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Reaching the end of the ICEV domination 35 years of BEVs in Norway

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Executive Summary

This paper summarizes the Norwegian BEV development as the result of a 35 year long interactive process of innovation, development of consumer needs and experiences, cost reductions, technical development of BEVs and batteries, and a long-term stable policy with a large incentive package introduced since 1990 and remained in place intact until 2021. Norway had specific national conditions that led to higher BEV sales than other countries from 2011, such as clean electricity, good access to low-cost home charging, and the large package of incentives that made BEVs affordable for all buyers of new vehicles. In addition, Norway got off to a head start from 2011 due to the existing pool of BEV owners developed up to 2010 following 20 years of continuous national BEV industrialization efforts. This pool of BEV owners was much larger than in all other European countries in absolute numbers. High visibility of BEVs up to 2010 due to national BEV production, access to bus lanes, and the use of BEV specific number plates, together with the large package of incentives, accelerated the BEV diffusion from 2011, contrasting other countries much slower diffusion.

Keywords: Electric Vehicles, Public Policy & Promotion, Consumer Behavior, Consumer Demand, Trends and Forecasting of e-mobility

1 Introduction

Norway is the world's leading Battery Electric Vehicle (BEV) market in terms of market and fleet shares [1] of 89% and 27% respectively at the end of 2024 [2]. Q1/2025 market share was 91%. The national target has since 2017 been to only sell BEVs from 2025, which has provided direction for BEV policies.

This achievement is the result of a 35-year-long innovation and market diffusion process enabled by long term stable BEV policies and large incentives. It started when the first BEV was registered in 1990, continued through two periods of failed Norwegian BEV industrialization efforts until the age of the modern OEM BEVs started from 2011. A rapid market expansion followed leading into the 2020s high shares, as seen in figure 1.

The enlarged part of figure 1 shows that the Norwegian industrialization with BEV production in 1999-2002 and 2008-2010 was not successful although overall sales increased somewhat from earlier numbers. The figure also shows that Plug in Hybrid Vehicles (PHEVs) increased total Plug in Electric Vehicle (PEV) 2016-2023 sales shares substantially. PHEVs are no longer an important technology in Norway due to policy changes and the fact that they do not count towards the 2025 target.

The BEV market share passed 50% in 2020. The end of the ICE-age started. Vehicle importers reduced ICEV and increased BEV availability. Some went BEV only from 2023. Others imported Chinese BEVs. A network of fast chargers was built out across Norway from 2011. Fuel station chains install fast chargers. Some moved ICEV fuel pumps to the back and placed the fast chargers in the front under the canopy. Norway is 5-10 years ahead of other European countries and demonstrates how a complete transition to BEVs may unfold elsewhere.

These facts form the background for the papers research questions:

RQ1: How can the Norwegian Battery Electric Vehicle development be explained from different perspectives?

RQ2: What makes Norway different from other countries in how the BEV development has progressed?

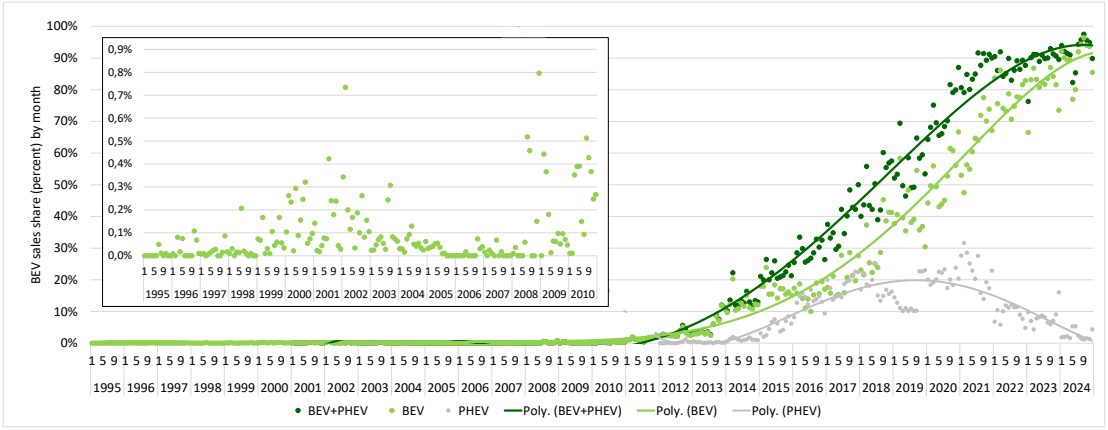

Figure 1. Monthly sales shares of BEVs (light green) and BEVs+PHEVs (dark green)

The paper contributes to the research literature by summarizing the main phases and events of this Norwegian development and explaining the reasons behind the overall result using different research perspectives and thus provide a holistic understanding of how the road to 100% BEVs in new vehicle sales has progressed.

The paper is organized as follows: Method and data are presented in section 2, the results in section 3, the discussion in section 4 and the conclusions are in section 5.

2 Method and data

This paper draws on a document study as the main data source, supported by press articles and a collection of BEV development metrics, that previously have been used to review the Norwegian BEV development from an innovation perspective [3,4], from a total cost of ownership perspective [5], and a policy development perspective [6]. In addition, an earlier subset was used when analyzing the development using the Multi-Level-Perspective (MLP) framework [7].

In total, more than 350 documents, of which 100 scientific article and works, 100 research documents, over 80 governance documents and 70 other document types, and 140 press articles, were reviewed of which a subset was selected for this paper to provide a holistic overview of the 1990-2025 BEV development in Norway.

