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# The Norwegian Electric Vehicle Market: A Technological Innovation Systems Analysis

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### ABSTRACT

Ever since the internal combustion engine vehicle usurped the plug-in electric vehicle (PEV) at the beginning of 20<sup>th</sup> century, PEVs have only ever been an inconsequential niche product in the market. Now, however, they appear poised to make a come-back in certain markets, driven significantly by new battery technologies, building upon the technological evolution of hybrids, and motivated by new policies focused on reducing greenhouse gas pollutants. Understanding how this market is likely to evolve in different jurisdictions requires an understanding of the major factors, technical, economic, and societal, that are driving this change. This paper applies a technological innovation system framework consisting of seven indicators- knowledge development and diffusion, influence on the direction of search, entrepreneurial experimentation, market formation, legitimation, resources mobilization, and development of positive externalities- to examine Norway as a case-study of actors, institutions, and networks that have led to relatively high levels of electric vehicle adoption. Factors that appear to contribute strongly to Norway's battery-electric market shares include significant consumer incentives including purchase and in-use incentives. Norway has also benefited from research, development, and market activity occurring elsewhere in the world that has contributed to the availability of the products that currently dominate the Norwegian market.

### INTRODUCTION

According to the International Energy Agency, as of 2012 180,000 plug-in electric vehicles (PEV) were on the road globally, representing .02% of all passenger cars [1]. This number is growing in parallel with rapid growth in international governmental investment in research and development related to PEV technologies. Between 2011 and 2012 global PEV sales more than doubled and worldwide governmental research and development investment totaled \$ 8.7 billion from 2008-12 [1]. While pure battery-electric vehicle (BEV) sales are relatively small compared to that of conventional vehicles, in certain markets the first three years of BEV sales has outpaced the first three years of conventional hybrid sales [2]. Some have argued that this bodes well for this relatively more expensive and less conventional technology [2]. However, BEV adoption rates vary dramatically in different countries. In 2012, BEV sales in Norway represented 2.9% of the market, while the average in Western Europe was an order of magnitude smaller at .21% market share (see **Figure 2**). Even in California, which, since 1990 has offered incentives and pursued aggressive requirements for vehicle manufacturers to sell BEVs and plug-in hybrid electric vehicles, in 2012 only 1.72% of new vehicle sales were BEVs [3, 4]. This article describes

#### Electric Vehicle Definitions

Conventional hybrids use an internal combustion engine fueled by liquid fuel (usually gasoline) supplemented with a small battery and electric motor system. All of the energy comes from the liquid fuel.

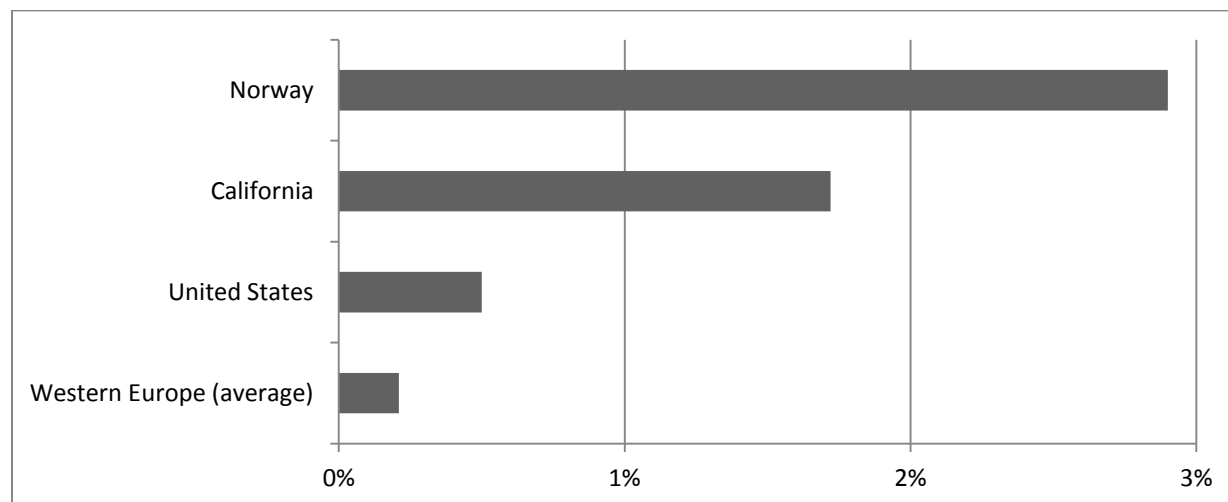
Plug in electric vehicles (PEV) include vehicles that get some or all of their energy from plugging into a electrical charging system of some form. PEV's include both plug-in hybrid electric vehicles and pure battery electric vehicles.

