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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

OCTOBER 2025

Optimizing supply-side regulations to advance India's zero-emission vehicle transition

ICCT INDIA

ACKNOWLEDGMENTS

Dale Hall, Gaurav Dubey, and Sunitha Anup co-authored this paper. The authors thank Krithika P.R., Oscar Delgado, and Sumati Kohli for their reviews. Tanzila Khan contributed research and analysis on non-compliance payments.

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EXECUTIVE SUMMARY

The transition to zero-emission vehicles (ZEVs) represents a profound opportunity for India to become a leader in automotive manufacturing while simultaneously improving air quality and reducing greenhouse gas emissions. ZEV sales are increasing, but growth remains uneven across segments. The national government has supported this shift primarily through financial incentive schemes such as the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE), Faster Adoption and Manufacturing of Electric Vehicles in India (FAME), and the Production Linked Incentive (PLI) programs. While effective in spurring ZEV adoption, such schemes would be costly to sustain in the mass market.

Supply-side regulations (SSRs) can help scale the ZEV market at a low cost to the government while creating confidence for investments across the ZEV supply chain. There are two main types of SSR policies: performance-based standards, which push manufacturers to decrease the average fuel consumption of new vehicles with a mix of technologies, and ZEV sales requirements, which require them to increase the share of new vehicles sold that are ZEVs. Table ES1 summarizes the key features of these two options.

Table ES1

Summary of key considerations for SSRs to promote the ZEV transition

	Performance-based standards	ZEV sales requirements
Metric	Average fuel consumption or CO_2 emissions of new vehicles sold	Percentage of new vehicles sold that are ZEVs
Ways to meet compliance	More efficient internal combustion engine vehicles, hybrids, and increased ZEV sales	Increased ZEV sales shares, potentially including limited plug-in hybrid electric vehicles
Typically implemented by	National governments	National or state/regional governments
Certainty for ZEV supply chains and infrastructure	Moderate	High
Certainty of meeting ZEV targets	Moderate	High
Encourages internal combustion engine vehicle efficiency improvements	Yes	No
Can allow trading among manufacturers	Yes	Yes
Administrative resources	Moderate (four-wheelers) to high (heavy-duty vehicles)	Low
Regions with policy in place	Australia, Brazil, Canada, Chile, European Union, India, Japan, Mexico, New Zealand, South Korea, United States	California and 17 other U.S. states, Canada, China, European Union (buses), United Kingdom

This report explores how the Government of India can use SSRs to accelerate its efforts to promote ZEV uptake and meet its climate, air quality, and economic objectives. Focusing on four-wheelers and heavy trucks and buses, it examines lessons learned from leading and emerging ZEV markets and provides insights for designing effective SSRs considering India's vehicle market and industrial context. It then assesses how strong SSRs could yield economic benefits for India and ambitious domestic ZEV manufacturers and offers considerations related to policy elements such as super credits, penalties, and trading.

This analysis supports the following conclusions:

Financial incentives have driven India's early ZEV market growth, but SSRs are poised to play a larger role. To date, ZEV adoption in India has been supported largely through financial subsidies for ZEV buyers, manufacturers, and charging providers. While such incentives have been effective, scaling them up to induce mass-market adoption would require substantial financial resources. SSRs require manufacturers to sell ZEVs at increasing rates, encouraging more investment and competition and providing a predictable environment for developing supply chains—all at a low cost to the government.

Integrating lessons learned from other markets related to policy design elements like target structure, super credits, credit trading, and penalties for non-compliance could make India's regulations best-in-class and help to achieve the country's ZEV goals. As the Government of India considers new fuel consumption standards or ZEV sales requirements, it can leverage lessons learned from other markets. Having standards that tighten annually, rather than every 5 years, encourages consistent expansion in the EV market and supply chains. Super credits could be phased down to encourage consistent year-over-year ZEV sales growth as cost parity approaches. A trading system could enable greater flexibility for manufacturers while providing a revenue source for manufacturers committed to ZEVs, including prominent Indian companies. Finally, penalties for non-compliance could be indexed to the gap between the target and a manufacturer's performance to promote fairness and avoid perverse incentives.