3 Results

3.1 Life-cycle development phases

The BEV development can be split into 2 main phases with 4 and 3 subphases as seen in figure 2. The phases are separated by specific events termed leverage points [3].

Main phase 1, Norwegian BEV producer led innovation

Sub-phase 1 (1990-1996): The development was initiated by actors wanting to introduce, sell, and produce BEVs in Norway. These actors were inspired by the California ZEV mandate that was thought to lead to a breakthrough for BEVs. OEMs developed “compliance” BEVs to be able to comply with the mandate. PIVCO developed BEV prototypes that were tested in Norway and California, enabled by politicians introducing exemptions from the registration and annual taxes. The political motivation was to enable market experiments and BEV testing. Danish Kewet BEVs were also imported. Energy companies and Oslo Municipality were the main supporters. These and other actors got together in 1995 and established the EV Association business network to raise awareness, improve incentives, and support BEV production plans.

Sub-phase 2 (1997-2002): The prototype testing evolved to full industrialization by PIVCO, now named THINK. THINK planned to produce 5000-10000 BEVs/year but went bankrupt just after launching their BEV in late 1999. THINK was bought by Ford who needed a low-cost BEV to meet the California ZEV mandate. France had as part of a national plan established small series BEV production, which enabled import of Peugeot, Citroën, and Renault BEVs to Norway, albeit in limited numbers. BEV sales increased somewhat from 1999 as the incentives were improved to support industry development. Free parking had been introduced in 1997, free road tolls came in 1999, and the Value Added Tax (VAT) exemption from 2001 [6]. Ford never got THINK production going for full and a new model for California was never put in production before

California changed the ZEV mandate so that BEVs were not needed. Ford subsequently decided to sell THINK. Germany, Switzerland, and Sweden tested BEV usability in research projects [8,9], but had no production.

Sub phase 3 (2003-2006): BEV interest declined across the globe. BEVs were considered not market ready. THINK soon went bankrupt, having been out of production since 2002. BEV activities ended in all other countries, Even in France that had a "top-down" BEV development process going until 2002, but with limited success. Some Norwegian Actors saw an opportunity to keep the market going with imported second-hand BEVs. France had completely had lost interest in BEVs so the used BEVs were very cheap. A small production of the Norwegian Buddy mini-BEV (based on the Kewet) started from 2005. BEVs got access to bus-lanes from 2003 in the Oslo area and nationwide from 2005 [6], which proved to be a very powerful incentive. The other incentives remained in place. Norway was the only Europena country that continued to develop a BEV market. New Norwegian investors bought THINK planning to re-industrialize.

Sub-phase 4 (2007-2010): A re- industrialization phase started at THINK and other Norwegian actors due to the increased global climate policy focus that seemed to provide industrial development opportunities. THINK got into production with a new model that had been developed for the Californian market in the Ford years, but due to financial issues, the production soon moved to the vehicle contract producer Valmet in Finland. The Buddy BEV was also renewed and an actor in the Grenland area planned BEV production with TATA. THINK and other entrepreneurs failed to get funding during the Global financial crisis and went bankrupt by 2011. The BEV fleet had grown slowly up to this point.

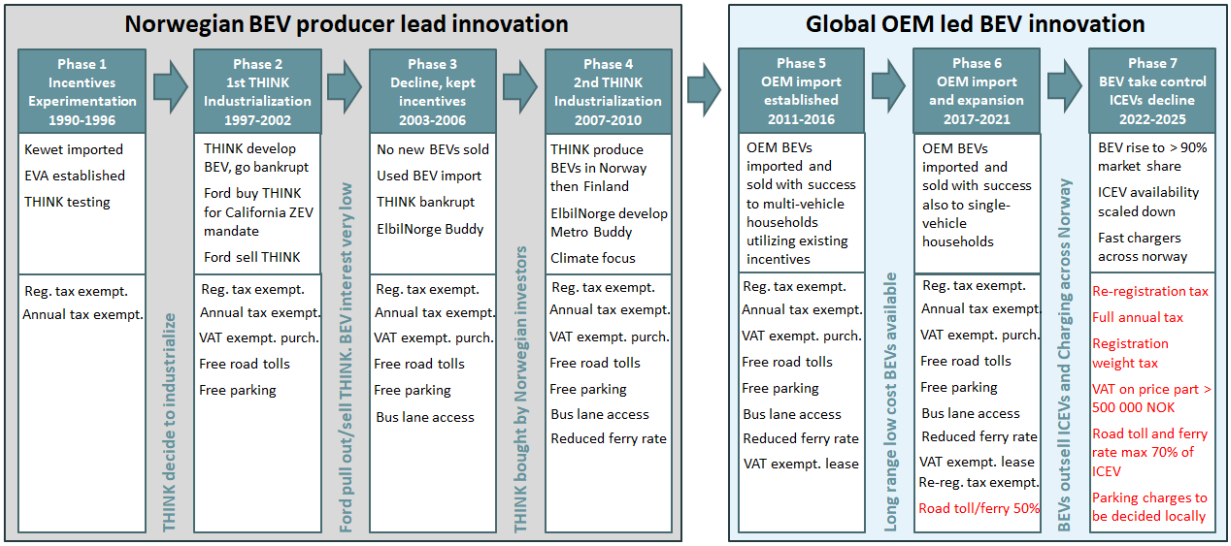

Figure 2 Overview of BEV development phases

Main phase 2: Global OEM led BEV innovation

Sub-phase 5 (2011-2016): Norwegian made BEVs were no longer available, but OEM BEVs had become available in unlimited volumes, as the global climate mitigation focus had reached the car industry and Li-Ion batteries enabled good BEVs. The incentive package developed for the earlier available small, short range BEVs, was still available. The result was that the market took off among multi-vehicle households and expanded rapidly as technology improved. Tesla proved that BEVs could be usable for driving long distances when combining a large battery with a high-quality charging infrastructure. BEVs became important for achieving climate policy goals so the policies continued unchanged in this period. The first fast chargers were installed in and around cities. Further charger installations evolved to a network across southern Norway.

