Driving the Future

A Comparative Analysis of Electric Vehicle Trends in Norway and Spain

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***Abstract*—This paper compares the Electric Vehicle (EV) situations in Spain and Norway by looking at policy frameworks, infrastructural growth, adoption rates, financial incentives, and environmental effects. In contrast to Spain, which has suffered due to limited charging infrastructure, and a complex regulatory environment, Norway has been successful due to strong government support, financial incentives, and well-developed charging infrastructure. The carbon footprint of EVs is smaller in Norway thanks to the country's emphasis on renewable energy sources, whereas Spain is having trouble making the switch to clean energy. The comparison allows us to draw some conclusions. It also emphasizes the significance of a favorable policy environment, financial incentives, and a reliable charging infrastructure in promoting EV adoption. The paper suggests creating a national plan for Electric Vehicles (EVs) in Spain, increasing the availability of charging stations in urban and rural regions, and encouraging collaborations between the public, private entities, and utility companies. Norway should prioritize assuring the accessibility of charging infrastructure in rural locations, encouraging the use of second-life batteries, and resolving issues with electricity demand. By sharing experiences and adopting the necessary measures, both nations may hasten the transition to sustainable transportation.**

Keywords-electric vehicles; charging infrastructure; adoption; incentives.

I. INTRODUCTION

Norway has the highest adoption rate of Electric Vehicles (EVs) per capita worldwide [1]. Spain has recently launched several initiatives to promote electric car adoption [2]. In this paper, we compare the adoption of EVs in Norway with the adoption in Spain. Spain is adopting some of the incentives shown to be effective in Norway. At the same time, Norway is removing some of its incentives due to the high adoption rate of EVs.

An EV is a vehicle that utilizes one or more electric motors for propulsion. It can run autonomously using a battery that can be charged using various techniques, including solar panels, fuel cells, or generators, or it can receive power from an external source through a collector system.

Battery Electric Vehicles (BEVs) are powered entirely by electricity. A BEV has no Internal Combustion Engine (ICE), fuel tank, or exhaust pipe. Instead, it has one or more electric motors powered by a large battery, which must be charged through an external outlet. Due to their lack of exhaust emissions, BEVs are regarded as the most ecologically beneficial form of electric car. However, they have a constrained driving range because the battery must be recharged. Several general advantages apply to EVs:

- Environmental benefits: EVs do not contribute to air pollution or the release of greenhouse gases because they do not have tailpipe emissions. Even when fossil fuels are required to produce the energy needed to power the EV, it still produces less pollution than a conventional gas-powered vehicle [3].
- Lower operation costs: EVs require less maintenance since they have fewer moving parts than gasoline or diesel vehicles and are generally less expensive than those fuels. Electric motors frequently have longer lifespans due to their superior durability to internal combustion engines [4].
- Efficiency: The power plant's efficiency will impact the well-to-wheel (WTW) efficacy. The overall WTW productivity of gasoline vehicles ranges from 12% to 28%, whereas that of diesel cars ranges from 26% to 38%. In contrast, EVs driven by natural gas-powered plants vary in WTW efficiency from 14% to 30%, while EVs powered by renewable energy sources exhibit up to 70% total efficiency [5].
- Energy independence: EVs might be powered by renewable energy sources like solar or wind energy. This reduces dependency on fossil fuels and could improve energy consumption sustainability [5].

The EV market differs from the typical Internal Combustion Engine (ICE) industry in many respects, which makes expanding EV service operations more challenging. Problems like the charging infrastructure make the EV market less convenient and less accessible than traditional gas stations, which presents difficulties for EV drivers, particularly when traveling large distances or in rural locations. Variations in charging interface standards and battery recharging rates make infrastructure development more difficult. Also, the related public policies, since the EV industry is still in its infancy, and public sector policies play a crucial role in encouraging EV adoption. Different taxation, carbon emissions, infrastructure for public

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charging, incentive, and support for research and development policies are implemented by governments: EV-specific market dynamics and uncertainty present decision-making issues. Business strategies are a challenge too. Innovative ownership models, such as battery swapping and EV sharing, aim to address range anxiety and high upfront costs. These models have been implemented in various cities, providing cost-effective access to EVs. A thorough examination of the business models is necessary for their successful implementation.

The following section defines provides an overview of policies and regulations on EVs in Europe. Sections III and IV discuss electric vehicles in Norway and Spain, respectively. Section V compares the findings from the two countries, while Section VI concludes the paper.

II. Policies and Regulations on EVs in Europe

The European Commission (EC) has proposed cutting emissions by at least 55% by 2030, with plans to increase the current 1.4 million EVs to 30 million by 2030 through regulations, targets, and initiatives such as encouraging low-emission vehicle production and developing charging infrastructure. The EU's EUR 750 billion stimulus package includes 20 billion euros for clean vehicle sales and plans for 1 million charging stations by 2025. This reflects the EU's commitment to promoting electric mobility and transitioning to sustainable transportation [6].

The European Union (EU) policy highlights the importance of renewable energy and smart grids for energy system decarbonization. A vital element of this policy is the Renovation Wave strategy, which focuses on integrating various sectors instead of treating them separately, enhancing the efficiency of future electrification projects.

The EU recognizes that transportation contributes to almost a quarter of Europe's greenhouse gas emissions. Thus, promoting electric mobility (E-mobility) is crucial in achieving climate objectives. Therefore, efforts are underway to align the expansion of charging infrastructure with these targets.

