri, and as such, plays a significant role in Missouri's economy.[23] In 2012, statewide expenditures on transportation fuels totaled $15 billion,[24] the vast majority of which flowed out of the state. This is because Missouri is not a major oil producer or refiner, and therefore all gasoline used for transportation purposes is imported to the state.[25] Using electricity as fuel, which can be locally or regionally sourced, can reverse this trend. In addition, numerous studies indicate that the fuel savings and maintenance cost savings associated with driving an EV translate into real and local economic benefits.[26] Just the opposite is true for money spent in the petroleum sector; according to the US Energy Information Administration, greater than 80% of the cot of gasoline immediately leaves the local economy.[27]

Oil price and supply shocks have been a significant contributing factor to economic recessions. "All but one of the 11 postwar recessions were associated with an increase in the price of oil, the single exception being the recession of 1960. Likewise, all but one of the 12 oil price episodes listed in Table 1 were accompanied by US recessions, the single exception being the 2003 oil price increase associated with the Venezuelan unrest and second Persian Gulf War."[28] Further, these episodes have particularly acute effects on the

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[23] Department of Economic Development, Division of Energy, *Missouri Comprehensive State Energy Plan* (2015) p. 99, *available at* https://energy.mo.gov/energy/docs/MCSEP.pdf
[24] *Id.* at 101.
[25] *Id.* at 101.
[26] J Todd et al, Creating the Clean Energy Economy: Analysis of Electric Vehicle Industry (2013); California Electric Transportation Coaliton, Plug in Electric Vehicle Development in California: An Economic Jobs Assessment (2012).
[27] U.S. Energy Information Administration. *Gasoline and Diesel Fuel Update*. www.eia.gov/petroleum/gasdiesel/
[28] Hamilton, J. 2013. Historical Oil Shocks. In Parker, R. E..and R. Whaples, 2013. Handbook of Major Events in Economic History. Preprint available from http://econweb.ucsd.edu/~jhamilton/oil_history.pdf.

automobile industry as is suggested by the following table of real GDP growth (annual rate) and contribution of autos to the overall GDP growth rate in five historical oil shock episodes.[29]

Period	GDP growth rate	Contribution of autos
1974:Q1-1975:Q1	-2.5%	-0.5%
1979:Q2-1980:Q2	-0.4%	-0.8%
1981:Q2-1982:Q2	-1.5%	-0.2%
1990:Q3-1991:Q3	-0.1%	-0.3%
2007:Q4-2008:Q4	-0.7%	-0.7%

Since the auto industry has accounted for 4.5% to 2.8% of GDP[30] during this period, contributions of this magnitude to GDP change by the auto industry illustrates substantial auto industry recessions, and in some cases the recession was entirely in the auto industry while the rest of the economy grew, as indicated by an auto industry contribution to the recession that is larger than the size of the recession itself.

The principal mechanisms by which oil shocks cause recessions are through large shifts in balance of payments for oil imports and large shifts in automobile product mix demand that cannot be satisfied with existing capacity[31]. Vehicle electrification will contribute to reduced oil imports, weakening the transmission of oil shocks to aggregate demand. Electricity prices are more stable than oil prices, so vehicle electrification will reduce or eliminate the effects of oil prices on product demand shifts. Thus, vehicle electrification will increase macroeconomic stability for the United States and for Missouri.

Q. How does accelerating electric vehicle adoption potentially benefit electric utility

[29] Ibid.
[30] Bureau of Economic Analysis, from http://bea.gov/industry/gdpbyind_data.htm.
[31] Hamilton, J. 2013. Historical Oil Shocks. In Parker, R. E..and R. Whaples, 2013. Handbook of Major Events in Economic History. Preprint available from http://econweb.ucsd.edu/~jhamilton/oil_history.pdf.

customers?

A. Electric vehicle charging will increase electricity sales, which if well integrated into the electric power system can dilute the fixed costs of transmission and distribution and lower electricity rates for all utility customers. An electric vehicle "can be recharged while its owner is sleeping, eating, working, or doing anything other than driving."[32] Consequently, if electric vehicle charging is well-integrated into the near-future electric power system, it can "fill valleys" in load without proportionally increasing overall capacity requirements; this can reduce the average cost of power for all utility customers. As variable renewable resources like wind and solar generation gain larger shares of electric power generation, flexible electric vehicle charging can add value to the electric power system by facilitating the integration of these resources and balancing electricity generation with demand; this can stabilize power flows and reduce the average cost of power.

Q. How much will vehicle electrification contribute to utility sales?

A. According to EPA fuel economy labels[33] for electric vehicles, current model electric vehicles use between 28 kWh and 54 kWh per 100 miles, with most models that have significant sales using between 35 kWh and 42 kWh per 100 miles. I assume for this illustrative calculation that future vehicles will average 40 kWh per 100 miles. According to the Federal Highway Administration[34], vehicle miles traveled in Missouri in 2014 totaled 70,909 millions. If this amount of vehicle travel had been fully electrified, then

[32] NRDC, 2016. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles. Available from: https://www.nrdc.org/sites/default/files/driving-out-pollution-report.pdf.
[33] These can be viewed at fueleconomy.gov.
[34] Available from the Federal Highway Administration at http://www.fhwa.dot.gov/policyinformation/statistics/2014/vm2.cfm.

electric vehicles would have consumed about 28.364 TWh. This would have been a 33.8% increase in electricity sales. Of course, this amount will scale with electric vehicle adoption and will therefore develop only gradually.

