Sustainable Incentives and Market Mechanisms for Accelerated Zero Emission Vehicle Transitions

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Abstract

Strong policies with sustainable incentives are needed to accelerate the EV transition. With the financial sustainability of EV incentive programs being questioned, a self-financing market mechanism such as feebates could be the 'need of the hour' solution. Different policy objectives could be served by feebates influencing its design and effectiveness. While there are key design elements that should be considered, there is no 'optimal' feebate design.

Irrespective of the policy goals, a feebate will impact both the supply side, i.e., the automotive industry and the consumer side. Globally, feebates can be used to effect technology leapfrogging while navigating the political economy of clean transportation policy in different country contexts.

In this dissertation, a case study approach is used to evaluate the use of a feebate policy in different geographical contexts, and their role in accelerating the transition to ZEVs. The first chapter reviews the European context wherein feebates have become a widely used policy tool and draws lessons for policy design. In the second and third chapters, a feebate policy is designed for the United States and India, while accounting for their distinct policy approaches to encouraging ZEV adoption.

The first chapter provides a comprehensive review of feebate mechanisms in Europe, their evolution and impact on EV sales between 2015 – 2022, compared to previous reviews that assessed these mechanisms in their early stages of implementation between 2010 - 2015. Key elements of a feebate design and its implementation are identified, that can be replicated in other country contexts, ensuring an accelerated ZEV transition is made feasible, in a sustainable and cost-effective manner for governments.

The United States, under the Biden Administration, has set an ambition of reaching a 50% sales share for zero-emission vehicles by 2030 and is pursuing a combination of aggressive fuel economy standards along with tax credits for EV purchase that supports both battery and plug-in hybrid electric vehicles. Some states in the US, led by California, have adopted ZEV sales mandates as well as additional purchase incentives to encourage increased sales. More importantly, feebates have been attempted in the past, both at the state and federal level in the US through legislation.

In contrast, India's approach to road transport decarbonization has been an 'all-possible technologies' and multi-fuel strategy, allowing for CNG, biofuels, strong hybrids and EVs. This also emerges from a relatively complex governance structure. India has a unique EV incentive program that favors only BEVs, with no support for PHEVs, but at the same time has a CO_2 regulation with no penalties for non-compliance and a vehicle taxation mechanism that promotes other alternatives. This has also led to lack of certainty for industry in terms of optimizing investments, which a clear policy and technology pathway would provide.

In both the second and third chapters focusing on the US and India respectively, a market-based mechanism, in this case, a feebate policy, that is self-financing and provides more market certainty for both producers and consumers for a long-term transition pathway is evaluated. These two chapters make two important contributions: (i) revenue-neutral incentive systems are possible while supporting increasing sales of light duty EVs along the target path, i.e. towards a 100% EV sales share by 2035 in the US and towards a 30-40% share by 2035 in India; and (ii) revenue-neutrality can be achieved with relatively low average fees on entry level ICE vehicles, at the very least, maintaining economic equity among vehicle buyers. In the case of India, the analysis evaluates the feebate design with a single policy objective of driving ZEV adoption (as opposed to inclusion of PHEVs in the US context), and thus, also focuses on a reform of the vehicle taxation system towards a CO_2-based taxation approach.

The analysis brings into context the case of developing countries like India, where poor quality regulations such as fuel economy standards with no penalties for non-compliance or attribute-based relaxations, limit the impact of supply side policies in driving technology shifts. A feebate mechanism, will align the push for fuel economy improvements, vehicle taxation structure and the EV incentive program towards a common goal of a targeted ZEV adoption.

Last but not the least, the analysis in this dissertation shows that even if the feebate mechanism is not implemented by government, it can be used by individual automotive manufacturers to establish their own internal pricing mechanisms across ICE and EV products to determine a profitable business pathway during the EV transition.

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Sustainable Incentives and Market Mechanisms for Accelerated Zero Emission Vehicle (ZEV) Transitions

Average light duty vehicle motorization rates globally have increased by about 4% between 2015 – 2019, reaching 209 vehicles per 1,000 population, with considerable growth in developing countries, growing 8% in Asia and Middle East and 4% in Africa in the same period (OICA, 2020). With this growing demand for vehicles, it has resulted in a set of market failures that include environmental externalities, vehicle supply and consumer choices (Santos et al., 2010).

Governments have a variety of policy and regulatory instruments to draw upon to accelerate EV market sales. Approaches include market instruments and incentives for industry and consumers such as subsidies, tax rebates, manufacturing incentives, R&D benefits, and provisioning of charging infrastructure, while regulatory measures include fuel efficiency standards or emissions norms imposed on automakers (Srivastava et al., 2022). In practice, acceleration of sales will likely depend on a mix of these policies. To support the adoption of EVs, two key policy approaches have been: (i) upfront purchase subsidies for EV buyers; (ii) strengthening fuel economy or CO_2 regulations (Fritz et al., 2019).

In the early years of vehicle growth, the primary objective was to reduce the dependence on oil imports and improve energy security, which was done through fuel taxes (increasing the cost of fuel, and potentially reducing the vehicle miles travelled) and fuel economy regulations (improving efficiency of vehicles, thus consuming lesser fuel for every unit distance travelled). In due course, the objectives shifted to focusing on environmental externalities, i.e., emissions control (both GHG and non-GHG), as well as addressing market failures related to availability and cost of low emission vehicle technologies, and suboptimal consumer choices. Since 2015, with the historic Paris Climate Agreement, there has been a focus on reducing GHG emissions from road transport, with vehicle electrification seen as the primary strategy towards addressing direct CO_2 emissions (tailpipe).

Many automotive companies (such as GM, Honda, Mercedes-Benz), countries (such as Norway, UK, Germany) and sub-national governments (like State of California) expect almost all vehicle sales to be electric or a combination with hybrids by 2035 (International Energy Agency, 2023b). While the ambitions exist, it requires a robust policy framework to facilitate and sustain this transition, with regulations aimed at a ZEV transition as compared to the current focus on including hybrids as well. These commitments and assertions are motivated by rapid reductions in battery costs. Are these commitments and technology improvements sufficient to pivot vehicle buyers?

Theory of environmental economics proposes the role of taxing negative externalities, which essentially imposes a higher price on the commodity borne by the buyer, in this case, emissions from the sale and use of an ICE vehicle. This is also known as the Pigouvian tax (Cerruti and Huse, 2019). Imposing such a tax linked to emissions may not be politically acceptable in many countries, especially in developing nations. In the absence of any cost on negative externalities, the full savings from EV adoption may not be realized by a consumer and would likely lead to slower EV adoption rates (Rapson and Muehlegger, 2023a). This can be addressed through upfront purchase subsidies, which if designed well can be useful in addressing the primary goal of emission reduction and support EV adoption in the early stages of market transformation.

The question is how governments should best intervene to alter relative purchase prices. Simple vehicle purchase incentives (i.e., subsidies) have been used by countries as early-stage policy measures to influence consumer purchase decisions and vehicle manufacturer investments, but with mixed success; and critically, often without clear funding streams for these incentives. Studies have indicated the limitations of subsidies in achieving the intended outcomes of an EV transition, including issues of system efficiency and leakages, long-term sustainable market signals, and fiscal constraints (Thorne and Hughes, 2019; Wu et al., 2023). It has been found that EV incentives are often received by relatively affluent households, posing the question of equity and efficacy (Bauer et al., 2021). While many economists will debate the efficacy of subsidies in general, the central issue remains at what point do policy mechanisms push for a paradigm shift from a subsidy-only approach to a mixed regulatory ecosystem for accelerating ZEV adoption.

To sustain high ambitions of government and industry, long term certainty of public funds and equally strong disincentives towards selling and purchasing ICE vehicles will give a strong signal to vehicle buyers and manufacturers. In this regard, fees on high-polluting vehicles and rebates on clean ones have become an effective and increasingly common strategy in many European countries (Dornoff et al., 2021; European Automobile Manufacturers' Association, 2022). Whether called "feebates", "bonus-malus", "revenue-neutral incentives", these policies have the attraction of creating very strong price signals without imposing a cost on taxpayers—unlike direct subsidy schemes.

Feebates, while providing a mechanism to disincentivize vehicles (fees) with lower fuel efficiency and higher emissions, also offers an opportunity to generate a sustainable stream of revenues from those fees to finance rebates for purchase of cleaner vehicles. Feebates are a good approach to raise the necessary capital for financing the vehicle sales part of a ZEV transition, in combination with other regulatory mechanisms.

In this dissertation, a case study approach is used to evaluate the use of a feebate policy in different geographical contexts, and their role in accelerating the transition to ZEVs. The first chapter reviews the European context wherein feebates have become a widely used policy tool and draws lessons for policy design. In the second and third chapters, a feebate policy is designed for the United States and India, while accounting for their distinct policy approaches to encouraging ZEV adoption.

Based on a series of engagements with policy makers in the US and India, there is growing acceptance for "feebate"-like mechanisms, while the nuances of implementing the same may differ across countries. The US and India while different economies from a development perspective, are both automotive majors from a manufacturing and demand perspective. The potential impact of this thesis can result in real-time impact to policy making in these countries and can also form the basis for extending the same mechanism to other vehicle segments such as medium and heavy-duty trucks.

Chapter 1: Lessons from European Feebates for a ZEV Future

1.1 Introduction

Transport emissions will have to decline dramatically to achieve net-zero greenhouse gas goals in the next few decades (International Energy Agency, 2021; UNFCCC, 2021a). Vehicle electrification is widely considered the most important strategy to dramatically reduce GHG emissions from transport (Ramji et al., 2021;(Brown et al., 2021; International Energy Agency, 2021; Miller et al., 2021; Sperling et al., 2020; UNFCCC, 2021b).

The shift to very low emission vehicles, from here on referred to as zero emission vehicles (ZEVs), requires changes in vehicle supply and demand. Given the widespread expectation that ZEVs, especially electric vehicles (EVs) will dominate in the future—by both policymakers and the automotive industry (Hall et al., 2018; Muratori et al., 2021) – this paper focuses on policies to facilitate the transition in the most effective and acceptable fashion. Given these expectations, the declining costs of EVs (Goetzel and Hasanuzzaman, 2022; Rapson and Muehlegger, 2023b), and government commitments to significantly reduce GHG emissions, it is now widely perceived that aggressive performance standards (including stringent fuel efficiency norms and ZEV sales mandates) are the most important policy to accelerate EV sales, more so than consumer incentives – as being demonstrated in China, the world's largest EV market (Deng and Tian, 2020; Li et al., 2020; Xiao et al., 2020); the EU, the second largest EV market (Dornoff, 2023; Dornoff et al., 2021); and in the US, where EV sales are greatest in states with a ZEV sales mandates (Woody et al., 2023).

Clearly, even with these performance standards, consumers still need to purchase low emission vehicles, and thus, incentives are widely seen as essential to smooth the transition process. Since 2015, all major car markets saw governments providing purchase incentives for EVs. The sustainability of incentives has come into focus, as they put significant pressure on government fiscal bandwidth. More recently, governments have announced reductions in (such as California or the UK) or phase-out of (such as Germany or China) subsidies (California Air Resources Board, 2023a; EV-Volumes, 2022; Li and Lee, 2023; Reuters, 2022; Times of India, 2023), citing lack of public funds, largely because these incentive programs are subject to annual budgetary appropriations.

This paper addresses a form of consumer incentive that has gained acceptance in a few countries in Europe, but not elsewhere: feebates. It provides a comprehensive review of feebate mechanisms in Europe, their evolution and impact on EV sales between 2015 – 2022, compared to previous reviews that assessed these mechanisms in their early stages of implementation between 2010 - 2015. The paper identifies key elements of a feebate design and its implementation that will be critical in ensuring that an accelerated ZEV transition is made feasible, in a sustainable and cost-effective manner for governments, and the potential for replication in other geographies based on key policy objectives. Lastly, it combines a unique vehicle make-model-powertrain analysis based on a combination of three different datasets.

1.2 Role of feebates and design considerations

A feebate mechanism imposes a tax above a defined threshold value and offers rebates below the threshold. Feebates can be an effective tool to reinforce a level of carbon pricing across products and activities in multiple sectors including transportation, industry, electricity generation, electric appliances, and land use, among others (Batini et al., 2020; Scholz and Geissler, 2018). In this paper, the focus is on feebates for facilitating a ZEV transition. Feebates for vehicles are typically designed with two components: (i) a fee on the sale of vehicles that have higher rated CO_2 emissions (sometimes using proxy metrics such as engine size or pollutant emissions) than an identified threshold level, and (ii) a rebate for the purchase of vehicles with emissions below this threshold. A pivot point or zero point is defined as the threshold above or below which fees or rebates would apply, with the fee estimated based on an efficiency or CO_2 criterion but also possibly adjusted by other vehicle attributes such as weight or footprint (German and Meszler, 2010). Feebate policies are sometimes seen as small-car subsidies (Berthold, 2019a; Kley et al., 2010), but that is more the case when targeting mostly ICE vehicles and can be adjusted to reflect whatever goal is desired (for instance by separating cars from SUVs and pickup trucks). Further, feebates currently do not account for CO_2 emissions from EVs that are attributable to the electricity grid from charging and focus on tail-pipe emissions from vehicles. An extension of the feebate would be to include grid-related emissions as well.

A feebate policy instrument is compelling for a number of reasons: (i) it can be designed to be equitable and revenue neutral, with no burden on taxpayers or governments; (ii) it provides strong incentives to mitigate GHG emissions (Brand et al., 2013; Fazeli et al., 2017; Fridstrøm and Østli, 2017; Liu et al., 2012, 2011a); (iii) it is flexible and is usually designed to be readily adjusted over time usually without legislative intervention (which increases certainty for both consumers and manufacturers) (Kley et al., 2010); (iv) it harnesses market forces by adjusting price signals to consumers; and v) tends to be supported across much of the political spectrum because they do not require taxes and yet are a market instrument. They show promise, for all these reasons, to accelerate a ZEV transition, if designed efficiently (Antweiler and Gulati, 2013; Usher et al., 2015).

In the European region, a total of 23 countries (out of 31) have some form of emission-based taxation on either vehicle ownership or acquisition or both (European Automobile Manufacturers' Association, 2021; OICA, 2023). There are five European countries--France, Germany, Italy, Sweden, and the United Kingdom – that have experience with either a full or partial feebate mechanism and form the core of the review in this paper. Sweden's and Italy's program began in 2019 while all others began before 2015 with significant design changes in 2017.

1.3 Data and Methodology

Feebate mechanisms are compared across five countries, namely, France, Sweden, Germany, Italy, and the United Kingdom (UK). For automotive sales, data is obtained from Marklines, IHS Markit, and EV Volumes. For vehicle emission data, the European Environment Agency database monitoring CO_2 emissions from passenger cars is used. Further, the ACEA Tax Guide from multiple years is referred to obtain data on vehicle taxation and EV incentives in European countries. For the respective feebate regulations, the information is obtained from the regulatory authority in each country that is administering the program. The measurement of CO_2 emissions in this chapter is restricted to tail-pipe emissions and does not account for EV emissions from the electricity grid.

For the analysis, a comprehensive and unique dataset is created that includes automotive LDV sales by make-model, powertrain (ICE, BEV, PHEV), and CO_2 emission to create unique country profiles for 2010 - 2021. This dataset is then overlaid with the feebate design mechanisms to better understand its implementation and draw lessons in terms of best practices for an effective policy design that can help meet the objective of a transition to ZEVs.

1.4 Review of the feebate mechanisms in selected European countries

Prior to the detailed review of the feebate mechanisms in the select five countries (Table 1), a brief overview of the key elements of a feebate policy design are presented. While the French Bonus-Malus was introduced in January 2008, and is considered a strong success, countries have revised their fee and rebate mechanisms since 2017. Some common changes include: (i) non-linear fee function, with a steep rise in fees for higher emission values; (ii) flexibility in rebates to encourage EV adoption, with lesser fiscal constraints (revenue in-flow from fees); (iii) clear donut-hole[1] in feebate structures; and (iv) making Plug-in Hybrid Electric Vehicle (PHEV) performance parameters more stringent to be eligible for rebates, indicating a clear signal to push consumers to ZEVs (Bose Styczynski and Hughes, 2019; D'Agostino et al., 2022).

A. Functional form and parameters: Feebates be designed as step functions or continuous, and non-linear with differing slopes at different threshold values, or as a hybrid of these. The parameter used for determining fees and rebates can include vehicle weight, footprint, or engine displacement, and can be designed for specific vehicle segments (such as cars or SUVs) or apply uniformly (German and Meszler, 2010).

B. Pivot point: The pivot point decides who is taxed and who receives a rebate. The selection of a pivot point requires good forecasting of consumer choices and market behavior. The specification of the pivot point and slope of the curve for fees should account for consumers' valuation of fuel economy, which is typically only the first three years of savings, and not the entire life cycle of vehicle ownership (D.L. Greene et al., 2005).

[1] Donut-hole is referred to as the emission range (gCO_2/km) that does not attract any fee or rebate, thus not impacting any vehicles that fall in that range

Table 1: Feebate mechanisms across key European countries in 2021 (European Automobile Manufacturers' Association, 2021)

Country	Feebate type	Functional form and parameter	Pivot point	Fee structure	Rebate structure
France	Pure feebate	Continuous function for fee, step function for rebate; CO_2 emissions (gCO_2/km) + Vehicle Weight (kgs)	133 gCO_2/km	CO_2-based (non-linear curve) + vehicle weight (€10 per kg beyond 1800 kg; *w.e.f. 2022*)	€ 6,000 for BEV with purchase price < € 45,000 & emissions < 20 gCO_2/km; € 3,000 additional for low-income households
Sweden	Pure feebate	Non-linear, piece-wise continuous function for fee, continuous rebate function; CO_2 emissions (gCO_2/km)	90 gCO_2/km	SEK 107 per gCO_2 if emission is between 90 – 130 gCO_2/km SEK 132 per gCO_2 if emission > 130 gCO2/km	Graded rebates offered for all vehicles with emission < 90 gCO_2/km; Maximum rebate of SEK 70,000, not exceeding 25% of the vehicle price
Germany	Partial feebate	Non-linear, piece-wise continuous function for fee, step function for rebate; Engine displacement + CO_2 emissions	95 gCO_2/km	Tax on engine displacement + CO_2 tax (€ 2 per gCO_2 > 95 gCO_2/km up to 116 gCO_2/km; increases up to € 4 per gCO_2/km for emissions > 195 gCO_2/km)	Annual tax bonus of € 30 for emissions from 1 – 95 gCO_2/km; € 6,000 for BEVs and FCEVs, if purchase price < € 40,000, else, € 5,000; In case of PHEVs, bonus will be €4,500 if purchase price < € 40,000, else, € 3,750
Italy	Pure feebate	Step function for fee, discrete rebates CO_2 emissions	160 gCO_2/km	CO_2 tax (step-wise) from € 1,100 to € 2,500	€ 8,000 for 0-20 gCO_2/km with scrapping; € 4,500 for 21-60 gCO_2/km with scrapping; € 2,000 for 61-135 gCO_2/km; purchase price < € 50,000 or <€ 40,000 if >61 gCO_2/km
UK	Partial feebate	Step function for fee, single rebate structure; CO_2 emissions	50 gCO_2/km	GBP 10 for gasoline vehicles with emissions < 10 gCO_2/km; up to GBP 220 for vehicles emitting 150 gCO_2/km; up to GBP 1345 for vehicles emitting 200 gCO_2/km	GBP 1,500 for vehicles with emissions < 50 gCO_2/km, and at least 70 miles of all-electric range; purchase price < GBP 35,000

1.4.1 Assessing functional forms and impact of fees and rebates

In France, the feebate mechanism was originally structured as a step function, with discrete amounts based on classification of vehicle emissions. Automotive manufacturers took advantage of the step functions by making marginal improvements in CO_2 emissions and making vehicles qualify for lesser fees or greater rebates. After multiple corrections of the step function, France made an important change to the bonus-malus scheme in 2017, wherein, the 'fee' was converted to a continuous non-linear function (every marginal change in CO_2 emissions had a cost associated with it) while the 'rebate' was maintained as a step function (Figure 1). Further, France introduced an additional fee, based on vehicle weight, with effect from 2022 (€10 fee for every additional kilogram of weight over 1800 kg).

Italy also introduced a feebate mechanism in 2019 (Figure 2) structured as a step function (Asadollahi, 2021), even though the disadvantages of a step function have been well established. While there was a significant jump in EV sales in 2020 and 2021 reaching 8.6% of new sales after the feebate was introduced (compared to less than 1% in 2019), it has remained flat around 8% in 2022 and 2023 (January – September) (EV-Volumes, 2022). It is yet to be seen how the feebate will incentivize adoption of ZEVs in Italy, especially given that the rebates also apply to ICE vehicles (if older ICE vehicles are being scrapped) with emissions up to 135 gCO_2/km.

Germany, on the other hand, does not have a pure feebate mechanism, with the incentive and fee being separate legislations. The German fee function is essentially non-linear and piece-wise continuous, with a graded fee per gCO_2 (Figure 3). From 2020, Germany changed the "Umweltbonus" policy increasing the subsidy for EVs from the 2016 policy. Starting 2021, Germany has also imposed a revised CO_2-based vehicle tax, along with an existing tax based on engine displacement. The linear CO_2-based emission fee has now been amended with effect from 2021 to a non-linear, more stringent CO_2-based emissions fee, that ranges from €2 to €4 per additional gCO_2 above 95 gCO_2 (Bieker, 2019).

The UK also has a partial feebate mechanism, with the CO_2-based taxes being higher for diesel cars, like Germany (UK Government, 2023). The UK emission fee follows a step function (Figure 4).

Sweden introduced the feebate mechanism on 1st July 2018, replacing a rebate-only program for green cars. The Swedish feebate follows a non-linear, piecewise continuous function for the emission fee, and is the only country among those being reviewed in this analysis to have a continuous rebate function (Figure 5). Prior to the feebate, ZEVs received a rebate of €3,800 while PHEVs received a flat rebate of €1,800.

In addition, all countries have a higher fee on diesel vehicles, include price caps on EVs eligible for incentives, minimum all-electric range (AER) requirements for PHEVs and provide sales tax exemptions for EV purchases.

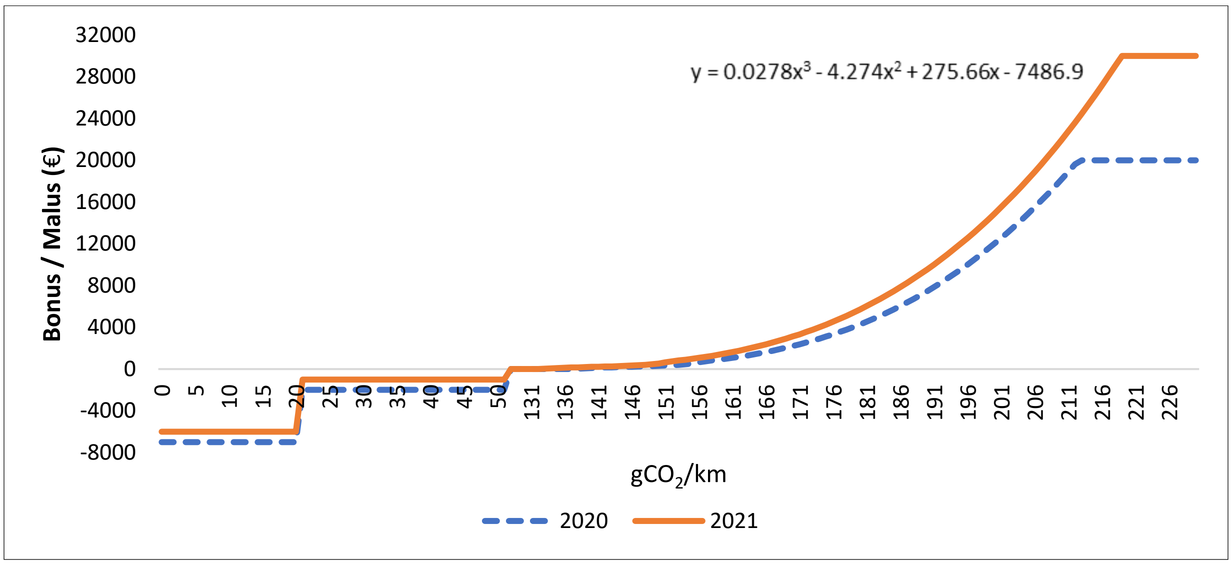

Figure 1: Feebate functional form in France for 2020 and 2021

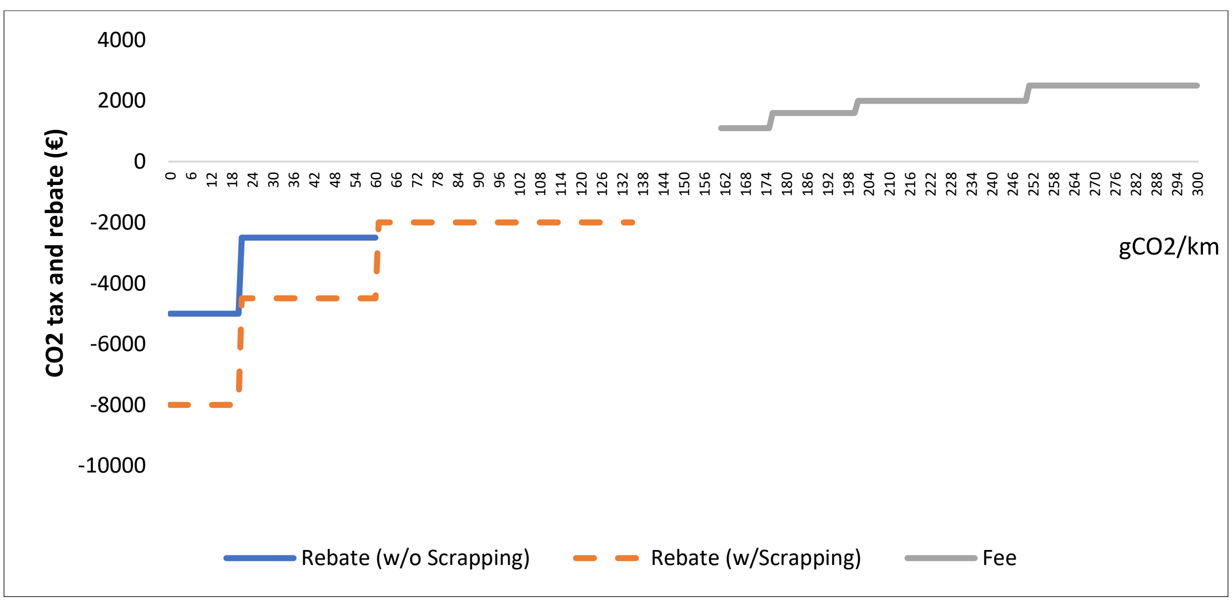

Figure 2: Feebate functional form for Italy, 2021

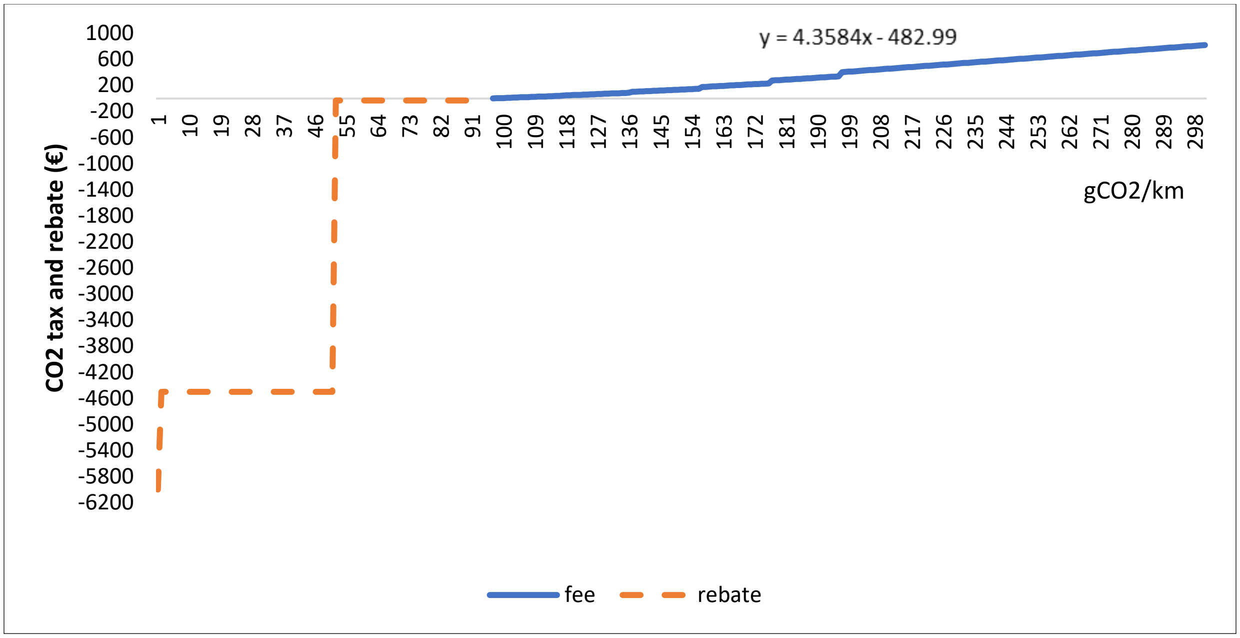

Figure 3: Feebate functional form for Germany, 2021

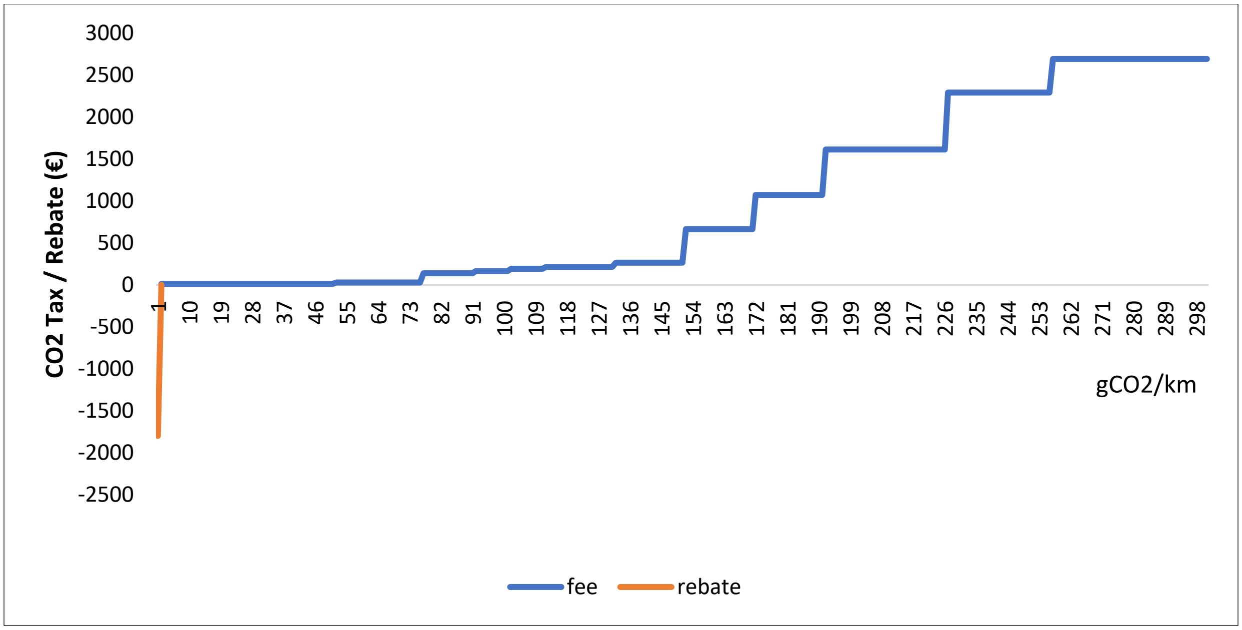

Figure 4: Feebate functional form for the UK (1 GBP = 1.2 EUR), 2021

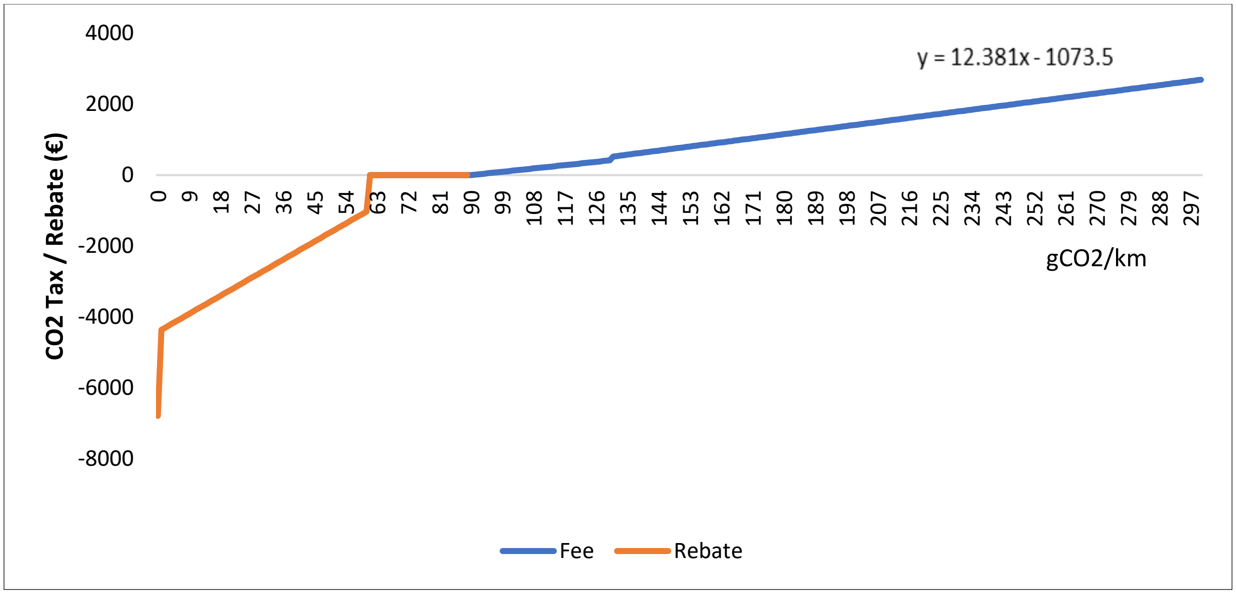

Figure 5: Feebate functional form for Sweden (1 SEK = 0.097 EUR), 2021

To provide a relative assessment of the impact the CO_2 fee has on purchase prices for consumers in the respective countries, Table 2 provides an insight with the VW Golf 2021 Gasoline model as a reference vehicle. We use the 2020 WLTP-based[2] emission value for the vehicle in each country as provided in the European Environment Agency (EEA) database. While the average rated CO_2 values for any vehicle is typically the same across the EU, the CO_2 values for the VW Golf are different in each country as it is based on the most selling variant of the VW Golf 2021 in that country.