In her State of the Union speech, EC President Ursula Von der Leyen emphasized this need for integration and expansion, where she proposed investing one million electric charging points as part of the Next Generation EU initiative [6]. This policy indicates the EU's holistic and integrative approach to decarbonization and sustainable energy use. Some examples of recent and upcoming legislation in the EU are:

Energy Efficiency Directive (EED): By 2030, the EED [7] aims to reduce the EU's overall energy consumption by at least 32.5% through energy efficiency advancements. This includes the transition to cleaner EVs and the enhancement of the efficiency of existing ones. Member states have introduced emission targets and awards to expedite the shift to e-mobility. All member states are encouraged to adopt ambitious transportation measures aligned with the EU's 2030 energy efficiency target.

EU Taxonomies: This classification scheme lists economically viable and ecologically sustainable activities vital to implement the European Green Deal and scaling sustainable investments. It mandates businesses seeking financing to document their emissions management [8].

The Energy Performance of Buildings Directive (EPBD): EPBD [9] necessitates installing charging stations or ducting infrastructure in new or significantly renovated buildings. It also suggests that charging stations should be "smart," i.e., responsive to grid signals, offering long-term economic benefits for consumers and property owners.

Electricity Directive (ED): ED, amended in 2022, [10] encourages member states to use smart metering technologies for power utilization and smart charging systems to ensure consumers can use, produce, store, and sell energy without extra charges, aiding in grid stability and flexibility.

A strong message is being sent to the real estate industry by the Clean Energy Package and other approaching EU regulations: electric vehicle charging is a solution that addresses several issues at once. Aside from complying with legal standards, real estate companies must also meet the enormous demand for EV charging services among tenants and consumers. M. Kumpula-Natri, a Finnish member of the European Parliament, recently expressed [11]:

"*I think that now there is momentum to create a comprehensive and smart EV charging infrastructure with these many legislative proposals. I just introduced to you, that will be based, as much as possible, on renewables, clean energy and supports the demand response of the smart grids. So, we need smart systems and digital solutions to cut emissions and now the opportunities are great – there is finance, there is political will. Now we need everyone on board to make this happen*."

III. Electric Vehicles in Norway

A. History and development

In 2016 the number of EVs reached 100,000. In 2017 the Norwegian Parliament decided on a national goal that all new cars sold by 2025 should be zero-emission. In 2022 the number of pure EVs reached 500,000. Norway has the highest adoption rate per capita worldwide [12].

B. Charging infrastructure

In Norway, the number of electric car charging stations has increased in recent years, reaching just under 19,300 for roughly 647,000 electric and plug-in hybrid cars registered as of 2021. The Type 2 or standard charger has been the most popular in the country. In 2021, there were about 12,900 of this charging type in the country. In comparison, the number of Tesla Superchargers amounted to 1,200 that year. The Supercharger was introduced by Tesla to make fast-charging cars accessible exclusively to their models, such as Tesla Model S and Tesla Model X. Both were among the best-selling EV models in Norway [13].

The "charging right" for residents of apartment buildings was established by a parliamentary act in 2015. Still, EV owners believe it is crucial to have the option to fast charge when necessary, even if they charge at home and seldom need the fast charge alternative.

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A well-planned charging network must be in place for more extended travels. In Norway, fast charging stations have been successfully installed on all major routes. By the end of 2022, they were trying to have more than 5,600 cars that can fast charge simultaneously. Customers are willing to pay more for the rapid charging service. On average, they spend three times as much on power than they do at home. Figure 1 shows the deployment of public EV charging stations by type from 2011 to 2021 [13]. According to nobil.no, the current number of public charging stations is 26,258 [14].

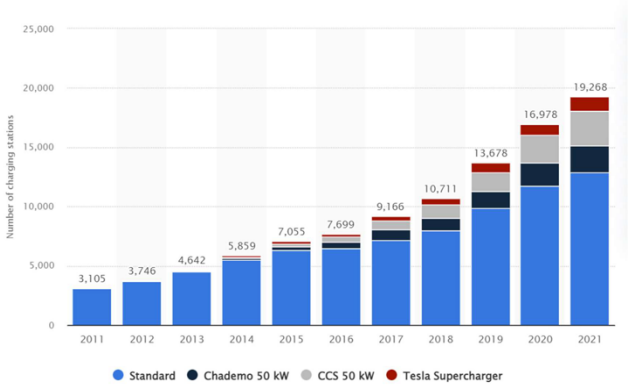

Figure 1. Deployment of public EV charging stations (Norway).

C. Energy and fuel price

Norway's average wholesale electricity price dropped to 83 euros per megawatt-hour in March 2023, a 60% decrease from December 2022's record high of over EUR 246. The surge in 2021 and 2022 prices was due to factors like widespread electric heating, irregular rainfall affecting power plant production, new cable connections with the UK and Germany, and the EU market's relationship with fluctuating natural gas prices.

Despite Norway's high cost of living, electricity was an exception until recent years. Peak demand times occur around 6:00 and 14:00, particularly in cold weather due to reliance on electric heating. Lower rainfall in the south in 2022 affected power plant profits, while the operation of two new international cables in 2021 contributed 10-25% to the price hike. The EU's advanced bidding system and rising natural gas prices, influenced by COVID-19 and the Ukraine war, also increased electricity prices [15].