Q. How much would vehicle electrification dilute fixed costs of transmission and distribution?

A. Many details are important to such a calculation. However, for a rough approximation I perused the annual reports of major Missouri utilities and determined that approximately 70% of electric utility revenue is to recover generation costs and about 30% is for transmission, distribution, customer service, and administration. If non-generation costs could remain unchanged and generation costs per kWh were unchanged as a result of adding load to fully electrify vehicle travel in Missouri, then average rates would be reduced by about 8%[35]. In the alternative, rates could be held constant if generation costs per kWh were unchanged and the costs of transmission and distribution increased by as much as 33%. It is likely that some additions to distribution system costs, in particular, will be required if electric vehicles are ubiquitous but nonetheless likely that the net effect will be significant dilution of fixed costs of transmission and distribution over enlarged electricity sales.

[35] This is calculated by multiplying the generation share of costs by the percentage increase in load, adding unchanged transmission and distribution costs, and dividing the result by the increased load.

Q. How much can "valley-filling" by electric vehicle charging reduce the average cost of power?

A. Pacific Northwest National Laboratory[36] found that nationally there is sufficient generation capacity to charge almost all passenger vehicles through "valley-filling". Missouri currently has total generation capacity of about 22 GW, providing approximately 88 TWh per year for a load factor of about 46%. If vehicle electrification added 28 TWh generation per year and this load was accommodated by "valley-filling", then this load factor would rise to 60%. A 60% load factor is somewhat high for most utilities but not unreasonable with the load-scheduling flexibility of electric vehicles. Assuming consistent with the current generation portfolio that generation capacity represents an average of 35% of total utility costs and that fuel and other variable costs represent an average of about 35% of total utility costs, then a revision[37] of the calculation I made above concerning the dilution of fixed costs suggests that vehicle charging would increase utility sales by 33.8% but only increase utility costs by about 12% so that rates would be reduced by 10.6%. In the alternative, rates could be held constant if the incremental costs of transmission, distribution, and generation capacity to support electric vehicle charging were less than 41% of the current costs of transmission, distribution, and generation capacity.

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[36] Kintner-Meyer, M., K. Schneider, and R. Pratt, Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Pacific Northwest National Laboratory, November 2007, energyenvironment.pnnl.gov/ei/pdf/PHEV_Feasibility_Analysis_Part1.pdf.

[37] In this case, multiplying only the variable costs of generation by the increased load, adding the unchanged costs of distribution, transmission, and generation capacity, then dividing the result by the increased load.

In *Driving Out Pollution*, a report by Natural Resources Defense Council, the authors present the following graph illustrating a similar but more detailed analysis for San Diego Gas and Electric, consistent with my results.[38]

FIGURE 1: SDG&E COST OF SERVICE BEFORE AND AFTER WIDESPREAD ELECTRIC VEHICLE ADOPTION

(Adapted from Kintner-Myer et al., 2007)

Q. To what extent can electric vehicle charging buffer the variability of wind and solar generation?

A. Two strategies for integrating electric vehicle charging with generation from renewables have been the subject of recent studies. One strategy focuses on integration at a utility customer site, usually combining solar generation with building loads and electric vehicle charging. The other, more relevant here, focuses on integration at utility scale. *Electric vehicles and the electric grid: A review of modeling approaches, impacts, and renewable*

[38] NRDC, 2016. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles. Available from: https://www.nrdc.org/sites/default/files/driving-out-pollution-report.pdf.

energy integration[39] is a good summary of some of that work which concludes that "[t]he existing literature is fairly unanimous and conclusive in its assessment that EVs can increase the amount of renewable energy that can be brought online while reducing the negative consequences for the grid." This conclusion is based in part on a number of studies that look at regional and national scale balancing and show that smart electric vehicle charging allows significantly greater increases in renewable generation than the amount of vehicle charging load. With 50% of US electricity generation from wind, the required regulation services can be provided by electrification of just 3.2% of the vehicle fleet and operating reserves can be provided by electrification of 38% of the vehicle fleet.[40] In short, vehicle electrification is a key enabler of very high penetration of renewable generation and is nearly sufficient for that purpose.

Missouri is far from a level of renewables penetration where electric vehicle charging or other new storage options are necessary for renewable resource integration to the grid. However, given the current power sector market trends and reinforcing policies that are shifting the nation's generation mix towards greater renewables penetration, it is prudent to prepare for the strategic integration of these resources and explore other valuable grid services that electric vehicles can provide. Thus, the Commission should be mindful of this long-run benefit but remain focused on the rate reduction that electric vehicles offer through dilution of fixed costs and load "valley-filling".

[39] Richardson, D. 2013. Electric vehicles and the electric grid: A review of modeling approaches, impacts, and renewable energy integration.
[40] Kempton, W and J Tomic. 2005. Vehicle-to-grid power implementation: from stabilizing the grid to supporting large-scale renewable energy. Journal of Power Sources 144: pp 280-294.

Q. What is the market coordination problem between electric vehicle adoption and electric vehicle infrastructure development?

A. A driver is reluctant to purchase an electric vehicle unless vehicle charging infrastructure is generally available, since the absence of charging infrastructure limits the uses of an electric vehicle and hence reduces its value to the driver. On the other hand, businesses cannot see a business case for providing electric vehicle charging infrastructure if there not enough electric vehicles in use to provide sufficient use and revenue to repay the investment. This problem is common in network industries and has been studied in contexts including but not limited to information technology hardware, software, telecommunications, broadcasting, markets for information, banks and ATMs, and airlines.[41] The universal effect of these coordination problems is that such a market grows or changes more slowly than the market optimum, sometimes to the point that it never develops. The particular form of this coordination problem present in the case of electric vehicle charging is called "indirect network effects". Indirect network effects arise because a decision by one driver to buy an electric vehicle increases the demand for vehicle charging infrastructure, supply of which attracts electric vehicle purchase(s) by other driver(s); thus one purchase indirectly increases other purchase(s). In the case of electric vehicle charging, there are indirect network effects on both sides of the market.

