

THE ELECTRIFICATION OF TRANSPORTATION IN OREGON: OPPORTUNITIES
FOR UNIVERSITY, GOVERNMENT, AND INDUSTRY COLLABORATION

by

ELAINE MARIE PHILLIPS

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Student: Elaine Marie Phillips

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This thesis has been accepted and approved in partial fulfillment of the requirements for the Master of Community and Region Planning degree in the Department of Planning, Public Policy and Management by:

Professor Robert Young	Chairperson
Professor Gerardo Sandoval	Member
Director Anthony Hicks	Member

and

Kimberly Andrews Espy	Vice President for Research & Innovation/Dean of the Graduate School
-----------------------	--

Original approval signatures are on file with the University of Oregon Graduate School.

Degree awarded June 2012

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THESIS ABSTRACT

Elaine Marie Phillips

Master of Community and Regional Planning

Department of Planning, Public Policy and Management

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Title: The Electrification of Transportation in Oregon: Opportunities for University, Government, and Industry Collaboration

To promote economic recovery and create jobs, Oregon has developed a collaborative approach to economic development and turned its attention to stimulating the growth of competitive industry (Porterian) clusters. The electric vehicle (EV) cluster is one of the state's 21 priorities. With federal funding for electric vehicle infrastructure and *The Electrification of Transportation* initiatives, momentum is building. The Oregon University System, a number of state agencies and a coalescing group of EV entrepreneurs are pushing Oregon forward as a major player in the global marketplace. This thesis reviews an Oregon Transportation Research and Education Consortium study to determine whether the institutions of the Oregon University System and the state government are meeting the needs of EV entrepreneurs in this effort. The review concludes that Oregon's institutions need to further develop their collaborative networks with entrepreneurs for Oregon to be a competitor.

CURRICULUM VITAE

NAME OF AUTHOR: Elaine Marie Phillips

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene

DEGREES AWARDED:

Master of Community and Regional Planning, Planning, Public Policy and Management, 2012, University of Oregon
Master of Science, Conflict and Dispute Resolution, 2012, University of Oregon
Bachelor of Arts, Planning, Public Policy and Management, 1998,
University of Oregon

AREAS OF SPECIAL INTEREST:

Economic and Community Development
Collaborative, Community-based Planning
Environmental Justice

PROFESSIONAL EXPERIENCE:

Development Director, Womenspace Domestic Violence Services, 2005-2008
Community Organizer, Stand for Children, 2003-2004
Program Manager, Lane MicroBusiness, 1998-2005

GRANTS, AWARDS, AND HONORS:

Collaborative Governance Award, Negotiated Rule-making with the Oregon Department of Fish and Wildlife and Citizen Task Force, National Policy Consensus Center, 2011
Savage Award for International Study, Northern Ireland Economic Development, University of Oregon, 2010

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For you, Mom. I hope I made you proud. 😊

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CHAPTER I

INTRODUCTION

With support from the Oregon Transportation Research and Education Consortium (OTREC), I conducted this study to determine the readiness of the consortium of the Oregon University System (OUS), the state government, and the business community to advance the growth of the electric vehicle (EV) industry in Oregon. While I make some recommendations on ways to improve the collaboration, my research is more focused on the stakeholders, their current activities and resources, their potential and their efforts at collaboration. I am also comparing similar collaborations among industry clusters in the Silicon Valley and along Route 128 so that the successful practices of these regions may be applied in Oregon.

There are two stakeholders among the public/private EV cluster participants that have unique functions, OTREC and the EV membership/trade association Drive Oregon. OTREC is promoting research and development relationships between the universities and the EV industry and has been funded by the federal government. OTREC is housed at Portland State University. Drive Oregon is acting as a policy and investment advocate. These entities have the ability to create linkages between public institutions and private industry. Perhaps more importantly, they also have the tools to build relationships among competing and complementary businesses as well. As this thesis unfolds and an understanding of “cluster” development is made clear, the importance of these collaborative roles will become clear.

A. Road Map

In the introduction, I will lay a foundation for investing in electric vehicle development in Oregon. I will begin with a look at the economy and the strength of Oregon industries to back such development. I will then show how the state is emerging as a leader in the green economy and explain the political underpinnings across the spectrum of national and local support. OTREC and Drive Oregon are bridging government and industry, and I will briefly explain their roles.

Chapter II will provide an overview of the literature about competitive industry clusters and I will discuss this type of collaboration as an economic development strategy. I will show how this applies to Oregon, provide some background on the identification of electric vehicles as a priority industry for the state, and provide guidelines for enhancing networking systems.

Chapter III will go over the methodology of the survey I conducted of EV entrepreneurs, as well as the mapping that was done of pertinent Oregon university resources.

Chapter IV contains an inventory of EV Activity in Oregon and summarizes state initiatives that focus on EVs.

Chapter V provides an overview of Oregon University System resources and lists programs at participating universities that are engaged in EV-related work.

Chapter VI presents the results of the *Needs Assessment Survey* and an analysis of the responses accompanying the results.

Chapter VII completes my thesis with a number of conclusions and recommendations.

This report also includes a bibliography and four appendices:

Appendix A presents the survey instrument;

Appendix B presents a transcript of written survey comments;

Appendix C presents more detailed information on university programs, and

Appendix D is a brief listing of EV programs outside of Oregon.

B. Brief Economic History

The State of Oregon has developed an interest in the electrification of transportation as an economic focus of sustainable development that serves both economy and the environment. Oregon has many advantages as it enters the electric vehicle arena and, depending on how the stakeholders collaborate and strategize, it could become a global leader in the industry.

Oregon has been hard hit by the recessions of the last thirty years. Oregon was especially impacted by the recession of the 1980's when timber lost its role as the main economic force in the state. In the ten years prior to that decline, the state's population had increased by 26% so when the down turn came and unemployment reached a peak of 12% in 1982, the impact was severe. The state lost a total of 131,000 jobs, or one in eight from 1979-1982. While Oregon's economy did recover, the timber industry never

fully bounced back.¹ The next recession in the 1990's was relatively mild for Oregon. The state lost 1.5% of its jobs, faring better than the nation as a whole (1.7%) and much better than California. People came from all over and especially from just south causing Oregon's population to increase another 20% during the 1990's.²

Currently, we are still in the grip of the two recessions that occurred in this decade. According to the U.S. Census, Oregon ranked 17th in the number of persons living below poverty among the 50 states in 2008,³ and at 8.6%, only ten other states had higher unemployment rates in March of this year.⁴ Oregon needs jobs, and it needs to develop and expand the industrial sectors of its economy where it is likely to have unique advantages and the opportunity to create exports. Figure 1.1 demonstrates Oregon's unemployment rates over a six-year period by region.

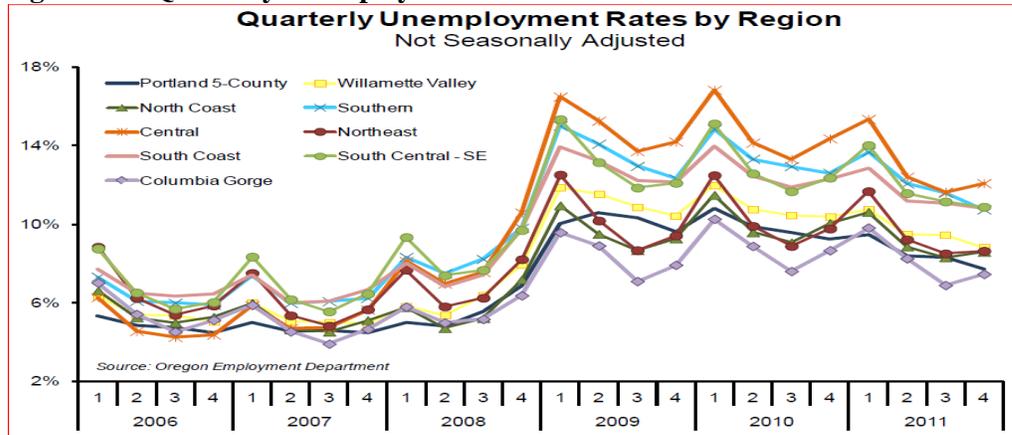
¹ Kaylor, C. "Oregon's Recessions: A History". *Worksource Quality Info.org, Oregon Employment Department, Oregon Labor Market Information System*. (2009) Web. 22 April 2012. <<http://www.qualityinfo.org/olmisj/ArticleReader?itemid=00006417>>

² Ibid.

³"Persons Below Poverty Level 2008. State Rankings—Statistical Abstract of the United States 2008." *United States Census Bureau*. Web. 22 April 2012. <<http://www.census.gov/compendia/statab/2011/ranks/rank34.html>>

⁴ "Unemployment Rates for States. Bureau of Labor Statistics." *U.S. Department of Labor*. March 2012. Web. 22 April 2012. <<http://www.bls.gov/web/laus/laumstrk.htm>>

Figure 1.1. Quarterly Unemployment Rates



Source: Oregon Employment Department as cited by OEA/DAS in the Oregon Economic Review and Forecast: March 2012, p. 41

C. Economic Indicators that Show the Electric Vehicle Industry Is Viable for Oregon

Despite general economic woes and high unemployment rates, Oregon shows potential in the electric vehicle arena because of the strength of related primary and secondary industries and its leading position in the growth of the green economy.

1.) Oregon's Status in Pertinent Sectors

In March of this year, the Office of Economic Analysis published its economic forecast for the coming year and identified manufacturing, transportation, utilities, and electronics as sectors with projected growth, all of which are primary and secondary contributors to the expansion of the electric vehicle industry. The OEA went on to say, "The metals and machinery sector experienced a very good year in 2011 ... and

employment held steady through the end of the year. The industry employment increased 5.3 percent in 2011, marking the strongest gain the industry has seen since 1996. Job gains are projected at 1.2 percent in 2012, 2.4 percent in 2013, and 2.2 percent in 2014...The computer and electronic product sector slowed somewhat in second half of 2011 following a blistering pace from the fall of 2010 to the summer of 2011 – however job growth did remain positive. The semiconductor equipment book-to-bill ratio is back up to 0.88 in December after falling all the way down to 0.71 in September. Overall, industry sales are projected to stay at relatively high levels through 2012. Hiring in this sector will likely be dominated over time by the Intel expansions.”⁵

It is significant to note here that Intel, which is expected to continue expanding, has shown a particular interest in the electrification of transportation in the last few years. In 2009, John Skinner, the director of marketing for its Eco-Technology division, told *Reuters* that Intel was exploring the opportunities for expansion in the areas of power generation and electric vehicle telematics.⁶ Last year, Annabelle Pratt, Senior Power Research Engineer talked further about Intel’s involvement:

“We are more focused on the conversion processes and the control within the car. The cars are becoming richer and richer computing environments. We have very complex dashboards and we have our music and our navigation systems and we’re syncing with our phones. Intel is involved in bringing more intelligence into the car, and that imbedded intelligence can now be put to use... There are new computing challenges that ... our technology can address. ...The electric vehicle

⁵ Oregon Economic Review and Forecast: March 2012. (2/2012) *Office of Economic Analysis, Department of Administrative Services*. February 2012: Vol. 32, No. 1, p. 46. Print.

⁶ Young, Tom. Intel Eyes Up Wind and Electric Vehicle Markets. *businessGreen Sustainable thinking*. (2009, November) Web. 22 April 2012. <<http://www.businessgreen.com/bg/news/1806259/intel-eyes-wind-electric-vehicle-markets>>.

connects to a home, [and] it might connect to a commercial building when you go to work... [Intel is interested in this] but not the battery technology itself.”⁷
2.) *Oregon’s Success in the Green Economy and the Potential for Jobs*

Last summer the American Institute for Economic Research (<http://www.aier.org/>) designated Oregon as the ideal place to conduct business “when measured by production costs per dollar of output rather than just by costs, such as labor, tax and energy expenses.”⁸ It also has the second highest number of clean economy jobs in the nation according to a report by the Brookings Institution, *Sizing the Clean Economy*, which described the Portland Metro Area as a “multi-dimensional” clean economy. These jobs typically offer higher wages than general economy jobs and provide more opportunities within the traded sector.⁹ Traded sector companies sell goods and services outside the local area, bringing in fresh dollars from other states and around the world.

In the analysis of specific metropolitan areas, Portland statistics revealed that between the years of 2003-2010, jobs in the green economy increased by 4.1% and added 6,697 positions. The average wage was \$42,548 which is nearly 3% higher than the average wages of the general economy. The exports in this sector produced \$13,952 worth of exports on average per job.¹⁰

⁷ Pratt, Annabelle. Interview segment from the *Discovery Channel Online*. (2011) Web. 6 May 2012. <<http://curiosity.discovery.com/question/developing-electric-vehicles>>.

⁸ “Oregon Ranks Number One Nationally for Manufacturing Location.” *Business Oregon*. August 2011. Web. <<http://www.oregon4biz.com/Business-Oregon-News/August-2011/>>.

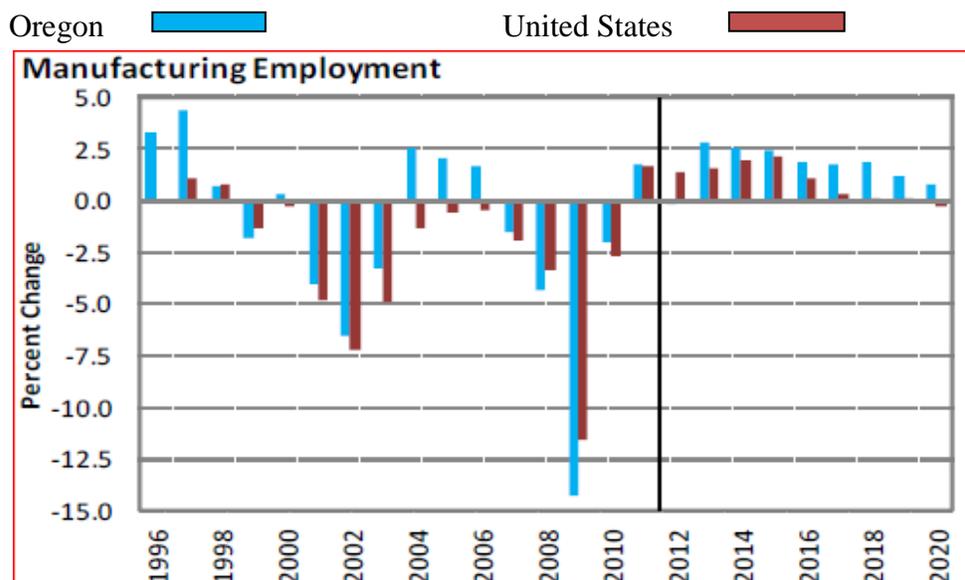
⁹ Williams, C. Western States have the Most Clean Economy Jobs. *Sustainable Business Oregon*. July 2011. Web. 6 May 2012. <<http://sustainablebusinessoregon.com/articles/2011/07/western-states-have-the-most-clean.html>>.

¹⁰ *Sizing the Clean Economy: The Clean Economy in the Portland, OR-WA Metropolitan Area*. *The Brookings Institute* 2011. Web. 6 May 2012. <http://www.brookings.edu/about/programs/metro/clean-economy/~/_media/Series/Clean%20Economy/38900.PDF>.

Americans have decried the loss of manufacturing jobs for decades now, and the fact that the green/clean economy is heavily reliant on manufacturing promises a welcome resurgence of these kinds of jobs. The Brookings Institute “analysis suggests that the clean economy is producing jobs relevant to the nation’s need to renew its economic base. Clean economy jobs are inordinately oriented toward manufacturing and exporting. Likewise, the segments of the clean economy encompass a balanced array of jobs and occupations, with substantially more opportunities and better pay for lower-skilled workers along with other positions in higher-end “innovation” fields. Having more clean economy jobs as the sector’s younger, more innovative segments advance in technology, deployment, and market penetration would be good for the nation.”¹¹

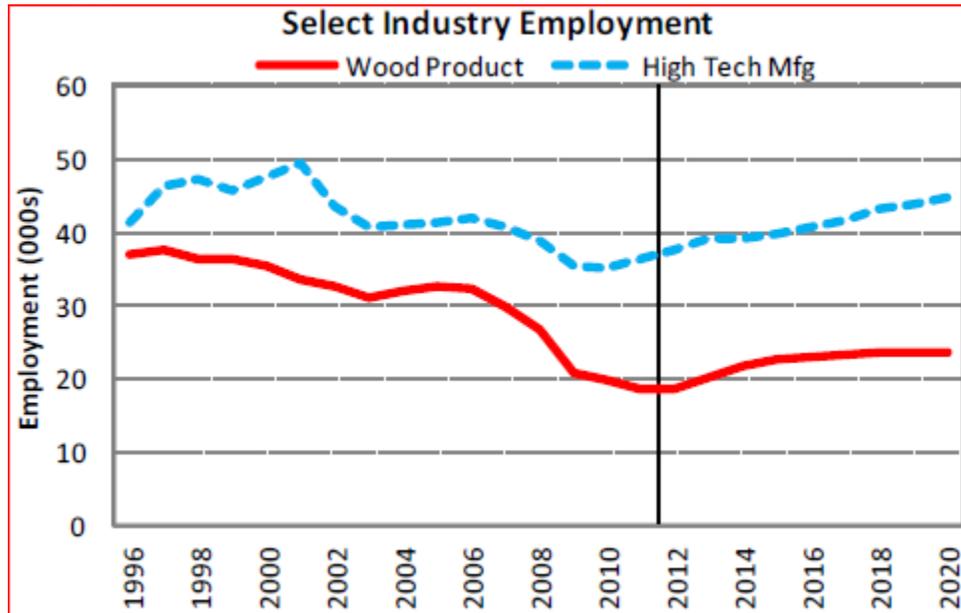
Figures 1.2 and 1.3 show the rates and types of manufacturing employment in the United States from 1996, and projected through 2020.

Figure 1.2. Levels of Manufacturing Employment 1996-2020



¹¹ Muro, M., Rothwell, J. , Saha, D., and Battelle Technology Partnership Practice. “Sizing the Clean Economy: A National and Regional Green Jobs Assessment.” *The Brookings Institution Metropolitan Policy Program*. Washington, D.C. 2011: 47. Print.

Figure 1.3. Trends of Manufacturing Employment for Wood Products and High Tech 1996-2020



Source: Oregon Employment Department as cited by OEA/DAS in the Oregon Economic Review and Forecast: March 2012, p. 51

High tech manufacturing is projected to continue increasing through 2020 and will support the business environment the electric vehicle industry will need to thrive.

D. Building Momentum Among State Stakeholders

Oregon has laid the road for success by developing expertise in green technology and electronics; a “silicon forest” has grown here from the many spin-offs originated by Tektronics and Intel. The state is recognized worldwide for its “green culture,” sometimes facetiously as in the hit series *Portlandia*, but also with respect for the state’s pioneering accomplishments. Since the mid 1970’s, when Governor Tom McCall advocated for open public beaches and universal land-use planning, and promoted the novel idea of bottle deposits, Oregon has developed a reputation for environmental

stewardship. The expansion of clean tech and the green economy is a natural outgrowth of this history and last year the Business Courier of Cincinnati, a publication of American City Business Journals, ranked the Portland-Vancouver-Beaverton metro area first among 43 U.S. metro areas in a report on America's "green cities."¹²

In addition to the statewide growth of the green economy and Portland's highly recognizable reputation for enthusiastically embracing sustainability, momentum is building in Oregon for electric vehicles. In 2009 Oregon was selected to be one of seven participating markets for EV development under a federal grant to eTec, a subsidiary of ECOtality, and its partner Nissan. A \$99.8 million grant from the Department of Energy supported the development of charging infrastructure throughout the state, and Nissan made its electric vehicle, the Leaf, available at Oregon car dealerships.¹³

At the state level, Oregon has identified Electric Vehicles (EVs) as one of the top industry clusters to focus on for future job creation. Oregon InC, a group commissioned by Business Oregon (the state economic development department) allocated lottery funds to Drive Oregon for the 2011-2013 biennium. (Drive Oregon is the public-private membership organization that provides advocacy and resource development for electric vehicle entrepreneurs.) Oregon InC is also working to connect Oregon's universities and research labs with industry partners to commercialize newly developed technologies.

¹² "Portland Ranked Greenest U.S. City." *Sustainable Business Oregon*. 8 May 2011. Web. <http://www.sustainablebusinessoregon.com/articles/2010/03/portland_ranked_greenest_us_city.html>

¹³ Miller, Tim, President of Drive Oregon. Audio Presentation to Oregon Chapter of the Society of Automotive Engineers (Oregon SAE). 27 February 2011. Web. 30 March 2012. <<http://driveoregon.org/news/10-minute-introduction-to-drive-oregon/>>.

The Oregon Department of Transportation has been involved in planning for the arrival of EVs and is supporting a number of projects around the state focused on electric vehicles and EV infrastructure, including the following:

- The EV Project run by ECOtality aimed at supporting widespread adoption of the technology.
- EV fast charge stations in Southern Oregon, part of the West Coast Green Highway infrastructure building efforts.
- Tiger II Grant for EV infrastructure, funding EV fast charging stations in northwest Oregon along key corridors such as Oregon’s coast and interior.¹⁴

In addition, Oregon has begun work on smart grid technology and energy transmission infrastructure to support the anticipated changes in consumer, municipal (transit and fleets) and industrial behavior.¹⁵

As the major metropolitan market place in the state, the City of Portland has significant influence on economic development for the state as a whole. In 2009, Portland created a climate action plan and committed itself to altering its transportation infrastructure to decrease greenhouse gas emissions. A high emphasis has been put on the electrification of transportation. In 2010, the Portland City Council affirmed:

“The City embraces new approaches and innovations in transportation electrification because these technologies have the potential to significantly reduce transportation related carbon emissions in Portland. The thoughtful use and promotion of EVs is one

¹⁴ *Office of Innovative Partnerships and Alternative Funding*. Oregon Department of Transportation. Web. 3 March 2012.<http://www.oregon.gov/ODOT/HWY/OIPP/inn_ev-charging.shtml>.

¹⁵ *Expanding EV's in Oregon*, Portland General Electric.. Web. 19 May 2012. <http://www.portlandgeneral.com/community_environment/initiatives/electric_vehicles/evs_in_oregon/expanding_evs_oregon.aspx>.

of several key strategies that will help the City achieve its climate action targets while also achieving our complementary goals of reducing local air pollution and vehicle miles traveled, and increasing the share of trips done by walking, biking, and transit.”¹⁶

The Oregon University System is also involved with growing the electric vehicle industry. In 2005, Congress created the University Transportation Centers (UTC) to encourage students to become involved in transportation research. In October 2010, the Oregon Transportation Research and Education Consortium (OTREC) began as a UTC housed at Portland State University. OTREC initiated the multidisciplinary, multi-campus Transportation Electrification Initiative for the Oregon University System. This initiative was started with federal funds and the President’s support of electrifying transportation. OTREC takes a ‘living laboratory’ approach using local settings and organizations to test a range of projects. Most of these projects focus on “urban freight mobility, consumer behavior, transport telematics, and transportation electrification and the impact on and integration with the electric grid...”¹⁷ According to John MacArthur, Principal Investigator at PSU:

“The intent is a truly collaborative and cross-disciplinary approach with various parties and partnerships to deliver education, training, and research and information exchange accelerating the adoption of electric vehicles and the development of a smart mobility system within a smart grid. The Initiative will provide policy and technical guidance to the state and nation, and help solve research questions for transportation electrification.”¹⁸

¹⁶ Electric Vehicles: The Portland Way. Report adopted by the City Council. (August 2010). City of Portland. August 2010. Web. 30 March 2012. <<http://www.portlandonline.com/shared/cfm/image.cfm?id=309915>>.

¹⁷ MacArthur, J. *2011-419: Transportation Electrification Initiative*. Portland State University in association with Oregon Institute of Technology and the University of Oregon. 2010. Web. 17 January 2012. <<http://otrec.us/project/419>>.

¹⁸ Ibid.

Along with state and university focus, Oregon's expanding consortium on the growth of the electric vehicle industry includes a number of growing and successful businesses (as well as the established corporations such as Intel that have an interest in developing new opportunities with EVs). Some examples include:

- Brammo is a leading electric vehicle company that produces motorcycles and is based in Ashland, Oregon. (<http://www.brammo.com/company/>) The company collaborates with investors and partners all over the world, but designs, manufactures and tests its first models in Ashland. Brammo employs more than 30 people and is expanding.¹⁹
- United Streetcar (a subsidiary of Oregon Iron Works) is the only manufacturer of modern streetcars (electric) in the United States and they are based in Portland, Oregon. (<http://unitedstreetcar.com/>) The company employs more than 400 workers and has sales of over \$100 million per year. This month (May 2012) they received a major contract from Washington D.C. to build two new public transit cars for the District of Columbia's new streetcar line slated to open in 2013. The cars will be added to a list of contracts totaling 15 cars. The streetcars are being built for lines in Portland and Tucson in addition to Washington, D.C.²⁰

¹⁹ "Brammo to Build Electric Motorcycles in Hungary." *Budapest Journal*. 2011. Web. 17 January 2012. <http://www.bbj.hu/business/brammo-to-build-electric-motorcycles-in-hungary_58632>.

²⁰ Williams, C. Oregon Iron Works to Make Street Cars for D.C. *Sustainable Business Oregon*. 1 May 2012. Web. <<http://www.sustainablebusinessoregon.com/articles/2012/05/oregon-iron-works-to-make-street-cars.html>>

Drive Oregon, the public-private membership organization that promotes the EV industry, points out that along with innovative vehicle manufacturing companies, the industry is producing tremendous opportunity within the supply chain. With its strength in software and electronics manufacturing, along with the state’s support for green technologies, the supply chain for EV’s is where Oregon is likely to prosper.²¹ Drive Oregon shows 45 members on its website (May 2012) and they include supply chain manufacturers, alternative vehicle manufacturers, consultants, and companies profiting from the EV industry.²²

Oregon has clearly developed an environment and an infrastructure conducive to becoming a global player in the electric vehicle market. With its unique mixture of green consciousness, a major metropolitan market, advanced technology industries, public policy leadership, and research institutions, this state has the chance to be a major competitor in the electrification of transportation. To transform this potential into success, the stakeholders will need to invest in the consortium of the state, the Oregon University System, and business interests in a deliberate way that clearly defines roles, identifies strategies, and takes coordinated action over a long period of time. The following table (Table 1.1) provides a list of the stakeholders who are currently working with Oregon’s electric vehicle industry.

Table 1.1. Electric Vehicle Industry Stakeholders

Organization	Description	Contribution	Affiliation	Related
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²¹ Oregon’s Electric Vehicle Cluster Rethinks its Image. *Drive Oregon*. April 2012. Web. <<http://driveoregon.org/news/oregons-electric-vehicle-cluster-rethinks-its-image/>>.

²² Membership. *Drive Oregon*. Web. 14 May 2012. <<http://driveoregon.org/membership/>>.

				Associations
The Oregon Transportation Research and Education Consortium (OTREC)	Federally funded transportation research program housed at Portland State University	Transportation Electrification Initiative— research on EV’s and how they can be integrated	Working with the Oregon University System	The Federal University Transportation Centers
The Oregon University System (OUS)		Research labs, faculty and students		Oregon Institute of Technology, Oregon State University, Portland State University, University of Oregon
Oregon Built Environment and Sustainable Technologies Center (Oregon BEST)	An independent non-profit research lab established by the Oregon Legislature	Connects businesses and investors with our university-based network of shared-user lab facilities and faculty expertise	Works with OUS for tech transfer and commercialization	Oregon Institute of Technology, Oregon State University, Portland State University, University of Oregon
Oregon Nanoscience and Microtechnologies Institute (ONAMI)	An independent non-profit research lab established by the Oregon Legislature	Connects businesses and investors with our university-based network of shared-user lab facilities and faculty expertise	Works with OUS for tech transfer and commercialization	Oregon Institute of Technology, Oregon State University, Portland State University, University of Oregon
Organization	Description	Contribution	Affiliation	Related Associations
The Governor’s Office		Executive guidance on economic development	Works with Business Oregon and various state task forces and committees to create policies for EV growth	

Alternative Fuels Vehicle Infrastructure Working Group (AFVIWG)	Established in 2009 by executive order	Provided recommendations to the Governor on several key issues surrounding the burgeoning alternative fuel vehicle industry.	Reported to the Governor's Office	Comprised of business, utilities, education and government
Transportation Electrification Executive Council	Established in 2010 by Governor's executive order following recommendation from AF	Created a strategic framework that includes a mission, strategies, metrics and 2011 goals	Appointed group reports to the Governor's Office	Members from industry, utility companies, universities, ODOT, Oregon Department of Energy and Business Oregon
Business Oregon	The state's economic development department.	Works to create, retain, expand and attract businesses that provide sustainable, living-wage jobs for Oregonians.		
Oregon Department of Transportation (ODOT)	The state's transportation management and planning office.			
Organization	Description	Contribution	Affiliation	Related Associations
Office of Innovative Partnership Programs (OIPP)	A program of ODOT concerned with electric vehicles.	Works to collaborate with the private sector on infrastructure supports for electric vehicle adoption		
Innovation in Oregon (Oregon	Created in 2005 by the	Advisory council on economic		50 members from industry,

InC)	Legislature and the Governor	development; provides grant funding to economic development initiatives.		education and government
Oregon Business Council	An association of top business leaders	Writes the “Oregon Business Plan.” Advises state government and Oregon’s federal representatives on economic and social issues impacting Oregonians	Standing committees study issues	Works with a variety of business associations and nonprofits concerned with Oregon
Drive Oregon	Nonprofit membership organization purposed to provide resource referral, advocacy, opportunity and networking opportunities to the electric vehicle community	Initiative to establish Oregon as a world leader in the design, manufacture, and integration of ultra-efficient vehicles and related infrastructure and technologies	Received funding from Oregon InC. for the 2011-2013 bienium.	