As shown in Figure 2, fuel prices increased in 2022 due to the Russian invasion of Ukraine and a hike in Norway's CO_2 taxes on fossil fuels [16]. In April 2023, gasoline and diesel prices stood at EUR 1.90/L and EUR 1.73/L, respectively. Despite these increases, EV sales have risen rapidly, with over 800,000 units sold by the end of 2022.

D. Sales and adoption of EVs

"*Eight out of ten people choosing fully electric instead of combustion engines is a considerable step towards Norway reaching its climate goal of 100% BEV sales in 2025. This proves beyond doubt that affordable BEVs are the number one choice for new car owners*", said Christina Bu, Secretary General of The Norwegian EV Association. One-fifth of the Norwegian population has EVs.

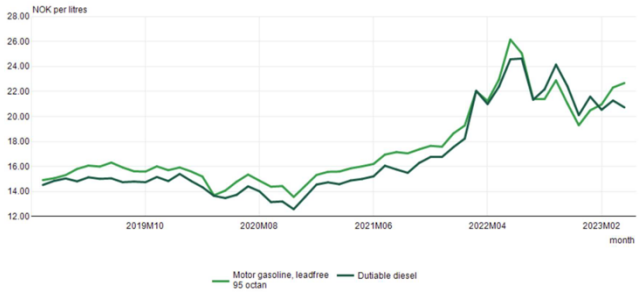

Figure 2. Gasoline and diesel prices through the last years (Norway).

"*Our message to the rest of the world is crystal clear: Now there is no excuse for the internal combustion engines' unnecessary pollution when the climate crisis is so urgent to solve*," she said in a statement [17].

Table I shows the number of registered vehicles by energy sources in 2020 [18].

TABLE I. REGISTERED VEHICLES 2022

	Petrol	Diesel	Electricity	Gas	Petrol hybrid	Diesel hybrid
Cars	822,133	1,135,538	599,169	195	333,765	14,975
Buses	153	12,771	840	755	0	165
Vans	18,931	466,490	21,657	457	591	535
Lorries	1,962	65,056	455	813	0	11
Total	843,179	1,679,855	622,121	2,220	334,356	15,686

E. Government incentives and support programs

The high adoption rate results from a comprehensive set of incentives encouraging the market adoption of zero-emission automobiles. Since the early 1990s, the incentives have been steadily added to speed up the transition by several governments and large coalitions of parties.

All new cars sold in Norway must be zero-emission (electric or hydrogen-powered) by 2025, according to a national target established by the Norwegian Parliament. More than 20% of Norway's registered cars by the end of 2022 were Battery Electric Vehicles (BEVs). In 2022, BEVs held a 79.2% market share. Policy tools and various incentives are crucial in determining how quickly the transformation occurred.

Weight, CO_2, and NOx emissions are combined to determine the purchase tax for all new cars with emissions. Since the tax is progressive, big vehicles with significant emissions are expensive. The purchase tax has steadily changed over the last few years to place more emphasis on emissions and less on weight.

EVs have long been excluded from VAT and Norway's high new-car purchase tax. But Norway will begin charging a 25 percent VAT on purchases costing NOK 500,000 or more in 2023. A new weight tax will also be in effect for all EVs.

"*We are unable to predict how these additional EV taxes would impact EV sales*," adds Christina Bu. She argues that the Norwegian government has to be reminded of the

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importance of these incentives if they are to succeed and continue to demonstrate to the rest of the globe that a cold environment and inaccessible infrastructure are not reasons to switch to 100% electric transportation [17].

The following list shows incentives offered to Norwegian EV owners [12]:

- No purchase or import tax on EVs until 2022, with a new purchase tax based on weight for new EVs starting in 2023.
- Exemption from 25% Value-Added Tax (VAT) on EV purchases until 2022, but from 2023, a 25% VAT will apply for the amount exceeding NOK 500,000.
- No annual road tax until 2021, but reduced tax rates were introduced from 2021 onwards, and full tax is in effect from 2022.
- EVs were previously exempt from toll road charges until 2017, and from 2018 to 2022, a maximum of 50% of the total toll amount was charged for EVs. This increased to 70% from 2023.
- Similarly, EVs enjoyed no charges on ferries until 2017, and from 2018, a maximum of 50% of the total ferry fare was charged for EVs.
- Free municipal parking was provided for EVs until 2017.
- EVs had access to bus lanes since 2005, although new rules implemented in 2016 allow local authorities to restrict access to EVs carrying one or more passengers.
- Various reductions in company car tax have been in place, such as a 25% reduction until 2008, a 50% reduction until 2017, a 40% reduction from 2018 to 2021, and a 20% reduction from 2022 onwards.
- Leased EVs have been exempted from 25% VAT on leasing payments since 2015.

The Norwegian Parliament set a national goal in 2017 for all new cars sold by 2025 to be zero-emission (electric or hydrogen).

"Charging rights" were established in 2017 to ensure access to charging infrastructure for residents in apartment buildings.

Public procurement rules require Zero-Emission Vehicles (ZEVs) for cars starting in 2022 and city buses starting in 2025.

