Lessons Learned: A Five Pillar Empirical Analysis of Whether or Not Norwegian Incentive Schemes for Purchasing Electric Vehicles Can Be Implemented in British Columbia

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Introduction

Norwegian Incentive Schemes have been the driving reason that electric vehicle (EV) prevalence in the country is the highest in the world per capita (Barnato, 2016). Norway has been a pioneer for introducing comprehensive incentive schemes to entice consumers to purchase EVs over conventional Internal Combustion Engine (ICEs). They are introducing these schemes with the purpose of reducing carbon emissions from their transport sector, and mitigating the negative effect of ICE's on the environment. Norway is also considered to be a first-mover in funding schemes as they were one of the first countries outside of the EU to spend significant funds on pilot projects, and bear the risks of spending tax payer money on a shift towards a less carbon intensive transport sector. It is for this reason, that other countries around the world have started to follow Norway's example and introduce incentive schemes of their own, yet few are as robust as Norway's. The purpose of this paper is to analyze and assess if it would be feasible to apply Norway's most cost-effective incentive schemes to a British Columbian market. This is important as it will add to the growing literature of assessing viable EV markets around the world. This research will also benefit the Canadian and British Columbian governments with a case for either enhancing or reducing their budget for electrifying their transport sector. The Canadian and British Columbian governments have the benefit of comprehensive Norwegian literature on which of its incentive schemes are most cost-effective and beneficial to society. In a sense, they will be able to free-ride on Norway's research and development into electrifying their vehicles. It would be redundant and costly for British Columbia to implement more of their own incentive schemes without prior research and assessment into a pioneer-country who has already absorbed much of the R&D cost of implementing their own electric vehicle schemes first.

1.1 Motivation

The underlying motivation of this thesis was spurred by a curiosity of how two places similar in population, climate, topography, and environmental attitudes could have such a marked difference in electric vehicles per capita. This curiosity was further deepened by an existing literature gap that seemed to lack an analysis beyond economics of the schemes. Researching the reasons for Norway's success in the other four pillars outlined in this paper have helped fill this gap into how much of an anomaly Norway is for introducing these schemes and their effect on exaggerating the economics that allows the country to run such a large scale environmental program. This paper attempts to fill this literature gap and curiosity by creating a 5 pillar explanation of why schemes exist in Norway, but can be extremely difficult to replicate in British Columbia and other developed nations similar to Norway.

1.2 Roadmap

There is a heavy debate in Norwegian literature on how cost-effective and beneficial their EV program has been. Therefore, this paper will analyze and use data from multiple sources to assess each of Norway's incentives before suggesting which may be applicable to Canada and more specifically British Columbia. This paper will first assess Norway's current incentive schemes, followed by assessing British Columbia's and any federally implemented Canadian incentive schemes. This paper will also review Ontario's and Quebec's incentive schemes, as they may also be applicable to a British Columbian market[1] [2]**.** A brief contrast will be made following this, and will outline the key differences of these schemes in the two markets through five pillars; geographical, economic, social political and technological. This paper will then reference successful areas of implementation in Norway, and then attempt to analyze which incentive schemes may be viable in British Columbia through these five lenses. British Columbia was chosen as the most appropriate province in Canada based on its similarities to Norway's landscape, natural resource based economy, political attitudes, and social aspects of its society. This paper will conclude with whether Norway's most effective incentive schemes are viable in British Columbia based on five pillars of analysis; Geographical, Political, Economic, Social, and Technological.

1.3 Scope

Before outlining the current status of Norwegian incentive schemes, it is important to outline the scope of this research paper. The purpose of this is to maintain a focus throughout the paper, and give the reader expectations about the contents in this research.

This paper will not be conducting any new quantitative research in the Norwegian market. Extensive data exists from multiple sources, and complex forecasting models for EV uptake exist, such as SERAPIS conducted by the transport institute of economics (TØI). This paper does not intend on conducting primary research on the Canadian market to create new data, but rather it will compile existing literature to assess the feasibility of implementing some of Norway's EV schemes. The latter part of this paper will discuss existing British Columbian EV incentive schemes, and analyze whether they should be expanded to mirror Norway's though a five pillar comparative analysis.

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[1] Quebec and Ontario are other provinces within the country of Canada

[2] Provinces have different incentive schemes from one another that are tailored to their needs, electricity production, and financial capabilities

Financial Incentives	Norway	British Columbia
25% VAT Exemption/12% PST Exemption[3]	Y	N
Registration Fee Exemption	Y	N
$5000 Purchase Incentive	N	Y
$6000 Scrap-It Incentive[4]	N	Y
Operating Incentives		
Free Parking	Y	N
HOV Lane Access	Y	Y
Free Ferries	Y	N
Toll Road Exemptions	Y	N
Free Charging	Y	N

Table 1.1 – Source: Own Development

1.3 Language

In addition to the scope, it is important for the reader to understand exactly what each term or contraction is referring to in this body of research, so that there is no confusion with facts and abbreviations listed. The term “EV” will refer to vehicles that operate entirely on electricity. This excludes vehicles using alternative fuels such as biofuels, or hydrogren fuel cells. This term also excludes hybrid vehicles or “PHEV’s”, which run on both gas and electricity. The term TØI will be used frequently throughout this paper, and this refers to the institute for transport economics in Norway. The TØI will be cited for research, and referred to throughout the body of this paper. The term “Incentive Schemes” in this paper is used solely in the context of electric vehicles.

1.4 EV Background in Norway

Norway’s initiatives for electric vehicles began in the 1990’s as an attempt to cut pollution, congestion and noise in its urban centres. Presently, Norway has the highest number of

[3] The VAT tax applies to Norway at a rate of 25%, while a 12% PST applies to British Columbia

[4] This incentive comes with a caveat that you must trade in your old vehicle to receive it

EVs per capita in the world with more than 100,000 in a population of 5.2 million people (Hockenos, 2017). In 2016, EVs constituted nearly 40% of the nation's newly registered passenger vehicles (Hockenos, 2017). Despite this milestone, this figure only represents three percent of the total vehicle fleet in Norway. Nonetheless, having 100,000 electric cars on the road contributes to an estimated 200,000 tonnes of CO2 being reduced annually (Lambert, 2016)[5]. Looking forward, Norway has set the goal for 100% of new car sales to be zero-emission vehicles (ZEVs) commencing in 2025 (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016). Although this is an ambitious target, it is not unachievable as there is an increasing EV uptake due to improvements in range, advances in technology, and decreasing price due to greater economies of scale. Until costs and technology improve, the government incentives in place have served as a bridge for purchasing vehicles, and for EV manufacturers to have a viable mass market to both produce vehicles in catalyzing research and development. Before discussing current EV incentives, this paper will briefly outline key EV organizations in both Canada and Norway.

1.5 Key EV Organizations in Norway

1.5.1 Transnova

Transnova is an ad hoc force set up by the Norwegian Ministry of Transport for the purpose of lowering GHG emissions in the country (Holtsmark & Skonhoft, 2014). Transnova's mandate is to take steps in catalyzing the phasing-in of new technologies to Norway's transport sector. (Holtsmark & Skonhoft, 2014). To accomplish this, Transnova's annual allocated budget was 50 million NOK in 2009 and 2010 (European Commision, 2016). In 2009, Transnova also was administered an additional 50 million NOK to establish charging infrastructure across the country (European Commision, 2016). This program led to nearly 200 new charging points, and an increase in Transnova's budget to 78.8 million NOK from 2012 onwards (European Commision, 2016).

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[5] It should be noted that the original article fails to specify if this figure take the production of these EV into account, and that 100,000 vehicles will reduce different amounts of carbon depending on the source that is used to provide them with electricity

1.5.2 The Institute of Transport Economics

The Institute of transport Economics (TØI)[6] is a national institution in Norway that conducts research on issues with transport and promotes their findings (Institute of Transport Economics, 2017). The institute places a special emphasis on applied research, and most of the work that they perform is commissioned predominantly by government bodies and local authorities (Institute of Transport Economics, 2017). The TØI's research has extensively covered the cost-effectiveness of Norway's EV incentive schemes, as well as other European countries[7]. They have reported using multiple forecasting models for scheme cost-effectiveness and EV uptake such as SERAPIS (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Their model predicts the annual total value of each incentive scheme to EV users per year, the value each user receives for each scheme, and the cost-effectiveness of each scheme per EV in NOK annually (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). This paper will review each of the inventive schemes analyzed in the SERAPIS models, as well as research from other sources after reviewing key EV organizations in British Columbia and Canada.

1.6 EV Background in Canada

To date, only three provinces offer significant rebates for EV purchases in Canada (Electric Mobility Canada , 2017)[8]. Currently, over 25% of Canada's greenhouse gas emissions come from the transport of goods and people (Melton, Axsen, & Goldberg, 2016). With Canada's electricity grid, EVs have the potential to reduce GHG's by 45-98% compared to a traditional ICE vehicle fleet (Melton, Axsen, & Goldberg, 2016)[9]. These incentives will be

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[6] The Institute was set up in 1958 and in 1986 the institute became a private independent research foundation.

[7] See comparison of effectiveness of incentive schemes between Norway & Austria in (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

[8] Canada is made up of 10 provinces, and 3 territories, which vary heavily in size, population, wealth, legislation, political parties in power, and other socioeconomic factors.

[9] Canada is the second largest producer of hydroelectricity in the world, with over 378 terawatt hours produced in 2014. This capacity has generally existed where there is favourable geography in British Columbia, Quebec, Ontario, Labrador and Manitoba. Canada's total electricity supply mix is as follows: hydro 59.3%, Nuclear 16%, 9.5% coal, 8.5% natural gas, 1.3% petroleum, other renewable resources 5.2% (Natural Resources Canada, 2017).

discussed in their own section after describing Norwegian incentives to provide the reader for a comparison between the two countries.

One criticism of Canada's overall EV policy is that it has implemented the same incentives for PHEV's as EV's in many places, and therefore consumers have generally opted for purchasing an PHEV to reduce range anxiety, instead of making a full technological switch. The adoption of PHEV's in Canada has been far greater than fully electric vehicles because they are generally cheaper, the technology is more developed, and car salespeople are able to communicate PHEV technology more fluently to potential purchasers. Due to greater PHEV adoption, a lot of current electric-mobility research and literature in the country currently centres on hybrid vehicles.

However, Canada has made progress over the past few years in developing a plan to aggressively reduce GHG levels by 30 per cent below 2005 levels by 2030 (Plug,n Drive, 2016). This means reducing emissions by 200-300 megatons (Mt) in the country. Reduction in transport is important because transport is currently the second largest contributor to GHG emissions in Canada (Plug,n Drive, 2016). Federal, provincial, and territorial governments have started to work together to develop an all-encompassing plan to focus on clean growth and climate change in the country. However, presently EV incentive schemes are implemented separately by provincial governments. The transport sector is a vital part of achieving the objectives set in the federal emission reduction plan.

Canada is fortunate to have relatively low-carbon electricity production, which makes it an optimal country to adopt EV's (Plug,n Drive, 2016). British Columbia, Ontario, and Quebec are currently leading the way for EV adoption at the provincial level. When considering where to introduce more in-depth schemes in Canada, the following determinants and subsequent outcomes should be considered: electricity supply mix, electricity distribution, demand and grid stability, public charging infrastructure, public awareness and government coordination

1.6 Key EV Organizations in Canada

1.6.1 Plug'n Drive

Plug'n Drive is a non-profit organization committed to accelerating the uptake of EV's in Canada to maximize their perceived environmental and economic advantages (Plug'n Drive, 2017). Since 2011, Plug’n Drive has established itself as a non-partisan leader in the Canadian Electric Vehicle industry (Plug'n Drive, 2017). Plug’n Drive has engaged with over 55,000 individuals to date and sponsored over 480 days of events[10] (Plug'n Drive, 2017). The organization also has provided over 6800 electric vehicle test drives to users in the Canadian market (Plug'n Drive, 2017). Similar to Transnova, the organization also provides charging infrastructure research and information to EV users and the government. Plug’n Drive has partnered with Ontario’s electricity distribution companies to inform users where they can buy charging stations for their homes and business’. (Plug'n Drive, 2017)[11]. The organization also offers consultation on large-scale implementation of public charging infrastructure. Plug’n Drives research on EVs includes GHG emission profiles, operational costs of EVs, availability of public charging stations, and other relevant EV topics in the Canadian context (Plug'n Drive, 2017). Plug’n Drive engages with three levels of Canadian government (municipal, provincial and federal) to implement policies. Through an analysis of their company website, and annual reports, it appears that their research and policy recommendations predominantly takes place in the province of Ontario.

1.6.2 Other Organizations

While no other organizations are working with multiple levels of government to a large extent in Canada, many institutions have conducted research projects within their geographic areas, and will be referenced later on in this body of work. Organizations and academic institutions alike have provided research on implementing charging infrastructure, cost-benefit analysis, cost-effectiveness of incentive schemes, and more on EV related topics.

[10] These events primarily take place at trade-shows with the objective of increasing public awareness of EVs. This primarily takes place through informational sessions, as well as EV user test drives with vehicles supplie by Plug’n Drive

[11] Canada’s electricity generation, transmission, and distribution structure differs by province, in that some provinces have certain degrees of deregulation, whereas others are governmental monopolies

1.7 Literature Review

The literature gap between Norway and Canada is vast, as it seems that Norway has many institutions and organizations conducting research with vast data, whereas Canada's institutions seem to produce research that is more localized. This may be the result of a vastly larger country with varying legislation, energy production, EV incentive schemes, and electricity costs by province. Compiling research from 10 provinces and three territories would be extremely difficult for any single organization to produce EV research on a national level. Due to the existing literature gap, this literature review section will be described in two parts; in a Norwegian context and in a Canadian context. This will allow the reader to make comparisons between existing research in the two markets, as well as understand who the various EV stakeholders and researchers are when reading the remainder of the paper.

1.7.1 Norwegian Literature Review

This section will provide some insights on what the organizations above, and others, have argued for and against in the EV market in Norway. There are currently heated debates within the country about the purpose and cost-effectiveness of EV schemes (in terms of mitigating greenhouse gases), and whether these schemes should be continued, phased out, or halted immediately.

1.7.2 TØI

The Institute of Transport Economics has possibly contributed the most to the Norwegian understanding of the EV market, and the effectiveness of its incentives. Their primary works cited in this paper include their 2013 report titled "Electromobility in Norway – Experiences and Opportunities with Electric Vehicles", their 2015 report titled "E-Vehicle Policiess and Incentives – Assessment and Recommendations" (Institute of Transport Economics, 2017) (Figenbaum & Kolbenstvedt, Electromobility in Norway - Experiences and Opportunities With Electric Vehicles, 2013) (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Their reports are generally favorable of extending EV incentive schemes, and list in objective terms their absolute costs per EVs as well as display them in informative graphs. *When listing the costs, especially in their 2015 report, E-Vehicle Policies and Incentives – Experiences and Opportunities with Electric Vehicles, they conclude with budget balancing strategies to balance* *these cost figures they have listed for promoting EVs.* To TØI's detriment, these reports tend to leave out how much it costs to offset each unit of carbon dioxide through incentives relative to what it cost to buy a unit of carbon on the European Market and not burn it. This is the critics main economic argument for not continuing EV schemes; the vast cost difference between purchasing carbon and offsetting it through incentives is not economical. As a proponent of EV incentives, it would be in the TØI's interest to present findings surrounding this in their future works. However, aside from this criticism, TØI's reports and forecasts for EV uptake due to incentives is well researched. The TØI's 2015 report's SERAPIS forecasting model is the driver behind this paper's quantitative analysis of the Norwegian market.

1.7.3 Electric Vehicles in Norway – A Qualitative Study of the Electric Vehicle Market in Norway

This empirical thesis conducted by Ida Furnes Breivik and Malin Olsson Volder of the Copenhagen Business School provided insightful subjective primary research into what drives EV uptake in Norway. The pair conducted much of their research in the form of interviews, as well as from existing literature similar to this research paper.