Sub-phase 6 (2017-2021): Long range BEVs became available in all segments at acceptable cost to most new vehicle buyers, including single vehicle owners, due to the generous Norwegian incentives package. The market share passed 50% in 2020, when most vehicle importers offered a variety of BEV models. Charging infrastructure covered all of Southern Norway and was eventually expanded to Northern Norway. Charging support became available to flat owners that also got a right to access charging in the common parking facilities.

Sub-phase 7 (2022-2025): The roles of the technologies were turned upside down. ICEVs became the niche market with rapidly falling model availability and less equipment level choices, whereas BEVs was the mainstream technology. Norway's target to only sell ZEVs from 2025 seemed possible as the market share

reached 79% in 2022, 82% in 2023, 89% in 2024, and passed 90% the first quarter of 2025 [2], which is high enough to declare that the target has been met. Ultra-fast chargers were built out on a purely commercial basis. Some of the incentives were scaled back without negatively impacting the market because Tesla reduced prices significantly from 2023. Tthe other OEMs had to follow. These reductions have masked out BEV tax increases.

3.2 Norway got off to a head start in 2011 due to the earlier development

Norway had managed to keep a slow BEV market going all the way from 1990 until 2010, resulting in a slowly growing BEV fleet. In 2010, Norway had over 3360 BEVs in the fleet [2]. Denmark, Sweden, the Netherlands, Italy, Germany, and France only had a few hundred each, the UK had half as many as Norway, and several countries had none [10,11,12]. These countries had abandoned BEVs in 2002/2003. In fact, Norway had 35% of all BEVs registered in Europe in 2010, with the UK second with 15%. Only the US and Japan had a few hundred more BEVs in the fleet than Norway, as seen in figure 3. This means that Norway also had by far the highest share of BEVs relative to the vehicle fleet of any country in the world.

The Norwegian BEVs were also quite visible due to the use of BEV specific number plates, recognizable BEV designs and the access to and extensive use of BEVs in the bus lanes around the Oslo area, These factors had led to awareness of BEVs in the Norwegian population, whereas BEVs were largely unknown elsewhere. Asker municipality had the biggest BEV fleet share, i.e.1,15% of the total fleet [2]. Asker's inhabitants could drive in the bus lane to Oslo saving up to half an hour in the morning rush hour, which had a very high value to users that therefore accepted BEVs reduced range and limited comfort [5,7]. Asker's 2010 BEV fleet share is higher than the laggard countries (14) in Europe had in 2023, as seen in section 3.8.

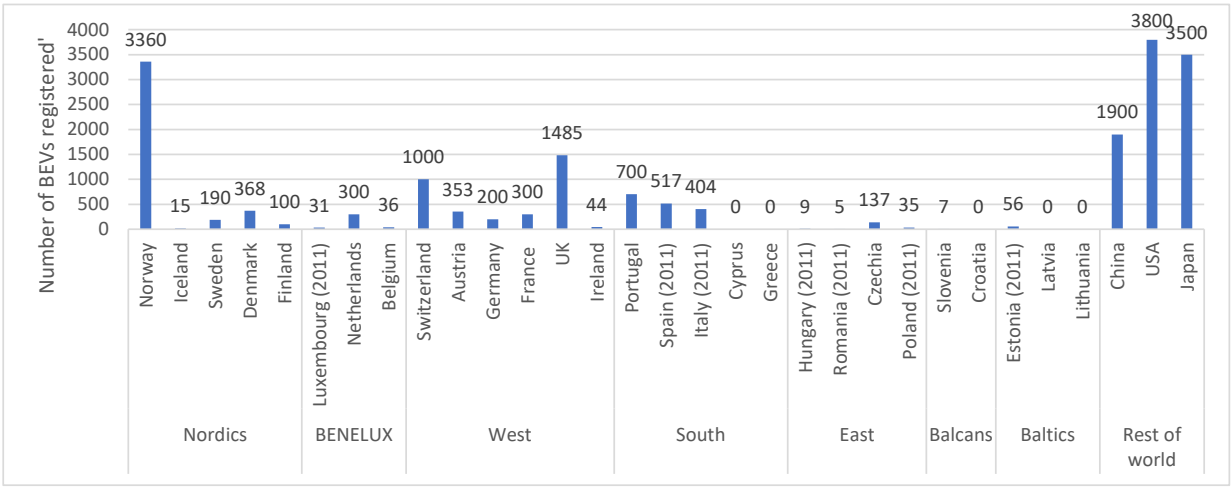

Figure 3 Number of BEVs in the vehicle fleet in 2010 (some countries 2011)

Of all the other European countries, only the UK and France had a broad policy package in place as seen in table 1, but they were far inferior in total value to Norway's large incentive package. Norwegian BEV buyers were fully compensated for the extra cost of BEVs when the OEM BEVs became available from 2011 and overcompensated later in time [5], whereas they were at best partially compensated in other countries, as seen by the list of incentives in different countries in table 1. Eastern and Southern European countries including the Balcans and Baltics, have had very weak incentives as seen by the example of Poland. The result of these weak incentives were low sales shares all the way to 2025, as discussed in section 3.8.