[41] See Shy, Oz. 2001. The Economics of Network Industries. Cambridge University Press.

Q. Why is this market coordination problem best addressed through utility engagement in accelerated development of charging infrastructure?

A. *The Market for Electric Vehicles: Indirect Network Effects and Policy Design* is a recent paper[42] that specifically estimates the quantitative elements of this coordination problem. The authors estimate that a 10% increase in the number of non-residential charging stations will increase EV sales by 8% and that a 10% increase in the number of EVs will increase non-residential charging station deployment by 6%. Thus any non-market "shock" to the supply of either electric vehicles or charging stations will produce a "virtuous circle" of feedback between the two markets that will significantly accelerate electric vehicle adoption. They further show based on their parameter estimates that a given financial subsidy to electric vehicle infrastructure will increase electric vehicle sales by more than twice the amount of increase if the financial subsidy is offered for electric vehicle purchase.

Schedule SC-2 is a 2015 report of The National Research Council Committee on Overcoming Barriers to Electric Vehicle Deployment. After examining the case for various entities to provide electric vehicle charging infrastructure in various settings, the committee concluded with respect to electric utilities:

> "The electric utility companies could emerge as a willing source of capital for public charging stations. That conclusion reflects the prospect that a network of public charging stations would induce more utility customers to purchase PEVs, which would lead not only to electricity consumption at the public chargers, but also to much greater consumption of electricity at residences served by the utilities. If public charging infrastructure drives greater eVMT and greater deployment of vehicles, capital and variable costs for public infrastructure might be covered by the incremental revenue from additional electricity that PEV

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[42] Li, S. et al. 2016. The Market for Electric Vehicles: Indirect Network Effects and Policy Design. SSRN 2515037.

drivers consume at home, where roughly 80 percent of PEV charging takes place (Francfort 2011)."[43]

No entity other than the electric utility is able to benefit from the indirect network effects of providing non-residential charging stations, especially in settings where additional market failures prevail (which I discuss below). It is therefore uniquely possible for a utility to strategically scale and equitably locate charging infrastructure during early development of the electric vehicle market. Thus it is logical that, if the Commission is moved by the benefits described above to accelerate the adoption of electric vehicles, then the logical strategy is to support utility investment in electric vehicle charging infrastructure.

Further, because the utility already has established connections to its customer base it is also well positioned to provide education and outreach to both potential electric vehicle drivers and charging site hosts. The benefit of increased electricity sales from electric vehicle load should also incentivize the utility to leverage its existing customer relationships to meaningfully engage potential electric vehicle drivers and site hosts on the aforementioned benefits of vehicle electrification.

UTILITY EV CHARGING PROGRAM STRUCTURE

Q. How should utility programs be structured in order to accelerate electric vehicle adoption?

A. There are two essential features such programs must have. First, they must comprehensively meet the growing vehicle charging needs of electric vehicle drivers. Second, they must equitably enable electric vehicle adoption.

[43] National Research Council. 2015. Overcoming Barriers to Deployment of Plug-In Electric Vehicles at 92. Available from http://www.nap.edu/catalog/21725/overcoming-barriers-to-deployment-of-plug-in-electric-vehicles

Q. What is necessary to comprehensively meet the vehicle charging needs of electric vehicle drivers?

A. This is shaped by the technical possibilities for vehicle charging and depends on the type of electric vehicle and driving pattern of the driver. Chapter 2 of Schedule SC-2 is a detailed discussion of charging technologies. I summarize the most salient points here. The industry has developed standards and equipment for three types of charging.

AC Level 1 Charging standard is for charging equipment that plugs into a 120 V wall outlet and delivers up to 12 amps to a SAE J1772 plug that connects into a socket in the car. AC Level 1 equipment is typically carried in the car and enables charging wherever there is access to a "wall outlet". At 12 amps, an AC Level 1 charger transfers energy at a rate of 1.4 kW. Each hour of AC Level 1 charging adds range of 4 to 5 miles, depending on vehicle efficiency and driving conditions.

AC Level 2 Charging standard is for charging equipment that uses 240V, split-phase alternating current circuit and connects to the car through a SAE J1772 plug. AC Level 2 charging allows up to 80 amps of current, which would transfer up to 19 kW power but the on-board chargers (which convert AC to DC power) in most vehicles cannot accept that throughput. Moreover, most residential circuits and many small commercial circuits cannot support that much current, so common installations are 40 amps or less. Each hour of charging at maximum current for AC Level 2 could add approximately 60 miles to vehicle range but vehicle and circuit limits make 20 to 30 miles per hour of charging more representative.

DC Fast Charging has multiple, competing, incompatible "standards"—the Tesla Supercharger, CHAdeMO, and Combined Charging System (CCS). Tesla superchargers only work with Tesla vehicles. Other vehicles, if they accept fast charging, are compatible with one, but not both, of the CHAdeMO or CCS connection. Faster charging is accomplished by connecting a high-amperage direct current directly to the vehicle battery, unlike the AC chargers which go through an AC-DC conversion on-board the vehicle. CHAdeMO fast chargers typically are able to transfer energy at the rate of 44 kW, which can add range to a typical compatible vehicle at a rate of more than 100 miles per hour of charging.

It should be apparent that AC Level 1 and AC Level 2 charging is suitable for either quite limited driving range or long-dwell vehicle parking. Fast charging is intended to support longer distance (highway) travel but still requires a stop of sufficient duration that most customers will require comfort and alternative activity while waiting for charging to complete.