Pure battery electric vehicles (BEVs) use an all-electric motor drive system, in lieu of an internal combustion engine. This all-electric motor drive is powered by a battery system, which, in turn is charged from an electrical charger.

Plug-in hybrid electric vehicles are vehicles that include batteries that can be charged from the grid AND an internal combustion engine that can be powered from liquid fuels like gasoline.

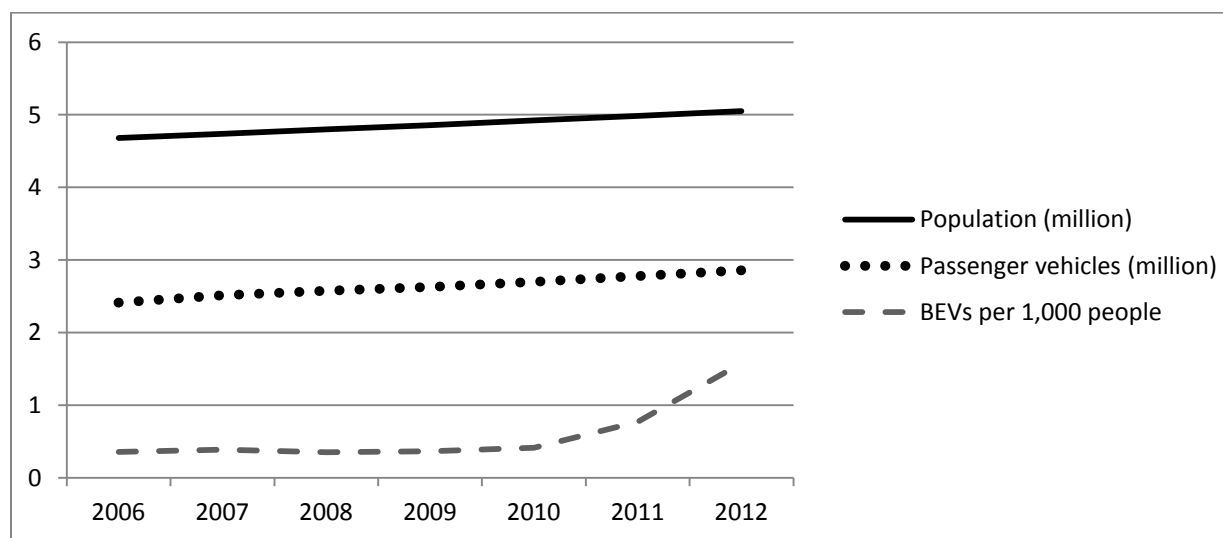
**Figure 1: Electric Vehicle Definitions**

the political and technological forces that have created the conditions for this early lead in BEV adoption by Norway.



**FIGURE 2 2012 BEV sales- Percent Market Share, by Selected Country.** Sources: [1, 4, 5]

Several factors make Norway a particularly relevant case study in BEV technology development and market acceptance. In 2008, the Norwegian government signed the Agreement on Climate Policy (Klimaforliket), which committed the country to a greenhouse gas reduction target of 44 Gt of CO<sub>2e</sub> per year by 2020 [6]. As compared to Norway's 2011 emissions, this target represents a 17% annual reduction [6]. Key measures in this legislation include a commitment to reduce emissions from the transportation sector, which currently accounts for 19% of all emissions in Norway [7]. Since 2008, BEV sales have been on the rise (see **Figure 3**) and no country has sold more Nissan LEAFs per capita than Norway, which represented 1.7% of all vehicle sales in 2012, its first full year on sale [8].