Table 2: CO_2 fees for VW Golf 2021 across countries

	France	**UK**	**Germany**	**Sweden**	**Italy**
MSRP* *(€)*	25445	31640	25445	34510	25445
CO_2 fee - Year 1 *(€)*	0	1074	70	91	0
CO_2 Fees - Year 2 to 4 *(€)*	0	0	210	216	0
% fee on MSRP	0.0%	3.4%	1.1%	0.9%	0.0%
gCO_2/km (WLTP)	119	171	127	102	121

**Maximum sales retail price; all monetary values are adjusted to Euros as per reference exchange rate*

As is evident from Table 2, the VW Golf 2021 model attracts no emission fee in France and Italy, as the vehicle emission value falls in the donut-hole of the feebate mechanism in both countries. The emission fee

[2] The Worldwide harmonized Light vehicles Test Procedure (WLTP) is a global standard for determining the levels of pollutants, CO_2 emissions and fuel consumption of traditional and hybrid cars, as well as the range of fully electric vehicles (European Union, 2017).

is the highest in the UK, followed by Germany and Sweden, as a share of the MSRP, which is due to the differential in the WLTP emission factor of the VW Golf in each country. Germany and Sweden both impose an annual emission-based fee, compared to the other countries. The potential impact of a one-time initial higher fee compared to an annual fee on consumer choices is worth considering. As consumers tend to discount subsequent cash flows, an initial higher one-time emission fee can be the difference between consumers choosing an EV or continuing with an ICE vehicle.

Table 3: Purchase rebate for Tesla Model 3 BEV and Ford Kuga PHEV 2021 across countries

		France (€)	**UK (£)**	**Germany (€)**	**Sweden (SEK)**	**Italy (€)**
Tesla Model 3 BEV	MSRP (before rebate)	43800	40490	39990	440000	35331
	Rebate	6000	1500	6000	70000	5000
	MSRP (after rebate)	37800	38990	33990	370000	30331
	% rebate of MSRP	14%	4%	15%	16%	14%
	MSRP (after rebate) in €	*37800*	*46285*	*33990*	*35980*	*30331*
Ford Kuga PHEV	MSRP (before rebate)	40950	35915	39300	512700	36350
	Rebate	1000	0	4500	31552	2500
	MSRP (after rebate)	39950	35915	34800	481148	33850
	% rebate of MSRP	2%	0%	11%	6%	7%
	MSRP (after rebate) in €	*39950*	*42660*	*34800*	*46720*	*33850*

In Table 3, it can be observed that except for the UK, the BEV rebates are in the range of 14-16% across countries, while there is a wide variance with regards to rebates for PHEVs. The PHEV rebate is highest in Germany at 11% of the MSRP, compared to about 6-7% in Sweden and Italy. It may be interpreted that France, Sweden and Italy are focused on incentivizing BEVs over PHEVs, especially given that the top selling BEV and PHEV model compared are in similar price ranges.

1.4.2 Choice of efficiency parameter for feebates

Table 4 provides a comparison of the five countries across key efficiency parameters that are currently being used or considered, to determine the feebate mechanism, i.e., CO_2 emissions, vehicle weight, engine capacity or displacement, and vehicle length. For ease of comparison, the NEDC[3] test cycles for 2015 and

[3] The New European Driving Cycle (NEDC) was last updated in 1997. It's limitation was that it collected data under ideal conditions, which did not reflect real world driving emissions, and hence, was phased out in 2017.

2020 are used, as the CO_2 emission testing standards shifted from NEDC to WLTP from 2021 (European Union, 2017; Mian et al., 2023).

First, average emissions from the NEDC cycle tests have improved considerably across all countries for all new cars sold between 2015 to 2020, with Sweden showing a significant reduction at 6% CAGR, compared to an average of about 2% CAGR reduction in other countries.

Second, all countries have shown an increase in vehicle mass in the range of 1 – 1.5% CAGR on average, with Sweden and the UK indicating the maximum increase, while Italy continues to have the lowest vehicle mass among the five countries. While France and Italy have relatively comparable vehicle parameters, the average emission reductions have been greater in France, and can probably be attributed to the longer running bonus-malus scheme, and more significantly, the higher malus component compared to Italy. Figure 6 plots the transition of countries from 2015 to 2020 across their average vehicle mass and NEDC emission ratings.

Table 4: Country comparison across key efficiency parameters for feebate (European Environment Agency, 2023)

Country	***Year***	**Avg NEDC (gCO_2/km)**	**Avg. Mass (kg)**	**Avg. Engine Capacity (cm^3)**	**Vehicle Size (mm)**
France	2015	111	1315	1481	2609
	2020	98.5	1360	1404	2613
Germany	2015	128.4	1447	1710	2643
	2020	113.6	1534	1698	2680
Italy	2015	115.6	1300	1464	2400
	2020	108.6	1351	1420	2573
Sweden	2015	126.3	1530	1773	2697
	2020	93.5	1656	1735	2733
UK	2015	121.3	1393	1635	2620
	2020	111.5	1510	1591	2678

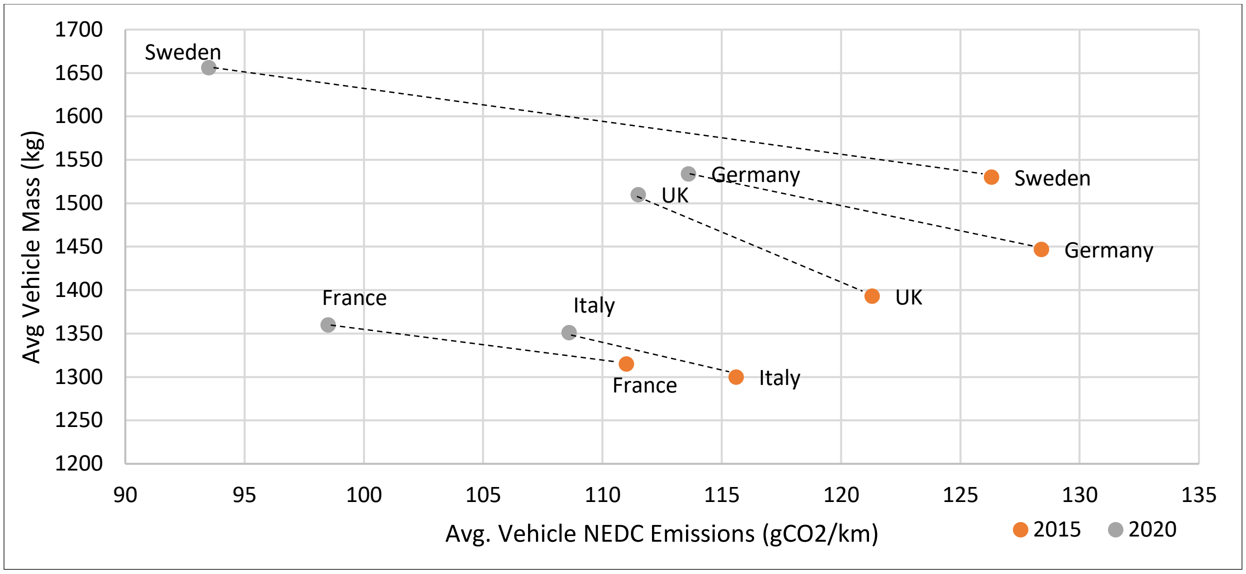

Figure 6: Average vehicle mass and NEDC emissions across countries, 2015 - 2020

With an average mass of 1360 kgs in 2020, the additional weight-based penalty introduced in France in 2022, will impact less than 5% of new vehicles sold, and is seen as a disincentive towards purchase of heavier and larger SUVs. Also, France has the highest average increase in vehicle mass (kg) to vehicle size (mm) ratio of 11.3 kgs/mm between 2015 to 2020, compared to an average of 2.6 kgs/mm among other countries in the same period, that possibly pushed French regulators to pre-empt automotive trends and introduce weight-based taxation measures.

Third, average engine displacement has reduced across all countries, even though average vehicle mass and length have increased, between 2015 to 2020 (Table 4). Engine displacement can be seen as a measurement of engine power, and the power to weight ratio of an automobile is a good indicator of engine performance, speed, and acceleration. If the engine displacement to vehicle mass ratio for 2015 and 2020 among the five countries were to be considered, Germany remains the highest in both years. Interestingly, Germany has been using engine displacement taxes since 2009 but has achieved the least reduction in power to weight ratio between 2015 to 2020. As the share of EVs increase, automotive manufacturers will adapt technology and engine displacement could evolve across segments. Since the ultimate objective is to reduce CO_2 emissions, having a single CO_2-based fee structure would have greater merit and efficiency.

Fourth, vehicle footprint in terms of average size has increased across all countries in varying magnitudes, with France seeing only an average 4mm increase in vehicle size between 2015 and 2020, whereas Italy has seen the highest increase of 173mm, followed by the UK (58mm), Germany and Sweden (around 36mm) in the same period.

This raises the following key questions: (i) whether a simpler CO_2-based taxation (compared to other attributes) with a large penalty amount is equally impactful for a ZEV transition; and (ii) whether attribute-based taxation serves as a mechanism of hedonic pricing for emissions externalities where CO_2 taxation is difficult to implement.

1.4.3 Choice of pivot point and donut-hole

In the French Bonus-Malus scheme, the donut hole has been revised continuously. In 2008, the donut hole was between 125 gCO_2/km - 160 gCO_2/km; in 2016, between 110 gCO_2/km - 135 gCO_2/km. In 2021, the donut hole was 50 gCO_2/km – 133 gCO_2/km, with significantly more stringent vehicle penalties, capped at €30,000 above 219 gCO_2/km. For the years 2022 and 2023, the upper threshold of the donut hole reduces to 128 gCO_2/km and 123 gCO_2/km, respectively, while the highest penalty cap will increase to €40,000 (>224 gCO_2/km) and €50,000 (>226 gCO_2/km), respectively (European Automobile Manufacturers' Association, 2022).

In the Italian feebate, the 2022 donut hole stands between 136 gCO_2/km to 160 gCO_2/km. The fee is a step-function for vehicles emitting above 160 gCO_2/km, with the highest fee at €2,500 for all vehicles emitting more than 250 gCO_2/km. In the Swedish feebate mechanism, the "donut hole" is between 60 – 90 gCO_2/km, above which a fee applies, and below which a rebate applies.

In the German policy, there was a donut hole up to 2021, wherein, there were no taxes for vehicles with emissions below 95 gCO_2/km, which has been replaced with a flat annual tax bonus of €30 for emissions between 1 – 95 gCO_2/km. This can be considered a flat rebate "donut hole". In contrast, the UK system has no donut hole as such, except that there is no taxation for hybrids that meet the criteria of emissions below 50 gCO_2/km and an all-electric range of at least 70 miles.

The following section reviews the potential impacts of the feebate on vehicle registrations, emissions and consumer choices.

1.4.4 Impact on vehicle registrations and emissions

The choice of the functional form, efficiency parameter and the pivot point also bring into question which of the vehicles being sold are being taxed and which are benefitting from the rebate or being excluded from the feebate altogether. In France, while ICE vehicles were initially eligible to receive rebates, the scheme was revised in 2018 to make only EVs eligible for rebates, as is the case in all other countries (except Italy). Figure 7 provides the EV sales trend and the year of feebate changes for each of the countries. The year 2019 was an inflexion point across all five countries, with EV sales rising significantly in the following years. France, Germany and the UK follow a similar trajectory up to 2019, after which Germany saw a sharp increase in EV market share in 2020-21 compared to France and the UK.

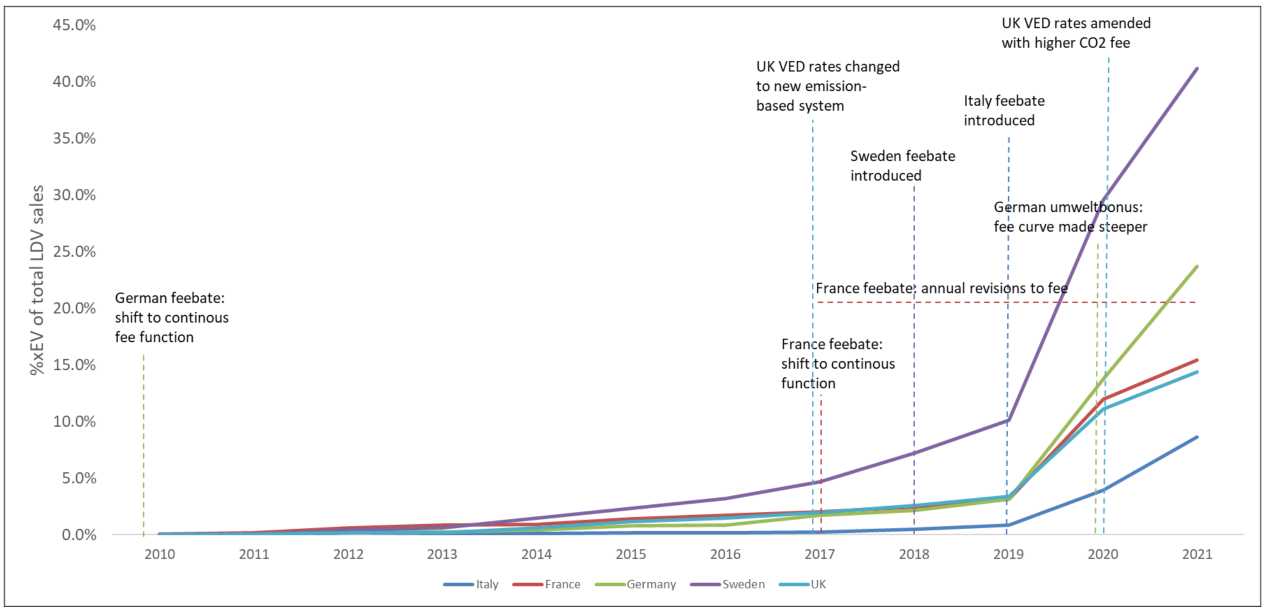

Figure 7: Share of EV sales and changes in feebate mechanisms across countries, 2010-21

While the EV share in total LDV sales reached around 15.4% in France and 14.4% in the UK for 2021, the share in Sweden jumped to ~41.2% in 2021, driven by a continued momentum in PHEV sales since 2020, and a significant increase in BEV sales in 2021. Italy has shown a doubling of market share in new EV sales for 2021, reaching 8.6%, compared to 4.3% in 2020, also driven by a greater increase in PHEV sales. In Germany, the EV market share reached 23.7% in 2021, compared to 13.7% in 2020. The impact of the feebate mechanism in each of the countries provides important insights into the larger goal of achieving of a ZEV transition.

France and the UK are the only two countries with dominant BEV shares in 2020-2021, while PHEV sales have been increasing as well (Figures 8 and 9). In Germany, there has been a moderation in the growth of BEVs compared to PHEVs in total EV sales, although BEVs were marginally dominant in 2021 (Figure 10). There was an inflexion point in 2020, where the BEV and PHEV shares are equal in Germany, with Italy not being very different (Figure 11). A recent study by ICCT indicates that the tax benefits introduced in 2019 for low and zero-emission company cars has boosted PHEV sales in Germany during 2019-20 (Bieker, 2019; Bieker et al., 2022; Transport and Environment, 2022). Sweden, on the other hand, remains the only country among the five, to have dominant PHEV sales since 2011, although BEV sales have grown steadily since 2018 (Figure 12).

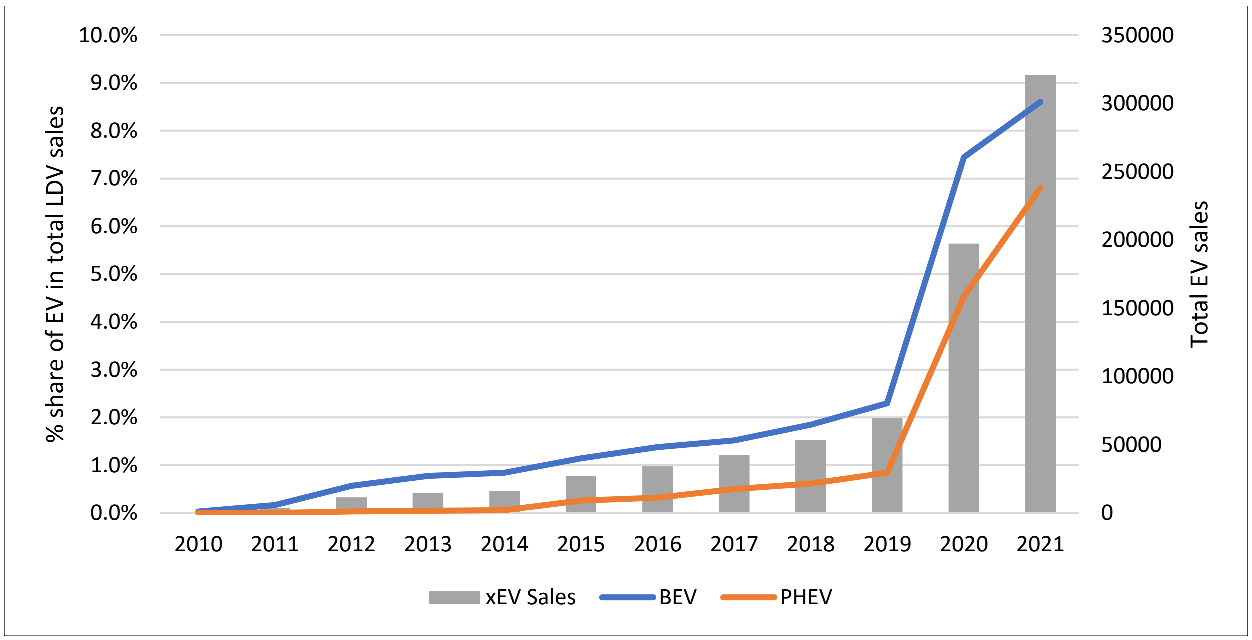

Figure 8: Total EV sales and share of EV sales in total LDV Sales – France, 2010-21

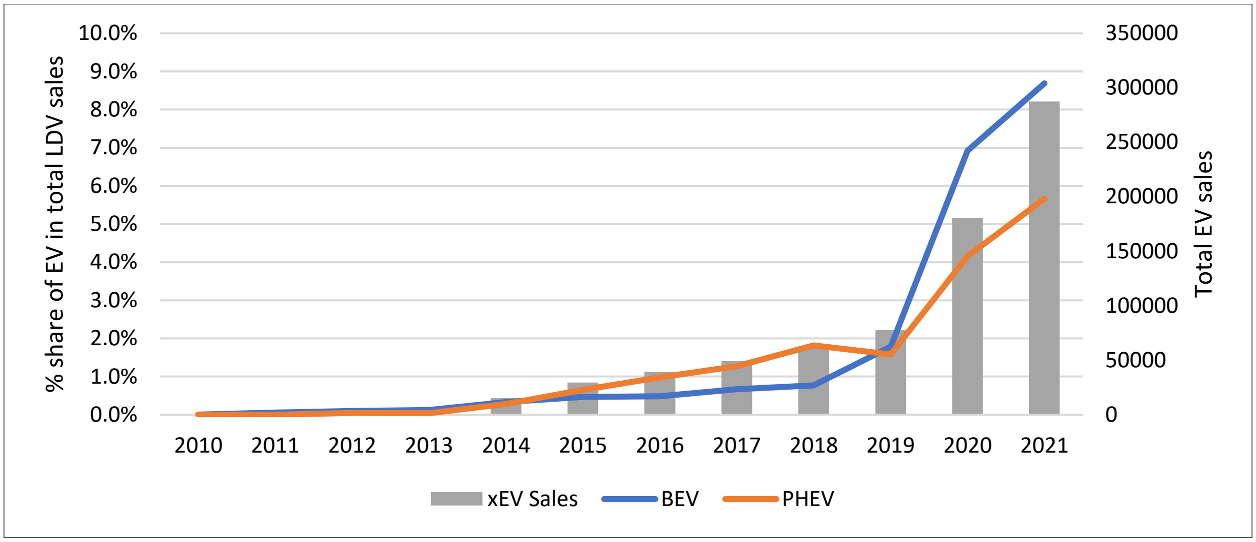

Figure 9: Total EV sales and share of EV sales in total LDV Sales – United Kingdom (UK), 2010-21

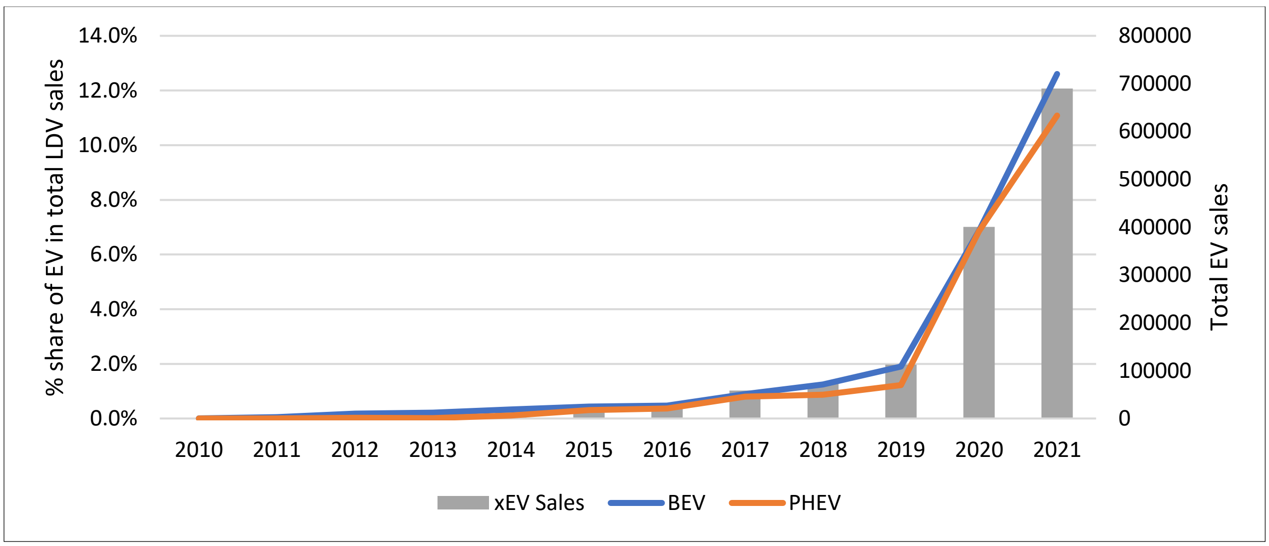

Figure 10: Total EV sales and share of EV sales in total LDV Sales – Germany, 2010-21

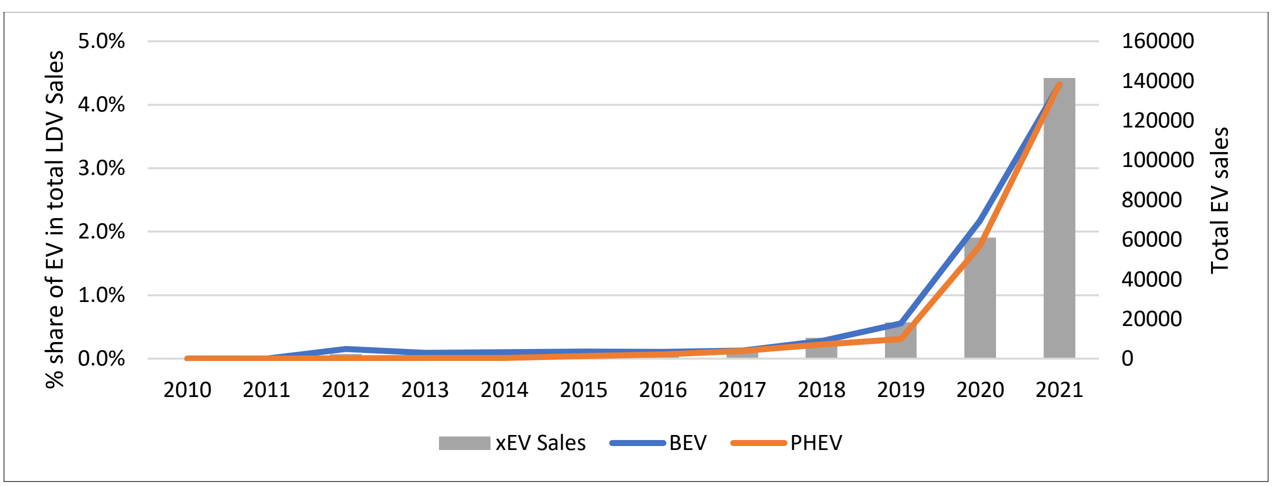

Figure 11: Total EV sales and share of EV sales in total LDV Sales – Italy, 2010-21

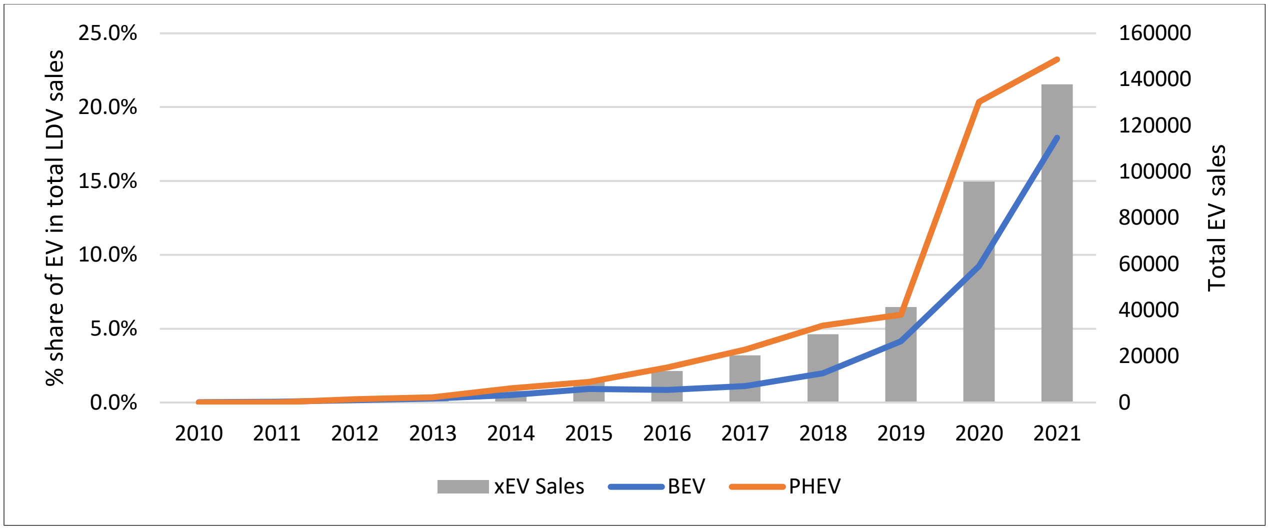

Figure 12: Total EV sales and share of EV sales in total LDV Sales – Sweden, 2010-21

Given the differences in EV sales across the five countries, this analysis further investigates the model availability across BEVs and PHEVs. Between 2010 to 2017, the total number of EV models and variants sold across the five countries are relatively similar (Figure 13). Based on the data, the number of EV models are estimated if in any given year, the volumes sold in that year is greater than zero (EV-Volumes, 2022). It is only in 2018 that differences are observed in model availability across countries, the year after revisions in the feebate mechanisms. The availability of models alone does not drive higher shares of EV adoption and will depend on the other factors including vehicle prices, (dis-)incentives, among others, including the feebate mechanism design in this case.

Germany leads in terms of model availability since 2014 with a significant increase from 2018-20, while France and Italy move similarly between 2017-20. In 2021, Sweden has a lower availability of EV models compared to others but has the highest market share (41.2%) of EV sales in that year. The UK which has the lowest number of EV models in 2021, has an EV market share of 14.4% in 2021, which is much higher than the 8.6% EV market share in Italy for 2021, even though the latter has a higher number of EV models sold for that year. It has also been established that the Italian feebate has a larger donut-hole than the UK, impacting lesser vehicles within the scope of the emission tax, thereby impacting the rate of EV adoption.

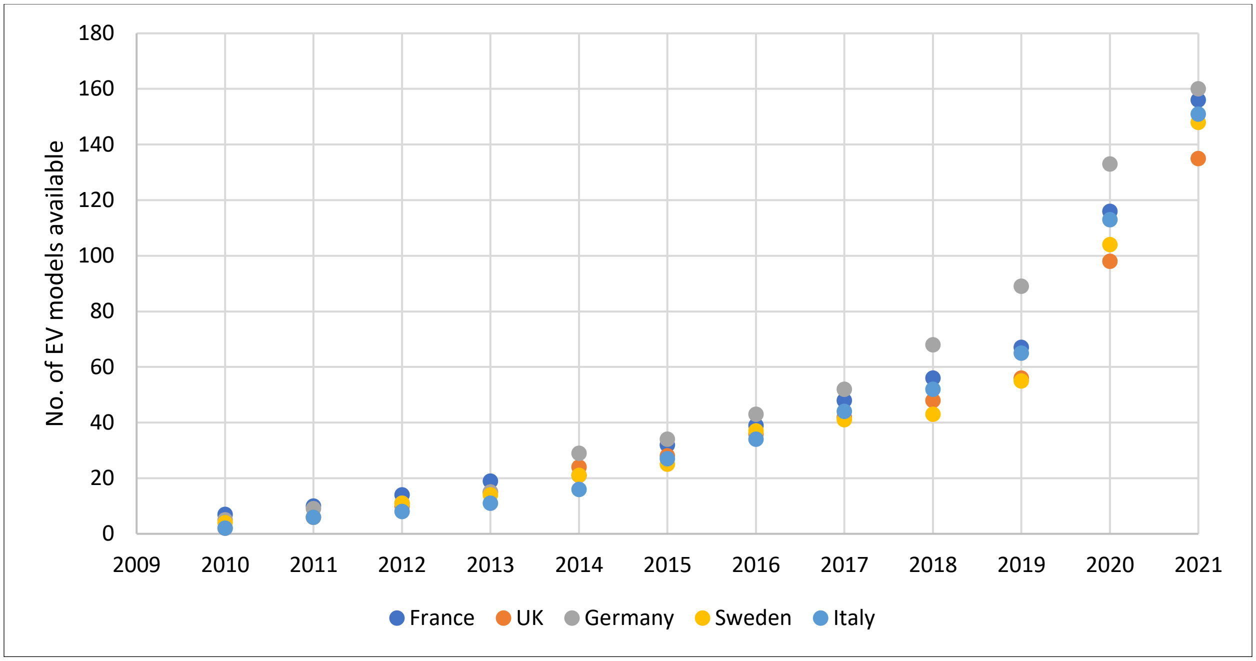

Figure 13: EV model and variant sales by country, 2010 – 2021

Table 5: Country-wise availability of BEV and PHEV models between 2010 – 21

Country	EV	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
France	BEV	7	10	10	13	14	16	17	17	21	27	48	66
	PHEV	0	0	4	6	7	15	20	29	32	38	66	87
UK	BEV	2	5	7	10	12	12	13	14	16	21	32	54
	PHEV	0	1	3	4	11	14	21	26	31	33	64	79
Italy	BEV	2	5	7	8	12	14	16	17	20	28	47	68
	PHEV	0	1	1	3	3	12	18	27	31	35	64	82
Germany	BEV	5	7	8	11	16	14	15	18	26	29	51	68
	PHEV	0	2	3	4	12	19	26	31	39	57	78	89
Sweden	BEV	4	4	6	8	13	9	13	11	15	20	37	60
	PHEV	0	2	5	6	8	15	22	28	27	34	66	86

The average ratio of PHEV to BEV models available has been declining, indicating more BEV models being made available in the automotive markets across the five countries. From an average ratio of 1.6 (PHEV to BEV models sold) between 2017-20, the ratio has declined to 1.35 in 2021, marking a rise in BEV model availability (Table 5).

A further analysis of the sensitivity of EV sales to model availability can be seen in Figures 14 – 18, which plots EV sales to model availability for 2015 to 2021 and fits a linear trendline to further understand the correlation between model availability and EV sales (but not implying any causality). It is observed that for every additional model available, BEV sales indicate higher growth propensity compared to PHEV sales among all countries except in Sweden. Further, in Sweden the model availability to additional EV sales is relatively similar for both BEV and PHEVs. For every additional model available, the response ratio of BEV sales to PHEV sales is highest for the UK and France, followed by Germany and Italy (Table 6).