The existing pool of Norwegian BEV owners provided an initial market to grow from that was not available in other countries and the reaped large local benefits in addition to being compensated for the extra cost of the purchase. The result was a much more rapid market expansion in Norway compared with the rest of Europe. Elsewhere in Europe BEV awareness and interest from scratch. The OEMs had much weaker incentives available to develop an initial market with.

Table 1 BEV Incentives 2010-2024, European countries. Sources: [10,12,13,14,15]

	Incentive	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Norway	Registration tax exemption															
	Value added tax exemption															
	Value added tax exemption leasing															
	Annual tax exemption/reduction															
	Re-registration tax exemption															
	Reduced company car tax															
	Free road tolls															
	Free parking															
	Bus lane access															
	Public regional support for normal chargers (national 2010)															
	Public financial support for fast chargers															
	Right to access charging flat owners parking															
EU	CO_2 regulations new vehicles "requiring" BEV sales															
Sweden	Purchase incentive national budget, "Supermiljøbilspremie"															
	BEV purchase bonus and ICEV malus, "Klimatbonus"															
	Annual tax reduction ("Fordonsskatt")															
	Reduced company car tax															
	Support for home charge wall box and installation (50%)															
	Public financial support for fast chargers ("Klimatklivet" etc.)															
Denmark	Purchase support scheme															
	Exemption from registration tax / Tax reduction (from 2016)															
	Purchase tax rebate/kWh battery installed (225 USD/kWh)															
	Exemption from annual tax /Reduced tax															
	Free parking in some cities															
	Charging infrastructure support scheme															
	Support for private chargers															
	Reimbursement of electricity fees / Costs (business/private)															
	Tenders for fast charger deployment															
Finland	Purchase subsidy															
	Registration/purchase tax reduction (2024: 100% reduction)															
	Annual tax (vehicle tax) exemption/reduction															
	Reduced energy tax															
	Reduced company car tax															
	Reduced/exempted parking fees in some municipalities															
	Charging at workplace income tax exempted/reduced															
	Charging at public chargers tax-free															
	Charger support programs															
France	BEV purchase bonus/ICEV malus scheme															
	Exemption business car tax /CO_2 and emission tax (ex-TVS)															
	Home charger installation support program (Tax credit)															
	Charging infrastructure condominiums support program															
	Charging infrastructure workplace/parking support program															
	Charging infrastructure in municipalities general support															
	High power charging specific support – Grants/Competition															
	Right to access charging flat owners parking															
UK	Zero-Emission Vehicle sales mandate															
	Purchase support scheme (plug in vehicle grant															
	Reduced annual tax															
	Reduced company car tax															
	London congestion charge exemption															
	Electric vehicle homecharge (support, up to 75%) scheme															
	Workplace, on-street parking, flats charge support schemes															
Germany	Purchase support scheme															
	Annual tax exemption/reduction															
	Reduced company car tax															
	States can offer bus lane & restricted zone access, free parking															
	Charging infrastructure support (slow and fast)															
Netherlands	Purchase incentive															
	Registration tax exemption/reduction															
	Exemption from annual (road) tax															
	Exemption/Reduced company car tax															
	Reduced energy tax charging stations															
	Charging infrastructure support															
Poland	Purchase incentives															
	Registration tax exemption															
	Reduced ownership tax															
	Reduced company car tax															
	Free parking and charging incentives in some cities															
	Access to bus lanes some cities															
	Public and Housing Communities charging infrastructure support															

3.3 A radical innovation needing user adaptation that became a drop-in replacement

BEVs were in the first two decades a radical innovation requiring large user adaptations to be taken into use due to the very short and often unreliable range and the lack of fast-charging capability. The early BEVs had mainly 2 seats (some had 4) and were rather slow [5,7]. Had this status continued, BEVs would likely have remained a small niche market for local driving purposes, mainly of interest to fleets as they were too small, too expensive, and too unreliable to be a replacement for ICEVs in multi-vehicle households. When OEM BEVs came on the market with Li-Ion batteries, a big increase in BEVs reliability, usability, efficiency, power, cost efficiency, and perceived quality occurred as seen in table 2 and figure 4. BEVs got a long enough range to be useful for multi-vehicle households [16], and big enough with 4 seats to be an everyday family run-about. Long warranties on the batteries assured consumers that BEVs were a safer investment than they had been earlier, but battery life and second-hand value remained uncertainties for buyers for a long time [16,17].

BEVs range increased gradually until long range large BEVs became available from Tesla in 2013 and low cost long range compact BEVs became available from Opel and other OEMs from 2017. This was another big technological improvement as seen in table 2 and figure 4. For users with home charging, BEVs became more of a drop-in replacement for their ICEV, with few adaptation issues [17,18]. Very long trips exceeding the range would however still take somewhat longer time and come with a risk of inconvenient charge queues on peak travel days [18,19,20]. PHEVs became increasingly popular as a bridging technology that enabled driving on electricity locally and on fuel on long trips. The PHEV interest faded out after peaking in 2021, as BEVs usefulness increased, and they had local incentives not available to PHEVs. The tax policy was also changed to make PHEVs less attractive so that the 2025 ZEV target which does not include PHEVs, could be met.