Their thesis indicated that major challenges of EV uptake at the time was range anxiety[12], lack of battery technology, inconsistencies in the plugs used to charge certain EVs, as well as a technology lock-in to fossil fuel vehicles (Breivik & Volder, 2014). They argue that necessary and sufficient funds must be dedicated to EV development to overcome this lock-in, and that the Norwegian government and EV producers should collaborate to standardize charging infrastructure and vehicle plugs to make implementation of infrastructure more timely and cost-efficient**.** (Breivik & Volder, 2014). They also cited uptake as important for Norway meeting its internationally agreed to climate change goals such as the Kyoto Protocol, The EEA agreement, The Norwegian Climate Agreement, and both White Papers (2007 & 2012) (Breivik & Volder, 2014). As explicitly stated in their title, their paper is primarily qualitative and does not conduct in-depth quantitative analysis.

[12] An anxiety among EV drivers, or those considering purchasing EV's that their range is not sufficient for everyday use of their car, and that they may become stuck without the necessary infrastructure readily available to refuel their vehicle

1.7.4 The Increase of Electric Vehicles Usage in Norway – Incentives and Adverse Effects

Although many critics of EV inventive schemes will be cited throughout this body of research, this paper by Marie Aasness and James Odeck filled a gap in the TØI's literature. This paper was able to quantitatively outline some of the negative effects created by local incentives such as exemption from Oslo toll rings, and bus lane access. These effects were found to increase travel time for public transit users due to increased congestion, while discouraging the use of public transit in favor of purchasing a second EV**(reread)**. The paper uses the Oslo toll ring as a case study for presenting their critic of EV incentive schemes, and was a necessary piece of research to create many of the counter arguments outlined in this paper.

1.7.5 The Norwegian Support and Subsidy Policy of Electric Cars. Should it Be Adopted by Other Countries?

This paper essentially asks the same question that this thesis does on a macro-level: Are Norway's incentive schemes exportable to other countries? This paper critiques Norway's incentives schemes in that they add additional vehicles to the road, while mitigating carbon at an exorbitantly high cost (Holtsmark & Skonhoft, 2014). Although their paper does concede that Norway's generous policies have led to a large uptake of EVs, they conclude that it is at the cost of public transport users, cyclists, and tax payers. They argue that EV purchasers tend to use their EV as an additional car for city trips that would not take place otherwise due to incentives such as free parking, bus lanes, free tolls, and relatively low range compared to traditional ICEs (Holtsmark & Skonhoft, 2014). This claim may have been more accurate in 2014 when the paper was written, but it is becoming less valid today.

Three years later in 2017, presumably battery technology has improved drastically, and EV users will be more likely to use EVs as a full-substitute for their ICEs rather than as an additional car. In turn, it seems reasonable this is will reduce GHG emissions, while ideally not adding less private EVs to the road as second vehicles.

1.8.1 Canadian Literature Review

As mentioned at the top of this section, Canada's literature on electro-mobility topics seems to be more regionally focused. The country's incentives vary from province to province, as well as views on electro-mobility. Canadian literature also does not have the advantage of being able to study its own EV incentive schemes to the same extent that Norway has.

1.8.2 Plug'n Drive

The Plug'n Drive organization releases an annual research reports making it an important contributor to electric mobility research in Canada. There website describes their purpose, background, and inception, while their reports are more ad hoc and tend to cover specific subjects. Their two most relevant reports to this thesis are; Electric Vehicles: Reducing Ontario's Greenhouse Gas Emissions (Plug'n Drive, 2015), and Accelerating the Deployment of Plug-In Electric Vehicles in Canada and Ontario (Plug,n Drive, 2016)[13]. Plug'n Drives' 2015 report provides information on Ontario's electricity consumption and carbon reduction statistics. (Plug'n Drive, 2015). The report runs an economic analysis with different scenario settings and uptake figures to provide a range of outcomes for the reader based on future forecasts.

Plug'n Drives' 2016 report is slightly less focused on a particular niche in EV mobility. This report provides the reader with the electricity production profiles across all provinces in Canada, policy recommendation and implementation plans, current provincial emission standards and policies, charging infrastructure information (Plug,n Drive, 2016). It also outlines how to improve public-private partnerships (PPP's) with various levels Canadian government for catalyzing the uptake of EV's and implementation of charging infrastructure in Ontario (Plug,n Drive, 2016).

1.8.3 Simon Fraser University

Simon Fraser University (SFU) has produced literature on the potential of an EV market in the province of British Columbia[14]. Their report, Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study aims to consider potential markets for plug-in electric vehicles in Canada (Axsen, Goldberg, & Bailey, Electrifying Vehicles: Insights from the Canadian Plug-in Vehicle Study, 2015). This paper takes an interdisciplinary approach using

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[13] Additional information used throughout this thesis is found via their organization's website: https://plugndrive.ca/

[14] SFU is located in Burnaby, British Columbia, part of the greater Vancouver area which is Canada's third most populous city

economics, engineering, marketing, policy, and psychology into their analysis of electro-mobility remedies in Canada (Axsen, Goldberg, & Bailey, Electrifying Vehicles: Insights from the Canadian Plug-in Vehicle Study, 2015). Their report contains statistics and analysis on both PHEV's and EVs. Although PHEVs are out of this paper's scope, SFU provides valuable information on why potential consumers in Canada choose PHEVs over EVs when making a choice to purchase a vehicle utilizing electricity to any extent. Their report also identifies user preferences, motivations, and lifestyles when assessing potential consumers. Their paper makes for a useful comparison when qualitatively comparing what drives Norwegian user preference for EV uptake versus British Columbia. Additionally, their research forecasts Plug-in Electric Vehicle (PEV) uptake under certain policy conditions with different forecasts for different markets within Canada. They predict in 2020 that without new policies latent demand for EVs will be 32% (Axsen, Goldberg, & Bailey, Electrifying Vehicles: Insights from the Canadian Plug-in Vehicle Study, 2015). However, constraints such as model availability, home charging access and dealership availability, and familiarity with EVs will drop market share to 1% or about what it is today (Axsen, Goldberg, & Bailey, Electrifying Vehicles: Insights from the Canadian Plug-in Vehicle Study, 2015).

1.8.4 Green Drivers or Free Riders? An Analysis of Tax Rebates for Hybrid Vehicles

Similar to the TØI in Norway, SFU's & Plug'n Drive's research in Canada, this paper does not appear to provide figures for what it cost to purchase carbon on the market in comparison to what it costs for reducing it through EV's. "Green Drivers or Free Riders…" provides figures for different provinces in Canada's cost of cutting carbon through PHEV incentive schemes. Their paper argues that incentive schemes for purchasing cars are influencing people who already have fuel efficient cars, creating a little difference, while imposing negative externalities on non-adopters of PHEV or EV technology (Chandra, Gulati, & Kandlikar, 2010).

2 Norwegian Incentive Schemes

2.1 Current Status of Norwegian Incentive Schemes

Norway currently is the epicenter of a shift towards electric vehicles. Since the early 1990's, their EV incentive program has been gradually introduced expanded by multiple political parties (Norsk Elbilforening, n.d.). The zero emissions incentives discussed in this paper include: No Purchase/Import taxes (1990), exemption from 25% VAT on purchase or lease (2001 and 2015), no charges on toll roads or ferries (1997 and 2009), free municipal parking (1999), access to bus lanes (2005) (Norsk Elbilforening, n.d.). The Norwegian government has also launched a program to finance the establishment of at least two standard fast charging stations every 50km on all major routes in Norway by 2017 (Norsk Elbilforening, n.d.). These policies will be discussed below in terms of their cost-effectiveness, values to EV users, and criticisms (if any) for each schemes.

2.2 Cost Effectiveness of Norwegian Incentive Schemes

The Institute of Transport Economics has measured vastly different costs and benefits of individual incentives in Norway. To display this, they have forecasted the effects in 2020 of individual Battery Electric Vehicles (BEV's) incentives by the cost (In NOK), and the effect in terms of BEV stock generated (in thousands). They have also included an aggregated effect, and cost for the total incentive package in Norway. This is the graph displayed below:

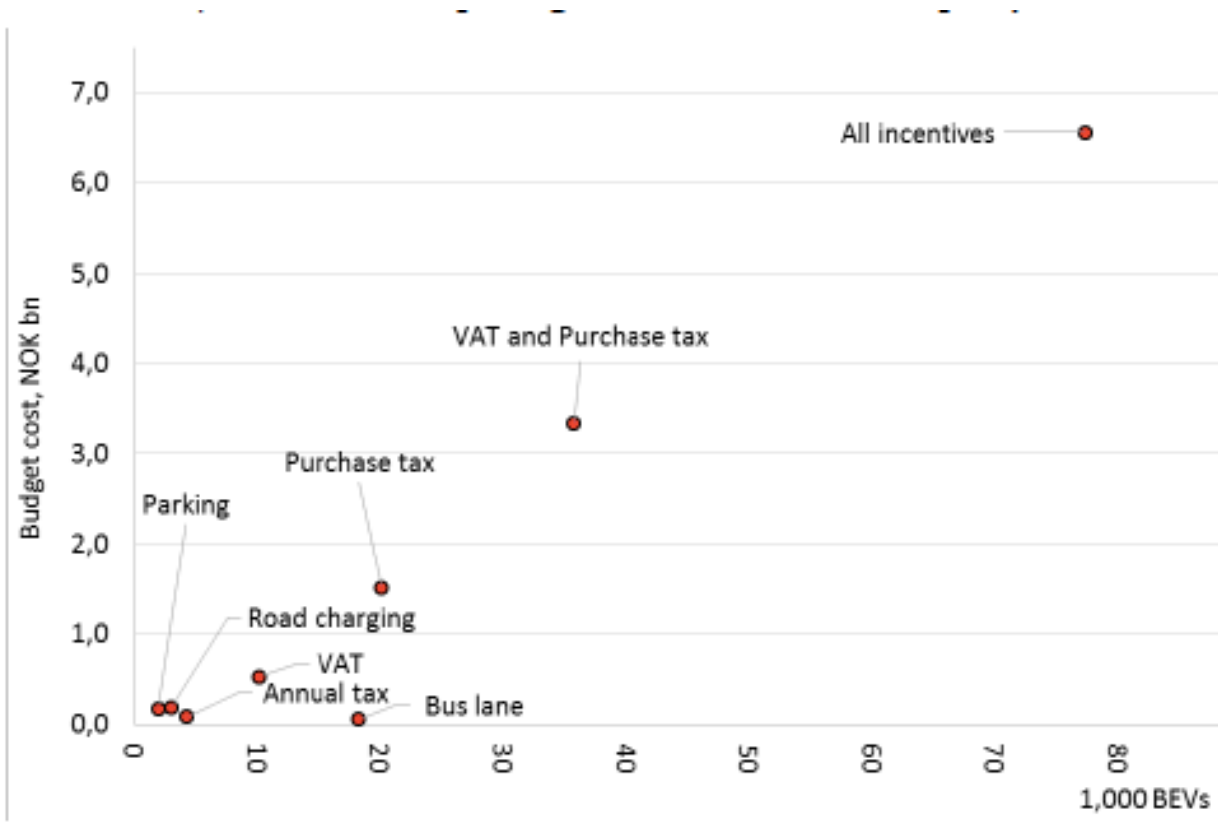


Figure S.2: Effects in 2020 of individual BEV incentives: Budget cost (in NOK) and effect in terms of BEV stock generated (in thousands), and a linear trend.

Figure 1 – Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)

In*t*uitively, the costliest incentives are the ones that cause a direct loss in government revenues, such as tax exemptions. These revenues are especially costly in Norway relative to other countries because of the extremely high tax rates on conventional vehicles (Hockenos, 2017). Conversely, the cheapest incentives to implement in society are the ones that utilise already existing infrastructure with excess capacity to spare, such as bus lanes. However, the above graph solely displays these incentive's costs and benefits in monetary terms. There is a debate around the social costs and benefits around these incentives as well. This paper will outline arguments for the respective incentives below.

Federal EV incentives, such as the VAT, registration tax exemption and reduced annual tax appear to out-perform local and regional incentives (Fearnley, Pfaffenbichler, Figenbaum, &

Jellinek, 2015). These policies enjoy state backing and are implemented in all parts of the country, reducing the perceived risk by EV stakeholders, such as car importers (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). However, local incentives can be tailored to local needs by individual communities. For example, bus lane access in high traffic volume areas, or free ferries for EV owners living on island communities are complimentary municipal schemes that increase uptake in local areas when combined with federally implemented ones. There are clear benefits of having incentives on various levels of government. Norway's combination of local, regional, and national incentives have been beneficial to Norway's EV penetration success. It has helped target users who each can reap operational benefits that are their customised to their living scenario, while providing generous financial incentives to all purchasers of EVs within the country. This variety of incentives in marketing this new technology has catalysed EV adoption in Norwegian society (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Before discussing each of the schemes individually, a table is listed below with each schemes quantitative cost-effectiveness figures that are referred to in the following section. For each incentive, the cost-effectiveness, and relevant social costs and benefits are explicitly mentioned **(Are they? Check)**.

Table 4.5: Government cost, market impact and cost per BEV of incentives in 2020. NOK and number of BEVs.

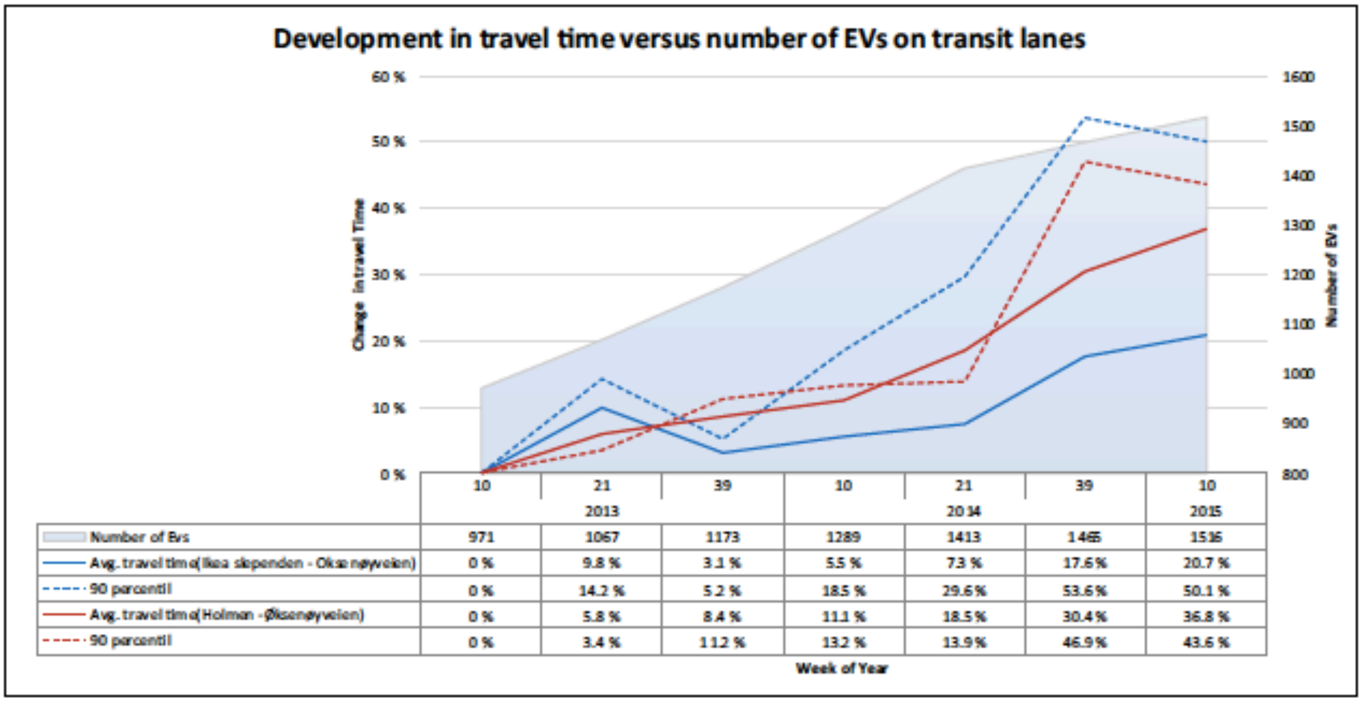
BEV policy	Effect, number of BEVs	Budget effect ("cost"), NOK millions	Cost per BEV ('Cost effectiveness'), NOK
VAT exemption only	10 102	527	52 143
Road charges only	2 949	186	63 021
Free Parking only	1 882	171	90 719
Annual Tax only	4 240	82	19 305
Purchase Tax only	20 101	1 514	75 332
VAT and Purchase Tax	35 700	3 340	93 546
Bus Lane Access only	18 255	55	3 025
All incentives combined	77 335	6 563	84 861

Figure 2 – Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)

2.1.1 Bus Lanes

EV access to bus lanes was first implemented in 2003, and then in 2005 in additional areas (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). As stated above, incentives that utilise excess capacity in already existing infrastructure are the most cost-effective policy tools for encouraging EV uptake. In the TØI's study, bus lanes are the most fiscally effective policy, however, there is a debate on some of the other costs associated with using public transit lanes for private vehicle use. Theoretically, transit lanes ought to be reserved for public transport in urban areas as a means of encouraging its use (Aasness & Odeck, 2015). Based on the National Value of Time Study, the value of time saved from avoiding traffic during rush hour trips to and from work for BEV users is approximately 280 NOK per hour (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The total value per car in Euro's per year of the bus lane incentive in 2014 was 940 euros (8961 NOK) (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). However, all other vehicles using public transit lanes, especially during rush hour when there is little to no capacity to spare will have an adverse effect in terms of time and travel costs on public transport users. Consequently, this incentive benefits only a select few, who own electric private transport, while penalizing those who have opted to use public transport, which is relatively environmentally friendly compared to private ICEs.

