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Developing an Integrated Technology Roadmapping Process to Meet Regional Technology Planning Needs: The e-Bike Pilot Study

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***Abstract*--Smart grid is a promising class of new technologies offering many potential benefits for electric utility systems, including possibilities for smart appliances which can communicate with power systems and help to better match supply and demand. Additional services include the ability to better integrate growing supplies of renewable energy and perform a variety of value-added services on the grid. However, a number of challenges exist in order to achieving these benefits. Many utility systems have substantial regulatory structures that make business processes and technology innovation substantially different than in other industries. Due to complex histories regarding regulatory and deregulatory efforts, and due to what some economists consider natural monopoly characteristics in the industry, such regulatory structures are unlikely to change in the immediate future. Therefore, innovation within these industries, including the development of smart grid, will require an understanding of such regulatory and policy frameworks, development of appropriate business models, and adaptation of technologies to fit these emerging requirements. Technology Roadmapping may be a useful method of planning this type of future development within the smart grid sector, but such technology roadmaps would require a high level of integrated thinking regarding technology, business, and regulatory and policy considerations. This research provides an initial examination of the process for creating such a type of integrated technology roadmapping and assessment process. This research proposes to build upon previous research in the Pacific Northwest and create a more robust technology planning process that will allow key variables to be tested and different pathways to be explored.**

I. INTRODUCTION

A. Problem to be Investigated

Power grid modernization offers the opportunity to implement technologies with new capabilities that may have been difficult or impossible in the past. From remotely operated energy management system, self-monitoring and self-healing systems, to smart electric vehicles, smart grid can open a myriad of new opportunities for businesses, consumers, and decision makers [1]. Therefore, it is critical to examine how smart grid is likely to develop in the future, what its effects may be, and to create a detailed roadmap showing how this vision might occur.

The next section will describe the need for development of roadmaps to guide the deployment of smart grid technologies, including current efforts in Oregon and the US Pacific Northwest. This field is very broad, so only a limited number of technologies and the capabilities they provide will be described, with an emphasis on technologies that are currently being introduced and seen as important in the region. A more detailed analysis of such technologies, roadmapping, and technology adoption issues has been provided in previous literature [2-6]. In particular, this research will focus on how smart grid technologies can be used to meet key regional goals, such as enabling the integration of renewable energy, which according to recently enacted legislation, must now provide 25% of the energy mix in Oregon by 2025 [7, 8].

1) Research Problem Description

The topics discussed in the previous section raise a number of issues that are important to explore both in the industry practitioner literature and the academic research literature. Specific research objectives, goals, gaps, and questions are defined in section 2.3.4. However, in general terms, the goal of this paper is to deal with how a tool like technology roadmapping can be extended to include policy elements, business / service model elements, and technology-product needs elements. The research further raises the question of the interaction between technology push versus market pull. It then extends these concepts by considering how they might be affected by regulatory and policy push-pull dynamics and the effect this may have on business model development.

II. TECHNOLOGY ROADMAPPING FOR BUSINESS & REGULATORY INTEGRATION

A. The Case of Smart Grid & Vehicle-to-Grid Charging Technologies

This section presents a summary of the needs and challenges for constructing a technology roadmap that integrates business, market, regulatory and policy factors to provide a more complete understanding of how emerging technologies can be developed in ways that fit with regulated utility industry structures, energy policy goals, and effective business models. For the case of smart vehicle-to-grid technologies, it is important to be able to tailor this process to the development needs of Oregon and the Pacific Northwest. Each of the methods presented in the research schema will be explained and discussed later in this chapter. First, however, a brief review of specific literature relevant here is presented, along with a justification of why these methods should be used.

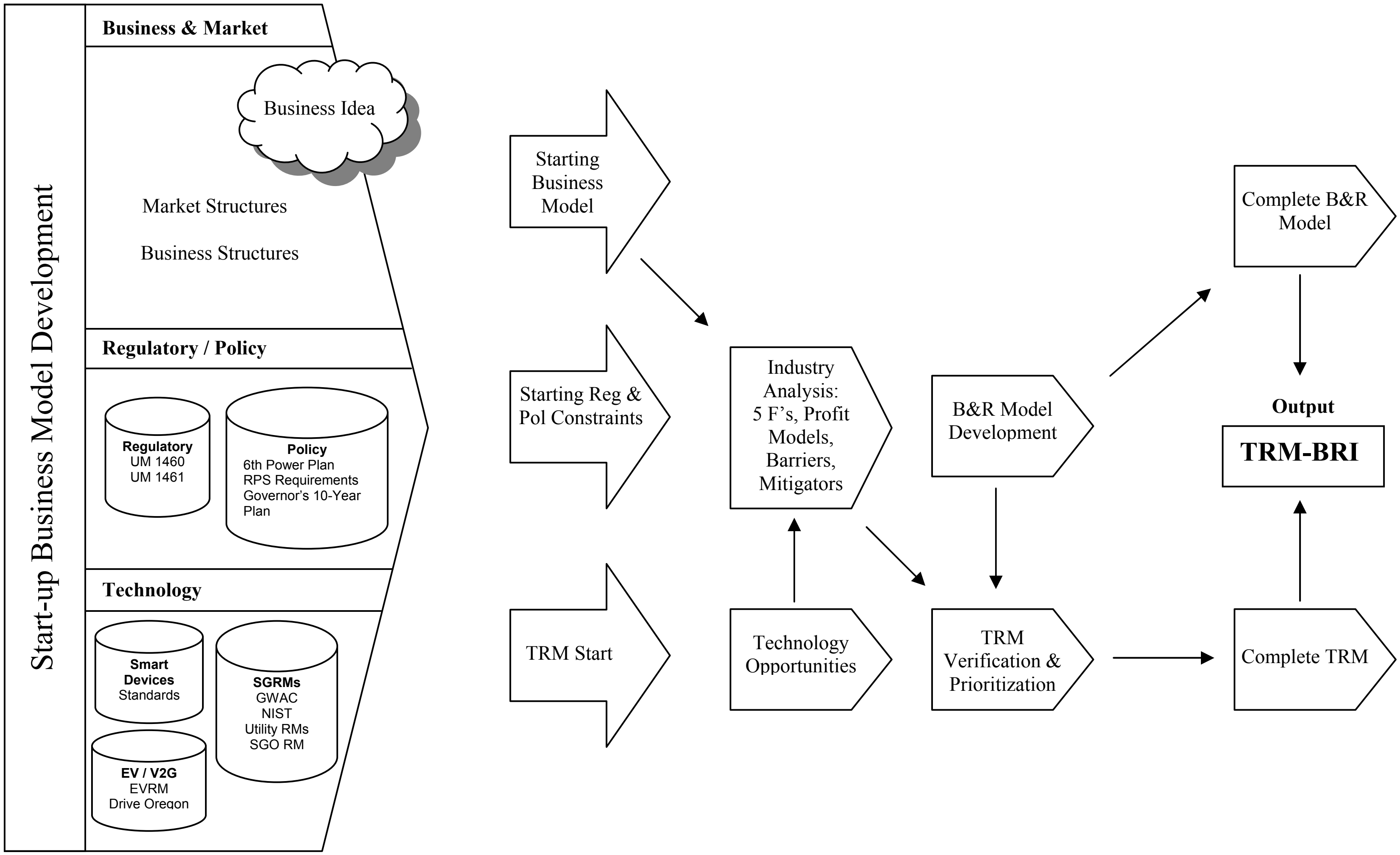


Figure 2.1.1: Research Schema - Technology Roadmapping for Business and Regulatory Integration (TRM-BRI)

B. Justification of Methodologies

What methods are needed to study the development of the emerging vehicle-to-grid smart charging industry and understanding the various business and market needs, regulatory and policy requirements, and technology development gaps that must be filled in order to achieve the multiple benefits offered by such technology? To fully answer this, an analysis is required for the entire industry ecosystem, its stakeholders, and value chain. However, Smart Grid, Electric Vehicles, and vehicle charging technologies are still in an emerging state. Likewise, relevant industry structures, regulatory structures, and policy structures are at a nascent stage as well. Previous sections have provided additional details regarding each of these areas. However, a clear and comprehensive set of methods is required to study this problem in detail. Therefore, a key goal of this research will be to propose, explain, and implement a set of methodologies that is appropriate for improving understanding in this area. Additional explanations and references to relevant literature will be provided in the next section, which summarizes the methodological needs.

Why are TRM and related methods useful for studying V2G? Industries and sub-industries are already beginning to coalesce around Smart Grid, Electric Vehicles, and vehicle charging technologies. However, many such efforts lack clear guidance and standards regarding development even within particular sub-industries, much less coordinated planning among related industry clusters and value chains. Technology roadmapping can help provide a vision of where trends are headed.

In situations where clear business opportunities already exist, a technology roadmap makes it easier to identify and understand the nature of such opportunities. However, in many cases, opportunities and strategies for capturing them are just being identified. In some cases, business models have not yet been developed to accommodate evolving regulatory and policy structures. However, as industry and trade associations develop for smart grid, the need is growing to help a wide range of potential Smart Grid users understand how such new grid infrastructures could benefit specific industries or sub-industries.

Business Concept Development is therefore an important initial step. This provides a way of understanding stakeholder needs, values, and drivers based on regional integrated resource planning goals, policy needs, customer preferences, and opportunities that can be filled by bridging technology gaps. The next critical step is an industry analysis that makes use of tools like Porter’s Five Forces to understand the viability of particular business concepts with an industry. However, this tool needs to be modified to focus particular attention on the effect of barriers that exist within regulated industries, such as utilities, which generally have evolved as natural monopolies. While regulated monopoly structures in many cases are unlikely to change for such industries, it is important to understand how changes in technology, policy, and limited market restructuring can create new opportunities. Therefore, the goal of this phase of industry analysis is to understand what factors can mitigate existing barriers and how appropriate business targets can be designed and used to create technology roadmaps. The next phase is then the actual technology roadmap construction, including prioritization of key technology gaps, as well as barriers and mitigators. Finally, an outcome analysis is used to summarize the main paths to desired outcomes and what factor dependencies exist in order to achieve these outcomes.