The public charging infrastructure was developed to a network of fast chargers around cities from 2011, in and between cities from 2015, and across Southern Norway by 2020, and Northern Norway by 2021. BEVs developed from being a local use vehicle to a vehicle capable of covering all travels. Cities like Oslo and Bergen put in place curbside and parking house slow chargers up to 22 kW AC and supported part of the cost of putting in place charging infrastructure in common parking facilities for flat owners. The latter got from 2017/2020 (depending on ownership type) a legal right by law to access charging in such facilities [6].

Table 2. BEV and charging infrastructure characteristics 1990-2025

	1990-1996	1997-2002	2003-2006	2007-2010	2011-2016	2017-2021	2022-2025
Vehicle segments	Mini	Mini-Small	Mini-Small	Mini-Small	Small-Compact	Small-Large	All
Number of seats	2	2-4	2-4	2	4-5	4-7	All variants
Battery type	Lead/Ni-Cd	Lead/Ni-Cd	Lead/Ni-Cd	Li-Ion/Ni-MH	Li-Ion	Li-Ion	Li-Ion
Battery warranty (years/km)	2/-	2/-	2/-	2/-	5/100000	8/160000	8/160000
Average range summer (WLTP)	30	60	60	50-86	120 → 209	301 → 433	433 → 484
Average range winter (est.)	20	40	40	35-60	80 → 150	210 → 300	300 → 340
Charge power (normal)	2,3	2,8	2,8	2,8	2,8-7	4,6-7 (11)	4,6-11 (22)
Charge power (fast) (average)					30-80	40-150	60-150 (350)
Use area	Local	Local	Local	Local	Regional	Everywhere	Everywhere
Average price (2024 NOK)	186-202	201-368	190	209-263	315-411	466-542	487-609
Price/range (1000 2024 NOK)	6,7 → 6,2	6,1 → 4,4	3,8 → 3,7	3,8 → 3,0	3 → 2	1,6 → 1,1	1,2 → 1,0
Public Normal Chargers	0-30	30-50	n.a.	Ca. 0 → 1163	2297 → 7830	6858→12962	17558→18932
Public Fast Chargers	None	None	None	None	5 → 529	847 → 2950	5183 → 9478
Tesla Chargers (only for Tesla)	None	None	None	None	0 → 228	364 → 1085	484 → 4
BEVs/Fast Charger (incl. Tesla)	n.a.	n.a.	n.a.	n.a.	165 → 129	115 → 100	114 → 83
Geography fast chargers	n.a.	n.a.	n.a.	n.a.	Local/regional	South-Norway	All of Norway

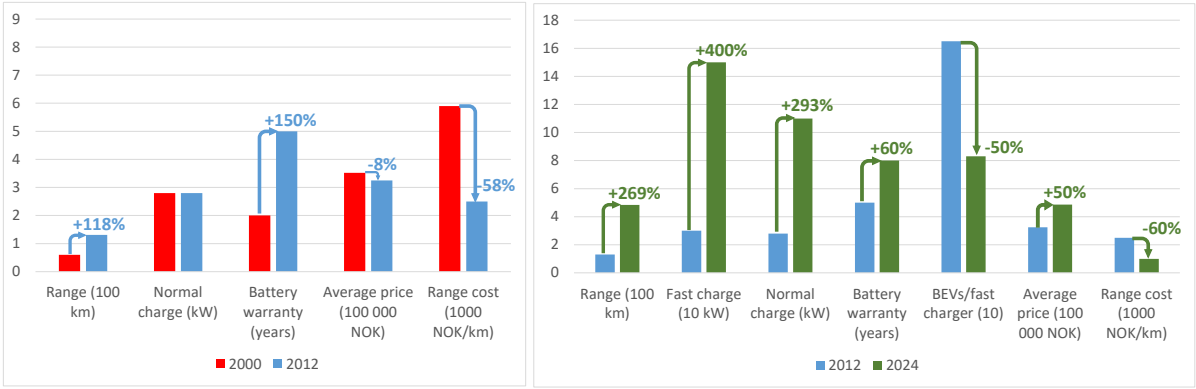

Figure 4. BEV and charging infrastructure improvements between 2000 and 2012 and 2012 and 2024 (scale is different)

Norwegian BEV buyers could clearly see the improvements in table 2 an figure 4 because BEVs were available in the market all the time from 1990. The post 2010 BEV models were compared with the old BEV models. Vehicle buyers in countries that were less involved in the early BEV development, and abandoned BEVs in 2002, saw little advantages with the 2011 OEM BEVs as their

point of reference was ICEVs.

3.4 Sales took off when the Total Cost of Ownership became favorable

Consumers are not buying more expensive BEVs instead of ICEVs due to altruistic motivation. If you want them to behave climate friendly you will need to make it rational for them in terms of economic or practical benefits. Norway combined the two into a large package of incentives ranging from exemptions from VAT and registration tax to free road tolls, free parking, and access to bus lanes not available to ICEV owners. Factoring in the economic benefits of these incentives, BEVs became more economic to own on a total cost of ownership from 2012, when the market accelerated [5], as seen in figure 5. The advantage in 2004 was due to the very low purchase price of almost new second hand imported BEVs from France that gave up on BEVs. The value of local incentives has played an important role in making BEVs attractive. Their value is based on self-reporting in national BEV user surveys [16,18,20,21,22]. In sum, BEV users have been over-compensated since 2012 [5], which de-risked BEV buying and increased diffusion to be able to reach the 2025 ZEV target.

