Toward an Electric Vehicle Policy for the University of Massachusetts Amherst

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5/3/2012

Executive Summary

Electric vehicles (EVs) are vehicles that use electric motors for propulsion and have the potential for significant environmental impact with regard to reducing Carbon Dioxide (CO2) emissions, the largest contributor to global warming. With a heightened attention on "energy independence" and awareness of the effects of transportation on global warming, demand for electric vehicles is projected to rise rapidly over the next several decades. Researchers have found various ways to understand the "well-to-wheels" impact, which despite involving emissions at the source of electricity generation, still show environmental advantages over conventional fuel vehicles. Given the early lifecycle stage of this technology, the uncertainty of climate implications, and political support behind industry growth, some questions in this landscape are: What are the critical factors that will help encourage consumer adoption of electric vehicles? How do public entities marry their own climate action goals with what is happening in the marketplace for EV infrastructure? What can institutions like the University of Massachusetts Amherst learn from those who are paving the way?

This paper seeks to identify the ideal Electric Vehicle policy for UMass to adopt to align with the goals of its Climate Action Plan. Pursuing a pilot program on campus requires an assessment and integration of the opportunities and barriers to installing electric vehicle supply equipment (EVSE), the various options for equipment ownership and operations, and the policies that the University could adopt in order to encourage and enable the use of electric vehicles by faculty, staff, students and visitors. The evaluation elements necessary to determine a scalable solution for affordable charging stations at UMass can also be useful for successful rollouts on other campuses.

Undergirding the recommendations for UMass are an analysis of sales and usage models for electric vehicles to project adoption rates on campus and interviews with representatives from universities and municipalities about what they have learned from their investment in EV infrastructure. Understanding state laws about the resale of electricity as well as what consumers might pay for it direct how to charge consumers for the use of a charging station. Assessing commute patterns and comparing emissions with and without EVs help situate whether or not deploying EV stations are on par with other sustainability efforts on campus to meet the goals of the Climate Action Plan.

The findings show that EV growth will be steady, but still only make up between .36% and .66% of all light duty vehicles on U.S. roads by 2020. While battery technology is expected to decline, the high upfront cost of an EV will drive consumers to seek the lowest cost to "plug in;" private and public entities looking to deploy EVSEs for environmental and political reasons must balance the desire to encourage adoption with the price they will charge. Further, many public entities face the challenges that involve forgoing premium parking space revenue and negotiating internally who pays for the installation, maintenance and operations.

The recommendations of this analysis include UMass purchasing, installing and operating an EV charging station. For EVSEs located in public access lots, UMass could reasonably charge $1-2 per hour. Parking Services should offer a 20-50% discount on permits for EV drivers, in addition to premium parking spaces.

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Introduction

Electric vehicles (EVs) are vehicles that use electric motors for propulsion. Conventional vehicles use an internal combustion engine (ICE), which converts fossil fuels (like gasoline) to propel the motor. There are multiple vehicles on the spectrum between the conventional ICE vehicle and a pure electric vehicle (also called a battery electric vehicle or BEV), which runs solely on a battery and needs to be charged via plugging into an electric socket. Hybrid Electric Vehicles (HEVs), the most notable example of which is the Toyota Prius, operate on both an ICE and a small electric motor. This car runs primarily on gasoline, and secondarily on the electric motor for about 40 miles as it is charged through regenerative braking. Plug-in Hybrid Electric Vehicles (PHEVs) also have an ICE but a slightly larger electric engine than the HEV; these vehicles need to be plugged into an electric socket to charge the battery. This report focuses on both EVs and PHEVs since they both require charging equipment.

When an electric vehicle that requires charging is sold, it is bundled with a home charging station that gets installed in the consumer's home, typically in their garage. These devices are called electric vehicle supply equipment (EVSE) and have either a 120 volt (Level 1) or 240 volt (Level 2) capacity. Level 1 charging is considered "slow" and takes all electric vehicles 7-8 hours to fully recharge their battery. This type of EVSE is what typically gets installed at home so consumers can charge their vehicle overnight. Level 2 charging is considered "fast" and takes 3-4 hours to fully charge a battery. These types of stations are being installed in public spaces like malls, airports, and supermarkets and are often referred to as "opportunity charging".

The two biggest barriers to buying an electric vehicle for consumers are price and "range anxiety". Most EVs will have approximately a 40-mile range before the battery is completely discharged, thus leaving the driver stranded if they are not able to "plug in". As a result, the primary debate is that of the chicken and the egg – whether we need to produce more EVs to flood the market or whether we need the infrastructure in place before there will be widespread adoption.

The two most recent electric powered vehicles, the Nissan Leaf and Chevy Volt, both came available for sale to the public in 2010. All of the major automakers have plans for additional models to hit the scene starting in 2012 and will include not only light duty vehicles, but also SUVs and trucks. With the support of the auto industry, the U.S. government, and electric utilities, America has the opportunity to wean itself from our oil dependence, resulting in greater energy and economic security and fewer greenhouse gases (GHG).[1] Because the transportation sector is responsible for more than one-third of national GHG emissions,[2] electrifying America's vehicle fleet has a significant opportunity to stave off the negative repercussions of climate change. Recent research on a global scale by a graduate team at Harvard's Kennedy School found that in London "road transport is responsible for 66% of particulate emissions and 42% of NOx emissions…and that each EV that displaces a conventional car produces savings of approximately 1.5 tons of CO2 per year, compared to a conventional vehicle. This represents a 62% reduction compared to a petrol-powered car, and a

[1] Greenhouse gas emissions (GHG) are interchangeably referred to as carbon dioxide (CO_2) and carbon dioxide equivalent (CO_{2Eq}). Carbon dioxide equivalent acknowledges other greenhouse gases like methane and nitrous oxide. However, since the other greenhouse gases are negligible compared to carbon dioxide, CO_{2Eq} and CO_2 are used interchangeably.
[2] *Emissions of Greenhouse Gases in the United States 2008*. U.S. Energy Information Administration, November 2009. ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057308.pdf.

53% reduction compared to a diesel-powered car."[3] Electric vehicles are touted as having zero tailpipe emissions with negligible hydrocarbons (HC), nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM), and formaldehyde (HCHO) released by driving. However, the critical measure of emissions is not at the tailpipe, but from the full cycle of energy production called "well-to-wheels," which encompasses everything from the manufacturing process to the production of the electricity that powers them. In fact, a recent report by the Union of Concerned Scientists demonstrates the emissions impact of EVs based on the source of energy generation across the United States. They analyze regions by how much renewable energy powers their grid and their average emissions intensity (global warming pollution per unit of electricity) over the course of a year to delineate between those that are "good" "better" and "best" (see Appendix A). A primary finding from their analysis makes implicit sense:

> The benefits of electric vehicles are inherently tied to our electricity grid, and a continued shift from coal-fired power plants to natural gas and cleaner renewables must occur at the same time as our vehicles transition from burning oil to running on electricity. This shift will not only decrease the global warming emissions from electric vehicles but also reduce many of the other pollutants associated with coal-fired electricity.[4]

Given the early lifecycle stage of this technology, the uncertainty of climate implications, and political support behind industry growth, question in this landscape are: What are the critical factors that will help encourage consumer adoption of electric vehicles? How do public entities marry their own climate action goals with what is happening in the marketplace? What can institutions like the University of Massachusetts Amherst learn from those who are paving the way? In 2010, the University adopted its Climate Action Plan as a result of President Jack

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[3] A. Wiederer and R. Philip, *Policy options for electric vehicle charging infrastructure in C40 cities*, 2010.
[4] Anair, Don and Amine Mahmassani. 2012. *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States.* Cambridge, MA: Union of Concerned Scientists.

Wilson's 2007 signing of the American College and University Presidents' Climate Commitment (ACUPCC) and his dedication of the entire UMass system to "neutralize greenhouse gas emissions and accelerate the education and research efforts of higher education to equip society to re-stabilize the earth's climate."[5] As the state's leading research and technology institution, UMass wants to stay ahead of the curve with regard to CO2 mitigation strategies.