Table 6: Country-wise EV sales and model availability from 2015-21

Country	**BEV sales per additional model**	**PHEV sales per additional model**	**Sensitivity difference *(BEV per model / PHEV per model)***
France	2457	1191	2.1
UK	2860	1275	2.2
Germany	4138	2375	1.7
Sweden	889	871	1.0
Italy	792	566	1.4

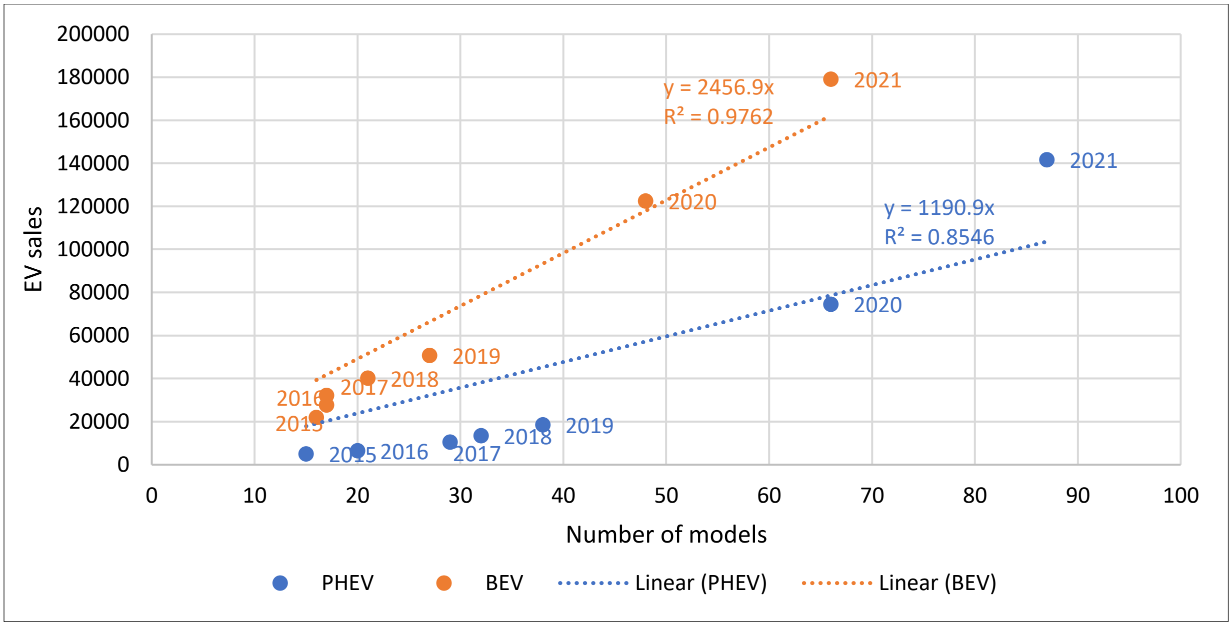

Figure 14: EV sales vs model availability sensitivity in France, 2015-21

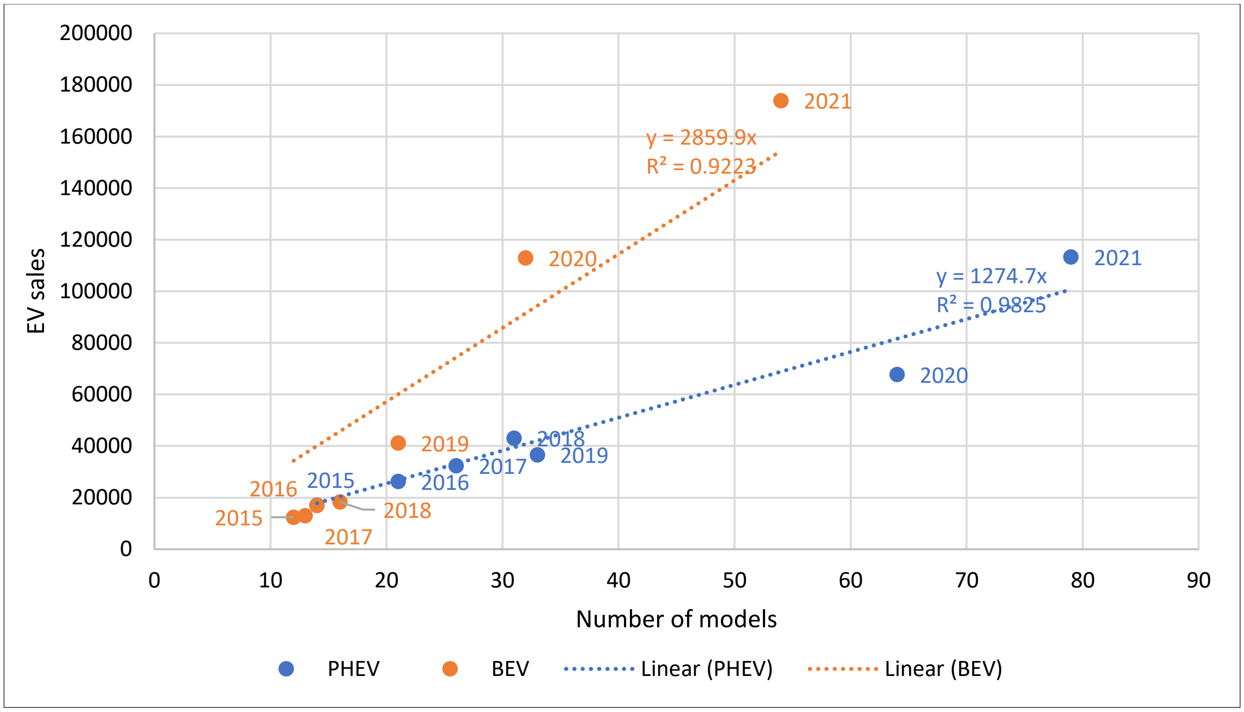

Figure 15: EV sales vs model availability sensitivity in the UK, 2015-21

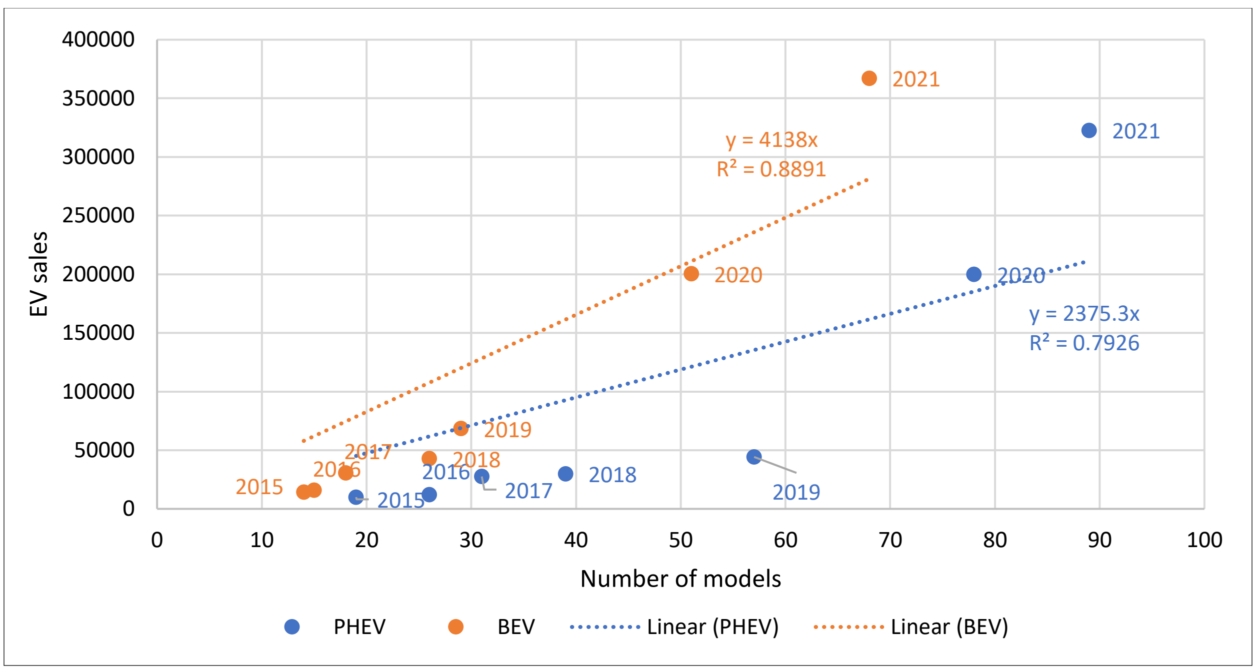

Figure 16: EV sales vs model availability sensitivity in Germany, 2015-21

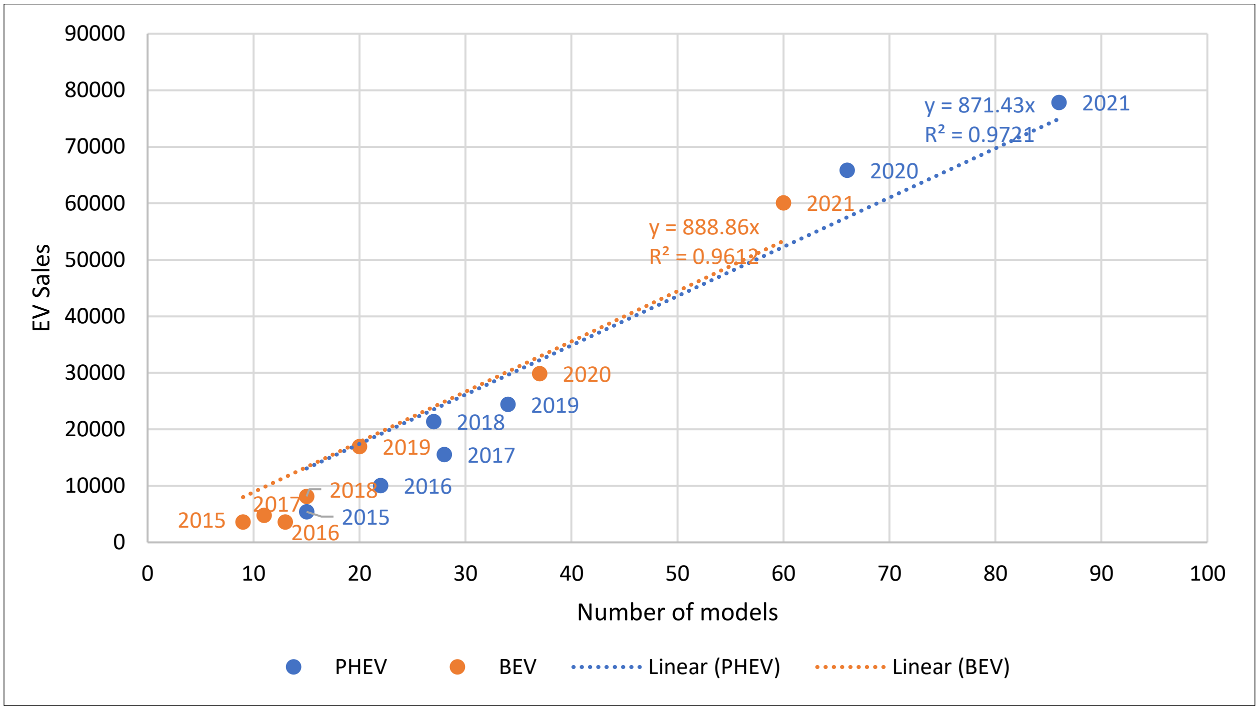

Figure 17: EV sales vs model availability sensitivity in Sweden, 2015-21

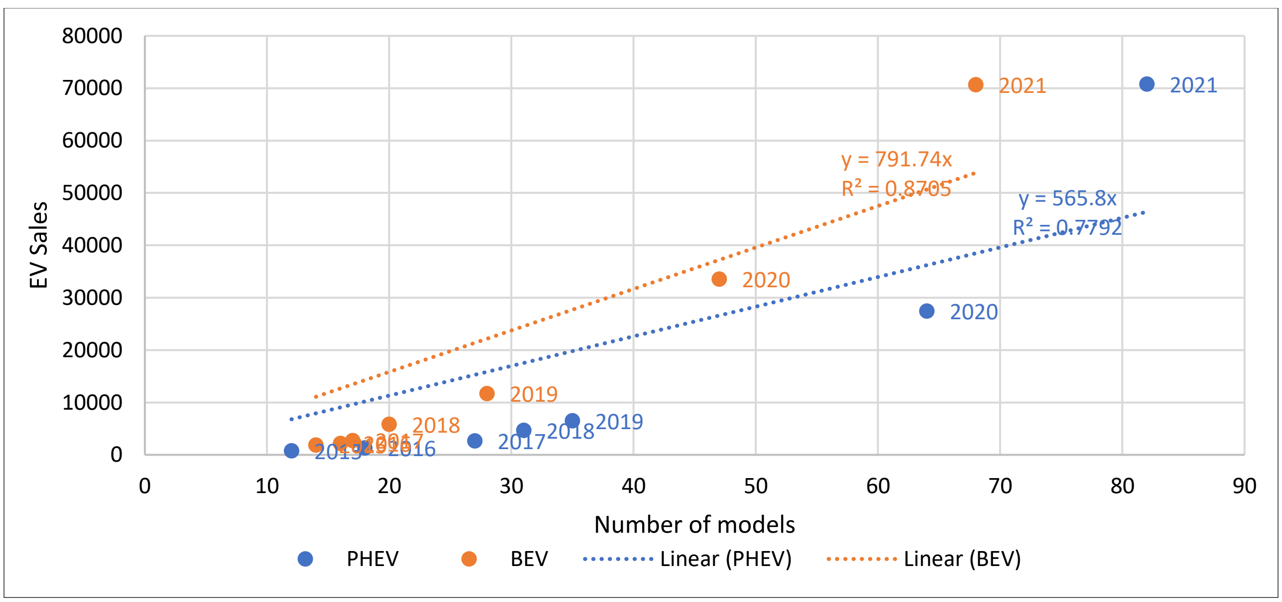

Figure 18: EV sales vs model availability sensitivity in Italy, 2015-21

To understand the distribution of vehicle registrations in the context of the feebate mechanisms, this section analyzes vehicle registrations and vehicle parameters data for the year 2020 (European Environment Agency, 2023). NEDC emissions cycle estimates are considered for this analysis, as not all reporting had transitioned to WLTP in 2020. Based on the EU emission target in 2020, three emission classes are considered between 0-95 gCO_2/km, 96-130 gCO_2/km, and greater than 130 gCO_2/km (Table 7).

Table 7: Country-wise vehicle parameters by emissions class for the year 2020

Country	Avg. CO_2 (NEDC)	% of total registrations	Avg. WLTP	Avg. Mass (kg.)	Avg. Engine Capacity (cm^3)
France	0-95	28%	75.8	1398	1481
	96-130	66%	135.3	1315	1330
	> 130	6%	175.9	1678	1935
Germany	0-95	19%	45.6	1629	1632
	96-130	50%	137.8	1367	1452
	> 130	31%	188.9	1749	2123
Sweden	0-95	40%	42.8	1799	1775
	96-130	35%	139.2	1415	1475
	> 130	26%	180.7	1759	2018
UK	0-95	21%	64.0	1566	1498
	96-130	53%	137.3	1354	1367
	> 130	26%	187.0	1776	2068
Italy	0-95	23%	102.3	1239	1298
	96-130	63%	135.2	1315	1351
	> 130	14%	179.7	1695	1904

Sweden has the highest share of vehicle registrations in the 0-95 gCO_2/km NEDC range, which translates to an average of 43 gCO_2/km (WLTP), which is in line with the dominant PHEV sales. In this segment, Sweden has the highest average mass per vehicle (1800 kg) and average engine capacity (1775 cm^3), indicating the dominance of gasoline-electric hybrids. As in Figure 6, the Swedish CO_2 tax is relatively low, compared to the rebates being offered, thus, not serving as a strong disincentive for larger cars.

In the case of France, the 96-130 gCO_2 range has 66% of the vehicle registrations in 2020, which has remained relatively the same when compared to the 2015 data at NEDC test levels. In this segment, while the average vehicle mass has increased by about 2% between 2015-20, the average engine capacity has declined by about 6.5%. The average WLTP emission value for over two-thirds of the vehicles registered in France is 135 gCO_2/km, which is at the lower end of the malus, as the donut hole extends till 132 gCO_2/km.

Italy has a similar distribution to France, with two-thirds of the registration in the 96-130 gCO_2/km category and having similar average WLTP emission values. **Italy would likely need to consider a similar policy**

to France but will also have to re-calibrate its malus curve to be more stringent and include more vehicles within its scope, as the French experience has shown.

The UK, Germany, and Sweden have almost one-third of vehicle registrations in the highest emissions bracket and could likely have a significant impact on EV adoption if they raised the emission-based taxes sufficiently for all vehicles with emissions above at least 180 gCO_2/km (WLTP), and then, gradually increase the fee rate for all vehicles. Germany has the highest weighted average engine capacity, and it will be interesting to see how the engine displacement-based taxation, in addition to the CO_2 tax, will play a role in consumer choices.

In Figure 19, the data shows the change in average CO_2 emissions of all new passenger cars sold in each year between 2010 – 19 in France relative to EV sales. A logarithmic curve fit for EV sales and average new car emissions provides the best trendline fit based on R-squared values, indicating that the early benefits of increasing EV sales saw a rapid decline in average emissions, and going forward, France will require a significant increase in EV sales to achieve substantial emission reduction benefits. This is likely a consequence of the EU CO_2 standards design, which was typically set every 5-years, while feebate revisions are not aligned in the same timeline.

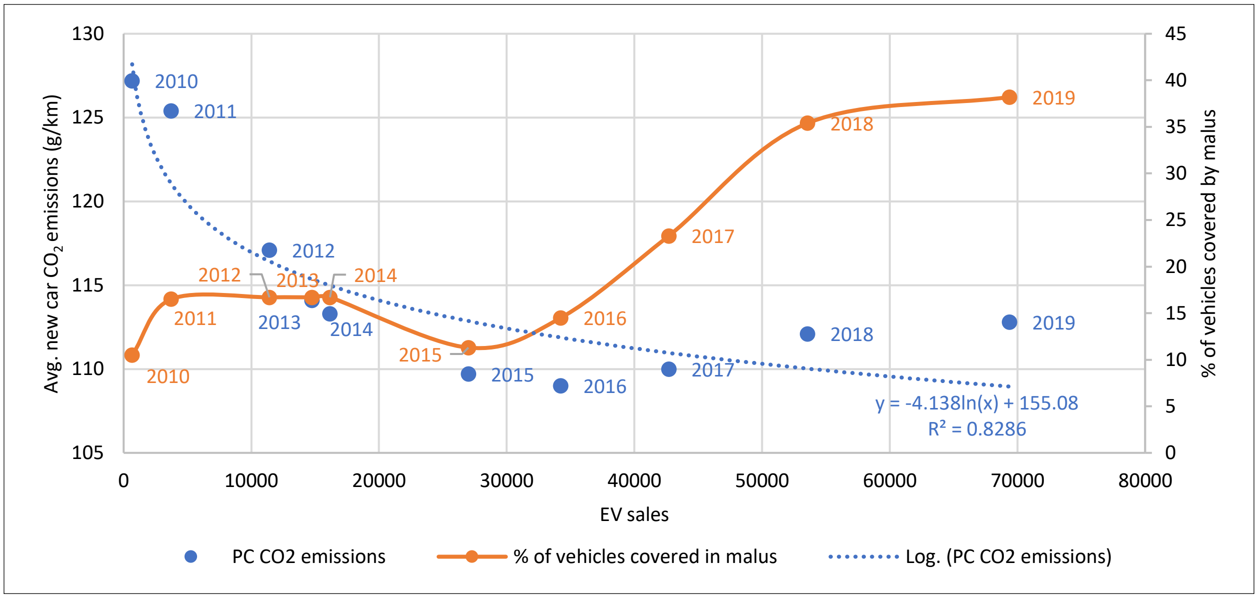

Figure 19: EV sales vs average passenger car CO_2 emissions (g/km, NEDC) in France, 2010-19

Figures 20-23 plot the share of registrations by emission class as defined in each country's emission tax regulation, and the secondary axis plots the emission tax for the mid-point in each emission class (with the highest emission class measured up to 300 gCO_2/km). Sweden and Germany are the only two countries that have most registrations within the coverage of the emission fee. In the UK, the slope of the fee curve becomes much steeper after the 150 gCO_2/km threshold, covering over two-thirds of the registrations below that. In Italy, the malus curve only covered 13% of vehicle registrations in 2020.

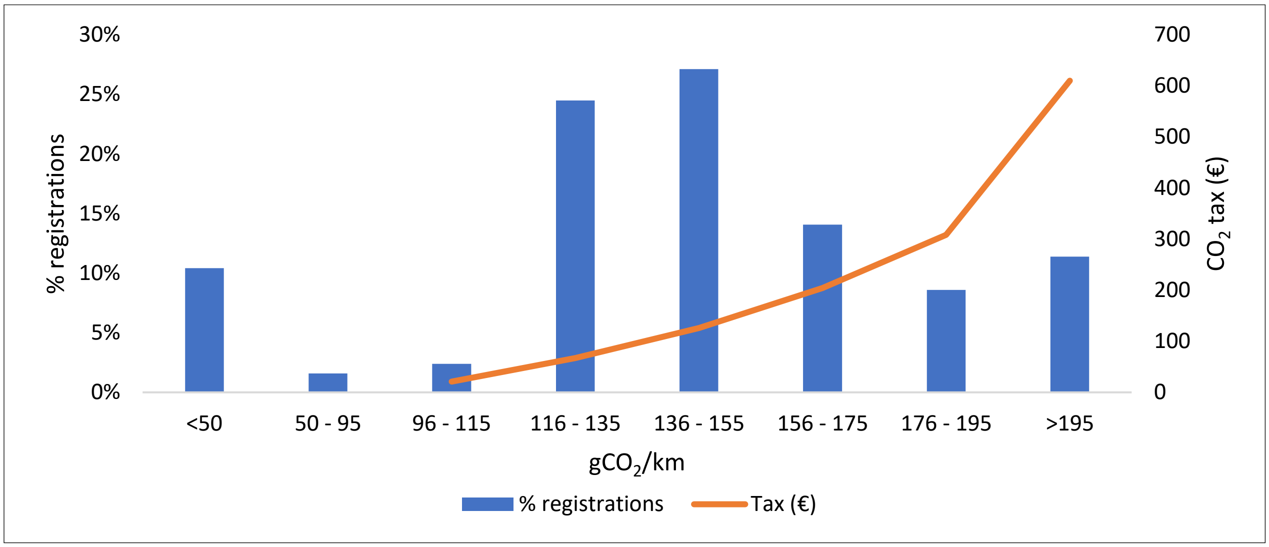

Figure 20: Share of vehicle registrations by emission categories in Germany (2020)

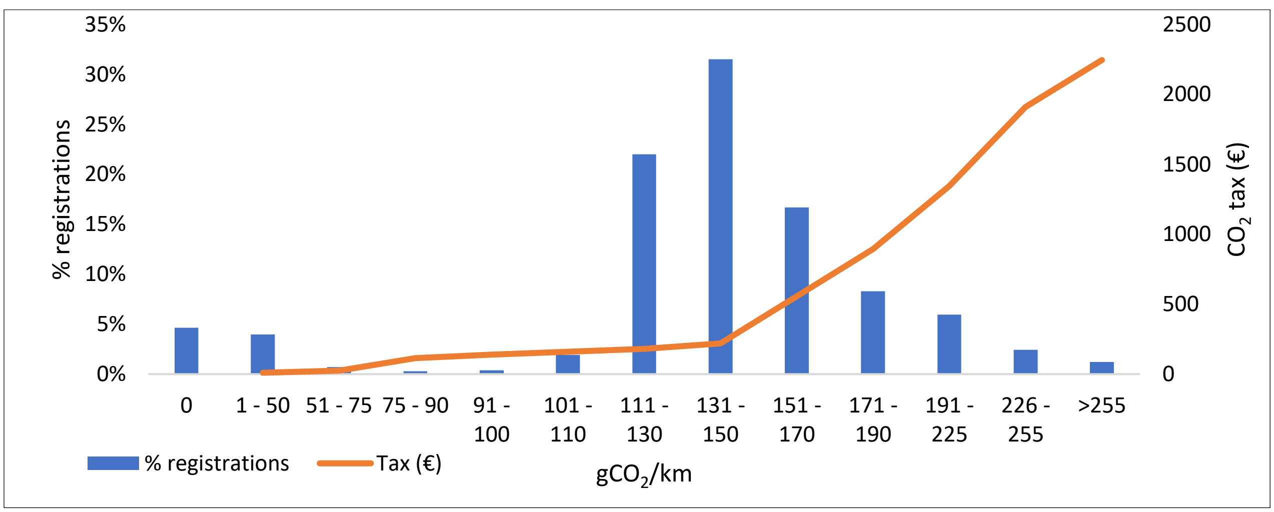

Figure 21: Share of vehicle registrations by emission categories in the UK (2020)

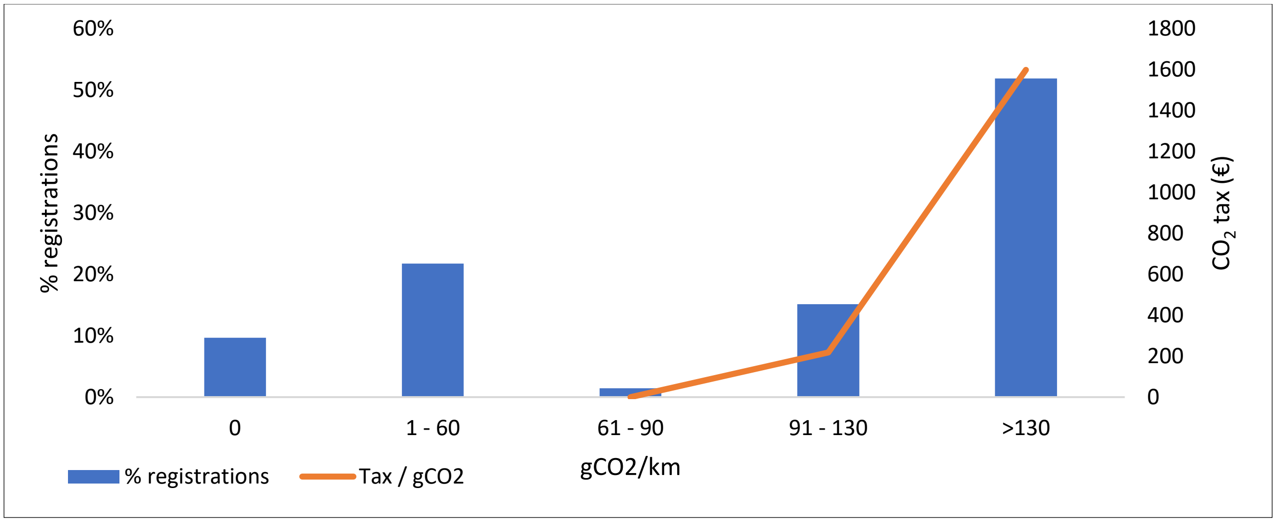

Figure 22: Share of vehicle registrations by emission categories in Sweden (2020)

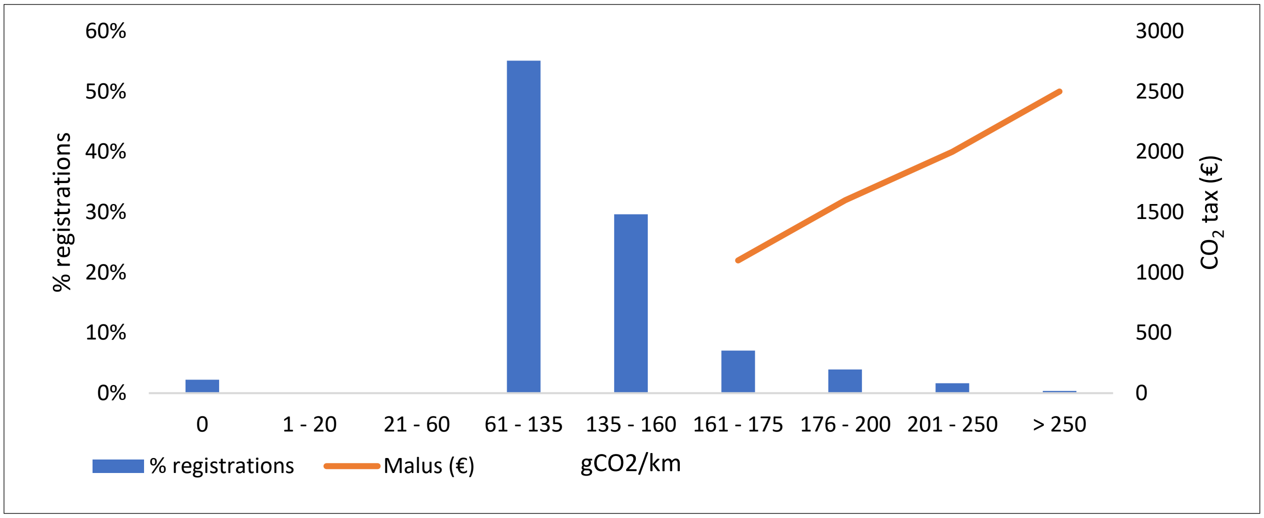

Figure 23: Share of vehicle registrations by emission categories in Italy (2020)

1.5 Other Considerations in Designing a Feebate System

The above analysis sets the base to understand two other important aspects of a feebate mechanism: (i) consumer preferences, and (ii) revenue neutrality.

1.5.1 Preserving consumer preferences

The feebate mechanism can be designed to preserve consumer choice by imposing a fee and rebate within a range of vehicle sizes and types preferred by car buyers in any given market. If there is a fuel efficiency (Corporate Average Fuel Efficiency or CAFE) standard with multiple vehicle types, an equivalent feebate can have separate functions for each vehicle type (Gillingham, 2013a), although, a feebate system that treats all vehicles equitably, without any attribute adjustments across different categories would be ideal (German and Meszler, 2010). Challenges of a size-neutral design would most likely include differential impacts on automakers based on vehicle portfolios, although studies find that feebates can lead to enhanced manufacturer revenues, given the higher value-add for new-technology vehicles (Changzheng et al., 2012; David L. Greene et al., 2005a; Liu et al., 2011b).

The French government in 2007 underestimated the response to the feebate scheme. The demand for smaller and more fuel-efficient cars in the early years and subsequently, for EVs, rose rapidly. While the fees were increased over years, the bonus eligibility included a price-cap on EVs (as in most countries for EV incentive eligibility), thus, in part, forcing automakers towards mid-sized, cost-effective EVs. But given the urgency for a shift to EVs, it was imperative that the slope of the fee line be adjusted to accelerate EV adoption. EV sales saw a significant increase in France from a 3.1% share in 2019 to 15.4% in 2021. During this time, they also extended the 2020 purchase bonus to 2021 instead of phasing it down, keeping demand robust during the pandemic.

This section investigates the consumer preferences for vehicle segments across passenger cars and SUVs as can be seen in Figures 24-26 (for this analysis, MPVs are included within the SUV segment). Essentially, it is observed that there is a general shift to D-segment EVs among cars in most countries, except Italy, where there is a clear shift to A-segment EVs. Similar emerging trends in the case of SUVs are also observed, with all countries moving to C-segment EVs, with France, Germany and Italy moving upwards in size, while Sweden and UK move downwards in size. Overall, in case of EVs, France and Germany have transitioned in a similar manner, while Sweden and the UK have shown a similar transition.

Comparing the EV consumer choice trends to overall LDV sales in these countries, a similar trend is seen, wherein LDV sales have essentially been dominated by C-segment in most countries. Germany, Sweden, and the UK are all dominant C-segment markets for LDV sales, while Italy and France are dominant B-segment markets (Figure 27).

Two key insights evolve: (i) between 2015-2021, all five countries have seen an overall convergence to C-segment EVs being the dominant share; and, (ii) in the early years of the transition, consumer choices were probably constrained by affordability and model choices, but gradually over time, with greater model availability as well as significant changes to the CO_2-based taxation, consumers are tending to preserve their choices, and not necessarily change vehicle size preferences.