A significant number of plug-in electric vehicle models are produced or have been announced, with a variety of specifications. A number of them are intended for only local use and are purely electric with modest battery capacity and AC charging (Limited-range BEV). Two approaches have been taken for vehicles that are used for greater distances. Plug-in hybrid vehicles (PHEV) can be powered electrically but also have on-board engines such that in short-range usage they function as electric vehicles but for extended-range usage they function more like a typical gasoline hybrid vehicle. Long-range battery electric vehicles (Long-range BEV) rely exclusively on electricity but use large batteries and fast charging to support extended-range travel. Most recently announced models are battery electric vehicles with range of at least 80 miles.[44]

Given these technologies, the evolving paradigm for charging infrastructure to comprehensively meet the needs of electric vehicle drivers is to supply AC Level 1 or AC Level 2 charging in places where people naturally park for extended periods and DC Fast Charging along travel corridors. The various charging and vehicle technology combinations and the related effects of infrastructure are well summarized in Table 5-1 of Schedule SC-2, reproduced here for ready reference.

TABLE 5-1 Effect of Charging-Infrastructure Categories on Mainstream PEV Owners by PEV Class[a]

Infrastructure Category	PEV Class	Effect of Infrastructure on Mainstream PEV Owners
Interstate DC fast charge	Long-range BEV	Range extension, expands market
	Limited-range BEV	Not practical for long trips
	Range-extended PHEV	NA – not equipped
	Minimal PHEV	NA – not equipped
Intercity DC fast charge[b]	Long-range BEV	Range extension, expands market
	Limited-range BEV	2 × Range extension, increases confidence
	Range-extended PHEV	NA – not equipped
	Minimal PHEV	NA – not equipped
Intracity DC fast charge[b]	Long-range BEV	Not necessary
	Limited-range BEV	Range extension, increases confidence
	Range-extended PHEV	NA – not equipped
	Minimal PHEV	NA – not equipped
Intracity AC levels 1 and 2[b]	Long-range BEV	Not necessary
	Limited-range BEV	Range extension, increases confidence
	Range-extended PHEV	Increases eVMT and value proposition
	Minimal PHEV	Increases eVMT and value proposition
Workplace	Long-range BEV	Range extension, expands market
	Limited-range BEV	Range extension, expands market
	Range-extended PHEV	Increases eVMT and value proposition; expands market
	Minimal PHEV	Increases eVMT and value proposition; expands market
Home	Long-range BEV	Virtual necessity
	Limited-range BEV	Virtual necessity
	Range-extended PHEV	Virtual necessity
	Minimal PHEV	Virtual necessity

[44] https://www.fueleconomy.gov/feg/pdfs/guides/FEG2016.pdf, which does not yet list the Chevrolet Bolt that is reported to have a range of about 200 miles.

The typical electric vehicle is driven 4% of the time, is parked at home 50% of the time, and is parked elsewhere 46% of the time.[45] In most cases, the majority of time parked elsewhere is at the workplace.

Q. Where should charging infrastructure be deployed in order to enable electric vehicle adoption?

A. In order to equitably enable electric vehicle adoption, each infrastructure category needs to be equivalently available to all potential electric vehicle drivers. In particular, AC charging at home is a "virtual necessity" and must potentially be available before a potential electric vehicle driver will make an electric vehicle purchase. Employers with employees who commute any significant distance will need workplace charging. For extended range travel using battery electric vehicles, fast charging must be available along enough routes to effectively connect most trip origin-destination combinations.

Q. What is your evaluation of KCP&L's Clean Charge Network by these criteria?

A. The foundational vehicle charging infrastructure category is home charging. Drivers are unlikely to purchase an EV without access to charging at home. KCP&L's Clean Charge Network does not address home charging for single-family residences. While customers with dedicated parking that is under their control—as is typical of single-family dwellings—might benefit from assistance with charging infrastructure, they do not face fundamental market barriers that prevent them from obtaining home-based charging so that they can use an electric vehicle. By contrast, most multifamily housing has a shared parking area, typically without assigned parking. Someone who lives in a multifamily setting and is contemplating an electric vehicle purchase faces a number of challenges not

[45] NRDC, 2016. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles at Figure 3. Available from: https://www.nrdc.org/sites/default/files/driving-out-pollution-report.pdf

faced by an owner-occupant of a single-family dwelling. Parking is a common area not under exclusive control of the erstwhile electric vehicle owner, so some kind of permission will be required. Exclusive control of a parking place equipped for charging may be difficult, and shared infrastructure may be appropriate to the setting. Costs of charging infrastructure at remove from the building, such as in a parking lot, will likely be higher than installation in a single-family house garage. In the case of a renter, investment in charging infrastructure may not be recoverable within their expected tenure. Thus, utility support for charging infrastructure in the multi-family setting addresses unique market barriers and seems appropriate. KCP&L has previously testified before the Kansas Corporation Commission that it has a target of 5% deployment in the multi-family setting[46] for the Clean Charge Network, and stated in a data request in the instant case that 23 stations had been deployed in that setting to date.[47] KCP&L makes no mention of charging infrastructure for fleets. School buses, local delivery fleets, local transit fleets, garbage trucks, and similar short-range fleets are typically parked overnight in a way that is analogous to residential charging.

The second-most important charging location is the workplace. On-site workplace charging potentially provides a focused benefit to employees and thereby provides value to the employer; employees may be able to negotiate the provision of vehicle charging infrastructure in on-site employee parking. Workers in downtown areas where parking is primarily in shared public or private parking systems are unlikely to be able to negotiate provision of electric vehicle charging in the same way that they might for on-site parking

[46] *Direct Testimony of Kristin L. Riggins* at 5, In the Matter of the Application of Kansas City Power & Light Company for Approval of its Clean Charge Network Project and Electric Vehicle Charging Station Tariff, Docket No. 16-KCPE-160-MIS (filed February 16, 2016).
[47] *Response to PSC Staff Data Request 0205* (October 13, 2016).

at their workplace, for reasons similar to those that impeded at-home charging for residents of multi-family dwellings. Thus, there is arguably a greater need for KCP&L to engage in the provision of charging infrastructure in shared "public" workplace-oriented parking than in exclusive workplace-oriented parking. KCP&L has previously testified to a goal of deploying 25% of Clean Charge Network stations in workplaces.[48] However, it is not clear whether KCP&L has affirmatively sought to deploy charging in the "public" locations where a degree of market failure might be expected to occur, nor it is not clear whether the deployments are focused on serving the patrons of the host businesses or the employees.