IV. ELECTRIC VEHICLES IN SPAIN

A. *Charging infrastructure*

One of their biggest drawbacks is the need for more driving range in EVs compared to internal combustion vehicles. EVs can only become a substantial part of the market if their use aligns with people's normal movement patterns. For a vehicle to cover at least 80% of the daily driving profiles of regular customers in various countries, a range of roughly 50–60 km is required, which led to a battery's nominal size of 16 kWh. Therefore, the driving distance should be within the battery's operating range, or parking arrangements should permit recharging. Regarding the average daily driving distance in Europe, three groups of nations can be distinguished [19]: the first group includes countries that are over 70 km or even 80 km (Poland and Spain), the second includes nations that are around 40 km (UK), and the third includes countries that are between 50 and 60 km (Example: France, Germany, and Italy). In this regard, if current driving habits are maintained, Spain has better prospects for EVs in urban areas.

Looking through the last few years, we can see the evolution of Spain's charging infrastructure.

Starting with the charging points of public access in 2021, this year, 4,866 points were installed, a growth four times less than necessary to keep pace with market growth. Additionally, this growth occurs at power levels associated with slow charging, with a maximum power of 22 kW. Just 12% of the charging infrastructure for public access in Spain corresponds to loads with power greater than 22 kW [20].

Of the total points installed in 2021, 2,234 were in urban areas, which makes a total of 7,685 points in this type of area. On the other hand, 2,632 points were in interurban regions, leaving a total of 5,726 points. Table II shows the 2021 distribution of charging points based on region and charging capacity [20].

TABLE II. SPANISH PUBLIC CHARGING POINTS (2021)

Region	P < 22 [kW]	22 < P < 50 [kW]	50 < P < 150 [kW]	150 < P < 250 [kW]	P < 250 [kW]	Total
Andalucía	1,194	32	89	2	10	1.327
Aragón	337	11	33	2	6	389
Asturias	191	22	24	0	2	239
Balears, Illes	862	9	15	0	2	888
Canarias	691	14	23	0	0	728
Cantabria	131	7	12	0	0	150
Castilla y León	573	52	102	2	8	737
Castilla-La Mancha	212	28	50	1	4	295
Cataluña	3,190	110	234	1	14	3,549
Ceuta	6	0	0	0	0	6
Comunitat Valenciana	1,435	79	135	6	6	1,661
Extremadura	146	33	23	2	2	206
Galicia	398	20	28	0	8	454
Madrid, Comunidad de	1,427	65	92	1	16	1,601
Melilla	9	0	0	0	0	9
Murcia, Region de	284	19	31	0	4	338
Navarra, Comunidad Foral de	171	12	31	0	4	218
Pais Vasco	488	12	41	0	6	547
Rioja, La	60	3	6	0	0	69
Total	11,805	528	969	17	92	13,411

84% of the intercity charging points have powers less than 22 kW, which means long recharge times and a very important barrier for the consumer. Long-distance charging should focus on high powers as recharging points below 22

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kW are unacceptable in intercity routes since using these points assumes a minimum recharge time of 3 hours.

The recharge points of 250 kW (less than 15 min) were almost doubled throughout the year, going from 50 to 92. These figures are far from the forecasts, which they were aiming for approximately 150 points to yearend. The 92 existing public access charging points are 350 kW and 400 kW spread over 33 stations. Canary Islands, Cantabria, La Rioja, Ceuta, and Melilla don't have any charging point high power public access. 95% of public access charging points high power responds to projects of automobile manufacturers. The administrative difficulties associated with the development of these projects are one of the major barriers. Because of this, many projects have stopped.

Moving forward with this study of the evolution of the charging infrastructure, in the last quarter of 2022, it increased by 1,563 recharging points (the pace of deployment continues to be lower than desired).

Eight hundred ninety-three charging points have a power of up to 22 kW. In other words, 79% of the points of public access recharge are low power (up to 22 kW). This makes 14 387 low power points (recharge time 19 - 3 hours). Long-distance charging must focus on high power since 72% of the intercity points have power up to 22 kW.

Only 52 load points between 22 and 50 kW have been installed. This leaves 823 points with this power (recharge time 3 - 1:20 hours).

And in the last quarter of 2022, 400 recharge points between 50 kW and 150 kW of power compared to the 177 installed in the third quarter (recharge time 27 - 40 min). This number represents 25% of the growth of the quarter. This makes a total of 2,220 points. Finally, between 150 kW and 250 kW, there are 227 points (recharge time 15- 27 min), 442 in total [20].

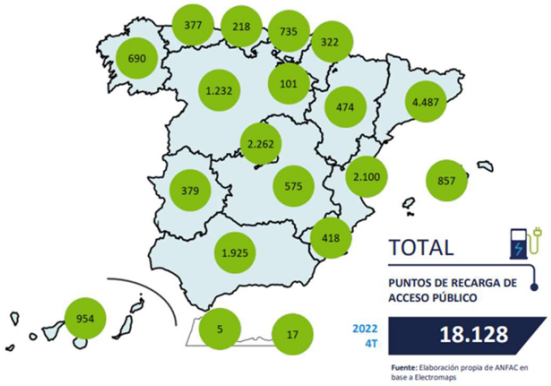

Figure 3. Charging points for each region (Spain).

The deployment of this type of infrastructure high power, which allows recharges like the refueling experience of an internal combustion vehicle, is essential for the proper growth of the electrified vehicle, even more considering that current technology of light-duty vehicles batteries already presented with power load exceeding 100 kW and shall rapidly increasing with the introduction of new models. It is also necessary for mobility associated with heavy vehicles that are from load powers of 150 kW already at present.