This paper seeks to identify the ideal Electric Vehicle policy for UMass to adopt to align with the goals of the Climate Action Plan. Pursuing a pilot program on campus requires an assessment and integration of the opportunities and barriers to installation, the various options for equipment ownership and operations, and the policies that the University could adopt in order to encourage and enable the use of electric vehicles by faculty, staff, students and visitors. The evaluation elements necessary to determine a scalable solution for affordable charging stations at UMass can also be useful for successful rollouts on other campuses.

Methods

There were two main objectives for the methodology to address the above questions: become familiar with the EVSE landscape, including the players, incentives and financials; and understand the commitment UMass Amherst has made with regard to sustainability goals vis à vis its Climate Action Plan. A combination of quantitative methods (e.g. EV sales and usage models and commuter data analysis) and qualitative methods (e.g. literature and case study reviews, interviews and meetings), bring the impetus for EV and EV charging station adoption and a feasible EV policy for UMass to the surface.

[5] UMass Climate Action Plan.

EV Sales and Usage Models

Several research bodies have begun collecting data on EV usage to understand and model the need for charging station prevalence. The Institute for Transportation Studies at UC Davis, the Electric Power Research Institute (EPRI), and the National Renewable Energy Laboratory (NREL) have all published studies on emerging usage. In addition, there is preliminary information about EV charging usage from the first 148 state funded stations in Massachusetts, though data has not yet been released. Using projected light-duty vehicle sales data of electric and plug-in hybrid electrics from the U.S. Energy Information Agency in their Annual Energy Outlook (AEO2012) in combination with the number of vehicles on U.S. roads from the Department of Transportation, the degree to which electric vehicles will be substituted for those fueled by gasoline can be measured.

Household Commuter Data

In order to understand whether there will be a demand for EV charging stations on campus, it is important to have a sense of commuter data, including average distances traveled to school and/or work. The National Household Transportation Survey serves as a guide for patterns with respect to UMass. Commuter survey data collected by UMass Parking Services and parking projections from the Planning Office inform the case for installation.

Literature Review and Case Studies

Several papers have been published reviewing EV charging station use to date, which point to the critical components of installing EVSEs. Speaking with representatives from municipalities (e.g. Brookline, Boston) and other universities (e.g. University of Arizona, University of Maryland, and North Carolina State University) about their processes, policies and lessons learned informs potential models for installing stations by other public entities.

Interviews and Meetings

Conversation with staff in the Planning office, the Director of Transportation, and the Sustainability Manager on campus shed light on current opportunities and barriers for a successful EV policy. A Transportation Subcommittee meeting of the Environmental Performance Advisory Committee (EPAC) on March 15 clarified the relationship between the offices and who has the power to make particular decisions with regard to a forthcoming policy. Attending a Clean Cities Coalition meeting for the state of Massachusetts promoted conversation with the Director of the Department of Energy Resources (DOER) about current state policies around EVSEs. Multiple manufacturers and installers of charging equipment were also in attendance. Their interest in UMass resulted in specific proposals for the purchase of charging stations directly as well as contracting for service with a provider who would install and operate the equipment on campus. With the agreement of UMass Parking and Transportation staff, proposals from several companies were solicited to provide campus with various ownership options.

Background

Electric Vehicle Adoption

Advances in battery technology make it possible for our transportation sector to be powered by the variety of domestic and renewable sources that utilities across the U.S. are increasingly employing. Further, relying on a diverse set of fuels frees the U.S. from our dependence on foreign oil and associated price fluctuations since electricity prices are far more stable. With a heightened attention on “energy independence” and awareness of the effects of transportation on global warming, demand for electric vehicles is projected to rise rapidly over the next several decades. The U.S. Energy Information Agency (EIA) produces the Annual Energy Outlook (AEO), in which there are data on expected sales of conventional vehicles in addition to alternative fuel vehicles, including electric cars and trucks. According to AEO2012, electric vehicles will see an average annual growth rate of 23.8% from 2013 through 2035.[6] Pike Research is a clean technology analyst firm respected in the EV market as fair and reasonable forecasters grounded in the best available information. Their recent report, "Electric Vehicle Market Forecasts," estimates a similar 20% annual growth rate of electric vehicles, reaching 5.1% of vehicle sales by 2017.[7] By the EIA's more conservative projections, the U.S. would only see 1.1% in sales by the same year. Comparing that to the total number of vehicles on the road,[8] which grows 1% annually, electric vehicles could represent 2.1% of all light duty vehicles on the road by 2035. Of course, these models are dependent on the consumer behaving the way researchers expect based on information at present. As the Center for Entrepreneurship and Technology (CET) states, "in order for consumers to switch from the entrenched technology of internal combustion engines, with their benefits of a fully deployed refueling and repair network, consumers must perceive benefits to electric car ownership in excess of the uncertainties involved in adopting a new technology".[9] CET estimates that the growth will be due to the fact that the total cost of ownership for an electric vehicle will be less than a conventional car or truck and with the help of a $7500 federal tax credit, the initial purchase price will be lower than a fuel-efficient gasoline vehicle. High costs are driven by the battery technology, which is still being researched and developed though projected to fall in price over the next few years. It

[6] U.S. Energy Information Administration. 2012. *Annual energy outlook 2012 - early release* U.S. Energy Information Administration, DOE/EIA-0383ER(2012).
[7] Jeff Siegel. Electric vehicle market growth 2011. http://www.greenchipstocks.com/articles/electric-vehicle-market-growth/1467.
[8] William H. Moore, ed. 2012. *National Transportation Statistics* U.S. Department of Transportation, Research and Innovative Technology Administration, http://www.bts.gov/publications/national_transportation_statistics/excel/table_01_11.xls (accessed 4/15/2012).
[9] Thomas Becker. "Electric Vehicles in the United States: A new model with forecasts to 2030." Center for Entrepreneurship and Technology, http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf

would be ideal to leverage economies of scale and produce more to lower the cost; in fact, "many analysts predict that [the price of batteries] could drop to as little as $420 per kilowatt hour [from about $700 to $1,500 per kilowatt hour in 2009] by 2015 under an aggressive cost reduction scenario."[10] However, even with these technology improvements EVs will still have a higher sticker price which is a barrier for many consumers. McKinsey estimates that by 2015, a PHEV with a 40-mile range will cost $11,800 more than a traditional gas fueled car and a 100-mile all electric will cost $24,100 more.

Besides price, the other significant barrier to electric vehicle adoption is range anxiety. This term was coined to represent the nervousness drivers feel about running out of power on the road with no place to recharge. The U.S. Department of Energy (DOE) reported 750 publicly accessible chargers in April 2011, which has grown to over 9,000 by April 2012.[11] Given this trend, Pike Research expects that number to multiply to 13,000 stations by the end of 2012.[12] In Massachusetts there were 148 stations as of March 2012, many of them approximately 60 miles apart across the state. While many of those are located in the denser part of the eastern side of the state – the distance apart heading west is not much help for a driver with a 40-mile range EV. In an email exchange with one EVSE representative, he pointed to this challenge with regard to coming to Amherst from Boston: "Not sure if my EV will make it (85 miles to get out there and then I would need to recharge fully to get back)."[13] Clearly, early adopters are willing to accept the current landscape and simply adjust their driving and parking habits appropriately. According

[10] Russell Hensley, Stefan Knupfer, and Dickon Pinner. 2011. Electrifying cars: How three industries will evolve. *McKinsey Quarterly* 3, (February), https://www.mckinseyquarterly.com/Automotive/Strategy_Analysis/Electrifying_cars_How_three_industries_will_evolve_2370.

[11] http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

[12] James R.Hagerty and Mike Ramsey. "Charging stations outrun electric cars," *The Wall Street Journal*, 10/17/11, sec Technology.