Observations were made with a case study on the Oslo Toll Ring to assess the adverse effects on local BEV incentives within the area. This study measured the percentage delay in travel time on transit lanes by week of the year and number of EVs on two main roads on the route E18 in Oslo (Aasness & Odeck, 2015). It is clear from the figure that the travel time on transit lanes has increased and is proportional to the increase in EVs using transit lanes. For example, in week 10 of the study, the travel time in transit increased by 15%, and 30% respectively (Aasness & Odeck, 2015). A secondary argument against entitling BEV to access of public transit lanes is that it may discourage those who are already using public transport to drive their EV operated vehicles instead, or purchase an EV vehicle adding to vehicles already on the road, congestion, and emissions that did not previously exist.



	10 (2013)	21 (2013)	39 (2013)	10 (2014)	21 (2014)	39 (2014)	10 (2015)
Number of Evs	971	1067	1173	1289	1413	1465	1516
Avg. travel time(Ikea slependen - Oksenøyveien)	0 %	9.8 %	3.1 %	5.5 %	7.3 %	17.6 %	20.7 %
90 percentil	0 %	14.2 %	5.2 %	18.5 %	29.6 %	53.6 %	50.1 %
Avg. travel time(Holmen - Øksenøyveien)	0 %	5.8 %	8.4 %	11.1 %	18.5 %	30.4 %	36.8 %
90 percentil	0 %	3.4 %	11.2 %	13.2 %	13.9 %	46.9 %	43.6 %

Fig. 5 The adverse effect of EV incentives on travel time in transit lanes (source: Unpublished traffic counts, Norwegian Public Roads Administration (This data is available on request to the authors.) (vegvesen.no))

Figure 3 – Source:(Aasness & Odeck, 2015) – graph showing increase in travel time with increasing EV in transit lanes

2.1.2 Toll roads

The free toll road incentive was introduced in 1997. It is one of the earliest schemes to be introduced for EV users in Norway, and it serves to exempt EV users from road toll charges in Norway (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). As given by the table at the beginning of this section, road charge exemptions do not cost the government a lot in absolute terms (186 million NOK) (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). However, they benefit a relatively low amount of EVs, and they directly take away from government revenues. Therefore, they are not as cost-effective as bus lanes, but their costs can be easily mitigated by slightly altering this policy. This will be discussed at the end of this section.

It can be difficult to calculate the average value of road-toll exemption for EV users. This is because there are large regional differences in toll frequency and prices. The Norwegian Electric Vehicle Association (NEVA) conducted a survey and found that the exemption from toll road charges was rated as the most significant EV incentive by 23% of respondents to their survey (Breivik & Volder, 2014). This 23% would be heavily weighted to those EV users living geographically close to tolls, and who save money on their daily commute to and from work making this incentive extremely valuable to them.

The TØI estimated this incentive's value by combining respondents' information about usage of toll-roads, and the price for the toll-road that they are paying. TØI estimates that EV users on average save 434 Euros (4137 NOK) per car per year by being exempted from these tolls. However, this value will vary greatly with the user's geographic location, the amount and purpose for which they choose to drive their EV, and how many tolls fall along their daily commute. The TØI calculated this number by taking the total EV fleet in Norway at the time of calculation in 2014 (25,000), and dividing it by the total exempted value of road tolls for the fleet per year (11 million Euros).

Roads in Norway are often fully financed by these tolls, and ought to be paid for by any vehicle that diminishes their value. EVs contribute to the wear, tear, and occupation of these roads as much as traditional ICEs, and therefore, in the views of many, should not be entirely exempt from contributing to their payback and upkeep (Breivik & Volder, 2014). If this incentive is to be maintained beyond 2017, alterations should be made to it. A reduced toll-rate should gradually be phased in for EV users, to represent their usage, and occupation of the road. In turn, this would help to compensate for some of the revenue loss that the government incurs from this incentive, while helping to maintain heavily travelled toll routes. Users should still reap some benefit of being environmentally friendly to the local areas surrounding these roads, and therefore a reduced rate seems rational until EV's are cost competitive.

2.1.3 Reduced Rate Highway Ferry Ticket

The reduced rate on ferries for EV users was introduced relatively late in 2009 (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Similar to the road-toll exemption the value of this incentive to the end EV user is extremely geographically dependent. For those not living in coastal areas, this incentive does little to entice consumers to purchase an EV. Reduced rate ferries were rated the most important incentive scheme by fewer than 5% of EV users (Breivik & Volder, 2014). Furthermore, this exemption applies to ferries connecting major roads, but not local or country roads (Figenbaum & Kolbenstvedt, 2013). However, there is one marked difference from this incentive compared to toll-roads, and it is that the end user is not entirely exempted from the ferry fare. The end EV user still must pay a passenger fare to enter the ferry, offsetting some of the lost tax revenue that municipal governments with this incentive incur (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

A second challenge related to this incentive is that the companies running many of these ferries are private. This means that private companies are incurring losses because of a public policy, and this is unjust to the owners of these companies. Research conducted by the Sør-Trondelag county administration shows that operators of the ferry over The Trondheim Fjord lose 2 million NOK annually because of EV exemptions (Breivik & Volder, 2014). Ferry operators have vouched for the government to either compensate them for lost revenues, or remove this incentive altogether. However, these ferry operators still collect a passenger fee for each EV that boards their ferries, and have not researched how many additional passenger fares this incentive creates through their increased usage of the ferries at a reduced price. This incentive is especially important in rural areas, where few other local incentives such as toll-road exemptions, or charging infrastructure exist to entice consumers to buy EVs. For those living in coastal rural areas, this may be one of the few local incentives that really holds an advantage to owning an EV in these areas.

2.1.4 Free Parking

Free Parking was introduced for EV users in 1999 (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). This incentive's value also varies widely with geographic location. It is mainly dependent on the demand for parking in the municipality or region which it is implemented in. Intuitively, this incentive would have a far greater impact for those living in cities where parking spaces can be challenging to find, and expensive to rent. TØI made an estimate that the average EV user saves 398 euros (3795 NOK) per year through this incentive. The value of free parking was calculated via a weighted average of EV owner's stated weekly savings (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). When NEVA conducted a survey about which incentives had the most impact for consumers purchasing an electric vehicle, only 11% of respondents considered this in the top three incentives for inducing them to purchase an electric vehicle (Breivik & Volder, 2014). This may be reflective that this incentive targets a limited amount of potential EV users who have access to these spaces at a reasonable distance from their workplace or daily commute terminus.

The main consequence of this incentive is that it designates parking spaces for electric vehicles only, where there already may be a shortage of spaces for a municipality's total vehicle fleet. Additionally, this incentive directly effects municipal revenues and because of this vast cost, this incentive will likely be phased out after 2017. TØI estimates that the Free Parking incentive would create a lost revenue cost of 171 million NOK per year by 2020. This is a relatively low figure compared with other incentives in absolute NOK value. However, free parking will only effect 1882 vehicles by this stage, making its cost-effectiveness drastically expensive; 90,719 NOK per vehicle, the least cost-effective incentive per vehicle on its own.

2.1.5 Value Added Tax (VAT)

Norway traditionally has had a 25% Value Added Tax (VAT) on all vehicles sold in the country (Hockenos, 2017). Since 2001, Norway has exempted all EVs from this tax. This represents a huge cost savings for consumers, and makes the price of EVs cost competitive with ICE's (European Alternative Fuels Observatory, 2017). The Norwegian government has recently added to this incentive in 2015, by including the exemption on the VAT applicable to leased vehicles as well (European Alternative Fuels Observatory, 2017). The Norwegian government also introduced an exemption in 1990 that excludes EV users from purchase and import taxes (European Alternative Fuels Observatory, 2017). Norway's VAT exemption for EV users cost 51,143 NOK per vehicle (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The VAT tax is especially fiscally important because its benefits are realised right away in a single lump sum, as opposed to some of the operating benefits such as free parking, exemption from tolls fees, and gas savings, all of which aggregate over time.

2.1.6 Registration Fee

Before introducing the VAT exemption, the Norwegian government already had a registration fee exemption in place which was originally introduced in 1990 (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The value of the registration fee in Norway is comprised of: The weight of the vehicle, the amount of C02, NOx emissions, and environmental effects that the vehicle emits per kilometre (Aasness & Odeck, 2015). Therefore, the importance of this incentive is consumer dependent, in that it can have vastly different NOK values based on the model EV that the theoretical consumer is purchasing. The registration tax incentive on its own has a relatively low cost effectiveness per EV at 75,332 NOK per vehicle (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). This incentive is similar to the VAT tax exemption in that its benefit is realized right away, and it is perhaps a more scalable benefit as its amount depends on the consumer chosen vehicle model that they are considering purchasing. This registration tax and VAT tax exemption have a combined cost-effectiveness of 93,456 NOK per EV (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). On average the value of the exemption of the VAT and purchase tax adds up to 50% of the cost of the vehicle (Mirani, 2015)

2.1.7 Charging Infrastructure

Charging infrastructure is supposed to be implemented according to demand for EV vehicles in Norway. However, in recent years, the spike in sales of EVs has vastly outpaced the public charging infrastructure available throughout the country (Breivik, 2014). This is because to date, charging infrastructure providers have found it difficult, in general, to establish a profitable business model (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Many have gone bankrupt, however others have decided to stay in business, and incur a loss in order to be a first-mover when a critical mass of EVs is in place to make their ventures profitable (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The TØI has suggested support schemes, or various forms of public-private partnerships (PPP's) to be implemented in the same way that EV incentive schemes are to ensure that charging infrastructure keeps up with the number of EV's on the road as the development of one has a profound effect in the development of the other.

The Norwegian government has recognized this need, and has played a major role in implementing charging infrastructure through their organization, Transnova, who delegates money to private companies which have implemented Norway's existing infrastructure to date (Breivik, 2014). For example, in its first year of operations, Transnova received 50 million NOK to establish its organization, and an additional 50 million NOK to delegate to building charging infrastructure (Breivik, 2014). Transnova's budget in 2014, 2015, and 2016 was allocated to be 50 million NOK, 80 million NOK and 180 million respectively (Breivik, 2014).

2.1.8 Charging Infrastructure Discussion

As with incentive schemes, charging infrastructure will likely vary widely in cost-effectiveness. This cost will depend on the infrastructure's geographic location, and the type of charger that is implemented. Chargers with easy access to the grid, clean, and cheap electricity are going to be much more cost-effective than those located in rural areas with long distances to the grid, or expensive electricity. More importantly, if the electricity that is being used to charge the cars is not clean, than these vehicles are less environmentally friendly than traditional ICE's, rendering the transition to EVs obsolete within certain areas presently.

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Installing free charging infrastructure is another idea that appears to be beneficial to all EV users, but not necessarily too charging infrastructure as a whole. If a government is to install charging infrastructure that is free of use to end users, then this will discourage private companies from installing their own pay-per-use, or membership fee based infrastructure as users will always choose free public charging over paid private charging. An analysis should be conducted on how long free electricity for EV users should last before switching to a subsidised cost, and then fully phased out. Much like other incentives, there is an argument that free charging should be phased out gradually as the incentive schemes are intended to be, so that other charging providers can enter the market and expand its scale making it cost competitive.

3 Models used for assessing EV Incentive Scheme Cost Effectiveness

The above cost-effectiveness figures were obtained by using the Serapis model. Lending to its credibility, the EV forecasting and costing model in Norway that was developed and used by the TØI. For this reason, it would be unnecessary to attempt to create a more accurate model for the Norwegian market. This model is briefly described in the appendices to give the reader an idea of how it works on a conceptual level. This will include the data needed to run the model, and how it produces its quantitative results.

4 Canadian Incentive Schemes

4.1 Current Status of Canadian Incentive

EV's only make up 1 percent of new car sales in Canada (Anxen, 2017). Furthermore, Canada's transportation sector is still 95% fossil fueled (Anxen, 2017). Canada's electric Vehicle Policy Report Card is the first comprehensive study of EV policy in Canada across federal, provincial and municipal jurisdictions, and it states that currently our incentive schemes are overly demand-based, and too short sighted to create a lasting stimulus for EV uptake (Anxen, 2017). More than 80% of policies of the in Canada are demand-based, in that they attempt to make purchasing an electric vehicle more attractive to customers, however their study found that these policies will have miniscule impact on EV sales in the long-haul. The underlying reasoning to these findings will be discussed in the technology pillar between Canada and Norway.

Aforementioned, only three Canadian provinces currently offer significant incentive schemes or rebates for EVs[15]. Furthermore, there are no federally implemented incentive schemes in Canada to date (Electric Mobility Canada, 2015). For this reason, this section will be divided by the provinces offering incentive schemes. This will provide an internal comparison within Canada **(You need to include this if stating it here)** before focusing on the comparison between Norway and British Columbia for the remainder of the paper.

4.2 Quebec

Quebec currently offers a rebate of up to $8000 Canadian dollars (CAD) off the purchase of an electric car, as well as 50% off the cost of buying and installing a charging apparatus up to a

[15] Incentives for all Canadian Provinces can be found at: https://emc-mec.ca/wp-content/uploads/Canadian_Funding_Program_for_EVs_updated_2015_10_13.pdf OR https://sustainabletransport.ca/portfolio/canadas-electric-vehicle-policy-report-card/

maximum cost of $600 CAD[16] (Plug'n Drive, 2017). However, as of March 28th, 2017, the government of Quebec has made sweeping caveats to their electric vehicle policy in conjunction with their 2017-2018 budget (Quebec, 2017). These will be outlined below:

1. Adjustment of the vehicle rebate according to the manufacturer's suggested retail price (MSRP): Starting April 1, 2017 the amount of the rebate for fully electric vehicles will be:
    - Unchanged for vehicles on which the manufacturer's suggested retail price is below $75,000
    - Not more than $3000 for vehicles on which the MSRP is at least $75,000 but no more than $125,000
    - There will be no rebate for rechargeable hybrid vehicles whose MSRP is above $75,000
2. Rebates for conventional hybrid vehicles starting with 2018 models will be eliminated
3. New types of eligible vehicles: Starting April 1, 2017, a rebate is offered for fuel cell vehicles ($8000) and low speed electric motorcycles ($500)
4. Addition of a rebate for used fully electric vehicles (Pilot Project)
    - Starting April 1, 2017, a rebate is offered for the first 1000 applicants who have purchased a used fully electric vehicle
    - Max rebate offered is $4000 for the pilot project

Source: (Quebec, 2017)

Currently, Quebec is the only province with a supply-side ZEV incentive and to date it is the most effective policy for EV uptake within Canada (Axsen, 2017). This policy requires that 15% of automaker sales within the province be ZEVs by 2025, with the threshold beginning at 3.5% in 2018, and incrementally increasing each year (Axsen, 2017).