Figure 3 shows the number of public charging points for each region in 2022 [21].

B. *Energy and fuel price*

Currently, at EUR 70-80/MWh, energy prices are rising rapidly due to increasing gas prices, low renewable energy use, higher energy demand, and CO_2 emission costs. Gas price hikes, especially caused by the instability in Ukraine and Russia, directly impact electricity costs. Spain's heavy reliance on imported energy and the resurging global economy has exacerbated this issue, escalating gas prices from EUR 10/MWh in 2020 to over EUR 100/MWh in 2022. Additionally, the EU's measures to reduce CO_2 emissions are increasing consumer electricity bills. Figure 4 shows the increase in Spanish average energy prices since 1998 [22].

Energy peaks occur around 8:00 and 22:00, aligning with the highest demand periods. Currently, gasoline and diesel prices in Spain are EUR 1,637 and 1,611, respectively, influenced primarily by oil costs and taxes. Figure 5 shows the daily energy demand in Spain [23].

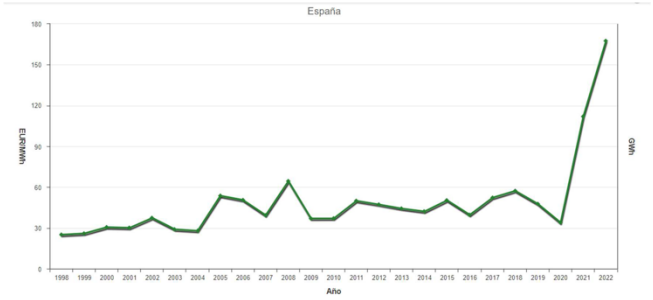

Figure 4. Average energy price since 1998 (Spain).

Factors impacting oil prices include OPEC's production limits, Russia's role in energy exports, and the conflict with Ukraine. Taxes account for 50% of the fuel price, with fixed logistics and distribution costs making up another 12%.

Despite a 17.1% growth in the EV market in 2022, the total sales volume remains low at 9.63% of the general market, indicating the need for urgent measures to promote renewable energy adoption and emission reduction targets.

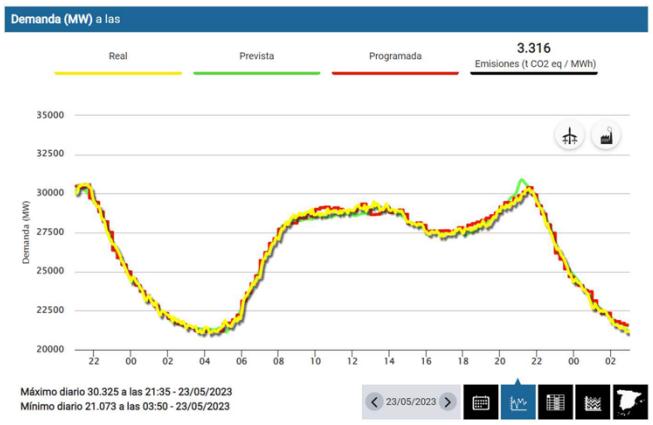

Figure 5. Daily energy demand (Spain).

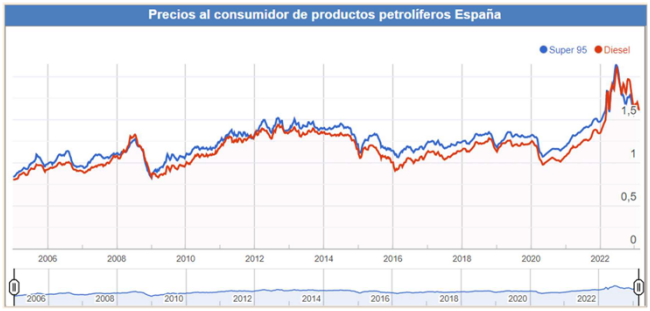

Figure 6. Consumer prices of petroleum products (Spain).

The current price of gasoline (blue line) is EUR 1.637, and diesel (red line) is EUR 1.611, with the corresponding taxes added. If we look at their evolution over the years, in Figure 6, we see how they have also been increasing [24].

C. Sales and adoption of EVs

Table III shows the numbers of registered vehicles by energy sources at the end of 2021 and 2022 [25]. While the total registrations in December 2022 decreased slightly compared to the previous year, the overall registrations from January to December 2022 increased. Gasoline vehicles had the highest number of registrations in 2022 (346281 registrations), followed by diesel vehicles. However, electric vehicles (EVs) showed a significant increase in registrations, indicating a growing interest in sustainable transportation options. Within the EV category, Battery and Extended-Range Electric Vehicles (BEV and E-REV) and Plug-in Hybrid Electric Vehicles (PHEV) experienced an increase. Hybrid vehicles remained popular, with Hybrid Electric Vehicles (HEVs) dominating the category (with 243,267 registrations). Hydrogen vehicles had minimal representation. These trends suggest a shift towards cleaner and more sustainable mobility choices, with EVs gaining traction in the market, going from being 30.17% of the market to 35.84% [25].