**FIGURE 3 Registered BEV and passenger vehicles in Norway.** Sources: [9, 10]

To describe the actors, institutions, and processes at work in Norway, this analysis uses the technological innovation system (TIS) framework developed by Bergek et al (2005, 2008) and Hekkert et al (2007). This paper proceeds by describing this TIS and then applies it to the Norwegian market. This analysis does not attempt to assess whether or not governmental support for BEVs is worthwhile from a public benefit standpoint; only what actions were taken and what policies have been significant contributors to building the BEV market in Norway.

## LITERATURE REVIEW

Innovation Systems (IS) are generally used to describe the network, actors and institutions that contribute to the development and market acceptance of new products [11-13]. Different ISs have been proposed for studying innovation at various levels of government including national, regional, and sectoral systems (e.g. [14-19]). The TIS put forward by Bergek et al (2005, 2008) and Hekkert et al (2007) has the benefit of focusing on the development and diffusion of new technologies and provides the flexibility to describe the various actors, networks, and institutions that contribute to the new technologies and products [20-24]. Actors refer to organizations or individuals that have had an influence on technology innovation such as stakeholders, policymakers, and industry representatives [11]. Networks refer to how new information is channeled to the market (e.g. media) [11]. Institutions, in contrast to actors, refer to organizations that exist beyond any one individual to store knowledge and set market expectations [11]. Institutions may include governments and research institutions [11]. TIS studies are often used in the context of sustainable technologies, to identify the inducement mechanisms that have facilitated bringing a new technology to market. For example, Nisson et al (2012) used the TIS developed by Bergek et al (2005, 2008) and Hekkert et al (2007) to describe innovation and governance related to low-carbon vehicle and fuel technologies using case studies of innovations taking place in countries such as Germany, Japan, the United Kingdom, and the United States. While these are major vehicle manufacturing countries, they have not achieved the market sales rates of BEVs that Norway has.

This paper contributes to this existing body of literature by describing the efforts of Norwegian actors, networks, and institutions using the Bergek et al (2005, 2008) and Hekkert et al (2007) TIS framework to review how the country's BEV market has evolved and identify the Norwegian policy interventions that have had the most impact on the market. This case study relies on academic literature, government reports, and publically available databases to detail how Norway has contributed to the deployment of BEVs. Since very few plug-in hybrid electric vehicles have been sold in Norway to date, this paper focuses primarily on pure BEVs [25].

**Table 1** describes the seven elements of the TIS, which are used here to frame the analysis of BEV deployment in Norway. It is important to note that appraising the relative performance of each individual TIS element, is not a focus of TIS studies. Instead, the TIS framework takes a comprehensive view of the evolution of particular markets by considering the holistic context in which a new technology is emerging.

**TABLE 1 TIS framework- description and study indicators**

<b>TIS element</b>	<b>Description</b>	<b>Norway indicators</b>
Knowledge development and diffusion	Generation of knowledge related to BEV technologies	Patents
Influence on the direction of search	Incentives or pressure for actors to direct their activities	Technological bottlenecks such as BEV range

	toward BEV development	
Entrepreneurial experimentation	Entrepreneurial activities supporting BEV development	Private investment Government grants to national BEV companies
Market formation	Consumer demand and market size	Market-supporting mechanisms such as policies, standards, consumer incentives, and government supported public charging infrastructure
Legitimation	Social acceptance of BEVs	Symbolism Alliances
Resource mobilization	Human and financial capital	Volume of resources available in different parts of the system
Development of positive externalities	Complementary products, services and infrastructure	Related business ventures Environmental benefits High gasoline prices

Table adopted from [20].