E. Establishing a Managed Collaborative Process

It is crucial at this juncture, to establish a managed collaborative process to facilitate coordination, planning, agreement building, decision-making, and problem-solving. Drive Oregon, as an industry association, is in an ideal position to take this on with the help of OTREC. In the chapter that follows I explain the phenomenon of “industrial clusters” and I will explore two regions where industry clusters rose to prominence due in large part to their

success at collaboration. Both of them provide models that Oregon can gain from. While these regional network relationships arose organically, and caution is warranted in constructing a non-industry lead collaboration process, it seems logical to assume that a deliberate effort to design and sustain a system for collaboration will help the EV cluster obtain the benefits of previous clusters. These benefits include:

- collectively addressing impediments to success such as government policies and infrastructure;
- creating economies of scale for small businesses and start-ups;
- shared costs of research and marketing;
- information and experience exchange;
- inspiration from competition;
- attracting regional investment and securing government assistance.²³

OTREC initiated this research project, specifically because of the desire to develop cross disciplinary partnerships, and has supported the development and funding of the Drive Oregon initiative. As a membership organization that currently advocates, holds meetings, organizes events and promotes opportunities, Drive Oregon is the rational choice to take on the job of convening the multiple stakeholders of the EV cluster, and is in fact beginning to do so. While the exact method for doing this is beyond the scope of my research, guiding principles can be found in the literature describing natural resource collaborations. The following general points form the basis on which to design a process:

²³ Schaper, Michael, ed. *Making Ecopreneurs: Developing Sustainable Entrepreneurship*. 2nd ed. Surrey, England. Gower Publishing, Ltd. , 2010. Print.

- Identify a convener
- Establish rapport with firms in the cluster
 - Build on common ground
 - Identify their needs
- Design a process that works for the business community
 - Easy, often, on-going
 - Inclusive and representative
 - Real, substantive involvement (let the parties do the driving)
 - Consensus decision-making
 - Facilitated, well-managed
 - Enduring
- Focus on problem-solving
 - Big picture, flexible, holistic
- Foster ownership, flexibility and commitment
 - Partnerships are made up of people, not institutions
- Proactive and Entrepreneurial
 - Take advantage of opportunities (government and university programs)
 - Mobilize support²⁴

²⁴ Wondolleck, Julia and Steven Yaffee. *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Washington, D.C., Island Press, 2000. Print.

CHAPTER II

LITERATURE REVIEW

To develop a background for analysis, I examined the literature for examples of collaborative economic development, as well as history on the electrification of transportation in Oregon. Noting that Oregon has invested in a cluster approach to economic development, I began by reviewing sources that explained this strategy. The Council on Competiveness, a nonprofit think tank that launched the “Clusters of Innovation” project in 1999 with economist Michael Porter, believes that the success of regional economic development depends on a region’s ability to “link innovation assets – people, institutions, capital and infrastructure (to)... generat[e] robust, localized ecosystems that turbo-charge a region’s economy.”²⁵ Assuming that’s true, what would it take for Oregon to think, plan, and act collaboratively to develop an electric vehicle cluster? This chapter will offer a sampling of information and analysis from a variety of books, articles, reports, blogs, internet e-zines, and presentations to answer that question. It will also identify roles among the participating institutions and business interests that are necessary for stimulating the EV industry cluster in Oregon. Ultimately, this chapter will supply a basis for determining the readiness of the Oregon University System, the state government, and the business community to collaborate effectively to reach this goal.

²⁵ Leiken, S., et. al. (2010) National Prosperity/Regional Leadership: Economic Development Administration, 21st Century Regional Leadership Initiative. *The Council on Economic Competitiveness*. Washington, D.C. Contract # 99-07-13856, p.1 Print.

A. Regional Competitiveness Via Industry Clusters

As mentioned in the introduction, there are a number of nonprofit councils and business associations that have come together in advisory and advocacy capacities to influence the direction of Oregon's economic development policies. These institutions have focused on enhancing emerging industry clusters through collaboration, strategic planning, policy-making, and economic incentives.

1.) Oregon's Economic Development Councils

The Oregon Business Council (OBC) was formed in 1985 as a stakeholder group of more than 40 business executives from around the state to generate The Oregon Business Plan. The OBC was established through "a bipartisan leadership committee comprised of Oregon's two US Senators, the Governor, and the Speaker of the House, the Senate President, and the Oregon Senate and House minority party leaders."²⁶ Since 2002, the OBC has published annual updates to the Oregon Business Plan, providing research and recommendations on economic development, education, the environment, transportation, and fiscal reform among other broad interests impacting Oregonians. This plan has been referred to by Business Oregon, the executive level economic development department, as it organizes strategies to support economic growth and create sustainable, living wage jobs. In 2010, the Oregon Business Plan reflected the Council's thinking

²⁶ OregonBusinessPlan.org *Oregon Business Council*. 2011. Web. 12 May 2012.
<<http://www.oregonbusinessplan.org/About-the-Plan/Who-is-Involved.aspx>>

about industry in terms of “clusters” and identified twenty-one priority industry clusters, electric vehicles among them.²⁷ The Oregon Business Plan recommended these actions for the electric vehicle industry in the matrix of “Cluster Specific Priorities” as shown in Table 2.1:

Table 2.1. Recommended Actions for Electric Vehicle Industry Advancement

Clean Technology	
	Cluster-Specific, Actionable Initiatives
Electric Vehicles and Sustainable Transportation (Drive Oregon)	<ul style="list-style-type: none"> • Support the Oregon Innovation Plan – particularly the recent inclusion of Drive Oregon in the 2011 – 2013 Innovation Plan. • Maintain the BETC (Business Energy Tax Credit) for energy efficiency (conservation) investments and Renewable Energy Resource Equipment Manufacturing, enterprise zones, and other targeted programs for clean energy/energy efficiency-related manufacturing and development. • Integrate Electric Vehicles with smart grid and energy storage technologies through green buildings and EcoDistricts.

<http://www.oregonbusinessplan.org/LinkClick.aspx?fileticket=1qaAC2VfH7o%3d&tabid=58>
pg. 2

Oregon InC, also known as the Oregon Innovation Council was formed by the Governor and the legislature in 2005 to move a number of strategic initiatives forward. The Council is made up of more than 50 leaders from the Oregon University System and industry. Initially the Council endeavored to link Oregon university research with economic opportunities and built three signature shared research labs “open to all

²⁷ “Cluster-specific Priorities.” *OregonBusinessPlan.org*. Oregon Business Council. 2010. Web. 13 May 2012. <<http://www.oregonbusinessplan.org/>>

researchers from every Oregon university, and requiring collaboration between multiple campuses and faculties as a condition of funding.”²⁸ They are:

Oregon Nanoscience and Microtechnologies Institute (ONAMI) ...<http://www.onami.us/>
OR Translational Research & Drug Development Inst. (OTRADI) <http://www.otradi.org/>
OR Built Environment and Sustainable Technologies (BEST)..<http://www.oregonbest.org>

Each biennium, Oregon InC. holds a competition to fund programs, projects, and initiatives that will create jobs and stimulate an innovation-based economy within the prioritized clusters. In 2011, the Council approved funding for a new initiative through Drive Oregon, the electric vehicle association. Electric Vehicles have been designated as a priority cluster and the funded initiative will push for policies and commercialization of developed technologies to ramp up the EV industry and foster collaboration. The 2011-2013 Innovation Plan describes the intent as follows:

While Oregon has a strong manufacturing sector that will be crucial in the development of EVs, *Drive Oregon's mission isn't to create a Northwest version of Detroit.* With other states already spending tens of millions to build large-scale manufacturing plants, Drive Oregon instead will leverage areas where Oregon is uniquely positioned to lead, including high-end embedded electronic components, engineering, design, software and semiconductors. All of these are critical to EV development no matter where vehicles are ultimately assembled.²⁹

Oregon InC expects that its efforts will help start-up companies compete for federal grants and private investments, and that the industry will form a symbiotic

²⁸ “About Oregon InC.” *Business Oregon*. Web. 13 May 2012. <<http://www.oregon4biz.com/Innovation-in-Oregon/About-Oregon-InC/>>

²⁹ “Oregon InC. Creating Oregon’s Future: 2011-2013 Innovation Plan.” *Business Oregon*. 2010. Web. 12 April 2010. <<http://www.oregon4biz.com/assets/docs/11-13InnoPlan.pdf>>

relationship with the Oregon University System that will perpetuate innovation, productivity, and competitiveness within the traded sector of the economy.

Oregon has embraced the phenomenon of cluster development in the modern economy and the entities involved with economic development in the state are working zealously to make this work in our state. However, Oregon institutions must take care to avoid claiming a central role in cluster development or assuming that the public sector will drive innovation and productivity. That would be contrary to the organic process that Michael Porter has documented in his study of thriving industry clusters.

2.) Cluster Economics and the Role of Public Institutions

Harvard Business School Professor Michael Porter first began describing his observations and explaining business clusters in his book *The Competitive Advantage of Nations* (1990). In the past, corporations have typically developed as vertically integrated, self-contained entities. Being careful to guard proprietary information, most companies did their own designing, manufacturing, and selling with very little collaboration among firms. Globalization has changed the structures of corporations and how they compete. Profits are no longer made simply by delivering a unique product, but rather by maintaining a strong position in the global marketplace. This requires continual upgrading, rapid innovation, and high levels of productivity. Corporations need to be nimble and effectively connected to all the significant players in an industry in order to track changes and respond quickly—including their competition.

The point at which globalization began in earnest is debatable, but the explosion of international financing in the 1990's definitely changed the game. Corporations

rapidly disaggregated their operations and began outsourcing as a regular way of doing business. More and more often, successful companies were operating in confederations of suppliers and partners and institutions. Maintaining a competitive position meant learning to be innovative, and this was critical for generating good jobs. When production became static, those jobs were moved to lower-wage locations. Success was based on knowledge, skill, and meeting the challenge of constantly re-inventing a company's products and even the company itself. This was how clusters began evolving as the dominant players in the global marketplace.

Business interests have clustered for centuries, but the structural shift towards industrial clusters as the primary way to engage in the new world market correlates with the dramatic increase of interdependency in the world economy. A paradox has materialized with globalization; "...the enduring competitive advantages in a global economy lie increasingly in local things—knowledge, relationships, motivation—that distant rivals cannot match."³⁰ With its proclivity towards "regional mindset" and the local specialization of alternative EVs (motor cycles, bicycles, neighborhood electric vehicles (NEVs), and other urban EVs) Oregon is evolving a holistic, collaborative way of doing business that is in line with the demands of the global economy.³¹

What exactly are business clusters? A paraphrased explanation given by Michael Porter at a 2008 EU conference is as follows:

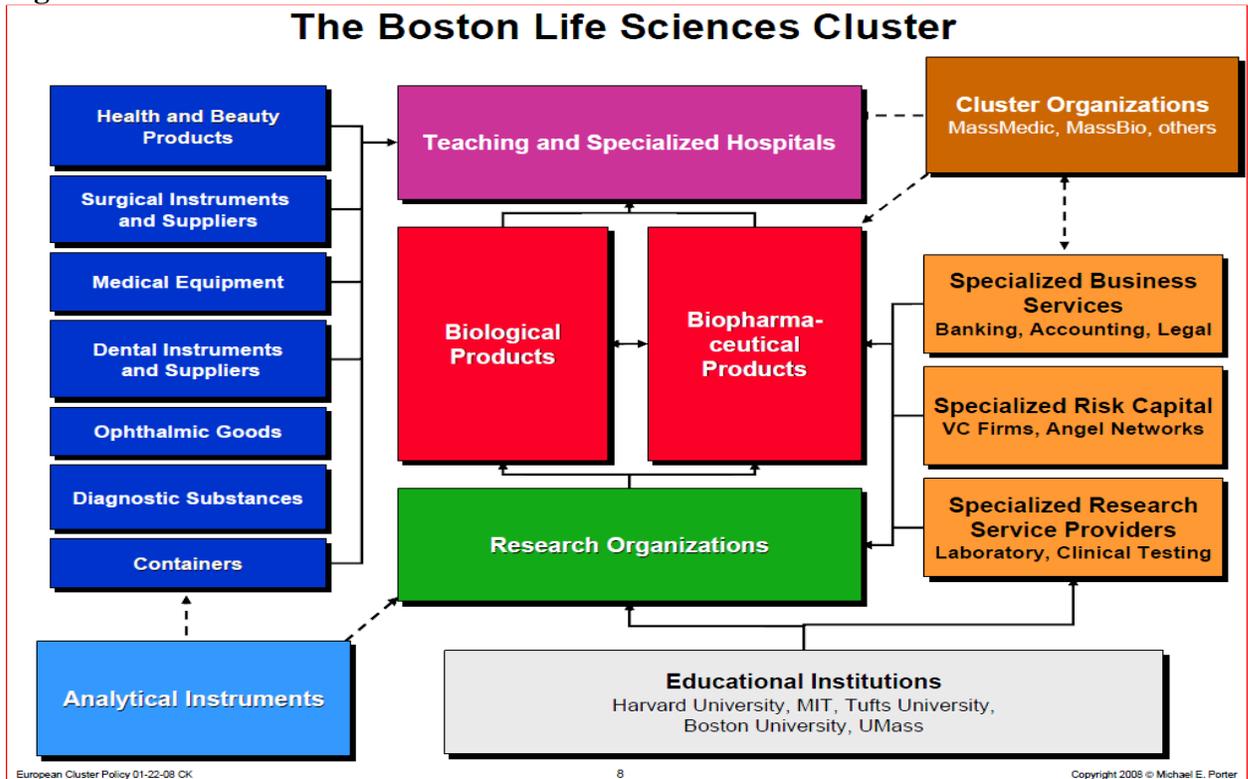
³⁰ Porter, M. "Clusters and the New Economics of Competition." *Harvard Business Review*. Nov-Dec 1998: Vol. 76. No. 6, p. 78 Print.

³¹ Leiken, S., et. al. "National Prosperity/Regional Leadership: Economic Development Administration 21st Century Regional Leadership Initiative." *The Council on Economic Competitiveness*. Washington, D.C. Contract # 99-07-13856 2010. Print.

Clusters are geographic co-locations of inter-related firms and institutions in a particular field. A cluster is not an industry. A cluster is a group of related industries often involving a series of suppliers and related services and industries. A cluster breaks down the traditional boundary between manufacturing and services. They are made up of suppliers that are horizontally related. They have very strong commonality in terms of skills and technology (pharmaceuticals and skin care industries for example, which use similar packaging, ingredients and labor).³²

Figure 2.1 provides an example.

Figure 2.1. The Boston Life Sciences Cluster Chart



Source: This example is a slide from the EU Conference on Innovation and Clusters, 2008.³³

³² Porter, M. "Clusters, Innovation and Competitiveness." Presentation given at the E.U. Conference on Innovation and Clusters. Stockholm, Sweden. 2008. Video.

³³ Ibid.

The business environment and proximity of complimentary services and supply chains determine success in the modern economy. The structure of the cluster and the blend of competition and collaboration that the cluster engenders is the catalyst for high levels of productivity. Clusters encourage innovation, both because competing firms are trying to claim market share, but also because opportunities are more obvious when you can see how your competitors are operating and what they are creating. Opportunities for specialization also emerge for similar reasons; gaps are readily apparent within an interdependent system. “A cluster creates a crucible for sharing ideas and competition—rapid access to suppliers, rapid access to best practices, and intense rivalry of local competitors... Competition involves ego, pride and status as well as profits. Ideas emerge; firms see ways to merge and combine and experiment.”³⁴

Clusters encourage business start-ups. Within an incubating environment of established companies, rapid prototyping is cost effective and there are fewer barriers to entering the market. Spin-offs tend to stay in the general area and often engage in information sharing—which stimulates innovation and competition. These cycles create ecology of interdependence within clusters which gradually become self-perpetuating.

With this model, productivity will result from competitiveness, and the ability to compete will rely on two factors. First, the companies must make good use of their resources, capital, and workforce. Secondly, the environmental context must be conducive to the growth of the business cluster. This second factor is where public institutions can influence success.

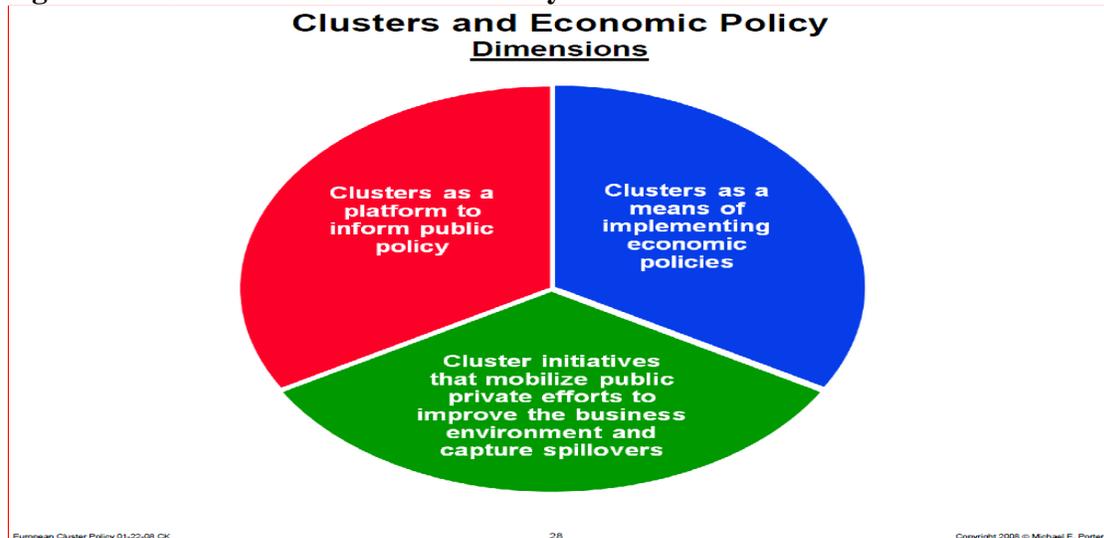
³⁴ Ibid.

Public supports are part of a healthy business environment. Most successful clusters include local government agencies that manage policies, political stability, and social conditions. The government also promotes business confidence by ensuring trustworthy legal systems and predictable regulations. Clusters develop over long periods of time and innovation doesn't happen evenly, so governments need to take care that political cycles and changing parties don't undermine long term business growth. Universities and community colleges provide research and development support, educated professionals and trained laborers that enable companies to develop the high levels of specialization they need to innovate and compete.

It used to be that economic development was top-down and government driven, but in the modern era, it's more collaborative. Public institutions need to be clear about their facilitating role. Flourishing economic development cannot be driven by government demand and government agencies must resist taking on that task. Convening collaborations and aligning job training institutions are examples of effective public support. Interventions to limit competition or subsidies to give an advantage to a particular industry don't work in the long run according to Porter's observations. "Governments should not choose among clusters, because each one offers opportunities to improve productivity and support rising wages. Every cluster not only contributes directly to national productivity, but as shown in Figure 2.2 also affects the productivity of other clusters."³⁵

³⁵ Porter, M. "Clusters and the New Economics of Competition." *Harvard Business Review* 1998: 89. Print.

Figure 2.2. Clusters and Economic Policy



This is a slide from the EU Conference on Innovation and Clusters, 2008.³⁶

The chart above gives a visual depiction of how the government can contribute to economic development within a cluster structure. Industries that begin gaining success will indicate what their needs are as they emerge and governments need to be ready to receive that information. As well, governments can note patterns and see linkages upon which they can act. Convening focus groups and supporting relationships and information exchanges will open a conduit that informs public policy. As the clusters form, government entities will be able to implement their policies and establish public-private partnerships to continually improve the business environment.

The OTREC research which will be described in the coming chapters was initiated by grant funding from federal legislation, and by the desire of the Oregon University System (OUS) to put its research laboratories into the service of the emerging electric vehicle cluster. In doing the analysis, it appears that the needs of Oregon's EV

³⁶ Ibid.

entrepreneurs and the desires of the OUS are not an exact match. Porter's caution against public institutions trying to drive cluster development is particularly appropriate here. Oregon institutions have a high need to justify themselves in these difficult economic times. As a consequence, there is an impulse to somehow make EV businesses use OUS labs and research, rather than have the labs and resources at the ready as the industry takes the lead on looking for solutions. The biggest need that the targeted EV entrepreneurs expressed in my survey was that of access to capital followed by business development support. While research for technical developments and improvements is critical and was an expressed need of the survey respondents, it was not the primary support that these generally small and early stage EV businesses expressed a need for. It may be that OUS needs to strengthen relations with a more sophisticated group of industry partners to fully utilize their research capacity, perhaps in conjunction with prototyping and by building relationships with larger companies like Intel or United Street Car to foster start-ups and spin-offs from established firms.

It may be that the entrepreneurs who are part of Drive Oregon and the Oregon industry cluster need assistance in maturing their businesses before they can take advantage of the research and development resources of the OUS. It could also be, as in the case of Stanford and the Silicon Valley, that science and technology students within the Oregon University System need to have their educations framed as practical science that they can commercialize. In any case, there is a strong temptation for OTREC and OUS to take the wheel and "decide" what the industry needs and what should be avoided. The pace of development needs to be set by the business community. Oregon institutions can help promote inter-industry collaborations and create a supportive business

environment through a facilitated collaboration process, but they need to scoot over and let the entrepreneurs drive.

B. Case Studies of Regional Economic Development and the Impact of Collaboration

In 1996, AnnaLee Saxenian, Dean of the School of Information at U.C. Berkeley, wrote a definitive work on the phenomenal growth of the Silicon Valley titled, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* in which she coined the motto of the Silicon Valley by stating: “competition demands continuous innovation, which in turn requires cooperation among firms.”³⁷ Her work compares the Silicon Valley to the economic cluster of Route 128 on the east coast and she highlights the factors that differentiate them. I am basing the following historical overview on her work. Looking at the history of the two regions is instructive for those seeking to encourage similar growth for the EV cluster here in Oregon. Collaboration, communication, and culture impacted the growth trajectories of the two areas, and understanding the differences will allow leaders to cultivate business models that advance Oregon’s competitiveness with electric vehicles.

³⁷ Saxenian, A. (1994). *Regional Advantage: Culture and Competition in the Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press, 1994. 164. Print.

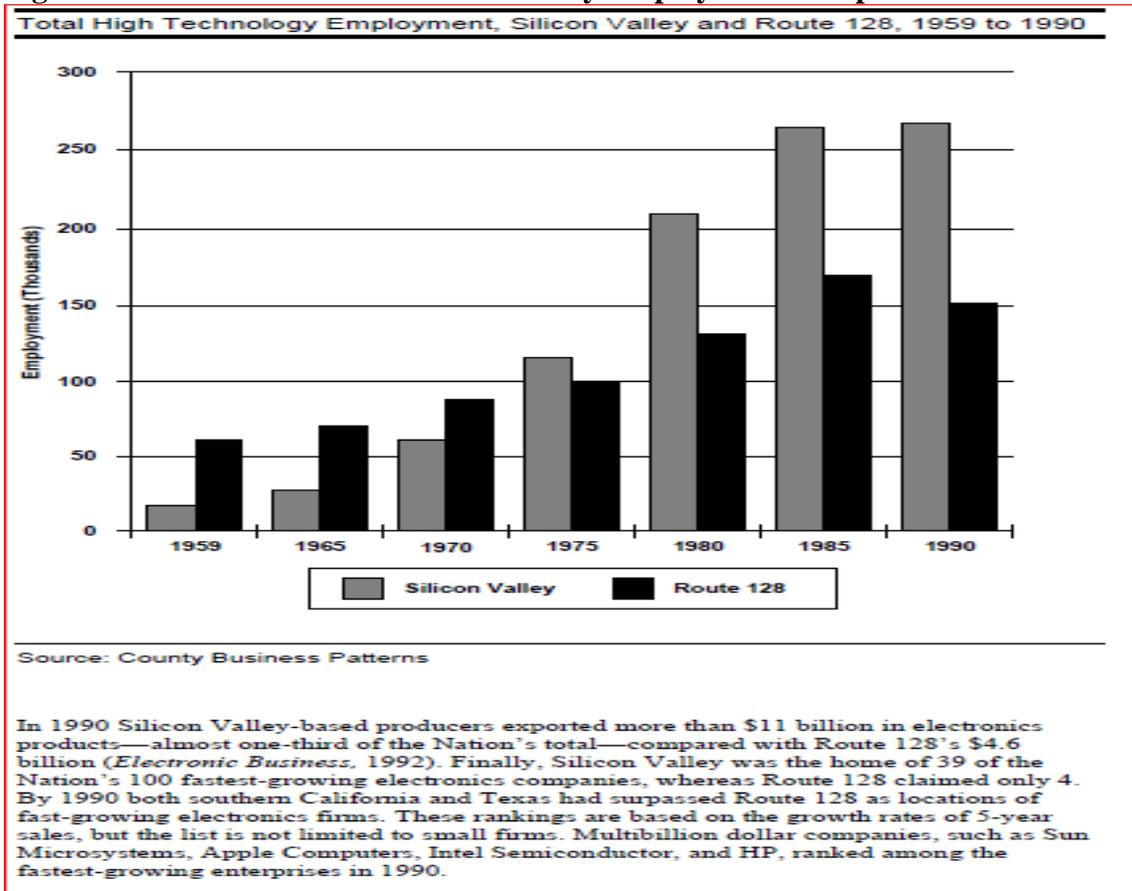
1.) Route 128

The Silicon Valley and Boston's Route 128 are two of the world's most concentrated centers of high tech industry. They've both been active innovators in electronics since World War II. Route 128 evolved from centuries-old industrial behemoths in eastern Massachusetts, and the Silicon Valley began as a transplanted cutting, so to speak, on the west coast via Frederick Terman. Terman received his ScD in engineering from MIT in 1924 and went out west to join the engineering faculty at Stanford the following year.

A confluence of industry, academia, and government sparked the development of electronics-related companies along the 65-mile highway that forms a belt around the Boston and Cambridge area. In 1918, the Massachusetts Institute of Technology created a technology plan to encourage large corporations like Dupont, Kodak, and GE to maintain on-going financial investments in the university. MIT produced world class engineers and became the leading research university in the U.S. during WWII. In later years, MIT students were hired by companies such as Digital Equipment Corporation, Data General, Wang, Apollo, and IBM's Lotus Development Corp. During the 1950's and 1960's, the Department of Defense and the National Science Foundation provided more than 50% of the funding that moved through the region via grants and contracts; first to the research universities (particularly MIT) that would develop technology, and then to the firms that would manufacture the products. During the early 1970's, the region stumbled when the Department of Defense cut back, but re-invigorated itself with the growth of the minicomputer industry. By 1975, Route 128 employed 100,000 people—at which point it was surpassed permanently in its rate of growth by the Silicon

Valley. The trajectory continued to trend upward however through 1985 when the minicomputer lost the market to smaller work stations and personal computers. This economic pause occurred, at least in part, due to Route 128's resistance to adapting to the changing business market. Figure 2.3 provides a visual for this concept.

Figure 2.3. Route 128 and the Silicon Valley Employment Compared



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The east coast culture of Route 128 has promoted stable growth for decades, and while the region fell behind the pace of the Silicon Valley in the 1980's, the area continues to be a remarkable hub of development. In recent years, Route 128 has become

³⁸ Saxian, A. "Inside-Out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128." *Cityscape: A Journal of Policy Development and Research*. U.S. Department of Housing and Urban Development May 1996: Vol 2, No. 2. Print.

the world's undisputed epicenter of Product Lifecycle Management, or PLM.³⁹ The values espoused are conventional: independence, self-reliance, loyalty, hard work, and decorum. Although the region has developed an environment of industry-academic-government interactions, industry to industry collaboration is not a part of the culture in the way that it is in the Silicon Valley, and this lack may account for Route 128 losing ground. With the latest iteration of cluster development and the influence of the Silicon Valley, this may change, but the culture of self-reliance and vertical integration remains a hallmark of east coast industrial culture.

2.) *The Silicon Valley*

The headwaters of what would become the rushing river of the Silicon Valley are thought to have originated in a Palo Alto garage in 1937 where two Stanford graduate students started a little electronics instrumentation business. Encouraged by their electrical engineering professor, Frederick Terman, William Hewlett and David Packard commercialized the audio-oscillator that Hewlett designed while working on his master's thesis. Professor Terman even lent the boys \$538 to start their venture. HP took off during World War II as the military contracted the company to provide electronic measuring devices and receivers to detect enemy radar signals.

Terman had grown up in California but went east for graduate school at MIT. While there, he had greatly enjoyed access to the surrounding industries that always seemed to have projects where students and faculty could develop their special interests.