TABLE III. REGISTERED VEHICLES BY ENERGY SOURCES

	December				From January to December			
	2022		2021		2022		2021	
	Total	%	Total	%	Total	%	Total	%
Total	88,591	100.00	98,901	100.00	962,020	100.00	1,037,255	100.00
Gasoline	29,854	33.70	33,345	33.72	346,281	36.00	392,076	37.80
Diesel	25,191	28.44	29,258	29.58	270,915	28.16	332.245	32.03
Hydrogen	1	0.00	2	0.00	11	0.00	11	0,00
EVs Total	33.545	37.86	36,296	36.70	344,813	35.84	312,923	30.17
BEV + E-REV	4,140	4.67	4,203	4.25	36,452	3.79	27,767	2.68
PHEV	4,641	5.24	4,833	4.89	48,193	5.01	43,311	4.18
Gas Hybrid	2,058	2.32	2,067	2.09	16,901	1.76	18,459	1.78
HEV	22,706	25.63	25,193	25.47	243,267	25.29	223,386	21.54

D. Government incentives and support programs

Boosting EVs is essential for achieving zero-emission mobility by 2050. To this end, the Spanish Government has created a series of incentives that make purchasing EVs and installing charging points more feasible. Currently, incentives for electric mobility in Spain are included in Moves II Plan and Moves III Plan.

The Moves II Plan was introduced in June 2020, and in March 2021, 20 million euros were added as several communities distributed all their aid. This program currently coexists with the Moves III Plan, which was introduced in April 2021 as an improved continuation of the previous one. The Moves III Plan will last until 2023 and aims to improve support for charging infrastructure for individuals and small and medium-sized enterprises, as well as for fast and ultra-fast charging infrastructure.

1) Moves II

The program Moves II provides a set of incentives to promote EV adoption [26]. They depend on the engine and vehicle category, from EUR 600 for light electric quads to EUR 15,000 for purchasing trucks and electric buses. Aid for the purchase of EVs can reach, depending on the type of beneficiary, up to EUR 5,500 with scrapping, and in the case of commercial vehicles, up to 3,500 kg, up to EUR 6,000, also with scrapping.

In the case of purchasing passenger cars for disabled people with reduced mobility, the amount of aid shall be increased by EUR 750, provided that the adaptation is indicated on the technical data sheet of the vehicle purchased.

Regarding e-bike loan systems, the aid will be around 30% of the eligible cost, with a ceiling of EUR 100,000.

For the establishment of measures of Transport Plans to Workplaces and of measures to be carried out by Municipalities in urban centers to adapt mobility in a scenario of new demands arising from the post-COVID-19 period, the aid will be 40% or 50% of the eligible cost, depending on the type of beneficiary, with a ceiling of EUR 500,000.

2) Moves III

The program Moves III provides a new set of incentives [27]. For individuals, self-employed or administration, in the case of commercial up to 3,500 kg, this aid can reach up to EUR 7,000 (EUR 9,000 with scrapping) and up to EUR 4,500 (EUR 7,000 with chargeable) in the case of passenger cars.

The above aid amounts may be increased by 10% (not cumulative) in the following cases:

- Purchases of passenger cars by recipients who are disabled persons with reduced mobility. Also, in the case of the acquisition of light commercial vehicles by self-employed persons with disabilities with reduced mobility.
- Vehicle purchases by persons registered in municipalities of less than 5,000 inhabitants (registration must be maintained at least two years from the date of registration of the application).

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- Purchases of passenger cars by persons with economic activity (self-employed) intended for the use of taxis and services of transport vehicles with driver.

The amount of aid in the charging infrastructure for EVs may be up to the following percentage of the eligible cost:

- Up to 70% for self-employed individuals, communities of owners, and administration without economic activity (in the case of Municipalities <5,000 inhabitants, it will be 80%).
- Companies and public entities with economic activity (public access recharge P ≥ 50kW): up to 35% (45% for medium-sized enterprises or 55% for small businesses). But in the case of municipalities with less than 5,000 inhabitants, it will be up to 40% (50% for medium-sized enterprises or 60% for small businesses).
- Companies and public entities with economic activity (public access recharge P<50kW): up to 30% (in case of Municipalities <5,000 inhabitants, it will be up to 40%).

The five main differences between the two programs are:

- Maximum help: The Moves III Plan offers a higher maximum help than the Moves II Plan.
- Support for recharging infrastructure: The Moves II Plan offers 30 to 40% (up to a maximum of EUR 100,000) of the cost of purchasing and installing public and private chargers, while the Moves III Plan offers up to 80%.
- 10% extra in three incentives: Unlike the Moves II Plan, the Moves III Plan offers 10% more aid for people with disabilities, self-employed using EVs as work tools, and holders registered in municipalities with less than 5,000 inhabitants.
- List of eligible vehicles: The Moves III Plan does not offer aid for electric trucks, buses, or gas vehicles.
- Vehicle purchase date: The Moves III Plan focuses on acquisitions made as of 9 April 2021. Therefore, vehicles purchased before this date can only apply to Moves II aids.

E. Challenges and obstacles

The Spanish Association of Automobile and Truck Manufacturers (ANFAC) proposes the three challenges that must be faced immediately to make the mobility ecosystem's development possible [2].

1) Decarbonization and air quality

Environmental concerns and stringent EU regulations on vehicle emissions drive manufacturers to reduce emissions. They've made significant technical advancements, reducing NOx and particle emissions by 85% and 90%, respectively, over 15 years, and aim for future vehicles to be carbon neutral.