The types of methods presented in this section are needed in order to deal with the unique nature of smart grid technology and product development for regulated regional utility systems in general and for electric vehicle smart charging systems in particular. Many problems cannot be solved at just a local or state level, but must instead be solved at higher levels, such as through the coordinated development of regional power system planning, policies, and technologies. Smart Grid and Electric Vehicle Smart Charging applications are new, and the characteristics of such systems are not well understood yet. Multiple perspectives are needed to understand how regulatory and policy issues, as well as market characteristics, can lead to the creation of new business models that are appropriate for the rapidly evolving smart grid technologies that are now emerging.

C. Summary of Methodological Needs

Literature from several key literature streams is reviewed below. The goal in the following sections is to synthesize the lessons learned from reviewing these literature streams and to determine if additional elements are required to develop a comprehensive methodology for achieving the goal given in the title of this research: *Technology Planning for Emerging Business Model, Policy & Regulatory Integration - The Case of Smart Electric Vehicle Charging in Regional Utilities Systems.* To achieve this, gaps are identified in three main literature areas: Technology Roadmapping, Smart Grid & Electric Vehicles, and Integrated Resource Planning. More detail about each of these areas is provided in the sections below.

1) **Methodological Needs:** Technology Roadmapping Literature

The first key area analyzed was the Technology Roadmapping literature. The following research gaps are summarized on the table below.

TABLE 1 TECHNOLOGY ROADMAPPING LITERATURE GAPS

Research Concept	References	Research Gaps
Various processes developed for applying TRM in current and emerging industries	[9-13], [14-23], [24-33]	Method is needed to integrate business modeling, policy, and regulatory factors into TRM for the utility industry
Several methods integrate aspects of business modeling with TRM	[26, 27], [29, 30], [34-39], [3, 40-43], [44-57], [58, 59]	
Few studies consider policy dimensions of TRM or regulatory frameworks, particularly in the utility industry	[60, 61], [40], [41], [44]	TRM goals must align with regional-level factors for utility industry and associated products
TRM generally used at company-, industry-, and national-level, rather than incorporating regional utility concerns	[62-70] [60, 61, 71-74]	Additional work needed prioritizing R&D, acquisition processes, and barriers in utility related industries
More work also needed prioritizing R&D, acquisition, and barriers	[3, 39-50], [75-82]	

A number of processes have been developed for applying TRM to current and emerging industries. General methods have been created for examining both the strategic landscape and technology performance characteristics of new technology product development [9-13]. In section 1.2.5 and an initial study was begun to apply such processes to a particular smart grid sub-industry involving demand response products. Application of such processes to disruptive technologies is highly relevant for smart grid and has been well examined in the literature [14-23]. The process has also been applied to emerging technologies in the renewable and sustainable energy industry, which have strong overlaps with and similarities to the smart grid industry [24-33].

However, the customization of such processes to meet the needs of specific industries, business models, and emerging technology products is an important need that must be addressed. A variety of methods have been developed for integrating aspects of business modeling with technology roadmapping [26, 27], [29, 30], [34-39]. The application of roadmapping to smart grid related industries also need to consider regional implications associated with region spanning utility systems [3, 40-43] and development of business models to address strategic, regulatory, and policy landscapes [44-59].

However, few studies have done detailed analysis of the policy dimensions of TRM or regulatory frameworks, particularly with regard to the utility industry [60, 61], [40], [41], [44] TRM has generally been done at company-, industry-, and national-level, rather than incorporating regional utility concerns [62-70] [60, 61, 71-74]. More work is also needed to understand how to prioritize R&D needs, acquisition efforts [75-82] as well as to understand barriers what may affect implementation. It then may be possible to determine how such barriers could be mitigated with practices involving appropriate business models, market, and regulatory elements [3, 39-50].

Therefore, a method is needed to integrate business modeling, policy, and regulatory factors into TRM for the utility industry. This method is particularly important for the utility industry, due to it unique characteristics and the need for regional scale solutions. Additional research is also needed regarding prioritization of R&D acquisition processes, and barriers in utility related industries. An improved methodology could provide a more complete and better integrated smart grid roadmap to improve planning in the industry. Without such a method, technology planning for regional scale utility systems is likely to be slower, more difficult, and less integrated.

2) **Methodological Needs**: Smart Grid & Electric Vehicle Literature

The second key area discussed was the Smart Grid and Electric Vehicle literature. The initial discussion of this included only general literature. The following research gaps are summarized on the table 2.

Smart grid roadmap literature typically focuses on operational plans [83], [1], [84], [85-89], for utilities as opposed to regional energy planning [92-98]. Some studies examined limited aspects of wider regional planning and generally indicated advantages over more narrow operational plans [90, 91], [99].

However, most current studies examined to date generally have not emphasized regional level considerations [100-113]. Research on important elements of regional level smart grid planning has been initiated [62, 66-69, 114-118]. But, these results have not generally been integrated into models that systematically consider and assess regional goals [71, 72, 119-122]. Process needed to create roadmaps for smart grid technologies that integrate business modeling with regulatory factors and policy factors to meet regional energy planning objectives and overcome structural barriers.

TABLE 2 SMART GRID & ELECTRIC VEHICLE LITERATURE GAPS

Research Concept	References	Research Gaps
Smart grid roadmap literature typically focuses on operational plans for utilities as opposed to regional energy planning	[83], [1], [84-89], [90, 91], [92-98], [99]	Smart grid planning literature could benefit from better alignment with technology roadmapping literature
Generally do not consider regional goals and structural barriers to business and market adoption	[100-109], [110-113], [114, 115], [62, 66-69, 116-118], [71, 72], [119-122]	Process needed to create roadmaps for smart grid technologies that integrate business modeling with regulatory factors and policy factors to meet regional energy planning objectives and overcome structural barriers
No current SG roadmaps for Oregon or the Pacific Northwest.	[101, 102, 104, 105]	
Significant planning also needed for electric EV smart charging roadmap	[63-65], [123], [17-23], [34], [124-127]	Customization needed to develop technology roadmapping processes for EV smart charging systems

Although some initial state-level studies have been conducted, no current smart grid roadmaps have been created for Oregon or the Pacific Northwest on a regional basis [101, 102, 104, 105]. Supporting important goals like the Renewable Portfolio Standard in Oregon and most other Northwestern states has been discussed in chapter 3, along with smart appliances, such as electric vehicles. Electric Vehicle Smart Charging technologies appear to offer significant potential to support key state and regional goals for meeting the portfolio standard and enhancing to robustness of the power system. However, significant planning efforts [63-65] are needed to created roadmaps related to these emerging technologies [123], [17-23], [34] and adapt them to the needs business and market, policy and regulatory, and technology needs that have been discussed for such a system [124-127].

Processes are needed to create roadmaps for smart grid technologies that integrate business modeling with regulatory factors and policy factors to meet regional energy planning objectives and overcome structural barriers. Smart grid planning literature could benefit from better alignment with technology roadmapping literature. But, significant customization is needed to develop roadmapping processes for EV Smart Charging Systems.

3) Methodological Needs: Resource Planning & Policy Literature

The third key area discussed was the Resource Planning literature. The initial discussion of this included only general literature. The following research gaps are summarized on the table 3.

Strategic alignment of business model and policy frameworks is particularly important for regulated industries like electric utilities [128], [7], [129], [130-132]. As discussed in chapter 1, utilities generally have large capital costs, high barriers to entry, and increasing efficiencies of scale. This gives them many characteristics of natural monopolies. Traditional structures present a number of advantages and disadvantages. But, with rapid technology advances in the utility sector, one key issue is the need to overcome chronically low levels of R&D investment in the industry, estimated at around 0.25% of revenues [133]. There is also a need to understand that many aspects of utility regulatory structures have been useful and durable [134-136]. Thus, it is necessary to incorporate an understanding of utility regulation and planning processes [90, 91, 100-103] to create alignment [62, 66, 116-118] between business models and policy frameworks [119], [137, 138], and technology development [107], [94, 95].

In particular, unique energy policy planning issues exist in Pacific Northwest due to multiple regulatory frameworks at the state [104-106, 108], federal [98, 114, 115], and regional [67-69] levels. Implementing improved smart grid roadmaps will take considerable amounts of discipline spanning knowledge [3, 40, 41], [121]. A multiple perspectives view [76-81] is critical for creating robust planning models in the utility industry [63-65], [139, 140] and incorporate these inputs into a roadmapping process that an understanding of utility regulation and planning processes to create strategic alignment between business models and policy frameworks. TRM methods need to be adapted to unique regulatory frameworks for regional utility industries [9-11]. Overall, there is a strong need for robust, multiple perspective planning models in the utility industry that create strategic alignment between business models, policy, and regulatory requirements

4) Research Gaps, Goals, and Questions

The following sections summarize the Research Gaps, Research Goals and Research Questions determined after performing all the analysis up to this point in this study.

The gaps identified in sections 2.3.1, 2.3.2, and 2.3.3 are consolidated here and used to synthesize a Research Objective. The Research Objective is to develop an integrated planning process to address technology, business models, regulatory, and policy issues for electric vehicle smart charging systems to meet regional utility industry needs. Based on this objectives, three main research questions are created to guide this study. The first research question is: What are the highest priority technologies, gaps & barriers for creating V2G systems that meet business, regulatory, and regional energy policy objectives? The second research question is: Is TRM an appropriate tool for understanding technology, business, regulatory, and regional energy policy objectives?