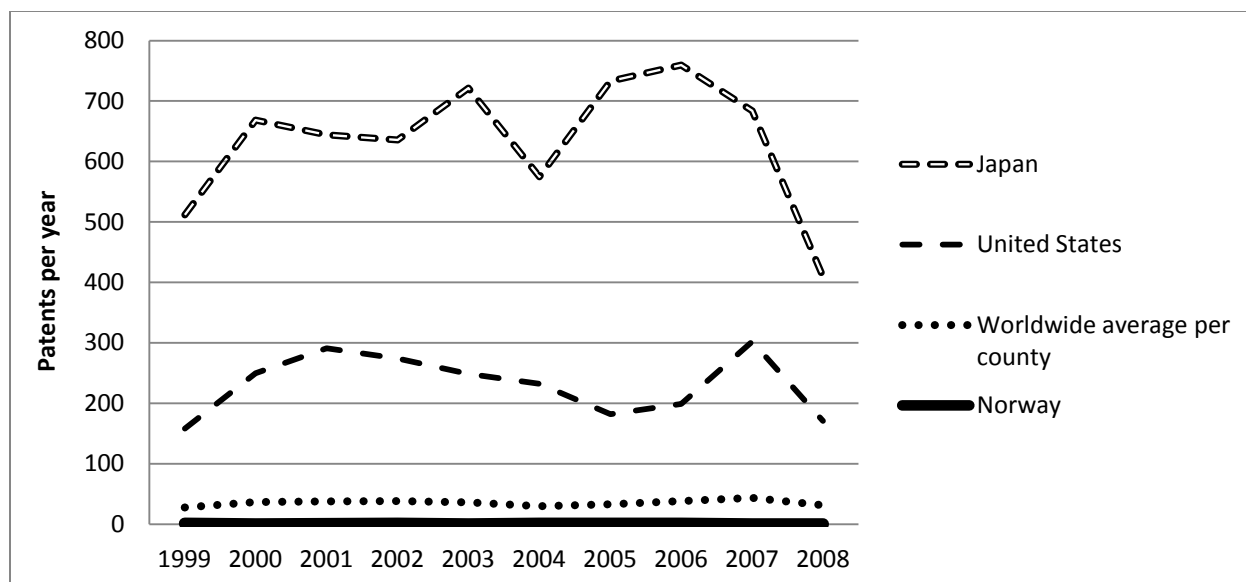
## NORWAY'S TECHNOLOGICAL INNOVATION SYSTEM

### Knowledge Development and Diffusion

Patent activity is commonly used as a criterion that indicates knowledge development and diffusion [26]. The Norwegian government does provide some direct support to local companies engaged in developing BEV technologies, however, support provided to major vehicle manufacturers by other countries like the United States and Japan has resulted in significantly more patent activity [20, 27]. By searching annual patents related to BEVs through the Organisation for Economic Co-operation and Development database, one can see that patent activity in Norway was substantially lower than the worldwide average (see **Figure 4**) [28]. This is not altogether surprising given that despite efforts to foster domestic vehicle manufacturing no large vehicle manufactures are located in Norway and the country's BEV market is primarily imported vehicles [29].

Government- supported research and development efforts aimed at BEV technologies has been on the rise in other countries, which like Norway, have provided support to electric vehicle research and development. For example, in the United States, government support ranged from \$18 million per year in 1990 to \$100 million per year in 2000 [30, 31] and the Japanese government has been supporting private company and university research in alternative drivetrain technologies since the 1970s [27].

The Norwegian BEV market has recently gained traction in spite of limited opportunities to affect research and development of related technologies. While extensive knowledge and diffusion efforts related to researching and developing BEV technologies may not have originated in Norway, efforts outside of Norway have been effectively supporting related BEV technology development.



**FIGURE 4 Patent activities related to BEVs in selected countries.** Source: [28]

### **Influence on the Direction of Search**

This TIS element examines the use of incentives and/or pressures for actors and institutions to focus their activities on various aspects of innovation including addressing technological bottlenecks. Norway does have some unique challenges in relation to BEV range. For example, colder temperatures in Norway have the effect of reducing BEV range due to slower chemical reactions in the battery and the use of the battery to power the vehicle's heating, ventilation, and air conditioning system [32]. Instead of directly addressing the limitations of battery technology, some Norwegian companies, in particular PIVCO, chose instead to work on developing lightweight automotive bodies which can provide similar benefits such as increased range for the same sized battery. One Norwegian-based company, Mijobil Greenland, worked on BEV battery development, but has since shifted from vehicle to maritime applications.