However, 80% of global emissions come from older vehicles, with the average vehicle age in 2018 being 12.4 years, among the oldest in Western Europe. Regulations at various levels could promote fleet renewal, contributing to environmental goals.

2) Deployment of infrastructure

Implementing future vehicle infrastructure requires a focus on four areas:

- Traffic management infrastructure: Incorporating smart signage, intelligent traffic systems, and 5G networks for autonomous vehicles.
- Daily network infrastructure: Expanding the charging grid and redefining service stations due to longer recharge times.
- Smart materials: Incorporating self-control, interactive features in roads and bridges, and photosensitive paint in pavements.
- Fleet management: Modifying current parking infrastructure and dealership business models.

3) Intelligent regulation

Intelligent regulation must address mobility needs, ensure progress, propose a realistic timeline for transformation, and attract automotive sector investment. This requires legal certainty, investor and user confidence, and support for the sector committed to new mobility, thus creating a conducive framework for vehicle production and market strengthening.

F. Roadmap for 2040

To continue playing a relevant role in the international context, a framework that helps the industry to enhance its strengths and to devise appropriate strategies to overcome the challenges looming on the horizon is essential.

This scheme [2] is presented in four temporary moments to advance in an orderly transition to respond to the need to rationalize efforts, resources, and capacities of the industry that will allow maintaining the competitive position of Spain. The Administration, at all levels, must accompany the industry to make this path possible, and there will be six pillars that must generate the necessary ecosystem for its development focus:

1) industry and companies,
2) the environment and energy,
3) mobility,
4) people,
5) the vehicle and
6) public-private collaboration.

Figure 7 elaborates on the details of the roadmap. As it shows us, the action plan for the EV market in Spain from 2020 to 2040 aims to unify the messages of all sectors and stakeholders involved, establish a stable regulatory framework, and optimize existing assets. By 2025, the objective is to attract investments, increase productivity, and encourage innovation-related activities, particularly in low-emission and alternative vehicles. By 2030, the goal is to align the production mix with demand, adopt new business models, and occupy distinct market niches. By 2040, the

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plan aims to fully deploy the Spanish mobility ecosystem, digitalize production and sales processes, become information managers, and capture value within the mobility ecosystem.

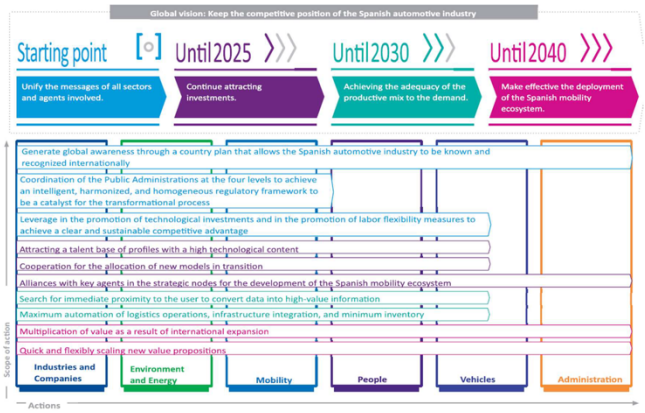

Figure 7. Plan 2020-40 scheme by ANFAC (Spain).

G. *Spanish owners experience*

To know if all the incentives and efforts are working, let us see what the owners say by checking the official forum of the Electric Vehicles Users Association (AUVE).

One of the most common topics is "Trips, routes, and experiences." For traveling with an EV is essential to have a good plan, decide where and when to stop and charge the vehicle, following the next steps:

Organize the route: Some apps will help, like ABRP (A Better Route Planner), used to calculate approximately where you must stop. Also, you can check all the available recharging points and their respective managers (Ionity, Endesa, Iberdrola, Wenea, etc.).

Check the recharging points: The drivers check the charger's condition with apps like ELECTROMAPS, which also include comments from other users.

Choose the cheapest rate: The ABRP app will show the price of kWh for each charging station and makes it possible for the user to select the best alternative (like Ionity, Kia charger, Juicepass or Endesa, Iberdrola, etc.). Payment can be made by an app or, alternatively, by card.

This shows us all the planning needed to go on a trip. Other topics on the website are news, charging information, sports with EVs, and purchase and selling. You can also talk with the rest of the users to share information, ask questions, etc.

Joana, an EV owner for six months and forum user, has shared with us her experiences where she tells us that for her daily life, it is perfect.

"*It is very efficient (I live 40 km from my work). When you have to consider longer distances, things get complicated. At the moment, I have always gone well, but it requires much more planning.*"

Regarding the difficulties that can be found with EVs, she tells us that they would be the purchase price and the complication of having a charging point at home if you do not have a parking space on your property; it is very common in Spain to have a community garage which can make even more difficult to install chargers. Nevertheless, Joana highlights the remarkable convenience of charging an EV at home. She describes it as a seamless process comparable to charging at work. Joana explains that this is inconsequential despite the slow charging speed since the vehicle remains parked for several hours, making it imperceptible when the charging is taking place. Home charging enables EV owners to integrate charging into their daily routines and eliminates the need for frequent visits to public charging stations. Since she also highlights the difficulties associated with public charging infrastructure, especially when using free charging stations. She emphasizes that these stations are often fully occupied, making it arduous for other EV owners to find an available spot. Furthermore, Joana expresses disappointment over the lack of empathy from some users who fill their batteries for as long as they need, disregarding the fact that public charging is a shared service.