TABLE 3. RESOURCE PLANNING & POLICY LITERATURE GAPS

Research Concept	References	Research Gaps
Strategic alignment of business model and policy frameworks particularly important for regulated industries like electric utilities	[128], [7], [129], [130-136], [90, 91, 100-103], [107], [94, 95], [62, 66, 116-118], [119], [137, 138]	Need to incorporate an understanding of utility regulation and planning processes to create strategic alignment between business models and policy frameworks
Unique regional energy policy planning issues in Pacific Northwest due to regulatory frameworks	[104-106, 108], [98], [114, 115], [67-69], [3, 40, 41], [121]	TRM methods need to be adapted to unique regulatory frameworks for regional utility industries
Multiple perspectives view is critical for creating robust planning models in the utility industry	[9-11], [63-65], [76-81], [139, 140]	Strong need for robust, multiple perspective planning models in the utility industry that create strategic alignment between business models, policy, and regulatory requirements

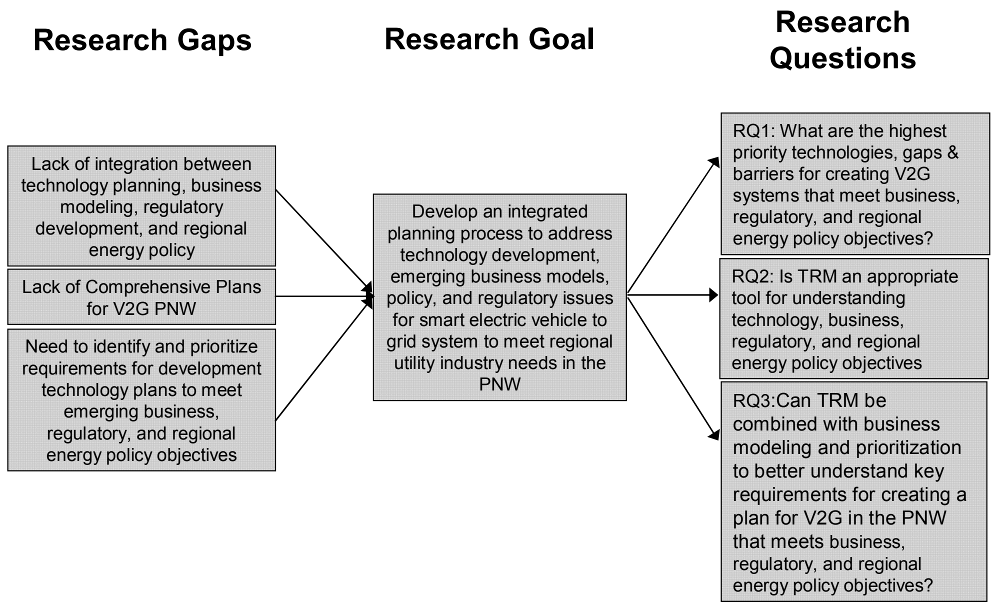


Figure 2.3.4.1: Summary of Research Gaps, Goals, and Questions

The third research question is: RQ3:Can TRM be combined with business modeling and prioritization to better understand key requirements for creating a plan for V2G in the PNW that meets business, regulatory, and regional energy policy objectives? The next section then explains the industry focus for this study.

D. Methodologies Proposed

1) Business Concept Development

An important step in understanding the technology, business, regulatory, and policy landscapes for emerging smart grid appliances, like electric vehicle smart charging systems, is to examine key opportunities that are arising in this area and see if these opportunities can be developed into viable business concepts and business plans. A number of steps are necessary in order to identify and analyze such opportunities.

It is first important to thoroughly define a complete set of stakeholders who may support or oppose a particular business opportunity. In the preliminary analysis matrix for the business sub-model, an initial list of stakeholders was created, but little about them was defined. Unlike many traditional business opportunities that have been studied outside the utility industry, the unique regulatory structures that exist for companies in Oregon and the Pacific Northwest mean that there are many significant stakeholders who are not direct customers for the product under consideration. A common tools used for analyzing stakeholders and their values is the stakeholder-objective matrix [141, 142]. An example of this type of matrix is shown below.

The stakeholder-objective matrix shown here summarizes the key stakeholders and the main objectives they both support and oppose. This matrix specially addresses issues related to renewable energy integration and demand response.

As the data is collected for this research, additional information could be added regarding the stakeholder issues for of electric vehicles and vehicle-to-grid system specifically.

To illustrate how a stakeholder-objective matrix could be applied to small, manageable business case, a pilot study was performed examining the concept of introducing electric bicycle rentals and/or charging on the Portland State University campus. The following diagram illustrates the stakeholder-objective matrix that was derived.

The stakeholder-objective matrix for this pilot study summarizes a number of important points. The main participants envisioned in the electric bicycle enterprise for this pilot study can be divided into Stakeholders (S), Customers (C), and Providers (P). Several participants fall into more than one categories. These participants include: University (S)(C)(P); Government (S)(C); Community Groups (S) and Community Members (S)(C); Students (C); Faculty (C); Staff (C); Utility Companies (P); and Third Party Vendors (P). Each participant has specific issues labeled "what they support" and "what they oppose," which are summarized on the above chart. This information can then be used as an input to determine how stakeholder objectives can be translated into drivers of value production for products and services on a technology roadmap. This information will then be fed into the next stage of the research process, which is to conduct an industry analysis to design and obtain a business target, define business model alternatives, establish content to construct a technology roadmap, and understand key barriers and mitigators to development.

TABLE 4. STAKEHOLDER-OBJECTIVE MATRIX FOR E-BIKE PILOT STUDY

Stakeholder (S) / Customer (C) / Provider (P)	**What they Support**	**What they Resist**
UNIVERSITY (S)(C)(P)	Reducing campus parking. Reducing campus traffic. Reducing emissions. The university is potentially a stakeholder, customer, and/or provider of goods and services related to e-bikes.	Large initial investments. Uncertain technology. Locked in obsolescence. Unless partnerships could be negotiated, access to e-bikes would probably be limited to students, faculty, and staff to avoid shortages of bikes or other resources.
GOVERNMENT – City, County, State (S)(C)	Reducing city traffic. Reducing street parking. Reducing emissions. City could potentially participate as a stakeholder or customer. They support clear regulations and standards for charging, operating, and parking. City government and its employees may consider sponsoring or becoming customers of an e-bike system. Tax credits or other incentives (mainly at the city, county, or state level, but possibly also federal) to encourage a campus e-bike system could be important to make the initial system feasible to establish. Governments are more likely to support systems that are accessible to the wider community and not just those affiliated with the university.	Unclear regulations for parking or operating e-bikes on city streets around campus. They may initially loose some parking revenue if street parking drops, but it is likely to be compensated for by additional customer parking tor businesses. Concerns about bike safety would have to be addressed. City government would probably resist becoming a partner or customer in such a project unless technology and business risk could be sufficient reduced to make long-term success probably and avoid a politically embarrassing failure. Governments would be reluctant to establish substantial incentives, credits, or other financial support, especially during the recent economic downturn, unless clear benefits and performance goals could be met and the risk of business or technology failure could be shown to be low.
COMMUNITY GROUPS (S) / COMMUNITY MEMBERS (S)(C)	Civic organizations are concerned with reducing traffic, parking, pollution, noise, as well as bike safety. Envrionmental groups support reduced emissions, use of green power for bike charging. Individuals community members might consider participating in an e-bike system, especially if it spread beyond the university campus and into the surround community.	Civic groups may be concerned about enforcing bike safety requirements and concern about bike vs. car traffic issues. Environmental groups would resist initiates without clear benefits in terms of emissions reduction, green power use, and recycling of toxic battery components.
STUDENTS (C)	Reducing fuel costs, reducing parking costs, increased convenience, reducing emissions.	High upfront fees, long-term commitments, inconvenience, steep learning curves, lack of reductions of emissions or other pollutants, lack of use of renewable energy.
FACULTY (C)	Reducing fuel costs, reducing parking costs, increased convenience, reducing emissions. Faculty are like to want increased cargo capacity and convenience compared to students.	Difficult financing, long-term commitments, steep learning curves, inconvenience, steep learning curves, lack of reductions of emissions or other pollutants, lack of use of renewable energy.
STAFF (C)	Reducing fuel costs, reducing parking costs, increased convenience, reducing emissions.	High upfront fees, long-term commitments, inconvenience, steep learning curves, lack of reductions of emissions or other pollutants, lack of use of renewable energy.
UTILITY COMPANIES (P)	Cost recovery, fair rate of return, stable long-term market, clear regulations, pricing.	Lack of standards, locking in technological obsolescence
THIRD PARTY VENDORS (P)	ROI, market share development, intellectual property development, business model scalability.	Unprofitable,or marginally profitable markets, lack of standards, lack of clear regulation, unproven technology.

Source: Adapted from [141, 142]

After an opportunity is recognized, such as through literature, consultation with experts, or other means, a business modeling process can be performed to further define and assess the potential opportunity. A model is then defined describing the opportunity both in it current state, the "as is" model, and what is desired in the future, the "to be" model [26, 58, 59]. However, prior to creating this model, a preliminary sub-model is created to assess initial ideas. A series of basic questions are answered as shown below to begin defining an opportunity that may later be developed into a complete business model. The questions have been modified to make them relevant for creating an integrated smart grid roadmap, which may have a number of stakeholders who are not necessarily direct customers.

To illustrate how this type of business sub-model matrix could be applied, a pilot study was performed examining the case of electric bicycle rental and/or charging on the Portland State University campus. The following diagram illustrates the business sub-models that were derived.

Several key pieces of information can be seen from the above figure. Key stakeholders include university faculty, staff, and students, as well as businesses or organizations in the local area, and local government. Decisions must be made regarding whether to focus first on specific user segments among these stakeholders or on a combination of segments. Further decisions must be made regarding the possibility of university, utility, or third-party ownership of an electric bicycle venture and if the primary profit mechanism will be rentals, battery charging, leasing, or some combinations thereof. Options for financing and distribution can then be determined that are appropriate for each of these cases. The next step in this process explains more details about defining a business model.