The Norwegian government's approach to addressing this battery performance limitation has primarily been to support widespread public charging stations to provide greater range potential. In 2011, Oslo installed 400 public charging stations and since then has been installing 100 more each year. By 2012, more than 3,300 normal chargers and 40 quick chargers were installed in the country and offered, for the most part, free of charge [33]. Norsk Elbilforening, a BEV interest group, estimates that by the end of 2013, 4,000 charging points and 100 quick charging stations will be publically available [34]. To provide consumers with location and real-time availability information for these stations, Norsk Elbilforening in partnership with the Norwegian government, developed the open database called NOBIL. This database may be used as a phone application for Android and iPhone users [35].

The direction of search outside of Norway has been more focused on innovating electric-drive technologies, like motors, controllers, and battery systems. Advancing the state of these BEV and PEV technologies in other major vehicle manufacturing countries has been influenced and supported by political pressures and government incentives [27, 31, 36]. Partially as a result of these pressures for major manufacturers to innovate improved technologies, the BEVs on the road in Norway, are predominately from Japanese, French, and American manufacturers [37].

While government policies in other countries may have been pushing vehicle manufacturers toward advancing the state of electric vehicle technologies, Norwegian entrepreneurial efforts have been more focused on manufacturing materials and Norwegian governmental policies have provided consumer –based solutions, such as providing publicly available vehicle charging stations, to address the technological bottleneck of limited BEV range.

### **Entrepreneurial Experimentation**

From 2000 to 2010, three Norwegian manufactures were directly involved in the production BEVs and BEV components: Mijobil Grenland, the Personal Independent Vehicle Co. (PIVCO), and Pure Mobility (ElBil Norge) [38]. These companies are described below.

#### Mijobil Grenland

Mijobil Grenland received funding from the Research Council of Norway, a government agency, to research battery systems for electric vehicles, new module and control systems of BEV batteries, and test development for large automotive lithium ion battery packs [39]. The company also leased BEV fleets from 1997-2005 but has since shifted focus from BEVs to maritime operations [40]. In 2012, the Canadian company, Electrovaya Inc. took over a majority share of Mijobil Grenland. Electrovaya develops battery systems for BEVs and PEVs, along with developing products related to energy storage [41].

#### Personal Independent Vehicle Company (PIVCO)

PIVCO was established in 1991 and early support for PIVCO’s BEV manufacturing efforts came from a number of private and governmental sources. Jan-Otto Ringdal, managing director of Bakellittfabriken, PIVCO’s predecessor, gained support from Norwegian politicians who wanted to compete with Sweden’s auto industry. Ringdal also built support for the company's efforts by reaching out to the Norwegian Oil company, Statoil, and persuading Statoil to install BEV charging stations at their existing gas stations. The Royal Ministry of Transport and Communications also provided support to PIVCO, with the goal of starting a Norwegian auto industry that would provide stable jobs and support innovation in green transportation. Other supportive regulations and policies are discussed further in the section “Influence on the direction of search.” Prior to BEV manufacturing by PIVCO, there had been no vehicle manufacturing industries in Norway. [42]

PIVCO did not focus on improving vehicle batteries, as many BEV manufacturers have; instead, the company focused on innovating lightweight BEV vehicle bodies. PIVCO's BEV, the City Bee, consisted of a thermoplastic body, which was built on an aluminum frame. These materials made the vehicle’s body rustproof and did not require painting. The benefit of using these materials were not only the weight benefits, but also the investment required to manufacture these simple vehicle bodies, was relatively low as compared to conventional vehicle manufacture. However, drawbacks to the City Bee included a limited battery range (68-93 miles and variable depending on weather), and design defects including water leaks and battery charging issues. [43]

The company has undergone a number of ownership changes. In 1999, Ford purchased and rolled PIVCO in with its electric vehicle branch, Th!nk. After Ford Th!nk took over the company, the next generation of City Bee vehicle attempted to address some of these early problems including installing better battery packs and manufacturing vehicle frames out of sturdier materials.



In 2002 Ford CEO Jac Nasser and Norsk Elbilforening, requested that the Norwegian government contribute to BEV development through production and consumer incentives. Norwegian Th!nk operations were sold by Ford shortly thereafter to a series of different companies. [44] Plagued with vehicle recalls and lawsuits by investors, in 2011 the re-named company, “Th!nk Global”, declared bankruptcy and was subsequently purchased by the Russian company, Electric Mobility Solutions AS. Production of BEVs were scheduled to resume in 2012, but this has not yet occurred [45].