[13] Scott Miller, email correspondence with author, April 3, 2012

to a survey by McKinsey, "this attitude reduces the need for public investments in the start-up stage, though a broad plug-in infrastructure will no doubt be critical as electrified vehicles migrate to mass adoption in large cities and elsewhere. In fact, among the 30 financial and nonfinancial measures [they] tested with New York consumers, some low-cost options—such as electric-vehicle-preferred lanes or conveniently located charging spots—were surprisingly effective."[14] The flexibility of early adopters with regard to incentives can serve as a guidepost for public entities looking to attract and support the growth of EVs.

Electricity Resale

A perceived barrier to the installation of charging stations is the prohibition of electricity resale. State laws are complicated and many have language indicating that electricity can only be sold by licensed utilities; but, states vary with regard to selling electricity to a consumer on your property. While the law requires electricity be delivered over the poles and wires of the local utility, in at least 14 retail access states[15] entities can purchase their electricity from the provider of their choice and sell it at retail to any end user.[16] In fact, there are examples of this being done in harbors and trailer parks who charge boats and mobile homes to plug into their outlets. For states where there is no retail access, there may be provisions around the law. Given the growth in this industry and need for reform, there is evidence that states are making such provisions. In

[14] Russell Hensley, Stefan M. Knupfer and Axel Krieger. 2009. "The fast lane to the adoption of electric cars." *McKinsey Quarterly* (June), https://www.mckinseyquarterly.com/The_fast_lane_to_the_adoption_of_electric_cars_2738.

[15] Retail states include all of New England (except VT) and NJ, NY, DE, MD, PA, IL and TX. For states where there is no retail access, there may be provisions around the law, which would need to be researched by an entity looking to deploy EV stations.

[16] Rich Silkman, Partner at Competitive Energy Services (CES), in conversation with the author, May 2, 2012. The University of Massachusetts System has selected CES, a national energy consulting company, as the service provider to help manage its energy needs for its five campuses around the state. After a very competitive bid process, CES was chosen to provide UMass with energy management services which will include energy procurement, utility management and relations, risk management, budgeting, sustainability and a myriad of other energy services. Under the agreement, CES will advise the UMass System on controlling costs for all energy products; including electricity, oil, and natural gas for UMass facilities and enable the University system to deliver significant savings to the Massachusetts taxpayers who, in part, fund the System.

January 2011, the Virginia Legislature passed a bill that states the following:

> The provision of electric vehicle charging service by a person who is not a public utility shall not constitute the retail sale of electricity if the electricity furnished in connection with the provision of electric vehicle charging service is used solely for transportation purpose and the person providing the electric vehicle charging service has procured the furnished electricity from the public utility that is authorized by the State Corporation Commission to engage in the retail sale of electricity within the exclusive service territory in which the service is provided.[17]

Public institutions hoping to deploy EV stations outside of the retail access states would need to research any such provisions, or even advocate their legislature for change.

Willingness to Pay

Consumers

Given the high cost of battery technology at present, a necessity for consumers – and the primary way to defray the high initial expense – is to be able to access inexpensive electricity over the course of their vehicle's life. Because consumers will be wary of spending in excess and because they will be able to charge at home there will be, as noted by the Electrification Coalition,[18] "an upper bound on the price consumers are willing to pay to charge their vehicles."[19] There are a few predominant ways to access public charging stations: pay per use and subscription. Pay per use allows a driver to park at a station and swipe their credit card to pay per hour or per session charge, typically up to four hours. Network providers offer the subscription model so account holders can either pay by the charge or by the month. Either way, drivers pay around $5 for a card (that looks much like your grocery rewards key fob) and get the

[17] Bill HB2105 Electricity vehicle charging service; excludes certain persons from retail sale of electricity. HB 2105 Electric vehicle charging service; excludes certain persons from retail sale of electricity. http://leg1.state.va.us/cgi-bin/legp504.exe?111+sum+HB2105

[18] The Electrification Coalition is a non-profit advocacy organization focused on economic, environmental and national security for the U.S. through oil independence and electrification of transportation. Its members are leaders of companies representing the entire value chain of an electrified transportation system.

[19] Electrification Coalition. 2009. *Electrification Roadmap: Revolutionizing transportation and achieving energy security.*

convenience of being registered with the network so they can locate and reserve stations and get notified when their vehicle completes charging or gets interrupted. The monthly payment model is much like a cell phone plan: pay a monthly fee to a certain network for unlimited access to their stations. Drivers who pay by the charge keep a minimum balance in their account which is debited at the station.

There is a range of prices per hour across the country, from $0.75 or $1 in Washington, DC to $2/hour in front of City Hall in Richardson, TX to $3.50/hour on the campus of Clark University in Worcester, MA.[20] There is also growing number of networks (and therefore competition); the largest network is ChargePoint America, which is owned by the leading EVSE manufacturer, Coulomb Technologies. Charging stations are not prevalent enough for consumers to have the luxury of only subscribing to a singular network, but with the mobile applications to locate stations and see their availability and pricing beforehand, they can be choosy about where they plug in. As competition between networks grow, station hosts will need to carefully select not only which EVSE to install, but also how to price its use in order to continue encouraging EV adoption.

Hosts

There are private entities without concern for remuneration, but rather want to build goodwill with their customers toward increased business. If most entities thought this way, the deployment would not be a coordinated and reliable enough network in the long term and ultimately, range anxiety will not be addressed. In addition, once EVs are more widely adopted, electricity will cost more and entities will have to begin requiring payment at the risk of financial losses. Instead, charging station "hosts" are considering ways around the specifics of this law by

[20] According to ChargePoint America Network's station map and information. https://www.chargepointportal.net/index.php/device/devicelocation.html

charging an additional fee to park in the space. In fact, many private entities and service providers are operating on the premise that consumers are used to paying for parking, and to charge an additional fee for the service of charging is not unreasonable. Despite their willingness to charge, EVSE operators are not leasing spaces from parking lot owners. Instead, many charging infrastructure providers are partnering with owners of parking spots for mutual benefit: service providers need real estate, and parking spot owners want to improve the attractiveness of their space while also building societal goodwill. Based on the research as well as the business models many service providers are using, charging for station use (if not electricity directly) will maximize profit.

On the other hand, many entities are not charging for the use of the station or the space (even if that space was once metered) in order to draw users in and demonstrate publicly that they are proponents of carbon emissions reducing vehicles. They want to encourage adoption to support the emissions reductions goals in their locale and are willing to absorb the upfront investment costs often with an internal commitment to stakeholders to reassess the policy in two years.

Data and Findings

EV Infrastructure Lessons

The growing band of public entities who are investing in EV Infrastructure to spur the adoption of EVs for political, economic, and environmental reasons have much to offer by way of lessons learned. Many of the public universities and municipalities interviewed were recipients of grant funding of some kind, though some were not. Those that did receive funding qualified for the Clean Cities Grant from the Energy Efficiency and Renewable Energy Office within the DOE. Between 2009 and 2010, the DOE awarded ECOtality, a clean technology company, nearly $115 million in grant funding to deploy EVs and EVSEs across the country – otherwise known as the EV Project.[21] This funding was available in six states across the country and was intended to collect data, take lessons learned and streamline future deployment.