A number of additional steps are required in order to define a business model. However, before proceeding, it is important to define what is meant by a business model. In creating the framework for this research, we referred mainly to Hamel [52], Slywotzky [53, 54], and Chesbrough [55]. Slywotzky's definition is perhaps most clear and succinct. A business model is described as:

> "*The totality of how a company selects its customers, defines and differentiates its offerings, defines the tasks it will perform itself and those it will outsource, configures its resources, goes to market, creates utility for customers, and captures profit. It is the entire system for delivering utility to customers and earning a profit from that activity.*"

Understanding appropriate business models for emerging technologies, such as electric vehicle-to-grid smart charging appliances, is critically important, since much of the new technology is in a nascent state and the direction of development can depend strongly upon perceived business opportunities. This can likewise be affected by perspectives regarding the market, regulatory and policy goals, and the rate at which technical capabilities are developing. Therefore, the next step in this process is to examine each of these key perspectives and to have experts determine what that they consider to be the highest priority issues in these areas during the following time periods: 1 year; 2 to 4 years; and 5 to 10 years.

Sub Model	Sub Model Features
Who? *Stakeholders?* ***UNIVERSITY, GOVERNMENT, COMMUNITY*** *What do they support / oppose* ***(See stakeholder matrix)*** *Customers?* ***STUDENTS, FACULTY, STAFF, LOCAL GOVT, COMMUNITY*** *Markets?* ***UNIVERSITY-AFFILIATED, COMMUNITY-AFFILIATED, COMBINATION*** *Segments ?* ***SHORT-, MED-, LONG-DISTANCE COMMUTERS***	*Structure of Market?* ***UNIVERSITY-OWNED, UTILITY OWNED, 3RD PARTY*** *Target Customers?* ***STUDENTS, FACULTY, STAFF, OTHERS AS OPPORTUNITY ARISES***
What? *Value Proposition?* ***INEXPENSIVE, CONVENIENT, GREEN TRANSPORTATION*** *What do stakeholders have now?* ***FOSSIL FUEL VEHICLES, NON-ELECTRIC BIKES*** *What do stakeholders want?* ***LOWER FEUL COSTS, LOWER PARKINGING COSTS, EASIER BIKE COMMUTING FROM LONG DISTANCES, LOWER EMISSIONS***	*Products?* ***ELECTRIC BICYCLES, CHARGING SYSTEMS*** *Customer Utilities?* ***CONVENIENCE, REDUCED COSTS, LOWER POLLUTION*** *Competitiveness?* ***LOW E-BIKE OPERATING COSTS. OVERCOMING INITIAL SKEPTICISM ABOUT HIGH PURCHASE COSTS AND UNCERTAINTY ABOUT E-BIKES IS A CRITICAL CHALLENGE TO BE ADDRESSED.***
How? *Value Delivery?* ***BIKE RENTAL, BIKE LEASING, BIKE SALES, BIKE CHARGING, MEMBERSHIP / SUBSCRIPTION***	*Finance Acquisition?* ***PRIVATE, BANK, VC, CROWD SOURCE, MICROFINANCE*** *Manufacturing? N/A* *Distribution Channel?* ***B2C, B2G, B2C2G COMBO***
Profit & Revenues? *Customers?* ***STUDENTS, FACULTY, STAFF, LOCAL GOVT, COMMUNITY*** *Markets?* ***UNIVERSITY-AFFILIATED, COMMUNITY-AFFILIATED, COMBINATION*** *Segments ?* ***SHORT-, MED-, LONG-DISTANCE COMMUTERS***	*Profit Model?* ***FOR-PROFIT, NON-PROFIT,*** *Ownership Structure?* ***PRIVATE, PUBLIC, PUB-PRIV PARTNERSHIP***

Source: Adapted from [26, 58, 59]
Figure 2.4.1.2: Business Sub Model Matrix for e-Bike Pilot Study

As was done in the previous section a pilot study involving electric bicycle use at Portland State University has been used to illustrate how this type of business concept development can be applied. The following diagram illustrates the business concept development information that was obtained from this process.

The next step in this process is to provide more details about the necessary business structure and goals. This information is summarized in the next figure.

By answering the types of questions presented below, it should be possible to determine the following (at least tentatively):

- What is the "as is" situation or opportunity to be explored?
- What is the "to be" vision?
- What are the business goals over time (i.e. 10X growth in 10 years…)
- What are the key gap areas or needs?

A brief example of how this tool would be used is to estimate potential sales of a specific product, like residential electric vehicle chargers in Oregon over the next 10 years. A company engaged in a similar type of electronic equipment business might consider getting into this business through one or more of the potential distribution channels, but only if it could expand sales in a current business area by some goal (commonly 10X over 10 years). The estimated sales are the "to be" number and the current product sales are the "as is" number. If the number for the goal of increasing sales by 10X is greater than the "to be" number, this means there is a gap in what the new industry is estimated to achieve versus the business's goal of increasing its current sales. After determining if such as gap exists and how large it is, various alternatives can be examined for achieving the business goal through one or more business models. This helps understand key decisions that are likely to make regarding business entrant to an industry therefore this research proposes to use this as an input into an integrated roadmapping process.

Based on the pilot study, the "as is" situation is: Use of non-electric bicycles on campus as a transport alternative primarily for short-range commuters. The "to be" situation is: Use of electric bicycles on campus as part of an integrated campus commuter system aimed at reducing car use for intermediate- and long-range commuters. The initial business goal can be stated in several ways. In terms of return on investment, a goal of achieving a 10X or ten-fold return on investment within

10 years is envisioned. In terms of market share, the goal is to achieve participation equal to 20% of the student population. At this point in the analysis of this pilot study, such goals can be considered "stretch goals." However, they are useful in defining some possibly metrics of success that were considered reasonably attainable, based on the data gathered for this study. Key gaps or needs that would be necessary to address in order to achieve these goals would be to make decisions regarding the choice of specific value delivery methods, distribution channels, and finance methods. To better understand the possibilities that exist for each of those alternatives, an industry analysis is helpful. Therefore, an industry analysis is performed in the next section, and a more detailed analysis of results for each of these alternatives is provided there.

Opportunity Recognition (Worksheet 1): What is the basic opportunity and why is it valuable?
(IRP, Policy Analysis, ISRM)

A. *Ask:* **What?** — **Value Proposition**
Products? *ELECTRIC BICYCLES*
Capabilities? *SIMPLE, INEXPENSIVE, GREEN TRANSPORTATION*
Competitive Advantage? *LOW COST, CONVENIENT*

B. *Ask:* **Where?** *PORTLAND STATE UNIVERSITY CAMPUS, MICROGRID, ECODISTRICT…*

C. *Ask:* **Why?** Why is this important? (See Perspectives in next section for more detail)

Perspectives Recognition (Worksheet 2): Priority Issues in next 1 to 10 years (Based on S-Plan elements)

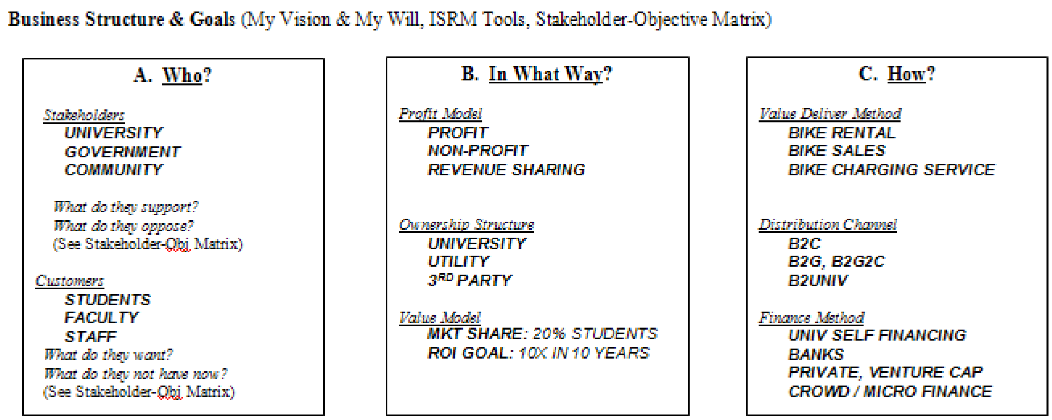
A. Technical Characteristics
- *LOW COST ELECTRIC TRANSPORTATION*
  - *CHEAP TO CHARGE*
  - *HIGH INITIAL CAPITAL INVSTMNT*
- *RENEWABLE ENERGY USE*
  - *GREEN SIGNAL*
- *GRID SUPPORT ABILITIES*
  - *MICROGRID*
  - *ECODISTRICT*

B. Policy Goals
- *REDUCE CAMPUS VEHICLE TRAFFIC*
- *REDUCE CAMPUS PARKING*
- *REDUCE EMISSIONS, GHGs*
- *SUPPORT LOCAL GRID*

C. Regulatory
- *CAMPUS VEHICLE POLICY*
- *PARKING POLICY*
- *CHARGING POLICY*
- *VENDOR / SERVICE PROVIDER POLICY*
  - *UNIV-OWNED*
  - *UTILITY-OWNED*
  - *3RD PARTY-OWNED*
  - *COMBINATION*

D. Market
- *REDUCE CONSUMER GAS COSTS*
- *REDUCE CONSUMER VEHICLE EXPENSES*
- *REDUCE CONSUMER PARKING COSTS*
- *FAST TRAVEL TO EXACT DESTINATION*
  - *EASY BIKE PRKNG*
  - *EASY BIKE USE*

Source: Derived from [10, 39, 141, 142]
Figure 4.4.1.3: Opportunities & Perspectives in e-Bike Pilot Study



Source: Adapted from [26, 58, 59, 143]
Figure 4.4.1.4: Business Structure & Goals in e-Bike Pilot Study

2) Industry Analysis

Industry analysis is a critical step in this research process. It makes use of well known tools, like Porter's Five Forces, to understand the viability of particular business concepts with an industry. However, this tool needs to be modified to focus particular attention on the effect of barriers that exist within regulated industries, such as utilities, which generally have been structured as regulated monopolies. While, in most cases, regulated monopoly structures are not expected to be fundamentally changed in these industries, it is important to understand how changes in technology, policy, and limited market restructuring may lead to the creation of new opportunities. Therefore, the goal of this phase of industry analysis is to understand what factors can mitigate existing barriers and how appropriate business targets can be designed and incorporated into roadmaps.