³⁹ Denison, D. "Route 128 at the Center of Manufacturing." *Boston Globe*, *boston.com*. 13 May 2012. Web. <http://articles.boston.com/2012-05-13/business/31679721_1_products-operations-enterprise-software>

When Terman moved back to the west coast in 1925 and became a professor at Stanford, he made a point of facilitating relationships between the university and the local business community, encouraging his students to begin a small cluster of pre-war technology firms just as he did with Hewlett and Packard. His goal was to establish a community of technical scholars at Stanford, having in mind the model of MIT in the Boston area. In Terman's words, "Such a community is composed of industries using highly sophisticated technologies, together with a strong university that is sensitive to the creative activities of the surrounding industry. This pattern seems to be the wave of the future."⁴⁰

According to Saxenian, there were three institutional innovations that Terman made that laid the foundation for the Silicon Valley's meteoric progression. First, he established the Stanford Research Institute to "pursue science for practical purposes," which was a change from the university's traditional role. Secondly, Terman worked with Stanford to launch the Honors Cooperative Program to entice local engineers to enroll in specialized graduate courses to keep them up to date with industry changes. Third, Terman promoted the development of the Stanford Industrial Park, one of the first such business parks in the country. This industrial campus co-located complimentary and competing firms, allowing them to develop side by side, cooperating at some points and working to outperform each other by turn. These institutional pillars began the

⁴⁰ Bernstein, A. et al. "Silicon Valley: Paradise or Paradox?" *Pacific Studies Center*, Mountain View, CA. 1977. Print.

collaborative infrastructure that connected the university with industry, but more importantly created a cooperative community among the businesses themselves.⁴¹

This was the beginning of a technical culture that transcended firm and function. Companies in the Silicon Valley went on “to develop collaborative traditions that supported experimentation. They created firms that were organized as loosely linked confederations of engineering teams. Without intending to do so, Silicon Valley’s engineers and entrepreneurs were creating a more flexible industrial system, one organized around the region and its professional and technical networks rather than around the individual firm.”⁴² This established an environment of sharing ideas, developing specialties, competing with innovation and generating responsive, interconnecting supply chains.

The camaraderie that came about created an exciting feeling of mutual trailblazing, and the people employed within this system took pride in taking calculated risks. Their bonds went beyond the work place and they socialized regularly after work, often talking about what was happening at work.

The fluidity of the boundaries between work and play and among the different companies led to a high degree of occupational mobility. “During the 1970’s, the turnover rate exceeded 35% in local electronics firms and was as high as 59% in small firms” with the average tenure being about two years.⁴³ Jeffrey Kalb, who resigned from Digital Equipment Corporation and came west in 1987 to found MasPar Computer

⁴¹ Saxenian, A. *Regional Advantage: Culture and Competition in the Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press 23-24. 1994. Print.

⁴² Ibid. p. 30

⁴³ Ibid. p. 34

Corporation talked about how this contributed to the high rate of new companies that were popping up in the Silicon Valley. “We laugh about how often people change jobs. The joke is that you can change jobs and not change parking lots. There’s a culture associated with that which says moving is okay, that rapid change is the norm, that it’s not considered negative on your resume... So you have this culture of rapid decisions, rapid movement, rapid changes, which is exactly the environment that you find yourself in as a start-up.”⁴⁴

These labile employment patterns effectuated a local concentration of technological knowledge that was unrivaled. Combined with the pro-risk-taking attitudes and dense networks of support, start-ups were a regular feature of the landscape. The decentralized, responsive, and nimble Silicon Valley also proved well prepared for competition in the global marketplace.

3.) Translating the Comparison for Oregon

Comparing and contrasting the best-known regional economies in the United States highlights the efficacy of employing a “regional mindset.” The Council on Competitiveness described what this means in 2010:

“...Regional collaboration differs substantially from the kind of collaboration within a corporation or public agency or among nonprofits. It evokes a combination of the “three C’s”: Conversation, Connection and Capacity. Any meaningful regional action requires sufficient consensus to enable its leaders to

⁴⁴ Ibid. p. xi

move forward. But regions are fragmented in countless ways and advancing regional consensus is an on-going undertaking—a regional conversation.”⁴⁵

Creating an economic phenomenon around the electrification of transportation will require such a conversation. Drive Oregon, with the support of the OTREC, the OUS and the state economic development agencies, has a role to play in convening and facilitating the discussions. Although the EV cluster in Oregon differs in many ways from the evolution of the Silicon Valley, Oregon’s similar culture of networking, informalism, and collaborative innovation also has the potential to catapult the EV cluster to world prominence. In order to create an infrastructure analogue here, we will need to be cognizant of the benefits of industrial networking and intentional about sustaining a “cluster mindset.” Again, this can be managed through facilitated, coordinated dialog among the stakeholders.

It is easy to slip into guardedness in the zeal for competitiveness, and an obvious case of that is occurring nationally over the current struggle with developing standard EVSE (electric vehicle service equipment, i.e. the charger). Nissan and GM currently produce the major brands of electric, plug-in vehicles and have different charging cables. There is an industry push to standardize this equipment and Oregon would do well to be on that side of the issue. A supporting fable is the tale of Apollo Computer and Sun Microsystems.

In the 1980’s, Apollo Computer (a Route 128 company) and Sun Microsystems (a Silicon Valley firm) were competing for shares in the engineering workstation market. Apollo

⁴⁵ Leiken, S., et. al. “National Prosperity/Regional Leadership: Economic Development Administration 21st Century Regional Leadership Initiative.” *The Council on Economic Competitiveness*. Washington, D.C. Contract # 99-07-13856. 2010: 11. Print.

had pioneered this field and had a superior product in the mid '80's, but in 1987 lost its lead to Sun. Apollo's strategy and structure reflected its east coast culture of independence and proprietary standards—which protected it from imitators, but kept Apollo's products expensive. Sun Microsystems, on the other hand, pioneered open systems and adopted the UNIX operating system. “That strategy allowed Sun to focus on designing the hardware and software for workstations and to limit manufacturing, choosing instead to purchase virtually all its components off the shelf from external vendors. As Sun grew into a multibillion-dollar company, that focus enabled it to rapidly introduce complex new products and continually alter its product mix.”⁴⁶ As a result, the Sun workstations were much more affordable and accessible and quickly dominated the market.

The story of Apollo and Sun show how the independent and isolating practices of Route 128 can put companies at an ultimate disadvantage against competitive industries that develop in a networked, cluster environment. A better model for the Oregon EV cluster is that of the Silicon Valley. As one of the founders of Joint Venture Silicon Valley, Tom Hayes, put it, “our aim is to build a comparative advantage for the Silicon Valley by building a collaborative advantage . . . to transform Silicon Valley from a valley of entrepreneurs into an entrepreneurial valley.”⁴⁷ The same philosophy can be applied in Oregon.

The EV industry suits this model particularly well. Inc. Magazine ran a brief synopsis of the “Electric Vehicle Ecology” in 2010 and had this to say:

⁴⁶ Saxenian, A. “Silicon Valley versus Route 128.” *Inc.* 1 Feb. 1994. Web. 12 April 2012. <<http://www.inc.com/magazine/19940201/2758.html>>

⁴⁷ Henton D., et al. “Preparing for the Next Silicon Valley: Opportunities and Choices.” Joint Venture. San Jose, CA, 2002. Print.

It is important to understand that electric cars will benefit from a supplier base already structured like an ecosystem—and there are far too many living things in the emerging ecosystem to be anticipated by any single OEM. It will take an implicit partnership of hundreds, perhaps thousands, of suppliers to fill out the technology. The key is to bring them into alignment and, for that, the public sector may play a major role. "If governments act to consolidate standards, they can really make a difference in catalyzing competition among suppliers," says Tony Posawatz, the line director for the Volt.⁴⁸

Creating and maintaining Oregon's advantage in the electric vehicle industry will require regional leadership coordinating all the stakeholders. "Network systems... are fragile constructs that must be continually renewed and redefined to meet new economic challenges."⁴⁹ In 2010, a study generated by the Washington D.C. think tank, Council on Competitiveness (<http://www.compete.org/>) concluded, "Effective regional leadership creates a shared regional narrative, builds consensus, and leads change. It is also a systems integrator that brings together a cross section of institutions to focus on regional issues and build collaboration with the ability to respond rapidly and collectively to opportunities and challenges. The qualities required of individual regional leaders reflect the distinct tasks they face. For example, regional leaders need to be bridge builders, boundary crossers, and conveners."⁵⁰ Facilitating the shared narrative and building consensus are the tasks that Drive Oregon should spearhead. OTREC can contribute to

⁴⁸ "The Electric Car Ecosystem; 6 areas of Opportunity in the Electric Car Ecosystem." *Inc.com* slide show, *Inc.com* (<http://www2.inc.com>). 27 February 2011 Slide #7. Web. <<http://www.inc.com/ss/6-areas-electric-car-ecosystem?nav=related#0>>

⁴⁹ Saxenian, A. (1994). *Regional Advantage: Culture and Competition in the Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press, 1994. 163. Print.

⁵⁰ Leiken, S., et. al. (2010) "National Prosperity/Regional Leadership: Economic Development Administration 21st Century: Regional Leadership Initiative." *The Council on Economic Competitiveness*. Washington, D.C. Contract # 99-07-13856. 2010. P. i. Print.

the discussion by convening Oregon's public institutions to make state and university resources available to the EV industry.

CHAPTER III

METHODOLOGY

The Oregon Transportation Research and Education Consortium, OTREC, in cooperation with Drive Oregon, the association of EV entrepreneurs, and interested stakeholders, initiated an investigation to identify key needs of EV business owners. The findings of this study will be used to support the development of collaborations and networks of entrepreneurs and researchers who can utilize the testing laboratories, incubators, and business support services of Oregon's university system to meet the needs of existing and emerging EV-related companies. OTREC is in an ideal position to construct this supportive infrastructure, linking the innovative exploration of academia with the ambitions of business owners, but should be mindful of the developmental role it plays as a participant rather than the driver of industry growth. This will ensure that the collaboration is mutually beneficial and works effectively to help Oregon rise to prominence in the global EV market.

Information gathering methods used for this report included an examination of the state agencies involved with EV industry development, and the system of signature research laboratories, institutes, and business services managed by the Oregon University System. Information was collected on the activities of Oregon EV entrepreneurs by way of a survey to the members of Drive Oregon (DO) and the Oregon Electric Vehicle Association (OEVA). To supplement the surveys, key stakeholders and interested parties were interviewed using open-ended conversation designed to encourage sharing

perspectives from the unique experience of the interviewees. From these perspectives, gaps and priorities were identified to move this sector forward.

The resources of the Oregon University System were also mapped in this study, including the state's signature research labs and the research institutes housed at the different university campuses.

CHAPTER IV

INVENTORY OF EV ACTIVITY IN OREGON

This chapter summarizes state-level programs and activity that relate to the EV industry in Oregon. The inventory includes programs sponsored by state agencies, nonprofits, and businesses. It also includes collaborative efforts that cross the boundaries of the organizations listed above.

Electric vehicle production has significant global market potential, and Oregon offers many unique advantages with which to compete for a share of this trade sector. Recognizing that the state cannot outspend the high-tech industry competitors north and south, the governor's office concluded that becoming competitive requires the state to "concentrate key resources in areas where it already held unique advantages and for which there would be significant global markets."⁵¹ Key resources include Oregon's unique capacity for innovation, its universities and research labs, and its embrace of new, clean technologies. Electric Vehicles present opportunities related to the state's key resources.

A. Oregon Business Council and the Oregon Business Plan

The Oregon Business Council (OBC) was formed in 1985 as a stakeholder group of more than 40 business executives from around the state. Since 2002, the OBC has

⁵¹ "About Oregon InC." *Business Oregon*. Web. 12 April 2012.
<<http://www.oregon4biz.com/Innovation-in-Oregon/About-Oregon-InC/>>

published annual updates to the Oregon Business Plan, providing research and recommendations on economic development, education, the environment, transportation, and fiscal reform among other broad interests impacting Oregonians. This plan has been referred to by Business Oregon, the executive level economic development department, as it organizes strategies to support economic growth and create sustainable, living-wage jobs. Years of assessment and evaluation led OBC to conclude:

“Business Oregon works to create, retain, expand and attract businesses that provide sustainable, living-wage jobs for Oregonians through public-private partnerships, leveraged funding and support of economic opportunities for Oregon companies and entrepreneurs. Supporting collaborative efforts by industry and universities to design and implement new business processes and commercialize new products was an early initiative of the Oregon Business Plan. Many of these efforts are bearing fruit, not the least of which are the state’s signature research centers and industry cluster initiatives supported by the Oregon Legislature through the Oregon Innovation Plan. The push for innovation is also gaining traction through other models of support, such as business incubators and accelerators, entrepreneur networks, the Oregon model for technology deployment, and economic gardening.”⁵²

B. Business Oregon and Oregon InC Assist

In 2005, the governor’s office and the Oregon legislature gathered a council of 50 business leaders and the state’s three research laboratories to form an economic development planning team, Oregon InC (the Oregon Investment Council). Oregon InC partners with Business Oregon to create incentives that encourage business to locate and grow within the state. One of the important ways Oregon InC does this is by

⁵²The Oregon Business Plan Steering Committee. “The Oregon Business Plan Summary.” *The Oregon Business Council*. 2010. 7. Print.

recommending funding for innovations and initiatives with strong commercial potential. It also leverages state funding to garner federal and private support.

During the 2011 legislative session, Oregon InC reviewed 22 proposals and recommended six for funding. Oregon's three signature research labs have proven highly successful in working with industry to generate innovation, jobs, and new businesses and will continue to receive funding. Drive Oregon was also allocated \$1.2 million to energize Oregon's emerging EV industry by developing connections among businesses, utilities, and the OUS, and through leveraging federal support with state and private investments.

C. Drive Oregon: An Initiative to Support the Growth of the EV Industry Cluster

According to its website, "Drive Oregon (DO) is a coalition of businesses and interested stakeholders engaged in the electric vehicle industry and transportation electrification."⁵³ Its members include companies that develop and produce vehicles, components, perform conversions, and provide consulting services for hybrid and electric vehicles and energy storage technologies. DO also has members who are investors, government agents, consultants, academia, and retired people interested in the field.

Drive Oregon's mission is to "propel the growth of Oregon's electric vehicle industry to ensure Oregon develops and maintains its competitive advantage, and

⁵³ "About Us." *Drive Oregon*. Web. 26 July 2011. <<http://driveoregon.org/about-us/>>

maximizes the economic development potential of this emerging industry.”⁵⁴ DO supports businesses involved in all aspects of electric transportation in Oregon, including freight and mass transit, motorcycles, and electric bikes. The designers and makers of component technologies are interested in supplying all modes of transportation manufacturing.

Based on interviews with DO representatives, the organization sees itself playing a key role in connecting investors with Oregon’s EV companies as well as establishing links among EV businesses and the Oregon University System. With its attainment of 501(c)6 nonprofit status and an allocation of \$1.2 million to move forward with its agenda, Drive Oregon seeks to mobilize resources within the state to build a world class EV industry. DO is constructing support networks to move young EV companies into commercialization as they develop their capacity as worldwide leaders in design, components, and production of EVs. Planning and organizing the push for funding, advocacy and awareness, DO is a catalyst for the collaborative mindset of the EV industry in Oregon and an intermediary for connecting investors, the state and OUS to EV enterprises.

DO submitted a proposal to Oregon InC for funding in order to accomplish a number of high level objectives:

- Attract existing federal resources and private financial support to enable local endeavors to overcome commercialization barriers for EV and EV-related products and facilitate opportunities for external collaboration.

⁵⁴ Ibid.

- Leverage and connect Oregon University System institutions, utilities, state and local government entities and Oregon electric vehicle (EV) industry stakeholders to efficiently develop and commercialize next-generation transportation technologies and products.
- Foster collaboration between Oregon's existing clean tech, advanced manufacturing, software and high technology sectors to participate in the EV supply chain, both locally and globally.
- Aid in the creation of skilled, family-wage jobs to build the next generation of transportation solutions.⁵⁵

While awaiting approval from the 2011-2013 legislative session, Drive Oregon leaders were creative in their approach to starting their planned work with volunteer efforts. DO began roundtable meetings in April of 2009 as an advisory group, and focused on becoming the private sector representative for the public/private consortium being developed by the Oregon University System (OUS) and the Oregon Transportation Research Education Consortium (OTREC).

Oregon EV entrepreneurs are interested in opportunities for collaboration. Many of them are affiliated with the trade organization DO, and the Oregon Electric Vehicle Association (OEVA). Drive Oregon in particular has been eager to collaborate with Oregon's University System and gain the support of government to advance EV business growth. Oregon's emerging EV industry presents a concrete opportunity to build a

⁵⁵ "Advancing the Electric Vehicle Industry." An Oregon InC funding proposal from Drive Oregon. Portland: Drive Oregon. 26 July 2010. 1. Print.

structure that relies on interdependence and collaboration. Setting up, enhancing, and maintaining a network of relationships among education, research, business, and government establishes the groundwork needed for creating Oregon’s world class electric vehicle industry.

D. State Advisory Councils

1.) The Alternative Fuel Infrastructure Working Group (AFIWG)

Established in 2008 by an Executive Order from Governor Kulongoski, the goals of the AFIWG working group were to identify opportunities and barriers to the implementation of alternative transportation fuels with specific attention to “building and maintaining a consistent and reliable alternative fuelling infrastructure.”⁵⁶ The group included individuals with expertise in alternative fuel vehicles who came from the transportation and utility industries, state and local government, and the business community. Governor Kulongoski emphasized the development of electric vehicles and the AFIWG agreed with him that EVs presented Oregon’s “biggest opportunity for job creation and vehicle adoption.”⁵⁷

In January of 2010, the AFIWG submitted a final report to the governor with recommendations for advancing alternatively fueled vehicles. Of the top seven, the first

⁵⁶ ‘Oregon’s Alternative Fuel Infrastructure, Executive Order 8-24.’ *Office of the Governor of Oregon*, Salem, Oregon. 2008. 1. Print.

⁵⁷ ‘Report of the Alternative Fuel Infrastructure Working Group.’ *Office of the Governor*. Salem, Oregon. 2010. 2. Print.

one focused on collaborative planning for the advancement of electric vehicles: Create an Electric Vehicle Executive Council by Governor's Executive Order.

“Oregon’s development of, and leadership in, the electric vehicle market will not advance at an optimal pace and purpose unless key players convene to focus on a common agenda and a shared set of priorities. The Governor should empanel a group of individuals who possess the stature, perspective, experience and organizational legitimacy to set a statewide agenda for the introduction and general deployment of electric vehicles, infrastructure and related services in Oregon. This Executive Council should formulate strategies, plans, partnerships, and key initiatives that position Oregon for leadership in the use of electric vehicles.”⁵⁸

The suggestion was taken up by Governor Kulongoski and the Transportation Electrification Executive Council (TEEC) was formed. An expansion of this type of facilitated collaborative planning is also included in my recommendations.

The report goes on to describe the advantages of moving towards alternatively fueled vehicles, particularly EVs. Oregon may have its best opportunities in the component and subsystems levels of electric vehicles, and in the aftermarket and software development niches. The report offered the following rationale:

- Auto design, development, and production now involve considerably more jobs on the component and subsystem level than at the vehicle assembly level.
- All automobiles – and especially electric vehicles – make heavy use of embedded electronics, and Oregon has a relatively large pool of embedded systems talent to leverage, from semiconductor companies like Intel and LSI, engineering design automation companies like Mentor

⁵⁸ Ibid, p. 4

Graphics and Synopsys, and equipment and systems companies like Radisys, Flight Dynamics, and Variant.

- Oregon has a strong base in the field of Open Source Software. Electronic subsystems that are particularly important to the EV industry that are well represented in Oregon include graphics and displays (for both telematics and in-vehicle infotainment), battery power management, and wireless communication.
- Battery technology is also an area of potential growth. The recent announcement of ReVolt Technologies, a Swiss zinc-air battery maker, choosing Oregon as its U.S. headquarters and research and development facility is an excellent opportunity that could be leveraged to attract other non-traditional battery manufacturers to the state. Many of the skills from the chip manufacturing industry are directly relevant to the battery industry. Oregon can clearly offer advantages in technological know-how and with the state's educational institutions, specifically the Oregon Nanoscience and Microtechnologies Institute (ONAMI), if there is focused emphasis and dedication of resources to this area.⁵⁹

The AFIWG also pointed out that education is the “biggest long-term driver of EV related jobs.” The federal government is becoming more and more interested in supporting alternative energy sources and uses and will continue to make grants available to exceptional educational and research institutions. Research and development at such

⁵⁹ Ibid, p. 9

universities will spur job creation as new technologies are transferred to the business sector for commercialization. As well, teaching and training jobs will be created at Oregon universities as our expertise in electric vehicle technology increases and the OUS establishes degree programs in EV related engineering and materials science.⁶⁰ OTREC is currently working to develop this capacity within the OUS.

2.) *The Transportation Electrification Executive Council*

Per the recommendation by the AFIWG, “the Transportation Electrification Executive Council (TEEC) was established through Executive Order by Governor Kulongoski on September 22, 2010 and re-designated by Governor Kitzhaber in March 2011 with the purpose of developing and implementing a strategy to make Oregon the leader in electric vehicle deployment and technology development.”⁶¹ The TEEC developed a policy statement and strategic framework in order to develop an action plan in 2011 for the execution of Oregon's *PEV Market and Community Plan* proposed by the State of Oregon. As of June 2011, the TEEC is committed to serving as a steering committee for the action plan, defining work groups, roles and responsibilities, securing commitments, establishing the timeline, and identifying possible barriers and challenges.

⁶⁰ Ibid, p. 11

⁶¹ Cogen, J. *Declaration of Cooperation: The Transportation Electrification Executive Council*. Multnomah County: Oregon Solutions, 8 June 2011. 1. Print.

E. Oregon Department of Transportation, Office of Innovative Partnerships

The Oregon Department of Transportation (ODOT) is mainly concerned with the deployment of infrastructure needed to integrate EVs into the existing transportation system in Oregon. ODOT is committed to developing a sustainable transportation system, reducing greenhouse gas emissions, and reducing the state's reliance on fossil fuels. ODOT's Office of Innovative Partnerships Program was created to develop relationships with the private sector and involve them in projects that promote sustainable transportation—such as the Solar Highway projects. The OIPP has worked to identify transportation projects that can be implemented in collaboration with the private sector so that partnerships could be established. The Department has been specifically involved with planning for the electrification of transportation and supported several projects, including the following:

- The EV Project run by ECOtality aimed at supporting widespread adoption of the technology. EV fast charge stations in Southern Oregon, part of the West Coast Green Highway infrastructure building efforts (<http://westcoastgreenhighway.com>).
- Tiger II Grant for EV infrastructure, funding EV fast charging stations in northwest Oregon along key corridors such as Oregon's coast and interior.⁶²

⁶² Oregon Department of Transportation . Web. 2 February 2012
<http://www.oregon.gov/ODOT/HWY/OIPP/inn_ev-charging.shtml>

F. Willamette Angel Conference

The Willamette Angel Conference is held annually with a goal of connecting early stage businesses with investors. Although it is not an official OUS event, it is sponsored in part by the University of Oregon, Oregon State University, and ONAMI. Early stage businesses are invited to submit business plans for review and advice, and engage in a competition to win a \$200,000 investment. A significant number of these companies are OUS students and are working with OUS researchers on technology transfer projects. Participation in the conference offers access to both investors and entrepreneurs and is an event that should be regularly attended by OTREC and Drive Oregon.⁶³

In summary, the State of Oregon has made remarkable progress in developing a collaborative approach to economic development and, in particular, to using its collective resources to get behind the electrification of transportation in a concerted manner. Most recently, Business Oregon, ODOT, ODOE, and OTREC led the effort on a successful proposal to the federal U.S. Department of Energy that is intended to put 30,000 plug-in electric vehicles on the road by 2015. Titled *Energizing Oregon*, the plan will “address next-generation deployment strategies for the state and assess the electric vehicle market here. Energizing Oregon's three main objectives are to integrate all of the state's existing EV efforts, develop an EV plan to expand them and help Oregon exceed its share of the

⁶³ The Willamette Angel Conference. Web. 2 February 2012.
<<http://www.willametteconference.com/about/>>.

national goal of putting one million electric vehicles on the road by 2015.”⁶⁴ A number of state agencies will also be involved, including the Oregon Department of Transportation and the Public Utility Commission.

⁶⁴ van der Voo, L. “Oregon scores more federal EV Cash.” *Sustainable Business Oregon*. 15 September 2011. Web. <<http://www.sustainablebusinessoregon.com/articles/2011/09/oregon-scores-more-federal-ev-cash.html?ana=fbk>>

CHAPTER V

AN OVERVIEW OF THE OREGON UNIVERSITY SYSTEM AND COMMUNITY COLLEGES WITH AUTOMOTIVE INTERESTS

This chapter provides an overview of Oregon University System (OUS) programs that could potentially partner with the electric vehicle industry. The inventory focuses on the four OUS institutions that are currently participating in the Oregon Transportation Research and Education Consortium's (OTREC) Transportation Electrification Initiative: University of Oregon, Oregon State University, Portland State University, and Oregon Institute of Technology.

A. Oregon Transportation Research and Education Consortium

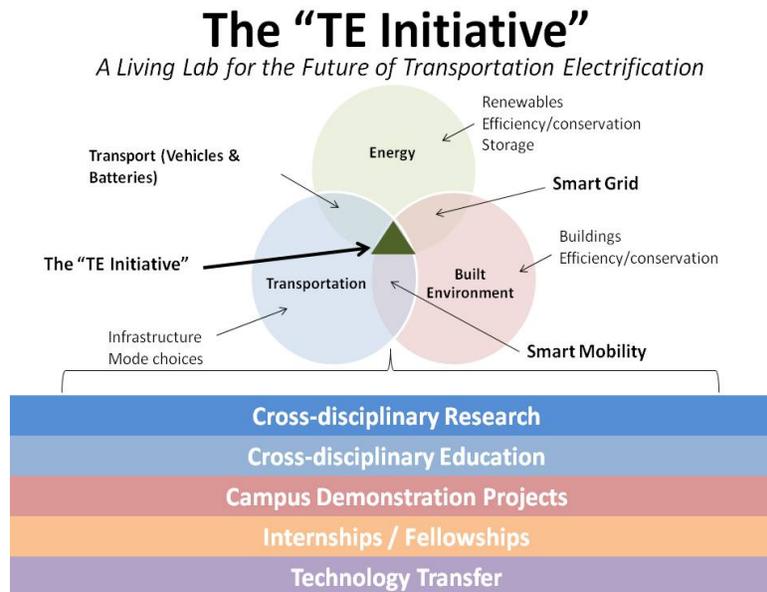
OTREC is a federally-funded university transportation center (UTC) that involves a partnership among Portland State University, the University of Oregon, Oregon State University and the Oregon Institute of Technology. OTREC's objective is to address the transportation needs of Oregon, the Northwest, and the nation through research, education and technology transfer projects.⁶⁵ Establishment of an Electric Vehicle research program under the OTREC was one of the executive level recommendations by the Oregon Alternative Fuel Vehicle Infrastructure Working Group (AFWG). In 2010,

⁶⁵ Oregon Transportation Research and Education Consortium (OTREC). Web. 8 Aug. 2011
<<http://otrec.us/about>>

OTREC sponsored the Transportation Electrification Initiative, which funded this report.

The following figure 5.1 visually displays the components of the initiative.

Figure 5.1. OTREC’s Transportation Electrification Initiative for the Oregon University System



Source: MacArthur, J. Portland State University Faculty Review. Working Document, Portland State University, OTREC, p. 11

1.) Purpose

The purpose is to establish a multidisciplinary Transportation Electrification Initiative for the OUS.

For the Portland region, the state of Oregon, the Pacific Northwest, and our nation transportation electrification is both a strategy and a transition in products and practices. OTREC’s Transportation Electrification Initiative will serve the Pacific Northwest region by identifying, field-testing, and generalizing knowledge about the practicality and suitability of promising mobility strategies, technologies, services, and practices that help mitigate pollution, congestion, and dependence on foreign oil.

The Initiative will build capacity within the OUS and will support students and faculty at all the Oregon university campuses as they plan for, field test, evaluate, and report on research transportation electrification. The intent is a truly collaborative and cross-disciplinary approach with various parties and partnerships to deliver education, training, and research and information exchange accelerating the adoption of electric vehicles and the development of a smart mobility system within a smart grid. The Initiative will provide policy and technical guidance to the state and nation, and help solve research questions for transportation electrification. Collectively, the OUS can serve the transition from a petroleum based transportation system to an electrified one. The wide array of disciplines and expertise within the OUS can help address the research needs of the EV industry, which can vary from vehicles to the impact on the electrical grid, to community planning.⁶⁶

2.) *Objectives*

John MacArthur, OTREC Research Associate at Portland State University stated that the goal of the first year of the Initiative has been to support the creation of a unifying strategic plan for the Oregon University System. He described the specific long-term objectives for this Initiative as being:

⁶⁶ “The Transportation Electrification Initiative. *The Oregon Transportation Research and Education Consortium*. Web. 3 June 2012. <http://otrec.us/research/transportation_electrification_initiative>

- Build the Research Capacity in the university system and collaboration among campuses, including bringing in new disciplines to focus on transportation electrification;
- align with state and regional efforts;
- capitalize and align the current transportation electrification and renewable energy momentum in Oregon and the Northwest;
- Attract partnerships and create opportunities for external funding and,
- Connect to education programs and improve student experiences.