Intracity AC Level 1 and 2 charging can add value for an electric vehicle owner, so it should not be neglected. Broadly, this appears to have been—and continue to be—the focus of KCP&L's host selection process[49]. However, dwell time of customers varies considerably amongst types of businesses. I was not able to determine whether KCP&L has assessed charging station use in relation to the type of business at which they charging station is hosted, and would recommend that such an analysis be done to inform KCP&L, the Commission, and other stakeholders about optimal site selection in future programs. Since stations are virtually free to hosts in the KCP&L Clean Charge Network, there has been no market pressure to guide host selection.

While access to home charging is commonly understood as foundational for EV ownership, access to direct current ("DC") fast charging likewise influences consumer's

[48] *Direct Testimony of Kristin L. Riggins* at 5, In the Matter of the Application of Kansas City Power & Light Company for Approval of its Clean Charge Network Project and Electric Vehicle Charging Station Tariff, Docket No. 16-KCPE-160-MIS (filed February 16, 2016).
[49] *See id.* (Explaining that KCP&L aims to deploy 70% of the charging stations at the following site types: education (7.5%); healthcare (7.5%); hospitality (10%); municipal (5%); parks and recreation (5%); retail (25%); parking (10%.).

choices and is therefore an important part of a comprehensive charging network. One critical benefit of DC fast charging is that it enables inter-city and long-distance travel that is otherwise impossible or impractical for all-electric vehicle drivers.[50] Further, consumer research indicates that a "lack of robust DC fast charging infrastructure is seriously inhibiting the value, utility, and sales potential" of typical pure-battery electric vehicles.[51] Consequently, increased access to DC fast charging stations must be achieved in order to build an effective EV infrastructure that will drive EV adoption. I reviewed the locations of KCP&L's Intercity Fast Charging stations on their website. The locations are not unreasonable, but I was not able to determine analytical support for those locations.

In summary, it appears that KCP&L's Clean Charge Network program was reasonably planned, but in hindsight could have been somewhat improved.

Q. Do you recommend that the Commission authorize rate recovery for Missouri jurisdictional costs of KCP&L's Clean Charge Network?

A. I do, subject to some recommendations in future testimony on rate design. I believe there is a strong public-policy case for vehicle electrification and for utility engagement in deploying electric vehicle charging infrastructure to lead the development of the market for electric vehicle ownership and use. KCP&L's Clean Charge Network program has been reasonably well planned and carried out at reasonable cost. Particularly with some portion of the costs offset by tax credits that will offset revenue requirements, this was a

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[50] Nick Nigro et al. *Strategic Planning to Implement Publicly Available EV Charging Stations: A Guide for Businesses and Policymakers* (2015) at 11.
[51] PlugShare, New Survey Data: BEV Drivers and the Desire for DC Fast Charging (March 2014).

reasonable investment that should bring substantial benefits to the residents of KCP&L's service territory.

Q. Does that complete your testimony regarding KCP&L's revenue request?

A. Yes.

Douglas B. Jester

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Professional experience

January 2011 – present 5 Lakes Energy

Principal Member

Co-owner of a consulting firm working to advance the clean energy economy in Michigan and beyond. Consulting engagements with foundations, startups, and large mature businesses have included work on public policy, business strategy, market development, technology collaboration, project finance, and export development concerning energy efficiency, smart grid, renewable generation, electric vehicle infrastructure, and utility regulation and rate design. Policy director for renewable energy ballot initiative and Michigan energy legislation advocacy. Supported startup of the Energy Innovation Business Council, a trade association of clean energy businesses. Expert witness in utility regulation cases. Developed integrated resource planning models for use in ten states' compliance with the Clean Power Plan.

February 2010 - December 2010 Michigan Department of Energy, Labor and Economic Growth

Senior Energy Policy Advisor

Advisor to the Chief Energy Officer of the State of Michigan with primary focus on institutionalizing energy efficiency and renewable energy strategies and policies and developing clean energy businesses in Michigan. Provided several policy analyses concerning utility regulation, grid-integrated storage, performance contracting, feed-in tariffs, and low-income energy efficiency and assistance. Participated in Pluggable Electric Vehicle Task Force, Smart Grid Collaborative, Michigan Prosperity Initiative, and Green Partnership Team. Managed development of social-media-based community for energy practitioners. Organized conference on Biomass Waste to Energy.

August 2008 - February 2010 Rose International

Business Development Consultant - Smart Grid

- Employed by Verizon Business' exclusive external staffing agency for the purpose of providing business and solution development consultation services to Verizon Business in the areas of Smart Grid services and transportation management services.

December 2007 - March 2010 Efficient Printers Inc

President/Co-Owner

- Co-founder and co-owner with Keith Carlson of a corporation formed for the purpose of acquiring J A Thomas Company, a sole proprietorship owned by Keith Carlson. Recognized as Sacramento County (California) 2008 Supplier of the Year and Washoe County (Nevada) Association for Retarded Citizens 2008 Employer of the Year. Business operations discontinued by asset sale to focus on associated printing software services of IT Services Corporation.

August 2007 - present IT Services Corporation

President/Owner

- Founder, co-owner, and President of a startup business intended to provide advanced IT consulting services and to acquire or develop managed services in selected niches, currently focused on developing e-commerce solutions for commercial printing with software-as-a-service.