A widely used tool for analyzing industry conditions is Porter's Five Forces [56, 57]. The tool identifies five forces based on industrial organization economics that indicate the overall attractiveness or profitability of an industry based on its intensity of competition. The tool is valuable for most industries with competitive structures. The forces examined include the internal market issues of: (1) bargaining power of buyers; bargaining power of suppliers; (3), the viability of substitutes for the product or service in question (4), and the external market issue of new entrants to market.

In the case of pure monopolies, there would be almost no threat of new entrants, so Porter's Five Forces would be of limited value. However, many utility systems function as regulated monopolies in limited service territories. In these cases, the five forces model is relevant and can produce some valuable insights. This is especially true, as many utility systems have considered various types of restructuring, creating de-regulated or partially de-regulated systems that have increased the competitive elements within the industry.

However, when using the five forces model, it makes sense to modify portions of it in a number of ways to fit the general nature of the utility industry. Typically, barriers to entry are still extremely high for utilities, even in the absence of traditional monopoly structures, since the investments for utility infrastructure are very capital intensive. So, a starting assumption for analysis in this industry is that is very important to understand the size and types of barriers that exist. Barriers can be further sub-divided into both the typical business & market barriers (1) and regulatory & policy barriers (2). So, the industry analysis portion of this research makes use of this modified structure for the five forces model.

Another area that is examined is business & market targets, as well as regulatory & policy targets for overcoming barriers in those areas. Finally, mitigation programs are examined, such as business & market programs, as well as regulatory & policy programs that could potentially be used for overcoming these barriers. The following diagram shows the modified framework. Information from electric bicycle pilot study mentioned in previous sections is provided here.

Based on the results of the pilot study, a number of key points can be observed. Industry Viability was rated as questionable to moderate. This was primarily due to high perceived barriers and high supplier power. Substitutes for electric bicycles were considered low to moderate. A number of mitigators were identified for addressing barriers, such as joint financing, and special rate structures or incentives that could be used to make the goal of a university-third-party partnership more attainable. The overall opportunity was considered somewhat attractive, as many potential buyers, are believe to exist for this type of system.

The industry analysis produces three main outcomes: (1) Designing and Obtaining a business target; (2) Establishing content to construct a technology roadmap integrating the business / market and regulatory / policy issues identified in the industry analysis; and (3) to understand the key barriers that exist and how they can be mitigated. This information will becomes an input for the next phase of the research, which constructs a roadmap based on these elements and begins the process of prioritizing them.

In situations where clear business opportunities already exist, a technology roadmap makes it easier to identify and understand the nature of such opportunities. However, in many cases, opportunities and strategies for capturing them are just being identified. In some cases, business models have not yet been developed to accommodate evolving regulatory and policy structures.

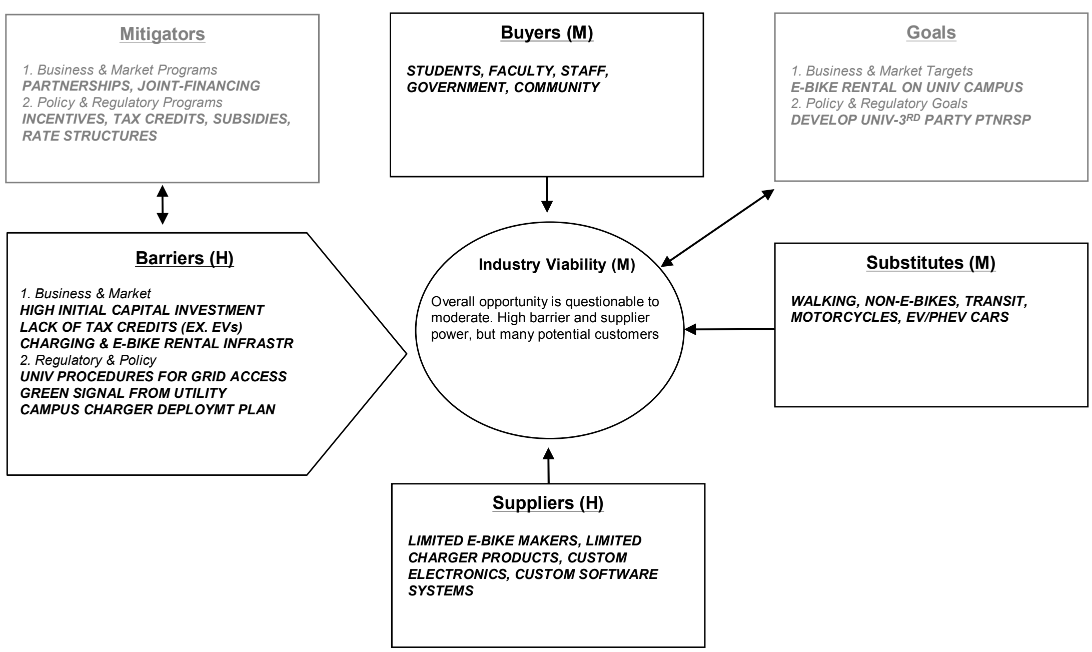
To better analyze and define the basis for various business models that are possible in the emerging smart grid industry, a technique will be used called My Vision & My Will is used in the next section [26, 58, 59]. As previously mentioned, a business opportunity can be examined in terms of both "as is" and "to be" conditions. By looking at gaps between these two conditions, different scenarios or alternative approaches can be envisioned for achieving the desired objective.

In cases where a set of industry roadmaps already exist, this information can be used as an input for considering alternatives to reach the "to be" condition. However, because the type of integrated roadmaps desired in this research do not currently exist, it will be necessary to come up with scenario alternatives through a process of expert judgment. The following matrix is one tool that is helpful in determining the type of business to customer relationship that is envisioned.

To illustrate how this type of business-stakeholder alternatives analysis could be applied a pilot study was performed examining the case of electric bicycle rental and/or charging on the Portland State University campus. The following diagram illustrates the business-stakeholder alternatives information that resulted from the study.

A number of key pieces of information are summarized on the figure below. The main business alternatives examined were Business-to-Consumer (B2C), Business-to-Government (B2G) with an additional Business-to-Business (B2B) option, and Business-to-Community-to-Government (B2C2G2B).

In the first case, B2C, the electric bicycle program is conducted directly to the end-consumers: The students, faculty, and staff at the university utilizing the program. Various products or services are available under this model, such as e-bike rentals, individual memberships, charging programs, e-bike leases, and e-bike purchases. Profit models are created based on each of these product service types. A number of operations systems are also available for enabling delivery of these products and services, such as software or web-enabled transactions, point of sales transactions at kiosks, or individual transactions between buyers and sellers. The growth model associated with B2C-oriented strategies is estimated based on an initial start-up in the first year, and then estimating growth over 5 years and growth over 10 years. Estimates for these time period are that an initial group of 500 customers (2% of the campus population) could be established in the first year of operations. After 5 years, the goal would be to grow this figure to 2,000 (10% of campus population), and after 10 years, the figure would be increased to 4,000 (20% of campus population). Such a strategy has the advantage of being focused on a single population in a well defined area. A number of the other strategies differ primarily in the fact that they reach out to a broader population in the area surround the campus and the community. So, they potentially can reach a greater population. However, they also have the disadvantage of being less focused on a narrow group with similar needs. Therefore, other techniques and strategies are expected to be required to serve these populations.



Source: Modified from [56, 57]
Figure 2.4.2.1: Industry Analysis for e-Bike Pilot Study

	B2C	B2G(2B)	B2C2GB
Customer / Stakeholder	*STUDENTS, FACULTY, STAFF COMMUNITY MEMBERS*	*UNIVERSITY, GOVERNMENT, COMMUNITY ASSNS.*	*STUDENTS, FACULTY, STAFF COMMUNITY MEMBERS, UNIVERSITY, GOVERNMENT, COMMUNITY ASSNS.*
Product / Services	*E-BIKE RENTALS, INDIV MEMBERSHIP, CHARGING FEE, *E-BIKE LEASE,* E-BIKE PURCHASE*	*E-BIKE LEASE, GROUP MEMBERSHIP, E-BIKE RENTAL, CHARGING FEED-IN, E-BIKE PURCHASES*	**E-BIKE LEASE INCENTIVES, *E-BIKE PURCHASE INCENTIVES*
Operations System	*PERSONAL BUYS, RENTALS SOFTWARE / WEB ENABLED, POINT OF SALE*	*GROUP BUYS &RENTALS SOFTWARE / WEB ENABLED*	*INDIV/GROUP BUYS & RENTALS, INCENTIVES, COMBINATION SYSTEMS SOFTWARE / WEB ENABLED, POINT OF SALE*
Profit Model	*INDIV: RENTALS, MEMBERSHIP, CHARGING LEASE, PURCHASE*	*GROUP: RENTALS, MEMBERSHIP, CHARGING LEASE, PURCHASE*	*INDIV/GROUP LEASE INCENTIVES, PURCHASE INCENTIVES, CHARGING FEED-IN*
Growth Model 2013 (now) 2018 (5 year) 2023 (10 year)	500 customers (2% campus) 2000 (10%) 4000 (20%)	850 (cam, gov, biz) 4000 (10%, 10%, 5%) 8000 (20%, 15%, 10%)	1000 (cam, gov, biz, com) 4500 (10%, 10%, 5%, 2%) 9500 (20%, 15%, 10%, 5%)

Source: Derived from [26, 58, 59]
Figure 4.4.2.2: Business-Stakeholder Alternatives for e-Bike Pilot Study

In the second case, B2G, the idea is that rather serving only the consumers on campus, the initial focus will be on faculty and staff at the university, as well as local government agencies, such as city and county employees in the immediate vicinity of campus. This group would act as a set of lead-users, testing the system. It is likely that rather than individually selling to consumers, agreements would be negotiated that would allow package deals for all employees or groups of employees at Portland State University, Portland City Government, Multnomah County Government, the Portland Development Commission, City Police, Firefighters, Public Safety workers, and others. This is expected to be a fairly large group, which often has a history of working with and frequently even sharing building space on the Portland State University campus. Due to the likelihood of group deals, a relatively large group of customers could probably be acquired quickly. The decision could also be made to expand the focus of this strategy to a B2G2B model, which would do the same as above, except that in addition to government employees, it would also add employees of businesses in the areas surrounding the Portland State University campus. This would allow for an even larger group of customers, but would carry the risk of being less focused, and potentially requiring a more diverse set of requirements to meet customer needs than would be the case with a more narrowly defined group. In the case of the later strategies, estimates are that the initial customer base in the start-up year would be approximately 850 (2% of campus employees, 2% government employees, and 1% of local business employees). After 5 years, the figure would be projected to grow to 4,000 (10% campus, 10% government, and 5% business). In 10 years the goal would be to increase this figure to 8,000 (20% campus, 15% government, and 10% business).