University of Arizona

The University of Arizona received an ECOtality grant in the spring of 2010 and installed a station in three of their campus garages. They are all free to the public – an incentive for the demonstration period that was supposed to end this spring, but is being extended to encourage use. The decision to install the stations was one of many initiatives that support the University's Climate Action Plan. In fact, it was the first university to add an all-electric car to its car sharing fleet, accessible to the more than 700 members who participate in the program. The University of Arizona (UA) is one of more than 650 universities that have signed the American College and University Presidents' Climate Commitment (ACUPCC). By signing the ACUPCC, the UA affirms its commitment to continue to lead by example in reducing its carbon footprint, track greenhouse gas emissions, report comprehensively on all steps being taken to reduce them and share proven innovations.[22] They have not seen a substantial increase in use, but an employee in the Department of Alternative Transportation was hopeful for future change: "If the government continues to support, subsidize and encourage [EV infrastructure], I am optimistic that something good will come of it."[23]

University of Maryland

In February 2011 of the ECOtality grant enabled a total of five charging stations in four locations to be installed on the campus of University of Maryland College Park. All locations are in visitor lots and are free to use for the public. The University's Department of Transportation

[21] http://www.theevproject.com/
[22] http://portal.environment.arizona.edu/campus-sustainability/climate-action
[23] Thomas A., in conversation with the author, March 13, 2012

Services (DOTS) was motivated by two presidential goals: to reduce Greenhouse Gas Emissions (GHG) and to blur the line between campus and the community.[24] In order to reduce the proportion of GHG (15% of their total) that come from faculty, staff, and student commuting, DOTS offers multiple incentives, including Green Permits. Drivers with a "Green Car" as approved by the EPA receive a 20 percent discount on the cost of their parking permit. Students, faculty and staff who drive an electric vehicle to campus are eligible for a 50% discount on their campus parking permit.[25]

North Carolina State University

Working from a different stream of funding, North Carolina State University partnered with their local utility and received a congestion and traffic mitigation grant from their Department of Transportation. They installed four charging stations, two at the campus conference center and two at their visitors center –all free to use. There are 10 more in the pipeline, all of which play a role in the University's near term Sustainability Strategic Plan and long term Climate Action Plan. A challenge they faced was the layered approval process required to bring EVSEs onto campus. Twelve different offices had to review the plans and policy before the installation could take place. A second and more significant hurdle was getting buy-in from the parking lot manager who is not an employee of NC State. He viewed the charging stations as revenue losers for him, since he would no longer be able to charge for parking in those spaces on account of the grant's stipulation they be free to the public. In the estimation of a transportation representative, NC State will likely continue to absorb the cost of the charging station and its use after the demonstration period ends in two years. She said they struggle with the perception that the University is using taxpayer dollars to fund the stations and

[24] http://www.transportation.umd.edu/chargingstation.html
[25] http://www.sustainability.umd.edu/content/campus/transportation.php#Permits

that when they sit idly they are going to waste. Both of these concerns are common to many public entities pursuing electric vehicle infrastructure as a means to reduce carbon emissions.

Brookline, MA

Multiple towns and cities in Massachusetts were recipients of the Department of Energy Resources (DOER) Electric Vehicle Infrastructure Grants in 2011. The town of Brookline made the decision to install two stations that are free for public use only after multiple rounds of internal negotiations. Driven by their Climate Action Plan, town planners had to convince Selectmen not to charge for usage during the first two years in order to build goodwill with the public and support their sustainability goals. Their second battle came in the form of ownership. Several offices including the DPW, Engineering, Transportation, and the Building Department had to coordinate who paid for what part of the installation and who manages it. One of the Town Planners, who splits her time with the Climate/Energy Office, reflected that they could have used more time to think about how they would pay for what the grant did not cover as well as where to place the stations. Her lesson learned was to install stations next to conduits; otherwise installation alone can cost more than $10,000. For Brookline, the DPW did the trenching and other preparation (estimated value: $6,000), subcontractors wired the stations for $4,000 and one of the three approved electricians in Massachusetts installed and networked the station for $1,000 each— an overall investment of $12,000 for two stations.[26] Their next challenge was sacrificing premium parking spaces, much like at NC State. Because town meetings happen on Tuesday and Thursday nights and one of the stations is in front of Town Hall, the otherwise designated EV space is open to the public during meeting times. Local businesses were concerned about the possible loss of customers if they could not use the new EV

[26] Lara Curtis Hayes, in conversation with author, March 12, 2012

space at Coolidge Corner on the weekends. The compromise between the Department of Public Works (DPW) and the Economic Development Division leaves the EV space open to all on Friday and Saturday nights between 6pm and midnight.

Boston, MA

The Planning Department for the city of Boston strategically decided to install their DOER grant funded EVSEs curbside in front of City Hall; it is free to the public in order to visibly underscore Boston's commitment to sustainability. The most significant issue that arose for Boston to get the EVSE's installed also involved the multiple actors who needed to be engaged in the process. There were questions about siting, trenching, proximity to existing electric conduits, networking, pricing, and ownership. For the city planners, the main question was building a consortium of players around the city who would invest in building an infrastructure network. In 2009, Mayor Menino launched the "Complete Streets" initiative as a part of his Climate in Progress plan to promote multi-modal usage. This initiative is "a multi-project effort with the goal of accommodating all modes of travel on Boston's roadways, designing green, environmentally friendly streets and using new 'smart' technologies to improve mobility,"[27] so it is critical to involve people at all levels of interest. The city's plan is to deploy EV charging stations near both bikeshare locations as well as public transit stations. In addition, the city is teaming with planners from New York City and Philadelphia to create an outreach engagement platform for commuters in the northeast corridor, so as EVSE installations increase, public awareness will enable utilization.

With all the planning involved in deploying charging stations comes a big question: Who finances the entirety of the system when the grant funding is gone? The rollout of EVSE's do not

[27] http://www.cityofboston.gov/news/default.aspx?id=5110

have an economies of scale advantage yet, so municipalities and universities must decide how much investment can be satisfied by political goodwill and efforts toward CO2 reductions. The University of Massachusetts Amherst has not received grant funding and faces an initial hurdle of how to make the installation of charging stations a viable policy lever (assuming there is little financial incentive) to undergird the university's emission reduction efforts.

Transportation Context for UMass Amherst

Commute Patterns

UMass Amherst's Climate Action Plan seeks to quantify the carbon footprint of the University, of which one large component is transportation. The best available data from surveys conducted by Parking Services show 17,792 commuters in 2000 and 19,567 commuters in 2010.

Table 2: UMass Commute Modes

	2000	2010
Personal Vehicle	77%	60%
Bus	17%	28%
Bike	1%	6%
Walk	3%	4%
Other	2%	2%

Of those, 77% came by car in 2000 and 60% in 2010. Where this mode declines, there is growth in other modes. In 2000, 17% of commuters used the bus and 1% biked to campus. In 2010, those ratios grew to 28% and 6%, respectively. According to the National Household Travel Survey (NHTS), the changes in UMass commuter behavior reflect national trends. The percentage of people commuting by private vehicle in the U.S. decreased from 91% in 2001 to 89% in 2009. The percent using public transportation or walking, 5% and 3% respectively, stayed steady, but the percent in "other"[28] rose from 1% to 3%. While these changes are not significant, it is likely that consumers respond to the price of fuel by seeking alternative means of transportation when gas prices rise. If the price of oil increases over time as is projected, it is likely that commuters will seek more efficient

Table 1: NHTS Commute Modes

	2001	2009
Personal Vehicle	91%	89%
Public	5%	5%
Walk	3%	3%
Other	1%	3%

[28] "Other" on the NHTS could mean bike, skateboard or any means of transportation not listed.

and environmentally friendly means of transportation, including electric vehicles. While there was 16% growth in the number of students, faculty and staff on campus between 2000 and 2010, there was conversely a 16% decline in number of commuters. Likewise on a national scale, there was a 6% increase in number of workers from 2001 to 2009 and a 4% decrease in commuters.

Assuming the percentage of commuters who come by personal vehicle remains at about 60%, and the total number of students, faculty and staff increase by another 17% as it has since 2000, we will have 12,911 commuters on campus in 2020. Projected EV sales from the U.S. Energy Information Agency and the projected growth of vehicles on the road today indicate that there will be just under one million EVs (.36% of total light duty vehicles) on the road by 2020. At this conservative adoption rate, there will be somewhere around 46 electric vehicles used for commuting to campus. If the U.S. meets President Obama's goal of 1 million EVs on the road by 2015, then EVs would number 1.7 million in 2020 (.66% of the total number of light duty vehicles on the road). At this more optimistic penetration rate, UMass might see 85 EVs on campus.