[16] 1 Canadian Dollar is equal to 6.44 Norwegian Kroner as at April 16th, 2017

Quebec is revoking some of their incentives, and adding caveats to others may reduce EV uptake in the province, especially for those purchasing expensive EV's. However, their revocation of the hybrid incentive scheme may increase uptake, as users who want an incentive will now have to opt for a full technology switch instead of purchasing a hybrid which they may be more comfortable with. As we can see by the sheer financial value of the incentive, and lack of operating incentives, Quebec does not offer nearly the same value in incentives as Norway.

4.3 Ontario

The government of Ontario offers up to $14,000 CAD off the purchase of an electric car, and up to $1000 CAD off the purchase and installation of a home charging station (Plug'n Drive, 2017). The amount each EV receives is based on four factors (Plug'n Drive, 2017):

1. Battery Size
2. Number of Passengers
3. Vehicle Price
4. Terms of Lease

They also grant EV drives access to a green license plate permitting them on high occupancy vehicle (HOV) and toll lanes when driving alone (Plug'n Drive, 2017). Although this may seem similar to the Norwegian exemption system, only two people are needed to use these lanes with ICE vehicles to begin with (Ministry of Transportation, 2009). Therefore, access to these lanes is already relatively liberal, making this incentive in Ontario less valuable to a potential EV purchaser as the lanes are generally being used up to capacity.

4.4 British Columbia

In 2015, 2% of new car sales were EV's (Clean Energy Vehicles for British Columbia , 2017). The government of British Columbia offers a rebate of up to $5000 CAD off a fully electric vehicle and up to $2500 off a plug-in hybrid vehicle (Plug'n Drive, 2017). As of February 2017, the British Columbian government added an additional incentive to their program called "Scrap-it" (BC Scrap-It Program, 2017). Scrap-it provides purchasers of a new EV $6000 CAD off their purchase when they turn in their old ICE, or $3000 CAD when they purchase a used EV and turn in their old ICE (BC Scrap-It Program, 2017). As of April 30th, 2017, the program has eliminated 41,984 ICEs off the road, and saved EVs from being delegated to a second vehicle (BC Scrap-It Program, 2017). British Columbia's rebate program is called the Clean Energy Vehicle Program (CEV program), and similar to Quebec. their schemes are not very comprehensive and have stipulations (Clean Energy Vehicles for British Columbia , 2017). Effective March 2, 2016, vehicles with an MSRP of over $77,000 shall not be considered eligible for the incentive rebate (Clean Energy Vehicles for British Columbia , 2017). Unlike Quebec, BC is not eliminating its incentives for Hybrid Vehicles, and has even greater incentives for fuel cell vehicles (Clean Energy Vehicles for British Columbia , 2017). This may pose a problem for a full technological switch to EVs, as consumers may opt for hybrids to reduce their range anxiety, as well as purchasing a technology that they better understand, and are more comfortable with **(Justify more)**.

The CEV program vision is to stimulate a market of 5% new light vehicle purchases by 2020 as clean energy vehicles. The program began with a $14,389,672 CAD (90,432,192 NOK) fund and will run until either the funds are exhausted, or March 31, 2018, whichever came first (Clean Energy Vehicles for British Columbia , 2017). However, the program received an extension and an additional $40 million CAD (252,452,200 NOK) February 3, 2017 that will be contributed to their existing incentives program (Clean Energy Vehicles for British Columbia , 2017). The program also aims to provide charging infrastructure around the province, and information to potential consumers (Clean Energy Vehicles for British Columbia , 2017). Currently the remaining funds sit at $23,802,172 CAD (150,206,684 NOK) (Clean Energy Vehicles for British Columbia , 2017). BC also currently has the highest price on carbon emissions in Canada at $30 a ton, and is the sole province in Canada to require a targeted reduction in carbon emissions from fuel[17] (The Low Carbon Fuel Standard) (Clean Energy

[17] The Carbon Tax applies to all fuels sold in the province. Because different fuels create different amounts of Greenhouse gases when burnt, a table has been included above to show the rates for each type of fuel burnt that equates to $30 a ton (Ministry of Finance, n.d.)

Vehicles for British Columbia , 2017).

Selected Carbon Tax Rates by Fuel

	UNITS FOR TAX	TAX RATE JULY 1, 2012
Gasoline	¢/litre	6.67
Diesel (light fuel oil)	¢/litre	7.67
Jet Fuel	¢/litre	7.83
Natural Gas	¢/cubic metre	5.70
Propane	¢/litre	4.62
Coal - high heat value	$/tonne	62.31
Coal - low heat value	$/tonne	53.31

Source: (Ministry of Finance, n.d.)

Intuitively, the remaining CEV funds will not be enough to stimulate all three kinds of technology (HEV, EV, and fuel-cell) before the program end date. Dispersing this program over all types of clean vehicles seems to be futile, as the program does not have a clear agenda on which form of clean vehicle it sees as best for the province. More than 90% of BC's energy is produced from clean hydro-electricity (BC Hydro, 2017). It therefore seems rational for the BC government to give additional funding to the EV program, and begin to focus on pure EV's like the government of Quebec has.

4.5 Canadian Municipal Schemes

To date, no significant municipal schemes exist for EV owners not only within British Columbia, but within Canada (Electric Mobility Canada, 2015). It is worth noting that Vancouver has invested $3 million CAD over the next five years to bring more EV charging stations to the city (CBC News, 2016). Yet, these charging stations will not be free for users. They will cost users $0.35 CAD/KWh of use, and beyond their installment, they cannot be considered a free operational benefit for users (CBC News, 2016).

Internal Comparison

Comparing Norway with British Columbia

5.1 Justification for Choosing BC

The remainder of this paper will focus on comparing and contrasting Norway's incentive schemes to British Columbia's on five pillars; geographical, political, economic, social and technological. Canada is geographically the 2nd largest country on earth, and with that it varies greatly in landscape, population density, electricity production, and socio-economic conditions. For this reason, each province has its own provincial governments with significant powers to develop their own policies that are tailored to their constituents needs. To make a focused comparison, British Columbia is the most similar province to Norway in terms of the 5 pillars listed above, and for this reason will be compared to Norway throughout the rest of this paper. However, EV policies from other provinces may be listed in these comparisons as well if they are deemed to be implementable in BC, but are not listed under Norway's incentive schemes.

5.2 Geography

Both British Columbia and Norway consist of mountainous terrain, and varying weather conditions. There are vast road networks that can be treacherous during the winter. This plays to people's range anxiety when choosing whether or not to purchase an EV. Therefore, in both of these places, charging infrastructure is vital to be developed proportionally to EV demand. Without it, many consumers will opt not to purchase an EV as a first vehicle. Instead, they will not purchase one at all, or purchase one solely for their city driving, adding even more vehicles to the road, and consequently actually adding to emissions in their respective areas.

According to a province wide census, British Columbia had a population of 4,648,055 people in 2016 (Statistics Canada, 2016). The overall population density in the province is approximately five persons per square kilometer (Statistics Canada, 2016). The province's topography is dominated by four large mountain ranges including the Coast Mountains, Cassiar Mountains, Columbia Mountains, and Canadian Rocky Mountains (World Atlas, 2016). The province's landscape is divided by multiple rivers, lakes, fjords, and islands making ferry infrastructure vital to many of its inhabitants for their daily transport and other needs (World Atlas, 2016).

Norway's population and topography are very similar to British Columbia's. In 2016, Norway has an estimated population of 5,265,158 people (Central Intelligence Agency, 2016). Norway has a population density of 14 persons per square kilometer (World Bank, 2015). Norway is one of Europe's most mountainous states, and it is covered by the many sub-ranges of the Scandinavian Mountains (World Atlas, 2016). The country's coastline is infiltrated with dozens of fjords, over 50,000 islands, and approximately 150,000 lakes (World Atlas, 2016).

The geography of British Columbia and Norway are relatively akin, and this provides a good ground for comparing the applicability of two incentives in specific to each region; charging infrastructure, and reduced or free ferry fares.

5.1.1 Geography – Charging Stations

As stated earlier Norway's EV uptake is outpacing its development of charging infrastructure. Transnova has been allocated over 50 million NOK by the Norwegian government each year to help subsidize the development of charging infrastructure, yet it still remains unprofitable for private firms within the country. It is clear that charging infrastructure providers must be subsidized until there is a critical mass of EVs to make their business models profitable. Without charging infrastructure, it would be hard for a rational person to not have range anxiety in a country of low population density, rough terrain conditions, and minimal charging points. A lack of this infrastructure logically would render the use of EV's to city use, as opposed to a full technological switch from ICEs. EVs may even be purchased as solely secondary vehicles, adding to a city's traffic congestion, as users may opt out of using public transport, as in the case of the Oslo Toll Ring.

95% if all car trips in British Columbia's urban areas are less than 30km, and within range of almost all EVs (PlugIn BC, 2017). *The question therefore is does it make economic sense to install charging infrastructure in more rural areas of the province to accommodate intercity EV users?* British Columbia is also beginning to subsidize charging infrastructure through their aforementioned Clean Energy Vehicle Program. The government of British

Columbia has invested \$2.7 million CAD (16,875,200 NOK) towards supporting public charging infrastructure through a Community Charging Infrastructure Fund (PlugIn BC, 2017). The vast majority of these charging stations are free, although a many require a membership where users are charged a flat fee monthly (PlugIn BC, 2017). An additional charging infrastructure-related platform called PlugShare has also been released in British Columbia (PlugIn BC, 2017). PlugShare is wiki-based map and app of charging stations across North America, and can enable EV users to plan trips with ease as a means of vastly reducing their range anxiety (PlugIn BC, 2017). This relatively cheap information platform could vastly reduce the need for excessive charging implementation if it enables users to plan their trips efficiently beforehand, although this still may be inconvenient to ICE users, as they can usually rely on no refueling planning at all. BC has a low population density, rough terrain, and lacks in charging infrastructure. Additionally, no profitable business models exist for charging infrastructure yet, and must therefore be subsidized until EV uptake hits a critical mass in the province.

Charging infrastructure is a difficult incentive to subsidize properly or economically as their profitability and feasibility is proportional with EV uptake. It is hard to justify buying an EV without proper charging-infrastructure in place, but it also hard to justify implementing proper infrastructure with their first being sufficient EV sales. In conclusion, subsidies for EVs must be coupled with subsidies for charging infrastructure to ensure each other's uptake reaches a critical mass where it is self-sustainable on the private market. It is clear that the BC government spends less on charging infrastructure than the Norwegian government, and debatably have less EV uptake due to this.

Does it make sense to increase charging infrastructure spending to federal Norwegian levels? It depends on the lens that you are assessing the answer from, and the goals of the government as a result of these schemes. If the goal is to modernize the transport sector and increase transport R&D, intuitively the answer is yes. Additionally, the government must be willing to commit funds enough to reach a critical mass, because if funding is cut before this point then additional charging infrastructure will have to wait until EV's are entirely cost competitive to develop with their uptake. However, if we are looking at the answer in terms of pure carbon reduction, the BC government may come up with a more efficient way of achieving this goal.

5.1.2 Ferry Reduced Rates

Norway's reduced and eliminated rates on many of its local ferries is a powerful incentive for island residents and those using their services on a regular basis. Akin to British Columbia, the vast majority of people in Norway live in large urban centers instead of the islands and surrounding fjords. For this reason, this incentive will not affect a large amount of people, and may not be essential for EV adoption reaching its critical mass.

In Norway the subsidy affects primarily private ferry company's revenues instead of public ones. The incentive is therefore a cheap way of incentivizing secondary or additional markets to purchase electric vehicles for tax payers (In Norway). As stated earlier, one common criticism is that the government of Norway should either reimburse these ferry companies or pay part of the lost revenue to them. However, because drivers of EV's still pay the passenger fee in Norway, an analysis should be conducted of how many more passenger fees are collected by the companies due to increased usage of EV owners due to this incentive. This incentive is also psychologically significant for consumers realizing the rural uptake of a new technology outside of cities, and users gaining confidence in EVs in low population density areas.

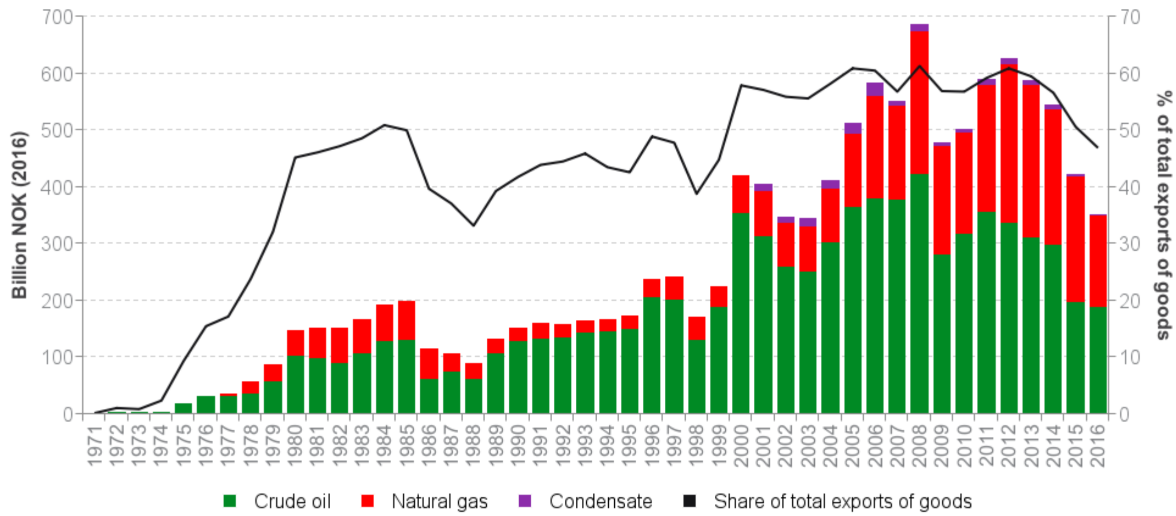
In British Columbia the primary ferry provider is not privately owned like the multiple ferry companies throughout Norway. British Columbia has essentially one provider: BC Ferries (Destination BC, 2017). They are a year round vehicle and passenger operator with 24 routes to 47 terminals and have 35 ships (BC Ferries, 2017). The company which was once was a provincially owned "Crown Corporation" was converted to a private company in 2003, but still receives government subsidies (BC Ferries, 2017). In 2015 BC ferries received their $175 million CAD (1,100,463,200 NOK) in annual ferry subsidies with the purpose of keeping fares low for the end consumer (Shaw R. , 2015). BC ferries in recent years have faced a lot of criticism for their generous public subsidy, while remaining what is essentially a private monopoly (Hopper, 2014). They spend outlandish amounts of tax payer money on their vacation department and marketing budget that are both primarily targeting tourists instead of local tax payers. As a provincial monopoly, the company's marketing budget should be miniscule as consumers do not have a choice between other providers and are well aware of the company's existence. A simple reallocation of part of this subsidy towards encouraging EV use within the province, and the positive externalities associated with EV technology may be a relatively well-received decision in the eyes of the public.

British Columbia should re-allocate part of its existing subsidy to BC Ferries to implementing a similar incentive scheme to Norway. With simple forecasting of the users that would take advantage of this scheme, they would be able to allocate an appropriate amount of funds to the incentive, and not incur an additional revenue loss to the tax payer, while spending their subsidies on resident benefits instead of marketing and selling to tourists.

5.2.1 Economy – Wealth & Resources

In 2014, the Norwegian government lost between 3-4 billion NOK through their EV subsidy schemes (Koranyi, 2015). After this figure was released, the governments schemes came under heavy criticism, but they continue presently in 2017. Norway now leads the global electric car movement, however, they are an anomaly in that their country's wealth and economy allows them to do so. This section will briefly describe the Norwegian economy and wealth that allows them to subsidize EV subsidies so heavily, even though they are one of the world's largest oil and petroleum exporters. Norway's economy is perhaps the most important pillar of the five discussed in this dissertation, as it is a pre-requisite for Norway's entire EV incentive package.