In the third case, B2C2G2B, this is essentially an all-of-the-above strategy. In additional reaching out directly to the end-consumers on the Portland State University campus (students, faculty, and staff), the customer base would also include local government employees, local business employees, and other community members in the surrounding area. This approach would have the advantage of a very large potential customer base, but would also have the disadvantage of being less focused than the other more narrowly defined approaches, and therefore having to meet a much more diverse set of customer needs. In this case estimates are that the initial customer base in the start-up year would be approximately 1,000 (2% of campus employees, 2% government employees, 1% of local business employees, and 1% of other community members). After 5 years, the figure would be projected to grow to 4,500 (10% campus, 10% government, 5% business, and 2% community). In 10 years the goal would be to increase this figure to 9,500 (20% campus, 15% government, 10% business, 5% community).

The goal of this analysis is to consider a variety of different business approaches with potential customer groups that would require different techniques for serving them and would ultimately result in very different sizes of initial customer bases, as well as the eventual size of the customer based after 10 years. The objective is not to provide forecasts to determine precisely how many customers will make a purchase in a given year. The objective is merely to begin quantifying general expectations regarding some of the different business approaches and to be considering the different techniques for reaching customers with a variety of different types of needs.

Another business modeling tool is then used to consider how various factors may be able to change the basis of competition over time. The following matrix provides a way of analyzing this. This offers a useful tool for examining potential factors that may impact an industry with respect to emerging dimensions of competition and overall industry viability.

Several categories of industry factor alternatives were considered for the electric bicycle pilot study at Portland State University. These factors were divided into Regulatory / Policy; Market / Product, and Technology / Function. The first two categories were further subdivided into new versus existing structures or conditions in those areas, and the analysis then considers changes that are envisioned based on those initial conditions over the next 10 years. The third category simply examined changes to technological and functional factors over this time period.

Several categories of industry factor alternatives were considered for the electric bicycle pilot study at Portland State University. These factors were divided into the following: Regulatory / Policy; Market / Product; and Technology / Function. The first category further subdivided into New Policy / Existing Regulatory versus New Regulatory / Existing Policy structures. The second category was divided between New Product / Existing Market versus New Market / Existing Product. The third category simply examined changes to Technological Factors versus Functional Factors. The analysis then considered changes over the next 10 years that are envisioned based on initial structures and conditions in each category.

For the Regulatory / Policy category, the main issues involved moving from a period in which few campus policies exist now regarding electric bicycles, electric charging stations, and policies regarding related vendors and/or partnerships to a period in 5 to 7 years when these policies would be expected to mature into comprehensive, standardized structures. Then, within 10 years, advanced options, such as transactive energy policy and smart appliance standards could be developed and strategic partnerships could be planned. At the same time that new policies were evolving, appropriate regulatory structures, rates, frameworks, and instruments would be developed that would make the new systems practical to implement.

For the Product / Market category, the main issues involved moving from a period in which new products are being developed related to electric bicycles and charging stations, but these products would have to be tested with a variety of currently envisioned market groups to determine the best products that would lead to the adoption of smart electric bicycle systems within the next 10 years. At the same time, new target market could be tested and to see if evolving electric bicycle products could be made to appeal to new groups of end-users and delivered in ways that better meet their needs.

		2015	2020	2025
Regulatory / Policy	**New Policy / Existing Regulatory Structure**	*CAMPUS E-BIKE POLICY, CHARGING POLICY, VENDOR POLICY / PRTNRSHPs*	*COMPREHENSIVE CAMPUS VEHICLE USE POLICY, STANDARIZED PARTNERSHIP STRUCs*	*TRANSACTIVE ENERGY POLICY, SMART APPLIANCE STDs, STRATEGIC PARTNERSHIP PLANs*
	New Regulatory Structure / Existing Policy	*E-BIKE AGREEMNT, CHARGING RATES, FEED-IN, VENDOR FRAMEWORK*	*VEHICLE USE FEES, STUDENT BIKE OR E-BIKE FEEs OR CREDITs, STANDARIZED PARTNERSHIPs*	*TRANSACTIVE VALUE SIGNAL, SMART APPLIANCE INCENTIVES, STRATEGIC PARTNERs*
Market / Product	**New Product / Existing Market**	*BIKE & E-BIKE RENTAL SOFTWARE, CHARGING SYSTEM / MEMBERSHIP, PARTNER MEMBER SYSTEM, VENDOR SERVICE SYS*	*E-BIKE RENTAL, LEASING & PURCH, SMART CHARGING SYSTEM, GOVT / COMM MEMBERSHIP PRGM, VENDOR SERVICE SYS*	*E-BIKE SMART TRANSPORT SYSTEM, SMART CHARGING SYSTEM, GOVT / COMM MEMBERSHIP PRGM, VENDOR SERVICE SYS*
	New Market / Existing Product	*MED & LONG-DISTANCE BIKE / E-BIKE COMMUTER SYSTEM, GOVT / COMMUNITY PARTNERSHIPs*	*LONG-DISTANCE E-BIKE COMMUTER SYSTEM, GOVT / COMMUNITY PARTNER SYSTEM*	*E-BIKE / SMART VEHICLE ALTERNATIVE SYSTEM, GOVT / COMMUNITY PARTNER SYS, BUS PARTNER SYS*
Technology / Function	**Technological Factor**	*POINT OF USE RENTAL, MOBILE RENTAL, CHARGING TRACKER, EMISSIONS TRACKER, VENDOR REVENUE SYS*	*MOBILE & POU RENTAL, LEASE / PURC FULLFMT, CHARGING TRACKER, EMISSIONS TRACKER, VENDOR REVENUE SYS*	*SMART VEHICLE ALTERNATIVE SYSTEM,, SMART CHARGING & EMISSIONS SYSTEMS, PARTNER MGT SYS*
	Functional Factor	*FAST, CONVENIENT RENTAL, TRAINING / EASE OF USE, ACCURATE TRACKING OF CHARGING, EMISSIONS PERF AND VENDOR REVENUES*	*EFFICIENT MOBILE & POU RENTAL, INTUITIVE EASE OF USE OPs, ACCURATE TRACKING OF CHARGING, EMISSIONS PERF AND VENDOR REVENUES*	*SMART "SCHEDULE AWARE" VEHICLE SYSTEM, INTUITIVE EASE OF USE, ACCURATE TRACKING OF CHARGING, EMISSIONS PERF AND VENDOR REVENUES*

Source: Derived from [26, 58, 59]

Figure 4.4.2.3: Industry Factor Alternatives for e-Bike Pilot Study

For the Technology / Product category, the main issues involved moving from point of use systems to more mobile systems in the next 5 to 7 years, and finally to smart and "schedule aware" systems in the next 10 years that would be capable of anticipating how to meet customer needs by using information that is already known about the customer's location and schedule. As technologies evolved these new capabilities, product development would also occur that would address concerns about things like emissions performance, cost effectiveness, and ease of use. Like the trends envisioned for the technology development, the product development would be expected to move more from point of use to mobile platforms in the next 5 to 7 years and within 10 years have products that easily and intuitively incorporate schedule aware and location aware functions.

A final method used for understanding business modeling that will provide input into the roadmapping process is the Static vs. Dynamic Business Model Matrix. An example of this matrix is provided below. The matrix examines core business areas and which, if any, have the potential to grow or shrink given current conditions and practices, or which areas have the potential to sustain long-term growth.

To illustrate how this type of static and dynamic business model matrix could be applied a pilot study was performed examining the case of electric bicycle rental and/or charging on the Portland State University campus. The following diagram illustrates the models that were derived.

Much of the information on the Static & Dynamic Business Model Matrix is just a summary of information presented on previous matrices, but it is then categorized according to the areas that contribute to long-term stable growth versus more variable growth. A variety of pros and cons related to each of the basic business models have already been discussed, but this tool allows a final comparison of similarities and differences, as well as a few new insights about risks and rewards associated with each. The basic value propositions between the main business models, B2G2B, B2C, and B2C2G2B, are all pretty much the same: Inexpensive, convenient, environmentally friendly transportation that reduces the impact of vehicle use and parking requirements in the campus community. Each of the models is aimed at a progressively larger potential market in the order listed above, from left to right. However, they also involve some progressively increasing risks, as the models move from markets in which the products are currently expected to have an appeal to new markets where the expectations are less certain. B2G2B can be described as a more focused and less risky strategic model, with a small domain of initial target users, simple supply method and fairly robust set of profit model alternatives. However, it has a more limited dynamic growth capability, focusing instead on slow, sustainable business growth and limited overall influence in the broader potential market. At the other end of the spectrum, B2C2G2B is truly an all of the above approach, but takes on some significant additional risks in exchange for the potential for higher dynamic growth potential. The B2C approach could be described as somewhere in between the other two approaches.

The information from each of business modeling tools discussed in this section will becomes an input for the next phase of the research, which constructs a roadmap based on these elements and begins the process of prioritizing them. This will be important, as the industry is undergoing rapid growth and development. A wide range of potential smart grid users will need to understand how such new grid infrastructures could be used with new business models for specific industries or sub-industries.