The national average daily commute length was 12.1 in both 2001 and 2009 whereas at UMass, the commuter survey found it to be 2.5 for students and 6 for faculty/staff. Following parallel trends at the national level in commuter mode, number of workers and commuters, this analysis assumes the longer commute length of 6 miles despite students reporting an average 2.5 miles. This also hinges on a greater likelihood that faculty and staff will come in electric vehicles than will students in the next ten years.

Measuring Carbon Emissions

Given commute distances and the contribution to GHGs that conventional vehicles make, many of the proponents of EVs argue that with enough adoption and substitution, our nation could see a significant reduction in carbon emissions. However, one of the biggest criticisms of electric vehicles is that while they may have zero tailpipe emissions, their usage still contributes to GHGs if the source of electricity used is a coal fired power plant. To account for the difference, the National Research Council of the National Academies performed a study on alternative fuel vehicles in 2010. They calculated the comparative CO2 emissions in the following way:

> CO2 emissions by US electric generators and combined heat and power facilities in 2007 were 2,517 million metric tons, or an average of about 1.3 pounds of CO2 per kWh. One kWh will take a small electrically driven car about 5 miles. Over the same distance, an equivalent gasoline-powered car that gets 30 miles per gallon (mpg) would emit 3 pounds of CO2, more than twice as much. An HEV at 50 mpg would release about 2 pounds.[29]

Assuming all EVs used for commuting to UMass drive an average of 12 miles per day, five days per week for eight months a year, the conservative adoption rate in 2020 would result in a decrease of 15 tons of CO2 emissions for UMass. Using the NRC's calculation under the same assumptions at the optimistic adoption rate of .66% (85 vehicles), UMass would reduce its annual emissions by 28 tons of CO2.

Another way to understand the well-to-wheels emissions of EVs is highlighted in a recent report made public by the Union of Concerned Scientists (UCS). As previously mentioned, their study assessed the U.S. power grid in 26 "regions" by the mix of fuels used to generate electricity and then compared the emissions from plugging in an EV to that of a conventional vehicle.

For example, for each unit of electricity produced, the global warming emissions of

[29] National Research Council (U.S.). Committee on Assessment of Resource Needs for Fuel Cell and Hydrogen Technologies. 2010. *Transitions to alternative transportation technologies: Plug-in hybrid electric vehicles*. Washington, D.C.: National Academies Press.

> coal-fired power plants are nearly twice those of natural-gas-fired power plants. Burning oil to produce electricity also is very dirty, but because it accounts for less than 1 percent of total U.S. electricity generation, oil's impact on overall emissions from that sector is limited. Renewable resources such as wind and hydro, on the other hand, emit no global warming gases at all when producing electricity. Thus a region's global warming emissions intensity (global warming emissions per unit of electricity), and therefore the global warming emissions of driving an electric vehicle there, will vary according to the region's mix of power plants.[30]

As federal and state tax incentives and renewable energy and air pollution standards continue, electric vehicles will only contribute less and less to global warming. The UCS found the following (see Appendix B for more information):

- Nearly half (45 percent) of Americans live in "best" regions—where an EV has lower global warming emissions than a 50 mpg gasoline-powered vehicle, topping even the best gasoline hybrids on the market. Charging an EV in the cleanest electricity regions, which include California, New York (excluding Long Island), the Pacific Northwest, and parts of Alaska, yields global warming emissions equivalent to a gasoline-powered vehicle achieving over 70 mpg.
- Some 37 percent of Americans live in "better" regions—where an electric vehicle has the equivalent global warming emissions of a 41 to 50 mpg gasoline vehicle, similar to the best gasoline hybrids available today. For example, charging an EV in Florida and across most of Texas yields global warming emissions equivalent to a 46 to 47 mpg gasoline vehicle; this is the fuel economy level of vehicles such as the Honda Civic Hybrid (44 mpg) and Toyota Prius Hybrid (50 mpg).
- About 18 percent of Americans live in "good" regions—where an electric vehicle has the equivalent global warming emissions of a 31 to 40 mpg gasoline vehicle, making some gasoline hybrid vehicles a better choice with respect to global warming emissions. The Rocky Mountain grid region (covering Colorado and parts of neighboring states) has the highest emissions intensity of any regional grid in the United States, which means an EV will produce global warming emissions equivalent of a gasoline vehicle achieving about 33 mpg. Gasoline- powered cars with fuel economy at this level include the Hyundai Elantra (33 mpg) and the Ford Fiesta (34 mpg).[31]

Many public entities have a multi-modal strategy in their climate action plans and are working to encourage commuters to think alternatively about their travel to and from work. Providing convenient charging options to the public would support this strategy to reduce carbon

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[30] Don Anair and Amine Mahmassani. 2012. *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States.* Cambridge, MA: Union of Concerned Scientists.
[31] Ibid.

emissions. Recognizing where their region's energy generation falls on the spectrum of equivalent global warming emissions, cities, towns and universities can educate their communities about the environmental benefits of EVs while demonstrating institutional support through the deployment of infrastructure.

Parking

At the time of this writing, UMass has 11,000 permitted spaces in surface lots and the campus parking garage, 871 metered parking spaces, and 751 public garage spaces. The revenue from each of those can be seen in the following tables both annually and monthly. By far, the garage is the highest revenue driver, followed by meters and then permits. As UMass pursues the installation of EVSEs and considers how to price their usage, it will be important to recognize that giving up a permitted space for the sake of an EVSE has a lower opportunity cost in the permitted lots than in the publicly available spaces. There will only be a small marginal impact on parking revenue from faculty, staff and students since those spaces bring one-third and one half of the revenue of the other two types This is advantageous, as UMass would more likely want to offer a parking discount for faculty, staff and students driving their electric vehicle to campus while it would charge for use by the general public.

Table 3: Annual Parking Revenue per space, 2010-2012 Actual and 2013 Projected

	2010	2011	2012	2013
Permits & Reserved Garage	$228.45	$224.15	$251.09	$258.63
Meter Revenue	$634.55	$674.50	$660.16	$677.38
Garage Revenue	$866.35	$874.99	$898.80	$898.80

Table 4: Monthly Parking Revenue per space, 2010-2012 Actual and 2013 Projected

	2010	2011	2012	2013
Permits & Reserved Garage	$ 19.04	$ 18.68	$ 20.92	$ 21.55
Meter Revenue	$ 52.88	$ 56.21	$ 55.01	$ 56.45
Garage Revenue	$ 72.20	$ 72.92	$ 74.90	$ 74.90

Ownership Options for EV Charging Stations

There are two predominant options for who owns and operates charging stations on campus. First, UMass could purchase, install and maintain them, with complete financial responsibility and benefit. Second, UMass could contract with one a growing number of third party service providers in the electric vehicle space. Two such companies, 350Green and Car Charging Group Inc. (CCGI), responded to a request for proposal from the author with the approval of UMass Transportation and Parking Services. Their services include identifying the best hardware and location for charging and covering all the installation and maintenance costs at a certain price to the host. The business model is built on is a monthly subscription fee from EV drivers, which they believe will outrun the capital and operational costs of equipping host locations. Their target market is the consumer who will prefer to pay a monthly amount for unlimited access and limited hassle. The more installations the third parties have the more consumers will want to subscribe to their network. Becoming the provider for a state institution like the University of Massachusetts with the opportunity to serve additional campuses adds value to their portfolio. As previously discussed, the particular network UMass associates itself with will make a difference to EV drivers coming to campus.

In House

UMass could purchase charging stations outright and do the installation and maintenance over its lifetime. One dual station from Coulomb Technologies would cost between $7,000 and $9,000 for the hardware and software,[32] installation could cost in the neighborhood of $10,000[33] and operations could cost $1,000[34] on an annual basis.