Norway has the 12 largest GDP per capita (PPP) in the world at $69,300 USD (Central Intelligence Agency, n.d.). Not only do the consumers have money, but so does the government through multiple revenue streams. The predominate share of their wealth comes from their vast oil reserves. They were discovered in 1969, and reshaped the country's economy into what it is today (The Economist, 2013). Today the country exports about NOK 350 billion annually in crude oil and natural gas, amounting to roughly 47% of the total value of its exports (Norwegian Petroleum, 2017). Almost all of the oil and gas produced on the Norwegian shelf is exported (Norwegian Petroleum, 2017). Even though in recent years the value of oil and gas exports has declined because of lower average prices for the commodities, they still continue to produce enormous revenues for the nation.



Source: (Norwegian Petroleum, 2017)

Since the oil boom, Norway has been a world leader in public spending. The number of people employed in education has doubled, and that in health and social services has quadrupled (The Economist, 2013). The public sector continues to account for 52% of Norway's GDP (The Economist, 2013). After witnessing "Dutch Disease", the Norwegians have aimed to not have history repeat itself[18]. It seems reasonable that the oil boom and subsequent aggregated wealth from it has permitted Norway to increase this spending significantly. In 1990 Norway established a sovereign-wealth fund (formally known as the Government Pension Fund Global) to prepare the country for a future after their fossil fuels run out and prevent deindustrialization in the country (The Economist, 2013). Through this they are attempting to improve returns on their aggregated wealth, and diversify risks (The Economist, 2013). As of late February 2017, the funds sits at 7.48 trillion NOK or ($903 USD **Change to Canadian)** and is currently the world's largest (Helgesen, 2017)**.**

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Norway has other various resources contributing to its wealth. Following Petroleum Gas and Oil, Norway's top exports are Fresh Fish (33.13 billion NOK) and Raw Aluminum (22.74 Billion NOK) (Observatory of Economic Complexity , n.d.). The top export termini for Norway are Germany (163 billion NOK), the United Kingdom (158.78 billion NOK), the Netherlands (113.18 billion NOK), Sweden (72 Billion NOK), and France (61.91 billion NOK) (Observatory of Economic Complexity , n.d.). Norway exported 945 billion NOK and imported 683.25 NOK consequentially leaving Norway with a positive trade balance of 263 Billion NOK (Observatory of Economic Complexity , n.d.)[19].

In 2015, The British Columbian government had a GDP per capita of $39,396 USD (334732 NOK) ranking 8th among the provinces in Canada[20] (World Atlas, 2016). British Columbia's top exports are lumber ($6943.0 million CAD/43,809,660,000 NOK), Coal ($4212 million CAD/26,577,320,000 NOK), chemical wood pulp/soda/sulphate ($2743 CAD/17,308,070,000 NOK), copper ores and concentrates ($2729.9 million CAD/17,225,410,000 NOK), liquefied petroleum ($2085.0 million CAD/13,156,150,000 NOK) and other commodities totaling exports at $38.7 billion CAD (244.2 Billion NOK) (British Columbia, 2016). British Columbia has a much more concentrated and less valuable profile of export partners. British Columbia's top export partners are the United States (117.61 billion NOK), China (38.78 billion NOK), and Japan (23.14 billion NOK) (Parliament of Canada, 2016)[21]. To highlight British Columbia's reliance on American trade, it should be noted that British Columbia exports 51% of its total export value to their country. British Columbia's imports in 2014 were $54.9 billion CAD (346.41 billion NOK) leaving British Columbia with a $16.3 billion CAD (102.85 billion NOK) trade deficit (Parliament of Canada, 2016).

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[19] Please note NOK figures in sentence have been converted from USD figures that were used in the original source for the reader's convenience

[20] This figure was converted from Canadian Dollars to allow the reader to make a valid comparison to the Norwegian GDP per capita

[21] Please note NOK figures in this sentence have been converted from CAD figures that were used in the original source for the reader's convenience

British Columbia has also recognized a need for a diversified future from its natural resource based economy and the province has debated the idea of starting a sovereign wealth fund of its own. In 2013, the province proposed an LNG prosperity fund that would ensure a long-term revenue from British Columbia's untapped LNG resources in the north part of the province through pipelines allowing the resource to be shipped in large quantities to Asia. The liquid-gas resources remain untapped within the province due to debates, referendums, changing governments, and native population opposition approval over the safety and profitability of the proposed pipelines to be put in place[22] (Trumpener, 2016)**.** However, even without construction beginning on these pipelines, British Columbia's most recent government has contributed $100 million CAD (625 million NOK) of taxpayer money to the fund (Shaw R. , 2016). Yet returns on this initial amount are not nearly enough to justify spending on environmental (or other public) programs before the fund even has a reliable revenue stream from the pipeline.

With the LNG fund aside, the British Columbia Liberal government has historically run balanced budgets (or a slight surplus) year to year (BC Ministry of Finance, 2016). Without additional revenues from an LNG fund, the government would have to make cuts elsewhere to increase spending on British Columbia's clean energy vehicle program. This is not impossible economically, but it is highly unlikely when taking into account the other pillars addressed in this paper.

5.2.2Wealth & Resources Insights with Respect to EV subsidy schemes

GDP per capita in Norway is 1.76 times that of British Columbia[23]. Subsidies aside, electric vehicle models vs their traditional same model ICE counterparts almost always have a higher price tag. For instance, the 2017 Ford Focus Electric starts at $31,248 CAD, whereas its

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[22] There are approximately 200,000 Aboriginal or Indigenous people in British Columbia. They are the native populations that existed in North America before European's conquered the continent. There are 198 distinct nations in British Columbia, each with their own traditions, history and cultures. Each of these nations have varying levels of sovereignty within Canada, and any pipeline or project crossing their land must meet their approval. Historically, there has been a mistrust between the Canadian government, and these populations, as they have suffered systemic abuse and mistreatment within Canada since its inception (British Columbia , 2017).

[23] Calculated by Dividing Norway's GDP per Capita by British Columbia's GDP per Capita

identical ICE hatchback model starts at $23,338 CAD (Ford, 2017). Furthermore, when subsidies do come into the equation of whether or not to purchase an electric vehicle, the total dollar amount saved is generally higher as the price of the vehicle goes up. This being said, the earliest adopters of electric vehicles will intuitively have a higher income as a group relative to ICE users, as they will be able to afford the upfront price of the technology switch before its cost comes down. Additionally, the earliest adopters of a new technology will commonly incur the largest depreciation expense, as the technology is rapidly improving while its costs are coming down as economies of scale ramp up (Shahan, 2016). This is especially the case with EV technology, as any type of vehicle has a large depreciation expense to begin with. The earliest adopters of EVs will have to have a genuine interest, and a disposable income to afford EV technology in its early stages. Generally, it may be argued that with perfect information, a rational consumer will choose the more expensive EV upfront, if he or she can forecast a net-savings over the lifetime of the vehicle. This argument may be correct, but it is geographically dependent on the price of gas and electricity, the returns on which the consumer could get with the money saved by choosing the traditional ICE, and the uncertainty of the new EV technologies lifetime. Furthermore, this potential consumer must have the funds to be able to purchase the EV model to realize these cost savings in the first place. This being said, without subsidies, without perfect information, with a rapidly changing technology, and all else being held equal, consumers in Norway with a higher GDP per capita will be more capable of purchasing an EV. It is easy to realize with Norway's superior EV subsidies and consumer wealth, why EV uptake will be higher when viewing uptake through an economic pillar.

Of course there are limitations to this argument, people in one area over another may place a greater value on the environment, a technology shift, or the social aspects of driving electric, and may therefore take these things into account, even if it costs them more in economic terms to purchase an EV. However, these areas are touched on in the other pillars of this paper.

Another aspect that comes into consideration when considering the GDP per capita with regards to electric vehicles is the availability of models. It seems reasonable that an average potential purchaser in Norway will have a greater choice of EV models available to them given their superior purchasing power. As a hypothetical example, a potential purchaser in British Columbia may have access to only the lower-echelon of electric vehicles consisting of 3 models, while the potential purchaser with equal purchasing power in Norway may have access to 6. Currently, there are only 10 models of purely electric vehicles in Canada, while 15 are available in Norway (British Columbia Automobile Association, 2017) (Lambert, 2017). Unless the potential purchaser is solely concentrated on making the switch from gas to electric, he or she may not actually have a choice of EV they like in their price range, but would still be able to afford their ICE vehicle of choice. Norwegian's enhanced purchasing power of vehicles allows them greater choice, and all else being held equal they will be more likely to purchase an electric vehicle with increased models available to them at their greater per capita income.

Lastly, and bringing incentive schemes into the decision making of a potential EV purchaser, Norwegian financial incentive schemes have greater scalability to each level of purchasing power, whereas British Columbia financial incentives are relatively flat no matter which model of vehicle is chosen. As stated above, Norway traditionally has a 25% VAT tax on all vehicles sold in the country (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). This tax varies with the purchase price of the vehicle, and therefore the value of this subsidy is scalable to the consumer by the model EV they choose. Additionally, because the registration fee exemption in Norway is based on the weight of the vehicle, its CO2 emissions, its NOx emissions, and the environmental effects that the vehicle permits per km, a total exemption from these mean that the value of this incentive is scalable to the consumer as well.

In British Columbia, up until February 2017, the incentive for purchasing an electric vehicle was up to $5000 CAD for new EVs, hybrids, or fuel cell vehicles (BC Hydro, 2017). However, this incentive is not available for vehicles costing more than $77,000 CAD (481,253 NOK) (BC Hydro, 2017). In 2017, the British Columbian government began to offer an additional $6000 to those who scrapped their old vehicle while purchasing an EV after receiving another $40 million CAD (274 million NOK) to fund the program (Clean Energy Vehicles for British Columbia , 2017). This maxes the British Columbia incentive out at $11,000 CAD (687,400 NOK) and puts an upper limit on those who are eligible for the province's incentive EV incentive schemes.

Although BC are less scalable then Norway's, and this may reduce overall EV uptake due to the fact that it makes higher end EVs uncompetitive with ICEs (for the time being), it may be argued that it is the correct strategy for a province with limited funds to spend on the program.

The upper limit of $77,000 may discourage purchasers from buying luxury EVs, but consequentially this means there is more funding for lower to mid end potential EV users who may need the subsidy to actually purchase them.

A common criticism of Norway's incentive schemes is that the value of the VAT subsidy, and registration fee often increases with the cost of the car, meaning that luxury EV purchasers are receiving more tax payer money for their purchases. Furthermore, because everybody pays into the Norwegian incentive schemes, average income earners in Norway are funding a scheme that gives greater value to those who do not need it – high income earners purchasing luxury EVs. With this being said, Norway has had the wealth to support these schemes, and not putting an upper-limit on incentives has resulted in an overall greater uptake of all EVs models within the country. However, in a province like British Columbia, with less wealth, less funding for EV incentive schemes, and a lower GDP per capita, this may be a good decision under these economic conditions.

5.2.3 Economy – Taxation & Pre-Existing Conditions

With the exception of the VAT tax, this section primarily discusses the difference in the number and value of operating incentives in both Norway and British Columbia. The VAT tax in Norway alone is 25% of the vehicle price, and the registration fee can range vastly but is always required in addition to the VAT for ICEs. In British Columbia, there is a Provincial Sales Tax (PST) charged with the purchase of a new car within the province (British Columbia, 2015). The PST tax is charged at a flat 12% (British Columbia, 2015). Right away, the value of a Norwegians tax exemption would be more than twice that of British Columbia's if the province were to introduce a PST exemption.

As at May 27th, 2017, the cost for 1 litre of gas in Norway was $1.85 USD per litre (15.62 NOK), while the price in Canada was $0.93 USD per litre (7.85 NOK) (Global Petrol Prices, 2017). Norway currently has the second highest fuel prices per litre in the world, only trailing behind Hong Kong (Global Petrol Prices, 2017). In 2013, the tax on a litre of gasoline in Norway was \$0.9175 USD (7.72 NOK), and in Canada it was \$0.3125 USD (2.63 NOK) (Tax Foundation, 2015)[24][25].

As a pre-existing condition, Norwegian's already pay more double what Canadian's do for fuel, mostly due to taxes. The Norwegian government originally introduced high taxes on fuel to discourage private automobile use, as well as simultaneously encourage the use of its vast public transit network. However, an unintended consequence of this original policy is that the operational benefit of switching to an alternatively fueled vehicle for private users is far greater than it is in most other countries. Subsidies aside, this increased operational savings for EVs allows Norwegian EV purchasers a faster payback on an EV versus any traditional ICE.

It should be noted that although the user receives a greater benefit in Norway than British Columbia, the government also incurs a larger revenue loss for every driver no longer purchasing fuel. Albeit, if it is in the Norwegians goal to increase EV users and make a full technological switch to EVs, the increased savings of using an alternative fuel to users is only helping them to achieve this goal. Additionally, with a lower fuel demand in Norway due to EVs, the government will be able to export part of the lost local demand to other markets and recoup parts of its lost revenue.

Although the benefit of this switching to an alternative fuel vehicle is lower for British Columbian's, it may be fitting for the province to begin with. The revenue loss for the province will be lower for each EV user making a switch from an ICE. Additionally, because citizens of BC have a lower GDP per capita, it could be argued that a smaller savings in fuel costs may be enough to entice them to make switch to electric vehicles as it will represent a larger percentage of their personal income on average compared to their Norwegian counterparts.

In conclusion to this section, Norwegian's are familiar with being taxed highly, and paying a high price for goods. Therefore, any exemption from these things will usually be of great monetary value to them than other nations. Of course, British Columbia could raise their

[24] Prices per litre have been calculated from the price per gallon used in the original source

[25] USD per Gallon have been converted to NOK per Litre for the reader's convenience

taxes to Scandavian levels for fuel to make their value of subsidies equal to Norway. However, this is largely unrealistic and unwise as it would make driving costs in British Columbia largely unequal to the US and other provinces to the east. Not to mention it would be political suicide, especially for the sole purpose of enhancing EV and other alternative fuel vehicle uptake.

In terms of operational subsidies, Norwegian's receive a greater value in subsidies that are either not applicable in British Columbia, or are not yet incentivized. As mentioned before the Norwegian government offers free toll-road access, free municipal parking, and free ferries to EV users. The value of these incentives on average together per vehicle is equivalent to 977 Euros per year (9274 NOK/$1487 CAD) (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)[26]. These operational incentives do not yet exist in British Columbia for their own individual reasons.

Toll Roads

Toll roads are a largely inapplicable and ineffective operational incentive scheme to provide to EV users in British Columbia. To date, there are only two toll roads occurring on the Port Mann Bridge, and Golden Ears Bridge in the province (British Columbia, n.d.). Furthermore, these tolls only exist where untolled alternative routes are available (British Columbia, n.d.). Therefore, implementing this scheme for the extremely limited number of EVs that use one of these two bridges in the province may be an ineffective way of incentivizing EV uptake, and would benefit very few users. This incentive would almost certainly not be the deciding point between an ICE and EV potential purchaser in British Columbia.

Toll roads in Norway are the primary financing instrument for building bridges, tunnels, and road infrastructure (Vegvesen, 2017). There are about 230 toll plaza's in the country that charge users automatically without them having to stop their vehicles (Vegvesen, 2017). An unintended benefit of having a vast and largely unavoidable toll network is that their exemption has been able to serve as one of the most important operational subsidies to driver's deciding on whether or not to purchase an EV (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The

[26] Values have been converted from Euros used in original source to NOK and CAD for reader's convenience

434 Euros (4150 NOK) saved on average per year is a significant monetary incentive over the lifetime of an EV. However, this is an average. There are potential EV adopters living in urban areas where they pass through tolls daily, and this value would represent a far greater monetary figure for them. This incentive has a positive value for those driving EV's, however it contains a negative value in increased congestion and time-value for those using public transit. Additionally, as stated earlier these vehicles contribute to wear and tear of the toll roads that they are exempt from, and many argue that this incentive should gradually be reduced and eventually phased out altogether once uptake has reached a critical mass. Similar to high taxes, toll roads are a pre-existing condition of Norway that would be unrealistic to replicate in British Columbia at this point in time. British Columbia's road network infrastructure is relatively matured, and justification for introducing tolls within the province would be negatively received by the public.