2004 – August 2007 Automated License Systems

Chief Technology Officer

- Member of four-person executive team and member of board of directors of a privately-held corporation specializing in automated systems for the sale of hunting and fishing licenses, park campground reservations, and in automated background check systems. Executive responsible for project management, network and data center operations, software and product development. Brought company through mezzanine financing and sold it to Active Networks.

2000 - 2004 WorldCom/MCI

Director, Government Application Solutions

- Executive responsible in various combinations for line of business sales, state and local government product marketing, project management, network and data center operations, software and product development, and contact center operations for specialized government process outsourcing business. Principal lines of business were vehicle emissions testing, firearm background checks, automated hunting and fishing license systems, automated appointment scheduling, and managed application hosting services. Also responsible for managing order entry, tracking, and service support systems for numerous large federal telecommunications contracts such as the US Post Office, Federal Aviation Administration, and Navy-Marine Corps Intranet.
- Increased annual line-of-business revenue from $64 million to $93 million, improved EBITDA from approximately 2% to 27%, and retained all customers, in context of corporate scandal and bankruptcy.
- Repeatedly evaluated in top 10% of company executive management on annual performance evaluations.

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1999-2000 Compuware Corporation

Senior Project Manager

- Senior project manager, on customer site with five project managers and team of approximately 80, to migrate a major dental insurer from a mainframe environment to internet-enabled client-server environment.

1995 - 1999 City of East Lansing, Michigan

Mayor and Councilmember

- Elected chief executive of the City of East Lansing, a sophisticated city of 52,000 residents with a council-manager government employing about 350 staff and with an annual budget of about $47 million. Major accomplishments included incorporation of public asset depreciation into budgets with consequent improvements in public facilities and services, complete rewrite and modernization of city charter, greatly intensified cooperation between the City of East Lansing and the East Lansing Public Schools, significant increases in recreational facilities and services, major revisions to housing code, initiation of revision of the City Master Plan, facilitation of the merger of the Capital Area Transportation Authority and Michigan State University bus systems, initiation of a major downtown redevelopment project, City government efficiency improvements, and numerous other policy initiatives. Member of Michigan Municipal League policy committee on Transportation and Environment and principal writer of league policy on these subjects (still substantially unchanged as of 2009).

1995-1999 Michigan Department of Natural Resources

Chief Information Officer

- Executive responsibility for end-user computing, data center operations, wide area network, local area network, telephony, public safety radio, videoconferencing, application development and support, Y2K readiness for Departments of Natural Resources and Environmental Quality. Directed staff of about 110. Member of MERIT Affiliates Board and of the Great Lakes Commission's Great Lakes Information Network (GLIN) Board.

1990-1995 Michigan Department of Natural Resources

Senior Fisheries Manager

- Responsible for coordinating management of Michigan's Great Lakes fisheries worth about $4 billion per year including fish stocking and sport and commercial fishing regulation decisions, fishery monitoring and research programs, information systems development, market and economic analyses, litigation, legislative analysis and negotiation. University relations. Extensive involvement in regulation of steam electric and hydroelectric power plants.
- Served as agency expert on natural resource damage assessment, for all resources and causes.
- Considerable involvement with Great Lakes Fishery Commission, including:
    - Co-chair of Strategic Great Lakes Fishery Management Plan working group

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- Member of Lake Erie and Lake St. Clair Committees
- Chair, Council of Lake Committees
- Member, Sea Lamprey Control Advisory Committee
- St Clair and Detroit River Areas of Concern Planning Committees

1989-1990 American Fisheries Society

Editor, North American Journal of Fisheries Management

- Full responsibility for publication of one of the premier academic journals in natural resource management.

1984 - 1989 Michigan Department of Natural Resources

Fisheries Administrator

- Assistant to Chief of Fisheries, responsible for strategic planning, budgets, personnel management, public relations, market and economic analysis, and information systems. Department of Natural Resources representative to Governor's Cabinet Council on Economic Development.

1983-present Michigan State University

Adjunct Instructor

- Irregular lecturer in various undergraduate and graduate fisheries and wildlife courses and informal graduate student research advisor in fisheries and wildlife and in parks and recreation marketing.

1977 – 1984 Michigan Department of Natural Resources

Fisheries Research Biologist

- Simulation modeling & policy analysis of Great Lakes ecosystems. Development of problem-oriented management records system and "epidemiological" approaches to managing inland fisheries.

Education

1991-1995 Michigan State University

PhD Candidate, Environmental Economics

Coursework completed, dissertation not pursued.

1980-1981 University of British Columbia

Non-degree Program, Institute of Animal Resource Ecology

1974-1977 Virginia Polytechnic Institute & State University

MS Fisheries and Wildlife Sciences

MS Statistics and Operations Research

1971-1974 New Mexico State University

BIS Mathematics, Biology, and Fine Arts

Citizenship and Community Involvement

Youth Soccer Coach, East Lansing Soccer League, 1987-89

Co-organizer, East Lansing Community Unity, 1992-1993

Bailey Community Association Board, 1993-1995

East Lansing Commission on the Environment, 1993-1995

Councilmember, City of East Lansing, 1995-1999

Mayor, City of East Lansing, 1995-1997

East Lansing Downtown Development Authority Board Member, 1995-1999

East Lansing Transportation Commission, 1999-2004

East Lansing Non-Profit Housing and Neighborhood Services Corporation Board Member, 2001-2004

Lansing – EastLansing Smart Zone Board of Directors, 2007-present

Council on Labor and Economic Growth, State of Michigan, by appointment of the Governor, May 2009 – May 2012

East Lansing Downtown Development Authority Board Member and Vice-Chair, 2010 – present.

East Lansing Brownfield Authority Board Member and Vice-Chair, 2010 – present.