The specific tasks of the Initiative as detailed in a draft paper by John MacArthur include:

- Establish an OUS EV task force. Each university will have an initial point person to lead the coordination efforts on campus. Currently Bob Parker is the contact person at the University of Oregon; James Long is the contact person at Oregon Institute of Technology, and John MacArthur and George Beard are the contacts at Portland State. (Oregon State University has not participated to date.)
- Establish an External Advisory Committee comprised of people from the public and private sectors who can share expertise and identify research needs.
- Create a research and education agenda based on the survey done of EV business owners and other expressed constituent needs.
- Develop a strategic plan to move the initiative forward including plans for building capacity and securing funding.

- Develop an Initiative website to serve as a clearinghouse of information activities and opportunities.⁶⁷

B. Oregon's Signature Research Laboratories

When Oregon InC was established in 2005, its first task was to establish a competitive process that would fund cutting edge ideas and generate ground-breaking industries. The goal was to transform Oregon's economy such that it became innovation-based and could support the creation of new jobs. After ten months of effort, Oregon InC. came up with three initiatives that established the three Signature Research Centers.

The Signature Research Centers made laboratories available to each of Oregon's research universities and allowed them to collaborate among faculty, researchers, students and industry. This collaboration has enabled Oregon to become a national leader in a number of fields, better able to compete for research funding and work with entrepreneurs to commercialize new technologies.⁶⁸ Two of the Signature Research Centers may conduct research supportive of EVs.

- ONAMI—the Oregon Nanoscience and Microtechnologies Institute is a collection of laboratories and researchers including the Lorry I. Lokey Nanotechnology Laboratories in Eugene, an internationally recognized facility with more than 20 advanced materials characterization and nanofabrication instruments; micro-level manufacturing and engineering research at the Microproducts Breakthrough Institute in Corvallis; and the Center for Electron Microscopy and Nanofabrication in Portland.

⁶⁷ This information provided by John MacArthur, Sustainable Transportation Program Manager, OTREC

⁶⁸ About Oregon InC. *Business Oregon*. Web. 22 September 2011.
<http://www.oregon4biz.com/Innovation-in-Oregon/About-Oregon-InC/>

- Oregon BEST—the Oregon Built Environment and Sustainable Technologies Center (BEST) connects the state’s building industry to its shared network of university labs at Portland State University, the Oregon Institute of Technology, Oregon State University and the University of Oregon, helping transform green building and renewable energy research into on-the-ground products, services and jobs.⁶⁹

The purpose of networking these labs is “to leverage university research in the commercial sector in areas including green building, wave energy, transportation and more...”⁷⁰ With the EV Initiative, OTREC’s job is to ensure that electric vehicle entrepreneurs have access to university research and testing facilities, and the opportunity to build businesses by commercializing the technology either developed jointly or licensed from university research. ONAMI has the capacity to assist in producing advanced technology and materials that will advance Oregon’s competitiveness with EV components and software, while Oregon BEST can propel the EV industry forward with research on the use of renewable energy, integration with the electric grid and EV related infrastructure.

C. Oregon State University

Oregon State University (OSU) has an overarching interest in alternative energy technologies. While there are no faculty dedicated to EVs or OTREC, research pertaining to electric vehicles occurs within the larger context of engineering approaches to transportation, civil engineering and construction, and alternative energy development.

⁶⁹ Business Oregon Signature Research Centers. *Business Oregon*. Web. 12 Dec. 2011. <<http://www.oregon4biz.com/Innovation-in-Oregon/Research-Centers/>>

⁷⁰ Williams, C. “Governor Kulongoski Lauded for Sustainable Leadership.” *Sustainable Business Oregon*. 18 November 2010. Web. <<http://www.sustainablebusinessoregon.com/articles/2010/11/gov-kulogoski-lauded-for-sustainable.html>>.

Dr. Bob Paasch is the faculty advisor for the SAE (Society of Automotive Engineers) and has been doing R&D on electric vehicles, associated with the Formula Student Electric car. OSU competed internationally with this vehicle and the team was #1 out of 475 world teams. They did the power train development in Oregon and the motor management system was developed by Rinehart Motion Systems in Wilsonville (a DO Member) and was custom-designed with students. The students have also developed battery management systems. There is currently no move towards commercialization with this research.

“Electric vehicles are clearly going to be important in the future of American automotive transportation, and OSU will be both a research and educational leader in creating that future,” said Ron Adams, dean of the OSU College of Engineering. “We’re already heavily committed to various research projects in this area, we have world-class testing facilities to help create optimal technologies, and we will train the engineers and other experts who will make this happen.”⁷¹

OSU has engineering programs in disciplines related to transportation vehicles and systems, and a range of multi-million dollar research initiatives on alternative transportation. Some relate to battery-powered vehicles, and others to electric cars that could be powered by hydrogen fuel cells. The two primary obstacles to making hydrogen fuel cell cars more practical are the cost of hydrogen and new technologies needed to store it, and OSU is working in both arenas.⁷²

The OSU College of Engineering is among the nation’s largest and most productive engineering programs. In the past six years, the College has more than

⁷¹ 2009 University Marketing and Public Relations Press Release. *Oregon State University*. Web. 23 December 2011. <<http://oregonstate.edu/ua/ncs/archives/2009/apr/nissan-electric-car-display-osu>>.

⁷² Ibid.

doubled its research expenditures to \$27.5 million by emphasizing highly collaborative research that solves global problems, spins out new companies, and produces opportunity for students through hands-on learning.⁷³

Smaller electric and hybrid electric vehicles are already in heavy use at the OSU Motor Pool, and are the most requested vehicles in the fleet but OSU has not been part of a greater collaborative effort regarding the growth of the EV industry. Although Dr. Katharine Hunter-Zaworski is the designated OTREC point person at OSU, there hasn't been active participation from OSU, and from talking with OSU faculty, this may have been assigned to her by default and not been made a priority. Additional information on Oregon State University programs is included in Appendix C.

1.) The Office of Commercialization and Corporate Development, and the OSU Venture Fund

OSU has the resources and academic excellence to be a change-maker in the electric vehicle industry. As well as offering advanced degrees in a variety of sciences, engineering fields, computer science, and business, the university supports a variety of institutions that generate research and innovative technologies, and then transfer the results to the business community for commercialization. The Office of Commercialization and Corporate Development (<http://oregonstate.edu/research/occd/>) exists for this purpose and has specialized support services for inventors, researchers, start-ups and industry. OCCD maintains the OSU Venture Fund that was set up by the Oregon Legislature to help commercialize OUS technologies.

⁷³ Ibid.

The purposes of a university venture development fund are to provide:

- Capital for university entrepreneurial programs
- Opportunities for students to gain experience in applying research to commercial activities
- Proof-of-concept funding for transforming research and development concepts into commercially viable products and services
- Entrepreneurial opportunities for persons interested in transforming research into viable, commercial ventures that create jobs in this state

The legislature has authorized state-supported universities to receive a total of \$14 million in tax credit eligible donations for university venture development funds. Within the OUS, each university's share of this total is based on a number of variables, including the size of its research enterprise.⁷⁴

2.) Research and Development Institutes

a.) The Center for Sustainable Materials Chemistry

OSU also houses several shared research facilities and is respected for scientific advances in areas such as green chemistry. The announcement was made in September that an Oregon State University/University of Oregon joint proposal for the Center for Sustainable Materials Chemistry won \$20 million from the National Science

⁷⁴ OSU Venture Fund Overview. *Oregon State University*. 2011 Web 14 Dec. 2011. <<http://oregonstate.edu/research/occd/osuvf-overview>>

Foundation.⁷⁵ Professor Doug Keszler, a chemist at OSU and the director of the center, described it as a very open and accessible institution. Keszler said that, under the new grant, the center will expand the work that it has been done in green chemistry, specifically the development of water-based processes that are of interest in electronics and renewable energy materials manufacturing. “Most importantly [the grant] gives us a base to establish an ecosystem to translate this research for companies,” Keszler said. “We’ll be expecting, and be training, students to be entrepreneurs.”⁷⁶

The National Science Foundation grant specified several areas of focus to include but not be limited to:

1. Developing clean, safe, and economical alternatives to traditional chemical products and practices.
2. Exploring alternatives to petroleum as a source of feedstock chemicals, including bio-renewables.
3. Exploring earth-abundant, inexpensive and benign alternatives to rare, expensive and toxic chemicals. Examples include indium, germanium, rare earth elements and platinum catalysts.

⁷⁵ Williams, C. “Oregon Green Chemistry Center Wins \$20 Million Grant.” *Sustainable Business Oregon*. September 2011. Web. <<http://www.sustainablebusinessoregon.com/articles/2011/09/oregon-green-chemistry-center-wins.html?ana=sbo>>

⁷⁶ Ibid.

4. Developing efficient recognition/sequestration and recycling of key elements essential for sustainability, for example phosphorus and rare earth elements.⁷⁷

The focus areas have implications for electric vehicle battery technology. The Center has facilities on both campuses; the Lorry I. Lokey Laboratories at the University of Oregon, and the Linus Pauling Science Center at Oregon State University.

b.) The Microproducts Breakthrough Institute (MBI)

MBI is a research and education collaboration between Oregon State University and Pacific Northwest Laboratory, and is one of ONAMI's signature laboratories. MBI seeks to advance microscale systems and create new microfabrication techniques for energy, environmental, medical, and defense applications. A primary goal is to spin off this technology and see it commercialized. Sister facilities are [CAMCOR](#) (Center for Advanced Materials Characterization in Oregon) at the University of Oregon in Eugene and [CEMN](#) (Center for Electron Microscopy and Nanofabrication) at Portland State University.⁷⁸

D. University of Oregon

As a partner in the Oregon EV collaborative, the University of Oregon has great potential for research and development, business assistance, and interns to advance the

⁷⁷The Centers for Chemical Innovation Program. *The National Science Foundation*. 2011. Web. 14 December 2011. <http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13635>

⁷⁸ About the Microproducts Breakthrough Institute. *MBI On-line*. Web. 2011. <<http://mbi-online.org/about-mbi>>

development of this industry sector. There are several colleges within the university that have a potential connection, interest, or academic resource to offer, including the School of Architecture & Allied Arts, the College of Arts and Sciences, the Lundquist College of Business, the School of Journalism & Communication, and the School of Law.

The UO also invests in community and government relations, and supports its employees' involvement in a variety of task forces and advisory councils. A pertinent example is Associate Vice President for Public and Government Affairs, Betsy Boyd, who is a member of the Transportation Electrification Executive Council (TEEC).

Table 5.1 details the schools, programs, contacts and resources that are available at the University of Oregon.

Table 5.1. University of Oregon Schools, Programs and Institutions

School	Program	Contacts*	Resources
Architecture & Allied Arts	Architecture	Dept. Head Christine Theodoropoulos	
	PUARL-Portland Urban Architecture Research Lab	Director Nancy Cheng	Urban Morphology and Urban Patterns
	ESBL-Energy Studies in Buildings Lab	ESBL Director G. Z. Brown	Research projects focused on understanding how buildings and related transportation determine energy and resource use
	Ecological Design Certificate Program	Brook Muller	Students and faculty providing interns, consultation and research on integration of the built environment with natural systems
	Product Design	Program Director Kiersten L Muenchinger	Students and faculty providing interns, consultation and research on product design
	Planning, Public Policy and Management	Department Head Rich Margerum	Students and faculty providing interns, consultation and research on planning and public policy

School	Program	Contacts*	Resources
	Non-profit Management Certificate Program	Director Renee Irvin	Students and faculty providing interns, consultation and research for stakeholders such as Drive Oregon or other advocacy, non-profit organizations
	SCI-Sustainable Cities Initiative	Nico Larco, Marc Schlosberg & Robert Young	Cross-disciplinary organization focused on design and development of sustainable cities
	Community Planning Workshop & the Community Service Center	Robert Parker	Supervised graduate students to do practicum projects and planning; applied research on markets and EVSE
College of Arts and Sciences	Economics	Bruce Blonigen	Student consulting teams through the Oregon Economic Forum, international trade, industrial organization, applied econometrics

School	Program	Contacts*	Resources
College of Arts and Sciences	Environmental Studies	Alan Dickman, Peg Boulay, Kathryn Lynch	Interdisciplinary, participant in Advancement of Sustainable Living, the Ecological Design Center, the Environmental and Natural Resources Law Program, the Institute for a Sustainable Environment, interns through the Environmental Leadership Program
	International Studies	Department Head Anita Weiss	International development, culture and globalization, environmental issues, cross-cultural communication
	Political Science	Department Head Pricilla Southwell	Political Economy, international relations
	Material Science Institute	Director Richard Taylor	Research on the structure and properties of materials; industrial internship program
	Solar Energy Center	Director John Duncan Jr.	Solar energy infrastructure design
The Lundquist College of Business	Innovation and Entrepreneurship/ Technology Entrepreneurship	Interim Managing Director, Randy Swangard	Flagship programs of the Office of Technology Transfer; Collaboration with UO's Law School, and Battelle's Pacific Northwest National Laboratories. TEP fellows perform market assessment and feasibility studies on emerging patented technologies

School	Program	Contacts*	Resources
	Center for Sustainable Business Practices	Managing Director Tom Osdoba	Creative solutions for reverse logistics and product take-back, life-cycle analysis, organizational change, measurement and customer segmentation; consultation and student interns
	Decision Science	Nagesh Murthy	Sustainable supply chain management
	Accounting, Marketing and Administration	Doug Wilson	Expertise in high tech industries
The Office of Technology Transfer		Donald Gerhart and Chuck Williams	Support for development, licensing and use of intellectual property and all aspects of technology Transfer

*Contact information can be found by following this link on the University of Oregon's website: <http://www.uoregon.edu/findpeople>

1.) University of Oregon Research Centers and Institutes

As well as academic departments, research institutes, and practicum programs, the University of Oregon can contribute to OTREC's Electric Vehicle Initiative in several other areas. The UO is establishing a reputation as an internationally competitive institution in industry and trade as well as in education. This enables the university to promote itself as an Oregon job creator.

a.) Center for Advanced Materials Characterization in Oregon (CAMCOR)

“CAMCOR is a full-service, comprehensive materials characterization center at the University of Oregon open to outside clients. The Center for Advanced Materials Characterization in Oregon (CAMCOR) facilities provide enabling infrastructure for research in chemistry, geology, archaeology, nanoscience, materials science, bioscience, and optics. CAMCOR houses capital-intensive equipment for microanalysis, surface analysis, electron microscopy, semiconductor device fabrication, as well as traditional chemical characterization. The staff members who run the facilities are expertly trained and highly experienced in sample preparation, data collection, and data analysis. In addition, they periodically offer workshops to provide hands-on training for users of the facility.”⁷⁹

b.) Community Service Center (CSC)

The Community Service Center is an interdisciplinary organization that assists Oregon Communities by providing planning and technical assistance to help solve local issues

⁷⁹ CAMCOR, Oregon's High Tech Extension Service. Web. 3 June 2012. <<http://camcor.uoregon.edu/>>

and improve the quality of life for Oregon residents. The role of the CSC is to link the skills, expertise, and innovation of higher education with the economic development and environmental needs of communities and regions in the state of Oregon, thereby providing service to Oregon and learning opportunities to the students involved.⁸⁰

c.) Computational Science Institute (CSI)

Computational Science is a multidisciplinary field that combines research in the physical sciences with work in applied mathematics and computer science. There are several faculty and graduate students in the department involved in computational science-related projects such as bioinformatics, parallel computing, and software tools for computational science.⁸¹

d.) Institute for Policy Research and Innovation (IPRI)

The Institute for Policy Research and Innovation is a source of ideas and energy for supporting and nurturing Oregon's rich tradition of innovation in public policy. IPRI emphasizes policy-relevant research, creating and disseminating knowledge about classes of problems or issues.⁸²

e.) Materials Science Institute (MSI)

The purpose of the Materials Science Institute is to study the structure and properties of materials, to educate in the sciences of materials, and to serve Oregon as a resource in these sciences. Since 1985 MSI has more than tripled the size of its research

⁸⁰ Community Service Center. University of Oregon. Web. 3 June 2012. <<http://csc.uoregon.edu>>

⁸¹ Computational Science at the University of Oregon. Web. 3 June 2012. <<http://www.csi.uoregon.edu>>

⁸² The Institute for Policy Research and Innovation. Web. 3 June 2012. <<http://ipri.uoregon.edu>>.

program, developed four new graduate programs in materials, and contributed to the State's prosperity through collaboration with more than 25 Oregon companies.⁸³

f.) UO Office of Technology Transfer

UO allocates significant resources to developing partnerships with the business community through research, and also through the Office of Technology Transfer (OTT). The goal of OTT is to “make targeted use of intellectual property rights to advance the uptake of UO innovations.” They do this by forming working relationships during the research and development phases of a project, and then by providing licenses, permissions and guidance to businesses that want to gain the intellectual property rights to UO innovation. During an interview last spring, Associate Vice President for Research and Innovation said that the Office of Technology Transfer provides help with a wide variety of innovative business supports, from providing basic research to applying new technologies to existing businesses. “We are here to help—not just to ensure compliance.” As an educational institution, OTT exists to teach both students and industry how to develop and use new technologies.

E. Portland State University (PSU)

This section of the mapping research and the section on Portland State University was provided by John MacArthur, Research Associate for OTREC and the initiator of this study.

⁸³ The Material Sciences Institute. Web. 14 April 2012. <<http://materialscience.uoregon.edu>>

Home to six centers making contributions to the advancement of sustainable transportation research and implementation of cutting-edge technology and innovations, Portland State University supports a wide breadth of individual researchers. Many of these individuals are located in the Maseeh College of Engineering and Computer Science (MCECS) and the College of Urban + Public Affairs (CUPA). Namely, the Department of Civil and Environmental Engineering at MCECS and the Toulan School of Urban & Regional Planning at CUPA each respectively house seven and eight individual transportation-focused researchers. Seven of these individuals are part of the Center for Transportation Studies at the Toulan School and four participate in Sustainable Transportation Systems research projects through the University's Institute for Sustainable Solutions (ISS). The Toulan School is a home to the Initiative for Bicycle and Pedestrian Innovation, where two faculty advance bicycle and pedestrian transportation research and practice.

Within MCECS, an additional fourteen researchers in the Departments of Civil and Environmental Engineering, Computer Science, and Electrical and Computer Engineering making contributions to transportation research. The Toulan School is home to another nine faculty researchers working on projects that inform sustainable transportation.

Within CUPA, four faculty members in the Hatfield School of Government and three in the School of Community Health do research that informs sustainable transportation systems.

Across the University, the College of Liberal Arts and Sciences hosts twenty-five researchers in ten departments conducting research related to sustainable transportation. The Department of Architecture in the School of Fine and Performing Arts hosts three faculty members working on ways to improve urban and community design to promote sustainable transportation. The School of Business Administration houses four researchers contributing to sustainable transportation systems. Systems Science and the School of Social Work each host two faculty members who work on research that could further sustainable transportation.

1.) The Portland State University's Electric Urban Mobility Initiative (EUMI)

The Portland State University's Electric Urban Mobility Initiative (EUMI) is a broad-based effort to examine and shape the future of sustainable urban mobility by exploring the nexus of energy, transportation, the built environment, and human behavior. It takes advantage of the collective expertise of Portland State University and its national and regional partners and builds on the widely-recognized reputation of the Greater Portland region as an innovator in sustainable urban development. It also capitalizes on the strong interest shown by auto manufacturers and electric transportation infrastructure developers in tapping into the unique experience and branding of the Northwest demographic.

Cities in U.S. are growing at an unprecedented rapid rate. Urban population has exploded to about 85% of the country's total and the Portland Metro Region is expected to gain about 1 million people by 2030. This translates into expanding but denser cities. Given the difficulties and high costs of updating the urban infrastructure, these factors

pose a real mobility challenge for today and for the future. This poses significant challenges for the region to maintain a high quality of life and an economic prosperity while meeting social and environmental goals.

EUMI explores timely questions about consumer behavior, grid integration, and vehicle use and performance. It serves the region by identifying, field-testing, and generalizing knowledge about the practicality of promising mobility strategies, technologies, services, and approaches related to electrification, low-carbon lifestyle choices, and economic development.

EUMI employs a ‘living laboratory’ approach where faculty, students, and their research partners can use local settings and organizations to intelligently deploy, measure and interpret how EVs are used in urban (and urbanizing) regions. These investigations are intended to lead to pragmatic policy and technical guidance at the local, state and national level, to help address questions of transportation electrification and the development of an integrated mobility system within a nested series of smart electric grids of different scales.

The Initiative is building PSU’s research capacity to plan for, field test, evaluate and report on transportation electrification. PSU has an unusually strong interdisciplinary core of investigators actively engaged in sustainable transportation, renewable energy and built environment research, including faculty in engineering, business, urban studies and planning, architecture, computer science, social sciences, and policy. EUMI offers a unique opportunity to focus all of this expertise toward a time-sensitive, socially critical and economically vital set of questions.

Our intent is for EUMI to be collaborative and cross-disciplinary, drawing on various public and private partnerships to deliver research, exchange information, educate, and train. The results from research will directly benefit a wide range of entities from cities and urban planners to utilities to vehicle OEMs.

Given the current state of the field and the expertise at PSU and its partners, emerging areas of focus include:

- Integration of infrastructure systems with the built environment;
- Potential markets, vehicle use and user behavior; and
- Evaluation, including societal and lifecycle environmental impacts.

Information about Portland State University programs is presented in Appendix C.

2.) Research Agenda

There are several research areas for PSU to move forward on quickly, to take advantage of some timely opportunities:

Integration with the Built Environment

- Renewable energy storage and systems
- Grid capacity and connections
- Infrastructure planning and modeling
- Charging methods and infrastructure evaluation
- Urban form and design of stations and parking
- Communications and IT Support
- Vehicle and infrastructure performance, including fleets

Markets, vehicle use & consumer behavior

- Market surveying and analysis
- Driver behavior and use
- Consumer demand analysis
- Use and behavior evaluations

Evaluation

- Economic and environmental analysis
- Governance and policy analysis

3.) Portland State's Expertise

Portland State University (PSU) has a national reputation as a university focusing on transportation and land use studies. PSU has an unusually strong interdisciplinary core of investigators actively engaged in sustainable transportation, renewable energy, and built environment research, including faculty in engineering, business, urban studies and planning, architecture, computer science, social sciences, and policy. Faculty are actively engaged in local, national, and international research issues that affect the national transportation system. PSU is committed to research excellence as well as improved experiences for undergraduate students through research.

The PSU faculty expertise in the following areas:

- Travel Behavior
- Transportation and Land Use Interactions

- Transportation and Land Use Modeling
- Transportation and the Environment
- Non-motorized Transportation
- Transportation Finance and Pricing
- Transportation and Land Use Planning

This expertise forms the foundation of The Portland State University's Electric Urban Mobility Initiative, which is a broad-based effort to examine and shape the future of sustainable urban mobility by exploring the nexus of energy, transportation, the built environment and human behavior.

4.) The Faculty and Staff

PSU's Transportation group is primarily made up of faculty Civil and Environmental Engineering Department and the School of Urban Studies and Planning. Presently, the key transportation faculty members are:

- Jennifer Dill, Urban Studies & Planning
- Kelly Clifton, Civil & Environmental Engineering
- Miguel Andres Figliozzi, Civil & Environmental Engineering
- Roger Chen, Civil & Environmental Engineering
- James Strathman, Center for Urban Studies and Urban Studies & Planning
- Christopher Monsere, Civil & Environmental Engineering

- Kristin Tufte, Computer Science and Civil & Environmental Engineering
- John MacArthur, OTREC

Transportation electrification is just one aspect of PSU's effort to understand, guide, and lead innovation regarding urban mobility. Other efforts are underway at these entities:

- The Oregon Transportation Research and Education Consortium (OTREC) is the National University Transportation Center (UTC) at Portland State University, in partnership with OSU, UO, and OIT.
- Intelligent Transportation Systems (ITS) Laboratory
- Oregon Modeling Collaborative
- Center for Urban Studies and Center for Transportation Studies
- Initiative for Bicycle and Pedestrian Innovation (IBPI)

5.) *Ongoing efforts*

The Portland metro region is positioned to be the leading U.S. launch market for electric vehicles. A strategic alliance between Portland General Electric (PGE) and Portland State University has been created in support of a common vision: The Portland region as a leader in developing and implementing urban sustainability. Currently the partnership focuses on two main areas: *urban mobility*, and *the integration of energy and sustainable design*.

PSU and PGE have already worked together on planning for deployment of electric vehicles, by sponsoring three EV Road Map conferences and other events convening industry, government, and academic leaders. This strategic alliance will grow through the Electric Urban Mobility Initiative and will directly focus on specific research projects, such as urban freight, consumer behavior, intelligent vehicle systems and the effect of electrification on the electrical grid in a living laboratory.

Additionally, PSU has a firm relationship with Toyota Motors, which has brought ten Plug-in EV Prius vehicles to Oregon for a demonstration project in which PGE is a partner.

PSU's expertise in travel behavior and modeling can be applied to the adoption of EVs to develop an understanding of what the drivers are that cause people to choose vehicles. This information will be extremely valuable to cities planners, utilities, and vehicle manufactures as EV infrastructure is developed.

6.) Proposed Research Projects

1. How do households adjust their travel behavior (trip frequency, length, destinations, trip chaining, vehicle substitution, and purpose) in response to the introduction of EVs? The introduction of new vehicle technologies is likely to induce changes in patterns of vehicle use and travel, based upon the new capabilities and limitations (both real and perceived). Understanding consumer response to these new vehicles is critical in understanding the impacts on travel demand, congestion, emissions, and the location of charging stations. While extensive data collection efforts

will be underway to monitor how the test vehicles are used, this information becomes more valuable when married with information about current travel patterns. The ability to mark these changes would then permit adjustment of current travel demand models and more realistic estimates of the future impacts of adoption of these vehicles.

2. How are EVs used in different urban environments? Given that the urban structure varies tremendously across and within metropolitan areas, one would assume that the patterns of EV use might vary across different urban configurations. For example, Portland, OR has a more compact urban form due to state and regional growth controls. The higher density and compact urban form brings origins and destinations closer together, supporting the use of alternative modes, and facilitating local trips. Houston, TX, on the other hand, has low-density, auto-oriented development resulting in different trip patterns. With EVs being tested in several metropolitan areas, the question of whether some urban forms support EV technologies more than others will be addressed. This research will provide urban planners with important information about how their future planning efforts better incorporate EVs into long range land use and transportation plans.
3. Where should charging stations be located? The information from research problem statements in 1) and 2) can shape the facility planning for vehicle charging stations. Better information about vehicle travel

patterns and use and the influence of urban form combined with vehicle performance information can form the basis of planning for the number and spatial distribution of these charging stations across the urban landscape.

4. How will commercial fleets adopt the new vehicle technology? The goal of this research proposal is to develop models that can represent economic, emissions, and logistics tradeoffs brought about by electric, electric-hybrid, and increasingly *heterogeneous* commercial vehicle fleets in urban areas. The fundamental research questions of this proposal are:

- (1) What are the key logistics and service constraints that may hinder the adoption of new commercial vehicle engine/fuel technologies in urban areas?

- (2) How to develop mathematical models that incorporate new engine/fuel technology idiosyncrasies in routing and customer service area modeling? and

- (3) How can we quantify the emissions and energy benefits (and costs) of new electric/hybrid commercial vehicles in urban areas? What are the appropriate levels of fiscal incentives?

F. Oregon Institute of Technology

This section of the mapping research and the section on Portland State University was provided by John MacArthur, Research Associate for OTREC and the initiator of this study.

Over the past eight years, professors and students from the Mechanical Engineering, Electrical Engineering, Computer Engineering Technology, Embedded Systems Engineering Technology, and Software Engineering Technology programs have been working on collaborative projects related to the design and construction of human power/gasoline/electric hybrid vehicles. Interest in these projects and technologies is growing. The planned expanded involvement of OIT in the Transportation Electrification Initiative gives OIT faculty the opportunity to further develop and expand on course content and projects directly related to electric vehicles and their integration into a supporting utility infrastructure. Expansion of transportation-based projects and programs will reach into Renewable Engineering, Civil Engineering, Mathematics, Business, Marketing and Applied Psychology. Information about Oregon Institute of Technology programs is presented in Appendix C.

1.) Current Assets

OIT has several programs and supporting facilities to draw upon for the Transportation Electrification Initiative. Programs at OIT are centered on a hands-on, laboratory/practical experimentation approach where students and faculty spend more time working on laboratory-based and project driven activities than in lecture settings. This mode of teaching requires strong laboratory facilities and a good experimental

equipment base. Each of the involved programs has dedicated laboratory space to bring to service in the project-based learning in support of the initiative.

a.) Electrical Engineering Laboratories

The EE program has several laboratory spaces dedicated to experimentation, study, and development of electrical systems. These laboratories are populated with scopes and test benches targeted at design and construction of complex electrical systems.

b.) Mechanical Engineering/Manufacturing Laboratories

The ME/Mfg programs have several laboratory space dedicated to the analysis, design, and fabrication of mechanical systems. This includes materials testing, CAD, and a full line machining devices including CNC. The ME/Mfg laboratory asset at OIT gives students and faculty the ability to fabricate all designed parts for use in construction of new vehicle assemblies.

c.) Computer Engineering/Embedded Systems Engineering Laboratories

The CET/ESET programs have four laboratories revolving around the analysis, design, and construction of digital electronic systems. Each laboratory is fully equipped with bench power supplies, digital oscilloscopes, and logic analyzers. There is also equipment available for the prototyping of multilayer PCB. One of the laboratories is fully instrumented for the design and development of System on a Programmable Chip (SOPC) supporting both ASIC and FPGA development.

d.) Software Engineering Laboratories

The SET program has four laboratories dedicated to analysis and development of software systems scaling from small, single purpose, embedded systems to large-scale enterprise systems. Each lab has a full range of compilers supporting development using C and C++ languages. One of the labs is special-purposed for enterprise database development. A second of the four labs is special-purposed for operating systems and network communications development.

e.) Shared Laboratory – Oregon Renewable Energy Center

The Oregon Renewable Energy Center at Oregon Institute of Technology in Klamath Falls, provides a shared laboratory space containing various tools, benches, and secured enclosures. OREC has been an ongoing sponsor of faculty/student projects acting as a project resource facilitator and enabler. OREC also has a Sparrow electric vehicle as an applied research platform. The mission of OREC fits nicely in with the goals of the Transportation Electrification Initiative.