Free Parking

Paid parking is a shared reality of driving a vehicle in both Norway and British Columbia. It is within the provinces reach to implement free parking stalls. The goal becomes more realistic if it is implemented within some of the province's wealthier and environmentally progressive municipalities. The entire value of the incentive in Norway is estimated at 10 million euros (95,643,171 NOK) per year (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Although the cost-effectiveness per EV as measured by the TØI is relatively high at 90,719 NOK per BEV in Norway, the absolute cost of the incentive is relatively low at 186 million NOK ($29 million CAD) over the subsidies lifetime (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

Why are you writing about Vancouver? Because they are a wealthy enough municipality/city to implement these schemes? How is there situation different from BC and where do they get additional revenues from to put towards environmental measures. For instance, the city of Vancouver in recent years has spent vast amounts of money trying to reduce congestion, and pollution within metro Vancouver by introducing 12 new bike lanes within the city (CBC News, 2015). The cost of just a single lane on Hornby was $3.2 million CAD **.** These bike lanes are a great way of reducing traffic congestion and vehicle emissions for those who are within cycling range of the city, however it is a reality that much of Vancouver has to commute into work from surrounding suburbs. Adding free parking would make the city's solution to congestion and the environment more inclusive for all types of commuters. The city would be able to either use existing meter parking spaces for the incentive, and would not incur large upfront costs. However, they would incur a revenue loss from the fee's that would have been charged to ICE users, assuming the parking spaces are near to or at 100% capacity.

Ferries

Lastly, Norway waives vehicle fees for those driving EV's on ferries, although they still charge the EV user a passenger fee. The economics and debates of this incentive were discussed in the geography section, but once again this operational incentive is viable in British Columbia. BC ferries may be able to reallocate some of its government subsidy or budget towards EV uptake in the province creating an additional value to potential EV adopters that they receive in Norway. To date this incentive does not exist in British Columbia, however the TØI has suggested that it is among the least important incentives for EV uptake in Norway (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). Perhaps this incentive is a good secondary and psychological incentive for uptake in rural areas of British Columbia, but should not be established before more effective incentives are.

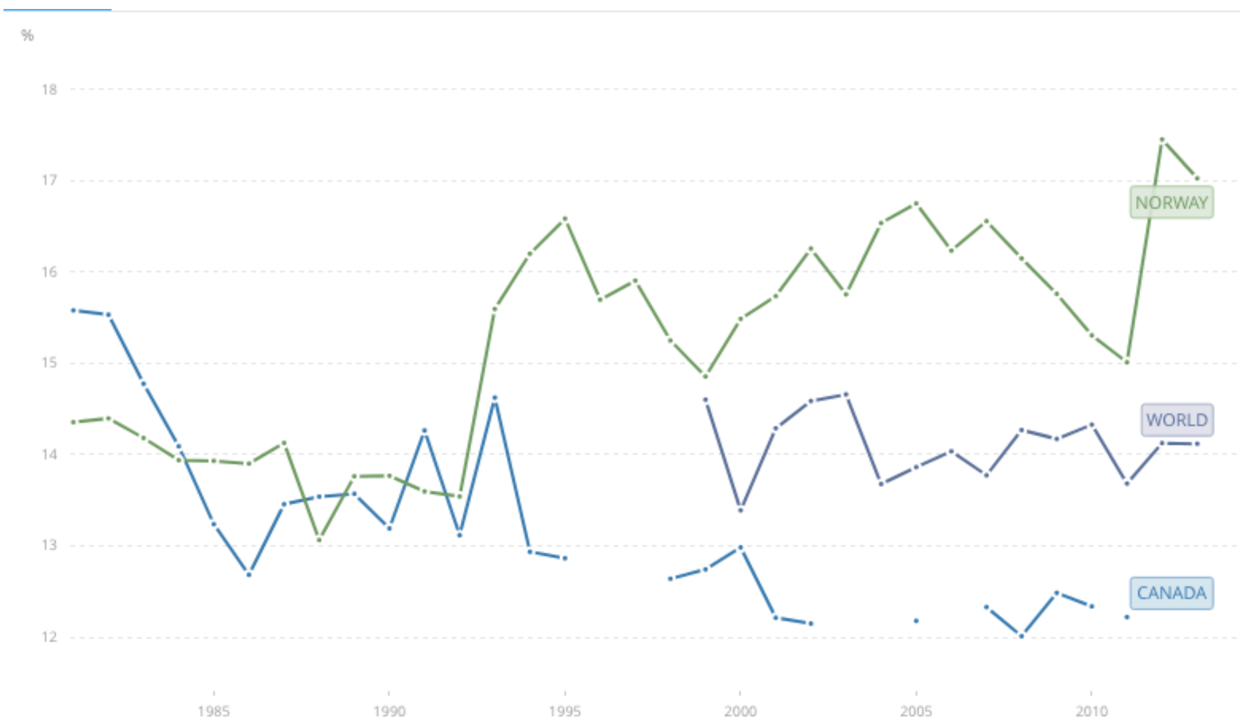
5.3.1 Social Aspects

In a hypothetical situation where British Columbia became prosperous enough to enhance British Columbia's spending on zero emission vehicles to the same levels as Norway, would it initially be ethical do so?

If British Columbia were to earn a return on its LNG prosperity fund, or raise its taxes to Scandanavian levels for the purpose of increased spending, the province would have to conduct an analysis of the best way to either spend, save, or further invest the money. Given that Electric Vehicle spending is just a small part of Norway's progressive social spending model, it may more sense for British Columbia to spend any newfound wealth on other social aspects of society as Norway did before their transport sector. Perhaps British Columbia would focus on more essential social programming that Norway focused on before spending money on its transport sector.

This section will be brief, as it is largely subjective and hypothetical. However, it is important to discuss competing issues within the province before automatically assuming any spending increases would be allocated towards British Columbia's transport sector. A limit of this section is that it does not discuss all competing social issues within the province, but highlights two key ones demonstrating what funding for the BC's clean energy vehicle program is competing with.

Post-secondary education in Norway is free at the Bachelor, Master and PhD levels, even for international students (Pasolea, 2017). In February 2017, student debt after a four year program in British Columbia averaged over $30,000 CAD (187,000 NOK) (Hernanez, 2017). Students are struggling to repay debt, and many in the province may put free-education as a priority before focusing new funds on electrifying the transport sector. British Columbians may argue that a more subsidized, or entirely free tuition may entice students in British Columbia to finish their education, and may provide future greater benefits versus vehicle electrification.



Expenditure on Education as % of total government expenditure (%)

Source: (UNESCO Institute for Statistics, 2017)

Housing is another heavily debated issue in British Columbia, especially in Vancouver that is the epicenter of an affordability crisis for renters who do not own their own homes, or are looking to enter the market. Foreign buyers have inflated housing prices so much so, that in August 2016 British Columbia Premier imposed a 15-per-cent tax on foreign home buyers in the Greater Vancouver Area (Jang, 2017)[27]. The average price for a detached house sold in May 2017 in Greater Vancouver reached a record of $1,830,956 CAD (11,420,953 NOK) (Jang, 2017). The average price for condos sold in Greater Vancouver in the same month also hit a record at $656,919 CAD (4,097,663 NOK) up 15.1% from last year, even after the foreign buyers tax was implemented (Jang, 2017). The largest issue with the foreign buyers was not that housing prices became inflated, but it was that most of the foreigners buying homes were still living in their respective countries, and not paying an income tax in British Columbia. Additionally, because the buyers were predominantly wealthy, many of them chose not to rent out their homes and they sit empty. This drove up the price of rent for the remaining homes or apartments that were available for rent. At the height of the issue, 22,000 homes sat empty, or underutilized in the city, forcing another municipal "Empty Homes Tax" of 1% to increase the rental supply (City of Vancouver, 2016).

There are various social issues that are debated in addition to the environment and transport in British Columbia (as in Norway). If British Columbia were to reap large monetary revenues from its expansive Liquid Natural Gas reserves, increased taxes, or other means it still could not be guaranteed that the transport sector would receive funding to the extent that Norway does at present. Additionally, the profits from the LNG resources would likely not be realized in the short term, and by this time Electric Vehicles may be cost-competitive with traditional ICE's.

British Columbia lags behind Norway in most social services, and is far behind Norway in its economic reserves. From a social and economic standpoint, Norway has been wise enough to focus its resources on its environment and truly become a world leader in the EV industry, but it also did so after spending money on more vital societal services.

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[27] A premier is the head of any provincial government in British Columbia

5.4.1 Norwegian Politics (Transport Policy)

Norway is a constitutional monarchy with a parliamentary system in which the power is dependent on the direct or indirect support of the legislature (Jakobsen, 2013). The current parliament in Norway, comprised of eight parties holding seats has established a broad agreement on EV policy framework as part of the country's larger climate goals (Figenbaum, Perspectives on Norway's Supercharged Electric Vehicle Policy, 2016) There is a cross-party consensus on EVs in Norway between the two most recent parties in power (Phillips, 2015). The Social-Democratic led coalition pioneered the majority of Norway's EV policies, however, the policies were revamped and continued by the conservative-led coalition that took power in 2013 (Phillips, 2015). This cross party consensus seems to be rare in North America, especially as of recently demonstrated by the divisive nature of politics across the continent.

5.4.2 Canadian and British Columbia Politics

. This section will briefly describe significant Canadian political parties and their platforms with regards to the environment and the transport sector. Federal Canadian Politics consists of three dominant parties that shapes the political sphere and party platforms in Canada. The three significant parties are the Conservatives, The Liberals, The New Democratic Party (NDP). Federally, the Conservative and the Liberal parties are dominant, however within the province of British Columbia the Liberals and the NDP are the two dominant parties. Each party's platform is vastly different, and their long term goals with respect to environmentalism for the country are usually not in line.

The Conservative party is in business, and mandates most of their policies on classical trickle-down economics. The conservative party generally provides the lowest corporate tax rates and is considered the party of business within the country. They are known to place a much heavier emphasis on Canada's economy and issues of national security than the environmental and social subsidies within the country. Although federally significant, the Conservative party is almost non-existent in British Columbia, having not won a single seat in the most recent election (Elections BC, 2017).

The Liberal party is considered the centrist party in the country. They are pro-business but usually include social aspects in their economic calculations, and are concerned with citizen's social welfare and the environment when making decisions. The Liberals introduced the country's first carbon tax in British Columbia at $30 per metric ton (Suzuki, 2017)**.** The British Columbia Liberal Party plans to extend the $30 per tonne carbon tax until 2021, and subject to a fairness review will match federal targets of $40 in 2021, and $50 in 2022 (Suzuki, 2017). In the most recent provincial election in May 2017, the British Columbia Liberal party did not put forward a zero-emission vehicle (ZEV) standard (Suzuki, 2017). However, they have put forward that they are committed to ZEV Alliance jurisdictions – where international governments are collaborating to adopt EVs more rapidly, and be emission free by 2050 (Suzuki, 2017).

The New Democratic Party (NDP) are the most left leaning party out of the three. The NDP seeks to spend money on social services, education, and solving financial inequality through changing tax rates based on personal and corporate income in the country (New Democratic Party, 2017). The party describes themselves as social democrats, although they removed the term "socialism" from their constitution in 2013 to make themselves more appealable to a wider audience in Canada (Payton, 2013). Although the word was taken out of their constitution they still base their party platform on social democratic ideals with labour and inequality at the heart of their party mandate **(Source)**. With regards to the environment, the NDP would meet the federal targets for a nationwide carbon tax of $40 per tonne, but on an expedited schedule - $36 in 2020, $43 in 2021 and $50 in 2022 (Suzuki, 2017). The NDP has also not put forward a Zero-emission vehicle standard in their most recent party platform, however, they have stated that they will adopt a target of 30% new zero-emission light duty vehicle sales by 2030, and retroactively add targets for 2020 and 2025 (Suzuki, 2017).

There is also a fourth party worth mentioning that holds little weight on the Canadian federal stage, but recently has played a key role in shaping politics through coalition governments in British Columbia. The Green Party is an environmentalist party with climate action at the heart of their platform. The Green Party plans to escalate the current carbon tax by

$10 each year for four years commencing in January 2018 (Suzuki, 2017). They plan to increase the tax to $70 per tonne by 2021 ahead of the federal schedule, in addition to setting an interim target of a 40% carbon reduction to emissions below 2007 levels by 2030 (Suzuki, 2017). The Green party plans to legislate a zero-emission vehicle standard to increase availability of non-emitting vehicles (Suzuki, 2017).

5.3.3 Political Insights

British Columbia's parties are all relatively right leaning relative to political parties in Norway. Any bill suggesting an increase in subsidies can be a huge political risk, especially if their intended benefit is not realized in the short term. For this reason, parties in British Columbia are often weary of making more than incremental policy shifts, which could land politicians out of power before the results of their programs are even realized.

Norway's parties have relatively similar climate change goals among themselves, and other countries surrounding them in Scandanavia and the EU. British Columbia faces a lot of competition from the US and other Canadian provinces within their natural resource based industries. Any change in British Columbian policy, such as a carbon tax*, or* an increase in environmental regulation in any industry can make their products uncompetitive with their US neighbors to the South, or provinces to the east. For this reason, it is more difficult than Norway to get a consensus on the way forward with regards to climate change policies, taxes, or subsidies between different political parties. In Norway, all states are bound to the EU's climate change goals, and their multiple trading partners are in much closer proximity. British Columbia on the other hand has Canada, and solely one nation on its southern border with vast trading power that it can negotiate with. This relates to British Columbia's clean energy vehicle program, in that any political party pushing more progressive climate change policy (such as a carbon tax) may be seen as making the province's economy less competitive.

Furthermore, the recent US election, their intent to withdraw from the Paris agreement, and their decision to renegotiate the North American Free Trade Agreement, has made Canada, and specifically British Columbia even more reluctant to introduce policies that may make their economies vulnerable. The election of Donald Trump, and his subsequent funding cuts, and repeals of at least six Obama executive policies aimed at climate change action and reducing carbon footprints has made exasperated these worries within the province (Diamond, 2017).

5.5.1 Technological – Electricity Production

Norway and British Columbia have a very similar electricity production profile due to their similar landscape and climate. Over 99% of all power production in Norway comes from hydropower (Statkraft, n.d.). British Columbia produces over 90% of its electricity from Hydropower (BC Hydro, 2017). Both of these places meet a clean electricity pre-requisite for supporting electric vehicles. However, it is worth mentioning that in many places, electric vehicles may actually end up polluting more than their hybrid or low emission ICE vehicle counterparts. For instance, in the mid-western, and southern United States where the electricity production profile is primarily coal fired power plants, EV's will produce more C02 than an hybrid vehicle (Biello, 2016). Although British Columbia meets a clean electricity pre-requisite for EV's as a means of pollution reduction now, they may have to install additional clean electricity capacity if they would like 40% if all new passenger vehicle sales to be EV's by 2040. Adding this many EV's to the grid will put an additional strain on its existing capacity, and without adding more, British Columbia may not be able to produce all EV electricity cleanly past a certain threshold. If British Columbia is planning on reach 100% penetration of EVs in the light-vehicle sector will consume approximately 7TWh of electricity annually (Phillips, 2015).

Norway sold 40,000 EV's in 2015 alone and could conceivably have 20% of total vehicles on the road being electric by 2021, or 520,000 vehicles (Barnard, 2016). This would require an additional 2.3 TWh of electricity produced annually in the country, but because of Norway's massive hydroelectricity producing capacity, most of this demand would still fall within the peak of their energy production (Barnard, 2016). Norway is an anomaly in its electricity production, although BC has a similar producing profile, it does is not capable of producing as much. British Columbia currently produces 80% of its electricity from just two of its dams, and with its natural resources in hydro, it would be able to build up more capacity with ease to meet future increased energy demand due to electric vehicles (BC Hydro, 2017). Although these two places are capable of meeting a future demand for EVs, it is still an important consideration in the technological pillar, as exporting EV incentive schemes to states who cannot produce the clean electricity to support them may be counter-productive to overall carbon reduction.