East Lansing Downtown Management Board and Chair, 2010 – 2016

East Lansing City Center Condominium Association Board Member, 2015 – present.

Specific Energy-Related Accomplishments

Unrelated to Employment

- Member of Michigan SAVES Advisory Board. Michigan SAVES is a financing program for building energy efficiency measures initiated by the State of Michigan Public Service Commission and administered under contract by Public Sector Consultants. Program launched in 2010.
- Member of Michigan Green Jobs Initiative, representing the Council for Labor and Economic Growth.
- Participated in Lansing Board of Water and Light Integrated Resource Planning, leading to their recent completion of a combined cycle natural gas power plant that also provides district heating to downtown Lansing.

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- By appointment of the Mayor of Lansing, member of Citizens Review Team to evaluate Lansing Board of Water and Light storm response and emergency preparedness.
- Angel investor in startup off-shore wind technology company, recently awarded ARPA-E commercialization grant.
- In graduate school, participated in development of database and algorithms for optimal routing of major transmission lines for Virginia Electric Power Company (now part of Dominion Resources).

For 5 Lakes Energy

- Participant by invitation in the Michigan Public Service Commission Smart Grid Collaborative, authoring recommendations on data access, application priorities, and electric vehicle integration to the grid.
- Participant by invitation in the Michigan Public Service Commission Energy Optimization Collaborative, a regular meeting and action collaborative of parties involved in the Energy Optimization programs required of utilities by Michigan law enacted in 2008.
- Participant by invitation in Michigan Public Service Commission Solar Work Group, including presentations and written comments on value of solar, including energy, capacity, avoided health and environmental damages, hedge value, and ancillary services.
- Participant by invitation in Michigan Senate Energy and Technology Committee stakeholder work group preliminary to introduction of a comprehensive legislative package.
- Participant by invitation in Michigan Public Service Commission PURPA Avoided Cost Technical Advisory Committee.
- Participant by invitation in Michigan Public Service Commission Standby Rate Working Group.
- Participant by invitation in Michigan Public Service Commission Street Lighting Collaborative.
- Participant by invitation in State of Michigan Agency for Energy Technical Advisory Committee on Clean Power Plan implementation.
- Conceived, obtained funding, and developed open access integrated resource planning tools (State Tool for Electricity Emissions Reduction aka STEER) for State compliance with the Clean Power Plan:
    - For Energy Foundation - Michigan and Iowa
    - For Advanced Energy Economy Institute – Arkansas, Florida, Illinois, Ohio, Pennsylvania, Virginia
    - For The Solar Foundation - Georgia and North Carolina
    - For Colorado Dept of Public Health and Environment - Colorado currently beginning development.
- Presentations to Michigan Agency for Energy and the Institute for Public Utilities Michigan Forum on Strategies for Michigan to Comply with the Clean Power Plan.
- Participant in Midcontinent Independent Systems Operator stakeholder processes on behalf of Michigan Citizens Against Rate Excess and the MISO Consumer Representatives Sector, including Resource Adequacy Committee, Loss of Load Expectation Working Group, Transmission Expansion Working Group, Demand Response Working Group, Independent Load Forecasting Working Group, and Clean Power Plan Working Group.
- Expert witness before the Michigan Public Service Commission in various cases, including:
    - Case U-17473 (Consumers Energy Plant Retirement Securitization)
    - Case U-17096-R (Indiana Michigan 2013 PSCR Reconciliation)
    - Case U-17301 (Consumers Energy Renewable Energy Plan 2013 Biennial Review);
    - Case U-17302 (DTE Energy Renewable Energy Plan 2013 Biennial Review);
    - Case U-17317 (Consumers Energy 2014 PSCR Plan);
    - Case U-17319 (DTE Electric 2014 PSCR Plan);
    - Case U-17674 (WEPCO 2015 PSCR Plan);
    - Case U-17679 (Indiana-Michigan 2015 PSCR Plan);
    - Case U-17689 (DTE Electric Cost of Service and Rate Design);
    - Case U-17688 (Consumers Energy Cost of Service and Rate Design);
    - Case U-17698 (Indiana-Michigan Cost of Service and Rate Design);

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- Case U-17762 (DTE Electric Energy Optimization Plan);
  - Case U-17752 (Consumers Energy Community Solar);
  - Case U-17735 (Consumers Energy General Rates);
  - Case U-17767 (DTE General Rates);
  - Case U-17792 (Consumers Energy Renewable Energy Plan Revision);
  - Case U-17895 (UPPCO General Rates);
  - Case U-17911 (UPPCO 2016 PSCR Plan);
  - Case U-17990 (Consumers Energy General Rates); and
  - Case U-18014 (DTE General Rates);
  - Case U-17611-R (UPPCO 2015 PSCR Reconciliation);
  - Case U-18090 (Consumers Energy PURPA Avoided Costs);
  - Case U-18091 (DTE PURPA Avoided Costs).
- Coauthored "Charge without a Cause: Assessing Utility Demand Charges on Small Customers"
- Currently under contract to the Michigan Agency for Energy to develop a Roadmap for CHP Market Development in Michigan, including evaluation of various CHP technologies and applications using STEER Michigan as an integrated resource planning tool.
- Under contract to NextEnergy, authored "Alternative Energy and Distributed Generation" chapter of Smart Grid Economic Development Opportunities report to Michigan Economic Development Corporation and assisted authors of chapters on "Demand Response" and "Automated Energy Management Systems".
- Developed presentation on "Whole System Perspective on Energy Optimization Strategy" for Michigan Energy Optimization Collaborative.
- Under contract to NextEnergy, assisted in development of industrial energy efficiency technology development strategy.
- Under contract to a multinational solar photovoltaics company, developed market strategy recommendations.
- For an automobile OEM, developed analyses of economic benefits of demand response in vehicle charging and vehicle-to-grid electricity storage solutions.
- Under contract to Pew Charitable Trusts, assisted in development of a report of best practices for electric vehicle charging infrastructure.
- Under contract to a national foundation, developed renewable energy business case for Michigan including estimates of rate impacts, employment and income effects, health effects, and greenhouse gas emissions effects.
- Assisted in Michigan market development for a solar panel manufacturer, clean energy finance company, and industrial energy management systems company.
- Under contract to Institute for Energy Innovation, organized legislative learning sessions covering a synopsis of Michigan's energy uses and supply, energy efficiency, and economic impacts of clean energy.