2.) Opportunities

The current Transportation Electrification Initiative provides resources to increase projects and curriculum related to electric vehicles and their deployment. The primary goal is to increase student involvement in hands-on projects related to electric vehicle development and deployment. OIT is currently the custodian of three grants that

provide synergistic resources with the Transportation Electrification Initiative. The three grants are:

DOE Smart Grid – This is a ~2.5M grant from the DOE targeted at development of curriculum and labs related to smart grid technologies.

Oregon BEST Green Lite Commercialization – This grant of \$73,000 has funded unification of the Green Lite Hybrid Vehicle propulsion systems into a simple control scheme providing a rich platform for control algorithm testing and performance enhancement.

OTREC Green Lite Vehicle Commissioning – This grant for \$136,000 is targeting further testing and commissioning of the Green Lite Hybrid Vehicle. A portion of this grant will go toward the purchase of a dynamometer for use in testing performance of the Green Lite Vehicle.

OIT is positioned to enhance current vehicle related applied research assets with equipment targeted at transportation electrification, specifically electric vehicles. The three grants mentioned above have provided facilities and faculty for use in smart grid, controls, and vehicle development. The opportunity now open to OIT as an institution is in the area of applied research for battery technology in battery charging, discharging, utilization as an energy resource in the grid, and integration of smart grid technologies into vehicles – standard internal combustion, gas/electric hybrid, and electric.

3.) Faculty and Administration

OIT has several faculty and staff interested and actively involved in vehicle related projects and educational opportunities. Following is a list of current faculty and

administrators directly involved in vehicle related projects and has interested in further involvement in the Vehicle Electrification Initiative.

Professor James Zipay	Electrical Engineering/Renewable Energy Engineering
Professor Hugh Currin	Mechanical Engineering
Professor Brian Moravec	Mechanical Engineering
Professor Rodger Lindgren	Civil Engineering
Professor Xin Wang	Electrical Engineering/Renewable Energy Engineering
Tom Chester	Oregon Renewable Energy Center
Linda Riley	Oregon Renewable Energy Center

4.) Projects in Progress

For the 2011-2012 academic year, several student/faculty projects began in direct support of the vehicle electrification initiative. These projects are cross-discipline collaborations involving students from electrical engineering, renewable energy engineering, mechanical engineering, embedded systems engineering, and software engineering. Each project will be a three-term effort.

a.) Vehicle to Grid

In conjunction with a DOE Smart Grid grant, work is being started to explore the technology behind utilizing the battery storage in electric vehicles as potential storage capacity for peak load utilization by electric utilities. Software and communication

systems will be explored and projects specified with the intent of interfacing electric vehicle systems with the electric utility grid. This will be a student project involving cross-discipline activities in the electrical engineering, renewable energy engineering, embedded systems engineering, and software engineering.

b.) Hybrid Vehicle Test

OIT received an OTREC grant for the 2011-2012 academic year revolving around the commissioning of the GreenLite Motors flagship vehicle. This is a high mileage commuter vehicle targeted at urban and suburban commute zones. A project has been undertaken to develop the vehicle tests for this gas/electric hybrid platform and designate and define protocol for data gathering, analysis, and dissemination. This will be a project involving mechanical engineering, embedded systems engineering, and software engineering students.

c.) Vehicle Telematics

Wireless networking and cell phone system allow the remote transmission of data related to vehicle health, performance, and geo-location. This data can be aggregated allowing analysis of traffic trends, areas of congestion, as well as geo tagging of charging stations. Students are working on a system allowing the transmission of vehicle borne data to a centralized repository where it may be further analyzed.

d.) Hybrid Gas-Electric Vehicle Control Systems

The GreenLite Motors platform is providing a unique opportunity to work directly on applied research revolving around the control algorithms for gaining the most efficient use of vehicle energy resources. Different control algorithms will be implemented in the GreenLite vehicle and studied through the Hybrid Vehicle test environment. This has involved student in software engineering, embedded systems engineering, and applied mathematics.

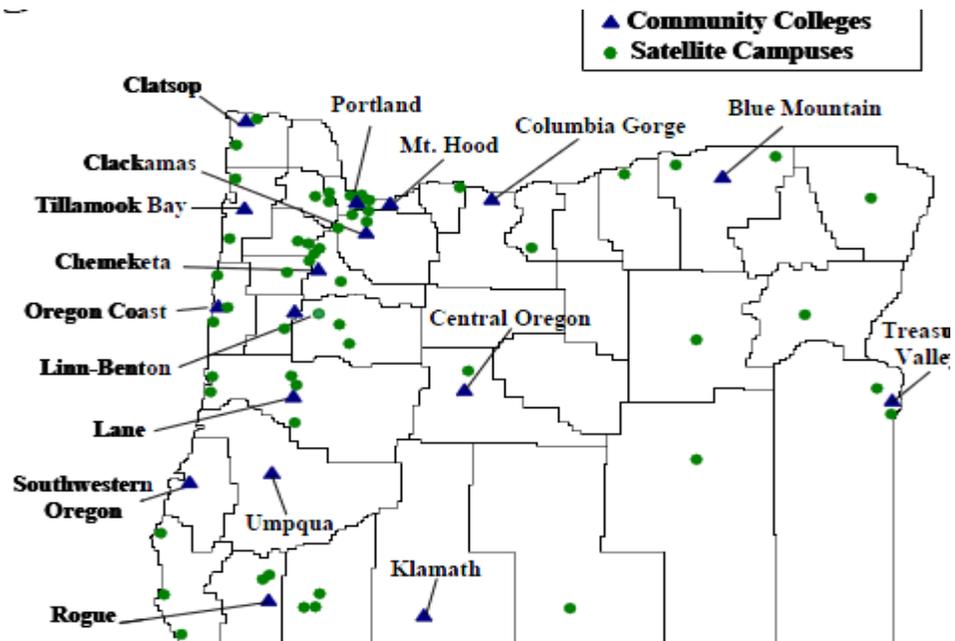
e.) Vehicle Internetworking and Security

Vehicles in a wireless Internet enabled society are key targets for hacker attacks and Internet mischief. Applied research will be done related to internal and external vehicle communication protocol standards. A reference implementation will be developed for creation of a secure, internet-enabled vehicle environment.

G. Oregon's Community Colleges

Oregon has community colleges in most counties throughout the state. Figure 5.2 shows where they are placed.

Figure 5.2. Community Colleges in Oregon



Source: Community College Profile, 2009-2010, Community Colleges and Workforce Development, Worksource Oregon

Because of the emphasis on vocational training and skill development, Oregon Community Colleges have much to offer to the EV initiative. The *New York Times* wrote, “The federal government is pouring \$500 million into training for green jobs, and the sector devoted to energy efficiency is estimated to grow as much as fourfold in the next decade, to some 1.3 million people, according to the Lawrence Berkeley National Laboratory.”⁸⁴

Oregon Community Colleges are on the cutting edge of green industry training; however they are not organized under an association like the Oregon University System. Each college is an independent entity. That said, the Oregon Department of Community

⁸⁴ Olson, E. Community College Training for Managing Green Jobs. *New York Times*. New York, NY. F8, 26 August 2010. Print <<http://www.nytimes.com/2010/08/26/education/26GREEN.html>>

Colleges and Workforce Development (ODCCWD) offers liaison support with the development and implementation of federal grants, and

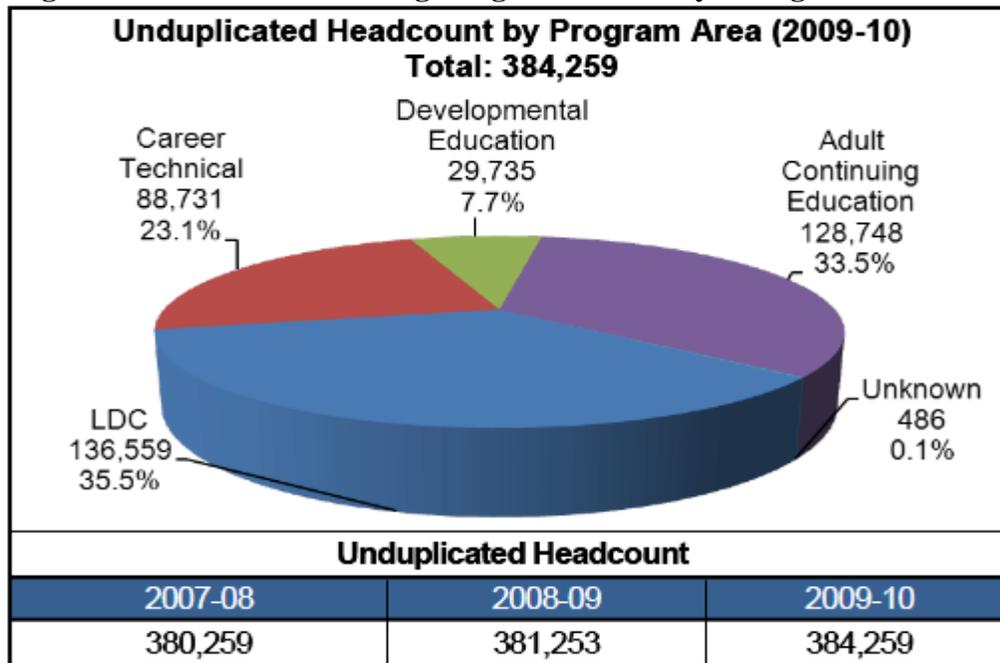
- Distributes state aid to community colleges
- Approves new programs and courses
- Adopts rules for the general governance of community colleges
- Organizes annual performance measures.⁸⁵

In line with the Governor's focus on collaborative planning around the EV industry, it would not be a stretch to include the ODCCWD in the OTREC Consortium, particularly in light of the number of workers and the amount of financial resources that are engaged by community colleges. ODCCWD could potentially organize community colleges to invest more in developing skilled workers for the EV industry.

The scope of this project does not include an in-depth assessment of community college resources in Oregon; however, it is instructive to consider a few examples. There are 17 community colleges in Oregon with 60 campuses. Eleven of the colleges have automotive programs. Because of the access to students, most of whom are interested in career and technical skill development on adult continuing education, setting up EV training programs would quickly create a workforce. Figure 5.3 shows the types of education being accessed by Oregon community college students.

⁸⁵ Department of Community Colleges and Workforce Development. 11 Jan. 2012. Web. <http://www.oregon.gov/CCWD/about_us.shtml>

Figure 5.3. Students Attending Oregon Community Colleges



Source: Community College Profile, 2009-2010, Community Colleges and Workforce Development, Worksource Oregon

Here is a sampling of how aware they are and how they are responding to electric vehicles entering the market.⁸⁶

1.) Chemeketa Community College

4000 Lancaster Drive

Salem, OR 97309-7070

Website: <http://www.chemeketa.edu>

Contact: Glen Miller, Dean, Applied Technologies

⁸⁶ Oregon Community College Viewbook, Oregon Department of Community Colleges and Workforce Development. Web. 4 June 2012. < http://www.oregon.gov/ccwd/Pages/pub_rpts.aspx >

Chemeketa Community College has set a goal to positively impact sustainability literacy within its service district. The college has institutionalized a Sustainability Advisory committee and has created a plan. By the year 2015, thirty percent of Chemeketa's courses will have integrated "green" or sustainability concepts into the curriculum. Included is the requirement that all new fleet vehicles and motorized campus equipment purchases must produce less carbon emissions than the vehicle or equipment being replaced. Examples are alternative fuel, electric or hybrid.

The following link goes to Chemeketa's Automotive Program and provides a list of the courses offered. The college offer's an Associate's Degree in Automotive Technology which includes curriculum that touches on electric vehicles and provides a course in advanced electronics and one in fuels.

<http://www.chemeketa.edu/programs/automotive/courses.html>

Dean Glen Miller said that the department is delving into battery reconditioning for hybrid batteries and developing new curriculum. Chemeketa has recently hired a new faculty member, Sam Olheiser, who will teach courses on alternative fuels, hybrids, and electric vehicles. The department also works closely with the electronics and electrical engineering programs.

The only thing holding the Automotive Department back from dramatically expanding into electric vehicle maintenance and repair is the lack of funding. Dean Miller recognizes that these skills are becoming increasingly needed in the field.⁸⁷

⁸⁷ Miller, G. Personal interview. Chemeketa Community College, Salem, Oregon. 9 Jan. 2012 Phone.

2.) *Lane Community College*

4000 East 30th Avenue, Eugene, OR 97405

Office: Bldg 12 Room 120D

Phone: (541) 463-5389

Email: riordone@lanecc.edu

Contact: Egan Riordon

Lane Community College is located in the City of Eugene, which itself has an ambitious agenda for creating “green jobs” and adopting sustainable technologies. Lane offers several applied sciences degrees in the green arena, including energy management, renewable energy and water conservation, and they have aggressively gone after funding to support expansion in this area. In 2009, they won an \$890,000 federal workforce grant, beyond the stimulus funds that were awarded.⁸⁸

Egan Riordan, faculty member of the Automotive Technology Department is eager to expand into electric vehicle technology. Automotive Tech is part of the Advanced Technology Division, which also houses the Sustainability Management Program. LCC has installed its own charging station and according to Riordan, lack of focused interest and a point person pushing for EV expansion are the barriers to developing specific curriculum for electric vehicles.

⁸⁸ Olson, E. Community College Training for Managing Green Jobs. *New York Times*. New York, NY. P. F8, 26 August 2010. Print. <<http://www.nytimes.com/2010/08/26/education/26GREEN.html>>

3.) *Linn-Benton Community College*

Greg Hamann, President of Linn-Benton Community College attended the Governor's Regional Solutions Meeting in September of 2011, and spoke about LBCC's readiness to partner with industry to spur economic development. He mentioned that the college was working on an Advanced Transportation Technology Center. John McArdle, Linn-Benton Development Director, later indicated during a conversation that LBCC was cultivating a relationship with Nissan and had an interest in training workers to meet the needs of EV consumers and dealerships. The current automotive program is sponsored by Snap-On.

4.) *Mount Hood Community College*

26000 SE Stark St Gresham, OR 97030

503-491-7130

Room IT 53

Contact: Bob McDonald, Faculty Advisor

Bob.McDonald@mhcc.edu

Mount Hood's goals are ultimately to prepare students for jobs and their mode of operating has been to train students according to the needs of particular companies in order to do this. In a phone interview, Bob McDonald pointed out that the Automotive Technology Program at Mt. Hood Community College is almost entirely focused on the requirements of the manufacturers who provide funding, internships, equipment, and vehicles to work on.

- The Chrysler's **College Automotive Program (CAP)** provides students with a unique opportunity to earn income while being trained as service technicians for Chrysler, Dodge & Jeep manufacturer's current and future vehicles.
- The **Ford Automotive Student Service Educational Training (ASSET)** is an Associate of Applied Science degree curriculum designed to provide technically competent, professional level technicians for Ford dealerships. Mt. Hood Community College is offering this opportunity in partnership with the Ford Motor Company. While most students will be from the metropolitan area, residents from throughout the state will be included.
- The **Honda Professional Automotive Career Training (PACT)** provides students with a unique opportunity to earn income while being trained as service technicians for American Honda Motor's Acura and Honda dealerships.
- The **Individualized Mechanical Program Of Repair Technicians (IMPORT)** provides students with a unique opportunity to earn income while being trained as service technicians for Acura, Audi, Bentley, BMW, Honda, Hyundai, Isuzu, Jaguar, Lexus, Mercedes Benz, Mitsubishi, Nissan, Porsche, Rolls Royce, Saab, Subaru, or Volkswagen manufacturers' current and future vehicles.⁸⁹

While this model is generally beneficial to all parties, it makes it difficult for Mt. Hood to develop new program areas that are not sponsored by a corporation. For the college to include electric vehicles in its training courses, it would need to have an EV manufacturer step into a sponsoring role similar to the Chrysler, Ford, and Honda

⁸⁹ Information copied from <http://www.mhcc.edu/AutomotiveTechnology.aspx?id=1692>

corporations. The industry hasn't grown enough to be able to make that happen. There are plans to create electric vehicle curriculum, however, and the first step will be a class on hybrid battery testing. Mr. McDonald noted that California DOT offered a grant to fund EV training last year, and he felt that could help in Oregon.

Concluding from the informal discussions with these four community colleges, it seems that there is fruitful ground for coalition-building and a desire for developing a skilled workforce to address the needs of EV retailers and consumers. What is needed is a focused strategy for organizing the colleges and developing clear plans for funding, curriculum development, and making connections with employers.

CHAPTER VI

THE RESULTS OF THE NEEDS ASSESSMENT

Drive Oregon estimates that there are over 40 businesses in the state that are focused on electric vehicles and many more that provide supportive goods and services. According to the membership listed on their website (<http://driveoregon.org/membership/>), the majority of these businesses are located along the I-5 corridor.

This chapter presents the results of a needs assessment survey that was administered online to members of the Drive Oregon (DO) and Oregon Electric Vehicle Association (OEVA) mailing lists. The University of Oregon's Community Planning Workshop (CPW), in collaboration with the Oregon Transportation Research Education Center (OTREC) and Oregon (DO) developed this survey to better understand the needs of businesses involved in Oregon's emerging electric vehicle industry. The results are intended to inform the consortium as it develops strategies to promote industry growth.

The survey was administered in the spring and early summer of 2011 via the online survey portal "Survey Monkey." A link to the survey was emailed to 119 members of the Drive Oregon Google Group and 308 members of the Oregon Electric Vehicle Association.⁹⁰ We received 45 valid responses.

⁹⁰ The Oregon Electric Vehicle Association (OEVA) is a non-profit association of electric vehicle enthusiasts. They promote electric vehicle education and encourage their safe construction and use. They are a chapter of the Electric Auto Association. <http://www.oeva.org/about/>

The survey was not, nor was it intended to be, a random sample survey. The method of administering the survey is what is sometimes called a “convenience” sample. A convenience sample is a sample that is taken because it is convenient to the researcher. In this instance, we targeted individuals who were either in industries that are related to EVs (Drive Oregon) or individuals who are knowledgeable about EVs (OEVA). The survey is intended to identify key issues and opportunities—an objective that does not necessarily require a random sample methodology.

The survey inquired about the type of EV businesses the respondents were involved with, and what stage of development they had attained. Respondents were asked to identify barriers they were encountering in growing their business and what resources could help them move forward. There were questions concerning access to capital, state infrastructure supports, and university research, laboratory and testing facilities. The survey also asked specific questions about the role that OUS and Drive Oregon could play and provided a number of opportunities for the respondents to give feedback on issues that weren’t addressed by the survey.

A. Characteristics of Survey Respondents and Responses to the Survey

Respondents to the survey were self-selected members of the above-mentioned organizations. The Drive Oregon Google Group is available to those people who sign up during the quarterly membership meeting of Drive Oregon. Many, but not all of the Drive Oregon group participants are business owners, however many of them are working in government agencies, research laboratories, university positions, or just have an interest in electric vehicles. The Drive Oregon website provides profiles of many of

the member businesses and this list can generally be taken as profile of the entrepreneurs who responded to the survey.

The Oregon Electric Vehicle Association (OEVA) is a chapter of the Electric Auto Association and posts news, holds meetings and events with electric car enthusiasts, and maintains a lending library of EV tools. It is not a business organization, but rather, a collection of EV enthusiasts.

The results that follow are presented in the order the questions were asked on the survey. For each result, we state the question and provide the question number in parenthesis. A copy of the survey instrument is included in Appendix A. Written comments provided by respondents are included in Appendix B.

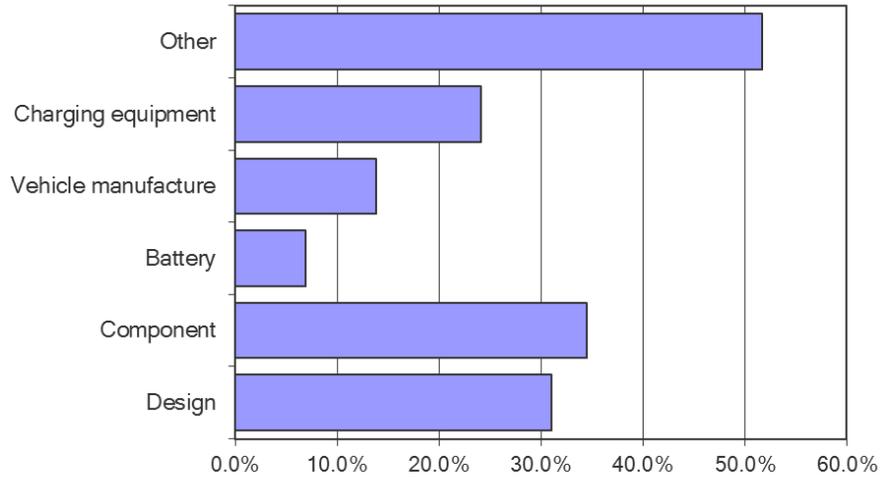
1.) Identifying the Respondents

The first series of questions in the survey identified the characteristics of the respondents. Question 1 asked, “Do you represent an EV business?” and Question 2 asked, “What is the nature of your business?” Of the 45 participants, 21 (48.8%) indicated that they were actively running small EV related businesses, 21 (48.8%) said they were not.

Figure 6.1 shows the types of businesses represented by survey respondents. The survey question allowed respondents to choose more than one answer. Only 14% are manufacturing vehicles, while 65.5% are involved with charging equipment and components. Design was included in the businesses of 31% and over half (52%) marked “other.” Those who marked “other” listed supportive goods and services including

media, consulting, investment, software, photovoltaic, aviation, military, and government work.

Figure 6.1. What is the nature of your business. (Q-2)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

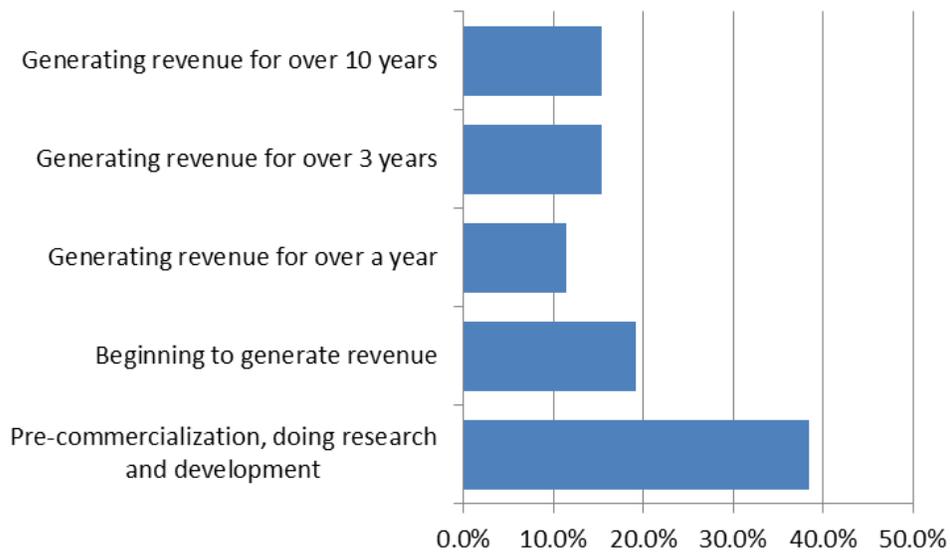
Note: responses add up to more than 100% because respondents could select multiple categories

2.) *Stage of Development*

The survey asked the respondents about the income their companies were generating as a way of identifying where the companies were in the stage of business development. The responses to this question show that the largest number of responding companies are at a very early point in their development with over a third focused on pre-commercialized research and development.

At later stages of development, nearly a third of those responding have been generating revenue for more than three years as shown by figure 6.2. This indicates that there is a significant need for support in helping these companies perfect their products and move their goods into the market.

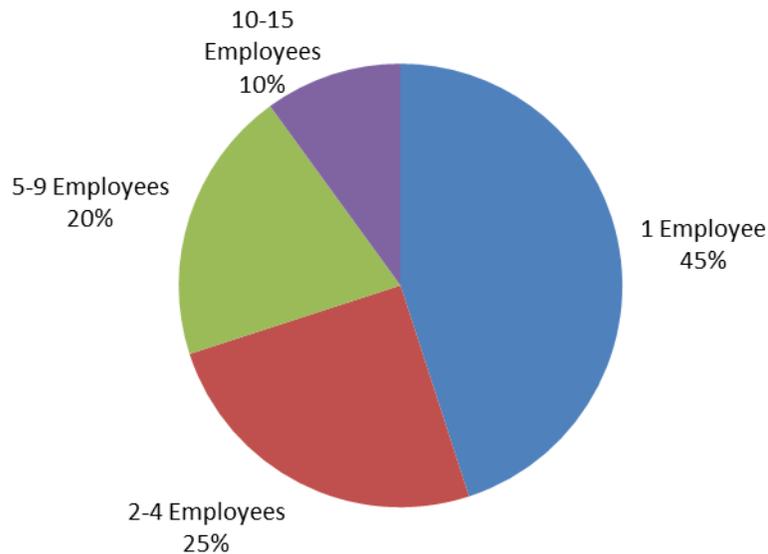
Figure 6.2. Please indicate the developmental stage of your business? (Q-3)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

The survey requested information about the number of people that were employed by the responding business. Corresponding to the developmental stage of the EV businesses, the survey shows a similar spread of the number of people employed by these businesses with 70% of the companies having only one or two full-time employees while the top 30% employ between five and twelve employees. This is demonstrated by the chart below, figure 6.3.

Figure 6.3. What is the approximate number of employees that work on EV-related business at your company? (Q-4)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

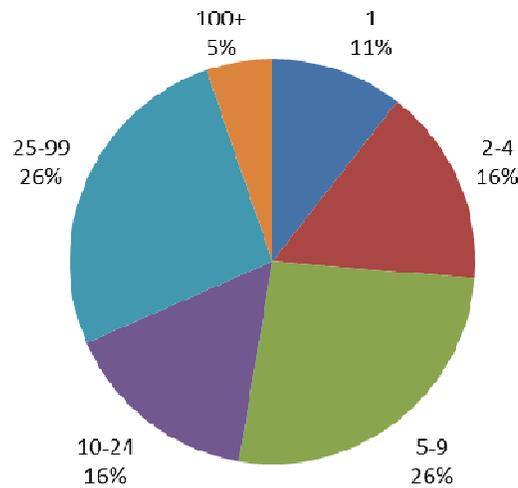
B. Preparing for the Future

1.) Expectations of Growth

The next set of questions looked at how optimistic entrepreneurs were about their potential for growth. Question 5 asked, “Assuming fairly strong growth, a reasonably receptive market and the collaborative support of Drive Oregon and the Oregon University System, what number of employees (measured in FTE) does you think you will have in 3 years?” While 16% of those who answered the question guessed that they would continue to generate three or fewer full-time equivalent positions, overall, the group of respondents thought that their businesses would grow nearly 600 percent in employment capacity during the next three years, implying that the group feels hugely optimistic. The top three companies believe they will be able to employ over 230 while

the group as a whole indicated an expected gain of 333 jobs overall. These responses are charted below in figure 6.4.

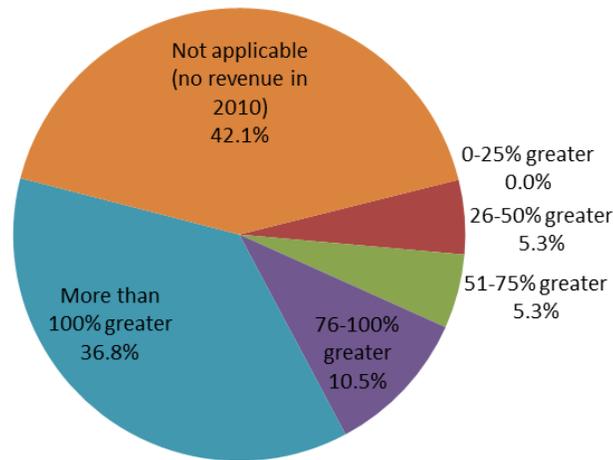
Figure 6.4. Assuming fairly strong growth, a reasonably receptive market and the collaborative support of Drive Oregon and the Oregon University System, what number of employees (measured in FTE) do you think you will have in 3 years? (Q-5)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

In Question 6, survey takers were asked, “If you had revenue in 2010, please compare your projected revenue for 2014 with your actual revenue in 2010.” Figure 6.5 shows that, consistent with positive expectations of employment growth, all of the respondents believe their revenues will grow a minimum of 26% over the next three years. Nearly 38% of the companies predict over 100% increase in revenues over three years.