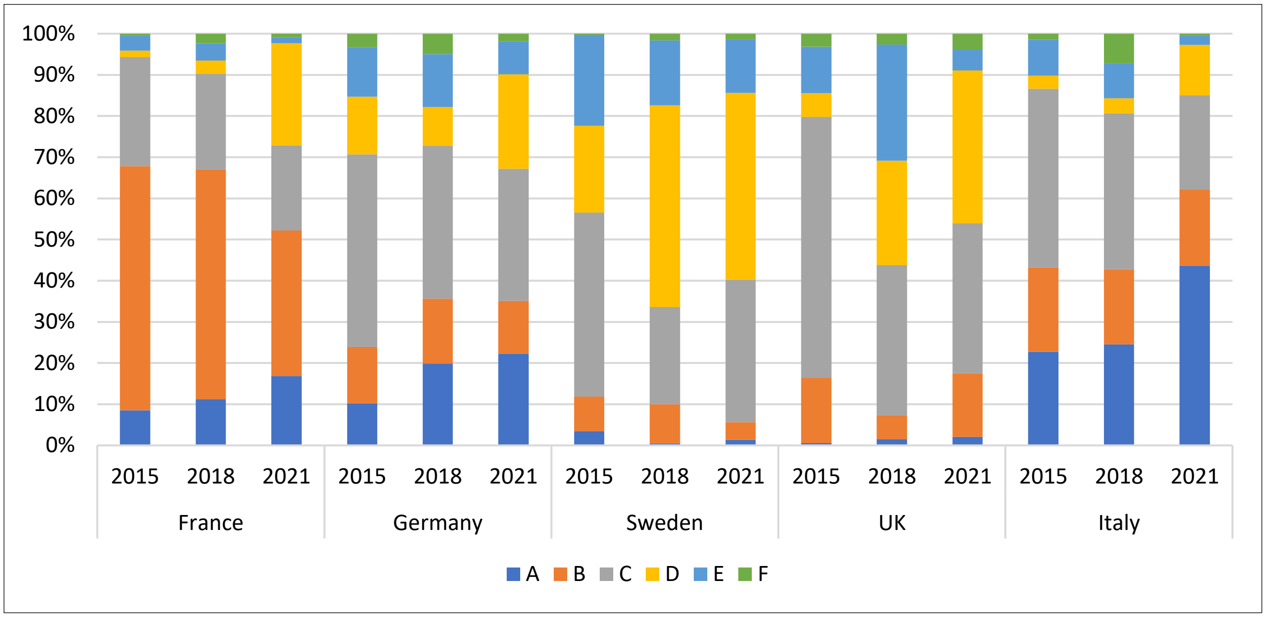

Figure 24: Share of EV car sales by segment size

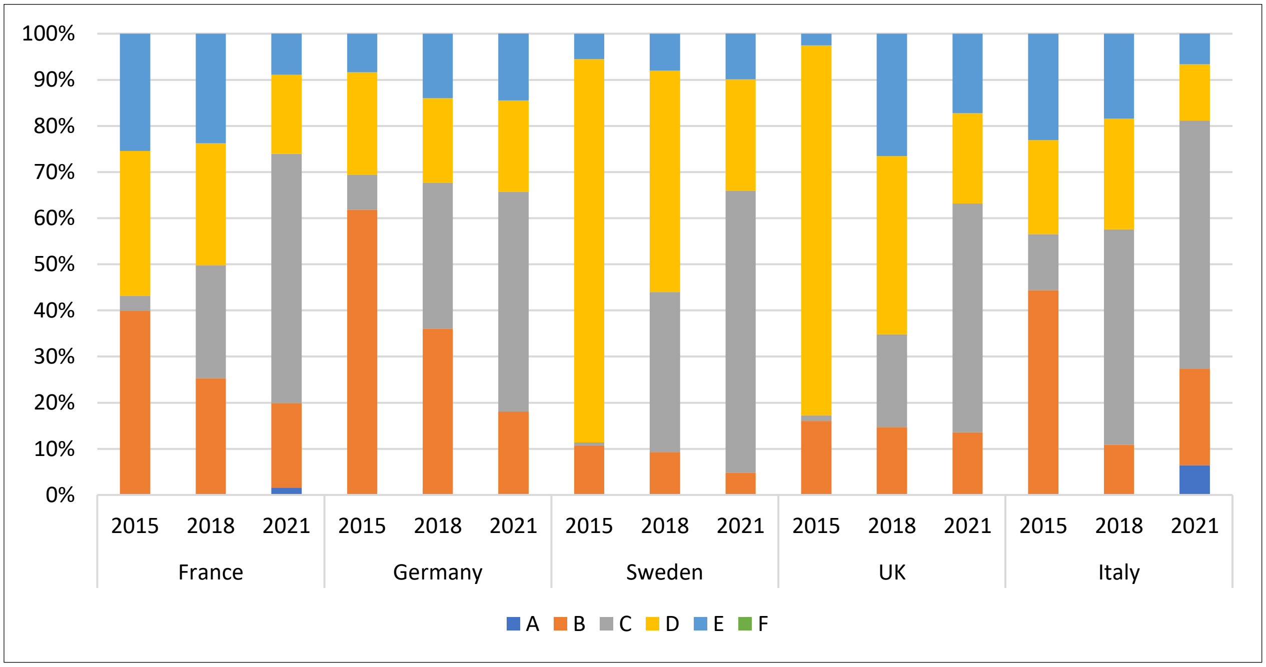

Figure 25: Share of EV MPV/SUV sales by segment size

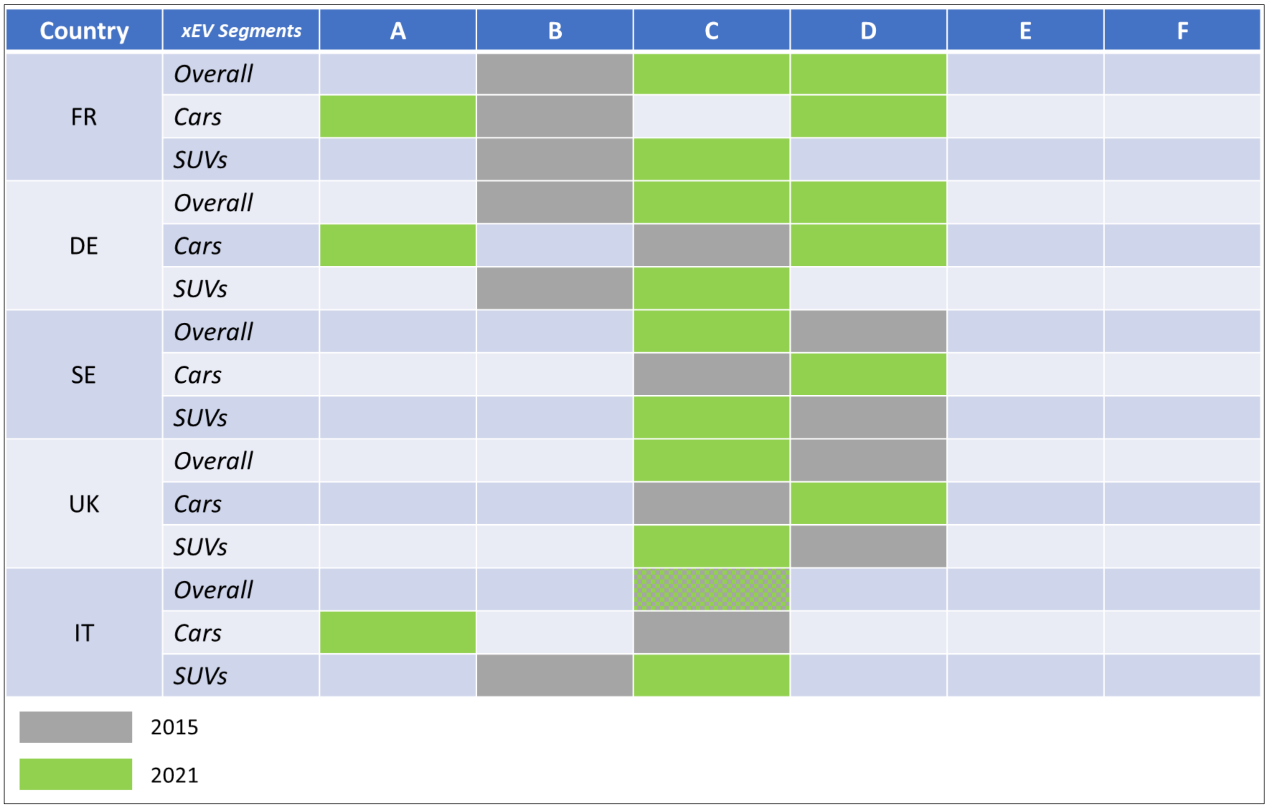

Figure 26: Transition of predominant vehicle segment choices for EVs across vehicle types, 2015-21

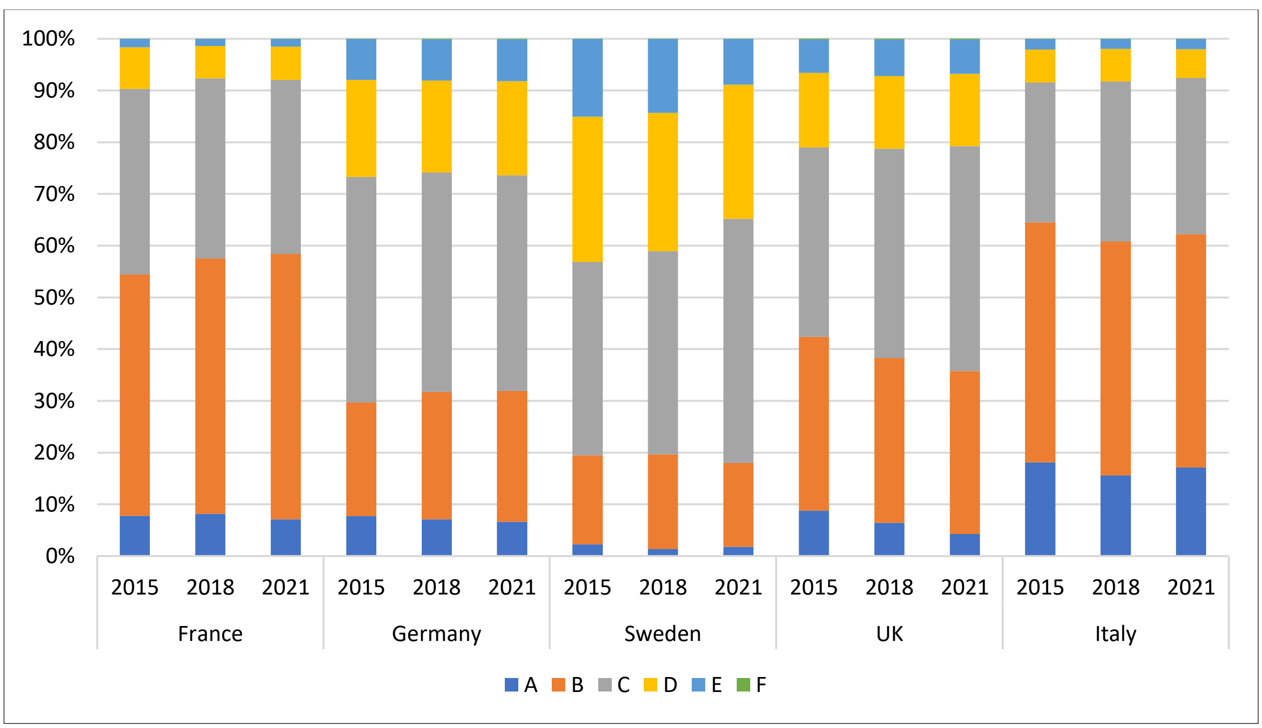

Figure 27: Transition of predominant vehicle segment choices for total LDV sales, 2015-21

1.5.2 Political acceptability and revenue-neutrality

Unlike general tax revenue which is often appropriated by congressional or legislative approved budgets annually, a specific feebate for clean vehicles would almost instantly redistribute the tax revenue gained from higher emitting vehicles to reward consumers purchasing efficient or low emission vehicles. Given its potentially redistributive nature, a feebate need not necessarily be seen as a tax, but rather a carbon dividend payout to society (Ramseur and Leggett, 2019). Feebates can also have strong public support if they are deemed to be fair, which is where the lessons for an effective feebate design play a critical role (Martin et al., 2014).

Another important feature of feebates is that of revenue-neutrality. They can be designed such that the fees levied can at least be equal to the rebates offered plus the administrative costs. From a fiscal perspective, this has worked for countries including France and Sweden. It took France a few years to forecast and manage the feebate to balance the flow of revenues, achieving surplus revenue since 2014. In Sweden, the government expected a surplus of SEK 0.43 billion (~€42 million) in 2018, SEK 0.09 billion (~€9 million) in 2019 and SEK 0.58 billion (~€56 million) in 2020 (Ministry of Finance, 2017). In Germany, given the hybrid nature of the policy, it is yet to be analyzed how much of the revenue collection will help co-finance the EV rebates. As per the German government, €2.09 billion have been earmarked from 2020 onwards to fund the EV rebates program, at least till 2025 (Federal Government of Germany, 2023). In Italy, the government had allocated €60 million for 2019 and €70 million for 2020 and 2021, for rebates towards BEVs and PHEVs. But given that the Italian bonus-malus scheme was launched in 2019, the revenue flows are yet to be analyzed in detail.

1.5.3 Ensuring equity to minimize the distributional impacts of the feebate

It will be critical to make EVs more affordable to all middle- and lower-income consumers, while also minimizing any adverse short-term impacts of the fees on ICE vehicles to achieve a scaled and effective ZEV transition. Various geographies have made efforts to address some aspects of equity, by way of additional rebates for EV purchases by low-income households, used-EV schemes, or vehicle trade-in programs (European Automobile Manufacturers' Association, 2022, 2021).

For 2021, France provided a maximum combined rebate of € 12,000 for the purchase of used or new BEVs and PHEVs for scrapping an older ICE vehicle subject to household income. They also have a bonus of €1,000 if an individual lives or works in a low emission zone. The low-income rebate conditionality also distinguishes between vehicle buyers as 'average commuters' or 'heavy drivers', based on their home-to-work commute distance. In Italy, the bonus-malus scheme includes a provision for low-income households who purchase new EVs with a power of less than 150kW and a list price less than €30,000 (excluding VAT).

Germany does not have a specific low-income grant for purchase of EVs but provides incentives on purchase of used EVs, although, the second-hand EV should not have received any federal rebate on original purchase. This could be a potential barrier for low-income households to access EVs and could be amended to ensure that a new EV sold with a rebate cannot be resold for at least 2 years from the date of original purchase.

The UK illustrates potential equity impacts arising out of changes to the feebate design. While it increased the CO_2 based taxation in 2020, the UK reduced the EV purchase rebate, with no safeguards for low-income vehicle buyers.

It will be imperative that policies are designed in a manner that helps shift middle- and higher-income households to EVs while still addressing issues around range anxiety and reliable infrastructure.

1.6 Key insights and considerations of a feebate design for a ZEV transition

As seen in earlier sections, various EU countries continue to rely on feebates as an effective policy tool to achieve transitions towards low and zero emission vehicles.

While there are key elements of a feebate mechanism that should be considered while designing it for implementation, there is no one single or 'optimal' design. Different policy objectives can be served by a feebate mechanism, which would influence its design and its effectiveness as a policy solution. This section highlights a few policy objectives where feebates can play a role in meeting them, and possible conditions under which they would work.

One of the most fundamental policy objectives could be to shift to more fuel-efficient ICE vehicles. Italy is a good example, which essentially imposed a fee on less than 15% of the vehicles sold (among the highest emission classes). The possible reasons for this policy design include protecting Italy's domestic automotive industry, and overall government commitment towards enhanced climate action.

Using feebates to facilitate a shift to EVs has emerged as a more recent objective. Feebates can be amended over time to meet differing policy goals, as in the case of France and Germany. France's initial objective was to shift the market to more fuel-efficient ICE vehicles, and over time has revised the feebate design to facilitate a shift to EVs. A more constrained version of the policy objective would be to use feebates to shift to ZEVs only.

At a global level, using feebates to shift to more fuel-efficient vehicles could be well-served in countries (especially developing economies) where technology leapfrogging to EVs is challenging. Countries like India, which have not set national EV targets but at the same time only incentivize a shift to BEVs (and no PHEVs), could benefit from a feebate mechanism designed to meet the ZEV transition objective. Moreover, the financial sustainability of stand-alone EV incentive programs has come into question, and thus, a self-financing market mechanism could be the 'need of the hour' solution.

Irrespective of the policy goals, a feebate will impact both the supply and demand side. In either case, the cost of an ICE vehicle in most segments becomes prohibitive for sale (industry viewpoint) or purchase (consumer viewpoint). Depending on the feebate design, the industry will shift its strategy towards more policy-compliant vehicles, likely to increase EV model availability and bring down technology costs. With the fee effectively imposed on consumers, it creates an equilibrium of sorts in the market between supply and demand objectives. Feebates could also be used to address additional policy goals, such as curtailing growth of certain kinds of vehicles, for example, very large SUVs.

Based on a review of the feebate mechanisms prevalent in major European countries as presented in this paper, **twelve key insights are highlighted towards designing a feebate policy that can facilitate an inclusive ZEV transition in the next decade** (Figure 28).

1. **Pure feebates, where fee revenue is utilized for EV incentives, provides greater certainty.** A clear mandate of funds utilization provides a certainty to the market and provides the government flexibility in planning for additional budgetary allocations to bridge the resource gap.
2. **Identify the distribution of vehicles sold by emissions (gCO_2/km).** To effectively decide the fee schedule, its functional form and the pivot point, it is important to first understand the average prices and vehicle type (SUVs or cars) across different emission classes. A further but not necessary step can be to better understand household income levels and prices of vehicles purchased.
3. **The choice of having a single pivot point or a donut-hole should be based on an analysis of the type of vehicles being sold in the market**, possibly a percentile approach based on vehicle prices and/or emissions. This will define which of the vehicles being sold in the market will be taxed or receive a rebate or be excluded from the feebate mechanism altogether (donut-hole). The choice of the pivot point goes together with the prevailing fuel efficiency and emission norms.
4. **Focus on a single fee parameter, i.e., CO_2 emissions, can be a simple yet effective mechanism.** A CO_2 emissions-based fee mechanism should form the basis of vehicle taxes, as it will provide manufacturers the flexibility around adjusting other vehicle attributes if they meet the emissions reduction targets. Having a single parameter, i.e., CO_2 emissions can be efficient, easy to interpret, monitor and implement within the feebate design. Where introducing emission taxes can be a challenge, there may be a case for attribute-based taxation as an alternate measure, but it may still not lead to a technology shift in terms of a transition to EVs, and even more so for ZEVs, as attribute-based taxation may not serve as a strong hedonic pricing mechanism for emissions externalities. Vehicle attributes are increasingly becoming complex variables with non-linear relationships to vehicle emissions.

   As the share of EVs increases, it will be important to address CO_2 emissions from the electricity grid, which will be critical to ensure efficiency for EVs as well. It can continue to generate revenue in a feebate mechanism, even in cases of high EV adoption.

5. **A continuous functional form for the fee and a stepwise rebate are likely to be most effective in driving EV adoption.** A continuous fee function (preferably a non-linear fee function, with a steep rise in fees for higher emission values) for every unit increase in CO_2 emissions (g/km), rather than a step function, provides the best way to avoid system gaming and ensure continuous incentives to build and purchase lower CO_2 vehicles. A piece-wise linear fee function can also be designed to generate sufficient revenues by imposing the highest tax burden on high-emission vehicle buyers as compared to the middle 50th percentile of vehicle buyers. Further, in case of rebates, it is seen that a stepwise function (as compared to the fee function) will likely be more efficient as it can be structured to incentivize PHEVs with higher all-electric range requirements in the interim and target greater rebates towards ZEVs.
6. **Periodic revisions in the slope of the curve and the pivot point can help ensure a revenue-neutral system.** Providing a clear horizon on the functional form for the fee gives positive market signals, as seen in the French and Danish experience. A relatively shorter frequency of revisions (every 2-3 years) to the feebate design are likely to result in more favorable policy outcomes, as compared to longer revision periods, which might lead to either under- or over-estimating the potential for technology and market developments.
7. **The feebate design needs to be supported by external policy choices** such as vehicle price caps for incentive eligibility for EV purchases and All-Electric Range (AER) requirements for PHEVs. Overall, as a basic principle, the rebates need to reduce over time, while the fees increase, forcing both, automotive manufacturers, and consumers, to reconsider their choices.
8. **The differences in the point of collection of the emissions-based fee for the consumer will likely play a key role in the transition to ZEVs.** A higher one-time fee collected at point of purchase is expected to be more effective than an annual fee, given consumer discounting of future cash flows, and could well be the difference between choosing an ICE or electric vehicle. Similarly, applying rebates at point of sale are likely to be more effective than tax rebates or staggered

incentive payments. Direct monetary benefits at the point of purchase have a stronger influence on consumer choice than annual tax refunds.

9. **Model availability alone may not be sufficient to drive higher EV adoption rates. BEV sales indicate a higher growth sensitivity than PHEVs for every additional model made available in the market.** It could provide an important basis for future feebate design focused on a ZEV transition, such that the pivot point, fees and external policy variables such as AER for PHEVs can be adjusted to preferentially drive the market towards BEVs (which are zero emission at tailpipe) as opposed to PHEVs.

10. **Feebates do not necessarily constrain consumer preferences for vehicle types (such as SUVs or cars).** Between 2015-2021, all five countries analyzed in this paper see an overall convergence to C-segment EVs, similar to ICE vehicle choices, without any specific disincentive on vehicle footprint.

11. **Equity considerations for those in low-income groups and other disadvantaged communities will be critical in ensuring a mass transition to EVs, as well as distribution of benefits across society.** Of the five European countries, except France and Italy, there is no explicit support for low-income households to purchase EVs. Various measures can be considered including used-EV schemes and vehicle trade-in programs. Also, low-income, and disadvantaged communities can be supported to transition to PHEVs before a move to BEVs, given constraints of access to infrastructure.

12. **It is important to have a robust monitoring framework.** It is essential to maintain a holistic database of vehicle sales, their pricing each year, emissions portfolio, and so on, to facilitate a periodic revision of the feebate mechanism, to make it self-sustaining. Making realistic forecasts of responses to feebates has been challenging given the lack of literature on relevant elasticities (Berthold, 2019b).

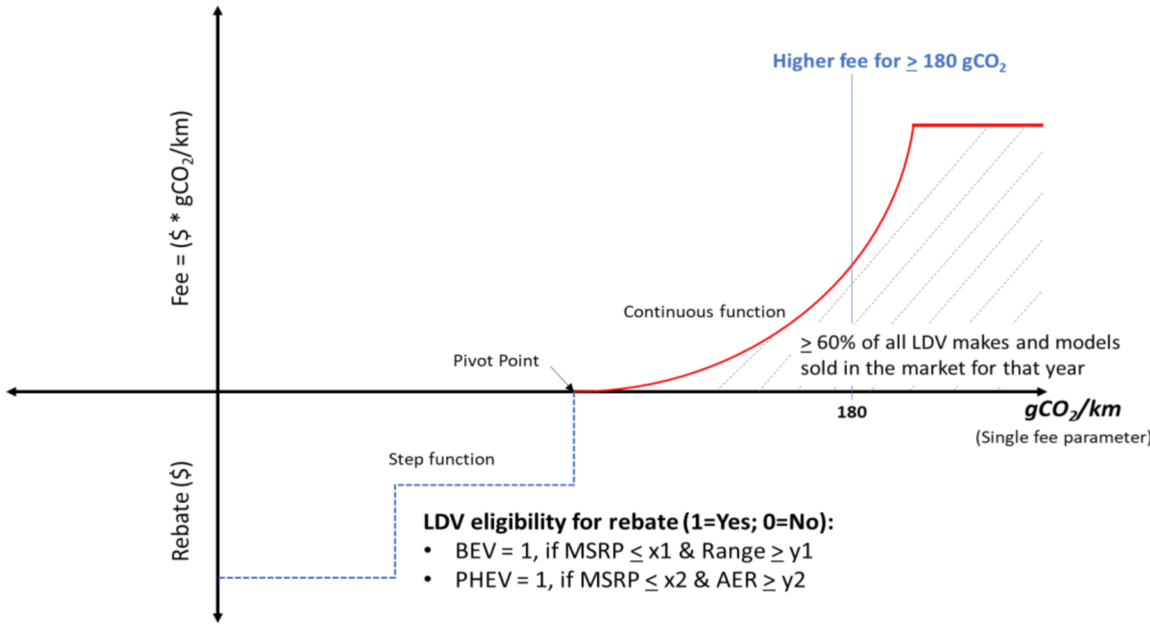

Figure 28: Key elements of a feebate mechanism towards an inclusive EV transition

1.7 Conclusions

Effectively, to achieve a ZEV transition, countries will have to re-align their feebate mechanisms in a manner that targets most of the ICE vehicles sold, while keeping in mind equity considerations for those in low-income groups and other disadvantaged communities. Having said that, reaching the goal of a ZEV transition will likely happen in phases, with a mix of PHEV and BEV sales as in present conditions, and then, a shift to only BEV and other ZEV technologies.

With the growing urgency for a ZEV transition, the fiscal pressure for many countries can be significantly higher, given potentially long-term rebate requirements to sustain the transition and higher technology costs for alternate ZEV technologies. The feebate mechanism is a good approach to raise the necessary capital for financing a ZEV transition, in combination with other regulatory mechanisms. They can also play a critical role in pushing manufacturers towards investing in ZEVs, thus, bridging the gap between TCO and price parity between EVs and ICEVs.

Based on the feebate design, it can be revenue neutral or revenue positive, the latter offering opportunities to utilize the additional funds, for example, to create public charging infrastructure, or be allocated towards subsidizing public transit or other active modes.

Feebates are essentially redistributive in nature and adhere to the more fundamental principles of taxation, which is to create a public good to the best extent possible. The tax is on higher polluting vehicles, and by design, can offer rebates targeted towards assisting middle and low-income households for EV purchases. Also, feebates need not be used in perpetuity. Once, price parity is achieved as the feebate pushes EV sales volumes to a critical mass, by impacting both consumer choices and manufacturer strategies, the rebate burden will decline significantly, and will be largely required for a smaller share of low-income households. In the future, innovations in feebate design can be adopted to meet specific transportation goals. In a high EV scenario, feebates could be adapted to target VMT (Greene, 2011; Musti and Kockelman, 2011; Paz et al., 2014; Zhang et al., 2009). At the same time, VMT-based feebates could have equity considerations as lower income households tend to travel longer distances out of compulsion and not voluntarily.

Future analysis could include: (i) an econometric evaluation to estimate the effect of feebates on EV sales compared to other vehicle parameters and market conditions; and, (ii) evaluating a potential for a feebate design for other leading automotive markets such as the US or India, to facilitate an EV transition.

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Chapter 2: Equitable Revenue-Neutral Incentives for Zero-emission Vehicles in the United States

2.1 Introduction

The transition to zero emission vehicles requires a change in consumer purchasing (and use) behavior. The United States, under the Biden Administration, set an ambition of reaching a 50% sales share for zero-emission vehicles by 2030 (US Government, 2023) and is pursuing a combination of aggressive fuel economy and greenhouse gas performance standards[4] along with tax credits for EV purchase (Internal Revenue Service, 2023). Some states in the US, led by California, have adopted ZEV sales mandates as well as additional purchase incentives to encourage increased sales (CARB, 2022). The overall ZEV market share rose to 9.2% for the US in 2023 (EV Volumes, 2023).

Assuming average annual US LDV sales remain at historical levels of 16 million, the 50% market share target would translate to 8 million new EV sales in 2032, requiring EV sales to grow at 20% compounded annual growth rate (CAGR), after 2023. Between the major provisions in the Inflation Reduction Act (IRA) of 2022 and the Infrastructure Investment and Jobs Act (IIJA) of 2021, the US Government has allocated $25.7 billion for EV purchase and infrastructure incentives, cumulatively up to 2032. Of this, about $7.54 billion are allocated towards EV tax credits for new sales between 2023-32 (McCarthy, 2022; U.S. Government, 2023a). Assuming an average incentive of USD 3,750 per EV, the funding would be able to support about 2 million EVs, which translates to about 5% of all EVs needed between 2023-32 to achieve the 50% EV ambition.

Further, the US EPA estimates an average compliance cost of $1,200 per vehicle in 2032 for CAFE compliance under the Phase-3 regulations (i.e. ICE vehicles only and does not include costs of electric powertrains for compliance), amounting to an additional cost of $180 - $280 billion between 2026 - 2032 (U.S. Government, 2023b), which could theoretically be diverted to EV investments as well for compliance.

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[4] As on 6 February 2024, the US EPA proposal on new CO_2 regulation for LDVs aims to reduce the average fleet GHG emissions by 56% in 2032, relative to 2026 standards (target of 82 gCO_2/mile in 2032). In its regulatory analysis, the EPA highlights two compliance pathways that include a 70% share of BEVs in 2032 across all LDV categories or a 40% BEV share in 2032 across medium duty vans and pickup trucks (NHTSA, 2023).

Irrespective, the amount of federal incentive funding for EVs does not come close to offsetting the additional cost of producing EVs. Moreover, the federal incentives are limited by a variety of conditions, including the source of the vehicle and batteries, the sale price of the vehicles, and the incomes of buyers (US Department of Energy, 2024).

State incentives are also sharply limited, highly uncertain, and not all apply at the point of purchase. State incentive funds are typically funded one year at a time, and often run out before the year ends (Alternative Fuels Data Center, 2023a; California Air Resources Board, 2023b; Department of Environmental Quality, 2023; Government of New Jersey, 2023).

Table 8 summarizes the ZEV regulations and incentives for states (Alternative Fuels Data Center, 2023b). As of December 2023, 12 states including California have adopted the Advanced Clean Cars (ACC) II regulation which requires manufacturers to meet increasing annual ZEV sales targets as a share of new LDV sales, from 36% in 2026 to 100% in 2035. These twelve states make up about 30-40% of total US LDV sales (California Air Resources Board, 2023c). But the ZEV sales mandates are imposed on automakers, not consumers. Consumers can delay new vehicle purchases and buy used vehicles. Indeed, there is considerable pushback against the required mandates (Friedman and Plumer, 2022). Given the uncertainty in costs of this transition and limited public funds, another policy mechanism might be compelling (Lazo, 2023).

Table 8: States adopting ACC II rules and current incentives for EV purchase

State	2023 in-state EV mkt. share	Target adopted	Incentives
California	26%	New ZEV sales at 35% for model year 2026; increases to 100% by model year 2035	Clean Vehicle Rebate Project (ended as of November 2023). Yet to announce new program.
Oregon	17%	Same as California; w.e.f. model year 2027 (43% new sales)	Oregon Clean Vehicle Rebate Project (suspended as of May 2023 due to lack of funds)
Washington	19%		EV Tax exemption only
New York	8%		Rebates of up to $2,000
Massachusetts	12%		Rebates of up to $3,500
Vermont	10%		Rebates of up to $4,000

Virginia	10%		Rebates of up to $2,500
Colorado	14%		State tax credit upto $5,000
New Jersey	13%		Rebates of up to $4,000 (temporarily suspended due to lack of funds)
Maryland	11%		One-time excise tax credit up to $3,000 (2023 - 2027)
Delaware	9%	Same as other states, but maxing out at 82% sales share in 2032	Rebates of up to $2,500
New Mexico	5%	Same as other states, but maxing out at 82% sales share in 2032	No purchase incentives

This chapter examines a market-based mechanism that is self-financing and provides more market certainty for both producers and consumers for a long-term transition pathway. The goal in this chapter is to: (i) design revenue-neutral incentive systems capable of rapidly increasing sales of light duty ZEVs along the target path toward a 100% sales share by 2035; and (ii) specify policy designs that preserve revenue-neutrality with relatively low average fees on lower emission vehicles in ways that improve social equity among vehicle buyers. This chapter addresses a national focus for the US LDV market, but could be applied in sub-national contexts, including California and other states that follow California ZEV regulations.

2.2 Feebates: Command-and-control versus market-based mechanisms

Moving beyond and often building upon traditional command-and-control approaches (referred to as regulatory instruments) to address externalities, environmental policy increasingly has relied on the use of market-based mechanisms to meet policy goals, including in transportation (Stavins, 2003). Market-based policies such as tradable development rights, industrial emissions control and tradable credits have been used especially in cases where abatement costs vary by polluters, aiming to shift the higher abatement burden on larger emitters (Lindsey and Santos, 2020; Neves et al., 2020; Peng et al., 2021; Xia et al., 2022; Zhang et al., 2020).

The shift to market instruments has been motivated by economic theory, which indicates that they are more economically efficient and less costly than regulatory approaches (Beiser-McGrath et al., 2022; Swaney, 1992). In the case of road transport, performance-based standards in the form of fuel efficiency requirements for cars and light trucks have been the primary policy tool used to regulate vehicle CO_2

emissions in the US, as in many other countries (Congressional Research Service, 2021; Greene et al., 2020). While such performance standards have led to overall efficiency improvements, they are not sufficient in the present context of achieving near zero LDV fleet emissions, in a short time frame of 2035 – 2040. This is because efficiency or CO_2 regulations provide limited incentive for vehicle manufacturers to go beyond the minimum compliance requirements as outlined in the policy (Anderson et al., 2011). Further, the frequency of revision of fuel efficiency standards is time consuming, i.e., they take about two years of rulemaking to notification and typically take four years from then to be enforceable. At the same time, while one can argue the case of the European Union setting a fuel economy target of 0 gCO_2/km by 2035 for the light duty segment, it is essentially the converse of imposing a ban on ICE vehicle sales or a ZEV mandate (European Union, 2023). More importantly, politically, it is part of the larger 'Fit for 55' climate package agreed by the EU in 2023 (European Council, 2023). The political economy of climate and transport policy is different in the US, and hence unlikely to deliver on a similar approach to the EU, making the case for a consideration of market-based policies to regulate vehicle CO_2 emissions in the US (Boasson and Tatham, 2023).

Various studies have compared the impact of market mechanisms such as feebates with performance standards such as fuel efficiency or CO_2 norms. A review of Japan's feebate policy found that it led to a significant increase in economic surplus, but design deficiencies led to less-than-ideal improvements in the average fleet fuel efficiency (Konishi and Zhao, 2017). In a comparison of feebates and fuel economy standards, a simulation study in the US and France found that performance standards lead to negative welfare effects, about 1.7 times larger as compared to feebates (Durrmeyer and Samano, 2018a). In Europe, major automotive markets such as France, Germany, Italy, and the UK have introduced feebates and strengthened the mechanism since 2017 with a focus on driving ZEV transitions. In the first chapter, I find that while EV sales share has rapidly increased in these countries, it has led to higher model availability across segments, more affordable EVs, and most notably, in the case of France, with a revenue-positive mechanism.

Overall, these and other studies find that market-based instruments can deliver significant cost savings while leading to environmental outcomes, in this case, zero tail pipe emissions. Moreover, such instruments also have the capability to provide greater flexibility, can be simpler for both producers and consumers to interpret and more importantly, can be monitored and enforced (Adamou et al., 2014; Rapson and Muehlegger, 2023c).

Thus, a market-based tax-subsidy approach such as feebates (David L. Greene et al., 2005b; Kessler et al., 2023a; Østli et al., 2022; Xing et al., 2021): (i) reduces the burden on government treasury and the average taxpayer; (ii) addresses the limited certainty on compliance costs through its own revenue generation potential; (iii) can be designed to be revenue-neutral or revenue-positive; (iv) provides greater certainty on emission reduction; (v) can be linked theoretically to a carbon market; (vi) allows for innovation in technology pathways; and, (vii) can be expanded to cover other aspects of the transportation system.

2.3 History of feebates in the US

Feebates have been attempted in the past, both at the state and federal level in the US. The Gas Guzzler tax which was imposed since 1978 has been possibly the closest federal law to a feebate mechanism (US Environmental Protection Agency, 2012). The tax essentially imposed a fee only passenger cars, and not on light duty trucks (LDT) (as these vehicles were not popular when the rule was passed) that had a fuel economy rating of below 22.5 mpg. But with very few cars below that threshold and over two-thirds of the market being LDTs today, the tax does not have any significance (Vehicle Technologies Office, 2021). The gas guzzler tax was essentially one half of a feebate, with just the fee and no rebate mechanism.

Among the earliest efforts to propose feebates in the US was the DRIVE+ (Demand-based Reductions in Vehicle Emissions PLUS Improvements in Fuel Economy) program in California, that proposed to create self-financing tax incentives for consumers willing to purchase cleaner and more fuel-efficient cars and trucks. The threshold was based on a combination of criteria pollutants and CO_2, with vehicles above the threshold facing a surcharge on sales tax, while those below would attract a sales tax reduction (Levenson and Gordon, 1990). The legislation was proposed as S.B. 1905 by California State Senator Hart in 1990 and while it passed the house, it was vetoed by the Governor.

In Maryland, a feebate law was enacted in 1991 but was never implemented (State of Maryland, 1991), largely due to the then interpretation of the U.S. Department of Transportation that Maryland's proposed feebate law for new vehicles conflicted with the federal government's authority to regulate fuel economy (Eilert et al., 2010).

Around the same period as California and Maryland, there were legislative proposals to emulate a feebate mechanism at the national level, none of which passed the US Congress. For example, Senator Wirth suggested a feebate in the proposed National Energy Efficiency and Development Act 1991 (S.1741), while the Clean Domestic Fuels Enhancement Act of 1991 (H.R. 2960), a bill by Rep. Synar, clearly stated the need to establish a fee and rebate program for vehicles. Later, in 2003, Senator Durbin proposed the Senate Amendment 1385 to S.14, which suggested the provision of additional tax incentives for enhancing motor vehicle fuel efficiency and other purposes (US Congress, 2003; U.S. Congress, 1991).

In the state of Rhode Island, there were various legislative efforts in 2003-04 to establish feebate mechanisms. In 2004, the Senate Bill 3024, also known as the Greenhouse Gas Vehicle Efficiency Act of 2004 proposed to introduce a feebate with an initial pivot point of 0.78 pounds CO_2 per mile (about 25.1 mpg), and an incentive rate of $2400 per pound per mile (State of Rhode Island, 2004). The proposal further suggested annual revisions to the feebate structure, as well as imposing the fee as a greenhouse gas surcharge, which would be used to fund the credits or rebates for those vehicles which would be compliant or below the pivot point. The fee or credit was to be estimated by multiplying the incentive rate and the absolute difference between the zero-point and the carbon dioxide emissions rate for that vehicle.

In Washington DC, the D.C. Council approved legislation in 2004 that increased the excise tax and registration fee on owners of large and luxury SUVs based on the premise that these contribute to air pollution and street damage (Yol and Woodlee, 2004). At the same time the legislation also provided a benefit to clean-air hybrid car owners, with a complete waiver of the excise tax and a 50% reduction in the registration fee.

In 2005, the state of Maine introduced a Bill (LD305) that proposed a 5% surcharge on the purchase or lease of new vehicles that did not achieve 27.5 mpg. In the same year, the state of North Carolina introduced a Bill (1038) also known as the Mobile Source Emissions Reduction Program, which proposed to charge a sliding fee on vehicles purchased, with the fee being a combination of miles travelled, pollutant emissions and fuel consumption (General Assembly of North Carolina, 2005). Both Bills failed in the respective state legislatures.

In 2005, the state of Massachusetts also saw Bill 2438 which pegged the sales tax on vehicles to CO_2 emissions. It proposed that consumers who purchased vehicles with the lowest emissions would pay zero sales tax, while vehicles with better than average performance would attract a sales tax less than 5%, and the high polluting would attract a maximum tax of 10% (Langer, 2005).

In Connecticut, the state assembly directed the Commissioner EPA to develop a feebate program to be implemented from January 2006. The plan outlined the implementation of a decrease in sales tax by not more than 3% for new motor vehicles with GHG emissions lower than a set threshold and an increase in sales tax by not more than 3% for new motor vehicles that have higher GHG emissions (State of Connecticut, 2005).