[32] Email correspondence with Scott Miller, Regional Director, Coulomb Technologies, Inc. April 2, 2012
[33] Based on interviews with municipality representatives
[34] EVSE manufacturers estimate 10% of installation cost

Third Party

350Green is a project developer that designs, builds and operates a scalable, nationwide network of electric vehicle (EV) charging stations. Their primary goal is to install stations where drivers need them most and their profit driver is the revenue from charging, primarily subscription based. 350Green would be the owner and operator of the EVSEs on campus and share 50% of the net revenue from them with UMass. An investment by UMass includes the cost of hardware, software, complete installation from permitting to trenching to hook up, maintenance and reimbursement for electricity. An ideal partnership from 350Green's perspective includes a multi-phase project: Phase 1 would be a pilot installation of a dual Level 2 (240Volt) station; Phase 2 would include additional installations on campus; Phase 3 would involve installations on other UMass campuses. 350Green prepared two partnership options for UMass to consider: Option A – Daily Equipment Fee; and Option B – Upfront Investment.

> *Option A* – Daily Equipment Fee: UMass pays $6.50/day for a period of 3 years for each <u>dual</u> Level 2 Charging station (totaling $7200) and UMass shares 50% of Net Revenue through the charging stations. Based on the rate of $2.00 per Level 2 60-minute charging session the 50% net revenue allocation per session would be approximately $0.30. The cumulative revenue share after 10 years is $12,492 and the projected return rate is 16%.
>
> *Option B* –Upfront Investment: UMass pays $6,500 for the installation of each Dual Level 2 charging station and receives the same 50% revenue share for a projected return rate is 15% after 10 years.

Net Revenue is defined as revenue after electricity, maintenance and networking fees. Typically these fees range from 50-70% of revenue, depending on the market and utility rates. For both options, 350Green presents a conservative 70% cost. 350Green currently has stations located in California, the Chicago metro area and the mid-Atlantic. Entering the New England area would provide them the opportunity to expand their market share.

Car Charging Inc. offers a similar service wherein they own, operate and maintain the charging stations they would install on campus. They too provided two options for UMass, of which one does not charge the consumer for usage, but rather is presumably subsidized by the monthly fee UMass would pay. Further, Car Charging Group Inc. would sub-meter each station and pay for the electricity used.

> *Option A* – Monthly fee, no charge to driver: A five year contract includes CCGI providing, installing, and maintaining a dual Level 2 charging station and paying for all electricity. EV Driver pays zero. UMass pays $100.00 to $300.00 per month (determined by install cost).
>
> *Option 2* –Revenue share, driver pays per minute: A five year contract includes CCGI providing, installing, and maintaining a dual Level 2 charging station. EV Driver pays per minute (one hour minimum). UMass receives 5% maximum gross revenue share.

In further conversation with the sales representative, it was made clear that UMass could charge an hourly fee to the EV driver in Option A and collect 100% of the revenues. CCGI has stations all over the country and their access card also works on the ChargePoint America Netrwork.

Utility Lease

My initial assumption for a third ownership model was that Western Massachusetts Electric Company (WMECO) might have an interest in operating charging stations and selling the electricity directly to consumers. However, during one of my interviews with a Manager at the utility, I learned that neither WMECO, nor their parent Northeast Utilities foresees them "getting into the charging station business." They do not want to take on the risk of ownership and operations, considering how much variance there will be in opportunity charging locations. A recent report by McKinsey suggests that utilities could profit from getting more involved, and may lose out if they don't:

> These companies, for example, could take steps with their regulators to capture emission credit for the abatement that utilities make possible in the transport sector. In

> addition, they could reposition themselves in the minds of their customers not only as electricity companies but also as enablers of an environmentally sustainable economy. Any failure to play an active leadership role exposes utilities to the risk of being disintermediated in the residential or commercial segments by other service providers, such as large IT players that already have strong positions in homes (for instance, Cisco and IBM), or by emerging innovators.[35]

As we can see, third party providers are growing in number, seeking ways to make it easy for private and public entities to satisfy EV drivers with the initial installation of EVSEs, while they intercept responsibility for electricity and plan to reap the long-term rewards. Public institutions will have to decide whether the benefit of a third party's services outweigh the added layer of complication that comes with contracting.

Recommendations

EV Policy

Due to the growth of electric vehicles on the horizon and their potential to contribute valuable CO2 reductions, public institutions like UMass are wise to take part in building the infrastructure that will soon be in high demand. In addition, the investment and CO2 savings falls in line with other projects currently being considered for campus by Sustainability Office (See Appendix C). One project on the docket is the installation of fume hood occupancy sensors for science buildings on campus for a cost of $15,000 and a reduction of 10.6 tons of CO2. Another is installing condenser pumps in the Recreation Center to maximize the efficiency of cooling the chiller. This project is also estimated at $15,000 for an estimated CO2 savings of 15.14 tons of CO2. Based on the various ownership models, bringing an EVSE to campus could cost the University between $6,500 and $20,000 and have the potential CO2 savings of between

[35] Hensley, Russell, Stefan Knupfer, and Dickon Pinner. 2011. Electrifying cars: How three industries will evolve. *McKinsey Quarterly* 3, (February), https://www.mckinseyquarterly.com/Automotive/Strategy_Analysis/Electrifying_cars_How_three_industries_will_evolve_2370.

15 and 28 tons. This alignment makes EVSEs a good candidate to join other initiatives in support of the Climate Action Plan.

As UMass considers its pricing strategy, there is a balance between the University's willingness to pay to support EV adoption, CO2 reductions and the Climate Action Plan with serving a public that is willing to pay for the service of being able to charge their vehicle. Given the range of hourly costs across the county, and a neighboring University at the higher end, UMass could reasonably charge $1-2 per hour to strike that balance. For the faculty, staff and students bringing an EV to campus on a permit basis, UMass can follow the lead of other public institutions by offering a 20-50% discount. Since permits are the smallest proportion of overall parking revenue, a higher discount rate would build a great deal of goodwill and perhaps even incentivize more faculty, staff and students to purchase electric vehicles for their commute.

UMass has an advantage over some other Universities in that many of the critical decision makers (i.e. Department of Transportation, Parking Services, Planners, and Sustainability Manager) are in favor of bringing EVSEs to campus, which will help mitigate some of the challenges around foregoing parking revenue or who pays for installation. The decision between purchasing, installing and maintaining the equipment in house versus bringing in a third-party is more than just a financial one. On its face, it may seem more streamlined and less expensive upfront to contract with an outside provider, but there are inherent risks. Lengthy negotiations, vendor lock in, changing contract terms or shifts in how they might charge EV drivers could all have negative implications. If UMass owns and operates the equipment, there will be more control over usage and pricing, and UMass will have the ability to make adjustments as the technology becomes more established in the marketplace. As the number of

EVs increase, the cost of infrastructure will go down, so the cost to UMass will likely decrease over time while there will be a positive effect on their CO2 savings and reputation.

EVSE Installation

With no constraints on selling electricity to end users, Transportation and Parking Services can freely move forward with including installations in their plans for re-surfacing lots and new construction. Parking Services should carefully consider where to place the first and following stations. From a meeting I attended with this team, UMass is in good position having just rewired the visitor's lot to install electronic parking meters. Future work on other surface lots and parking garages can then be planned to include the conduit needed for EVSEs, thus minimizing the installation cost. Because part of the goal with these stations is highlighting UMass' commitment to sustainability, EV spaces should be visible and premium. Other public entities would likewise benefit from pre-wiring and installing conduit in new construction projects where EVSEs may be deployed. In areas with no off street parking, the use of existing infrastructure will help avoid trenching and other significant construction costs.

Other factors to consider are space requirements and proper signage. Based on the lessons learned in this landscape to date, the leading turnkey solutions provider, Voltrek, recommends that the ideal installation includes:[36]

- Minimum 9-foot parking space
- 40 inches between spaces for cord maneuvering
- 15-inch reach from curb (allow for snow plowing, etc.)
- Solid surface under station
- White or yellow marking color is best for maintenance purposes
- Proper signage –no blue signs which compete with national standard for handicapped

Because the U.S. is still in the early part of this technology's lifecycle and the general public is not fully educated on EVs or how they charge, much less able to identify a charging station in

[36] Voltrek Presentation. Massachusetts Clean Cities Coalition Stakeholder Meeting, 3/8/12.

public, it is critical that UMass not consider the installation complete until proper signage a means for enforcement is in place. Hopefully as this technology becomes more proven, signage, safety and lighting standards will be established for publicly accessible stations.