5.5.2 Technology – Supply Side Vs Demand Side Incentives

Both British Columbia and Norway have chosen to focus their incentives onto enticing consumers to purchase EVs through demand side incentives. However, is this necessarily the most effective way of encouraging electric vehicle uptake in each of these places?

Norway's demand-side policies are so strong that it is reaching a critical mass as new EV sales reached a record breaking 37% in January 2017 (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016). In December 2016, Norway reached the 100,000 EV milestone, despite its small population (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016). The country has an extremely ambitious goal of 100% of new vehicle sales to be zero-emissions beginning in 2025 (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016). Any automaker seeking to establish a future profitable business model in Norway is taking into account its unprecedented demand side incentives, current demand for EVs, and future EV target goals. Automakers are realizing that even though they are not producing vehicles in Norway, they will not have a future business there unless they are committing funds towards Research and development to provide the country with clean vehicles. It is for this reason that 15 different purely EV models are offered in the country, more than most markets even though they are relatively smaller (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016). Yet suppliers are realizing that even this is not enough, and continuing to develop and market new EV models in the country to meet consumer's needs (Lambert, Norway Reaches Rare Milestone of 100,000 All-Electric Vehicles on the Roads, 2016).

As discussed in the Economics section, British Columbia may not have the funds available to push demand-side incentives to the same extent that Norway does. Additionally, the current electric vehicle market is much smaller as a percentage of the British Columbia's population. Lastly, as discussed in the Politics section above, the three dominant British Columbia political parties have not shared cohesive views on EVs being the way forward. All of these factors combined indicate to automakers and dealers in British Columbia that investing in supplying more models, research, and development surrounding EVs as potentially unprofitable or unstable.

In addition to considering expanding demand side subsidies, the British Columbia government may want to consider introducing supply-side subsidies for a variety of reasons. The most effective supply side policies to date have been Zero Emission Vehicle (ZEV) programs. ZEV programs require that automakers sell electric cars and trucks as a percentage of their total sales within a state, or province (Union Of Concerned Scientists, 2016). Currently in the US, California and nine states on the east coast have ZEV policies in place (Union Of Concerned Scientists, 2016). ZEV programs aim to ensure that auto manufacturers research, develop and market EVs with the goal of reducing emissions in these areas (Union Of Concerned Scientists, 2016). ZEV programs assign each automaker credits, which represent the sales of electric cars and trucks (Union Of Concerned Scientists, 2016). For example, in California in 2018, an automakers selling 100,000 cars will need at least 4500 ZEV credits (Union Of Concerned Scientists, 2016). Although the percentage of credits needed can be determined by the respective government where the policy is being implemented (Union Of Concerned Scientists, 2016).

From a policy perspective in British Columbia, a ZEV mandate seems to be a perfect fit. It has spawned innovation globally, in that it rewards automakers for producing low vehicle emissions, and makes manufacturers choosing not to innovate either purchase credits or pay fines. This market based policy scheme earned Tesla motors $140 million USD (1,180.41 million NOK) in revenue alone from credit sales in the third quarter of 2016 (Axsen, 2017).

This solves a number of problems for EV transition in British Columbia in ways that demand-side incentives cannot accomplish alone. Demand side financial incentives may entice a potential consumer to browse electric vehicles, but if there is a shortage of models to choose from, they may not find one that they like. Also, automakers are not likely to conduct research and development or introduce new models in markets where there is not yet a profitable demand from consumers for EVs. A ZEV policy encourages dealerships to carry a greater supply of EVs as they know that a certain percentage of their sales must come from ZEVs.

Additionally, ZEV policies send a message to auto manufacturers that the government is truly heading towards an electrified transport sector (or a zero emission transport sector). It is easier to implement politically as it does not require tax payer dollars to subsidize those buying

EVs, and will subsequently not lose many votes from angered citizens who do not agree with the EV movement. It should be noted that ZEV policies still distort prices, as manufacturers must either make EVs cheaper, or ICEs more expensive to reach their sales quotas. As a result consumers are receiving a sort of implicit tax, yet they must be politically attentive and economically adept enough realize this. Lastly, British Columbia is a good place to implement a ZEV policy because the automakers do not have a large presence within the province. Similar to Norway, British Columbia has no large scale auto sector, and therefore automakers lobbying power is limited here, meaning that they will not have a lot of influence to challenge a provincial ZEV policy.

In Canada's Electric Vehicle Policy Report Card, which is stated by the author to be Canada's first comprehensive analysis of EV policy within the country, demand side policies were deemed to be relatively ineffective without complementing supply side policies (Axsen, 2017). The policy report card was made by analyzing the top EV markets in the world (Norway, Netherlands, and California). The report card examined how existing Canadian policies could impact Canadian electric vehicle sales in 2040. The report found that more than 80% of policies in Canada are "demand-focused" in that they push to make EVs more attractive to consumers. (Axsen, 2017). Although many of these policies were politically popular, only a few had a significant effect on encouraging EV sales (Axsen, 2017). In their analysis of the Canadian market, one supply side incentive stood out as the most effective in Canada. Quebec implemented their own provincial ZEV policy requiring automakers to have 15% of their sales come from ZEV's by 2025. This policy commences in the 2018 model year, and will initially require car companies to generate ZEV credits as 3.5% of their sales, with the threshold increasing over time (Klippenstein, 2016). This supply side policy is good from almost all perspectives: It forces auto manufacturers and dealerships to carry a wider variety of EVs for consumers to choose from, it spurs research and development driving down EV vehicle costs in the long run, and it is market-regulating rewarding those for innovation, while penalizing those who refuse to adapt. Finally, it costs individual tax payers very little money, (explicitly as stated above), and puts the onus on large vehicle companies to adopt part of the cost of a technology shift. Lastly, it sets a fixed level for EV sales incentivizing sales personal to research and market their EV products.

Plug-in electric vehicle market share in Canadian provinces offering EV rebates

Year	CANADA	Quebec	British Columbia	Ontario
2018		3.5%*		
2016 (Jan - Aug)	0.47%	0.91%	0.81%	0.35%
2015	0.34%	0.67%	0.71%	0.25%
2014	0.26%	0.56%	0.37%	0.22%
2013	0.15%	0.27%	0.27%	0.14%
2012	0.11%	0.22%	0.16%	0.10%

** ZEV credit equivalent*

Data sources: automakers, IHS Auto, Statistics Canada.

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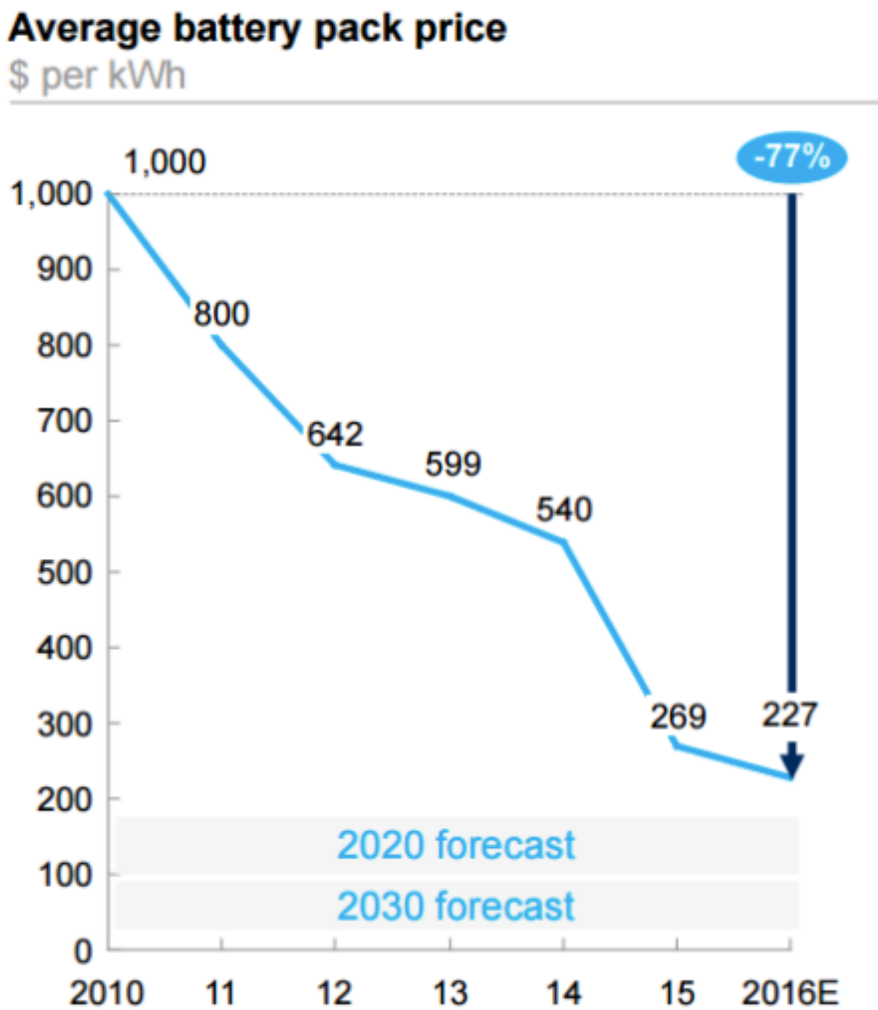
(figure?) Source: (Klippenstein, 2016)

5.5.3 Technology – Battery and EV Cost Development

When Norway introduced its first zero-emission vehicle incentive in 1990, EVs were not cost competitive with ICEs, even with the existing subsidies in place. The battery packs for EVs were exorbitantly more expensive than they are today, and the range and performance they provided made driving an EV only possible for a limited number of trips. As a result, EVs were purchased as secondary cars, and only by those with the disposable income to do so.

In just six years from 2010 to 2016, Mckinsey reported the cost of a battery dropping from $1000 USD (8485 NOK) per KWh to approximately $227 USD (1925 NOK) per kWh (Lambert, 2017). Tesla has made statements that their costs are have been below $190/kWh since early 2016 (Lambert, 2017). Mckinsey estimates that EVs will not be in true price parity with ICEs without incentives until battery costs are $100 per kWh, and estimates that this will take place somewhere between 2025 and 2030 (Lambert, 2017).



Source: (Lambert, 2017)

Does it make sense for British Columbia to incentivize EV users more greatly as their costs are rapidly declining to a point where they will be in price parity with ICEs in the next decade? Economically, perhaps not, British Columbia will not be the deciding market in going forward with cost lowering research and development for automobile manufactures. From a social and environmental perspective, many may argue that it would be good for British Columbia to be a leading EV market and environmental example in North America, even if it comes at a high cost to the public. The answer depends on the outcome that the province is trying to achieve. However, with battery costs lowering while EV performance is simultaneously improving, it is not far-fetched to imagine a British Columbia market where EVs are cost competitive, if not cheaper than ICEs by the time the province raises its carbon tax, and additional environmental regulations come in to play. Perhaps the question becomes an ethical one.

Places such as Norway, California, the Netherlands and other EV strongholds have committed the funds that have allowed EVs to be accessible though subsidies to the mass market. They have contributed significant amounts of public money to make viable EV markets for manufacturers which have allowed them to conduct further research and development to create profitable business models within these countries. Without subsidies, and locations to sell EVs, mass market manufacturers would have no economic reason to invest into EV R&D without incurring a huge loss, while other companies would be free riding on their research. By introducing subsidies, Norway has catalyzed the development of battery technology while simultaneously lowering its cost. Places like British Columbia, Canada, and other parts of the world have benefitted from markets like Norway from a technology perspective, because without them, technology would arguably not be close to where it is today. Norway has created a market for innovation (at a cost), and should be commended by the world for advancing a technology that will inevitably reshape an entire industry globally.

Should developed markets, such as British Columbia be further incentivizing EVs in their own societies to create more viable markets for EVs that will put an even greater onus on auto manufacturers to innovate or likely fail? Or should they be complacent in waiting for progressive markets like Norway to take on the bulk of the subsidization costs until technology is cost competitive within their own market?

Economically, the answer is clear: British Columbia can wait until EVs are cost competitive for users to make a switch. Environmentally, socially, politically, British Columbians may have it in its own interests to be an EV leader, especially given that it is suited perfectly for an EV market. The technological pillar of this paper is not so much a comparison between different technologies in British Columbia and Norway, as it is an ethical discussion for free riding off Norwegian subsidies that are the lowering costs for EV's globally through the research and development they have catalyzed. If British Columbia, and other developed nations have the means to develop EV programs, it will be up to their respective governments to decide if they have a duty to spur further innovation by doing so, or continuing to be complacent until EVs are cost competitive with ICEs.

6 Limitations & Further Research

This dissertation has predominantly been a broad discussion of the multi-dimensional conditions that exist in Norway that have allowed them to implement such extensive incentive schemes for purchasing EVs. Each of the dimensions is discussed through a respective pillar on a very macro-economic basis. This research has been very informing as to just how difficult it is to replicate Norway's progress in their electric vehicle revolution in other developed markets. However, because this paper's scope is conceptual, and based on five different dimensions, it relatively lacks a thorough enough analysis in each.

Most notably, the economic section lacks a proper quantitative analysis of how much both the Norwegian government and the Canadian government are paying to reduce carbon through EV incentive schemes, versus other methods such as carbon taxes, climate regulation, or simply purchasing carbon on the open market and choosing not to burn it.

Additionally, as this as a broad discussion not defining the goals of the government, it would be beneficial to analyze each pillar with the intended outcome of the government explicitly stated at the beginning, and throughout the paper. For instance, it would be interesting to analyze each of these pillars with the sole focus of the government to be increasing EV uptake, or to analyze each pillar through cost-effectiveness of reducing carbon versus other means. This paper defines no objective that governments are trying to achieve, but rather discusses the differences between the success of strategies depending on what outcome governments are trying to achieve.

Another limitation of this paper is the lack of a direct comparison i.e. cost-effectiveness figures between Norway and British Columbia. It would have been very hard to make a comparison between Norway and Canada as they vary so differently throughout these five pillars. However, by discussing a province with a nation, it was more difficult to find credible sources with direct comparisons between the two. For example, public expenditure as a % of total expenditure on education could not be found for the same years between British Columbia and Norway, and therefore Canada was used as a less accurate proxy.

This paper's discussion format is intended to make readers think beyond the economics and costs of introducing electric vehicle schemes. For instance, a study into British Columbia's current social spending budget, and where transport policy ranks on that versus other competing social programs such as education, housing, etc. would be interesting. Perhaps another example could be a study that is solely concentrated on the lifetime of environmental policies throughout changing governments to give potential EV users additional reassurance that their incentives will remain even when elections are in close proximity to their ideal purchasing date.

7 Conclusion

7.1 The Five Pillars

Without incurring a large debt, or strategically seeking out new revenue streams, the government of British Columbia will likely not have the funds to increase their EV subsidy programs to Norwegian levels. The two regions are similar in their geography, population, and commitment to the environment, however British Columbia is lagging in many of the other pillars required for world leading EV uptake that Norway possesses.

Economically, Norway has the largest sovereign wealth fund in the world, a higher GDP per capita than BC, and multiple pre-existing conditions that add value to EV incentive schemes. British Columbia is lagging in public wealth, and although they have a balanced budget with a slight surplus, they would need to reallocate funding from other programs to be able to increase EV funding without taking on additional public debt. Additionally, because of their lower GDP per capita, the average potential EV purchaser in British Columbia will have less purchasing power and therefore less choice when selecting an EV model, as there will be less models available in their price range. Norway's pre-existing conditions such as expensive fuel, high vehicle taxation, and use of toll roads make the value of purchasing an electric vehicle greater than that of British Columbia, and difficult to replicate. However, free parking, free ferries, and use of the HOV lane are all replicable incentive schemes in British Columbia. A further cost benefit analysis of introducing these schemes should be analyzed using a model similar to SERAPIS that is tailored to the province to assess whether implementing these schemes is feasible.