Figure 6.5. If you had revenue in 2010, please compare your projected revenue for 2014 with your actual revenue in 2010. (Q-6)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Although it may be tempting to consider the anticipation of growth at such high levels as being wildly optimistic, it is worth noting that previous episodes of economic recovery have been carried by young firms creating new jobs. In the 2009 Kauffman Foundation article, “Where Will the New Jobs Come From?” the authors point out that since 1980, all of the net new jobs have come from firms that were less than five years old. Of the twelve million jobs created in 2007, eight million of them came from young firms.⁹¹

⁹¹ Litan, R. and Stangler, D. “Where Will All the New Jobs Come From?” *The Ewing Marion Kauffman Foundation*, November 2009. 2. Print. <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1580139>

2.) *Industry Support Needs*

The next series of questions were aimed at identifying gaps in resources and barriers that stand in the way of the Oregon EV industry as a whole, as well as the challenges for individual businesses. In Question 7 (Table 6.1), 42% of respondents gave their opinions when we asked, “What barriers are keeping the electric vehicle industry from growing in Oregon?” In Question 8 (Table 6.2), 40% of respondents provided written comments when asked, “What barriers are you facing in growing your company?” Both of these questions were intentionally left open-ended (i.e. respondents wrote in their responses) so as not to narrow the discussion to the conclusions OTREC and DO leadership had surmised from their specialized perspectives. Eighty-four percent of the EV entrepreneurs offered the following answers and several of the non-business owner participants chimed in.

Topping the list of barriers to industry growth for the respondents was the lack of accessible capital for business development (this was by far the highest ranked problem for individual businesses, although secondarily identified as a problem for the industry as a whole). Oregon has few venture capitalists interested in EVs, and loans, grants, and subsidies are not providing enough money to EV entrepreneurs for expanding their businesses. One respondent also pointed out there were few contract opportunities for Oregon EV companies. These barriers are ranked in table 6.1.

**Table 6.1. What barriers are keeping the EV industry from growing in Oregon?
(Q-7)**

Barrier	Number of Respondents	Percent of Respondents
Awareness (national, public) of true costs and benefits	7	37%
Capital	6	32%
Clear, Business & Consumer Friendly codes, tax incentives /state support	3	16%
Cost of vehicles	1	5%
Infrastructure support	3	16%
Ease of use and low price of gas	3	16%
Externalized costs of carbon	2	11%
Lack of a successful company	1	5%
Cost of batteries	1	5%
Lack of control over federal investment funds (DOE)	1	5%
Cars aren't mainstream/ aren't easily available	3	16%
Depressed economy	1	5%
Lack of inter-industry cooperation & collaboration	2	11%
Lack of realistic, outcome oriented strategies	1	5%
Export ability	1	5%
Lack of national awareness of Oregon capacity for development	1	5%
Lack of business growth knowledge and expertise	1	5%
Lack of skilled workforce	1	5%

Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Note: Approximately 40% of the respondents answered these questions. Approximately 60% did not offer their opinions. Numbers marked indicate the opinions of 19 participants.

The second hurdle named most frequently was the issue of awareness. Business owners felt that Americans in general are not aware of the benefits of electric vehicles, the advantages of EVs over internal combustion engines (ICE), their ease of use, and their availability. Supporting this concern, business owners cited the lack of EVs as mainstream considerations in personal transportation, the lack of EVs in car dealerships, and the lack of successful EV companies competing in the markets aimed at the majority

of transportation consumers. The fact that gasoline prices remain artificially low and that the costs of carbon emissions remain externalized exacerbate the awareness issue.

Consumers also have limited financial incentives to adopt EVs in Oregon and the lack of demand puts the onus on the EV industry to create demand. While the Federal government still offers tax rebates for purchasing electric vehicles,⁹² the Oregon Legislature eliminated the State tax credit for consumers during the last legislative session. The tax credits for businesses purchasing electric vehicle fleets will end in Oregon at the end of this year as well.⁹³

Several respondents cited the cost of EVs and batteries as barriers, and the loss of incentives will worsen this issue in getting EVs into the hands of mainstream car buyers.

The third ranked problem for EV expansion was the confusion of regulations, changing policies, codes, possible road use taxes, as well as the unclear tax credits and incentives. One respondent specified as problematic local and payroll taxes and requirements for base-rate wages that increase overhead. Joined with this is a perceived deficiency of support infrastructure and the lack of a realistic, outcome-based strategy to catapult the EV industry into the conventional market place.

⁹² Federal Tax Credits for Electric Vehicles. Web. 4 August 2011.
<<http://www.fueleconomy.gov/feg/taxevb.shtml>>

⁹³ EVs qualify for up to \$7500 in Federal tax credits; small, neighborhood electric vehicles don't qualify for this, but may qualify for other programs. Internal Revenue Service 27 July 2009. Web. 4 June 2012
<http://www.irs.gov/irb/2009-30_IRB/ar07.html>

Several respondents brought up issues of the lack of industry-wide cooperation and collaboration. They have the sense that everyone is acting on their own while trying to appear that they are part of “the group.”

Both in this survey and in the interviews that were conducted with subject experts, the difficulty in finding skilled workers came up several times. Despite Oregon’s employment problems, finding workers with experience in EV technology, or even with the basic skills and capacity for applying those skills to EVs, is difficult. These environmental barriers are listed in table 6.2.

Table 6.2. What barriers are you facing in growing your business? (Q-8)

Barrier	Number of Respondents	Percent of Respondents
Access to capital and seed funding	9	47%
Access to grants	1	5%
contract opportunities	1	5%
marketing needs/market development	3	16%
consumer demand and incentives; consumers need financial supports	3	16%
legal help	1	5%
Product development/technology assistance (certifications) (simulation testing)	3	16%
confusing regulations	1	5%
lack of inter/intra business collaboration	2	11%
Business management expertise	1	5%
knowledgeable workforce	1	5%
lack of knowledge about publishing	1	5%
Gas is still too cheap	1	5%

Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Note: Approximately 40% of the respondents answered these questions. Approximately 60% did not offer their opinions. Numbers marked indicate the opinions of 19 participants.

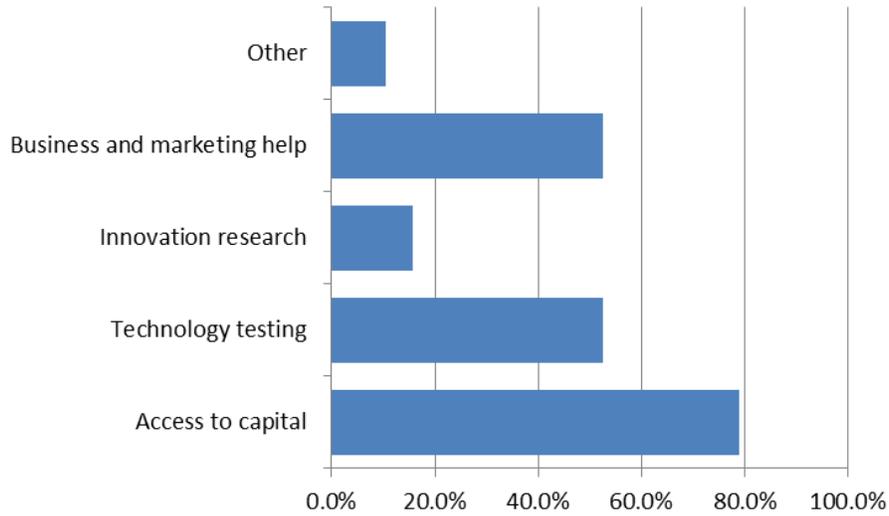
3.) Identifying the Oregon University System Technical Assistance Resources that Could Strengthen Business Growth

The next set of questions aimed at testing what OTREC and DO thought businesses and the industry might need and asked people to pick what would work for them from a list in Question 9 (Figure 6).

The need for capital showed up in the answers to this question as the highest priority, as it had previously, making the urgency of the situation clear. Business and marketing assistance as well as technology testing were also named as requirements for meeting projected growth. In the open text area for “other,” two people listed specifics:

- Access to Matlab/Simulink and one of the EV/HEV simulation modules (PSAT, VPSet, ADVISOR, or Autonomie) to demonstrate viability.
- Timing is the critical point. I believe it requires people to get to a certain level of EV awareness. Maybe some type of public awareness campaign?

Figure 6.6. What additional support do you need to achieve your projected growth? (Q-9)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

In Question 10 (Table 6.3), we looked for the level of concern the respondents had when asked to rank what resources they felt were needed to stimulate growth in the EV sector. Participants were asked to mark how they felt about needed support by assigning a one to those things that were not important, up to a five for those things that had increasing importance.

Table 6.3. Table Ranking of Resource Needs (Q-10)

Resource	Not Important	Important	Extremely Important
Start-up capital	37%	0%	63%
Operational funding	11%	22%	67%
New team members with specific expertise	11%	22%	67%
Connections with vendors and/or technology partners	12%	18%	71%
Customers (emphasis on commercial customers)	5%	16%	79%
Customers (emphasis on consumers)	53%	12%	35%
Marketing	21%	21%	58%
Research/product development assistance	28%	39%	33%
Supportive policies	17%	33%	50%

Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Note: The percentages shown as responses are based on the number who answered. The number who skipped the question was not factored into the percentage formula.

This scale shows that while most people thought start-up capital was extremely important, 37% didn't think it was important at all. Operating capital was deemed important by all who answered, but not as many respondents indicated that it was as "extremely important" as start-up capital; however, no one marked that it was completely unimportant.

Everyone ranked developing a commercial customer base as important, with 79% feeling that it was very important—more people felt this to be a priority over capital needs. Developing a consumer customer base was not ranked as highly with most of the respondents clustered in the middle. This most likely reflects that many of the participants are working on components and need to be better linked with other businesses that will use the components they are manufacturing.

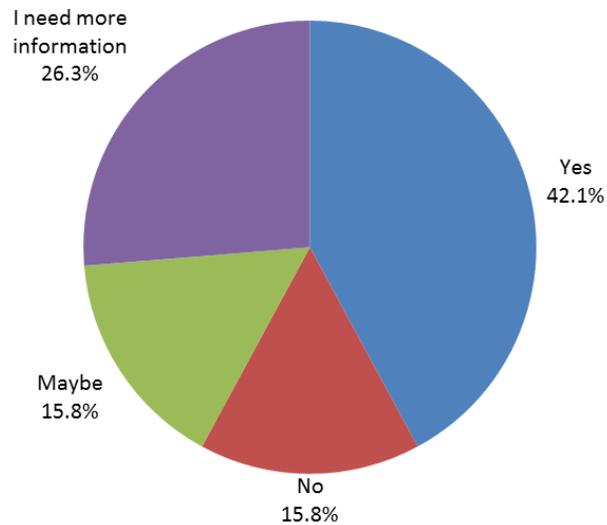
Advocating for supportive policies was very important to half of the respondents, however, several people indicated that this was not a priority. Similarly, support in product development and research also showed split opinions.

Collaboration seems to be desired by survey respondents. Connections with vendors and technology partners received high points for importance.

Finding qualified staff and employees was also ranked highly by 89% of the respondents with 67% indicating this was extremely important.

When asked if a shared technology and a testing laboratory, with staff and equipment, would be helpful in Question 11 (Figure 6.7), over 40% of the respondents responded affirmatively, with just over a quarter saying they would need more information and about 16% indicating that this might be helpful. Almost 16% answered that this would not be helpful.

Figure 6.7. If the Oregon University System could support you in accessing a shared technology testing laboratory with staff and equipment, would this be useful for expanding your business? (Q-11)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

In Question 12 (Table 6.4), 15 of our 45 respondents offered information about what type of equipment, services, and resources they would like to see as part of a lab or incubator. The respondents identified a broad range of equipment and services. Testing facilities were among the most frequently mentioned, with respondents identifying a range of potential testing needs. Business development assistance was mentioned by several respondents and included support such as supply chain connections, business operations mentorship, and marketing.

Marketing support and commercialization of products were ranked most highly, with one person commenting that collaborating with “grey haired execs who have had to make payroll and have brought leading edge technology to market” would meet the needs for business support in a realistic way as opposed to the theoretical support of academics. Next, product engineering and design along with cost-sharing opportunities and competitively awarded grants were ranked as important by just over half of the respondents. Help with business planning and intellectual property protection were desired by 44% of the respondents, while 33% were interested in help with interns.

Table 6.4. What types of services, equipment, and/or resources would you like to see a shared lab or incubator provide? (Q-12)

Service or Equipment	Number of Respondents	Percent of Respondents
Supply Chain Connections/and product testing	3	16%
AC DC load testing/ HI Pot tester/Computer Symulations/Wind Tunnel/Structural Testing Lab/Dynometer/enviro test facilities/EMI & EMC testing/ battery testing/CE test for Euro Mkts	7	37%
Interns	1	5%
SAE/Business/EV expert assistance	2	11%
EV library and resources/testing data/CANbus knowledge base	1	5%
Assistance in data collection and analysis/carbon calculations	2	11%
Certification help for Level 2 J1772 (NRTL/UL)	2	11%
Motor testing (pwr, efficiency, torque etc)	1	5%
Business operations mentorship/making payroll, new products to market/help with accessing new markets	1	5%
Vendor and mfg collaboration on new technologies	1	5%
Cars and equipment to sell and show to investors	1	5%

Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

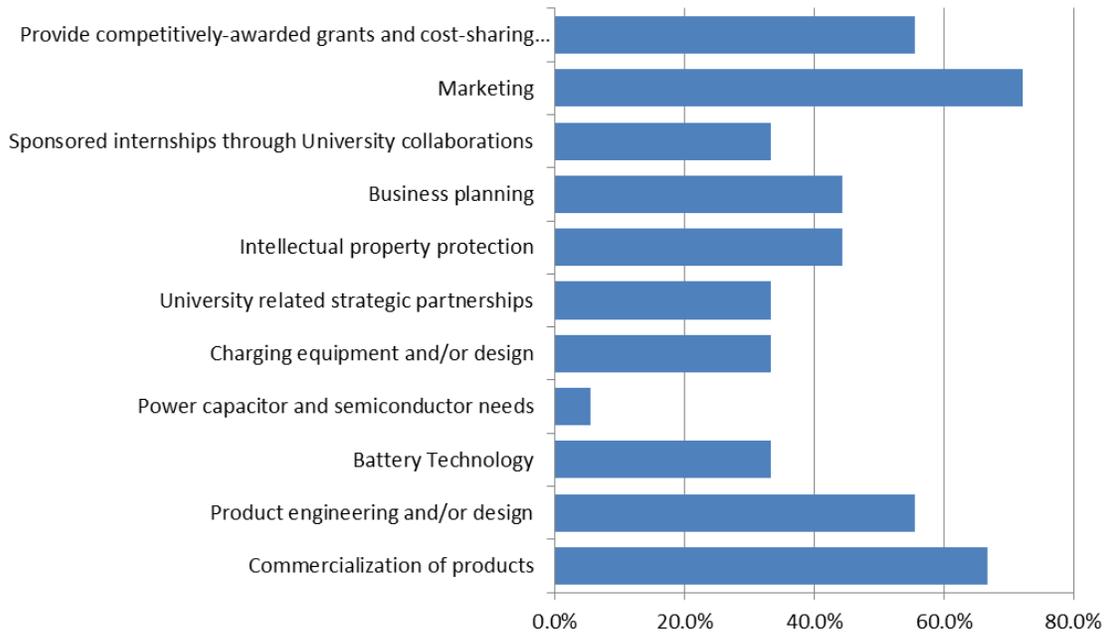
4.) Potential Roles for the Oregon University System

One of the primary objectives of the Transportation Electrification Initiative (and this survey) is to better understand how the Oregon University System (OUS) can better support the EV industry in Oregon. Our survey asked a series of questions related to potential roles for OUS; this section presents the results.

The first question in this series asked respondents to indicate what research and development projects or business services would help businesses (Figure 6.8). While respondents indicated a broad range of assistance would be beneficial, four services were identified by more than half the respondents. These were (1) commercialization of products, (2) marketing, (3) product engineering and/or design, and (4) providing

competitively awarded grants and cost-sharing. Overall, the responses suggest many areas that are ripe for university/business collaboration.

Figure 6.8. What research and development projects, or business services from the Oregon University System (PSU, OSU, UO, OIT) would help you improve and expand your product line? (Q-13)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Figure 6.9 shows what political/state resources would enhance respondents' viability and growth potential. Not surprisingly, categories of financial support were ranked highly, with nearly 80% of the respondents indicating tax incentives, over 70% indicating grants, and about 55% indicating loans. Industry advocacy was also highly ranked.

At the time this survey was being administered, the Oregon Legislature voted to eliminate the State tax credit for consumers. Oregon tax credits for converting to

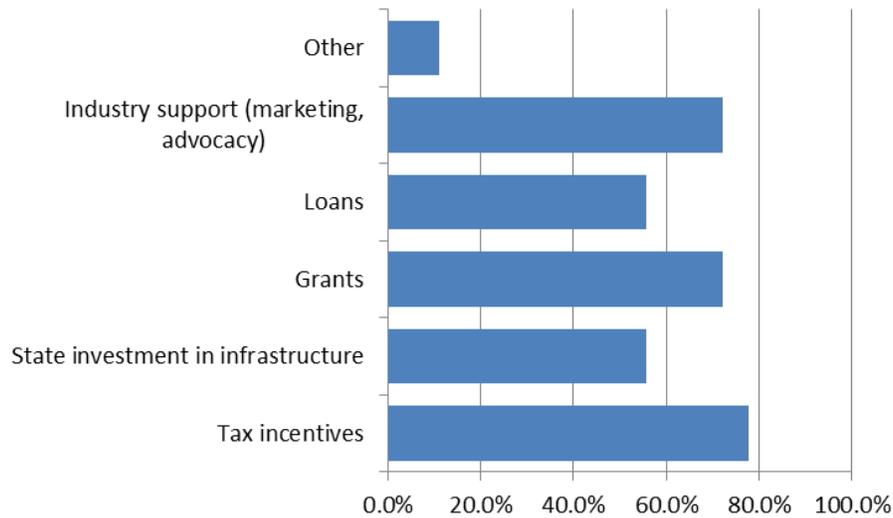
electric will also end at the close of the year. The tax credits for businesses purchasing electric vehicle fleets will end in Oregon at the end of this year as well.

Grants and loans, along with industry support in terms of marketing and advocacy were felt to be important state services by 72% of the respondents. Loans and State investment in infrastructure were deemed important by 56%. Answers under “other” included:

- A temporary 5-year tax holiday for EV businesses and consumers with full tax deductions for EV purchases at both consumer and commercial levels.
- Fund VCs, incubators and start-ups. Let the market figure out winners, not policies and politics!

One person indicated that political and state resources were not applicable to the growth of their business.

Figure 6.9: What political/state resources would enhance your viability and growth potential? (Q-14)

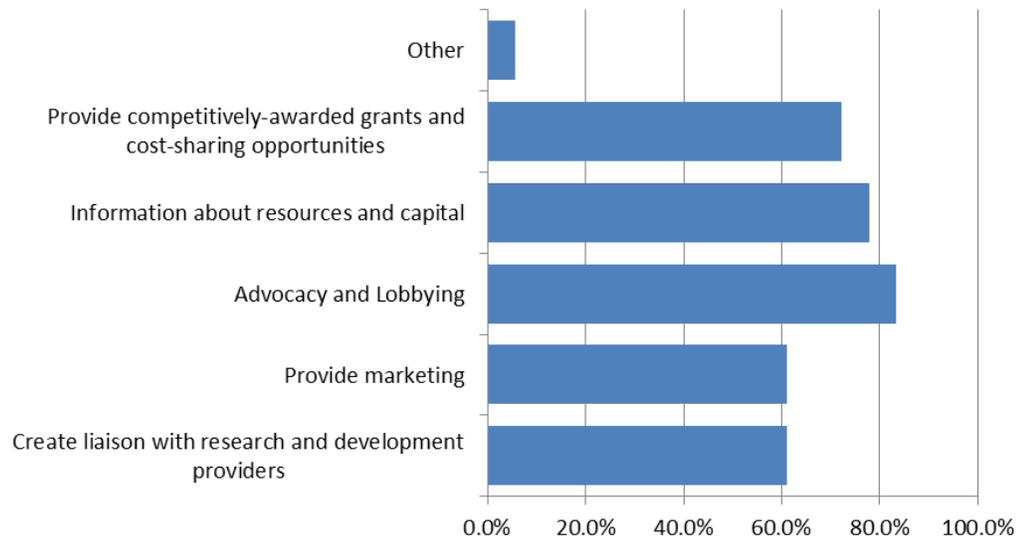


Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

5.) Potential Support Role for Drive Oregon

Question 15 (Figure 6.10) addressed the role of Drive Oregon in supporting industry growth. The responses suggest that the majority of respondents feel that Drive Oregon should play an advocacy role for the business organizations they represent, and their second task should be to help locate capital resources, and grant and cost-sharing opportunities. Creating liaison with R&D providers and providing marketing assistance was also endorsed by the majority of respondents.

Figure 6.10. What can Drive Oregon as a trade organization do to support your business? (Q-15)



Source: OTREC EV Industry Needs Assessment Survey, CPW July 2011

Additional suggestions made by respondents included:

- Do not increase government spending thereby do not increase taxes or debt.
- Partner with those service providers who can provide been there / done that expertise... in bringing leading edge technology to market.
- Reach & teach outside Oregon to promote Oregon resources as THE place to look for development and suppliers.
- Try to coalesce the Oregon suppliers that are on the fringe into a comprehensive resource list. We have lots of precision fabrication (sheet metal, tubing, castings, etc) resources that augment the ability for a company to find one-stop shopping for components in addition to

motors, controllers, batteries, and wire harnesses. That message needs to be developed and distributed.

- Create connections between EV companies and manufacturers with EV-related capabilities.
- Facilitate internship programs so they are easy to implement for busy companies.
- One of the participants felt that none of the suggested answers were applicable to what Drive Oregon should do to support the electric car industry.
- In the last question, Question 16, we provided space for the respondents to address any important issues we hadn't thought of in the survey.

Seven of the survey-takers offered the subsequent opinions and ideas:

- Partnership with universities for basic R&D to help private and public enterprise is greatly appreciated!
- We're 100% behind Drive Oregon and the new world of EV. Let us know how we can help.
- The consumer needs to buy EVs in volume in order for the any of the benefits of EVs to be realized. Therefore the consumer needs the break and incentive somewhat more than the business. The 1990's California fleet requirement along with the tax deduction incentives

helped bring very high priced EVs (relative to gasoline cars at the time) to market. Just do it again and void increasing the government debt and or increased taxes required for providing and administering grants or other spending.

- Don't let Oregon be its own best customer. We have to take the message outside Oregon to bring outside funds back into Oregon.
 - Identify the government agencies, City, County and State that are not beneficial to the operation of any small business.
 - Positive support from the media is an important component of marketing the EV to the general public.
- Oregon in general is very supportive of the EV industry, but most of the companies that have benefited most are large and from outside the state and would likely have been successful in any case. A goal of bringing jobs to Oregon and true direct support to Oregon companies would be helpful.

6.) Implications

At this time, Oregon is not necessarily positioned as a major industrial manufacturer of electric vehicles, however, 14% of our survey respondents are

manufacturing vehicles and 35% are making components. The rest of the entrepreneurs that responded to our survey have created businesses that have a direct interest in the success of these producers, forming the beginnings of a viable industrial system.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

A. Summary

The Oregon Transportation Research and Education Consortium (OTREC) funded the research for this project as part of a broader initiative in support of electric vehicle (EV) research—specifically research by institutions in the Oregon University System that supports development of the electric vehicle industry in Oregon.

Several factors make this work important at this point in time. First, through the EV project (<http://www.theevproject.com/>) and other efforts, electric vehicle supply equipment (EVSE, “charging stations”) infrastructure is being installed throughout the Willamette Valley. Second, with the support of Governor John Kitzhaber and the Oregon Legislature, the Oregon Innovation Council awarded \$1.2 million in funding for Drive Oregon, an initiative to bolster the state’s emerging electric vehicle industry. Finally, electric vehicles are gaining momentum as a pragmatic alternative to traditional internal combustion engines. The ultimate goal of Drive Oregon is to develop a strategy for Oregon’s development as a world class producer of electric vehicles/EV components, and to lay a foundation for moving forward through concerted, collaborative effort.

The goal of the research project is to support development of Oregon’s EV industry through university/industry collaboration. By assessing the market (through further research), Oregon’s current infrastructure assets and needs, the readiness of Oregon businesses to take advantage of this opportunity and the capacity of the stakeholders to

collaborate effectively, we are creating a map of strategies that have the potential to significantly impact Oregon's economy. Joining the strengths of academia and state economic development efforts with entrepreneurial activities through Drive Oregon will allow us to construct a powerful synergy to generate jobs and enter new markets.

B. Findings

My investigation included gathering information on the assets and resources maintained by the Oregon University System (OUS), and surveying Oregon EV entrepreneurs in order to match the resources to the needs of the industry. The research indicates that the priority for EV businesses has to do with capitalizing the expansion of this sector. In a convenience survey, we asked a variety of questions about barriers to growth, commercialization, policies, and research needs.

While the findings of our research identified a broad range of opportunities—and barriers, respondents most frequently referred to funding as key to their success. For example, when they were asked an open-ended question about barriers to growth, 54% of the responses related to funding in some form. From direct statements about needing capital, to indicating that consumers needed financial incentives and that gas was still too cheap, the lack of capital access is holding the EV sector back from its growth potential according to the survey participants. When asked what support they most needed to grow, 79% of the responders selected “access to capital.”

Another notable finding from the survey was the tremendous optimism EV business owners had concerning their growth. Nearly half of the entrepreneurs felt that their gross

revenues would at least double by 2014, and with the help of Drive Oregon they anticipate adding hundreds of employees to the work force.

Regarding the Oregon University System (OUS) research facilities and other resources,⁹⁴ more than half of the survey respondents indicated that this would be a boost to developing their companies. Several respondents mentioned limited access to skilled workers being a barrier to growth. Training interns and developing specific programs to meet the needs of the EV industry could be another function of the liaisons that will result between academia and businesses through the research laboratories.

The Oregon University System has a remarkable array of assets available to support the growth of the EV sector. Each of the universities, as well as some of Oregon's community colleges have programs devoted to sustainable business, renewable energy, transportation planning, research contributing to battery technology and power train systems, IT and communications, and automotive technology. Moreover, numerous faculty within OUS are interested in the development of electric vehicles and the community colleges are especially eager to partner with the business community on workforce development.

Complementing and partnering with the OUS' academic departments and faculty, Oregon has three signature research laboratories and numerous interdisciplinary research institutes, business incubators, technology transfer programs and experiential learning programs which make interns available to developing businesses and commercial firms. As a whole, these organizations are eager to partner with industry. At the 2010 Oregon

⁹⁴ This study focused on the four major research institutions in the OUS system: University of Oregon, Oregon State University, Portland State University, and Oregon Institute of Technology.

BEST Fest, this relationship was described as the “collaborative commercialization pipeline – from the research funding that generates breakthroughs to the creation and funding of new companies, products, and services that result from this research.”⁹⁵

The Oregon Transportation Electrification Research and Education Consortium (OTREC), a national University Transportation Center, has set out to create a network among the EV industry cluster, state economic development agencies and OUS to maximize the opportunity Oregon has to become a world-class center of EV production and adoption.

C. Recommendations

Cultivating systems to nurture EV development in Oregon is complex and requires inputs of capital and knowledge from all of the stakeholders. Research has shown that regional thinking and cluster mindset provide the greatest advantages for competing in the global market place. The severity of the economic crises in the last decade has evoked fear and caution. In times like these firms are tempted to increase their competitiveness by cutting costs rather than continuing to innovate and create new markets. Litigation may seem more expedient than negotiation. Protecting proprietary information may seem safer than collaboration. Concurrently, cuts in public funding for education and business development can undermine the infrastructure that supports industry clusters and regional strategies. Regional leadership from Drive Oregon and

⁹⁵ Oregon BEST Fest '10: Sparkling Collaboration for the Green Economy. Web. 14 December 2011. <<http://oregonbest.org/oregon-best-fest-10>>.

OTREC must include keeping EV industry growth on track by sustaining the networks that are evolving—despite periodic downturns in the economy. Advocating for “regional policies that are designed to catalyze and coordinate, rather than directly manage the myriad public and private actors” needed for success should be a central focus of both organizations.⁹⁶

Following are a set of recommendations that address the objectives of the OTREC Transportation Electrification Initiative⁹⁷ as well as Drive Oregon:

- **Promote collaboration as a foundational strategy to engage public and private resources.** The State can develop business-friendly policies and generate effective economic development programs, the Oregon University System can support entrepreneurs in developing and testing their technologies, and Drive Oregon can become the networking and communication coordinator with Oregon’s EV sector, actively promoting a collaboration process that maximizes the collaborative efforts throughout the state.
 - Creating an EV community culture and shared identity, such as has been created in the Silicon Valley and Route 128 will spur innovation and inspire capital investment.

⁹⁶ Saxenian, A. *Regional Advantage: Culture and Competition in the Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press 1994. 165. Print.