In 2022, the states of Vermont and New York pushed for the re-introduction of a feebate mechanism in the context of urgent climate action and the need for accelerated EV transitions. In New York, the 2022 Scoping Plan for Climate Action encouraged legislators to consider measures such as a "feebate" program, apart from suggestions such as charging higher registration fees based on vehicle emissions and establishing a per-mile user fee to fund transportation infrastructure (State of New York, 2022). More importantly, the plan states that the feebate could be designed as revenue-neutral and can incorporate other policy goals such as higher rebates or fee exemptions for low-income consumers, i.e. equity measures.

In Vermont, Senate Bill (S.277) introduced in 2022 by Senator MacDonald proposed to implement a self-funded system of personal car registration fees and rebates based on vehicle efficiency (MacDonald, 2022). The proposal had further design considerations for the feebates mechanism, that included revenue-neutrality, and linking the fee schedule to the fuel economy requirements as defined by the US EPA. It included three levels of fees and rebates based on fuel economy classification, applicable to purchase and lease of both new and used cars but with different schedules and decrease proportionally based on the depreciated value percentage. The idea of a feebate is not new to Vermont, since the first bill to propose such a mechanism was introduced in 1999 and then again in 2005 (H-444). The H-444 proposed a gas guzzler tax of $500 on each vehicle below 10,000 pounds and below 21 MPG in the city as a fee, while an energy conservation rebate of up to $5,000 was to be given if a consumer purchased a vehicle above 35 miles per gallon (MPG). The rebate was to be financed using 95% revenue from the gas guzzler tax (Vermont Agency of Transportation, 2019).

Among all legislative efforts, a detailed report by Vermont's Transportation Agency was tabled in the Vermont State Legislature in 2021 and provided some key insights into the current LDV market and feebate design (Vermont Agency of Transportation, 2019). The report assessed all LDV registrations in Vermont between 2016-19 and found that: (i) the median MPG was 25.3 and the median CO_2 emissions were around 352 grams per mile; (ii) the majority of new vehicle purchases were clustered between 18 and 30 MPG; (iii) between model years 2016 and 2019, average MPG improved from 24.9 to 26.4. Further, the report examined five different feebate design alternatives and concluded that a feebate program applicable uniformly to all LDVs would be the most effective as it would also incentivize a shift between different vehicle classes. It also found that a sustainable, self-funded feebate or incentive program could be designed that provides a larger incentive for EVs in the short term while still providing marginal incentives to shift to cleaner gasoline or diesel vehicles for consumers who may not be EV ready. It also highlighted the role of CO_2 or MPG as the most efficient fee metric and the need for both the fee and rebate to be implemented at the point of sale. These findings resonate with the feebate design strategy proposed by (Ramji et al., 2024), in their review of European feebates and are highlighted in the US feebate design methodology in the rest of this paper.

2.4 Methodology and Data

As described earlier, the aim of this chapter is to identify a good feebate policy design for the US that minimizes the cost to taxpayers for the transition to ZEVs, while ensuring sufficient incentives to achieve the rapid uptake are available.

To design an effective feebate, the current distribution of the US LDV market by CO_2 emission classes (g/mi), and their sales-weighted price and fuel efficiency must be known. Sales data of LDVs (2021) for the US from Marklines, IHS Markit and EV volumes are used to characterize the three data needs (EV Volumes, 2023; Marklines, 2023). The distribution of LDV sales across emission classes serves two purposes: (i) as the basic assumption for estimating the distribution of future ICE LDV sales across emission classes; (ii) to define a fee schedule for the feebate mechanism.

As a next step, it is important to determine future LDV sales scenarios for the US. This is done using the US Transportation Transitions Model (TTM), which is a stock turnover model developed by researchers at the University of California, Davis (Vijayakumar, 2022). TTM is largely based on the VISION model developed by Argonne National Laboratory (Argonne National Laboratory, 2022), but with additional modifications to simulate low carbon scenarios for California and the US. The forecasts are up to the year 2035 and provide a detailed split of the LDV sales by powertrain type, i.e., ICE, Battery Electric (BEV), Plug-in Hybrid (PHEV) and Fuel Cell (FCEV). Market penetration scenarios are input as percentages of sales for all vehicle types and technologies. The model has three scenarios: (i) BAU Scenario where EV sales share reaches about 40% by 2035; (ii) Low Carbon Scenario, where the EV sales share reaches around 80% by 2035; and (iii) a High ZEV scenario where EV sales share reaches 100% by 2035. This chapter assesses the design of a feebate mechanism that would help meet the EV sales share as defined in the Low Carbon and High ZEV scenarios.

To design the feebate policy, the methodology is described as below:

a) ***Distribution of ICE LDV by emission classes:*** Based on the distribution of ICE LDVs sold in 2021 across emission classes, it is assumed that all ICE LDVs sold from 2022 to 2035 are distributed in the same shares across emission classes as in 2021. Since majority of sales in the US LDV market are already SUVs and Pickups, with a general consumer trend indicating preference for larger LDVs, this assumption is expected to hold. For the purposes of this analysis, ZEVs include all Battery Electric and Fuel Cell Electric vehicles with zero tailpipe emissions as well as all vehicles with emissions greater than zero and lower than 90 gCO_2/mi, which are considered as Plug-in Hybrid Electric Vehicles (EPA, 2023). **Figure 29** provides the distribution of annual LDV sales by emission classes for 2021 *(numbers in green color are sales weighted fuel economy for each emission class).* Over 55% of the sales are above 300 gCO_2/mi.

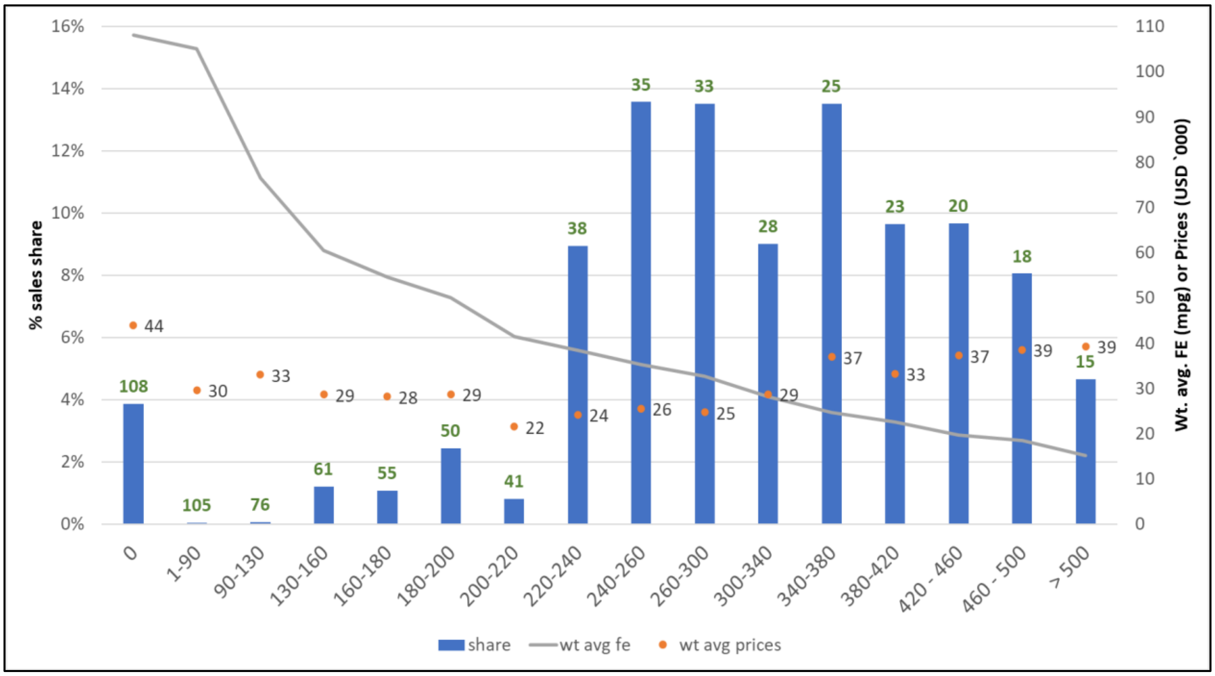

Figure 29: Distribution of US LDV sales by emission classes (gCO_2/mi), 2021

b) ***Estimating vehicle prices:*** First, we estimate the future trajectory of ICE prices. For this, historical vehicle price and inflation data are used. Based on US price inflation data (Bureau of Labor Statistics, 2023), an annual price increase of ICE vehicles by 2.46% is estimated**.** Based on an assessment of current vehicle prices between ICE and EV models across segments, it is found that the average BEV is about 1.7 times more expensive, while PHEVs are about 1.5 times more expensive than their ICE counterparts. Further, it is assumed that ZEVs reach price parity with ICE vehicles by 2032, while PHEVs remain about 5-7% more expensive than ICE vehicles in 2035 **(Figure 30).**

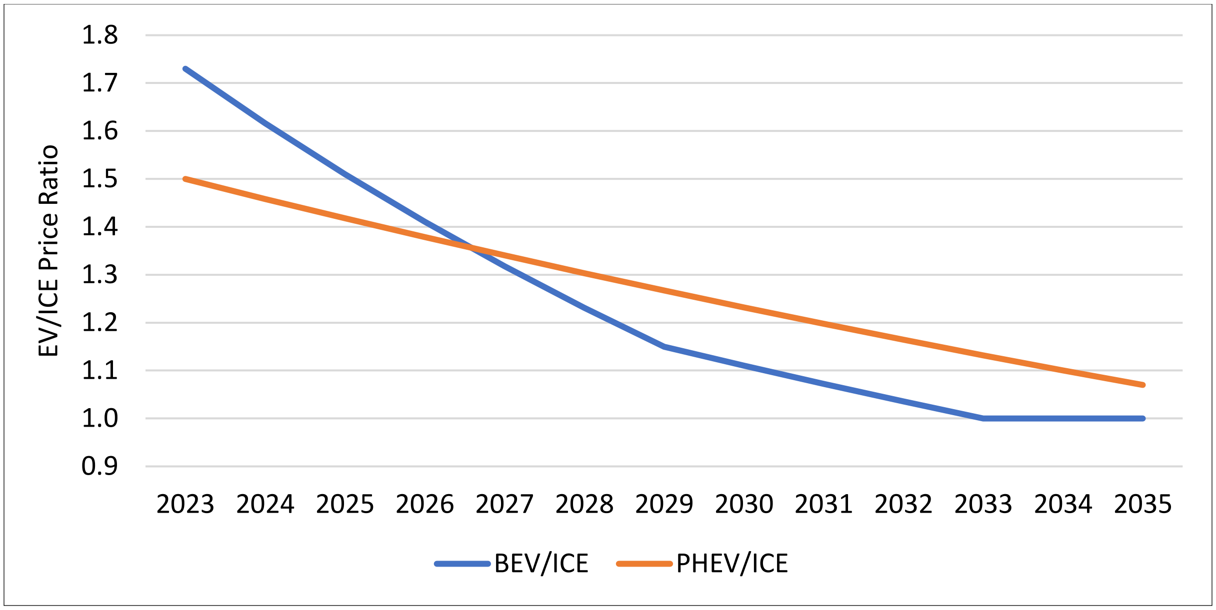

Figure 30: EV/ICE Price factor (multiplier for BEV/PHEV price vs ICE)

c) ***Estimating the number of EVs receiving rebates:*** To estimate the cost of the ZEV transition, and to determine the fee schedule, it is important to understand the number of EVs that would receive a rebate. A review of California EV sales, it is found that about half of the EVs sold cumulatively over time between 2010 – 2022 received subsidies under the Clean Vehicle Rebate Project (CVRP). A further disaggregated analysis shows that about 75% of the EVs sold in California in 2014 received a rebate, followed by 45% in 2018 and about 10% in 2022.

In the LC scenario, a similar trajectory is assumed for rebate eligibility in this analysis, going from 50% in 2024 to 10% in 2032 and remaining at that level up to 2035. In the HZEV scenario, given the trajectory to 100% EV sales by 2035, it is expected that in the latter years, a greater share of consumers would need incentive support to purchase EVs. Thus, the share of EVs receiving rebates goes from 50% in 2024 to 15% in 2032 and set at that up to 2035.

d) ***Estimating the revenue required to finance the rebates:*** To design the "fee" for the feebates, it is essential to estimate the total amount required in rebates to finance the ZEV transition. We identify two rebate scenarios as in **Table 9**. At this stage, having established the total revenue needed and the total ICE vehicle sales in each year, the total revenue is divided by the total ICE sales each year to get an average fee per ICE vehicle in each year. This is then divided by the estimated average ICE vehicle

MSRP to get the percentage increase in price due to the fee. The overall price elasticity for new vehicle sales defined as – for every 1% increase in vehicle prices, sales decline by 0.5% - is used to adjust the future year market size (Leard and Wu, 2023). The rebate values are drawn from the current incentive structure for EVs in the US, which offers $3,750 or $7,500 depending on certain criteria (Internal Revenue Service, 2023).

Table 9: Rebate schedules for eligible EVs

Scenario	Rebate schedule
High	[(60% of eligible EVs) * $3750] and [(40% of eligible EVs) * $7500]
Low	(All EV's eligible for rebate) * $3750

The total cumulative rebates required in each scenario are estimated based on the below two equations:

$$Total\ Rebates\ Required\ (Low) = \sum_{k=2022}^{2035} \left(BEV_{ik} + PHEV_{jk}\right) * \$3{,}750 \qquad \dots.(1)$$

$$\text{where, i} = \text{\%BEVs eligible in year k; and, j} = \text{\% PHEVs eligible in year k}$$

$$Total\ Rebates\ Required\ (High) = \sum_{k=2022}^{2035} (0.6 * \ EV_{ik} * \$3750) + (0.4 * \ EV_{ik} * \$7{,}500) \qquad \dots.(2)$$

$$\text{where, i} = \text{\%EVs eligible in year k}$$

e) ***Choosing the pivot point for the "fee"-bate:*** The US EPA has set a fuel economy target for the LDV fleet at 40.6 mpg for 2024, which is equivalent to about 218 gCO_2/mi. Thus, based on the emissions classes for the US LDV fleet as in Figure 1, the first pivot point of the feebate is set at 220-240 gCO_2/mi in 2024 **(Figure 31)**. The pivot point is revised every two years, shifting by one emission class each revision, eventually reaching 90-130 gCO_2/mi in 2034, which is in line with the EU trajectory.

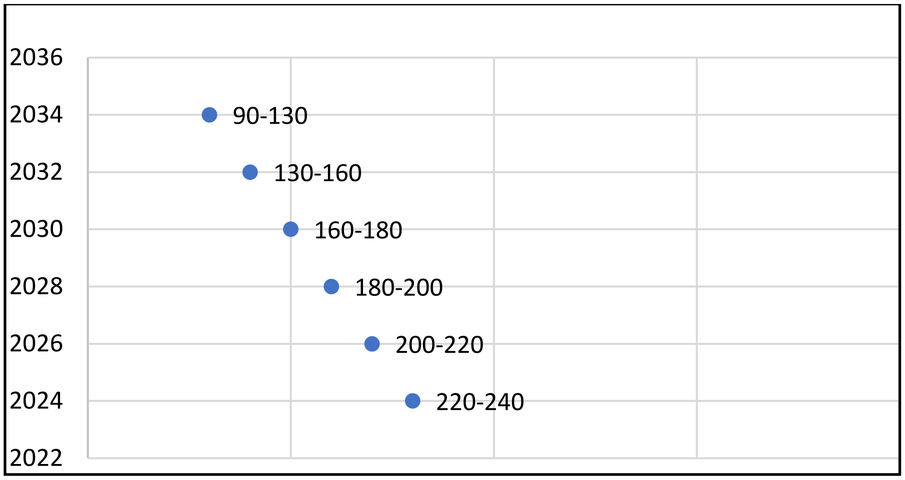

Figure 31: Pivot point ranges by year

f) ***Estimating the CO_2 penalty matrix:*** With the pivot point set for each year, the CO_2 penalty matrix is defined, i.e., the amount of CO_2 emissions per mile that the vehicle emits above the pivot point, resulting in a financial ("fee") penalty. The CO_2 penalty is calculated based on the deviation or difference of the mid-point of the emission class from the pivot point. For example, in year 2024, if the pivot is at 220 gCO_2/mi, and if a vehicle falls in the emission class 260-300 gCO_2/mi, then the CO_2 penalty is the difference between the mid-point of the emission class, i.e., 280 gCO_2/mi and the pivot point, which amounts to 60 gCO_2/mi. From covering nine emission classes in 2024, with bi-annual revisions, the feebate covers fourteen emission classes by 2034. The matrix of fee levels by emission class and year is shown in **Table 10**.

Table 10: Penalty matrix by emission class and year

Emission Class	***Emission Class mid-point***	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
0													
1-90													
90-130	*110*											**20**	**20**
130-160	*145*									**15**	**15**	55	55
160-180	*170*							**10**	**10**	40	40	80	80
180-200	*190*					**10**	**10**	30	30	60	60	100	100
200-220	*210*			**10**	**10**	30	30	50	50	80	80	120	120
220-240	*230*	**10**	**10**	30	30	50	50	70	70	100	100	140	140
240-260	*250*	30	30	50	50	70	70	90	90	120	120	160	160
260-300	*280*	60	60	80	80	100	100	120	120	150	150	190	190

300-340	*320*	100	100	120	120	140	140	160	160	190	190	230	230
340-380	*360*	140	140	160	160	180	180	200	200	230	230	270	270
380-420	*400*	180	180	200	200	220	220	240	240	270	270	310	310
420 - 460	*440*	220	220	240	240	260	260	280	280	310	310	350	350
460 - 500	*480*	260	260	280	280	300	300	320	320	350	350	390	390
> 500	*550*	330	330	350	350	370	370	390	390	420	420	460	460

g) ***Estimating the CO_2 fee matrix:*** In the LC scenario, the fee schedule per gCO_2 is set equivalent to the typical EU CO_2 emission taxes, which are equivalent to about \$2 per gCO_2 closest to the pivot point, increasing exponentially as a continuous upward sloping curve. The fee schedule remains fixed for a period of two years before it is revised. The highest fee is \$5 per gCO_2 up to 2027, going up to \$10 per gCO_2 up to 2031, and then \$14 per gCO_2 from 2032 onwards. In the HZEV scenario, a different fee schedule is used, which has the same starting point of \$2 per gCO_2, but the highest fee is \$14 per gCO_2 across all emission classes **(Figure 32)**.

The below equations describe the fee schedule for the LC and HZEV scenarios.

LC 2024: $y = 0.0211x^2 - 0.1352x + 1.743$ …. (3)

LC 2035: $y = 0.064x^2 - 0.3339x + 2.6688$ …. (4)

HZEV 2024: $y = 14.023x^2 - 369.37x + 2348.3$ …. (5)

HZEV 2035: $y = -2.5947x^3 + 85.771x^2 - 873.28x + 2668.7$ …. (6)

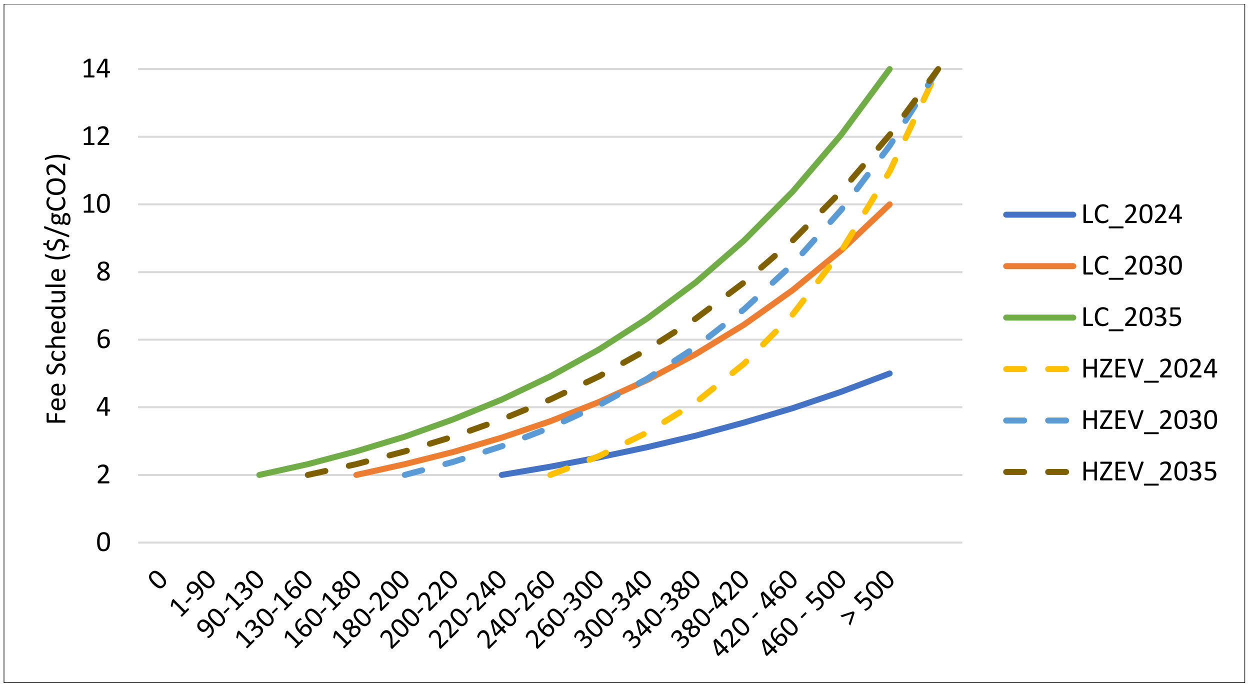

Figure 32: Fee schedule per gCO_2 in LC scenario by emission class and year

2.5 Designing a Feebate for the US

In this analysis, four scenarios are identified **(Table 11)** defined by the two EV adoption scenarios and two rebate scenarios, with the two fee schedules for the LC and HZEV scenario, to test which of these lead to revenue neutrality and its impacts on expected vehicle MSRP.

Table 11: Feebate scenarios

Rebate Scenario	EV Adoption Scenario		Fee Schedule
	Low Carbon (LC)	High ZEV (HZEV)	
Low	L1	H1	$2 - $5 (2024 – 27) $2 - $10 (2028 – 31) $2 - $14 (2032 – 35)
High	L2	H2	$2 - $14

2.5.1 LC Scenario

In the LC Scenario, the two rebate scenarios and the resultant funds required are highlighted in **Figure 33**. The cumulative revenue required to finance the rebates ranges from USD 59.9 billion to USD 83.8 billion between 2024-2035.

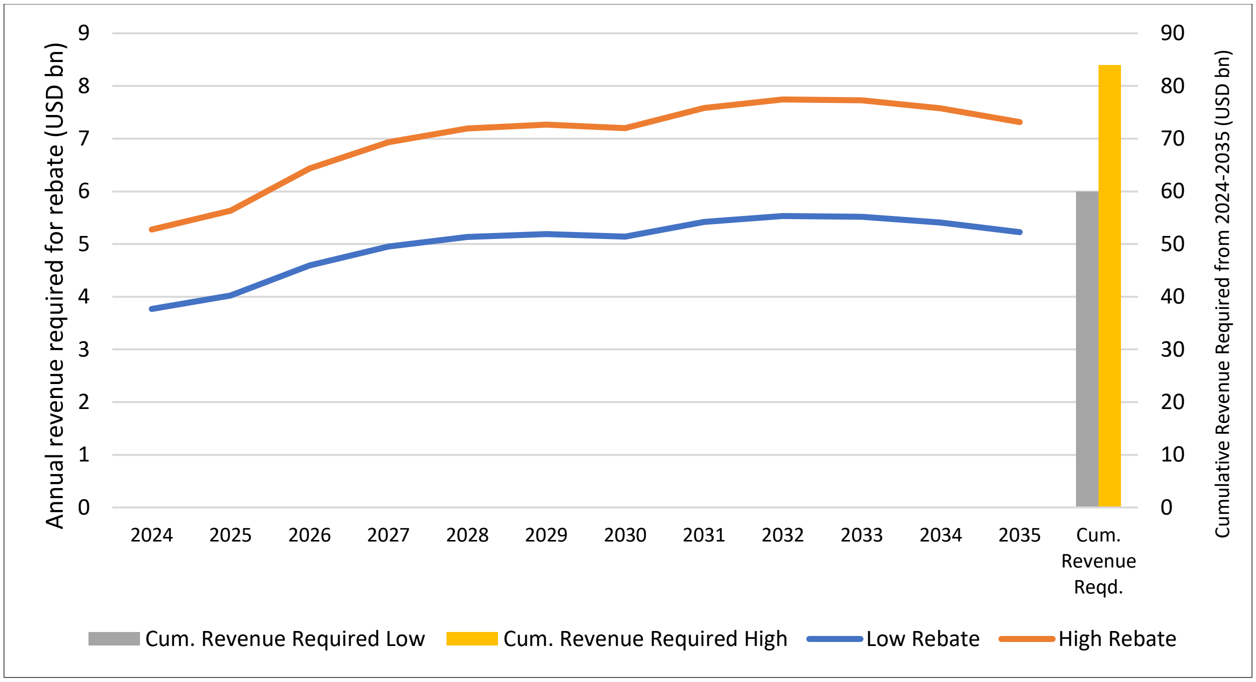

Figure 33: Revenue required to finance the EV rebates (LC Scenario)

In **Figure 34**, we find that the fee schedule generates surplus revenue to fund the rebate requirements up to 2035. There is a cumulative surplus of USD 32.9 billion and USD 56.9 billion respectively, for the high and low rebate cases, respectively. The fee program is essentially revenue neutral immediately from 2024 to 2027, after which it results in a surplus. This is also due to the declining share of EVs that receive a rebate over time.

The impact of the fees on consumers is equally important to understand, especially on the lower price-end of the vehicle market **(Figure 35)**. As already shown in **Figure 29**, the sales weighted average MSRP was about USD 26,000 for the lower emission classes between 200 gCO_2/mi to 340 gCO_2/mi. In the higher emission classes, the average MSRP was around USD 36,000, a segment also made up of large pickup trucks.

In the first year of the feebate mechanism (2024), the fee has an impact of 1 – 3% on vehicle prices with the highest emission class (>500 gCO_2/mi). The fee amount ranges from as low as $67 for average emission of 250 gCO_2/mi to $1,650 for vehicles emitting more than 500 gCO_2/mi.

Even in 2030, as the fee schedule changes, the impact is highest on emission classes above 420 gCO_2/mi, ranging from 5 – 8%. In absolute terms, the fee for the top three emission classes (420 gCO_2/mi) ranges from $2,090 to $3,900.

In 2035, the fee impact is greater with vehicles emitting more than 380 gCO_2/mi facing an additional impact of 6 – 12% (at the highest emission class). As the fee schedule increases in 2035, the fee ranges from $3,632 to $6,440 for the top three emission classes (420 gCO_2/mi).

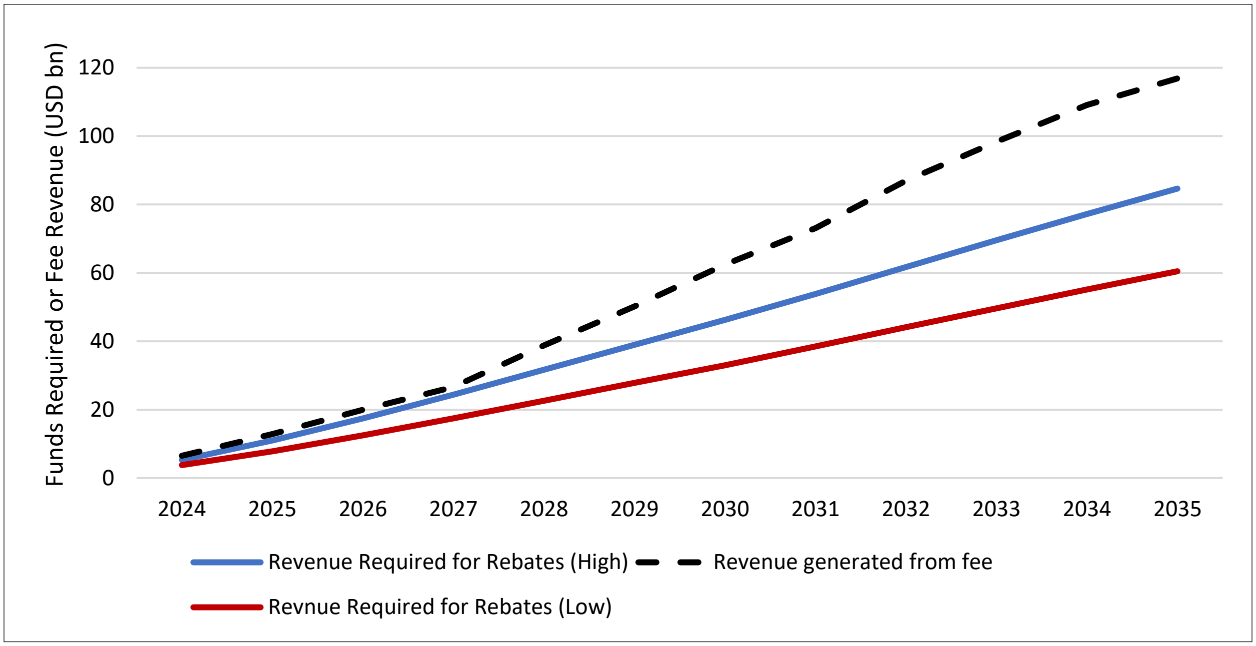

Figure 34: Funds required to finance the rebates and revenue generated by fees (LC Scenario)

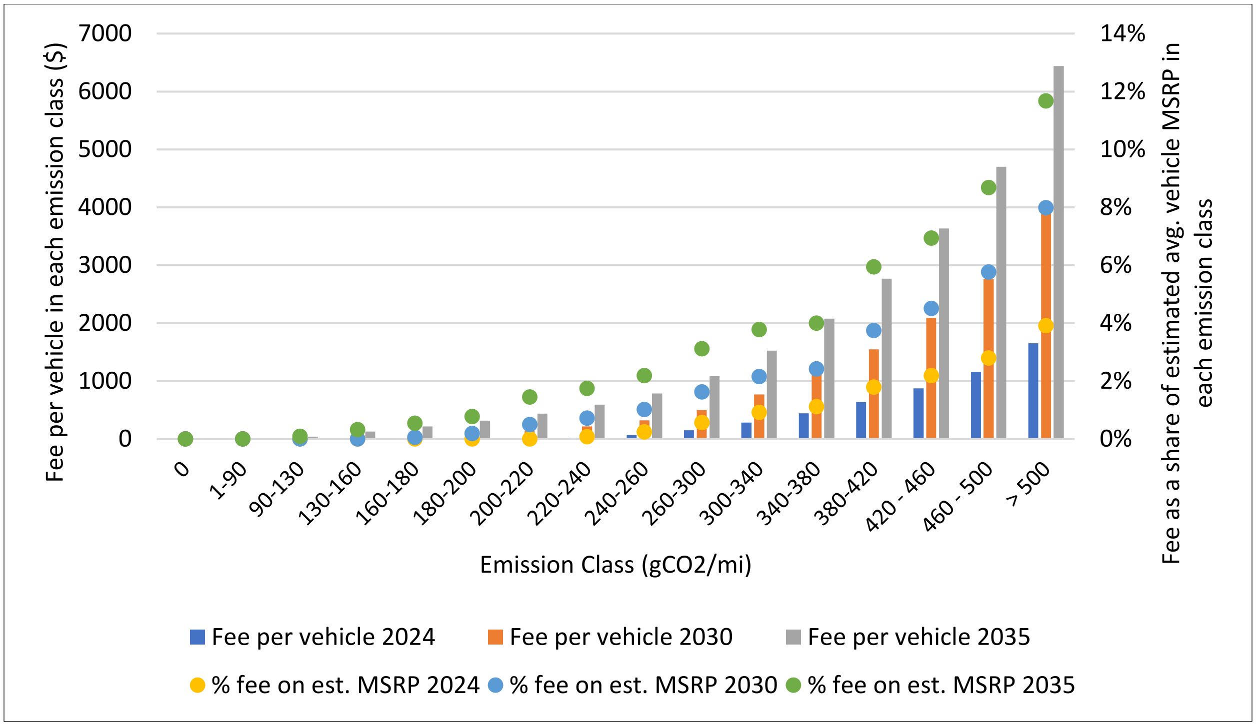

Figure 35: Fee impact on estimated vehicle MSRP in each emission class over time (LC Scenario)

2.5.2 HZEV Scenario

In this scenario, the share of EVs reaches 100% by 2035, increasing at a faster pace as compared to the LC scenario. This is also means that while the total cost of transition will be higher, there will be lower revenues from fees given the lower sales of ICE vehicles in each year compared to the LC scenario. As in **Figure 36**, the revenue required to finance the two rebate scenarios ranges from USD 96.1 billion to USD 134.5 billion over the same period.

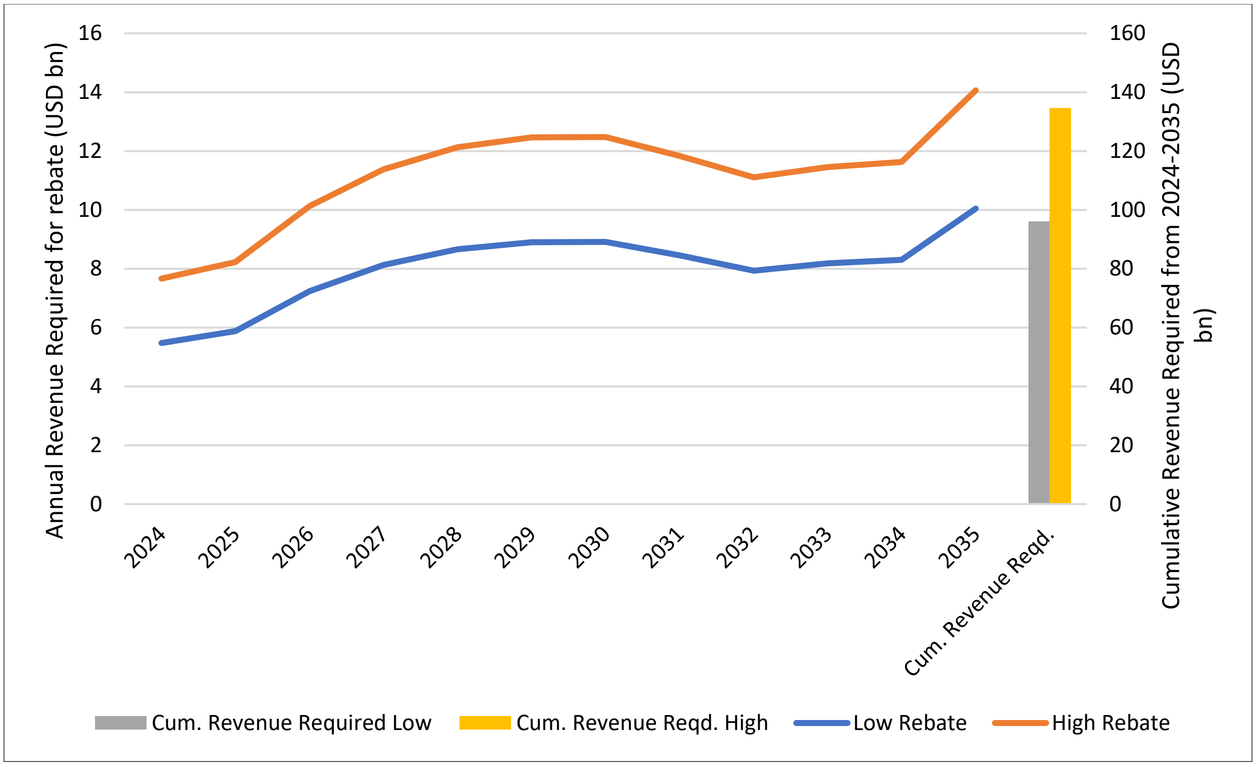

Figure 36: Revenue required to finance the EV rebates (HZEV Scenario)

If the same fee schedule as in the LC scenario is assumed, the fee revenue is only USD 62 billion, resulting in a significant shortfall. Thus, there is a need to readjust the fee schedule. Considering the higher fee schedule as indicated in Figure 4, the total cumulative revenue generated between 2024 – 2035 is USD 97.2 billion. As in **Figure 37**, the revenue generated by the fee schedule just about achieves revenue neutrality in the low rebate case but leaves a shortfall of USD 37.3 billion for the high rebate case.