Conclusion

Moving towards a greater electrified transportation system with EVs has significant potential to reduce CO2 emission and mitigate global warming. As cities and universities across the country are working to fulfill their own climate action plans, they have the opportunity to take part in building a public infrastructure that will push forward a new technology and encourage user adoption of electric vehicles. Encouraging multi-modal usage and educating communities about equivalent global warming emissions of EVs can potentially encourage consumer adoption. Learning from the first movers about what types of incentives drivers find to be valuable can also serve public institutions. Premium parking spaces, free public usage and reduced permit prices for employees indicate a willingness to support environmentally friendly technologies and serve as a win-win for both the institution and the consumer. Because the U.S. is still in the early part of this technology’s lifecycle and the general public is not fully educated on EVs or how they charge, much less able to identify a charging station in public, it is critical that public entities properly sign and enforce the use the EV charging spaces.

An adequate public infrastructure for electric vehicles requires participation from private and public entities. Auto manufacturers have plans to launch a series of new all electric and plug-in hybrid electric vehicles that will increase demand for opportunity charging locations. Ironing out the politics, finances and logistics of bringing EVSEs to a city, town or campus takes time and energy. Public institutions may not receive grant funding or tax breaks and therefore hesitate, but must recognize their ability to contribute by leveraging political will and connecting the investment to existing climate action plans. Together, public entities can be the economies of scale necessary to encourage massive adoption of EVs thus improving our nation's energy independence and security and reducing the greenhouse gases that contribute to global warming.

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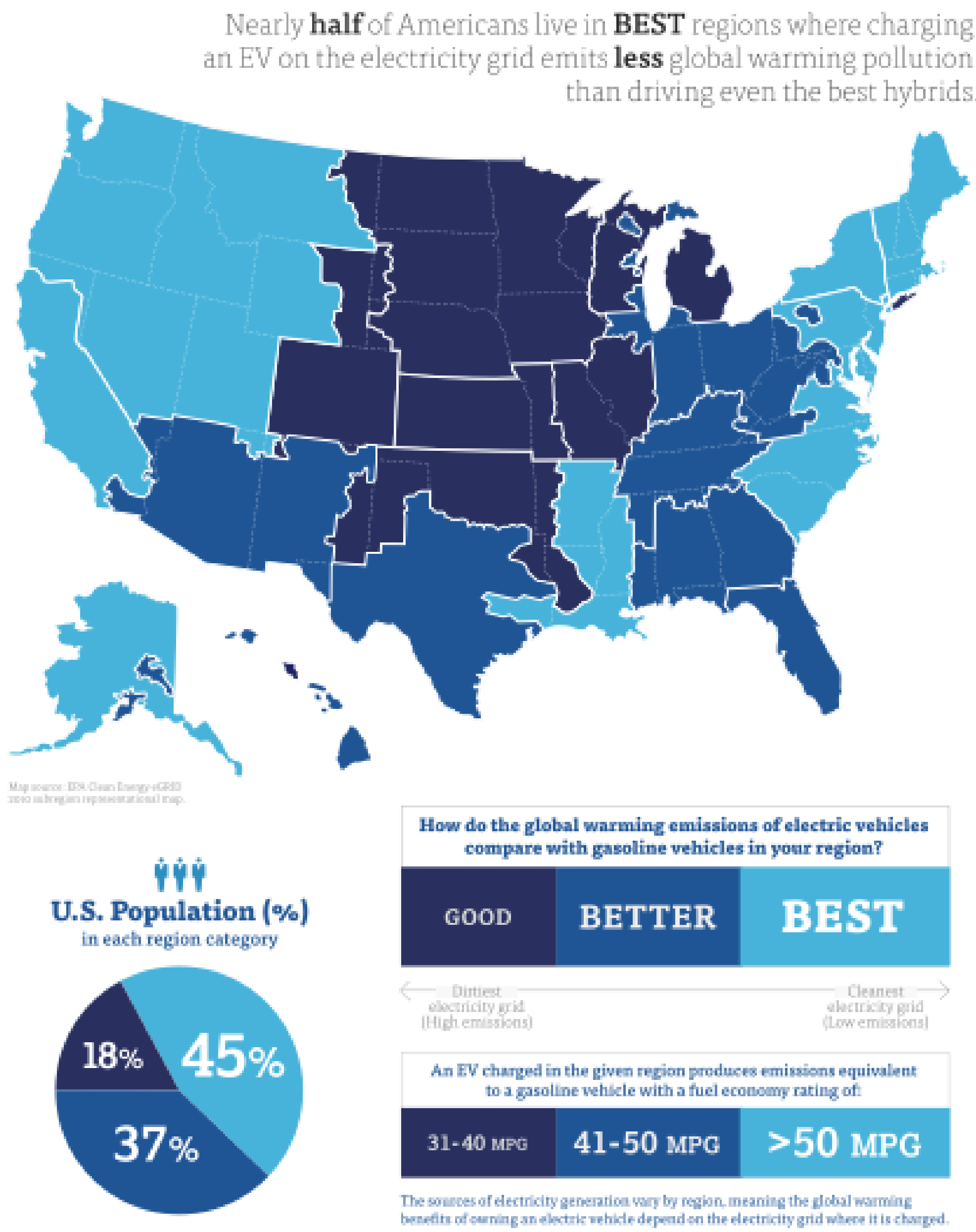
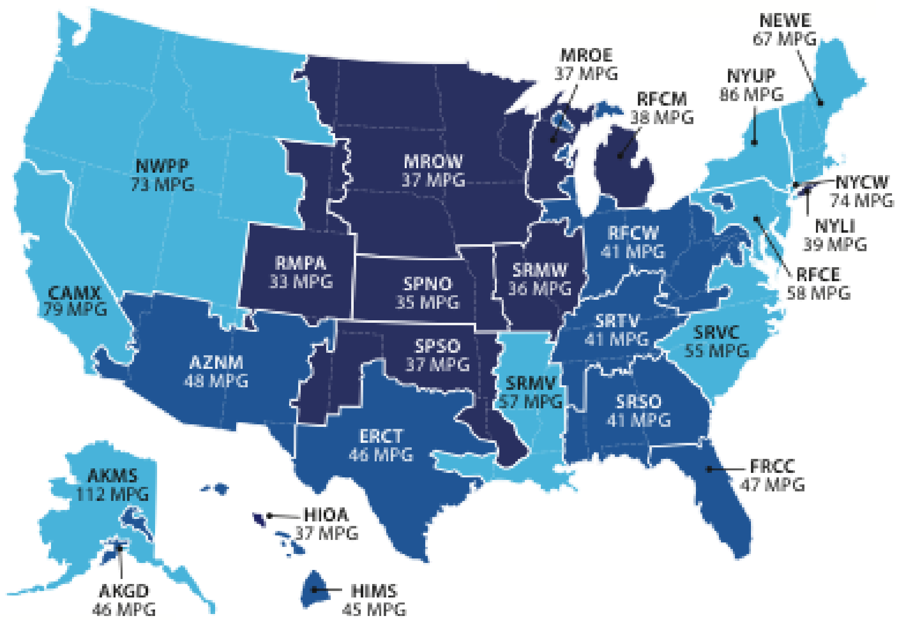
Appendix A: Regional Global Warming Emissions Ratings for EVs

The darkest regions on the map are served by utilities burning a high percentage of coal to generate power; in those regions, charging an electric car sends as much carbon dioxide into the atmosphere as driving a car rated at 31 to 40 m.p.g., about the same as a current compact model. In the lightest areas of the map the electricity is generated by cleaner fuels, so the equivalent miles per gallon is higher than the best of today's hybrids. (Source: *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States*, 2012. Union of Concerned Scientists)



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

The mpg 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 an EV. (Source: *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States*, 2012. Union of Concerned Scientists)



NOTES: Cities shown are a sample of those located in the electricity grid region. The EPA's power profiler tool *(www.epa.gov/cleanenergy/energy-and-you/how-clean.html)* provides a zip code look-up to determine primary utility and grid region. Cities listed here were assigned to grid regions based on the primary utility serving the city. Cities served by multiple utilities, some of which are in different regions, are indicated with an asterisk.