"*Charging it at home is very comfortable, just as if you can at work, even if it is slow charging, the car is stopped for many hours, so you don't even notice when it's charging. But charging it on the public infrastructure is a horror. If it's free, it's always full and people aren't empathetic at all, they fill their batteries for the hours they need, without taking into account that it's a public service.*"

An important concern raised by Joana is the issue of overnight charging and the need for regulations. She observes that in her town, the only regulation is not staying for more than 4 hours. Consequently, many EV owners leave their vehicles charging overnight, taking advantage of the lenient guidelines. To ensure fair usage of public charging infrastructure, it is crucial to implement clear guidelines, such as limiting charging times or introducing penalties for prolonged stays. So, she recounts having a more positive experience with fast charging points provided by electric companies. These fast chargers offer quicker charging times, making them useful when immediate charging is required. However, Joana notes that the need for fast charging is rare, indicating that slow charging options are generally sufficient for her daily driving needs.

"*There is not much regulation about leaving it overnight. In my town, they only ask that you please not stay for more than 4 hours, so people leave it at night. I have had a better experience with fast charging points from electric companies, although electricity is almost the same price as diesel, but you rarely really need it.*"

In conclusion, it is imperative to recognize the need for continuous improvement in public charging infrastructure. This includes increasing the number of charging stations, implementing smart charging solutions to optimize usage, and promoting a culture of empathy and responsible charging behavior among EV owners. These improvements will provide a more seamless and accessible charging experience for all.

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V. COMPARISON OF THE EVOLUTION OF EVS IN SPAIN AND NORWAY

Charging Infrastructure: There are some contrasts between Norway's and Spain's charging infrastructure expansion efforts. The implementation of high-power charging infrastructure has been limited in Spain, where the growth of charging points has lagged behind the expansion of the market. On the other hand, Norway has a well-established network of charging stations, including AC and DC fast chargers, providing quicker and more practical charging. This has aided in Norway's broad adoption of EVs.

Energy and Fuel Price: Energy prices in Spain have been rising rapidly due to increasing gas prices, low renewable energy use, higher energy demand, and CO_2 emission costs. In contrast, Norway has a significant share of renewable energy, mainly hydropower, which helps keep electricity prices relatively stable and lower than Spain. This has made EVs more cost-effective for Norwegian consumers.

Sales and Adoption of EVs: Electric vehicle acceptance and sales have increased in Spain and Norway. In contrast to Spain, Norway has achieved a far higher market penetration of electric automobiles. With a market share of more than 80% in 2022, EVs represented an essential percentage of new car registrations in Norway. Spain's market share of EVs remained low in 2022, representing just 9.63% of all recent car sales.

Government Incentives and Support Programs: Spain and Norway have implemented incentives and support programs to promote electric vehicle adoption. Moves II and III in Spain offer financial incentives for purchasing EVs and installing charging infrastructure. In contrast, Norway offers tax exemptions, toll discounts, free parking, and a comprehensive charging infrastructure until 2023. These incentives and infrastructure developments have played a key role in driving the high adoption rate of EVs in Norway.

Challenges and Obstacles: The necessity for effective regulation, the decarbonization of the vehicle fleet, and adequate infrastructure present issues for Spain. 2040 plan tries to deal with these problems. Norway must maintain charging stations and ensure the energy grid can handle the rising demand. It is crucial to control the market's impact on the nation's finances and maintain its continuing growth and prosperity.

VI. CONCLUSIONS

Recap of key findings: Spain and Norway have made efforts to promote electric vehicle adoption, but Norway has achieved a significantly higher market penetration of EVs due to government incentives, charging infrastructure availability, and energy prices. Spain has faced challenges in expanding its charging infrastructure, particularly in deploying high-power charging points, while Norway benefits from a stable and relatively low-cost renewable energy supply. This disparity can be attributed to government incentives, charging infrastructure availability, and energy prices.

Lessons learned and recommendations: The findings have led to lessons being learned, and suggestions can be made to enhance the EV industry and charging infrastructure in both nations. To make EVs more appealing and accessible, Spain should take a page from Norway's strategy and prioritize constructing high-power charging infrastructure, boosting government subsidies, and raising its investment in renewable energy sources. To achieve a smooth transition to electric mobility, public-private cooperation should be encouraged in both nations, utilizing the knowledge of diverse EV ecosystem stakeholders. Dispelling EV myths and misconceptions, addressing range anxiety issues, and emphasizing the advantages of electric mobility for the environment and the economy can all be accomplished through education and awareness campaigns.

Potential areas for improvement in each country: To bolster the EV market, nations need targeted strategies. In Spain, quickening the rollout of high-power charging infrastructure across all regions, boosting government incentives, and lowering energy prices can make EVs more affordable. In contrast, Norway must focus on expanding and upkeeping its charging network due to rising EV demand, vigilantly track the financial implications of EV incentives, and devise innovative solutions for surging electricity demand.

By implementing these recommendations, Spain and Norway can foster the development of their respective EV markets and promote sustainable transportation methods. These actions can significantly contribute to their national goals of reducing greenhouse gas emissions. A collaborative effort involving the government, private sector, and citizens is crucial to facilitate the transition toward electric mobility. This transition, in turn, could bring about substantial long-term environmental benefits and help both countries meet their commitments under international climate agreements.

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