#### Pure Mobility (Ebil Norge)

Pure Mobility, formerly Ebil Norge, was acquired in 1991 and production of the three-seater EV, known as the Buddy, was shifted from Denmark to Oslo, Norway. The company, funded exclusively through private investors, declared bankruptcy in 2011. [46]

At one time, the majority of BEVs sold in Norway were manufactured within the country. However, with the recent bankruptcies and struggles of PIVCO, its successors, and Pure Mobility, the BEVs currently sold in Norway are produced elsewhere (see **Table 2**) indicating the entrepreneurial experimentation activities related to BEV vehicle manufacture has mostly shifted outside of the country.

**TABLE 2 BEV market share in Norway, by vehicle manufacture for 2007 and 2012**

Vehicle Manufacture	Percent market share	
	2007 (Quarter 1)	2012 (Quarter 1)
PIVCO (Norway)	40%	--
Pure Mobility (Norway)	20%	--
Nissan (Japan)	--	74%
Mitsubishi (Japan)	--	9%
Citron (France)	14%	3%
Peugeot (France)	21%	3%
Renault (France)	3%	--
Ford (U.S.)	--	6%
Other	2%	--

Source: [37]

Government and private support for entrepreneurial activities appear to have primarily contributed to BEV deployment through lightweight materials innovations for autobodies; as opposed to innovations in BEV components, beyond Mijobil Grenland’s work on battery systems. Government and private efforts to enable sustained BEV manufacturing within the country have not been successful.

#### **Market Formation**

Market formation efforts by the Norwegian government have occurred through broad environmental policies, goals, consumer incentives, and investment in public charging infrastructure. Supportive government policies include the previously discussed Agreement on Climate Policy greenhouse gas reduction goals and projects such as the Green Highway. The Green Highway is a collaboration between Norway and Sweden that will result in an electric-

only transportation corridor between the two counties by 2020 [47]. Related policies that support the BEV market have been adopted by other groups, like the Grønn Bil. The Grønn Bil (Green Car Initiative) is a joint project funded by the Norwegian government, the non-profit group Energy Norway, and the environmental group ZERO. In addition to establishing national BEV sales and charging station installation goals, the Grønn Bil established standards for developing and installing charge points, helps support fleet purchases of BEVs, and is attempting to persuade battery suppliers to locate their business in Norway. [48]

While these efforts are notable and help raise the profile of the BEV market, Norway is becoming increasingly recognized for providing generous consumer purchase incentives for BEVs including sales tax exemptions, reduced registration fees, and a partial exemption from value added taxes. These incentives are particularly attractive since the Norwegian tax structure and related fees inflate the purchase cost of a new vehicle to double what the cost would be in other countries, like the United States [49]. In-use incentives for BEV purchases include exemptions from road tolls and allowed use of bus lanes. The annual cost associated with road tolls is approximately \$350 for the average driver [49].

These incentives have phased in since 1990 and recently were extended through 2018, or when 50,000 BEVs are sold, whichever occurs first. While the total value of these incentives depend on a variety of factors including vehicle weight and engine size [50], to give a sense of the scale of incentives offered, the purchase and in-use incentives have been valued at approximately \$14,000 for purchasing and driving a BEV, as compared to a Toyota Prius [51, 52]. Further, exemptions from vehicle fees and purchase taxes make electric vehicles cost competitive with conventional vehicles. For example in Norway, the purchase cost of a Nissan Leaf, a BEV, is approximately \$42,500, while the Volkswagen Golf, a comparable conventional gasoline vehicle, is \$42,000 [52].

Consumer incentives have been primarily focused on BEVs, but are starting to support purchase of plug-in hybrids. The Norwegian sales tax structure currently penalizes heavier cars, including plug-in hybrids, which weigh more than conventional vehicles due to the battery pack and other electric components. However, this sales tax structure changed on July 1, 2013 and increased the weight allowance for plug-in hybrids [53].