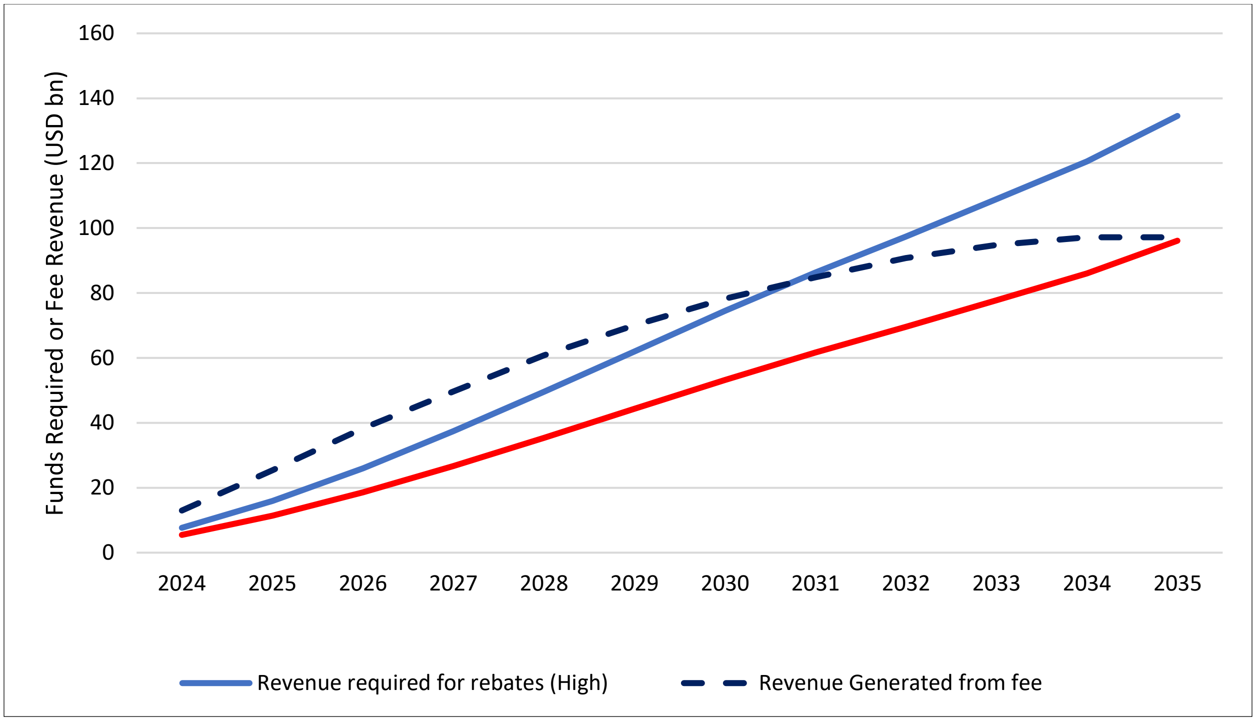

Figure 37: Funds required to finance the rebates and revenue generated by fees (HZEV Scenario)

In terms of impact on estimated vehicle MSRP **(Figure 38)**, in the first year of the feebate mechanism (2024), the fee has an impact of 7 – 11% on vehicle prices in the two highest emission classes (>460 gCO_2/mi). The fee amount ranges from as low as $77 for average emission of 250 gCO_2/mi to $4,620 for vehicles emitting more than 500 gCO_2/mi.

In 2030, the impact is highest on emission classes above 420 gCO_2/mi, ranging from 6 – 11%. In absolute terms, the fee for the top three emission classes (420 gCO_2/mi) ranges from $2,752 to $5,460.

In 2034, the fee impact is greater with vehicles emitting more than 380 gCO_2/mi facing an additional impact of 6 – 12% (at the highest emission class). As the fee schedule increases in 2035, the fee ranges from $3,632 to $6,440 for the top three emission classes (420 gCO_2/mi). This is the same as the impact on vehicle MSRP in 2035 in the LC scenario. This is because in 2035, there are no ICE sales in the HZEV scenario, and thus, zero revenue from fees.

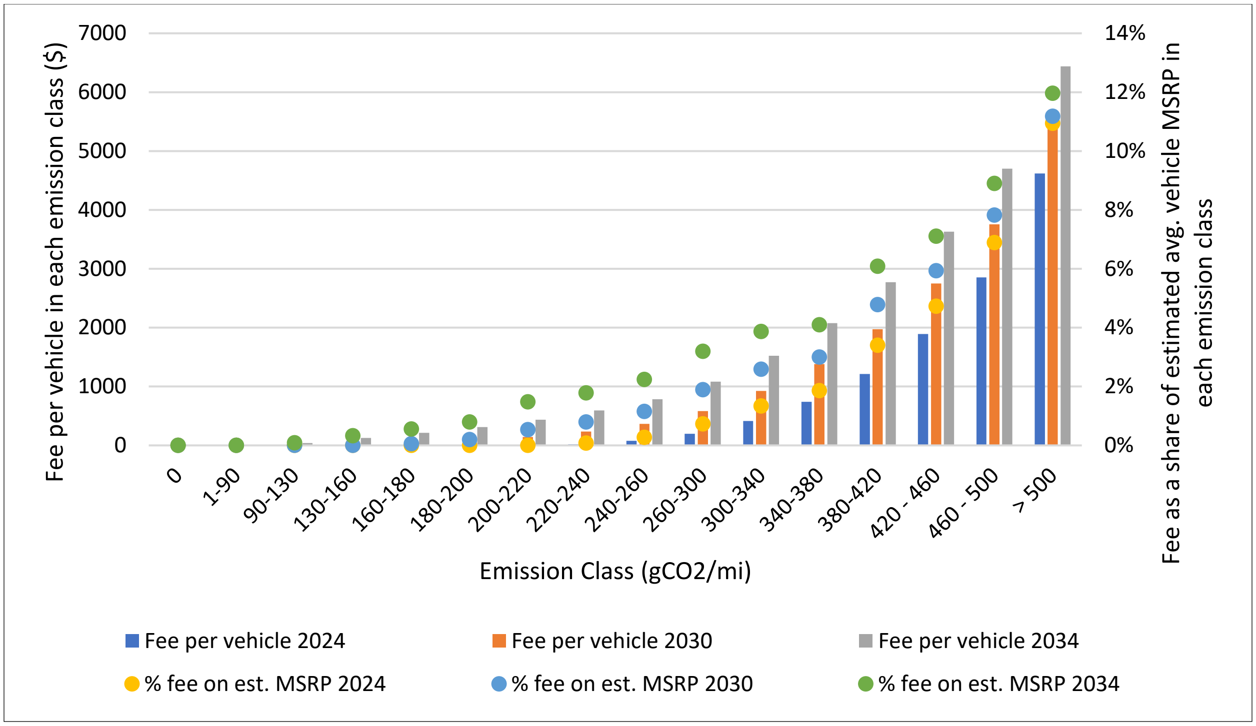

Figure 38: Fee impact on estimated vehicle MSRP in each emission class over time (HZEV Scenario)

2.5.3 Revenue neutral fee schedule for high rebate case in HZEV scenario

As seen in the previous section, given the revenue shortfall for the high rebate case within the HZEV scenario, an alternative fee schedule is considered that will achieve revenue-neutrality, and its potential impacts on estimated vehicle MSRP are analyzed. While there can be multiple different fee schedules that can achieve revenue-neutrality, in this case, the impact of one possible fee schedule is shown in **Figure 39**. The base fee starts at \$8 per gCO_2 (which is significantly higher than the \$2 per gCO_2 base fee applied in the HZEV scenario) from the pivot point for each year, while the highest rate remains at \$14 per gCO_2. As in **Figure 40**, the cumulative revenue generated from this fee schedule is USD 140.1 billion, compared to the requirement of USD 134.5 billion. The higher fee schedule has a significantly higher impact by 2034.

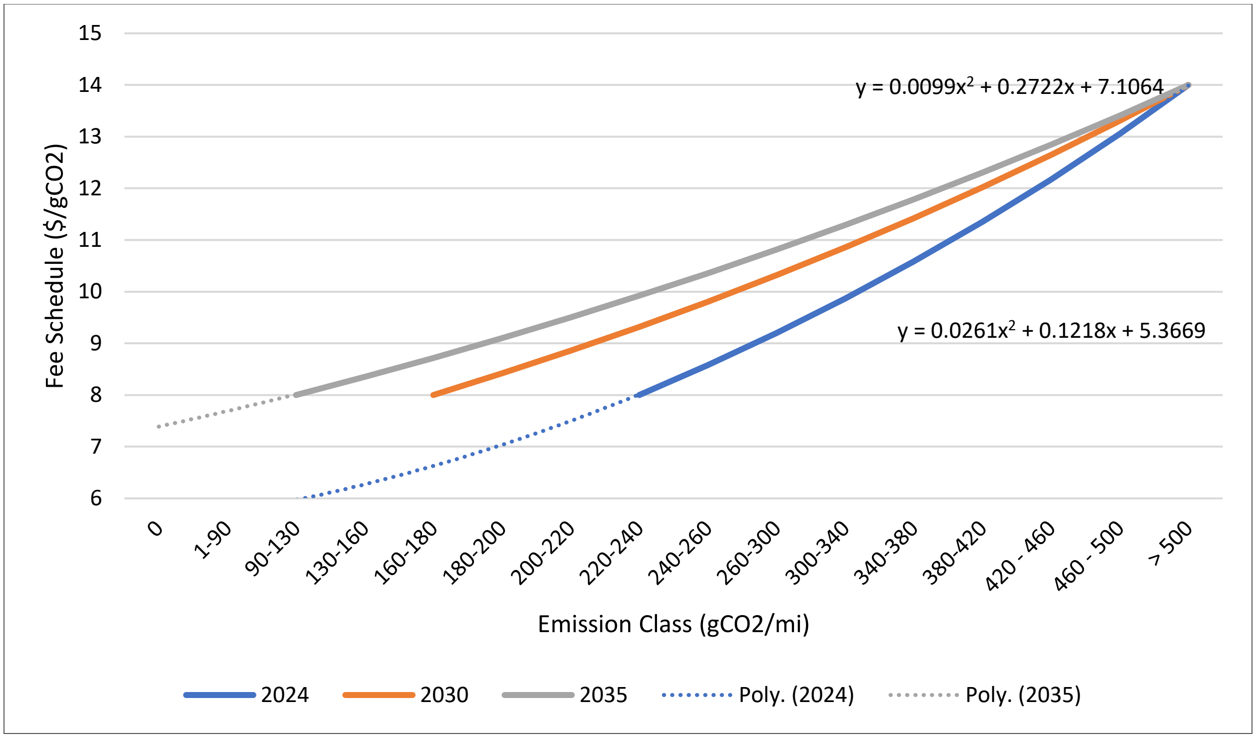

Figure 39: New fee schedule for revenue neutrality in high rebate case (HZEV Scenario)

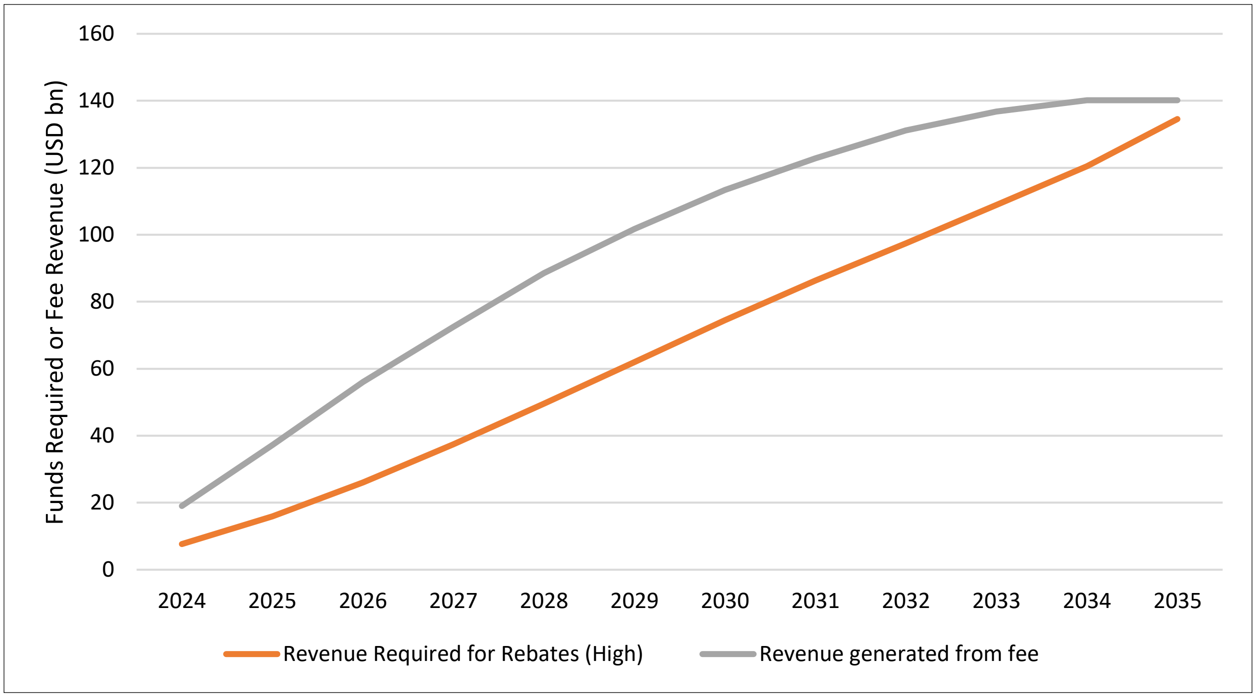

Figure 40:: Revenue needed for rebates and generated from fees under new fee (HZEV Scenario)

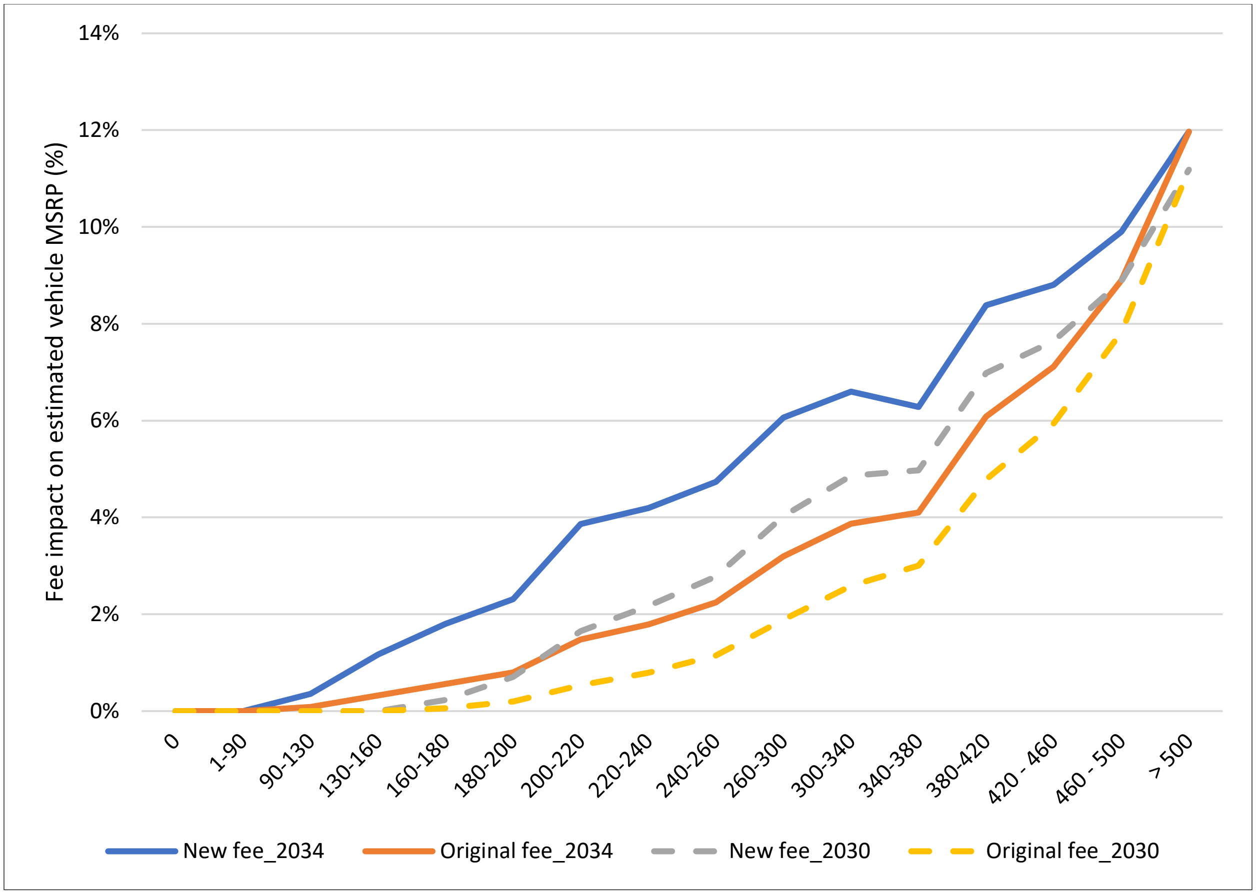

Figure 41: Comparison of fee impact on estimated vehicle MSRP (HZEV Scenario)

In terms of the impact of the fee on estimated vehicle MSRP, it is found that the average impact increases by about 2.5 times for emission classes between 200 – 340 gCO_2/mi in 2030, while the impact is about 2.3 times for the same emission classes in 2035. The average fee impact across emission classes increases to 6% compared to 4% in the original fee schedule for the HZEV scenario **(Figure 41)**.

2.5.4 Change in pivot points for proposed US EPA regulation: Case of the HZEV Scenario

The US EPA has proposed a new phase of CO_2 regulations up to Model Year 2032, which puts the 2032 threshold at 82 gCO_2/mi. This section assesses the change in the revenue generated from the fee schedule for the HZEV scenario and its original fee schedule with the pivot points of the feebate mechanism now aligned to the new EPA proposal **(Figure 42).**

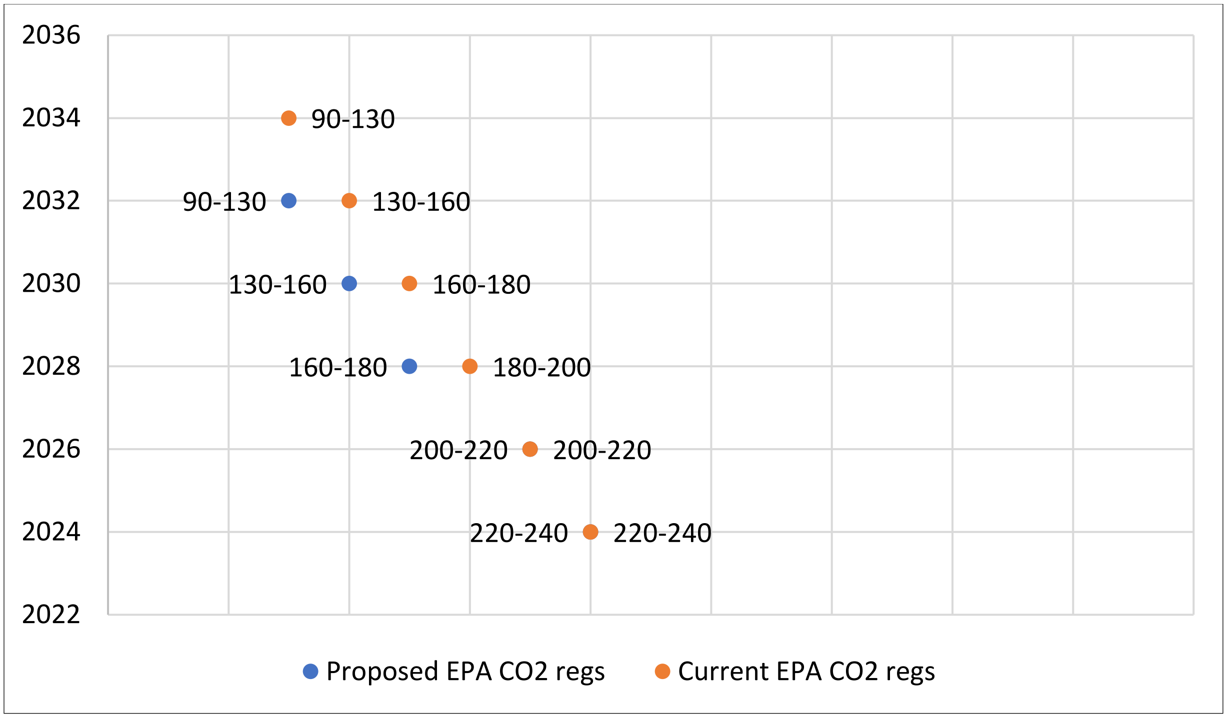

Figure 42: New pivot points based on the new EPA proposal

As in **Figure 43**, with the new pivot points, the revenue from the fee schedule increases by 6% to USD 103.1 billion. While this still means a revenue surplus for the low rebate case, the shortfall remains for the high rebate case. Interestingly, the fee schedule generates surplus revenue even in the high rebate case up to 2030, and becomes revenue neutral in 2031, after which it results in a deficit.

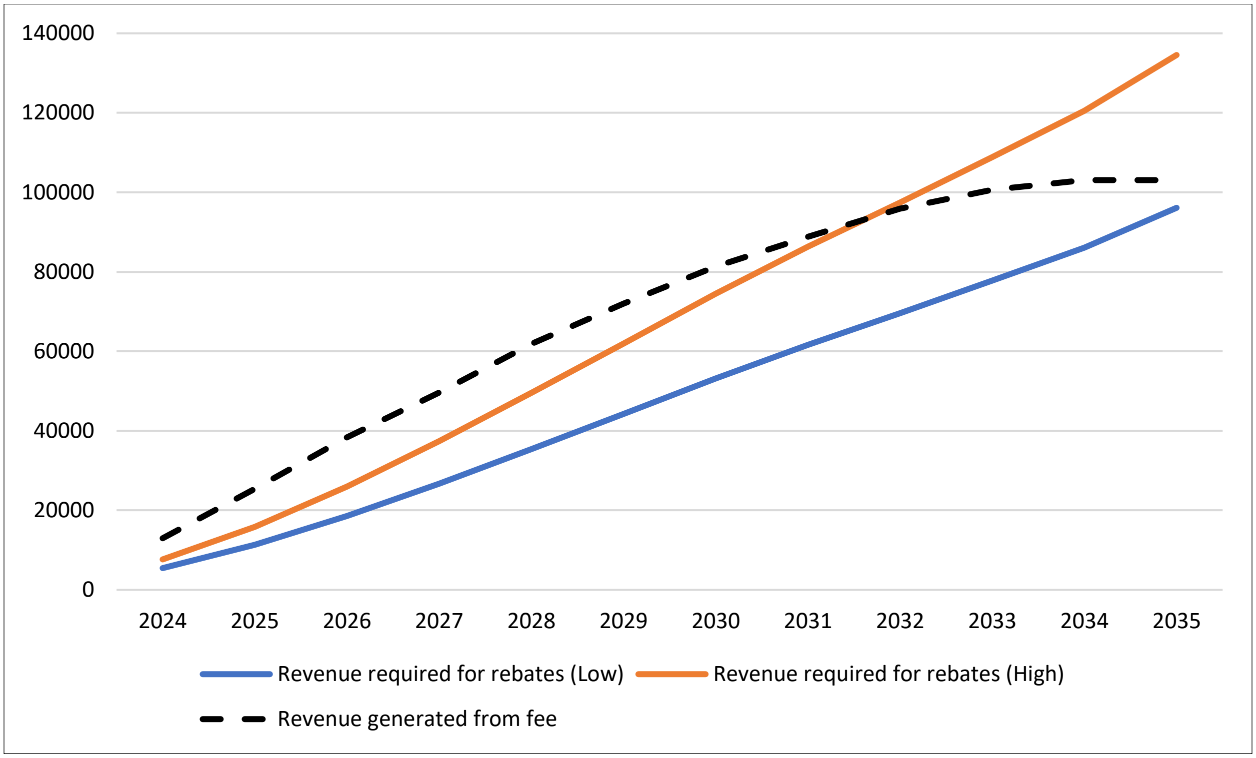

Figure 43: Funds required to finance the rebates and revenue generated by fees in HZEV scenario with pivot points as per new EPA proposal

2.6 Key findings

The most important finding in this analysis is that the use of fees on ICE vehicles to support rebates on EVs can be achieved with relatively low average fees per vehicle, on the order of 2-8%. Only at very high CO_2 levels do the fees rise above this for ICE vehicles, and even in those cases, the highest fee impact does not cross 12%.

Table 12 provides a summary of the different feebate scenarios analyzed in this paper. The low rebate case, wherein all EVs eligible to receive a rebate are given $3,750, a fee schedule with a base fee of $2 going up to $14, results in at least a revenue neutral feebate mechanism, across both the LC and HZEV scenarios.

In the LC scenario, the feebate results in a revenue surplus, with the impact on the highest emission classes in the range of 5 – 7%. In the HZEV scenario, the average fee impact on the highest emission classes ranges from 7 – 10% depending on the fee schedule.

If a flat fee schedule were to be considered in each of the scenarios, the average fee on every ICE vehicle sold beyond the pivot point each year would be around $7 - $8 per gCO_2 of deviation from the pivot point.

In the HZEV scenario, the average fee would be $11 per gCO_2 to meet revenue neutrality in the high rebate case.

Table 12: Summary of feebate scenarios

Scenario	Rebate	Fee	Status	Avg. Fee Impact by emission class		Avg. marginal fee rate
				Lowest 3	**Highest 3**	**per gCO_2/mi**
LC	Low	$2 - $5 (2024 – 27) $2 - $10 (2028 – 31) $2 - $14 (2032 – 35)	Revenue Surplus	1 – 2%	5 – 7%	$7
	High					
HZEV	Low	$2 - $14	Revenue Neutral	1 – 2%	7 – 9%	$8
	High		Revenue Deficit			
HZEV	High	$8 - $14	Revenue Neutral	1 – 2%	8 – 10%	$11
HZEV (EPA)	Low	$2 - $14	Revenue Neutral	1 – 2%	8 -1 0%	$8
	High		Revenue Deficit			

In the LC scenario, the fee schedule translates to $450 per ICE vehicle buyer above the pivot point in 2024 to $1153 in 2030. In the HZEV scenario, the fee schedule translates to $958 in 2024 (as per the base fee schedule), and $1400 in 2024 (for the high fee case). The highest fee impact ranges from $2100 – $2200 by the year 2034 across scenarios, with the high fee schedule in the HZEV scenario reaching about $3000 in 2034 **(Figure 44)**.

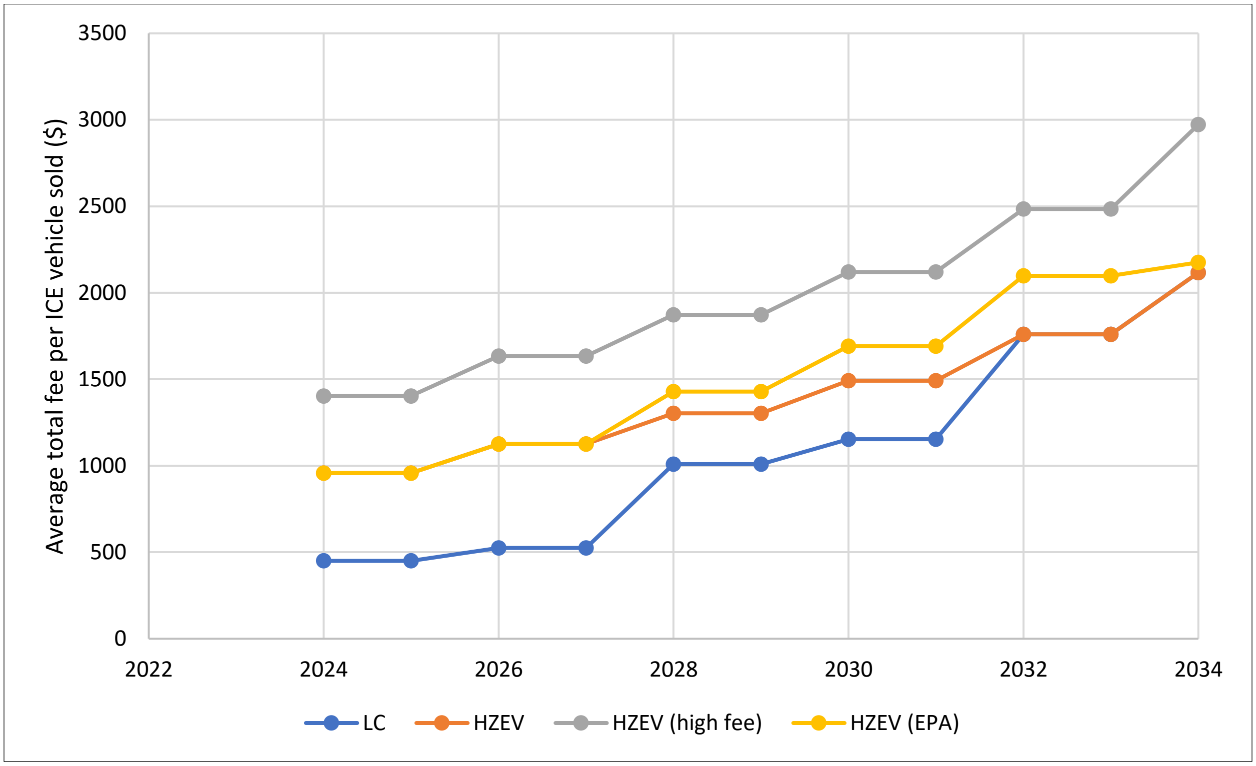

Figure 44: Average total fee per ICE vehicle sold above the pivot point each year

2.7 Conclusion

The current legislation within the US Infrastructure Act only provides for a limited budgetary allocation for the federal incentive program. From 2024, the EV tax credit will now be offered upfront like a purchase subsidy as opposed to being credited to the EV buyer in the year following the purchase when they file their tax returns. While this is expected to have a positive impact on consumer choices, overall budgetary allocations are limited for the incentive program, as identified in the beginning of the chapter.

Governments around the world are finding it increasingly difficult to finance EV purchase incentives in the long term. The uncertainties around the reduction in EV prices have not reduced, putting pressure on policymakers to find innovative solutions that can support the costs of the transition.

The need for some level of incentives in the long run is largely based on three key reasons: (i) with higher shares of EV adoption, it will put pressure on consumers buying lower priced vehicles to afford EVs; (ii) cost uncertainties driven by supply chain risks such as critical raw material procurement and regulatory changes such as the US Inflation Reduction Act and EU Critical Raw Materials Act (EU CRMA), and; (iii) pressure on technology cost reduction in the constrained timeline of achieving high EV adoption rates, given the pace of investments and costs of capital. Further, the new EPA proposal for more stringent CO_2 regulations, will lead to automotive manufacturers likely increasing sales of EVs to meet the regulatory requirements and increase EV model availability. But these will come at a cost to manufacturers, especially in the early years as they invest in both fuel efficiency improvements and EV production. These make the case for a market-based policy mechanism that can self-finance the rebate support and reduce fiscal pressure on government treasury to bear the costs of the transition.

From an industry perspective, a feebate mechanism, that incorporates the fuel economy targets into the fee schedule as pivot points, and has the capability of self-financing the rebate program, creates a strong market certainty for investment decisions that will increase EV production and model availability. From a consumer perspective, the certainty of the rebate program and the increased fees on ICE vehicles will result in shifting consumer decisions towards purchasing more EVs. Typically, an analysis like this should also account for demand elasticities across gasoline and EV buyers but given the relatively low share of the EV market, with the dominant consumers being relatively higher income households, it is not easy to assess good estimates of price elasticities of demand for EV buyers. While this is a limitation in estimating the dynamic effects each year of the impact of fees and rebates on consumer choices, the feebate design provides clarity on the direction of EV sales and the feasibility of the feebate mechanism.

Further, as already identified the first chapter, a feebate mechanism can have other exogenous features, such as price caps on EVs eligible for incentives, thresholds on household income above which incentives do not apply, and other incentives such as used EV rebates or vehicle scrappage programs that can all play a role in defining the eventual fee schedule and its net impacts on vehicle prices and consumer choice.

This paper makes two important contributions: (i) revenue-neutral incentive systems are possible while supporting increasing sales of light duty EVs along the target path toward a 100% sales share by 2035; and (ii) revenue-neutrality can be achieved with relatively low average fees on entry level ICE vehicles, at the very least, maintaining economic equity among vehicle buyers.

Last but not the least, the analysis in this paper shows that even if the feebate mechanism is not implemented by government, it can be used by individual automotive manufacturers to establish their own internal pricing mechanisms across ICE and EV products to determine a profitable business pathway during the EV transition.

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Chapter 3: Reforming India's vehicle taxation system for a ZEV transition

3.1 Introduction

Road transport emissions are expected to more than double in major developing economies including India, as these economies grow at a rapid pace and will need strong policies to decarbonize the road transport sector (IEA et al., 2023; International Energy Agency, 2023a). Major developing economies including India, South Africa, and Brazil among others, have acknowledged vehicle electrification as a key strategy but their overall policy approach towards a zero emission vehicle (ZEV) transition is mixed with competing policy goals (International Energy Agency, 2023b, 2023a; Nandi and Jayaswal, 2023; Reuters, 2023; UNFCCC, 2024). These include promoting biofuels, flex fuel vehicles, CNG vehicles, and hybrids, through tax benefits, fuel pricing strategies and other incentives.