⁹⁷ “The Transportation Electrification Initiative will test promising mobility projects focusing on urban freight, consumer behavior, intelligent vehicle systems and the effect of electrification on the electrical grid in a living laboratory.” The Principal Investigator is John MacArthur of Portland State University. Throughout the recommendations we refer to the OTREC Transportation Electrification Initiative as simply OTREC as the initiative is the main mission of the Oregon Transportation Research and Education Consortium. http://otrec.us/research/initiatives_detail/transportation_electrification_initiative

- Collaboratively staging high profile public events and demonstrations, such as Portland’s Electric Avenue, will contribute to public awareness of electric vehicles and hasten the growth of this sector.⁹⁸
- Leveraging this successful collaboration will increase consumer and commercial customers, attract investment capital and encourage further federal funding for Oregon’s economic development.

- **Invest in Drive Oregon to lead the industry to EV success.**

Drive Oregon is now receiving funding and can assume its role as Oregon’s lead promoter of electric vehicle industry development.

Drive Oregon is in the best position to build momentum and engage the business community to financially invest in the Electrification Initiative. Similar to Joint Venture

(<http://www.jointventure.org/>) the organization that formed to promote the “regional mindset” thinking of the Silicon Valley, Drive Oregon can raise awareness and promote collaborative problem solving for the EV industry cluster. OTREC should develop a strong relationship with Drive Oregon to build its capacity for long-term leadership of the EV industry.

⁹⁸ Electric Avenue is a research project that allows electric vehicle (EV) and electric bicycle owners to park and charge up. It’s a collaboration of Portland State University (PSU), OTREC, Portland General Electric

- **Support the development of a political advocacy function within Drive Oregon.** Current industry and marketing analysis, as well as the responses to the survey have indicated the impact government policies and economic development initiatives can have on the success of industry sectors. Drive Oregon should commit significant staff time and resources toward lobbying and building relationships with legislators and government officials, as well as encouraging the political involvement of its constituents.
- **Seek approaches to coordinate the OTREC EV Initiative and Drive Oregon so that these initiatives work together to enhance Oregon’s EV opportunities and avoid redundancy.** Drive Oregon is the “trade association” of EV companies, and as such is best prepared to act as the emissary and representative of the EV industry’s interests. As an advocate, Drive Oregon will organize initiatives to gain political backing, run events to raise public awareness, and write grant proposals to fund industry growth. Drive Oregon will also act as the primary ambassador to private investors and should be able to refer entrepreneurs to financial resources, public and private, that become available. Drive Oregon will establish a formal relationship with the OUS through OTREC as a means of ensuring entrepreneurial access to research and technical assistance.

(PGE), and the City of Portland that showcases EVs, charging technology, and urban design through

Taking on these tasks leaves OTREC/OUS to be the leader in identifying emerging technologies, best practices, policies, critical relationships and cutting edge opportunities that will advance Oregon's EV interest over the long term. OTREC needs to stay focused on its research role as a catalyst for industry and policy progress, and do all it can to position Oregon's EV efforts to be sustained. Communication between Drive Oregon and OTREC should be a regular and consistent priority. It may prove best to hire a communication coordinator to ensure this happens (among other tasks). Mutual support will increase the effectiveness of both organizations while improving access to funding opportunities, possibly through collaborative activities, and eliminating duplication of efforts.

- **Use the research capacity of OUS institutions to leverage industry efforts.**
 - The OUS technology transfer programs **should prioritize the progression of its science and technology students from scientist to entrepreneur**—encouraging a community of technical scholars who plan to commercialize their research.

collaboration. It opened in August 2011. Retrieved from <http://pdx.edu/electricavenue/>.

- **Offer special education opportunities to industry employees** to help local firms keep up with the latest trends as well as foster innovation.

- **Reach out to attract businesses to move to Oregon.** OUS research capacity and assets can be attractive for established companies who may be seeking to locate a new facility for better access to technology development support, a capable workforce and an EV friendly business environment. In both cases, the resources available through the OUS can be used to promote the success of EV production in Oregon.

OTREC will need to conduct outreach and networking among Oregon’s laboratories, universities, community colleges and business organizations to ensure that technical capacity and workforce training are aligned for EV entrepreneurs, large and small—and that consortium members can easily collaborate and engage in the stimulation of shared ideas. This is no small task—as is evidenced by the inventory of programs and faculty interests presented in Chapter 2 of this report. OTREC should also further investigate what will enable EV businesses to engage with OUS and set a permanent

pathway in place. This may require hiring a liaison position, and consideration of where that position should be housed will take some deliberation.

- **Recognize and prioritize the technologies that have the biggest potential to create growth, both in the electric vehicle industry and in interconnected industries as well.** For example, battery technology is the most expensive and complicated component of EVs. The impact of batteries on the price, safety and range of EVs will make or break their acceptance by consumers. Investing in technology improvements will be essential for moving cars into the marketplace, but has additional benefits for industries including energy storage and electronic components. Similarly, telematics installed in EVs to monitor performance have applications in providing data for the development of smart grids.
- **Continue working to create and promote a more robust platform for coordination and interaction.** The OTREC website is a good place to find links to news and resource information, if someone knows to look there, and plans are underway to improve both visibility and content.⁹⁹ Drive Oregon has a website and has added a Google Group that allows discussions and posting of relevant information. Drive Oregon members

⁹⁹ The OTREC site is http://otrec.us/research/transportation_electrification_initiative. OTREC also has a Twitter account @otrec_ev and there will also be development of a statewide website, EVRoadmap.com, that will drive people to OTREC and other sites. EVRoadmap is maintained by OTREC and Portland State University's Office of Research and Sponsored Projects with generous support from The Lemelson Foundation.

are automatically added as they join the organization. The Oregon Electric Vehicle Association (OEVA) sends out a weekly digest of news articles and event schedules that is also helpful, and OEVA is also using social media to keep in touch with people who have opted in. Attention needs to be given to coordinating these resources and upgrading Internet communication to the EV community. An interactive site like Oregon State University's Ecosystem Commons (www.ecosystemcommons.org) would be an ideal platform to inspire communication and collaboration. Moreover, designating a social media/communications staff person will be immensely helpful for ensuring that the largest number of stakeholders is receiving outreach and can be engaged in campaigns and decision-making opportunities. This will be critical to building support and following through on the potential of collaborating on the growth of the EV industry.

In addition, Drive Oregon could offer forums specifically on regional business collaboration, perhaps on a semi-annual basis.

- **Develop a strategy for attracting on-going research dollars from private investment as well as grant sources.** On-going public and private support through grants and investments is likely to hinge upon ensuring that research projects resulting from the EV initiative are a direct response to industry needs. With the constraints on federal spending, research universities must compete more effectively for

support. Collaborations with industry make academic projects much more compelling.¹⁰⁰ Both OTREC and Drive Oregon will need to pursue funding opportunities. Care should be taken to identify this function within a staff member's job description such that it is connected to a clear vision and is informed by the activities of the consortium. Defining mission, scope and stakeholder roles are crucial to ensure fundraising activities are efficient.

- **Value the OUS business schools as necessary collaborators in this consortium.** Science creates technology, but scientists are not necessarily the best business people. Marketing, commercialization, business efficiencies, and supply chain management are needs that emerged from the survey of business owners. These areas of concern, as well as strategic planning and attracting investment capital, may well be improved with the support of professors and interns from Oregon's university business schools and institutes. Specific projects should be developed for EV companies and relationships with academic programs such as the UO's Center for Sustainable Business Practice (http://www2.lcb.uoregon.edu/App_Aspx/CsbpAbout.aspx) or PSU's Capstone Consulting Experience (<http://www.gradbusiness.pdx.edu>), will be profitable for industry and academia alike.

¹⁰⁰ Ferreira, W. (2011) Academic-Industry Collaboration under Federal Grants and Cooperative Agreements: Financial, Administrative, and Regulatory Compliance. *Research Management Review*, Volume 18, Issue 1 Spring/Summer 2011

- **Incorporate the community colleges into this collaborative network.**

With their focus on vocational training and workforce development, community colleges are obvious partners and eager to be included. Many of them are experienced in forging relationships with industry and developing specific workforce training programs to respond to business needs. They also have experience in obtaining federal and state support to fund workforce training and partnerships. As well, many of Oregon's Small Business Development Centers (SBDC) are housed at our community colleges and provide shoulder to shoulder assistance with new small and micro-enterprises.¹⁰¹ Many of the members of Drive Oregon, and respondents of the survey are small businesses that may initially grow more rapidly with SBDC assistance. OTREC could initiate the inclusion of community colleges in the consortium by reaching out to the Oregon Department of Community Colleges and Workforce Development and move forward from there. OTREC could also facilitate/start a collaboration among either the state small business development centers and/or the Portland Business Accelerator, and the research labs and DO could develop a specific plan to focus tech transfer support small businesses.

¹⁰¹ Oregon Small Business Development Centers (BIZ). Web. 12 January 2012.
<<http://www.bizcenter.org/>>

In summary, my research indicates that a broad range of opportunities exist for OUS/Industry collaboration around EVs. The funding of Drive Oregon and OTREC's Transportation Electrification Initiative are a strong start towards capitalizing on these opportunities. Success, however, will require considerable effort on behalf of all interests. The dispersed and autonomous nature of the university research enterprises creates challenges in effectively linking university resources to industry needs. In our experience, the best way to make that happen in the immediate future is to create a staff liaison position that is dedicated to matching resources and could include the priority tasks mentioned in some of the above recommendations. A robust web portal like OSU's Ecosystem Commons would be an excellent long-term solution and is one that OTREC is currently examining.

From a higher perspective, serious effort needs to be made to create and maintain a “cluster mindset.” Clusters do not have independent identities and they are not bounded by municipalities, politics, technology, goods, or services. Charting the activities of Oregon’s public institutions and businesses within the EV cluster made it clear that there are plenty of stakeholders who are interested, but there is no one specifically in charge of monitoring the needs and progress of the cluster as a whole. Drive Oregon and its collaborative relationship with OTREC comes closest to being able to keep awareness high among leadership and citizens. Along with their public-private partnership goals, they should develop strategies for keep a cluster mindset in the public eye.¹⁰²

And in the meantime, Oregon continues to lead the way in the electrification of transportation. “As of this week, Oregon will become the first state to complete a chain of charging stations that will enable electric cars to travel from one end of the state to the other. It completed the last of eight 440 volt fast charging stations that allow travel for the full 310 miles on the beaver state's Interstate 5, from the Washington to the California border.”¹⁰³

¹⁰² National Prosperity/Regional Leadership: Economic Development Administration. 21st Century Regional Leadership Initiative. *Council on Economic Competitiveness*. Contract # 99-07-13856. February 2010: p. 12

¹⁰³ Thomas, J. Oregon Becomes The First All Electric State. *Mad Hedge Fund...’s Instablog*. 13 May 2012. Web. <<http://seekingalpha.com/instablog/341510-mad-hedge-fund-trader/616351-oregon-becomes-the-first-all-electric-state>>

APPENDIX A

SURVEY INSTRUMENT

Business Characteristics

Edit Question ▼ Move Copy Delete

Oregonians are well known as an early adopters and supporters of clean tech and green businesses. Oregon universities are in the process of developing a collaborative initiative to link university research to the emerging electric vehicle industry. The EV Initiative has seed funding through the Oregon Transportation Education and Research Consortium.

The EV Initiative is partnering with Drive Oregon to better understand the characteristics of Oregon's emerging EV industry. The purpose of the initiative is to help Oregon take advantage of its unique position and assets to develop a world class electric vehicle (EV) industry. This questionnaire is designed to provide information that will help us better understand how Oregon's research institutions can better support EV entrepreneurs.

Please take a few minutes to complete the survey. Your response is important and will take about 5 minutes to complete. **Thank you for your participation.**

+ Add Question ▼ Split Page Here

Q1 Edit Question ▼ Add Question Logic Move Copy Delete

1. Do you represent a business related to the EV industry?

- Yes
- No
- Don't know

Please provide a little background on your business.

+ Add Question ▼

Q2 Edit Question ▼ Add Question Logic Move Copy Delete

2. What is the nature of your business? (check all that apply)

- Design
- Component
- Battery
- Vehicle manufacture
- Charging equipment
- Other

Other (please specify)

Q3 Edit Question ▼ Add Question Logic Move Copy Delete

3. Please indicate at what stage of development is your business?

- Pre-commercialization, doing research and development
- Beginning to generate revenue
- Generating revenue for over a year
- Generating revenue for over 3 years
- Generating revenue for over 10 years

Anticipated Growth

+ Add Question ▼

Q4 Edit Question ▼ Move Copy Delete

4. What is the approximate number of employees that work on EV-related business at your company? In other words, if your firm has part-time participants/contractors/consultants, please estimate the total time they spend on a full-time-equivalent (FTE) basis, and round up to the nearest half-FTE. For example, if you are full-time and you have one half-time person and three quarter-time people, your FTE number would be $1+.5+.75 = 2.25$, rounded up to 2.5.

+ Add Question ▼ Split Page Here

Q5 Edit Question ▼ Move Copy Delete

5. Assuming fairly strong growth, a reasonably receptive market and the collaborative support of Drive Oregon and the Oregon University System, what number of employees (measured in FTE) do you think you will have in 3 years?

Q6 Edit Question ▼ Add Question Logic Move Copy Delete

6. If you had revenue in 2010, please compare your projected revenue for 2014 with your actual revenue in 2010. Would you predict that 2014:

- Will be about the same as 2010
- 0-25% greater
- 26-50% greater
- 51-75% greater
- 76-100% greater
- More than 100% greater
- Not applicable (no revenue in 2010)

Support Needs

+ Add Question ▼

Q7 Edit Question ▼ Move Copy Delete

7. What barriers are keeping the EV industry from growing in Oregon?

Q8 Edit Question ▼ Move Copy Delete

8. What barriers are you facing in growing your company?

Q9

9. What additional support do you need to achieve your projected growth? (choose all that apply)

- Access to capital
- Technology testing
- Innovation research
- Business and marketing help
- Other

Other (please specify)

Q10

10. How important are the following types of support in moving your company to the next stage? (Please rate the level of importance on a scale of 1 to 5 with 1 being not important and 5 being extremely important)

	Not Important	2	3	4	Extremely Important
Start-up capital	<input type="checkbox"/>				
Operational funding	<input type="checkbox"/>				
New team members with specific expertise	<input type="checkbox"/>				
Connections with vendors and/or technology partners	<input type="checkbox"/>				
Customers (emphasis on commercial customers)	<input type="checkbox"/>				
Customers (emphasis on consumers)	<input type="checkbox"/>				
Marketing	<input type="checkbox"/>				
Research/product development assistance	<input type="checkbox"/>				
Supportive policies	<input type="checkbox"/>				

Potential University Support

+ Add Question ▼

Q11 Edit Question ▼ Add Question Logic Move Copy Delete

11. If the Oregon University System could support you in accessing a shared technology testing laboratory with staff and equipment, would this be useful for expanding your business?

- Yes
- No
- Maybe
- I need more information.

Q12 Edit Question ▼ Move Copy Delete

12. What types of services, equipment, and/or resources would you like to see a shared lab or incubator provide?

Q13

13. What research and development projects, or business services from the Oregon University System (PSU, OSU, UO, OIT) would help you improve and expand your product line? (Choose all that apply.)

- Commercialization of products
- Product engineering and/or design
- Battery Technology
- Power capacitor and semiconductor needs
- Charging equipment and/or design
- University related strategic partnerships
- Intellectual property protection
- Business planning
- Sponsored internships through University collaborations
- Marketing
- Provide competitively-awarded grants and cost-sharing opportunities
- Other

Other (please specify)

State Support Opportunities

Q14

14. What political/state resources would enhance your viability and growth potential?

- Tax incentives
- State investment in infrastructure
- Grants
- Loans
- Industry support (marketing, advocacy)
- Other

Other (please specify)

Drive Oregon Support Opportunities

+ Add Question ▼

Q15 [Edit Question](#) ▼ [Add Question Logic](#) [Move](#) [Copy](#) [Delete](#)

15. What can Drive Oregon as a trade organization do to support your business?

- Create liaison with research and development providers
- Provide marketing
- Advocacy and Lobbying
- Information about resources and capital
- Provide competitively-awarded grants and cost-sharing opportunities
- Other

Other (please specify)

Parting Comments

Q16 [Edit Question](#) ▼ [Move](#) [Copy](#) [Delete](#)

16. Please add any additional thoughts, comments, or suggestions in the space provided below.

APPENDIX B

WRITTEN SURVEY COMMENTS

This appendix presents written survey comments provided by respondents. It is organized in the same order as the survey and only includes questions where respondents could provide comments.

What is the nature of your business? (check all that apply)

Institutional Investor (Q-2)

- Consultant developing policy & programs for early adoption and market introduction.
- Investor
- I provide professional legal services to EV related businesses ranging from design/manufacture to charging stations.
- We design and build human+electric powered trikes.
- Non-profit electric vehicle education and promotion.
- Government
- Consulting: Business development and growth
- Restoration and repair of maintenance and personnel carriers.
- "Media. We publish the Portland/Vancouver area Green Living Journal that distributes 16,000 copies quarterly from 400 locations.

- We advocate for the adoption of EVs with articles on EV owners, upcoming EV event listings, and new developments. in print, and online."
- Aviation services provider to operators of business aircraft
- retired from the coast guard. why is retired never a option on these survey's?
- city government
- Software for smartphones, in-dash computers and companion websites
- Equipment manufacturer for the PV industry, Applied Materials is a global fortune 500 company with over 12,000 employees.

What barriers are keeping the EV industry from growing in Oregon? (Q-7) "Awareness / PR.

- Seed capital."
- Business friendly environment (taxes, codes, incentives)
- "Barriers include:
 - vehicle cost
 - support infrastructure availability
 - public awareness"
 - Lack of venture capital, built out charging station infrastructure, gas prices that do not reflect carbon costs, consumer awareness
 - "Capital, capital, capital.

- Also, the continued ease of oil-based transportation. At least carbon concerns are coming to the fore, as noted in the increased concerns of Climate Change and Peak Oil.
 - We need financial support to grow the industry."
 - "access to capital
 - access to experienced EV investors
 - companies that have achieve some level of success"
 - Capital for product development and commercialization and loss of funding from customer base.
 - Low cost battery supply
 - Lack of state control of at least some of the DOE grant money that is funding the installation of EV charging infrastructure.
 - "1. Lack of mainstream vehicles = ""The Chicken"". We need many chickens and many eggs but the vehicles must be available in a major way. Delivery goals have been underwhelming to say the least...the Leaf is way behind schedule and the Volt is not officially available.
2. Lack of EVSE - ""The Egg"". Our company produces EV charging stations; the stations that have been sold/installed to date are primarily Public Relations machines. Oregon cities and private companies need to

adopt a wholesale attitude toward EVSE to encourage
adoptions/installation. This may be aided by tax incentives."

"changes in regulations, ev road tax confusion reduces customer interests, depressed economy reduces customers ability to purchase, handling sales taxes when selling to other states increases admin costs while reducing sales by increasing cost to customer, increased overhead related to various local taxes, base wage rate plus payroll tax makes starting and growing expensive, chasing government grants and loans takes too long and thereby increases tax requirements."

- "A conundrum:

[1] The ""We can do it alone"" mentality: Rugged individualism. and
(seemingly at odds with this)..

[2] A ""kumbaya"" way of doing things: where it's more important to feel
good about something, than to actually make shit happen

As Pogo might say, "I've seen the enemy and he is us."

- Customers from outside Oregon - National recognition of EV producers, suppliers, and development resources available in Oregon. Every major population center has some EV activity, and a select group of the vehicle manufacturers such as Tesla, Toyota, Chevy Volt, get lots of press. The dreamers in other states need to believe that they need to search out sources in Oregon to get their product good press, good suppliers, and national recognition/acceptance.

- "Collaboration at the manufacturing level.
- Workforce skills and development."
- Knowledge of the benefits of electric over ICE vehicles.
- Shortage of vehicles available in dealers' showrooms.
- People understanding the cost to charge the batteries is MUCH cheaper (today) than gasoline.
- Availability of cars and minimal, emergency charging infrastructure along main state and interstate routes
- Lack of monetary incentives and true support at the state level. The Oregon government should be able to sole source or specify Oregon manufacturing content to support Oregon businesses and jobs.

What barriers are you facing in growing your company? (Q-8)

- "Access to seed capital.
- Assistance in obtaining government grants."
- Lack of venture capital activity in Oregon.
- "Barriers include: - contract opportunities"
- I experience more marketing related issues
- Uh, capital.
- access to capital

- Legal and the inability of the primary customer, public transit entities, to find timely funding in the granting cycle.
- "Capital formation
- Product development
- Market development"
- "1. Growth capital. 2. Technology assistance - esp. with certifications 3. Sales/marketing"
- "changes in regulations,
- ev road tax confusion reduces customer interests, depressed economy reduces customers ability to purchase, handling sales taxes when selling to other states increases admin costs while reducing sales by increasing cost to customer, increased overhead related to various local taxes, base wage rate plus payroll tax makes starting and growing expensive, chasing government grants and loans takes too long and thereby increases tax requirements."
- The mentality above: We can do it alone.... as long as we feel good about it.
- Seed funding for prototype fabrication and system simulation by computer.
- Business management and finance experience.
- Operating capital and employee pool with technical background.

- "Our personal lack of experience and knowledge in the publishing field.
- My wife and I are foresters by profession so we are still getting up to speed."
- Stronger demand. I believe gas prices are close but not quite there yet to create the necessary demand just yet. People are at the "complaining" gas price point but not quite at the gas price point that would cause them to make significant changes.
- Missing relationships with business partners and paying consumers
- Access to sizable loans in the \$200k to \$1M range. Loan guaranties would also be helpful.

What types of services, equipment, and/or resources would you like to see a shared lab or incubator provide? (Q-12)

- "Assistance in connecting with local suppliers to the industry.
- Structural testing lab.
- Interns.
- Expert assistance at reduced costs.
- Expert service providers at reduced fees.
- EV specific library / resources."
- Dynamometer, environmental test facilities, EMI/EMC testing.
- " Testing data on new and developing EV related technologies

- Assistance in data collection and analysis"
- "Battery testing.
- Wind tunnel for analyzing vehicle shapes.
- Carbon calculations."
- not sure
- "Prototype testing and product optimization for use in broader applications
- Validation in simulated environments and conditions"
- "Aerodynamic testing
- Drive train testing
- Reliability testing
- Accelerated usage testing
- Battery testing from a wide variety of vendors"
- Certification help/testing for Level 2 J1772 (NRTL/UL)
- environmental testing (shake and bake)
- "As described before, computer simulation is one proof point that can be done early-on in development. OIT, PSU, or OSU could assist, especially if their SAE chapter could be involved as well.
- Motor testing (power, efficiency, torque, etc)

- Control theory - either working on it directly or being a critical review as companies develop it for their vehicles.
- CANbus knowledge base for applications requiring an on-board CANbus network.
- Business-case review and analysis - business and marketing students (with professor oversight) can observe and provide input on business and marketing aspects of companies both as startups and in transition to new markets."
- Dynamometer, product testing (UL, C-UL, EMI, environmental, vibration, etc) and CE testing for European sales.
- "Working with vendors and Mfg. that will provide new technologies from their R&D ."
- Not applicable
- A car, a charging station, office space, on-site visits from entrepreneurs and potential investors
- High powered AC and DC load testing equipment, EMI/EMC test equipment. HI Pot tester. J1772 tester.

What research and development projects, or business services from the Oregon University System (PSU, OSU, UO, OIT) would help you improve and expand your product line? (Q-14)

- Need to collaborate with grey-hair execs who have had to make payroll and have brought leading edge technology to market. Not just academic, theory / case-study-based help.
- Connecting real paying customers with Oregon manufacturers.

What political/state resources would enhance your viability and growth potential? (Q-14)

- temporary 5 year tax holiday for ev businesses and consumers with full tax deductions for ev purchases at both consumer and commercial levels.
- FUND VCs, Incubators and start-ups. Let the market figure out winners, not policies and politics!
- Not applicable.

What can Drive Oregon as a trade organization do to support your business? (Q-15)

- not increase government spending thereby not increases taxes or debt.
- Partner with those service providers who can provide been there / done that expertise... in bringing leading edge technology to market.
- "Reach & teach outside Oregon to promote Oregon resources as THE place to look for development and suppliers.
- Try to coalesce the Oregon suppliers that are on the fringe into a comprehensive resource list. We have lots of precision fabrication (sheet

metal, tubing, castings, etc) resources that augment the ability for a company to find one-stop shopping for components in addition to motors, controllers, batteries, and wire harnesses. That message needs to be developed and distributed."

- "Create connections between EV companies and manufacturers with EV-related capabilities.
- Facilitate internship programs so they are easy to implement for busy companies."
- Not applicable

Please add any additional thoughts, comments, or suggestions in the space provided below. (Q-16)

- "Thanks for the consideration.
- Partnership with universities for basic R&D to help private and public enterprise is greatly appreciated!
- We're 100% behind Drive Oregon and the new world of EV. Let us know how we can help.
- The consumer needs to buy EVs in volume in order for the any of the benefits of EVs to be realized. Therefore the consumer needs the break and incentive somewhat more than the business. The 1990's California fleet requirement along with the tax deduction incentives helped bring very high priced EVs (relative to gasoline cars at the time) to market. Just

do it again and void increasing the government debt and or increased taxes required for providing and administering grants or other spending.

- Don't let Oregon be its own best customer. We have to take the message outside Oregon to bring outside funds back into Oregon.
- Identify the government agencies, City, County and State that are not beneficial to the operation of any small business.
- Positive support from the media is an important component of marketing the EV to the general public.
- Oregon in generally is very supportive of the EV industry, but most of the companies that have benefited most are large companies from outside the State that would have been successful anyways. A goal of bringing jobs to Oregon and true direct support to Oregon companies would be helpful.

APPENDIX C

OREGON UNIVERSITY PROGRAMS

Appendix C includes information about OUS institution colleges and degree programs that are potential resources for the EV industry. These schools and programs are potential sources of interns and faculty assistance. The majority of this information, with the exception of the University of Oregon details, comes from John MacArthur, Research Associate and Project Investigator for the Transportation Electrification Initiative at OTREC and Portland State University.

Oregon Institute of Technology

Department of Civil Engineering and Geomatics

- Master's and Bachelor's degrees in Civil Engineering

Oregon State University

Topics of Research and Faculty

Dr. Kate Hunter-Zaworski

Associate Professor in the School of Civil and Construction Engineering

1 541 737 4982

School of Civil & Const Eng

303 Owen Hall

Corvallis, OR 97331-3212

hunterz@engr.oregonstate.edu

Research Interests: Professor Hunter-Zaworski is Director of the [National Center for Accessible Transportation](#) (NCAT). NCAT is an interdisciplinary and collaborative research center that promotes the development of technologies to make travel safe, seamless and dignified for all. Dr. Hunter-Zaworski conducts human centered research related to all modes of accessible public transportation systems. Her focus is on access to transportation and traffic flow.

Dr. Chris Bell

Professor and Associate School Head

Transportation Engineering

School of Civil and Construction Engineering

Oregon State University

220 Owen Hall

Office: 309 Owen Hall

Phone: 541-737-3794

Fax: 541-737-3052

Email: chris.a.bell@oregonstate.edu

Research Interests: Dr. Bell's interests include transportation materials; pavement design and evaluation; and heavy vehicle monitoring and management. Recent projects involve mainline preclearance and safety of commercial vehicles. He is not working on electric vehicles at this time.

Dr. Ted K.A. Brekken, Ph.D.

Assistant Professor in Energy Systems
Electrical Engineering & Computer Science
Oregon State University
3025 Kelley Engineering Center
Corvallis, OR 97331-5501

Ph: (541) 737-2995

brekken@eecs.oregonstate.edu

<http://www.eecs.oregonstate.edu/wesrf>

Research Interests: In the near future he aims to start investigating grid-level impacts of large-scale electrical vehicle penetration as a form of distributed energy storage. Researching novel direct-drive wave energy conversion technologies.

Dr. Robert Paasch

Boeing Professor in Mechanical Engineer
Office: Rogers 414
Tel: 541-737-7019

Fax: 541-737-2600

paasch@engr.orst.edu

<http://www.engr.orst.edu/~paasch>

Current research interests of Dr. Paasch include design of mechanical systems for reliability and maintainability, design of marine renewable energy systems, knowledge-based monitoring and diagnosis of mechanical systems, and applications of artificial intelligence for ecological systems monitoring.

He is a member of ASME and SAE, and is the faculty advisor for the Society of Automotive Engineers student group on campus.

Dr. Paasch was part of a Clemson University proposal to the Department of Energy that would develop an EV testing facility with CH2MHill as the contractor, on a Native American reservation in Madras. OSU would manage the Mechanical engineering, and Bob would be the principal investigator. The award has not yet been granted.

Dr. Annette von Jouanne, Ph.D., P.E., IEEE Fellow

3027 Kelley Engineering Center

Phone: (541) 737-0831

Fax: (541) 737-1300

E-mail: avj@eecs.oregonstate.edu

<http://eecs.oregonstate.edu/people/vonjouanne-profile>

Research Areas

- Ocean Wave Energy
- Wind Energy and Energy Storage
- Power Electronics
- Power Systems and Power Quality
- Adjustable Speed Drives

Dr. Alexandre (Alex) F. T. Yokochi

Assistant Professor of Chemical Engineering

School of Chemical, Biological and Environmental Engineering

Dept. of Chemical Engineering

207 Gleeson Hall

Ph: 541-737-9357

Fax: 541-737-4600

Alexandre.Yokochi@oregonstate.edu

<http://oregonstate.edu/~yokochia/>

Works at the Laboratory for *innovative* Reaction Engineering for Materials and Sustainability (*i*REMS lab)

Research Areas

- Battery related work that could tie into EVs;
- Plans to do some advanced fuel cell stuff directly related.