It appears that consumer incentives may be the dominant factor in driving Norway's leading position in the BEV market. In a study of 251 Norwegians EV owners, survey participants indicated that government benefits, including free road tolls, free parking, and reduced purchase prices were significant factors in driving their purchase decision [54]. While providing generous consumer purchase incentives, the Norwegian government also helped to support development of public charging infrastructure throughout the country. However, it is not clear what the impact of providing public charging infrastructure might be on market formation. Perdiguero and Jimenez (2012) speculated that a lack of public charging infrastructure leads to consumer concerns regarding vehicle range, which in turn can be a deterrent to BEV purchase and therefore, negatively impact market formation [55]. However, research on the availability of public charging infrastructure on consumer purchase decisions is limited. One survey of MINI E owners in Los Angeles, New York, and New Jersey found that these owners did not consider the lack of public infrastructure as a barrier in their purchase decision [56]. In this research effort, each respondent self-selected into the study by choosing to lease the vehicle. Additionally, each survey participant was provided at-home chargers. Therefore, we don't know how the findings of this study apply to a broader mass market or to international markets. It may be that public charging in early years of the BEV market are not a critical enabling factor for market formation,

although charge points may be important in terms of raising public awareness of BEVs as a viable purchase option.

Currently, research efforts are becoming increasingly focused on whether public availability of quick chargers supports a mass market for BEVs by providing greater utility for a broad range of users. Some private companies believe that quick chargers are integral to supporting a broader market and are acting on this belief. For example, Tesla is rolling out a network of "Superchargers" across the most frequently traveled highways in North America. Use of these Superchargers is free for Tesla owners, and a full charge takes twenty minutes to complete. These Superchargers are being installed without government subsidy. [57] Similarly, Nissan is installing quick chargers at North American car dealerships to support Nissan Leaf owners.

While providing public charging infrastructure appears to be an integral part of the Norwegian government's support of the BEV market, the actual value of public charging infrastructure on market formation is still indeterminate.

### **Legitimation**

Attempts to legitimize BEV technology occurred as far back as 1989, when the environmental organization, Bellona, imported the first BEV to Norway as a showcase vehicle. Shortly thereafter, political and cultural forces created an atmosphere conducive to promoting BEV adoption [58]. In 1995, an electric car rally in Sweden and Norway demonstrated that BEVs could compete at speeds of 78-93 miles per hour. Also that year, the Norwegian king and queen attended a highly publicized kick-off event for the BEV pilot program in San Francisco, to which PIVCO had provided 40 BEVs- a symbolic gesture of support for the Norwegian manufacturer [42].

Alliances began forming in the 1990s that played a pivotal role in raising the profile of BEVs. Norsk Elbilforening formed and lobbied the Norwegian government for BEV support, including supporting Ford's request for governmental credit guarantees for Th!nk production and assembly. Although these specific policies of direct assistance to manufacturers, were not implemented, the Norwegian government did end up adopting significant consumer purchase incentives partially as a result of these activities.[38, 59] These incentives are discussed further in "Market formation."

Consumer awareness and legitimization of BEVs has been furthered through high profile policies and targets set by the government and other interest groups. In addition to the carbon targets set by the aforementioned Agreement on Climate Change, the Norwegian Parliament has set a goal of reaching 50,000 BEVs on the road by 2018 [34]. These targets are further legitimized by efforts of non-profits and BEV interest groups. For example, Norsk Elbilforening, has set a more ambitious goal of reaching 100,000 BEVs by 2020 with the aim of achieving a sustainable market for BEVs. Similarly, Energy Norway, a non-profit organization consisting of industry members representing the electricity industry, adopted the previously mentioned Grønn Bil, which set a target of having 200,000 BEVs and plug-in hybrid electric vehicles on the road by 2020. [34].

In summary, legitimization resulting in consumer awareness can be attributed to longstanding political and symbolic support, dating back to the 1990s and visible support from BEV interest groups [33].