Surges in announced investments in ZEV supply chains following the adoption of SSRs in the European Union, United Kingdom, and United States suggest that such regulations could yield similar economic benefits in India. The European Union's adoption of extended carbon dioxide emission standards in March 2023 was followed by approximately €5 billion in announced investments in ZEVs and battery manufacturing by companies like BMW Group, Stellantis, and CATL. In the 2 years surrounding the start of the United Kingdom's ZEV mandate in January 2024, investments amounting to roughly £6 billion were announced by Ford, Tata Group, Nissan, and JATCO for ZEV and upstream manufacturing. Adopting well-designed SSRs in India could increase investment in ZEV manufacturing, battery production, and charging infrastructure from domestic and foreign companies. Domestic manufacturers committed to ZEVs could further benefit if trading schemes were included in the SSRs, creating a new source of potential revenue to expand operations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

India is the world's fourth-largest vehicle market and one of the fastest growing. Over 4.1 million passenger vehicles and almost 1 million commercial vehicles were sold in India in 2023, increases of 15% and 39%, respectively, relative to 2019 (Society of Indian Automobile Manufacturers, 2023). The country's growing on-road vehicle fleet is a major contributor to life-threatening air pollution, accounting for about 20%–30% of urban air pollution and an estimated 43,000 premature deaths each year (Anenberg et al., 2019; Handschuch et al., 2023). Furthermore, road transport is responsible for about 12% of India's carbon dioxide (CO_2) emissions; these emissions will have to decline for India to meet its commitment to reach net-zero emissions by 2070 (Handschuch et al., 2023; Ministry of Environment, Forest and Climate Change, 2023).

Zero-emission vehicles (ZEVs)[1] offer a promising pathway to reduce the air pollution and CO_2 emissions associated with road transport, particularly when coupled with India's transition toward renewable electricity (Bieker, 2021; Yadav et al., 2024). The transition to ZEVs also offers an opportunity for India's vehicle manufacturing sector to expand and become a global leader in new automotive technologies (Press Information Bureau, 2023). The Government of India has set an aspirational target for 30% of new vehicle sales in 2030 to be electric, with higher targets for specific vehicle segments. While not a mandatory requirement, this goal aligns with the country's broader policy objectives of supporting ZEV adoption and localization. ZEV sales in India have increased in recent years amid a series of government incentive programs to subsidize the purchase of electric vehicles (EVs). While effective, such programs could be costly to sustain over the coming decades.

Supply-side regulations (SSRs) could help accelerate India's ZEV transition at a low cost to the government. These regulations, which include performance-based regulations like fuel efficiency and CO_2 standards as well as ZEV sales requirements, can foster confidence in the government's commitment to reducing vehicle emissions and encourage vehicle manufacturers and other sectors to invest in the transition to ZEVs (Rokadiya & Yang, 2019).

This paper explores how India can use SSRs to encourage ZEV adoption in the four-wheeler, heavy-duty truck, and bus segments, examining evidence from SSR implementation in other leading markets. Though not the focus of this paper, such regulations could also be applied in the two- and three-wheeler segments with similar benefits and considerations; previous ICCT research has evaluated the potential for ZEV sales requirements for two-wheelers in India (Anup & Rokadiya, 2024). The first half of the paper reviews existing policies to encourage ZEV uptake in India and offers considerations for designing effective performance-based standards and ZEV sales requirements. The second half of this paper then elaborates on the economic benefits of SSRs related to supporting ZEV manufacturers, promoting investments in ZEV supply chains, fostering more efficient charging infrastructure buildout, and expanding options for consumers.

POLICY MEASURES TO ENCOURAGE ZEV ADOPTION IN INDIA

Over the past decade, the Government of India has demonstrated a strong commitment to promoting ZEV adoption, allocating approximately ₹25,000 crore ($3 billion) to directly incentivize ZEV purchases (Ministry of Heavy Industries [MHI], 2024a). Key initiatives have included the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, introduced in 2015 under the National Electric Mobility Mission

1 In this paper, unless otherwise noted, ZEVs and electric vehicles (EVs) refer to battery electric vehicles. Hydrogen fuel-cell vehicles also produce zero greenhouse gas emissions but have seen limited uptake.

Plan (NEMMP) 2020. NEMMP 2020 aimed to position India as a leader in the ZEV market, with an initial focus on achieving 6–7 million ZEV sales by 2020, particularly in the two- and four-wheeler segments (MHI, 2019). Implemented in two phases over 9 years (April 2015 to March 2024), the FAME scheme primarily provided financial incentives for ZEV purchases and supported the development of charging infrastructure.

After the conclusion of FAME, the government implemented the Electric Mobility Promotion Scheme (EMPS) from April to September 2024, offering short-term measures to accelerate ZEV adoption for a limited number of vehicles in the two- and three-wheeler segments (MHI, 2024a).[2] In October 2024, it introduced the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) initiative, which provides incentives for the purchase of electric two- and three-wheelers, buses, trucks, and ambulances, as well as funding to expand charging infrastructure and build the capacity of testing agencies (MHI, 2024c). A separate initiative, the PM-eBus Sewa Scheme, aims to enhance electric public transportation in cities (MHI, 2025).