EV sales share also considerably lags in developing countries, ranging from as low as 0.5% - 2.1% in markets like India, for the year 2023 (EV Volumes, 2023). At the same time, markets like Brazil and India have seen a rapid increase in CNG vehicle sales, growing 74% and 41% year-on-year in 2023 (Marklines, 2023). Lower priced ICE vehicles, highly price sensitive market with lower average incomes, limited infrastructure reliability and slow pace of technology development have been among the key barriers to EV adoption in developing countries (Asadi et al., 2022; Asif et al., 2023; Tarei et al., 2021).

While major developing economies including India use regulatory mechanisms like fuel economy or CO_2 norms as the primary approach to address transport GHG emissions, the attribute-based design of these regulations, i.e. linked to vehicle weight or footprint, provide regulatory loopholes for automakers to comply (Datta, 2010; Gillingham, 2021). For example, in the US, the standards are separate for cars and light trucks and linked to vehicle footprint, which results in the regulations operating separately within these vehicle categories, effectively taxing larger cars, but rewarding small trucks (Greenstone and Ori, 2017). On the other hand, in India, the fuel economy regulations are linked to vehicle weight, with relaxation in targets as weight increases (Roychowdhury and Chattopadhyaya, 2021). This has led to an overall increase in the share of SUVs and light trucks in both these markets, reaching 70% and 49% respectively, in the US and India in 2023 (Marklines, 2023).

Nevertheless, fuel economy standards have worked over the past few decades, during which time the primary policy goal was to shift from less efficient to more efficient ICE vehicles, without any significant powertrain technology shift (Atabani et al., 2012; Bezdek and Wendling, 2005; Wang and Miao, 2021). Further, fuel economy regulations have been found to be more politically feasible as compared to other instruments, globally (Greenstone et al., 2017). In the context of a ZEV transition, market-based policies such as feebates are likely to be more economically efficient compared to regulatory approaches, leading to larger welfare gains for consumers and limiting the fiscal burden on both the government and the taxpayer (Callejas et al., 2022; Dua et al., 2021; Kessler et al., 2023b; Lam and Mercure, 2021; Meireles et al., 2021; O'Riordan et al., 2023; Yadav et al., 2024). The combination of regulatory approaches and fiscal policies can be effective in driving rapid technological change, in this case, combining electric vehicle incentives, with CO_2-based taxation (Durrmeyer and Samano, 2018b; Gillingham, 2013b; David L. Greene et al., 2005c; Liu et al., 2011c; Mims and Hauenstein, 2008).

India, the world's third largest automotive manufacturer, has a strong automotive industry that relies on the scale of the domestic market, and crossed a record 4.1 million passenger vehicle sales in 2023 (SIAM, 2024). Among the fastest growing economies globally, India's road transport CO_2 emissions are expected to double at the current trajectory by 2040 over 2019 levels. The largest transport emission reductions for India are possible by vehicle electrification, followed by fuel efficiency improvements (International Energy Agency, 2023a). While India also has an EV purchase incentive program, its effectiveness in terms of increasing EV adoption rates and market transformation in terms of greater and affordable model availability of EVs are being questioned by the Ministry of Finance (Government of India), putting the overall ZEV transition at risk (Government of India, 2019; Mishra, 2023).

This chapter evaluates the design of a market-based feebate mechanism for India, that is self-financing and has a single policy objective of driving ZEV adoption, aiming to achieve a share of 30-40% ZEV sales by 2035. Further, key elements of the feebate will be evaluated to achieve revenue-neutrality, with relatively low average fees on lower emission vehicles, while preserving social equity among vehicle buyers. India has a unique EV incentive program that favors only BEVs and does not provide any support for PHEVs, but at the same time has a CO_2 regulation and vehicle taxation mechanism that promotes other alternatives.

3.2 India's regulatory approach to vehicle emission reduction

India's passenger vehicle market has grown at a 3.4% CAGR between 2017-18 to 2022-23. Along with this, there has also been a shift towards SUVs and crossovers, with the market share more than doubling, from 21% in 2017 to 49% in 2023 (SIAM, 2024). In 2023, Hatchbacks and sedans make up about 39% of the market and the remaining 12% is MUVs. Figure 45 shows the overall PV market and the trend in vehicle types. Table 13 provides the overall shift across different powertrains.

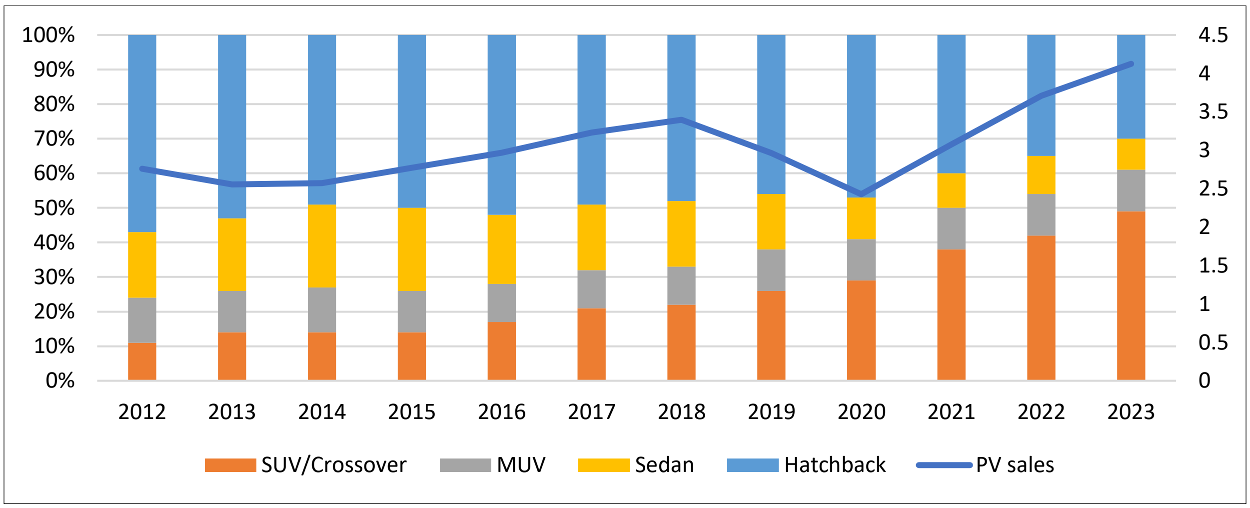

Figure 45: Annual passenger vehicle sales by vehicle type

Table 13: Shift in powertrains

% Share of annual sales	2012	2023
Petrol	43%	65%
Diesel	54%	18%
CNG	3%	13%
Strong hybrid	0%	2%
BEV	0%	2%

As in Table 13, the share of diesel has significantly declined from 54% in 2012 to about 18% in 2023, which has been largely driven by the changes in emission regulations and deregulation of fuel prices. At the same time, while petrol or gasoline vehicles have emerged as the dominant powertrain with a market share of 65% in 2023, it has been driven primarily by fuel economy regulations, vehicle taxation and reduced price differential between diesel and petrol fuel prices . Interestingly, with the decline in diesel, a fair share of the market has also been captured by CNG vehicles, aided by comparatively lower CNG fuel prices as compared to petrol, and is prevalent in the rapidly growing premium hatchback, crossover and MUV segment. In the premium vehicle segment that is essentially large SUVs, there is a shift towards strong hybrids, which have a similar market share to BEVs in 2023.

These transitions in the passenger vehicle market in India are driven by four key policy measures: (i) emission regulations (NOx, SOx, PM2.5); (ii) fuel economy / CAFE standards; (iii) vehicle taxation; and, (iv) EV purchase incentives. This section provides an overview of these four policy measures and their status.

Historically, India's focus has been on regulating non-GHG emissions from road transport, drawing on the Euro standards (known as the Bharat Standards in India). The first emission regulations were issued in 2000, with revisions every 4-5 years (Gajbhiye et al., 2023). The BS-VI (Euro 6 reference) was implemented in 2020 across the country, leapfrogging from BS-IV. The BS-VI emission norms resulted in diesel engines below 1500cc engine capacity being phased out, given the significant compliance costs, ranging from 10 – 15% additional cost increases depending on the make and model (Mohile, 2022).

3.2.1 Fuel Economy standards

India first implemented fuel economy standards in 2017, as a Corporate Average Fuel Consumption Standard (CAFCS), with a two-phase implementation (Bureau of Energy Efficiency, 2023a). Phase-I set a target of 130 gCO_2/km for the period 2017 – 2022, with the Phase-II target being 113 gCO_2/km from 2023 onwards. Furthermore, India has set a vision of achieving a target of 93 gCO_2/km for passenger vehicles by 2030, although it is pending any rule making (GFEI, 2021). Table 14 provides a comparison of India's fuel economy targets in CO_2 equivalent to other major countries.

Table 14: Comparison of India's fuel economy targets with other major countries (GFEI, 2023)

Country	2021-22 Target	2030 target
Chile	126	82
Brazil	122	Proposal underway

China	132	75
Japan	130	93
S. Korea	97	71
India	113	Proposal underway

In the period between 2009 – 2019, average CO_2 emissions decreased 1.4% a year. The sharpest decline in CO_2 emission was from around 137 gCO_2/km in 2012-13 to about 123 gCO_2/km in 2015-16. With India introducing the first phase target of 130 gCO_2/km in 2017, the fleet average remained relatively the same with a marginal decline in 2020-21 (Deo and German, 2021). More recently, the Phase 2 target of 113 gCO_2/km took effect from April 2023, and based on early estimates for 2023-24, the industry average is around 116 gCO_2/km including all flexibility mechanisms (off-cycle credits and super credits for EVs) (The Wire, 2024).

Importantly, non-compliance with fuel economy regulations did not attract any penalties on automotive manufacturers until a regulatory amendment was approved by the government in December 2022 (Government of India, 2022). Although, the penalty mechanism has not yet been implemented. The fines are to the tune of INR 25,000 (~$300) per vehicle sold if the CO_2 emissions for a company's fleet is 0-4.7 gCO_2/km higher than the prescribed target, and INR 50,000 ($600) if the deviation is greater than 4.7 gCO_2/km.

India's fuel economy regulations are linked to vehicle curb weight. The weight coefficient was revised from 1037 kg to 1082 kg from 2023, marginally tightening the fuel economy targets as weight increases. In the period between 2009 – 2015, the average curb weight increased rapidly from around 1037 kg to 1100 kg (Deo and German, 2021). Subsequently, average curb weight declined to about 1081 kg in 2022, largely driven by a declining market share of diesel vehicles, and the growth of sub-4 meter compact SUVs and crossovers as opposed to larger vehicles in the period between 2015 - 2022. In 2023, the sales weighted curb weight was around 1340 kg, with the average curb weight of cars around 1360 kg and that for SUVs around 1690 kg. With the share of SUVs expected to cross the 50% sales mark in 2024, it will have implications on India's ability to reduce real world CO_2 emissions as vehicles tend to get heavier.

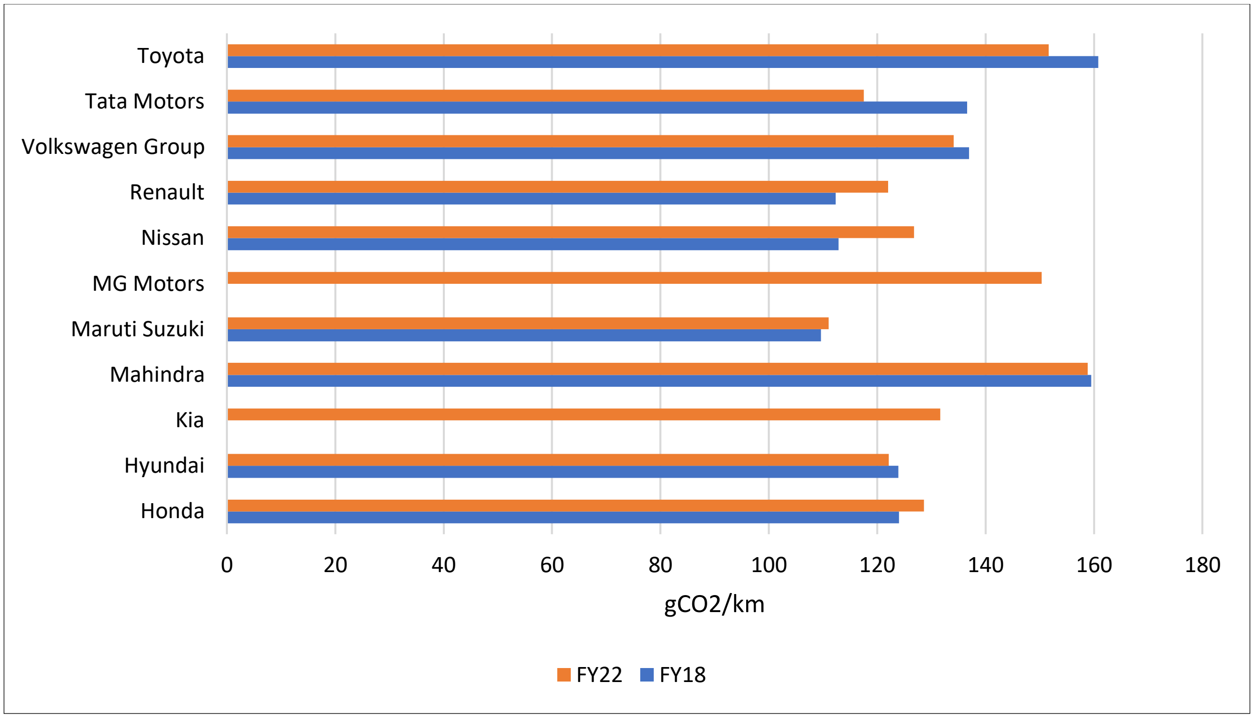

Figure 46: CAFE performance (gCO_2/km) of leading automotive manufacturers in India

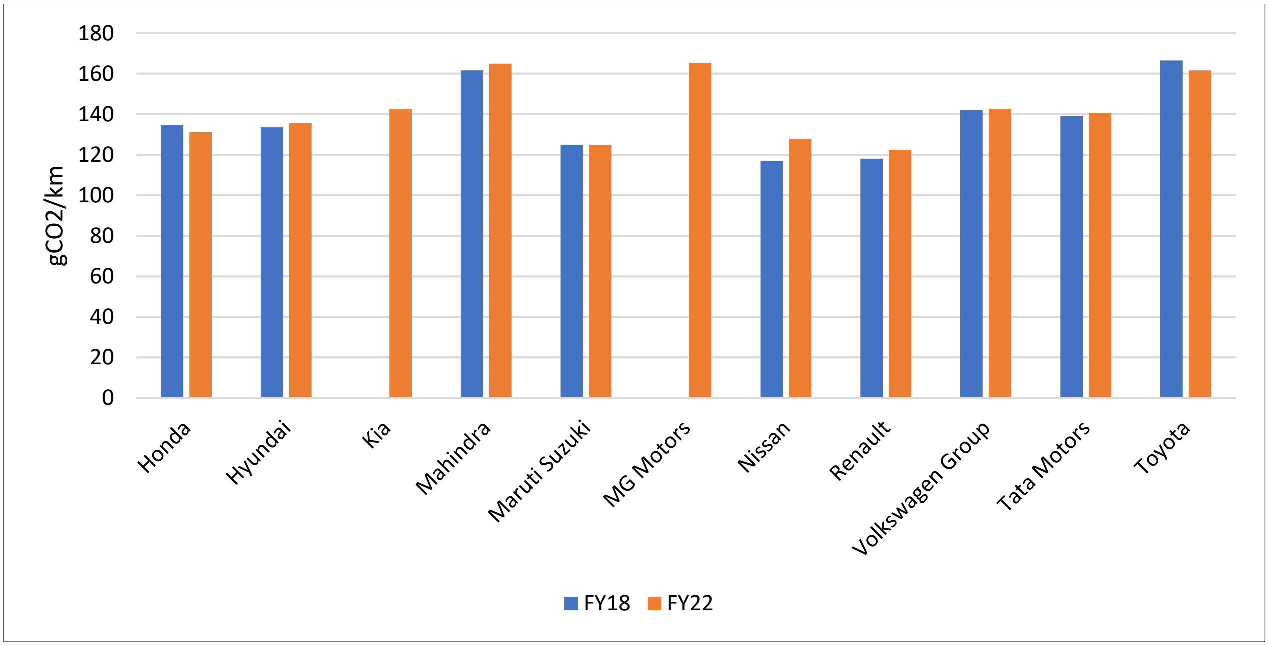

Figure 47: CAFE targets (gCO_2/km) for leading automotive manufacturers in India

Figure 46 – 47 show the corporate fleet CO_2 emission performance and targets[5] for major automotive manufacturers in India, contributing to over 90% of passenger vehicle sales (Bureau of Energy Efficiency,

[5] Average Fuel Consumption Standard = a * (W – b) + c, where a = 0.002, b = 1082 (weight coefficient), c = 4.7694, and W = curb weight of the vehicle; conversion to gCO_2/km = FE(kmpl) / 2371.35

2023b). Of the 11 manufacturers mapped here, four of them see an increase in average fleet CO_2 emissions between FY18 and FY22 (Kia and MG Motors entered the Indian market in 2020 and have also seen a decline in average emissions between FY20 and FY22). In terms of the corporate average target, which is set by the regulator, the performance targets have increased for 7 of the 9 manufacturers, with the largest increases for Nissan and Renault, both of which have seen a significant portfolio shift from small cars to SUVs. In the case of Kia and MG Motors, the target has declined over time for Kia, while it has remained similar for MG Motors between FY20 – FY22. Furthermore, Tata Motors, MG Motors, and Mahindra (which constitute 93% of the EV sales in 2023) have made use of the EV super credits to meet their fuel economy compliance targets, while Toyota and Maruti (which make up 98% of the strong hybrid market) have used other flexibility mechanisms for hybrids to meet compliance.

3.2.2 Vehicle taxation

The vehicle taxation mechanism in India essentially comprises of: (i) national-level Goods and Service Tax (GST); (ii) additional compensation cess (based on fuel type, engine size and vehicle length) applied above the GST; and, (iii) state-level road and registration tax. In India, all these taxes are applied upfront on the purchase of the vehicle, as opposed to annual registration fees applied in many other countries such as in Europe and the US. Table 15 provides the GST and compensation cess structure for passenger vehicles in India (SIAM, 2023).

Table 15: India's taxation structure for passenger vehicles

Fuel Type	Engine capacity	Length	GST	Compensation Cess	Total Tax
Petrol/CNG/LPG	< 4m	< 1200cc	28%	1%	29%
Diesel	< 4m	< 1500cc	28%	3%	31%
Hybrid Petrol	< 4m	<1200cc	28%	0%	28%
Hybrid diesel	>4m	>1500cc	28%	15%	43%
Hybrid Petrol	>4m	> 1200cc	28%	15%	43%
Petrol/CNG/LPG/Diesel	>4m	<1500 cc	28%	17%	45%
Petrol/CNG/LPG/Diesel*	>4m	>1500 cc	28%	20 - 22%	48 – 50%
Electric			5%		5%

**20% cess is for ground clearance ≤ 170mm and 22% cess otherwise*

In the small car segment (<4m length and <1200cc engine capacity), the taxation policy treats petrol and CNG vehicles at par. With the BS-VI emission regulations implemented in April 2020 and relatively lower CNG prices (especially as diesel fuel price was deregulated), this segment has seen a significant growth in CNG vehicles with a declining share of diesel powertrains. This has also led to a growing compact SUV and crossover market with gasoline and CNG powertrains. In the larger vehicle segment, to mitigate the tax incidence, large SUVs which used to be essentially diesel powertrains with length > 4m and engine capacity > 1500cc, have started to move to strong gasoline hybrids to lower the impact. Figure 48 shows the share of 2023 sales across different compensation cess categories. About 2/3rd of the sales are in the lowest cess category of 1%, followed by 17% of sales in the 17% cess category which corresponds to >4m length and <1500cc engine capacity (100% SUV share), with balance being either in the 3% or 22% cess category, largely made up of diesel powertrains.

Battery electric vehicles (BEVs) attract a lower GST of 5% with no additional taxes, and India does not have any incentives for plug-in hybrids (PHEVs), but they attract a 15% cess under the current regulation.

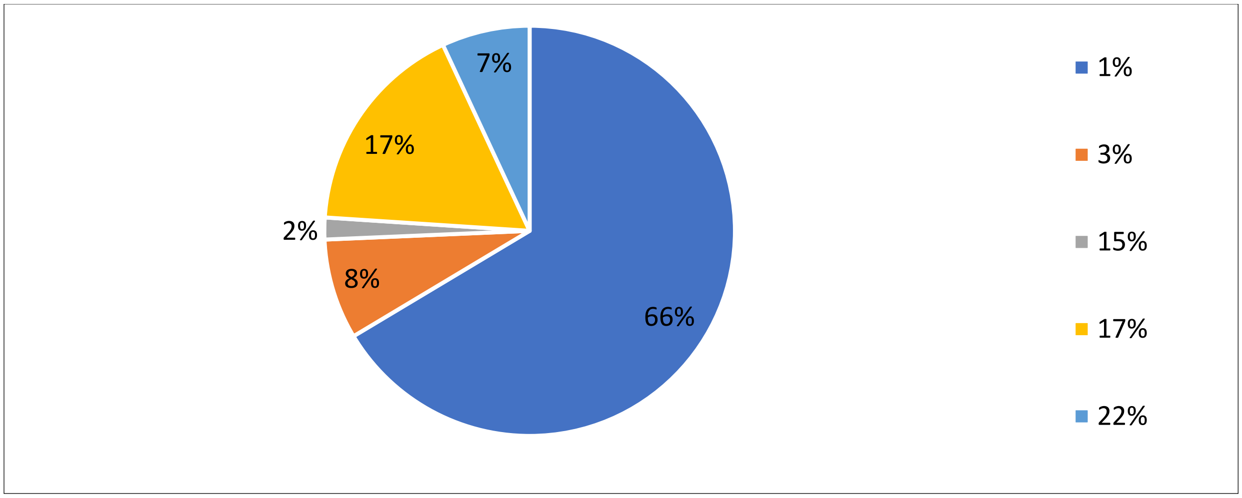

Figure 48: Share of sales across different compensation cess categories (2023)

3.2.3 Electric Vehicle Incentives

Within the EV transition narrative, India has taken an approach to incentivize BEVs only as opposed to many other countries where both BEVs and PHEVs are considered as ZEVs and given incentives. To support BEVs, India launched the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles

(FAME) Scheme in 2015, with a cumulative allocation of INR 10,000 crore (~USD 1.2 billion) between FY16 to FY24. The incentives were broadly aimed at supporting electric two-wheelers, three-wheelers, passenger cars, light commercial vehicles, and buses as well as public charging infrastructure.

The incentives for electric passenger vehicles is based on a subsidy of INR 10,000 per kWh of battery size (~USD 120), with the total subsidy not exceeding 20% of the ex-showroom vehicle price (final vehicle price including GST and cess but before state road and registration tax). Further, there is a vehicle price cap of INR 15,00,000 (~USD 18,000) for EVs in the PV segment to be eligible for incentives. There is no household income or any other restrictions on consumer eligibility.

The FAME-II scheme has supported about 1.36 million electric vehicles between April 2017 to January 2024. Of these, electric passenger vehicles constitute only 1.2%, with electric two-wheelers making up 88%, and the remaining being electric three-wheelers. In the same period, India sold 150,866 EVs in the passenger vehicle segment, of which only about 11.3% received incentives. With no consumer eligibility criteria, it is safe to assume that around 88% of the electric PVs sold were above the INR 15,00,000 price point (> USD 18,000). Given that majority of passenger vehicle sales in India are in the price range of INR 8,50,000 – INR 10,00,000 (USD 10,200 – 12,000), the majority of EVs in this segment were likely sold to higher income households, outside of the incentive ecosystem, and at a price point above USD 18,000, at almost double the price of an average ICE vehicle. Further, with no household income limits, it is also likely that the incentives went to relatively higher income households.

Further, while India has about 27 EV models in the passenger vehicle segment available in 2023, a significant increase from 5 models in 2019, there are only four models that are currently eligible for incentives under the FAME scheme in 2023 (all from a single automotive manufacturer, Tata Motors). Most EV models within the USD 18,000 price range have an average battery pack size of 30 – 40 kWh.

These findings are indicative of three trends: (i) major OEMs are not investing in affordable EVs within the incentive program; (ii) the combined effect of regulations sch as fuel economy standards, taxation and EV incentives are not aligned in driving a ZEV market transformation; and, (iii) the average cost of EVs is expected to remain on the higher side as newer models enter the market with larger battery packs and higher range expectations.

3.2.4 Complex governance structure and mis-aligned policy goals

Overall, India's approach to road transport decarbonization has been an 'all-possible technologies' strategy, allowing for CNG, biofuels, hybrids and EVs (International Energy Agency, 2023a). This also emerges from a relatively complex governance structure. The fuels strategy is driven by the Ministry of Petroleum and Natural Gas (MoPNG), which has an incentive in keeping some share of fossil fuels in the mix, thus, pivoting towards promoting natural gas. The fuel economy regulations are developed by the Bureau of Energy Efficiency (BEE), which is under the Ministry of Power (MoP), but their implementation and enforcement lies with the Ministry of Road Transport and Highways (MoRTH). Finally, the EV regulations are the responsibility of the Ministry of Heavy Industries. India has seen significant jurisdictional issues between key line ministries such as MoRTH promoting CNG vehicles since EV policy is not within their purview, thus leading to sub-optimal decision making and outcomes. With multiple decision makers and diverse policy objectives, there is no clear policy alignment towards a ZEV transition.

Further, while India has indicated its intent towards vehicle electrification as part of its climate commitments, it has not set a formal target or stated ambition for EV adoption, even though it is a signatory to the EV30@30 Clean Energy Ministerial campaign. Various government documents and estimates indicate achieving a 20 – 30% share of EV sales in the passenger vehicle segment by 2035 (BCG and NITI Aayog, 2022; Ramji and Kankaria, 2022).

Thus, with this context, the subsequent sections in this chapter focus on designing a feebate mechanism that aims to achieve the following: (i) change the compensation cess to a CO_2-based taxation system; (ii) align the fee mechanism to achieving a 30% share of electric PVs by 2035; and, (iii) assess the conditions for revenue-neutrality such that the fee revenue supports the rebates required.

3.3 Methodology

As part of this approach, first, it is important to understand the current distribution of the India PV market by CO_2 emission classes (g/km), and their sales-weighted price and fuel efficiency. In terms of data, 2023

PV sales and price data for India was procured directly as part of this study from the Society of Indian Automobile Manufacturers (SIAM), Marklines and EV volumes to analyze the same (EV Volumes, 2023; Marklines, 2023). This distribution of PV sales across emission classes serves two purposes: (i) as the basic assumption for estimating the distribution of future ICE PV sales across emission classes; (ii) to define a fee schedule for the feebate mechanism.

3.3.1 Demand forecast for India

Before designing the feebate policy, it is important to determine future passenger vehicle sales for India. An econometric model based on the authors' model development for the automotive industry in India is used here. The equation for sales projection is defined as below:

$$PV = a + b_1(GDP\text{-}Ser) + b_2(IIP) + b_3(CREDIT) \quad \text{.... (1)}$$

Where, PV = passenger vehicle sales; GDP-Ser = Services GDP; IIP = Index of Industrial Production; and CREDIT = Total consumer credit in the market

The model is trained based on historical data from 2001 to 2022, with corrections for the Covid-downturn. Figure 49 provides the passenger vehicle sales forecast up to 2035, with sales expected to reach about 4.66 million units by 2035 from about 3.89 million units in 2022-23. The EV sales share is determined as low and high adoption scenarios, reflecting the current stated national ambitions.

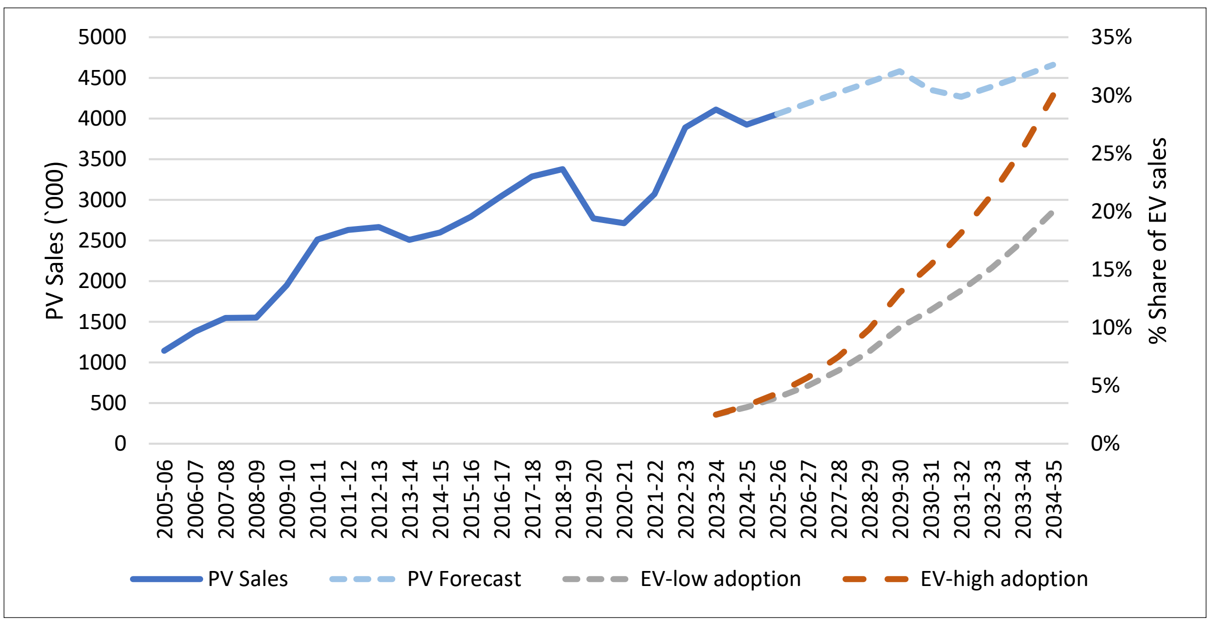

Figure 49: Demand forecast for PV sales and target EV share in India up to 2035

To design the feebate policy, the methodology is described as below:

a) ***Distribution of ICE LDV by emission classes:*** Based on the distribution of ICE PVs sold in 2023 across emission classes, we assume that all ICE PVs sold from 2024 to 2035 are distributed in the same shares across emission classes as in 2023. With the current mix of about half SUV sales and remaining between cars and hatchbacks, especially as the consumer market grows, this general trend is expected to hold. For the purposes of this analysis, ZEVs include only Battery Electric Vehicles and does not include any PHEVs given India's current policy focus on leapfrogging to BEVs. Further, no fuel cell vehicles are considered in the PV segment in India. Figure 50 provides the distribution of annual PV sales by emission classes for 2023 *(numbers in green color are sales weighted average vehicle prices for each emission class).*

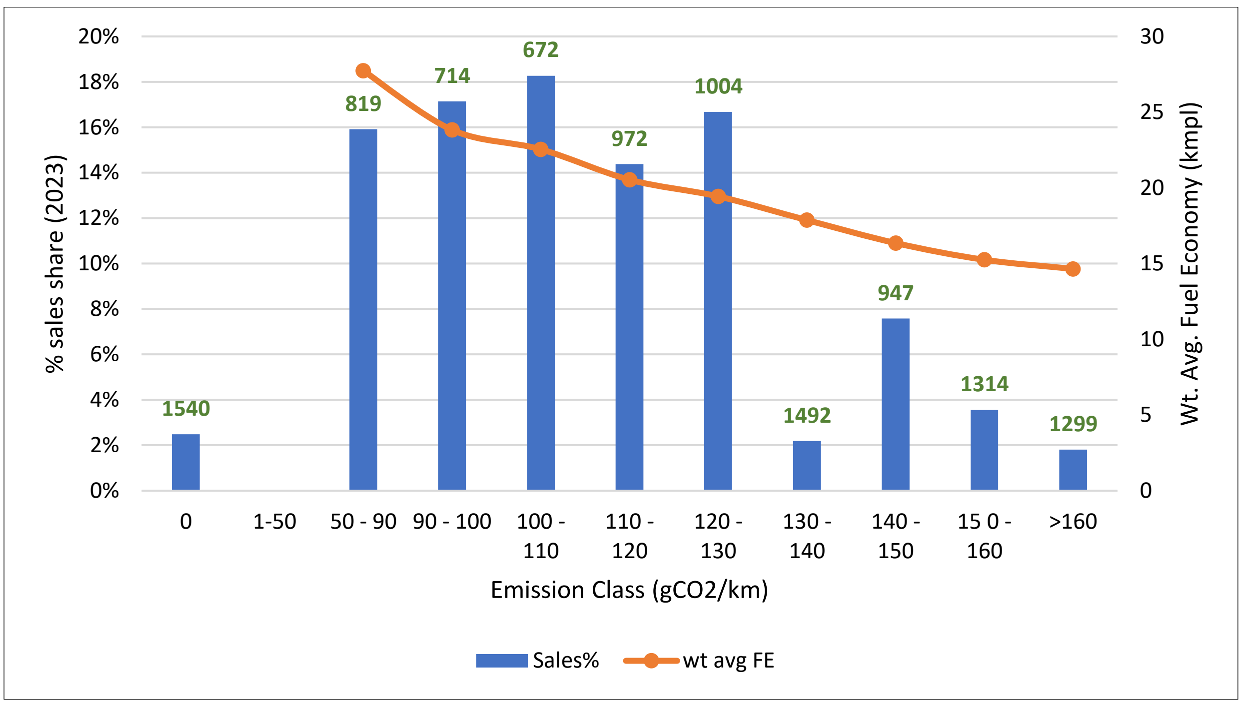

Figure 50: Distribution of PV sales by emission classes (gCO_2/km) (prices in INR thousand)

b) ***Estimating vehicle prices:*** First, the future trajectory of ICE prices is estimated. For this, historical vehicle price data is used from SIAM. Based on this data, an average CAGR price increase of different segments of ICE vehicles mapped to the sales profile by emission class is estimated**.** The average CAGR price increase ranges from about 1% for small cars to about 2% for large SUVs. Based on an assessment of current vehicle prices between ICE and EV models across segments, it is found that the average BEV is about 1.9 times more expensive than its ICE counterpart. Further, based on EV market shares and average EV to ICE price differential in European countries, it is estimated that for a 20-30% EV market share by 2035, the average EV is expected to be about 1.3 times more expensive than the average ICE price in that year (although specific sub-segments or models might reach price parity). Figure 51 shows the price trajectory as well as the EV to ICE price ratio over the years.