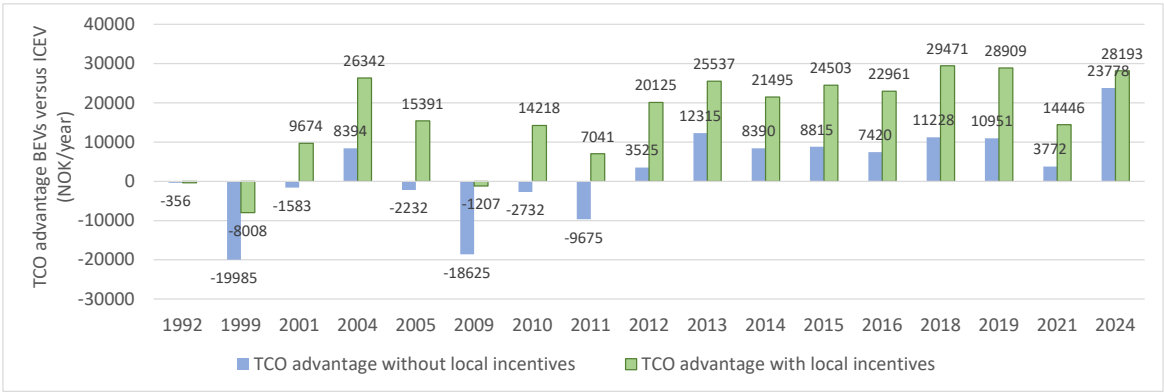

Figure 5 Total cost of ownership advantage BEV vs ICEV 1992-2024 with/without local incentives. Source: Adapted from [5]

3.5 User groups expanded and user perceptions and experiences improved over time

The 1990s users were fleets and a few enthusiasts [23]. Their user experiences were not positive [24]. When the bus lane opened, a new market among consumers started even if BEVs were still rather simple. BEVs could from then on provide a service inaccessible to ICEV owners. BEV owners could save substantial time using the bus lanes in the rush hour traffic, especially around Oslo. The market expanded from those benefitting the most from local incentives, especially Municipalities west of Oslo [21], to multi-vehicle households in general from 2011 [16,17]. They coped well with the limited range as they had an ICEV for long-distance driving and used the BEV as a local runabout to commute to work and escort children to activities. In total they drove locally annual distances equal to similar age ICEVs used more diversified [16,17]. The other vehicle in the household was used less locally than before. The biggest improvement was a close to 100% reliability of the

post 2010 OEM BEVs, although much of the positive user experience was linked to advantages from local incentives [16,17]. Tesla combined a large BEV with a large battery with a high-quality network of fast chargers and thus proved that long distance driving with BEVs was possible, but Tesla Model S and X were expensive vehicles. It was not until lower cost long range BEVs came on the market from 2017 that adoption among single vehicle households increased substantially in tandem with the nationwide build out of fast chargers between 2011 and 2020 that enabled long distance travel for all BEV owners. The fleet adoption of BEVs spread out from city areas having the best local incentives and the highest visibility of BEVs, to their surroundings and eventually across the country between 2012 and 2024, as seen in figure 6.

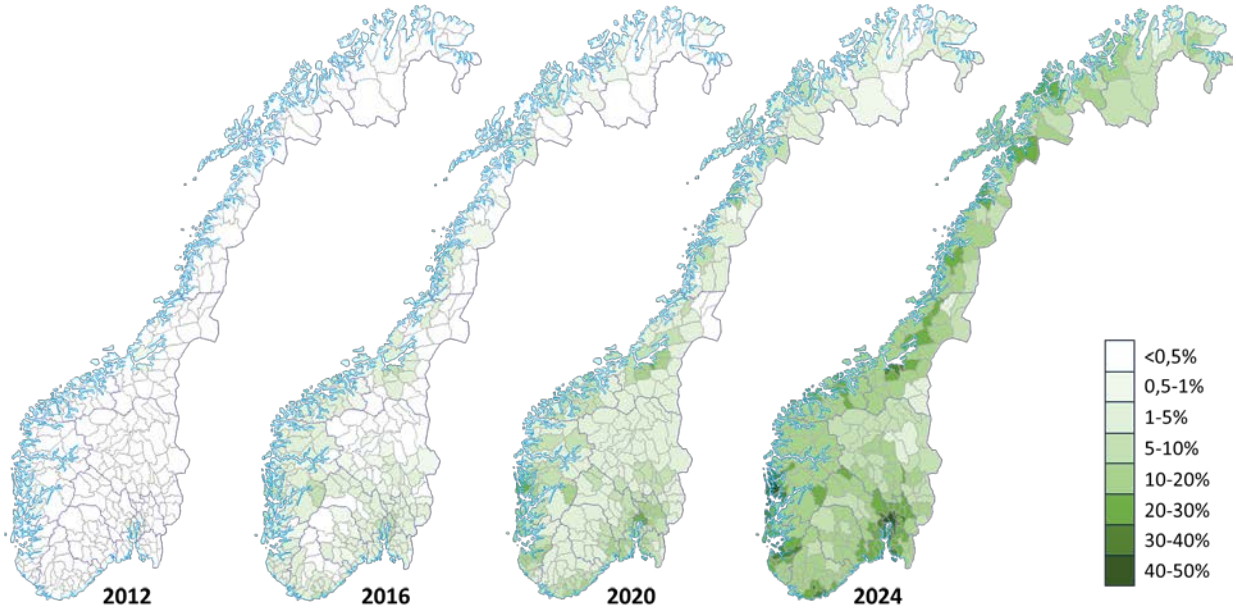

Figure 6. Diffusion of BEVs in the Norwegian fleet 2012-2024. Percent of total vehicle fleet. Source: SSB/Author

User experience became increasingly positive [19], apart from the charging experience of non-Tesla owners facing chaos of operators, charger designs, APPs, and payment methods [20]. Recent development points to an end to this chaos as the largest actors, barring one, now offer roaming. ICEV model availability has been drastically reduced by importers since 2022. Soon, laggards may not have a choice but to buy a BEV.