Biz Model \ Product / Service			Basic Business		
			Govt / Comm (B2G2B)	Direct E-bikes (B2C)	Combined Model (B2C2G2B)
Static	Strategic Model	Domain	Existing Prod / Existing Market: Focus on improving e-bike charging options for univ faculty/staff, govt, and bus partners in community (initial rollout) . Acquire limited number of e-bikes for sales and rental test	New & Existing Prod / New & Existing Mkt: E-bike charging for current owners in univ students, fac/st comm. E-bike sales and rentals for new users.	New & Existing Product / New & Expanded Market: E-bike charging, rental, leasing, and sales to univ students, fac/st, govt & bus partners.
Static	Strategic Model	Value Proposition	Affordable convenient, green, and healthy bicycle transportation for university community and partner organizations: Reduce fuel cost, reduce parking costs,	Cheap, convenient, green, and healthy bicycle transportation for university student and employees: Reduce fuel cost, reduce parking costs,	Affordable convenient, green, and healthy bicycle transportation for university community and partner organizations: Reduce fuel cost, reduce parking costs,
Static	Supply Method		E-bike charging, mainly through membership for existing owners, test e-bike sales and rental programs.	Direct E-bikes rentals, charging, and/or membership options	Direct E-bikes rentals, leasing, sales, charging, mainly through membership.
Static	Profit Model		E-bike charging, equipment, equipment sales, multi-level membership program with partner associations, and test rental programs.	Rentals, bike charging, membership	Rentals, bike charging, equipment leasing, equipment sales, multi-level membership program with partner associations
Dynamic	Sustainable Business Growth	Influence	Focus on extended campus market of faculty, and staff, as well as local government and community associations: 300 customers (2% fac/st, 1% gov, 1% bus by 2015; 1200 customers (5% fac/st, % gov 5% bus by 2018.	Focus on direct campus markets campus markets: 750 customers (3% campus) by 2015; 2500 customers (10% campus) by 2020; 5000 customers (20% campus) by 2025.	Serve extended campus, government, local business partners, and the community: 1,000 customers (2% campus, 1% gov, 1% orgs, 1% community) by 2015; 4500 customers (10% campus, 10% gov 5% bus, 2% com) by 2020; 9,500 customers (20% campus, 15% gov, 10% bus, 5% com).

Source: Derived from [26, 58, 59]

Figure 2.4.2.4: Static & Dynamic Business Models for e-Bike Pilot Study

3) TRM Construction & Prioritization

The diagram in section 2.4.3.2 shows the elements of a proposed regional roadmapping process. The process of Business Concept Development mentioned previously also takes place at this stage, as well as through pre-workshop information gathering. The information from the stakeholder-objectives matrix can be used as inputs for the first elements at the left hand side of the diagram. Several key stakeholders have been identified and added to this diagram, and more will be added to this list as needed. The process of Industry Analysis, which was also mentioned previously, is then performed to identify product and service gaps. This information is then used as an input to the next stages of roadmap construction. Additional details about each of the workshops in this process are described below in next sections.

In the first workshop, the stakeholder information will be translated into drivers of value production for products and services on a technology roadmap. Product and service performance factors necessary to satisfy these drivers will then be identified. Current products and services that meet existing performance requirements will be identified, along with any gaps or deficiencies in being able to meet these requirements.

The second workshop will analyze emerging technologies and compare them to required technology characteristics that are expected to be important for those technologies. Potential technologies will be examined to see how will they meet the required characteristics. This information will then be used to determine is gaps exist in technology requirements and the present state of development for these technologies. If gaps are identified, then descriptions of R&D programs necessary to fill these gaps will be created.

In the third workshop, the current market environment and policy environment with respect to the EVSC will be examined. If any market or policy elements negatively impacted product or service performance in the first workshop, solutions will be proposed to address such market or policy barriers. Specific mitigation strategies, such as policy instruments or market incentives may be proposed to overcome these barriers

The output of the second and third workshops will be analyzed and prioritized in order to determine which technology-product gaps are the most significant to address and which market and policy barriers are the important to address as well. This will result in a prioritized Regional EVSC Roadmap which will help stakeholders understand the most critical elements that are necessary to achieve goals.

A final stage of outcome analysis will then be performed using the prioritized roadmap to determine the main paths for key stakeholders to achieve desired outcomes and the factor dependencies for achieving these outcomes. More detail on the process by which prioritization information will be gathered from the workshops and aggregated is presented in the next section, along with a sample TRM.

a) TRM Prioritization Needs and Tools for this Study

The following section provides a set of tools designed to assist with the roadmap development and prioritization process. A series of data collection instruments, matrixes, and prioritization tools are presented to perform various stages of roadmap construction and assessment of the various input factors.

The first tool, shown below, simply provides a means of grouping data related to market and business drivers. Expert are also asked to rate the general priority level of each of these drivers based on their views of it overall future impact on the market. An example is shown below using data from the PSU electric bicycle pilot study that has been mentioned in previous sections.

The third tool used in this process takes the information gathered from the previous sets of grouped drivers and then attempts to match business and market, as well as regulatory and policy drivers to specific product features and performance goals desired by customers and other potential stakeholders for a particular product. For each row, or feature, on the matrix a score is determined as follows: 1 to 3 check marks are used (1 check = low, 2 checks = medium, 3 checks = high), or one to three "X's" can be assigned (1 X = -1 impact, 2 X's = -2 impact, 3 X's = -3 impact). For each column, a driver priority score of 1 to 10 is used, with 1 being a low high priority and 10 being a very high priority. Overall scores are then determined by multiplying each set of row and column scores and then adding up these scores for each category of drivers, such as the business and market, or regulatory and policy drivers shown below, and then normalizing the scores out of 10. These scores are then shown on the right hand side of the matrix under the heading "Prioritization." Additional score columns can be added if needed.

A similar process to the method above was followed for technology product features and stakeholder goals, which were compared against potential barriers that may exist. Also examined are mitigators which may help reduce such barriers. Finally, a third process like the previous two above is performed. Technology barrier and mitigators are compared against R&D barriers and potential mitigators. Scores are determined using the prioritization process previously described.

Once these processes are complete, the data is gathered, analyzed and used as an input for the next stage of the research, which involves construction of the visual roadmap model with appropriate time scales and prioritization data. A sample of the proposed design for such a model is provided in the next section.

#	Grouped Market Drivers	Priority	Notes and Constituent Drivers
1	Car transportation costs	√√√√	Fuel Costs, Vehicle Costs
2	Car parking requirements	√√√	Parking Permits Costs, Availability of parking, Distance of parking
3	Car traffic issues (campus & surrounding area)	√√	Time of travel
4	E-bike transportation costs	√√√	E-bike purchase or rental costs, E-bike charging costs
5	E-bike parking requirement	√√√	Parking Permits Costs, Availability of parking, Distance of parking
6	E-bike traffic	√	Time of travel

#	Grouped Business Drivers	Priority	Notes and Constituent Drivers
1	Business structure / partnership	√√√√	University-owned, third-party, utility-owned, etc.
2	Charging infrastructure requirements	√√√√	Campus grid upgrades/interface, charging system installation
3	E-bike charging system	√√√	Hardware & software deployment/customization
4	E-bike capital investment	√√√√	Vendor selection, purchase, financing
5	E-bike sales and/or rental infrastructure	√√√	Hardware & software deployment/customization
6	E-bike usage system	√√√	Short-term rental, long-term rental, membership, business partnerships

Source: [10, 39, 45]
Figure 2.4.3.1.1: Grouped Drivers - Market and Business

#	Grouped Regulatory Drivers	Priority	Notes and Constituent Drivers
1	Campus Grid Management Rules & Procedures	√√√√	Requirements for interconnections, grid management system
2	Utility regulations	√√√	Requirements for municipal grid connection
3	Campus Vehicle Use Incentives / Penalties	√√√	Vision for vehicle use on campus, vision for parking on campus
4	Campus Emission Incentives / Penalties	√√√	Goals for emissions reduction, energy efficiency, vehicle use
5	University Business Partnership Practices	√√	
6	University Facilities / Infrastructure Investment Practices	√√	

#	Grouped Policy Drivers	Priority	Notes and Constituent Drivers
1	City, County, State Energy Policies and Codes	√√√	Fit with energy & sustainability plans, meet codes & reqs
2	Utility Integrated Resource Plan	√√√	Consistency with utility infrastructure planning & upgrade needs
3	Campus Vehicle Plan / Goals	√√√	Vision for vehicle use on campus, vision for parking on campus
4	Campus Emission Plan / Goals	√√√	Goals for emissions reduction, energy efficiency, vehicle use
5	University Business Partnership Guidelines	√√	
6	University Facilities / Infrastructure Investment Guidelines	√√	

Source: [10, 39, 45]
Figure 2.4.3.1.2: Grouped Drivers - Regulatory and Policy

	Market				Business / Regulatory							
Driver Column Priorities	10	9	8	8	10	9	10	9	9	8	Normalized Prioritization	
	M1: Low transportation cost per mile (rental costs, fuel costs)	M2: Low upfront vehicle costs (lease or purchase costs)	M3: Convenient parking: Low cost, high availability & short distance	M4: Quick travel time to destination, efficient traffic flow	B1: Campus Grid Interface Standards & Utility Regulations	B2: e-Bike Charging Infrastructure Requirements to meet campus vehicle & emissions plan	B3: Business Partnership Policies, Guidelines & Selection Process	B4: Agreements on Business Ownership Structures, Terms & Conditions	B5: Agreement on e-Bike Capital Investment	B6: Agreement on e-Bike Rental / Purchasing Infrastructure Investment	Mkt	Bus
P1: Cost-Effective e-Bike - Low-Cost, Energy Efficient e-Bike with low operating cost and cost per mile comparison functions versus car.	3	3	2	2	1	1			1	2	10	4
P2: Smart e-Bike Usage and Parking System - Allows fast, convenient e-Bike usage and/or parking reservation.	3	1	3	3	1	1			1	2	9.8	4
P3: Membership System / Payment Options - Provide packages of high-value usage benefits (P1, P2, etc.) on either fee per use, or longer-term contract.	3	3	2	1			2	3	1	1	9.1	6
G1: e-Bike Charging Infrastructure Plan for Campus - Explains policies and practices for installing equipment on campus grid, interfacing with systems, performing charging, and plan for charging infrastructure investment.	1	1	1	1	1	3		2	1	3	3.9	8
G2: Partnership Policies & Guidelines for Campus e-Bike System - Document created by university and potential business partners establishing terms and conditions for business arrangements, business ownership stuctures, vendor selection process, and negotiation procedures.	1	1	1		1	1	3	3	2	2	3.0	10
G3: MOUs on e-Bike capital investments and sales/rental infrastructure investment.	2	2	2	1	1	1	2	2	3	3	7.0	10