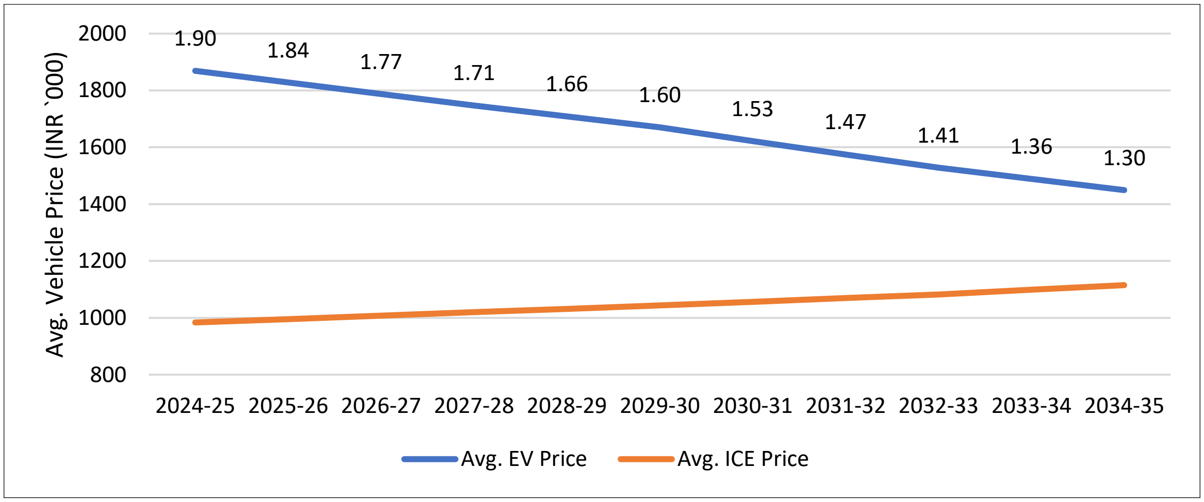

Figure 51: Average vehicle prices for ICE and EVs (and EV/ICE price ratio)

c) ***Estimating the number of EVs receiving rebates:*** To estimate the cost of the ZEV transition, and to determine the fee schedule, it is important to understand the number of EVs that would receive a rebate. A review of India's EV sales shows that only 11% of total EV sales in the PV segment received rebates. At the same time, as seen in earlier sections, the incentive program has not had significant effect on market transformation. Based on a review of other regions including Europe and California, it is found that in early stages of market development, about half of the EV sales received rebates, declining to about 10-15% as the market share crossed 20% of new sales. In the India context, it is assumed that a greater proportion of EV buyers will need support in the long term, even as market share increases given the highly price sensitive market for new vehicles. In the low adoption scenario, it is assumed that 50% of EV sales in 2024-25 receive a rebate, declining to 35% of EV sales in 2034-35. In the high adoption scenario, given the push to drive higher market shares, it is assumed that 50% of EV sales receive rebates between 2024-25 to 2029-30, followed by a declining share reaching 30% of EV sales receiving rebates by 2034-35, as shown in Figure 52.

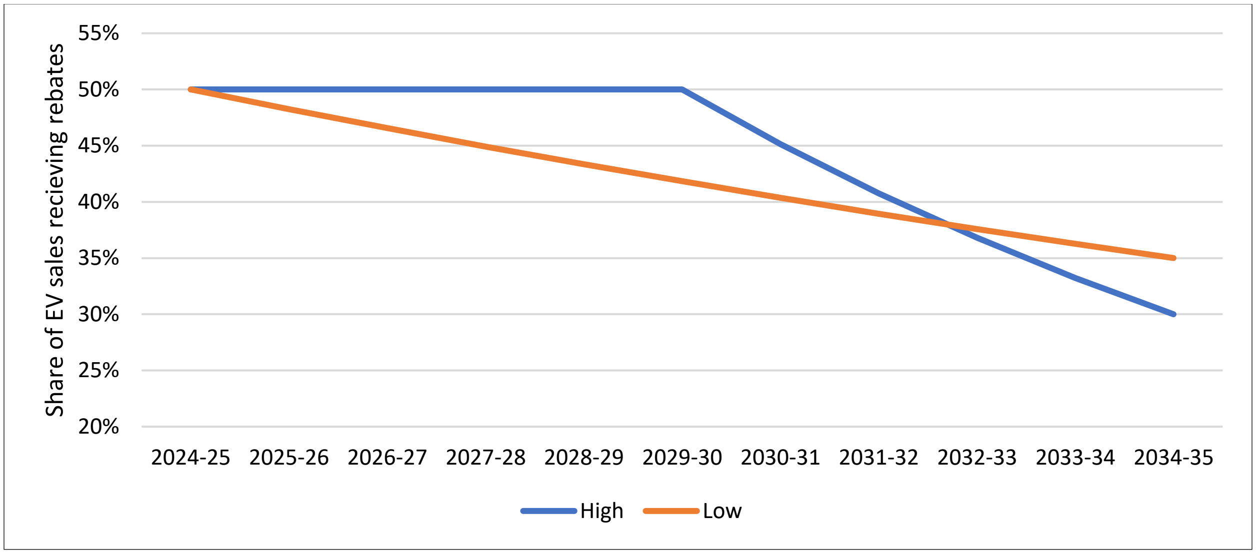

Figure 52: Share of EV sales receiving rebates by scenario

d) ***Estimating the revenue required to finance the rebates:*** To design the "fee" for the feebates, it is essential to estimate the total amount required in rebates to finance the ZEV transition. Two rebate scenarios are identified as in **Table 16**. In the base case, the rebate ranges from 12% of EV price in 2024 to 15% in 2035. In the alternate case, the rebate is fixed at 20% of the estimated EV price in each year.

Table 16: Rebate schedules for eligible EVs

Scenario	Rebate schedule
Base	(All EV's eligible for rebate) * INR 2,20,000 (~USD 2650)
Alternate	20% of average estimated EV price in each year

The total cumulative rebates required in each scenario are estimated based on the below two equations:

$$Total\ Rebates\ Required\ (Base) = \sum_{k=2024}^{2035}(BEV_{ik}) * INR\ 2{,}20{,}000 \qquad \dots.(1)$$

$$\text{where, i} = \text{\%BEVs eligible in year k}$$

$$Total\ Rebates\ Required\ (Alt) = \sum_{k=2024}^{2035}(0.2 * \ EV_{ik} * \ P_k)) \qquad \dots.(2)$$

where, P = average estimate EV price; i = %EVs eligible in year k

e) ***Choosing the pivot point for the "fee"-bate:*** India has set a fuel economy target for the PV fleet at 113 gCO_2/km as of 2023, shifting from 130 gCO_2/km in the previous years. Thus, based on the emission classes for the PV fleet as in Figure 53, the first pivot point of the feebate is set at 115 gCO_2/km in 2024 (Figure 9). The pivot point is revised every three years, shifting by one emission class each revision, eventually reaching 75 gCO_2/km in 2034.

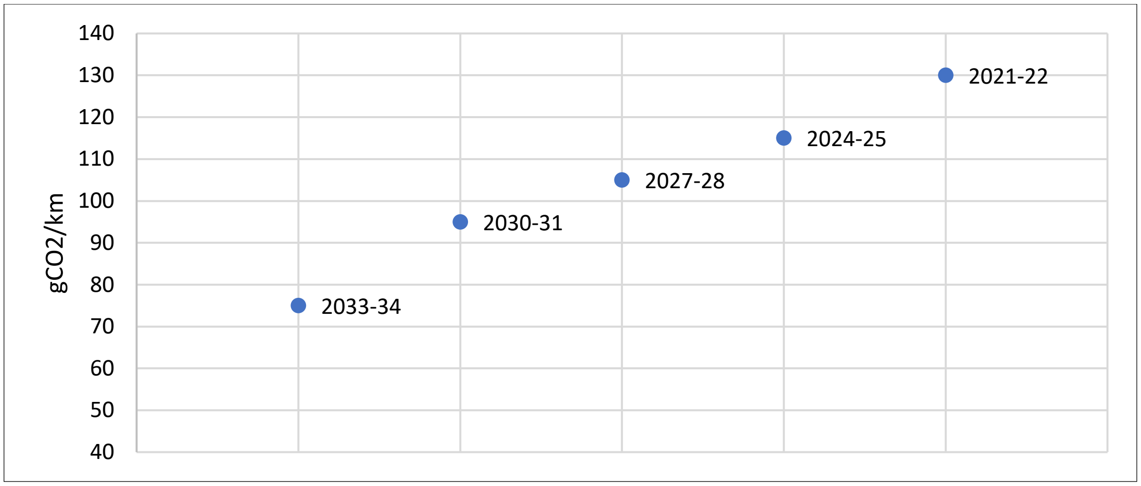

Figure 53: Pivot point ranges by year

f) ***Estimating the CO_2 penalty matrix:*** With the pivot point set for each year, the CO_2 penalty matrix is defined, i.e., the amount of CO_2 emissions per kilometre that the vehicle emits above the pivot point, resulting in a financial ("fee") penalty. The CO_2 penalty is calculated based on the deviation or difference of the mid-point of the emission class from the pivot point. For example, in year 2024, if the pivot is at 115 gCO_2/km, and if a vehicle falls in the emission class 130 – 140 gCO_2/km, then the CO_2 penalty is the difference between the mid-point of the emission class and the pivot point, i.e. 20 gCO_2/km. From covering six emission classes in 2024, with periodic revisions, the feebate covers nine emission classes by 2034. The matrix of fee levels by emission class and year is shown in Table 17.

Table 17: Penalty matrix by emission class and year

Emission Class	Mid-point	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35
0												
1-50												
50 - 90	75										5	5
90 - 100	95							5	5	5	15	15
100 - 110	105				5	5	5	15	15	15	25	25
110 - 120	115	5	5	5	15	15	15	25	25	25	35	35
120 - 130	125	15	15	15	25	25	25	35	35	35	45	45
130 - 140	135	25	25	25	35	35	35	45	45	45	55	55
140 - 150	145	35	35	35	45	45	45	55	55	55	65	65
15 0 - 160	155	45	45	45	55	55	55	65	65	65	75	75
>160	165	55	55	55	65	65	65	75	75	75	85	85

g) ***Estimating the CO_2 fee matrix:*** In the low adoption scenario, the fee schedule per gCO_2 is set similar to the current average compensation cess in India, which are equivalent to about $6 per gCO_2 closest to the pivot point, increasing as a continuous upward sloping curve. The highest fee is $12 per gCO_2 in the low adoption scenario, whereas it goes up to $19 per gCO_2 in the high adoption scenario from 2031 onwards (Figure 54). The overall fee schedule remains fixed for a period of three years before it is revised with a new pivot point.

The below equations describe the fee schedule for the Low and High EV adoption scenarios.

Low FY25: $y = 6.8688x^2 - 17.149x + 356.55$ …. (3)

Low FY35: $y = 2.6815x^2 + 24.634x + 403.22$ …. (4)

High FY25: $y = 21.482x^2 - 167.06x + 733.57$ …. (5)

High FY35: $y = 62.388x + 798.54$ …. (6)

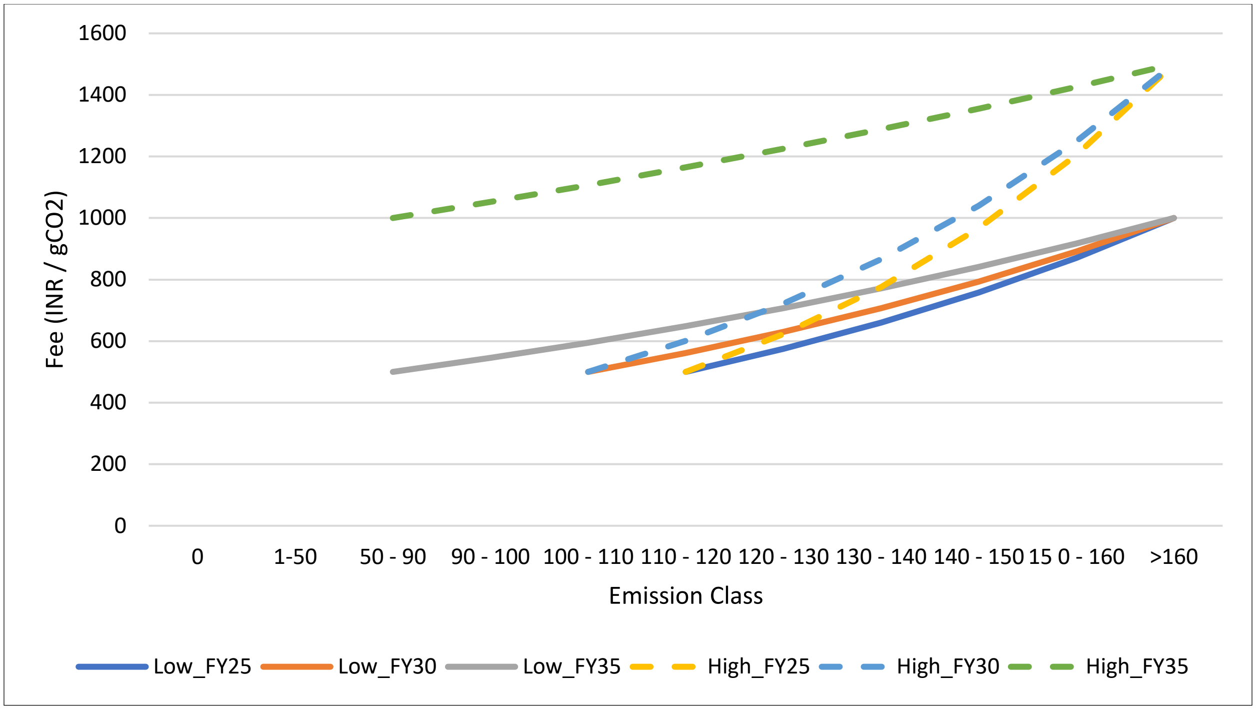

Figure 54: Fee schedule per gCO_2 low and high EV adoption scenarios across emission class

3.4 Designing a Feebate for India

In this analysis, four scenarios are identified (Table 18) defined by the two EV adoption scenarios and two rebate scenarios, and the respective fee schedules for the Low and High EV adoption scenarios. These scenarios are evaluated to see which of these lead to revenue neutrality and their impacts on expected vehicle MSRP.

Table 18: Feebate scenarios

EV Adoption Scenario	Rebate Scenario		Fee Schedule
	Base	Alternate	
Low	L1	L2	INR 500 – INR 1,000
High	H1	H2	INR 500 – INR 1,500 INR 1,000 – INR 1,500 (2030 – 2035)

3.5 Low EV adoption Scenario

In the low EV adoption scenario, the total rebates required range from INR 437 billion (~USD 5.5 billion) to INR 636 billion (~USD 7.9 billion), depending on the rebate. With the fee schedule in this scenario, the revenue generated is about INR 561 billion (~USD 7 billion). As can be seen in Figure 55, the feebate mechanism is revenue positive from the very first year in the base rebate case and is revenue deficit by about USD 0.9 billion over the period in the alternate rebate case, although it is revenue neutral in the first four years, up to 2027-28.

It is also seen that the fee schedule effectively translates to an average fee per ICE vehicle ranging from INR 3,577 (~USD 45) in 2024-25 to INR 19,250 (~USD 241) in 2034-35. As can be seen in Figure 56, the average additional fee impact on estimated vehicle prices is likely to range from 1% to about 5% for the highest emission class.

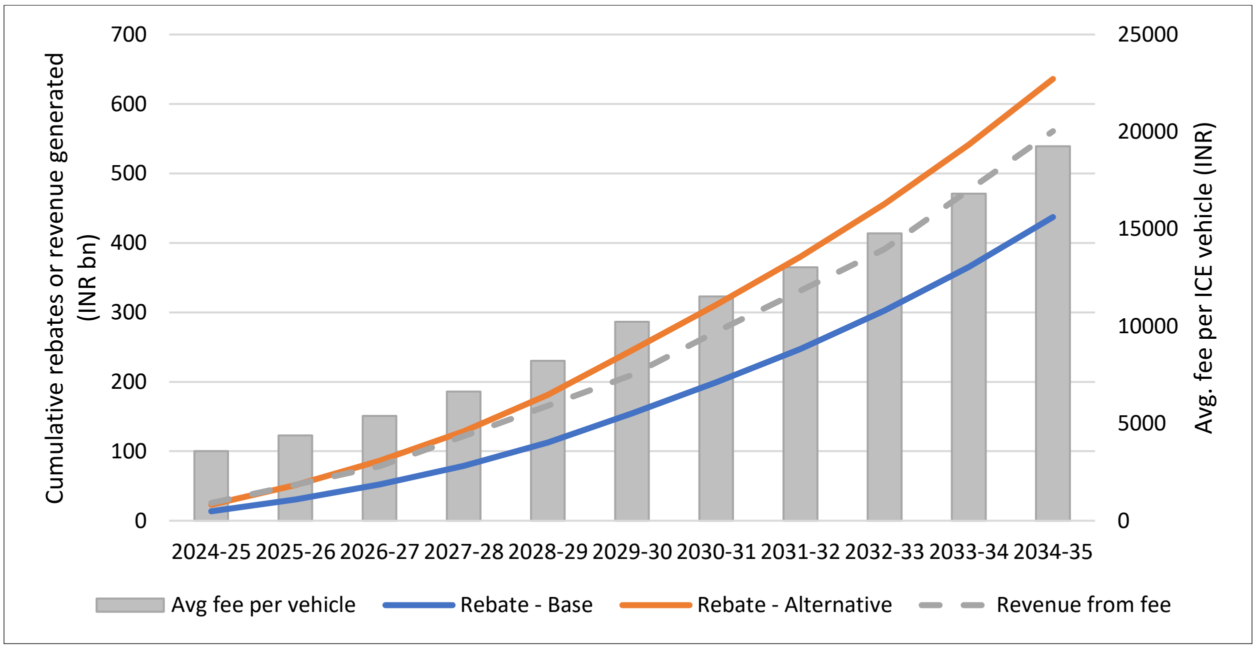

Figure 55: Total funds for rebates required, revenue generated from fees and average fee per vehicle in low adoption scenario

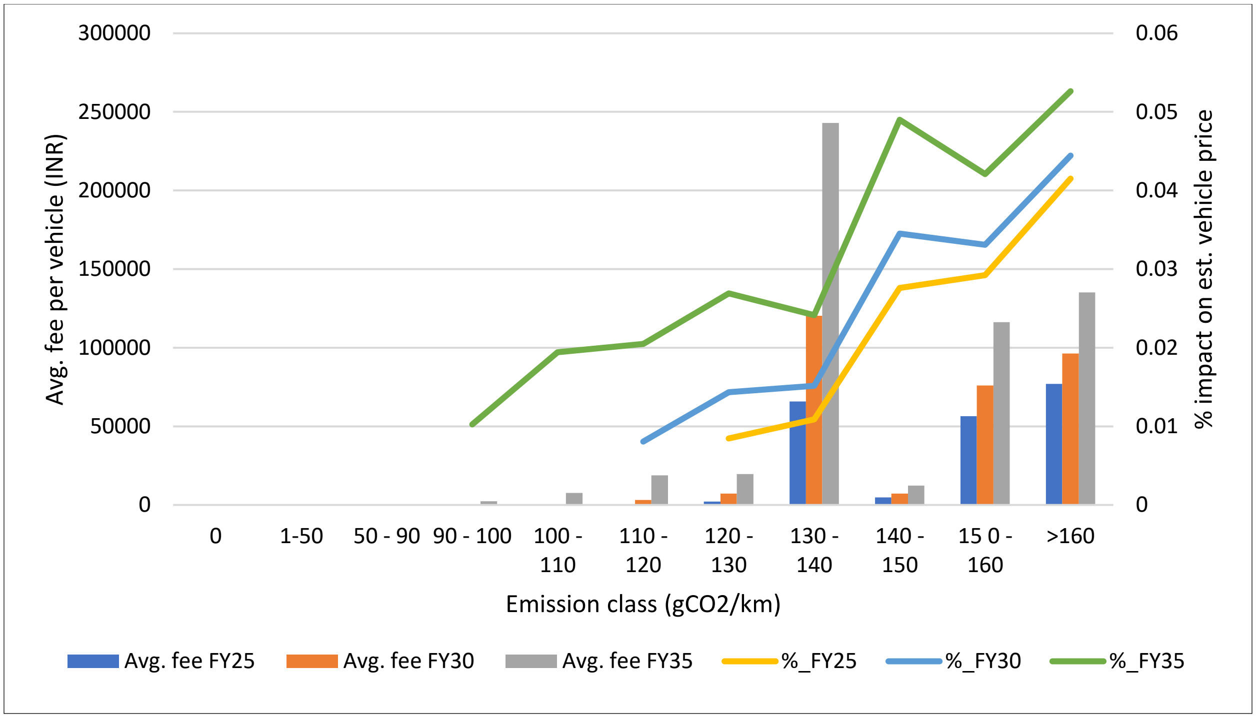

Figure 56: Average fee per vehicle and fee impact on vehicle price across emission class in low adoption scenario

3.6 High EV adoption Scenario

In the high EV adoption scenario, the total rebates required range from INR 598 billion (~USD 7.5 billion) to INR 868 billion (~USD 10.8 billion), depending on the rebate. With the fee schedule in this scenario, the revenue generated is about INR 812 billion (~USD 10.1 billion). As can be seen in **Figure 57**, the feebate mechanism is revenue positive from the very first year in the base rebate case and is revenue deficit by about USD 0.7 billion over the period in the alternate rebate case, although it is revenue neutral in the first four years, up to 2027-28.

It is also seen that the fee schedule effectively translates to an average fee per ICE vehicle ranging from INR 3,743 (~USD 47) in 2024-25 to INR 28,286 (~USD 354) in 2034-35. As can be seen in **Figure 58**, the average additional fee impact on estimated vehicle prices is likely to range from 1% to about 8% for the highest emission class.

In the high adoption scenario, by adjusting the fee schedule to start from INR 1,000 across all pivot points starting from 2024-25, as compared to the original fee schedule for this scenario, as given in Table 16, it is found that the feebate can be marginally revenue positive for the alternate rebate case as well. While the fee impact on the higher emission classes remains around 8%, the lower emission classes face a 2% impact on the estimated vehicle prices as compared to 1% in the original fee schedule.

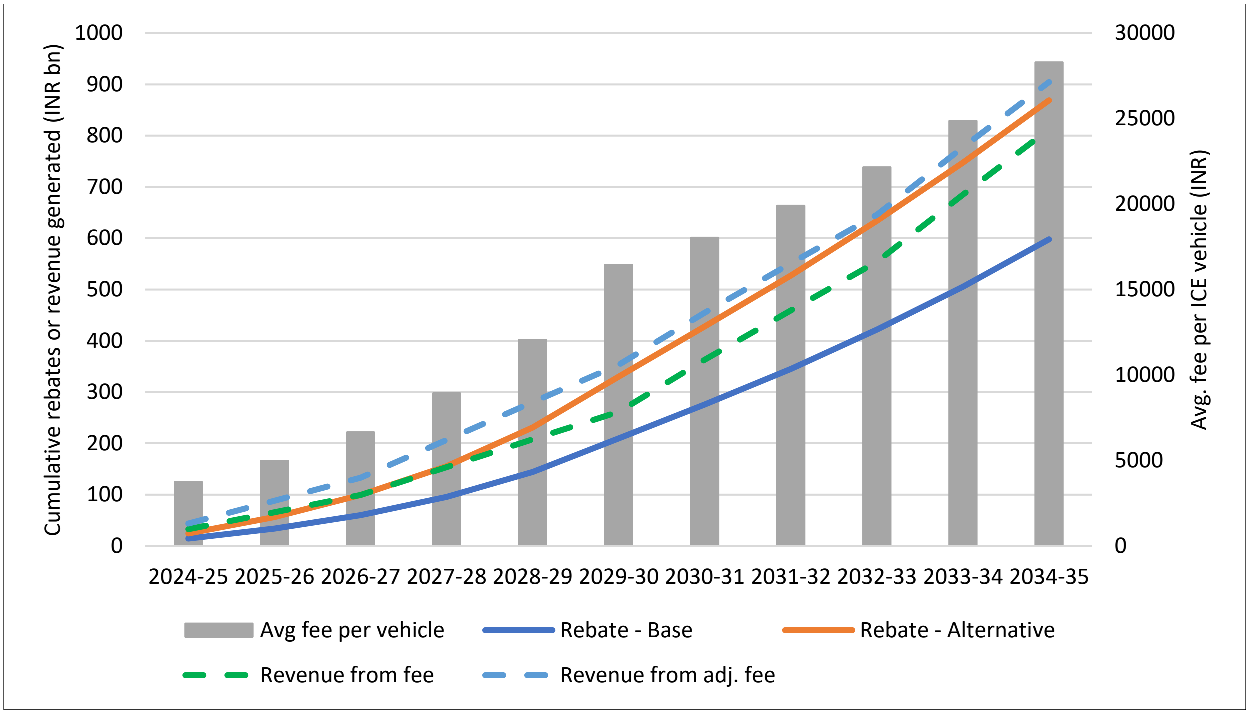

Figure 57: Total funds for rebates required, revenue generated from fees and average fee per vehicle in high adoption scenario

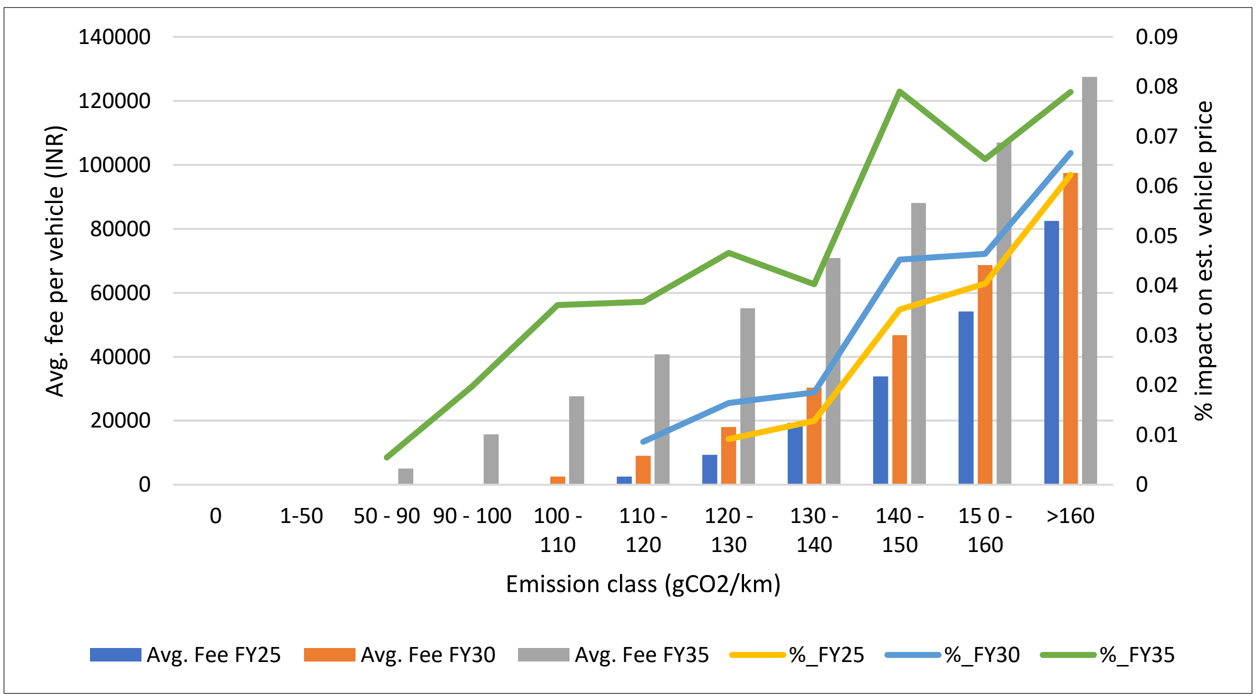

Figure 58: Average fee per vehicle and fee impact on vehicle price across emission class in high adoption scenario

3.7 Key findings and policy implications

Overall, across the different feebate scenarios, it is found that that with a fixed rebate of INR 220,000 (~USD 2,650) per eligible EV sold, it is possible to achieve revenue neutrality. Moreover, the feebate mechanisms assessed in this paper provide two key insights:

a. The fixed rebate structure provides an incentive support ranging from 11 – 15% of the prevailing average EV price, which is comparable to other countries in Europe.
b. The fee impact ranges from 1 – 4% across scenarios for the lower emission classes below 110 gCO_2/km in the early years.

The fee impact is comparable with the prevailing compensation cess of 1-3% on vehicles sold in these emission classes. This mitigates any adverse impacts on entry level vehicle buyers, but at the same time, provides strong fiscal foundation to support incentives for EV transitions.

As highlighted earlier, the effectiveness of a feebate mechanism in India is to support a focused ZEV transition as opposed to a multi-fuel pathway. While the current taxation structure has supported a significant growth in CNG vehicles, it takes away from a concerted policy focus on facilitating a clear transition pathway to zero emission road transport. Having a CO_2-linked fee mechanism allows for also moving both the industry and consumer towards considering BEVs as viable substitutes, instead of CNG. As seen in **Figure 59**, 71% of the CNG vehicle sales were between 76 gCO_2/km to 100 gCO_2/km. In the high feebate case, the feebate impact can be between 2 – 4% for vehicles with CO_2 emission below 100 gCO_2, in the post 2030 period. Also it should be noted that most vehicles in the lower emission class are hatchbacks and compact sedans, and thus, a mechanism aimed at driving a transition towards BEVs beyond 2030 would have limited impact in the short term on middle income households who typically purchase these vehicles, and give the industry a 5-year timeline between 2025 – 2030 to pivot their strategy and investments towards increasing model availability of EVs in this segment.

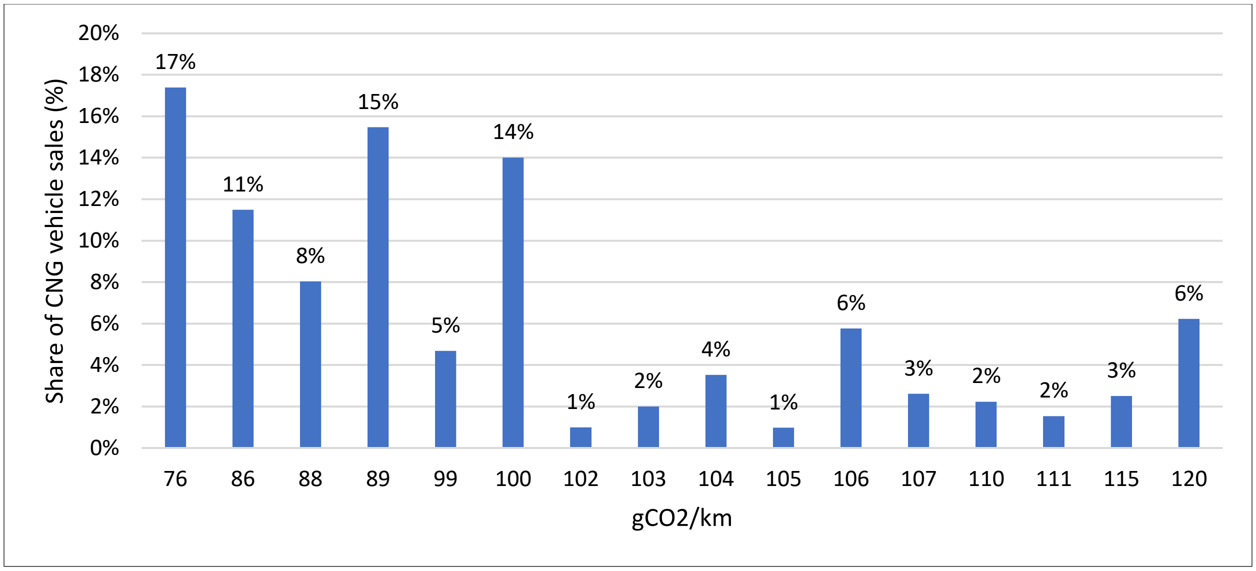

Figure 59: Share of CNG vehicle sales across CO_2 emission classes

Similarly, while diesel vehicles are around 18% of total sales, a majority of the sales have an emission range greater than 141 gCO_2/km. In the low adoption scenario, the impact of the fee on emissions above 140 gCO_2/km range from 3% in 2025 to 5% beyond 2030, whereas in the high adoption scenario, the fee impact ranges from 5% in 2025 to 8% beyond 2030. Typically, diesel vehicles are already priced about 10 – 20% higher than comparable gasoline vehicles in India, and hence, the price gap between diesel and electric vehicles is lower. Thus, with this fee impact, it will provide a clear signal for the market to transition towards BEVs in the short to medium term.

Further, based on a continuous review of vehicle sales across emission classes, the fee structure can be adjusted with suitable additional measures for diesel and CNG vehicles, to push a clear pathway towards lower emission gasoline vehicles and strong hybrids in the ICE portfolio, and a phased shift to BEVs substituting ICE vehicle sales from higher to lower emission classes over time.

Similar to Europe and the US, India can also consider household income requirements for incentive eligibility that can be revised every three years with the feebate revision, to continue targeting incentives towards lower and middle-income households who will find the transition more challenging, thus making the feebate more equitable and the rebate (subsidy) more economically efficient (reducing system leakages where high-income households benefit from incentives).

3.8 Conclusion

In developing country contexts like India, a regulatory approach such as fuel economy standards has been the mainstay for GHG emission control in the road transport sector. At the same time, its effectiveness is challenged by the strength of the regulatory measure such as lack of penalties for non-compliance or attribute-based relaxations (such as vehicle curb weight), limiting the impact on the supply side to drive technology shifts.

Further, a multi-fuel policy approach has also led to lack of certainty for industry in terms of optimizing investments, which a clear policy and technology pathway would provide. With India committing to a net zero target by 2070, it will need policy and regulatory certainty towards zero emission technologies, which will provide strong market signals (both industry and consumers alike) to support this transition.

A feebate mechanism, in the Indian context, will align the push for fuel economy improvements, vehicle taxation structure and the EV incentive program towards a common goal of a targeted ZEV adoption. As seen in this paper, the feebate mechanism can be designed to be revenue neutral, without disproportionately high impacts of the fee. Moreover, the feebate is essentially self-financing the EV incentive program for passenger vehicles, significantly lowering the impact on the average taxpayer who is more likely to purchase a two-wheeler as compared to a car.

Last but not the least, the impact of the feebate mechanism in India also provides for a strong case in supporting technology leapfrogging to BEVs (or truly zero emission vehicles by tailpipe) as opposed to a strategy that includes PHEVs in the scope of ZEVs, that is built on sustainable incentives through a market-based policy approach. This can have important learnings for other developing countries as well.

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