3.6 What happens when the end of the road is reached for ICEVs?

The most unique about Norway compared to other European countries is that BEVs market passed 90% in 2025 and the fleet share approached 30%. In 2025 the first Municipality, Bærum, passed 50% fleet share of BEVs [2], a global first. BEVs thus outnumbered the sum of all other vehicle types in the fleet. The traffic through Oslo's toll gates passed 45% in 2025 [25] and will likely pass 50% in 2026. In Norway, it is thus possible to study how actors adapt to very high BEV market shares and low ICEV shares and increasing BEV fleet shares, around 5-10 years ahead of other countries in Europe (and the world).

Actor adaptations to the BEV developments differ depending on where they are in the value chain. Actors involved in new vehicle sales have seen the ICEV sales vanish. They have mainly adapted by replacing ICEV sales with BEV sales as most OEMs also have included BEVs in their portfolio over time. The impact on importers and dealers has in general thus been limited. Those importers and dealers that did not have brands with BEVs in the portfolio have adapted by introducing Chinese BEV brands on the Norwegian market. The importer and dealer margins are similar for ICEVs and BEVs, and BEVs have, due to the incentives, been easy to sell [26]. The dealers have used a bit more time for the vehicle handover process and had to invest in knowledge of how to sell BEVs, and in charging infrastructure often including a fast charger [26]. Those servicing vehicles will be impacted by the gradual change of the fleet composition as BEVs require less service than ICEVs, having no oil to be changed, fewer moving parts, and less brake wear.

Actors providing fuel and services to ICEVs will see their market shrink steadily as the share of BEVs in the total fleet increases by 4-5% per year. As old ICEVs that are being used less than new vehicles are phased out by new BEVs being used more than an average vehicle, the share of replaced kilometers driven by BEVs will be 1-2% larger than the share of BEVs, i.e., the share of km driven by BEVs increases by 5-7% per year. The

latter effect will begin to taper off slowly when new BEVs start to replace old BEVs in the fleet. This effect is so far limited as the BEV fleet grew slowly until 2016. The majority of new BEVs will thus replace ICEVs at least until 2030. Fuel sales to ICEVs should thus shrink by about 5-7% each year towards 2030. The fuel station chains adapt by installing chargers. Some even position chargers in the prime location in front of the station and move the fuel pumps to the back. As the share of BEVs in the fleet increases it could result in a reduction in the number of fuel pumps and fuel stations. The first effect will be larger than the second, given that fuel stations become energy stations with chargers. Fuel pump access will likely remain in place for a long time along major roads as fuel stations are converted to energy stations. Cities are different. BEV chargers will have less advantages of being located at fuel stations so fuel can be more difficult to access locally within cities if there is no longer a business case for selling fossil fuels there.

3.7 Norway is 5-10 years ahead of other European countries

The only other countries that have managed to pass 50% market share that Norway did back in 2020, were Denmark in 2024 and Iceland in 2023. Iceland's market share contracted however substantially in 2024. All other countries lag the Norwegian BEV development by 5-10 years. The Nordic countries are together with the main BEV innovator Norway positioned as early adopting countries in Europe, as seen in figure 7, although their fleet shares are much lower than Norway's. The BENELUX countries can also be categorized as early adopters whereas the rest of Western Europe are followers due to weaker policies. The South and East of Europe, and the Baltics and Balkans, are all laggards apart from Portugal that is becoming more of an early adopter. The adoption rate differences are mainly explained by the lack of BEV policies in the laggard countries and less stable incentives in follower countries. The Nordics have advantage of strong grids, low-cost electricity, and a well-off population mainly living in small houses with easy access to low-cost home charging that are quick to take new technology into use. The latter is as seen by early mobile phone adoption rates [27].

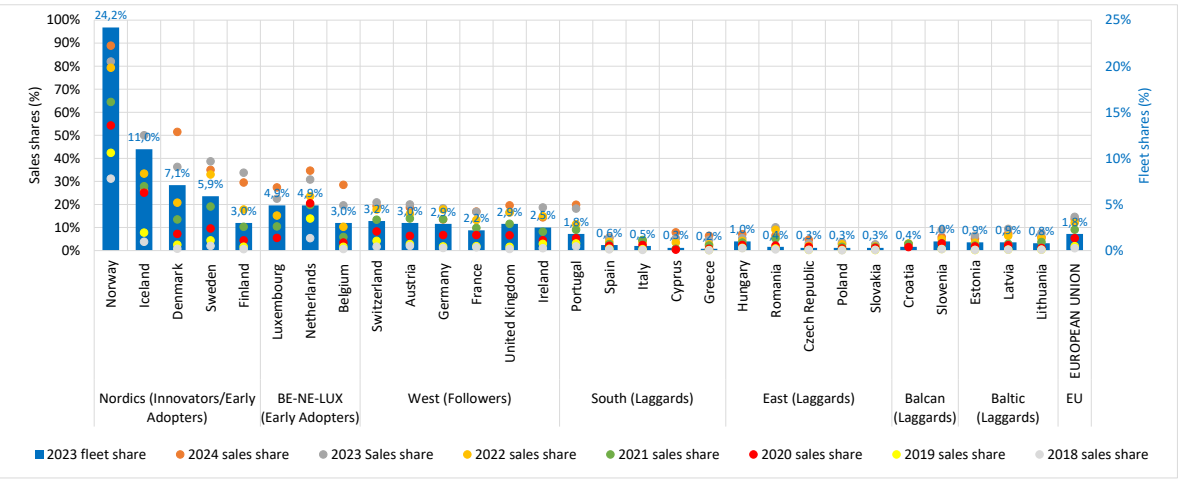

Figure 7 Sales shares 2023 (right axis), market shares 2018-2024 (left axis). Source: Acea.be