Portland State University

Departments and Programs

Department of Civil and Environmental Engineering

Maseeh College of Engineering and Computer Science

Bachelor of Science (BS) in Civil Engineering

Master of Science (MS) in Civil and Environmental Engineering

Master of Engineering (MEng) in Civil and Environmental Engineering

Master of Engineering (MEng) in Civil and Environmental Engineering Management

Ph.D. in Civil and Environmental Engineering

Toulan School of Urban Studies and Planning

College of Urban and Public Affairs

Master of Urban and Regional Planning (MURP)

Master of Urban Studies (MUS)

Ph.D. in Urban Studies

School of Business Administration

Supply and Logistics Management (BA/BS)

Interdisciplinary Programs

Dual Master's Degree in Urban and Regional Planning and Civil and Environmental Engineering

Graduate Certificate in Transportation

Topics of Research and Faculty at PSU¹⁰⁴

I. Vehicle Design, Performance, and Use

- Vehicle monitoring
 - *Monitoring private EV use & charge patterns*
 - *Monitoring fleet EV use & charge patterns*
 - *Development of EV-specific travel models, by EV type and ownership*
 - *Drive experience evaluation*

- Battery performance testing
 - *Charging behavior (frequency, charge level used) effect on battery lifespan and range.*
 - *Driving characteristics on battery lifespan and range.*
 - *Weather effect on battery lifespan and range.*

- Battery technology
 - *Materials development for future battery technology*
 - *Nanotechnology development for future battery technology*

- Powertrain Systems

- Communications and IT Support
 - *Smart Mobility Hub and Intellidrive component development*

¹⁰⁴ MacArthur, J. (2009) EV Roadmap: Research Faculty Report, Portland State University, Portland, Oregon.

- *Systems development*
- *Analysis of factors for determining range*
- *Accuracy of range forecasting techniques*
- *Initiate “Connected Car” program*

Faculty:

Jennifer Dill (CUPA – USP) <http://web.pdx.edu/~jdill/>

Research: Travel behavior, transportation and land use policy

Christ Monsere (CECS – CEE) <http://web.cecs.pdx.edu/~monserec/>

Research: Transportation safety, freight transportation, traffic operations

Miguel Figliozi (CECS - CEE) <http://www.cee.pdx.edu/faculty/figliozi.php>

Research: Impact of congestion on commercial vehicle movements.

Kelly Clifton (CECS- CEE)

Research: Transportation survey methods, travel behavior, travel planning & policy

Faryar Etesami (CECS – MME) <http://web.cecs.pdx.edu/~far/>

Research: Mechanical design; computer-aided design; mechanical tolerancing; and statistical process improvement

Dave Turcic (CECS – MME) <http://www.me.pdx.edu/people/index.php?action=12&uid=35>

Research: Analysis and design of high speed mechanical systems; system design; motion synthesis for manufacturing and material handling processes; design for manufacturing, robotics, computer aided design and computer-aided manufacturing; geometric modeling; automatic controls; and experimental methods

James Woods (CLAS – Economics) <http://www.pdx.edu/econ/james-woods>

Research: Teaches engineering economics, research in household conservation behavior

Richard Tymerski (CECS – ECE) <http://web.cecs.pdx.edu/~tymerski/>

Research: Power electronics & control

Paul Van Halen (CECS – ECE) <http://web.cecs.pdx.edu/~vanhalen/>

Research: Integrated circuit device physics; modeling; characterization and processing

II. Integration With The Built Environment

- Renewable energy storage and systems
 - *Analysis of battery second life programs*
 - *Advanced solar energy capture and charging systems*
 - *Renewable energy storage battery development*

Faculty:

Carl C Wamser (CLAS – Chemistry) <http://www.chem.pdx.edu/%7Ewamserc/>

Research: Solar energy conversion, using artificial photosynthesis.

Wayne Rifer (SBA – MIM Specialization instructor) <http://www.pdx.edu/sba/fp-wayne-rifer>

(Also: http://sustain.uoregon.edu/workshops/reg_instructor.php?instructorid=513510)

Work: Battery Recycling, Product Stewardship, Waste management

- Grid capacity and connections
 - *Peak load scenario analysis and management strategy*
 - *Temporal load analysis forecasting by market share penetration*
 - *Consumer choices regarding charging, time of day and location.*

- *Grid system connection and monitoring*
- *Analysis of EV user participation in voluntary green power programs*
- *Impact EV market share on electricity energy prices*

Faculty:

Robert Bass (CECS-EME) Power Engineering

Research: Interested in examining how EV charging will affect distribution systems and how demand-responsive loads can be used to ameliorate integration problems associated with renewable energy generation.

David J. Sailor (CECS-MME) <http://web.cecs.pdx.edu/~sailor/>

Research: Urban climate measurements and modeling; characterization of the urban heat island and assessment of mitigation potential; building energy efficiency and green building technologies; regional and local climate interactions with energy systems; including impacts on demand and renewable resources

Loren Lutzenhiser (CUPA – USP) <http://www.pdx.edu/usp/profile/meet-professor-loren-lutzenhiser>

Research: Energy use and global warming; household energy consumption practices

Dan Rogers (SBA – Finance) <http://www.pdx.edu/sba/fp-dan-rogers>

Research: Corporate Risk Management, particular history with Jet Fuel hedging

(See Also Jeff Hammarlund in Section IV)

- Charging methods and infrastructure evaluation
 - *Estimating private charging availability on metropolitan-scale*

- *Charging usage scenario planning*
- *Public charging location/allocation GIS model w/ sensitivity analysis*
- *Evaluation of decisions factors for corporate sponsoring of public charging.*
- *Evaluation of ROW, locate, liability issues in public charging. Who bears costs and risks?*

Faculty:

John Gliebe (CUPA – USP) <http://www.pdx.edu/profile/meet-professor-john-gliebe>

Research: Travel demand modeling

Scott Marshall (SBA – Management) <http://www.pdx.edu/sba/fp-scott-marshall>

Research: proactive environmental strategy, corporate governance, sustainability reporting, and environmental and social multi-stakeholder initiatives

Darrel Brown (SBA - Accounting) <http://www.pdx.edu/sba/fp-darrell-brown>

Research: Corporate social and environmental reporting, the relationship business reporting and business transparency, and the relationship between social and environmental reporting and firm performance.

Jiunn-Der (Geoffrey) Duh (CLAS – Geography) <http://web.pdx.edu/~jduh/>

Research: GIS, spatial decision support systems, landscape ecology, socioeconomic processes

- Urban design of stations and parking
 - *Evaluation of barriers to time reserve charging options*
 - *Design options for on-street charging (identification, safety, ease of use)*
 - *Design options for commercial facility retrofitting of EV charging*
 - *Impact of designated EV park/charge reserved on-street parking*
 - *Design of solar charging stations*

Faculty:

James Strathman (CUPA – USP) <http://www.upa.pdx.edu/CUS/about/meetthedirector.html>

Research: Transit operations, roadway supply, parking behavior & policies

Thomas Harvey (CLAS – Geography) <http://web.pdx.edu/~harveyt/>

Research: Urban geography, cultural landscape studies, sustainable cities

L. Rudolph Barton (Fine Arts – Architecture) <http://www.pdx.edu/architecture/faculty-barton>

Research: No research listed, sits on Sustainable Urban Development Board.

Graig Spolek (CECS - MME) <http://web.cecs.pdx.edu/~grraig/>

Research: Performance measurement and design of green roof systems; HVAC systems design and control; industrial drying; and industrial energy utilization

- Communications and IT Support
 - *Charging Station information protocols (availability, usage, location, error analysis)*
 - *User information privacy risk/protection at charging stations*

Faculty:

Nirupama Bulusu(CECS- CS) <http://web.cecs.pdx.edu/~nbulusu/>

Research: sensor networks; cyber-physical systems; environmental and urban sensing

Suresh Singh (CECS – CS) <http://web.cecs.pdx.edu/~singh/>

Research: Wireless networks, performance evaluation, protocol design

Kristin Tufte (CECS – CS) <http://web.cecs.pdx.edu/~tufte/>

Research: Data Stream management, application of database technology problems to ITS

Yih-Chyu (Y.C.) Jenq (CECS – CS) <http://web.cecs.pdx.edu/~jenq/>

Research: Communications and digital signal processing

Melinda Holtzman (CECS – CS) <http://www.ece.pdx.edu/Faculty/Holtzman.php>

Research: Electromagnetics; semiconductor materials and devices; mobile sensors

Erica Wagner (SBA) <http://www.pdx.edu/sba/fp-erica-wagner>

Research: Information systems

III. Use and Consumers

- Market surveying and analysis
 - *Consumer perception of EV Value (vs non-EV available products)*
 - *Consumer acceptance and demand for EV in car share market*
 - *Public interpretation of EV news and product marketing*
 - *Public perception of state government role in EV strategy*

- Consumer demand analysis
 - *Understanding choices towards purchase based on lifecycle vs. initial costs*
 - *Analysis of public charging payment options*
 - *Analysis of factors influencing solar charging demand*

- Use and behavior evaluations
 - *Multiple-vendor charging scenario implication for EV users*

Faculty:

Jill Mosteller (SBA-Marketing) <http://www.pdx.edu/sba/fp-jill-mosteller>

Research: Consumer decision making

L. P. Douglas Tseng (SBA – Marketing) <http://www.pdx.edu/sba/fp-douglas-tseng>

Research: Consumer Choice modeling, decision making, market research

Duncan Kretovich (SBA – Finance) <http://www.pdx.edu/sba/fp-duncan-kretovich>

Research: Corporate finance, working capital, personal financial planning, cash management.

Neil Ramiller (SBA – Information Systems) <http://www.pdx.edu/sba/fp-neil-ramiller>

Research: Rhetoric, narrative, discourse in information technology

Robert B. Harmon (SBA – Marketing) <http://www.pdx.edu/sba/fp-robert-harmon>

Research: technology marketing consultant, product life-cycle management, pricing strategy

Alan J. Resnik (SBAA - Marketing) <http://www.pdx.edu/sba/fp-alan-resnik>

Research: Strategy Planning, Market segmentation

Veronica Dujon (CLAS – Sociology) <http://www.sociology.pdx.edu/faculty/Dujon/research.php>

Research: Environmental sociology, globalization

IV. Evaluation

- Economic and environmental analysis
 - *Utility cost recovery models*
 - *Time and usage-based pricing models*
 - *Impact of EV market share on Metro/State VMT goals*
 - *Interaction of EV choice vs. other non vehicle use choices*
 - *GHG reduction estimates, refinement of forecasts with observed data*
 - *Evaluating non-GHG emission reduction*
 - *Estimating EV market share needed for air-quality improvements in metro area*
 - *Innovation analysis of Oregon EV start-ups*
 - *Analysis of factors leading to growth in solar industry from increased EV market share*
 - *Evaluation of opportunities for workforce development*

Faculty:

Melissa Appleyard (SBA-Management) <http://www.pdx.edu/sba/fp-melissa-appleyard>

Research: Innovation and process design in Silicon Valley

Jorge Walter (SBA – Management) <http://www.pdx.edu/sba/fp-jorge-walter>

Research: Strategic decision making, tech transfer in context of entrepreneurs, inter-firm alliances, high-tech industries

Vivek Shandas (CUPA – USP) <http://web.pdx.edu/~vshandas/>

Research: Environmental policy, GIS, natural resource management, participatory planning, urban ecology

David Ervin (CLAS – Environmental Science & mgmt) <http://web.pdx.edu/~dervin/>

Research: Environmental management, environmental policy reform, green business

Linda George (CLAS – Environmental Science & Mgmt) <http://web.pdx.edu/~h6lg/>

Research: Monitoring & modeling of urban air pollutants, assessing human exposure to and perception of air pollutants and climate change, linking health & traffic

Aslam Khalil (CLAS – Physics) <http://www.physics.pdx.edu/~aslamk/aslamk/>

Research: Directs Global Change Research Program, studying sources and characteristics of urban air pollution; long term global effects of man-made pollutants.

Randall A. Bluffstone (CLAS – Economics) <http://www.pdx.edu/econ/randall-bluffstone>

Research: Environmental and resource economics including pollution policies in developing and transition economies, environmental livability and privatization.

Dave Garten (SBA - instructor) <http://www.pdx.edu/sba/fp-dave-garten>

Background: Business strategy, with alt fuels and automotive background

David Raffo (SBA – Supply & Logistics Mgmt) <http://www.pdx.edu/sba/fp-david-raffo>

Research: Economic Analysis of engineering decisions / Business Case development

➤ Governance and policy analysis

- *Utility alternative fuel policy evaluation*
- *Evaluation of Public Utility Commission policy towards charging infrastructure*
- *Analysis of efficacy of government provided incentives towards EV users*
- *Analysis of efficacy of government provided incentives towards EV manufacturing*
- *Cost benefit Analysis of Smart Grid implementation*
- *Analysis of EV contributions to State & Metro economic development*
- *EV impact on state and federal transportation funding options*
- *Evaluation of methods to secure revenue from EV usage for transportation funding*
- *Public and stakeholder benefit analysis*
- *Oregon leadership example in EV strategy*
- *Analysis of considering EV towards Utility renewable portfolio standards*
- *Analysis of government fleet EV share standards*
- *Certification standards for EV conversion kits*
- *Joint public-private purchasing pools*

Faculty:

William J. Kenney (SBA - Accounting) <http://www.pdx.edu/sba/fp-william-kenny>

Research: Taxation

Jeff Hammarlund (CUPA - ELI) http://www.eli.pdx.edu/staff/bios/bio_jh.php

Focus: Energy Resources and Policy, Planning the Smart Grid for Sustainable Communities, National Policy Process

Anthony Rufolo (CUPA- USP) <http://www.pdx.edu/usp/profile/meet-professor-anthony-rufolo>

Research: State and Local Finance, Transportation, Urban Economics, and Regional Economic Development

Michael Fogarty (CUPA – USP) <http://www.pdx.edu/profile/meet-professor-michael-fogarty>

Research: regional growth and development through investments in science and technology, emphasizing the role of universities, government labs, and corporate R&D.

Gerard Mildner (CUPA – USP) <http://www.pdx.edu/cupa/profile/meet-gerard-mildner>

Research: Economics of local government, public finance, cost-benefit analysis, growth management, rent control, municipal sports stadiums, housing markets, land use regulation, and urban transportation.

Connie Ozawa (CUPA – USP) <http://web.pdx.edu/~ozawac/>

Research: use of scientific and technical information in public decision-making, the role of the professional, public participation methods.

Daniel Monroe Sullivan (CLAS – Soc.) <http://www.sociology.pdx.edu/faculty/Sullivan/index.php>

Research: Urban neighborhoods, gentrification, racial & socio-economic segregation/integration. Social research methods

John F. Walker (CLAS – Economics) <http://www.pdx.edu/econ/john-f-walker>

Research: American Economic History, Productivity Analysis, Government Spending

Craig Shinn (CUPA – ELI) <http://www.pdx.edu/hatfieldschool/craig-shinn-bs-mpa-phd>

Research: Adaptive management policy, social aspects of sustainability, civic capacity building and inter-jurisdictional administration of natural resources

Jennifer Allen (CUPA – Public Admin) <http://www.pdx.edu/sustainability/profile/jennifer-allen>

Research: environmental and natural resource policy and administration and sustainable economic development

V. Other Faculty

Engineering & Technology Management:

Dundar F. Kocaoglu (CECS – ETM) <http://www.etm.pdx.edu/faculty/kocaoglu1.asp>

Research: Decision analysis, technology management, competitive strategies, analytic hierarchy process (AHP), multi-criteria decision-making, project management, emerging technologies

Timothy R Anderson (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#6>

Research: Data Envelopment Analysis (DEA), productivity management, benchmarking; manufacturing management, engineering economy, operations research

Tugrul U. Daim (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#8>

Research: Technology evaluation and forecasting, research and development management, technology transfer, technology roadmapping

Robert D. Dryden (CECS – ETM)

Research: Rehabilitation engineering; construction productivity; human factors engineering; and safety

Antonie J. Jetter (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#28>

Research: Technology and innovation management, new product development, knowledge management, organizational learning

Dragan Milosevic (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#7>

Research: Total quality management, re-engineering; strategic planning; team building, communication, international project management

Paul Newman (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#33>

Research: New product development processes and tools; the evaluation and acquisition of emerging technologies; government roles in developing new products or services; the "pull side" of technology development; managing technological innovation in global settings

Charles M. Weber (CECS – ETM) <http://www.etm.pdx.edu/faculty.asp#17>

Research: Innovation management, technological entrepreneurship, new product development, semiconductor industry

Desiree Pacheco (SBA) <http://www.pdx.edu/sba/fp-desiree-pacheco>

Research: Business strategy and sustainability, Environmental entrepreneurship, Role of institutions on firm strategy, competitiveness, and knowledge creation, Social movements and firm strategy, Institutions and entrepreneurship

Table C-2: Portland State University EV Research Area / Department Matrix¹⁰⁵

	CECS				CUPA			SBA						CLAS					FA	
Portland State University	CS	CEE	MME	ECE	USP	PA	ELI	Marketing	Finance	Mgmt	Accounting	Info Sys	Other	Economics	Chemistry	Geography	Sociology	Env. Sci.	Physics	Architecture
I. Vehicle Design, Performance, & Use		X	X	X	X									X						

¹⁰⁵ MacArthur, J. (2011, May) EV Roadmap: Research Faculty Report. Working document, Portland State University, OTREC

II. Integration with the Built environme nt																				
Renewable Energy & Storage			X											X						
Grid Capacity & Connection			X		X				X											
Charging Methods & Infrastructu re					X				X	X					X					
Urban			X		X										X					X

Design of charging and parking																				
Communication & IT support	X										X									
III. Use and Consumers							X	X			X					X				
IV. Evaluation																				
Economic & Environmental Analysis		X			X				X			X	X				X	X		

Governme nt and Policy Analysis					X	X	X				X						X			
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University of Oregon

University of Oregon Departments and Programs

AAA: School of Architecture and Allied Arts

Departments:

Department of Architecture

Department of Landscape Architecture (LA)

Department of Planning, Public Policy & Management (PPPM)

Programs:

Product Design Program (PD)

CAS: College of Arts and Sciences

Social Sciences Departments

Economics

Environmental Studies (ES)

General Social Sciences (GSS)

Geography

International Studies (IS)

Political Science

Sociology

Natural Sciences Departments

Computer and Information Sciences (CIS)

Geological Sciences

Psychology

General Science Program

The University of Oregon doesn't have an engineering program per se, but covers the pre-requisites.

Research Institutes

Materials Science Institute (MSI)

The Solar Energy Center

LCB: Lundquist College of Business

Oregon MBA

Innovation and Entrepreneurship (I&E)

Sustainable Business Practices (SBP)

 Sustainable Supply Chain Management

Decision Science (DSC)

Accounting, Marketing, Administration

Table C-1: EV Research Area / Department Matrix

	AAA				College of Arts and Sciences													LCB				
	Architectur	LA	PPPM	PD	Economics	Env. Stud.	GSS	Geography	IS	Political	Sociology	CIS	Geo. Sci.	Psychology	Gen. Sci	Mat.Sci.	Sol. En.	I&E	SBP	DSC	Act Mkt	
University of Oregon																						
I. Vehicle Design, Performance, & Use				X								X				X			X			
II. Integration with the Built Environment							X	X									X		X			
Renewable Energy & Storage			X		X												X					
Grid Capacity & Connection			X									X					X					
Charging Methods & Infrastructure			X																			
Urban Design of charging and parking	X	X	X																X			
Communication & IT support			X									X										
III. Use and Consumers			X		X	X		X	X			X		X				X	X	X	X	X
IV. Evaluation			X									X				X		X	X	X		
Economic & Environmental Analysis		X	X		X	X		X											X	X		
Government and Policy Analysis			X		X	X		X	X													

APPENDIX D

A BRIEF LISTING OF EV RELATED RESEARCH PROGRAMS IN THE U.S.

I. EV Specific Research & Education Programs

A. University of California at Berkeley

1. *Center for Entrepreneurship & Technology*

<http://cet.berkeley.edu/>

EV initiative is prominent. This is the organization with faculty engaging in active research.

Research Focus:

- Deployment strategies
- Impact on utilities
- Impact on power supply
- Infrastructure rollout
- Economic Impacts
- Also: “The Technical & Business challenges of building an Electric Vehicle Sport Utility Vehicle”

2. *Transportation Sustainability Research Center*

<http://www.its.berkeley.edu/sustainabilitycenter/research/propulsionfuels.html>

California Electric Fuel Implementation Strategies (CEFIS) has hosted EV **workshops** (2008), and **data bank** from research to be shared with public. (Databank:

<http://www.its.berkeley.edu/sustainabilitycenter/data/>) However, this initiative does not appear to have gotten off the ground.

B. University of California at Davis

UC-Davis Plug-in Hybrid Electric Vehicle Research Center

<http://phev.ucdavis.edu/>

Research focus: consumer response, environmental impacts, vehicle technology.

Goal: Policy guidance to state

Has director, advisory council from private sector, 7 staff/faculty researchers, 5 grad students.

C. Illinois Institute of Technology

Power Electronics and Motor Drives Lab

<http://hybrid.iit.edu/index.php>

Spin off company: Hybrid Electric Vehicle Technologies, Inc. (HEVT)

EV & PHEV motor drives (e.g. efficiency, conversion kits, digital control)

Size, Director, 3 faculty/staff, 8 phd Students, 4 MS students, 2 other students.

D. Ohio State

Center for Automotive Research (CAR)– Smart Car projects

<http://car.eng.ohio-state.edu/smartatcar>

Focus:

Modeling PHEV interactions with grid

PHEV fleet studies

PHEV-Grid Connectivity issues

PHEV energy management

PHEV Battery Aging Studies

Commercially viable vehicle development

Size: 13 faculty, 25 students (in CAR, Smart Car not listed separately)

E. Bowling Green State University

Electric Vehicle Institute

Focus: ultra capacitor development from demonstration bus & car projects.

Web page updated in Feb, 2010 – but does not list researchers. Last project date is 2002.

<http://www.bgsu.edu/colleges/technology/EVI/>

F. Penn State

Hybrid & Hydrogen Vehicle Research laboratory

<http://www.vss.psu.edu/hhvr1/index.html>

Dedicated test track for vehicle testing

Heavy vehicle (truck/bus) testing facilities

Distributed power

Hydrogen vehicle demonstration

Students / faculty not listed

G. Indiana Advanced Electric Vehicle Training and Education Consortium

Education focus for certificate & associate degree programs for vehicle technicians.

Bach & Masters programs for EV design & manufacturing

Certificate program in EV safety for emergency responders

Schools are: Notre Dame University, Indiana University-Purdue University Indianapolis, Ivy

Tech Community College, Purdue University Calumet and Indiana University Northwest

Announced in August 2009, no real info available to public yet.

One of the announcements:

<http://www.purdue.edu/discoverypark/global/news/news.php?id=250¢er=1>

DOE grant (6\$ million) for project.

H. University of Texas

Center for Electro mechanics (CEM) - Texas Electric Vehicle Program

<http://www.utexas.edu/research/cem/Electric%20Vehicle.html>

Battery systems, motors, electromechanical suspension

Also at CEM: Hydrogen Fuel Cell Plug-in Hybrid Bus, w/ spin-off programs re energy storage,

Transit & DOD applications.

I. University of Western Michigan

Center for Advanced Vehicle Design and Simulation (CAViDS)

Breaking ground on a hybrid drive system lab

Feb 4th Announcement: <http://www.wmich.edu/wmu/news/2010/02/018.shtml>

Focus: Drive systems for Commercial and military HEVs

J. University of Michigan

Michigan Memorial Phoenix Energy Institute

Automotive Research Center:

Has a research focus in Advanced Hybrid Powertrains

http://arc.engin.umich.edu/arc/research/Thrust_4.htm

<http://www.engin.umich.edu/directory/DisplayPlace.do?name=ARC>

Also, in advanced Battery research.

Announcement:

<http://www.ns.umich.edu/htdocs/releases/story.php?id=6920>

(There may be more here, looks like web portal is being updated with many centers including
“more information coming.”)

K. University of Detroit Mercy

Advanced Electric Vehicle Graduate Courses

Ford sponsored program primarily with Ford engineering staff as target student audience.

Program scheduled to start Jan 2010

<http://eng-sci.udmercy.edu/programs/aev/index.htm>

L. Wayne State University

Announced in 2009: EV education program:

- Master's degree: Electric Drive Vehicle Engineering
- Bachelor's degree in Electric Transportation Technology,
- Associate's degree in Automotive Technology and Electronic Engineering Technology
- A graduate certificate program in Electric Drive Vehicle Engineering

<http://www.eng.wayne.edu/news.php?id=1430>

M. University of Tennessee Chattanooga

Center for Energy, Transportation and the Environment

<http://www.utc.edu/Research/CETE/research.php>

Development of a hydrogen Hybrid ICE vehicle

Inductive charging for a transit bus

Range prediction research for Electric Automobiles

Hydrogen conversion

Size: 6 faculty, students not listed

N. Missouri University of Science & Technology

Missouri Transportation Institute

<http://mti.mst.edu/>

- Received \$5 million in federal funding for EV initiative, but research focus not listed.
- Has program to work with city to electrify its fleet, but otherwise research focus is unspecified other than ~alt fuels, esp. PHEV.

II. Smart Grid & Related Programs

A. University of California at Los Angeles

Smart Grid forum

<http://winmec.ucla.edu/smartgrid/about.html>

Has specific research branch in program on EV integration.

B. University of Washington Seattle

Smart Grid, battery, energy storage with loose ties to electric vehicles:

<http://depts.washington.edu/clean/events.html>

Also, Faculty w/ research ties to EV:

<http://www.washington.edu/research/energy/researcher/mohamed-el-sharkawi>

C. Gonzaga U

No EV program, however a graduate certificate in Transmission & Distribution engineering.

D. University of Delaware

Vehicle2Grid

<http://www.udel.edu/V2G/>

- Director & many researchers tied to Marine Policy program, working on off-shore wind-power projects. Research papers include capacity, revenue, opportunity for grid stabilization, opportunity for renewable energy in V2G,
- Size: Director, 8 faculty/staff, 3 doctoral students, 6 master's students, 3 bachelor's students. Also, numerous private sector research partners listed.

E. University of Colorado

Testing of 10 Prius PHEV, announced October 20, 2009

<http://www.colorado.edu/news/r/93d8f4d8ef467b58928e6b90711d0760.html>

- Housed in the Renewable & Sustainable Energy Institute
<http://rasei.colorado.edu/index.php?id=64&page=Research>
- Research focus includes: Conversion of Solar Energy to Electricity & Fuels Energy
- Storage & conversion
- Smart grid
- Nothing “transportation” specific

III. Automotive research centers with EV research

A. Western Washington University

- Vehicle Research Institute
- Includes alternative fuels, but not EV as part of its curriculum

<http://vri.etec.wwu.edu/>

B. Texas A & M University

Power Electronics a& Motor Drives Laboratory

<http://www.ece.tamu.edu/programs/EPI/labs/PEMDL/Current%20Projects/Current%20Projects.htm>

- Has the Texas Applied Power Electronics Consortium (TAPC): Private companies pay about \$20,000 each year to participate in the research activities.

- Hybrid energy storage (ultra capacitors)
- Regenerative Dissipation breaking
- Hybrid drive trains (different configurations, vulnerability of)
- Simulation & design studies of HEV
- EV power supply
- 6 faculty, 1 research staff, 5 doctoral students, 6 master's students (In lab, not just on EV research)

C. Clemson University (South Carolina)

International Center for Automotive Research

- Does not appear to be an EV program but does have a research arm in Vehicular - Electronic Systems integration.

- Faculty research on Hybrid Manufacturing Process

http://www.cuicar.com/research/manufacturing/current_research/deformation_machine.html

Faculty research on charging of ultra-capacitors

http://www.cuicar.com/research/vehicular/current_research/efficient_charging.html

D. Georgetown University

Advanced Vehicle Development

Fuel cell bus:

<http://fuelcellbus.georgetown.edu/>

E. Rensselaer Polytechnic Institute

Center for Automation Technologies and Systems

Fuel Cell manufacturing

<http://www.cats.rpi.edu/research.html#>

<http://www.rpi.edu/dept/cfes/research/systems-engineering-integration.html>

- Fuel cell testing
- Distributed Energy & Smart Grid
- Energy Storage (Lithium Ion advancement)
- Also, materials science center has research on ceramic polymers for use in

EV batteries.

http://catalog.rpi.edu/preview_entity.php?catoid=8&ent_oid=433&bc=1

F. Massachusetts Institute of Technology

- Sloan Automotive Laboratory & Alliance for Global Sustainability

- “Before a transition to Hydrogen Transportation Research Project”

Goal of near term activities for reducing GHG from transportation sector including facilitating adoption of alt-fuels

<http://web.mit.edu/sloan-auto-lab/research/beforeh2/index.html>

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