The regional electricity emissions data used in this analysis are based on the most recent version of the EPA's eGRID database (which includes power-plant emissions from 2007) available at the time of publication.

Good	Better	Best
NPCC Long Island (NYLI) - 39 Hempstead	**WECC Southwest (AZNM) - 48** Phoenix, El Paso,* Las Vegas, Albuquerque, Tucson	**ASCC Miscellaneous (AKMS) - 112** Juneau
RFC Michigan (RFCM) - 38 Detroit	**FRCC All (FRCC) - 47** Jacksonville,* Miami	**NPCC Upstate NY (NYUP) - 86** Buffalo
SPP South (SPSO) - 37 Oklahoma City, Tulsa	**ASCC Alaska Grid (AKGD) - 46** Anchorage	**WECC California (CAMX) - 79** Los Angeles, San Diego, San Jose, Oakland, San Francisco, Sacramento, Long Beach, Fresno
HICC Oahu (HIOA) - 37 Honolulu	**ERCOT All (ERCT) - 46** Houston, San Antonio, Dallas, Austin, Fort Worth, Arlington	**NPCC NYC/Westchester (NYCW) - 74** New York City
MRO East (MROE) - 37 Madison	**HICC Miscellaneous (HIMS) - 45** Hilo	**WECC Northwest (NWPP) - 73** Seattle, Portland
MRO West (MROW) - 37 Omaha, Minneapolis	**SERC South (SRSO) - 41** Atlanta	**NPCC New England (NEWE) - 67** Boston
SERC Midwest (SRMW) - 36 St. Louis	**SERC Tennessee Valley (SRTV) - 41** Memphis,* Nashville, Louisville*	**SERC Mississippi Valley (SRMV) - 57** New Orleans
SPP North (SPNO) - 35 Kansas City,* Wichita	**RFC West (RFCW) - 41** Chicago, Indianapolis, Columbus, Milwaukee, Cleveland	**RFC East (RFCE) - 58** Philadelphia, Baltimore, Washington, DC*
WECC Rockies (RMPA) - 33 Mesa,* Denver, Colorado Springs		**SERC Virginia/Carolina (SRVC) - 55** Charlotte, Virginia Beach, Raleigh

Appendix C: UMass FY2011 Energy Efficiency Projects in Process

FY 11 E+ Projects

Project	Description	Est Cost ($)	Est. Annual Savings ($)	Simple Payback (Yrs)	Carbon Equivalent Reduction
1	Gorman Steam Line Replacement - Excavate, remove and replace 185 feet of 8" steam pipe and 2.5" condensate return pipe, backfill all excavated land and restore the landscaping.	295,600.00	66,592.00	4.44	448.36
2	JCI Occupancy Sensors - Install fume hood occupancy sensors in the following buildings:Polymer Research Center, Lederle,Goessmann, Morrill, Ag Engineering North & South, Holdsworth, Gunness, Hasbrouck, Fernald, Chenoweth. These sensors will tell when the room is unoccupied and reduce the exhaust flow through the fume hoods when they are not in use.	15,000.00	2,275.00	6.59	10.60
3	Student Union Ballroom Controls/Monitoring Points - this project involves the installation of five thermostats and control valves in the Student Union. After this equipment has been installed we will be able to control the heat in the facility more evenly as well as throttle back the heat when the building is closed.	24,110.00	21,675.00	1.11	145.94
4	VFD's on large motors in CHP - Variable Frequency Drives (VFD) will be installed on 9 large motors in the Central Heating Plant. Currently these large motors control boiler water or natural gas flow through the use of regulating valves which puts a constant load on the motor and therefore constant eneergy use by the motor. The installation of the vfd's will allow the removal of the regulating valves and flows will be controlled by changing the speed of the motors, thus lowering the energy use.	385,812.00	105,985.00	3.64	493.80
5	Traffic Lights LED conversion - The red, yellow, and green traffic lights on campus are lit with incandescent bulbs. We propose to change these bulbs to LED's which will have a twofule benefit. First, they will save energy compared to the incandescent lights currently used and second they have a significantly longer life.	43,175.00	7,332.00	5.89	40.37
6	Occupancy Sensors in Machmer and Herter - The classrooms in these buildings are heavily used from morning through evening. The lights in these classrooms are turned on in the morning and left on until the buildings are closed in the late evening. The lights stay on whether or not the classroom is in use. We propose to install ocupancy sensors in the classrooms in Herter and Machmer. Whenever the room is empty for more than five minutes the lights will turn off and not come on again until someone enters the room.	106,000.00	28,265.00	3.75	131.70
7	Hasbrouck District Chilled Water Connection - the chiller in Hasbrouck is 20 years old and in need of rebuilding or replacement. The Intgrated Science Building (ISB) project installed a chiller system that was large enough to handle the chilling load in Hasbrouck. In addition pipe connections wer put in in the ISB to cross N. Pleasant street and connect to Hasbrouck.. Using the chiling capacity in the large ISB chiller plant to cool Hasbrouck will be less expensive thatn using a chiller system dedicated to Hasbrouck.	390,000.00	62,234.00	6.27	435.51

8	Recreation Center Condenser Pumps - the condenser water pumps are used to cool the chiller in the Recreation Center. The pump runs at a constant speed and the water flow is controlled through throttling valves. We will install a variable frequency drive on the condenser pumps and remove the throttling valves. The flow will be adjusted by speeding up and slowing down the pump motors which means the motors will only use the energy they need to pump the correct amount of water to cool the chiller.	15,000.00	3,250.00	4.62	15.14
9	Recreation Center Chiller Controls - The current chiller ocntrols do not allow a reset of the chilled water temperature during period of light loads. These controls will reset the chilled water temperature based on the load that is on the building, when loads are light the chilled water temperature will be allowed to drift up thus reducing the amount of time that the chiller will run.	10,000.00	823.00	12.15	3.84
10	Recreation Center Occupancy Sensors for Lighting and HVAC Controls - The current occupancy sensors do not shut off enough lights when the building is closed or lightly used. Also the occupancy sensors are not tied to the HVAC system. The additional occupancy sensors will be tied to the HVAC system abd will also be tied to more lighting circuits which will throttle back the building when it is lightly used.	38,000.00	26,000.00	1.46	121.14
11	Elab II Fume Hood Controls - These sensors will tell when the room is unoccupied and reduce the exhaust flow through the fume hoods when they are not in use.	60,000.00	27,928.00	2.15	144.36
12	DuBois Lighting Controls - The current lighting circuits are tied to the main electrical panel which is only accessed by licensed electricians. This means the lights are left on 24 hours per day 7 days per week even in th elightly loaded upper floors. We propose to install occupancy sensors that will automatically shut off the lights when no occupancy is detected.	457,800.00	89,000.00	5.14	397.03
13	Knowles Air Handler VAV Conversion and Occupancy Controls - This building was designed for high cooling load electronic lab spaces operating 24 hours per day 7 days per week. The building is not as heavily loaded nor is the occupancy as continuous as the design plan. We propose to install temperature controls and occupancy sensors that will throttle back the building when it is unoccupied or lightly loaded.	135,000.00	19,336.00	6.98	88.32
14	GRC AHU1 Re-design -This unit was originally designed to provide cooling to the room that contained a large mainframe computer. With the advent of smaller file servers and computers this air handling unit has significantly more capacity than it needs. We propose to put on smaller motors, repair leaks in the ductwork and install varible frequency drives. When this project is complete the unit will still provide plenty of ventalition.	40,000.00	51,041.00	0.78	237.80