For Department of Energy Labor and Economic Growth

- Participant in the Michigan Public Service Commission Energy Optimization Collaborative, a regular meeting and action collaborative of parties involved in the Energy Optimization programs required of utilities by Michigan law enacted in 2008.
- Lead development of a social-media-based community for energy practitioners in Michigan at www.MichEEN.org.
- Drafted analysis and policy paper concerning customer and third-party access to utility meter data.
- Analyzed hourly electric utility load demonstrating relationship amongst time of day, daylight, and temperature on loads of residential, commercial, industrial, and public lighting customers. Analysis demonstrated the importance of heating for residential electrical loads and the effects of various energy efficiency measures on load-duration curves.
- Analyzed relationship of marginal locational prices to load, demonstrating that traditional assumptions of Integrated Resource Planning are invalid and that there are substantial

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current opportunities for cost-effective grid-integrated storage for the purpose of price arbitrage as opposed to traditionally considered load arbitrage.

- Developed analyses and recommendations concerning the use of feed-in tariffs in Michigan.
- Participated in Pluggable Electric Vehicle Task Force and initiated changes in State building code to accommodate installation of vehicle charging equipment.
- Organized December 2010 conference on Biomass Waste to Energy technologies and market opportunities.
- Participated in and provided support for teams working on developing Michigan businesses involved in renewable energy, storage, and smart grid supply chains.
- Developed analyses and recommendations concerning low-income energy assistance coordination with low-income energy efficiency programs and utility payment collection programs.
- Drafted State of Michigan response to a US Department of Energy request for information on offshore wind energy technology development opportunities.
- Assisted in development of draft performance contracting enabling legislation, since adopted by the State of Michigan.

For Verizon Business

- Analyzed several potential new lines of business for potential entry by Verizon's Global Services Systems Integration business unit and recommended entry to the "Smart Grid" market. This recommendation was adopted and became a major corporate initiative.
- Provided market analysis and participation in various conferences to aid in positioning Verizon in the "Smart Grid" market. Recommendations are proprietary to Verizon.
- Led a task force to identify potential converged solutions for the "Smart Grid" market by integrating Verizon's current products and selected partners. Established five key partnerships that are the basis for Verizon's current "Smart Grid" product offerings.
- Participated in the "Smart Grid" architecture team sponsored by the corporate Chief Technology Officer with sub-team lead responsibilities in the areas of Software and System Integration and Network and Systems Management. This team established a reference architecture for the company's "Smart Grid" offerings, identified necessary changes in networks and product offerings, and recommended public policy positions concerning spectrum allocation by the FCC, security standards being developed by the North American Reliability Council, and interoperability standards being developed by the National Institute of Standards and Technology.
- Developed product proposals and requirements in the areas of residential energy management, commercial building energy management, advanced metering infrastructure, power distribution monitoring and control, power outage detection and restoration, energy market integration and trading platforms, utility customer portals and notification services, utility contact center voice application enablement, and critical infrastructure physical security.
- Lead solution architecture and proposal development for six utilities with solutions encompassing customer portal, advanced metering, outage management, security assessment, distribution automation, and comprehensive "Smart Grid" implementation.
- Presented Verizon's "Smart Grid" capabilities to seventeen utilities.
- Presented "Role of Telecommunications Carriers in Smart Grid Implementation" to 2009 Mid-America Regulatory Conference.
- Presented "Smart Grid: Transforming the Electricity Supply Chain" to the 2009 World Energy Engineering Conference.
- Participant in NASPInet work groups of the North American Energy Reliability Corporation (NERC), developing specifications for a wide-area situational awareness network to facilitate the sharing and analysis of synchrophasor data amongst utilities in order to increase transmission reliability.
- Provided technical advice to account team concerning successful proposal to provide network services and information systems support for the California ISO, which coordinates power dispatch and intercompany power sales transactions for the California market.

For Michigan Department of Natural Resources

- Determined permit requirements under Section 316 of the Clean Water Act for all steam electric plants currently operating in the State of Michigan.
- Case manager and key witness for the State of Michigan in FERC, State court, and Federal court cases concerning economics and environmental impacts of the Ludington Pumped Storage Plant, which is the world's largest pumped storage plant. A lead negotiator for the State in the ultimate settlement of this issue. The settlement was valued at $127 million in 1995 and included considerations of environmental mitigation, changes in power system dispatch rules, and damages compensation.
- Managed FERC license application reviews for the State of Michigan for all hydroelectric projects in Michigan as these came up for reissuance in 1970s and 1980s.
- Testified on behalf of the State of Michigan in contested cases before the Federal Energy Regulatory Commission concerning benefit-cost analyses and regulatory issues for four different hydroelectric dams in Michigan.
- Reviewed (as regulator) the environmental impacts and benefit-cost analyses of all major steam electric and most hydroelectric plants in the State of Michigan.
- Executive responsibility for development, maintenance, and operations of the State of Michigan's information system for mineral (includes oil and gas) rights leasing, unitization and apportionment, and royalty collection.
- In cooperative project with Ontario Ministry of Natural Resources, participated in development of a simulation model of oil field development logistics and environmental impact on Canada's Arctic slope for Tesoro Oil.