Socially, Norway and British Columbia both have ambitions of resolving climate change, and taking care of their respective environments. However, Norway has spent significantly more on social causes than British Columbia has over the past decades. For that reason, Norway provides free health care (as does BC), free post-secondary education, superior public transit, and a high minimum wage. Intuitively, Norway's essential social programming is matured enough that it has started to diversify the issues that it spends its oil revenues on within the country. For instance, programming such as EV subsidies. Idealistically, British Columbia could do this to if it were to receive additional revenue, but the residents of the province may see competing programming as a more essential priority than electrifying the transport sector in the province.

Two British Columbia competing issues were discussed in the social pillar, but of course there are more. This is not to say that there are not competing issues in Norway, because there are, yet their essential social structures (education, healthcare, housing) seem to be ahead of British Columbia's. As stated in the limitations of this paper, it is hard getting data comparing provinces to other nations around the world. Most of British Columbia's data regarding social services compares it with other provinces within the country, albeit data can be found comparing social and economic metrics of Canada vs Norway on the interactive world bank site[28].

Politically, potential EV users, dealers, and manufacturers hold an uncertain view of EV future in the province, as parties do not share cohesive views on their subsidization and carbon tax policies over the short term. Additionally, the party holding government will be reluctant to introduce additional subsidies intended to effect a long term technology shift if their benefits are not realized in the short term as it may be an unnecessary public expenditure in the eyes of voters. This problem is further deepened by uncertainty in the US federal climate policy as their executive branch, and departments concerned with the environment are being run by an administration who openly denies climate phenomena. An introduction of additional carbon taxes, or other expenditures on the environment may be seen as making BC uncompetitive to those without climate policies in place around them.

Technologically, Norway and British Columbia both have access to the same EV technology and neither of them are major car manufacturers. However, Norway's incentives have been vital in creating a viable market and demand for EVs which presumably has led to EV

[28] http://data.worldbank.org/?locations=NO-CA

automakers having a viable market to compete in and increase the scales of their EV line production. Both the competition and increased scales are helping to drive down EV cost, while other markets are free riding off the technology shift that Norwegian incentives are helping to catalyze. Developed areas can either continue or increase EV incentives to contribute to this technology shift and subsequent cost decrease, or continue to be complacent until their costs are comparable with ICEs. It is a question of timing for EVs to enter these areas with and without incentives, as well as an ethical one of our shared global environment.

7.2 Lessons Learned

Norway's oil boom and subsequent sovereign wealth fund alone did not allow them to progress their country to where it is financially, socially, and environmentally today. Factors in each of the five pillars has contributed to allowing them to pursue and become the global epicenter of an EV revolution. Perhaps the underlying reason is the responsible management and long term vision of their natural resource wealth. Norway had the advantage of witnessing "Dutch Disease" happen in other resource rich countries surrounding it, and were taught not to make the same mistake. Although British Columbia likely will not replicate Norway's entire EV incentive program today, they may be able to gradually implement schemes discussed above that they see fit for the province depending on which party is in power. However, British Columbia can take out many unrelated lessons through an empirical analysis of Norway's incentive schemes and the conditions that allowed them to be implemented.

Norway and British Columbia from an outsider's view seem like very similar places to introduce EV schemes. They are similar in terrain, climate, population, and population density and their natural resource based economies. However, parties in Norway are bound to its federal commitment to the EU's climate change goal, and stakeholders in the EV industry can count on EV policies being left in place to meet these goals. British Columbia is a leader in carbon tax policies in Canada, however without the rest of the country being bound to the same goals makes it difficult for any political cohesiveness between parties on further implementing climate action policies if it is to make the province uncompetitive with others in the country. Furthermore, the US has exaggerated this problem as they have significantly regressed on their stance against climate change since the beginning of the body of this research, adding to uncertainty of environmental policies not only within BC but within Canada. British Columbia has a much more concentrated set of trading partners, and as the current leader in Canada and the US, it is hard for them to influence trade or policies in the right direction, or boycott those not living up to their environmental standards. This alone should push British Columbia, and other provincial governments to making agreements on the way forward with environmental policy so that parties within province can start implementing them with less perceived risk that they will hurt their own economies relative to the others.

British Columbia is on the verge of receiving long-term natural resource revenues from its potential liquid natural gas reserves. Norway should be seen as a leader in managing resource funds. As at June 14, 2017, The Government Pension Fund sits 8,073,590,000 NOK with the objective of building long-term intergenerational financial wealth for its people (Norges Bank Investment Management, 2017). The fund invests in 9000 companies in 77 countries with the aim of diversifying the countries risks, while simultaneously protecting the country from shocks in the oil market while ideally providing the citizens the highest possible return (Norges Bank Investment Management, 2017). After management costs and inflation, the fund has returned 3.9% annually since 1998 (Norges Bank Investment Management, 2017). There are multiple caveats limiting government spending of the fund and what it invests in, ensuring that it does not get abused or too risk prone in its investment strategy. British Columbia should carefully analyze this strategy for if, and when there LNG fund comes into play.

In terms of incentives themselves, British Columbia currently offers no operating incentives with the exception of access to HOV lanes in limited places. Operating incentives help to recoup the increased expenditure on an EV overtime and plays to operators psychologically when they save money each time they drive.

As stated before Norway as pre-existing conditions that cannot be replicated in British Columbia as incentive schemes. Examples include high taxation on vehicles, fuel, and road toll exemptions. However, if the British Columbian government still taxes its vehicles, and could exempt EV's from this, instead of with a flat fee, making the incentive more scalable to the vehicle that the potential purchaser is buying. Additionally, increasing the carbon tax, as planned by the governments in the long term may subsequently increase fuel pricing in British Columbia making switching to a vehicle powered alternatively more valuable as well.

These lessons mainly focus on the mid to long term for British Columbia. In the meantime, the province may choose to eliminate, continue, or enhance spending on their clean energy vehicle program. This choice will either make the province complacent with other developed nations in free riding off of the research conducted in subsidized markets such as Norway, while waiting for EV costs to fall to market competitiveness for them. Alternatively, their choice will earn them the same respect (or part of) in the international community that Norway has earned through its role in catalyzing a global transport technology shift towards a cleaner environment. Ultimately, it will be up to the citizen's public opinion on where British

Columbia's money is best spent following an analysis of all of their options that each party presents to them in their platforms.

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Appendices 1.0 – SERAPIS Conceptual Description

3.1 Serapis Model

Before describing Canadian and British Columbian EV incentives, it is important to discuss the model that produced the above cost effectiveness for EV schemes in Norway.

3.1.1 Serapis Model Background

SERAPIS stands for: Simulating the Emergence of Relevant Alternative Propulsion Technologies in the car and motorcycle fleet Including energy Supply (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The model was initially tested in only one area, however later versions of the model allowed the original version to be modeled into a discreet number of subdivided zones (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The model being used in this paper will be the revamped version of Serapis, and is therefore rightfully titled Serapis 2.0.

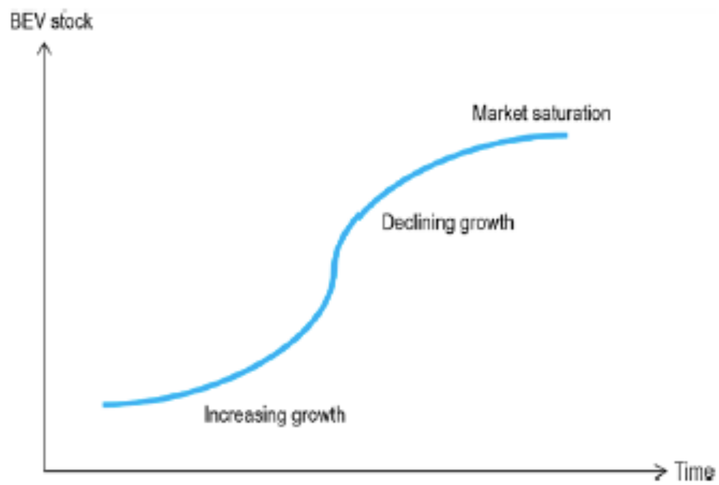
The original model also did not discern much between propulsion technologies, whereas Serapis 2.0 explicitly defines and discerns between propulsion technologies such as ICEs, PEVs PHEVs, BEVs EVs etc. (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The new model also differentiates between first and second vehicles, as well as categorizes vehicles into three categories: Compact, Family, and luxury (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

3.1.2 Mathematical Description of Serapis Model

The Serapis model uses a Multinomial logit model, which is standard practice in choice modelling. The mathematical description of this model will be outlined and cited to the TØI in an appendix of this work, as they are the best descriptors of their own model and the author of this paper has not made additional changes to this model. However, a brief conceptual description will follow.

The model includes: choice of propulsion technology in each model year, the probability that propulsion technology *I* is chosen for a car *n* (first or second car), in one of the three categories listed above; (compact, family luxury) is the exponential function of the utility of the propulsion technology *I,* divided by the sum over the exponential functions of all alternatives (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

The function produces a well-known S-shape curve that shows a period of increasing growth in EV uptake, followed by the market reaching its inflection point, after which the growth rate starts to decline while remaining positive as EV prevalence reaches market saturation levels.



Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)

There are 10 equations described in detail in the appendix of this paper (as TØI describes them). However, for the reader's purposes of this section, the equations are as follows:

1. *Basic form of the multinomial Logit Model (MNL) in Serapis 2.0*
2. *General form of utility of the choice of a propulsion technology*
3. *Utility and generalized costs*
4. *Marginal utility price*
5. *Utility and generalized costs*
6. *Generalized costs from investment costs*
7. *Generalized costs from operating costs*
8. *Generalized costs of makes and models*
9. *Generalized costs range and density of public charging stations*
10. *Generalized costs from time savings due to exemptions and regulations*

3.1.3 Data required to run Serapis Model

The Data required to use the Serapis model can be segregated into two different types:

1. Data for the base year and;
2. Scenario data representing changes between two different years

Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)

Below is the TØI's chart of all the base year data inputs that were run in their Serapis Model in Norway:

Description	Unit
Number of cars by zone, first and second+ car and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	-
Average number of years until car is disposed by zone and first and second+ car	years
Net investment costs per vehicle by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	Euro, NOK
Purchase tax by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	%
Value added tax	%
Net investment costs for private charging infrastructure by zone	Euro, NOK
Average yearly vehicle mileage by first and second+ car and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	km/a
Consumption liquid fuels by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	l/100 km
Consumption electricity by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	kWh/100 km
Average fuel costs at the pump by zone	Euro/l, NOK/l
Average electricity costs for the customer by zone	Euro/kWh, NOK/kWh
Discount rate	%
Average yearly parking charges by zone and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	Euro/a, NOK/a
Average yearly road charges by zone and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	Euro/a, NOK/a
Number of available makes and models by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	-
Average travel speed by zone	km/h
Estimate of the relative time savings due to exemptions for electric vehicles (use of bus lanes, dedicated parking places, etc.) for n=1 e-car by zone	%
Average range of a car with one tank refill/recharge by vehicle type (compact, family, luxury) and propulsion technology (internal combustion engine, plug in hybrid electric vehicle, battery electric vehicle)	km
Density of public charging stations relative to internal combustion engine cars by zone (petrol/diesel = 100%)	%

Below is a chart of the scenario data that is required to run the SERAPIS model

Description	Unit
Yearly rate of change in numbers of first cars by zone	%/a
Yearly rate of change in numbers of second cars by zone	%/a
Yearly rate of change life span of first cars by zone	%/a
Yearly rate of change life span of second cars by zone	%/a
Share of compact cars in the fleet of first cars by year and zone	%
Share of family cars in the fleet of first cars by year and zone	%
Share of compact cars in the fleet of second+ cars by year and zone	%
Share of family cars in the fleet of second+ cars by year and zone	%
Yearly rate of change net purchase price by car type and propulsion technology	%/a
Purchase tax as percentage of net purchase price by car type and propulsion technology	%
Value added tax by year	%
Direct subsidies for battery electric vehicles by zone and year	Euro, NOK
Direct subsidies for plug in hybrid electric vehicles by zone and year	Euro, NOK
Yearly rate of change in net investment costs for private charging infrastructure by zone	%/a
Direct subsidies for private charging infrastructure by zone and year	Euro, NOK
Yearly rate of change vehicle mileage first car propulsion technology ICE by zone	%/a
Yearly rate of change vehicle mileage first car propulsion technology PHEV by zone	%/a
Yearly rate of change vehicle mileage first car propulsion technology BEV by zone	%/a
Yearly rate of change vehicle mileage second+ car propulsion technology ICE by zone	%/a
Yearly rate of change vehicle mileage second+ car propulsion technology PHEV by zone	%/a
Yearly rate of change vehicle mileage second+ car propulsion technology BEV by zone	%/a
Yearly rate of change specific consumption liquid fuels by car type and propulsion technology	%/a
Yearly rate of change specific consumption electricity by car type and propulsion technology	%/a
Yearly rate of change costs for liquid fuels by zone	%/a
Yearly rate of change costs for electricity by zone	%/a
Average parking charges by zone propulsion technology and year	Euro/a, NOK/a
Average road charges by zone propulsion technology and year	Euro/a, NOK/a
Yearly change in the number of makes and models by car type and propulsion technology	-
Yearly rate of change average speed by zone	%/a
Relative time savings due to exemptions for electric vehicles (use of bus lanes, dedicated parking places, etc.) for n=1 e-car by zone	%
Yearly rate of change value of time by zone	%/a
Average range by car type, propulsion technology and year	km
Relative density public charging station (petrol/diesel = 100%) by zone and year	%

Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015)

The Serapis model outlined in TØI's report also notes the calibration of its model. For the purposes of the reader, Calibration is an approximation of specific model parameters to fit the model results with a set of observed data points (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). The table of parameters used in Serapis are below:

Table 3.3: List of parameters used in the model calibration

Parameter	Description	See
β_P	price elasticity for the calculation of the marginal utility price	Equation 4
α_I^V	weighting parameter vehicle investment costs	Equation 6
α_I^{ch}	weighting parameter investment costs private charging point	Equation 6
α_O^f	weighting parameter discounted lifetime fuel costs	Equation 7
α_O^r	weighting parameter discounted lifetime road charge	Equation 7
α_O^p	weighting parameter discounted lifetime parking charge	Equation 7
α_O^a	weighting parameter discounted lifetime annual vehicle tax	Equation 7
α_M	weighting parameter variety of makes and models	Equation 8
$\alpha_{R,D}$	weighting parameter range and density of public charging stations	Equation 9
α_T	weighting parameter time savings due to exemptions from regulations	Equation 10
$C_{r,l}$	willingness to pay for range equal to the maximum available on the market	Equation 9
$C_{d,l}$	willingness to pay for density of charging stations equal to the maximum available on the market	Equation 9
$b_{r,l}$	elasticity parameter range	Equation 9
$b_{d,l}$	elasticity parameter density of charging stations	Equation 9

Source: (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

3.1.3 Sensitivity Analysis and Model Assumptions

Serapis has conducted sensitivity tests to identify assumptions, parameters and input data that strongly affect their model's outcomes. They do this by comparing the base scenario (2005 for their Norwegian report) with various model runs where certain parameters are changed (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015). After running these tests, the model appears to be quite robust.

One critical factor was the demand elasticity for the compact and luxury vehicle segments which had large effects on the outcomes, but are not based on other empirical evidence than the input data on which SERAPIS is calibrated. It is also apparent that fuel prices (unleaded, and leaded or diesel), have considerable effects on BEV sales. Intuitively, this makes sense as the EV market largely depends on ICE operating costs. This model further suggests that EV energy costs have a lesser effect on EV sales, which is also understandable as the BEV energy costs are much smaller relative to ICE energy costs (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

The discount rate assumption also has significant affects results. In the Norwegian model run, a 3% rate resulted in an over-estimation of the EV market size. Finally, the supply side has important effects on the model outcome as well (Fearnley, Pfaffenbichler, Figenbaum, & Jellinek, 2015).

Is this all too mathematical for a relatively non mathematical paper? Does it create a disconnect between the two countries incentive schemes sections and take away from there comparison because of it being placed between them?