Source: [10, 39, 45]

Figure 4.4.3.1.3: Market, Business / Regulatory vs. Product & Goals

b) TRM Model Design

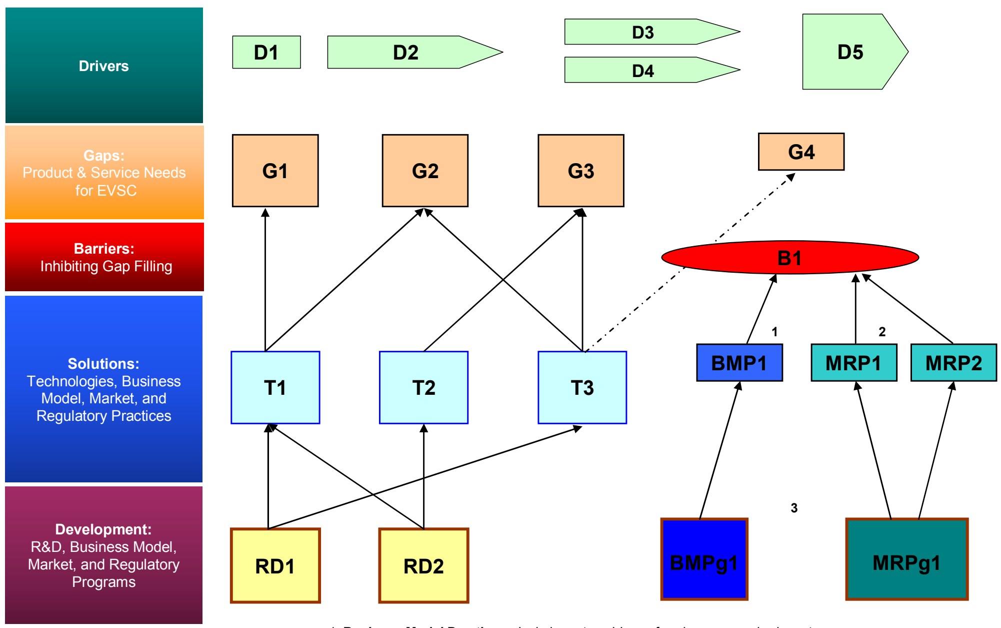
After finishing the initial data gathering and prioritization processes, a roadmap model incorporating all the data that has been collected can be constructed. A sample of the proposed design for this model is shown below.

The proposed design for the technology roadmap model to be used in this research has a number of features which can be seen above. It includes elements at the development level that consider both the needs for R&D development (RD1, RD2), as well as development of programs related to business model (BMPg1) development and programs involving market structure and regulatory considerations (MRPg1). R&D development programs can be matched to technology solutions (T1, T2, T3) that ultimately fill a gap or help accomplish a goal by satisfying product and service needs determined through analysis of drivers. Business Model and Market / Regulatory programs consist of a collection of practices that are used to accomplish a specific purpose, such as the mitigation of barrier. Examples of Business Model Practices might include the use of multi-level business referrals systems, review sharing, or various types of partnerships to capture a new business opportunity or achieve a goal. Examples of Market and Regulatory Practices might include the development systems with government, manufacturers, non-profits or other entities to promote market development for new products through mechanisms like subsidies, rebates, preferential rate structure, and etc. Such systems would be designed to fit stakeholder goals for regulatory, market or policy outcomes. Depending on the priority, or relative strength of impact, that each of these programs and practices may have, they could contribute toward the mitigation of a barrier. An example of a barrier in this sample model may be the absence of a transactive energy

market structure for buying and selling electric used to charge vehicles or fed back into the grid (similar to a feed-in tariff for residential solar panel systems). To promote the development of such a system regulators might establish specific rates and policy structures, while utility companies and third-party service providers would offer equipment and service with specific incentives designed to entice customers to use their systems. This could ultimately result in the lowering of the transactive energy system barrier (B1). The lowering of this barrier may allow an existing technology (T3) to pass through the barrier and accomplish a specific goal (G4). In this case, an example of such a technology might be existing energy efficiency aggregation systems which would then be able to accomplish key energy efficiency goals as outlined by the Northwest Power and Conservation Council.

While the model proposed here is just an example, it offers a number of interesting advantages over current roadmapping models. Technology development often occurs to meet multiple market and stakeholder needs and often must function in complex policy and regulatory landscapes. This is especially true in the case of technologies used by in public utility industries. It is difficult to visualize which technologies need to be developed to meet key stakeholder needs, because barriers often exist that would prevent those technologies from perform an intended function. By putting barriers directly on a roadmap, it becomes easier to visualize whether technology development is needed to meet specific goals, or if it could already meet those goals in the absence of barriers. Furthermore, in emerging industries, market structures and business models are often not well defined in the initial stages. By analyzing the need for business model and market development, significant insight may be gained regarding future progress in an industry. In addition, examining how such business model and market development may affect industry barriers could provide suggestions about the type and direction of technology development that needs to occur. Therefore, this roadmap design aims to integrate technology, business, regulatory, and policy issues into a single process that gives a powerful visual representation of the development priorities and pathways. A final stage of outcome analysis is then performed to examine the key learnings from the roadmapping in more detail and make a step-by-step action plan.

To illustrate how this type of business sub-model matrix could be applied a pilot study was performed examining the case of electric bicycle rental and/or charging on the Portland State University campus. The following diagram illustrates the business sub-models that were derived.



1. **Business Model Practices:** Include partnerships, referrals, revenue sharing, etc.
2. **Market & Regulatory Practices:** Includes rebates, subsidies, rate structure, and etc. to fit regulatory, market and policy goals
3. **Programs** are collections of one or more policies.

Figure 2.4.3.2.1: Sample Region EVSC Model

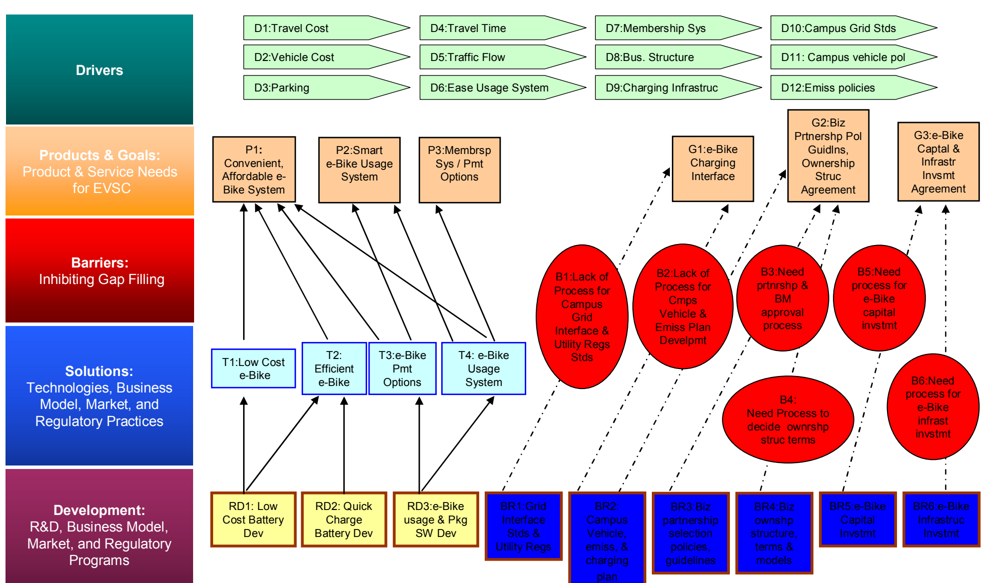


Figure 2.4.3.2.2: Sample TRM for e-Bike Pilot Study

Several key pieces of information can be seen from the above figure. Key stakeholders include university faculty, staff, and students, as well as businesses or organizations in the local area, and local government. Decisions must be made regarding whether to focus first on specific user segments among these stakeholders or on a combinations of segments. Further decisions must be made regarding the possibility of university, utility, or third-party ownership of an electric bicycle venture and if the primary profit mechanism will be rentals, battery charging, leasing, or some combinations thereof. Options for financing and distribution can then be determined that are appropriate for each of these cases. The next step in this process explains more details about defining a business model.

c) Prioritized Action Paths & Critical Analysis of Results

Using prioritized TRM, the main paths and dependencies for desired outcomes can be identified. Finally, an outcome analysis is used to summarize the main paths to desired outcomes and what factor dependencies exist in order to achieve these outcomes.

4) Conclusions on Methodologies

The types of methods presented in this paper are needed in order to deal with the unique nature of smart grid technology and product development for the regulated regional utility systems in general and for electric vehicle smart charging systems in particular. Many problems cannot be solved on just a local or state level, but must instead be solved at higher levels, such as coordination within regional power systems and policies. Smart Grid and Electric Vehicle Smart Charging application are new and the characteristics of such systems are not well understood yet. Multiple perspectives are needed to understand how regulatory and policy issues, and market characteristics can lead to the creation of new business models that are appropriate for the rapidly evolving smart grid technologies that are now emerging.

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