### **Resource Mobilization**

Resource mobilization refers to mobilizing financial capital throughout the TIS. The Norwegian government has played a direct role in resource mobilization by supporting research and development efforts by Norwegian vehicle and battery manufacturers (discussed in “Entrepreneurial experimentation”), providing purchase and in-use incentives (discussed in “Market formation”), and providing 50 million to 87.2 million NOK (*\$8-\$15 million US dollars*) per year for BEV pilot and demonstration projects through the government grant program, Transnova. Transnova projects have included installation public charging stations throughout the country (discussed in “Influence in the direction of search”). Other private partnerships that support BEV infrastructure have also been formed. For example, Nissan and McDonald’s have partnered to install fast charges at restaurants [60]. Transnova-funded demonstration projects include BEV taxi, postal delivery, and maritime fleets and projects. In 2011, the Norway Post became the first European customer of the Azure Dynamics Transit Connect Electric Van, to be used to mail distribution. Norway Post's initial order was for twenty vehicles, but is planning to replace 1,300 conventional mail delivery vehicles with BEVs by 2015. [61, 62] Additionally, Transnova supported the development of Nobil, the online database containing the locations of all the charging stations located in Norway [63].

### **Development of Positive Externalities**

Development of positive externalities refers to complimentary products and services that have benefitted the BEV market. In addition to the previously discussed infrastructure readiness activities, new business ventures and partnerships have helped support the commercial viability of BEVs in Norway. Business ventures such as Move About, have expanded consumer ability to access and experience BEVs. Move About is a BEV car sharing service, launched in 2007 in Oslo as well as several cities in Sweden and Denmark [64]. Customers use an online booking system to reserve pay-as-you-go BEVs. Move About also offers BEV car sharing services to companies looking to provide vehicles to employees. Business models like Move About help familiarize consumers with BEV technologies. This is important since previous research has identified lack of knowledge and experience with new technologies and uninformed perceptions, such as concerns regarding BEV performance, as significant barriers to purchase [65, 66].

The environmental benefit from BEV use can be attributed to Norway's clean electricity grid. Norway's electricity production consists of 96% renewable sources; most of which is hydropower [67]. Also benefitting the BEV market is the high price of gas to consumers. Unlike many oil producing countries, Norway does not subsidize gas prices and in fact, includes significant federal taxes. As of 2013, the average price of a gallon of gas is \$9.97. The only country with higher gas prices than Norway, is Turkey, at \$9.98 for a gallon of gas. [68]

## **CONCLUSION**

This analysis uses the TIS developed by Bergek et al (2005, 2008) and Hekkert et al (2007) to assess the actors, networks, and institutions that have led to relatively high levels of early BEV adoption in Norway. Charismatic leaders ("actors"), such as Jan-Otto Ringdale and early engagement of institutions such as Statoil, Bellona, and Norsk Elbilforening helped legitimize the Norwegian BEV market. Networks such as Nobil have helped contribute to market formation, primarily by providing information about the location and availability of charging infrastructure. Perhaps the most notable element is the extensive incentives from government ("institutions") for BEV consumers that reduce purchase costs relative to that of a conventional vehicle. Despite multiple efforts, Norway has been unable to support a sustained domestic BEV

manufacturing industry. However, the Norwegian BEV market has benefitted from the knowledge development and diffusion efforts taking place in other countries that has resulted in the BEV products available for Norwegian consumers to purchase.

Several characteristics of Norway are worth noting: it is an oil rich country and does not subsidize the price of gasoline, it can reap significant environmental benefits from supporting a BEV market due to its clean energy grid, and its tax and fee structure doubles the average purchase cost of a new vehicle as compared to other countries like the United States. However, one of the benefits of applying a TIS framework to a case study, is that applicable guidance and effective policy interventions may be extracted by stakeholders interested in promoting certain technologies or technological innovations [22]. In the case of Norway, a large part of promoting the BEV market is due to government policies that remove large taxes and fees normally associated with vehicle purchase. Therefore, stakeholders in countries with high vehicle taxes, like Denmark, Singapore, and Finland, who are interested in promoting a BEV market, may consider sponsoring policies that apply similar purchase incentive structures as Norway; specifically, by removing sales taxes and fees for BEVs. Countries that have not adopted relatively high sales taxes and fees may consider other measures that reduce the purchase costs of BEVs to be cost competitive with conventional vehicles. These measures may include purchase vouchers or income tax credits.

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