4 Discussion

Coming back to RQ1 *"How can the Norwegian Battery Electric Vehicle development be explained from different perspectives?"*, it is clear that there are several theories and framework that have been used to explain the development. Rational choice TCO perspective find that BEVs became more economically beneficial to buy, use, and own from 2012, but not why that happened. To explain how and why, the Multi-Level Perspective and the Technology Innovation System framework explores societal and innovation processes respectively. They can be used to find that the BEV innovation was tested in niche markets that politicians enabled with large incentives to support industrial development in Norway. This in turn allowed BEVs to take the step up and become a new technological and market regime when a window of opportunity arose when OEM BEVs came on the market, although the Norwegian BEV producers had by then gone bankrupt and could not take advantage of it. The developments post 2010 could however not have evolved as they did without the pre 2010 achievements with a full package of incentives being in place. The political priorities had by then shifted towards climate policy, which provided the necessary rationale for continuing to keep the BEV incentives intact. BEVs thus achieved dominating market share by 2020 as the technology improved. None of this would however have happened had not the landscape forces worked in tandem, i.e., the EU CO_2 regulations for new vehicles that forced OEMs to innovate in BEV technology and develop and sell BEVs, and the substantial

technical development of batteries that have enabled the development of a market for long range BEVs in all vehicle segment. These developments worked in tandem with the Norwegian BEV incentives and enabled the rapid BEV diffusion in multi-vehicle households from 2011 followed by single vehicle households from 2017.

Coming back to RQ2, *"What makes Norway different from other countries in how the BEV development has progressed?"*, Norway stands out among other countries in several ways. Norway have no ICEV industry. The electricity is 100% clean with 95% hydro-electric power and the remaining 5% wind-power. This situation has given BEVs a cleaner image than in countries using fossil energy carriers in their electricity production mix. The Norwegian grid is strong as most households use electricity for heating and have a large enough power connection with the grid to easily facilitate home charging access and low-cost electricity charging. Charging was not a barrier. It was first done using existing outdoor sockets available outside most buildings. Wallboxes with power levels between 4,6 and up to 22 kW are now installed in Norwegian garages and used for home-charging. Norway introduced earlier than other countries support programs and law changes to enable charging for flat owners and those relying on on-street charging in cities. Fast charger deployment started early with public support available between 2011 and 2021. A network of fast chargers covers all of Norway and enable long distance driving. The fleet is large enough for commercial actors to build out fast chargers without support.

The Norwegian innovation in BEV industry development up to 2010 built up the large package of incentives and Europe's largest BEV fleet, albeit still small, both of which gave Norway a head-start compared with other countries when OEM BEVs became available from 2011. The stable policy has continued since 2011 in-spite of increasing tax losses as the policy motivation shifted from supporting industrialization to support increasingly ambitious climate policy targets for 2020 and 2030. Other countries with vehicle production must take account of how policies impact the vehicle industry and have less economic leeway to provide large incentives than Norway which balances the national budget deficits with the large income from the oil sector. The result has been weaker incentives and much more policy wiggling in most European countries. Norway's incentives have also been on the income side of the national budget through tax exemptions/reductions whereas most other countries have used purchase subsidies from the budget expense side in competition with other good purposes. These issues make it more demanding to build up a stable market. Unstable policies influence user perceptions of BEVs negatively, but also market actor willingness to pursue BEVs. Bonus malus systems can be cost neutral to national budgets and thus emulate Norway's tax exemption in a more direct way, and are in some countries comparable in value to the Norwegian VAT exemption. The value of the Norwegian registration tax exemption is about as high as the VAT exemption and Norway's incentives have thus been at least twice as high as that of other countries. Tax reductions are less visible than purchase subsidies financed over the national budget and thus more stable. Subsidies could be used up early in the year, leading to a lack of incentives the rest of the year, and variability between years and government periods. The EU CO_2 regulations will push automakers to industrialize and sell BEVs on a large scale regardless of national policies.

Free road tolls are a cross subsidy between ICEV owners paying road tolls at higher rates or over longer time periods (to pay back the loan of the toll road project) to finance BEV owners' exemption or reduced rates. Bus lane access for BEV owners was a case of utilizing spare bus lane capacity and had thus no cost until buses started to get delayed and BEVs access had to be reduced. The policy and incentives have met little resistance as Norway has no ICEV industry lobby. The overall result was that the incentives could stay in place over time but can now likely be downscaled gradually without damaging the market too much [28]. Road tolls are common in other countries and a rate differentiation like Norway could be possible. The same goes for parking.

5 Conclusion

This paper demonstrate that the Norwegian BEV development can be understood as a 35 year long interactive process of innovation, consumer needs and experiences, costs, technical development of BEVs and batteries, and policies and incentives. Norway had specific national conditions that led to higher BEV sales than other countries from 2011, such as clean electricity, good access to low-cost home charging, a large package of incentives that made BEVs affordable to all new vehicle buyers, a head start from the existing pool of BEV owners that was larger than in all other European countries, and the high visibility of BEVs up to 2010 due to the Norwegian BEV industrialization activity, access to bus lanes and BEV specific number plates.

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