Table 1 shows ZEV sales in India by vehicle segment in 2023 and 2024, with the year-on-year growth rate indicated in parentheses. Sales increased in all segments except for heavy goods vehicles, where they declined. Sales increased the most among light commercial vehicles, buses, and two-wheelers.[3]

Table 1
ZEV sales in India, 2023–2024

Year	Heavy goods vehicle	Bus	Passenger car	Light motor/ goods vehicle	Three-wheeler	Two-wheeler
2023	324	2,700	82,563	2,283	583,434	860,418
2024	224 (-31%)	3,616 (+34%)	99,004 (+20%)	5,993 (+63%)	690,990 (+18%)	1,148,415 (+33%)

Source: Ministry of Road Transport and Highways, 2024

The Government of India also has implemented industrial policies to support the domestic production of ZEVs and their components, several of which have been administered under MHI. In 2021, it approved the Production Linked Incentive (PLI) Scheme for Advanced Chemistry Cell (ACC) Battery Storage, with a budgetary outlay of ₹18,100 crore. The PLI scheme aims to establish a cumulative ACC battery production capacity of 50 GWh. The government subsequently launched the PLI-Auto Scheme for Automobile and Auto Components to promote the domestic manufacturing of advanced automotive technology products, with a budget allocation of ₹25,938 crore over a 5-year period (MHI, 2022b). Separately, the Phased Manufacturing Programme (PMP) aims to encourage the domestic production of EVs (MHI, 2022a). In 2023, the Ministry of Finance granted exemptions to the basic customs duty for importing capital goods and machinery used in the production of lithium-ion cells for EVs (Ministry of Finance, 2023). Most recently, in 2024, MHI (2024b) adopted the Scheme to Promote Manufacturing of Electric Passenger Cars in India, which provides significant tax benefits for eligible manufacturers that make large investments in the production of EVs.

2 EMPS incentives were limited to two- and three-wheelers; to qualify, vehicles must have been manufactured and registered within the scheme's 4-month validity period.

3 Under the Motor Vehicles Act, light motor vehicles refer to any transport vehicles or omnibuses with a gross vehicle weight not exceeding 7,500 kg or motor cars, tractors, or road-rollers with an unladen weight not exceeding 7,500 kg. Heavy goods vehicles refer to any goods carriage with a gross vehicle weight exceeding 12,000 kg or a tractor or road-roller with an unladen weight exceeding the same limit. Heavy passenger motor vehicles include any public service vehicle, private service vehicle, educational institution bus, or omnibus with a gross vehicle weight exceeding 12,000 kilograms, or a motor car with an unladen weight exceeding this threshold.

State-level support for ZEV adoption

While the Government of India has provided most of the financial support for ZEV adoption, several states and territories in India have enacted supporting strategies and policies to encourage faster uptake. The National Capital Territory of Delhi, a leader in terms of ZEV adoption in India, enacted a comprehensive EV policy in 2020 with targets for each vehicle segment as well as incentives and measures to promote charging infrastructure (Government of National Capital Territory of Delhi, Transport Department, 2020). A new phase of Delhi's EV policy is now in development and is expected to be released in March 2026 ("Delhi government extends current EV policy," 2025).

Several other states have implemented measures to develop their local automotive industries and realize the environmental and economic benefits of the ZEV transition. Haryana, the auto manufacturing hub of India, has an EV strategy that is aligned with national goals; the ICCT previously identified opportunities to support EV uptake and production in the state through additional policies related to charging infrastructure, research and development, incentives, and low-emission zones (Goyal, 2025). Karnataka, meanwhile, recently adopted a policy to boost ZEV manufacturing and demand (Kohli, 2025).

Fuel efficiency standards in India

India's road transport sector, a significant consumer of oil, accounts for 90% of the energy consumed within the transport sector. India is the fourth-largest petroleum consumer globally, following China, the United States, and Russia, and half of all oil in India is used in the transport sector. The large majority of oil consumed in India is imported (88% as of 2022), with oil accounting for more than half of total energy imports (International Energy Agency, n.d.).

The Bureau of Energy Efficiency (BEE) administers fuel efficiency standards for vehicles. The first phase of fuel consumption standards for passenger cars was in effect from fiscal years 2017–18 to 2021–22, followed by a second phase implemented in April 2022 (Deo, 2021). These standards link a manufacturer's corporate average fuel economy (CAFE) to the corporate average curb weight of all passenger cars sold in a fiscal year. Building on these efforts, BEE is now working on CAFE III and CAFE IV norms, which would run from 2027–2032 and 2032–2037, respectively (BEE, 2024). Additionally, in 2017, the Government of India introduced fuel efficiency standards for commercial vehicles with a gross vehicle weight (GVW) of 12 tonnes or more (Garg & Sharpe, 2017). Efforts are also underway to develop the next phase of standards for heavy-duty commercial vehicles.

These fuel efficiency standards have resulted in a reduction in the fuel consumption of new vehicles in India and increased sales of hybrid and electric cars from some manufacturers (Deo & Kaur, 2024). New and stronger standards can help India meet its ambitions for electric light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs). The following sections discuss how SSRs are leading to greater ZEV sales and economic benefits in other markets and how best practices from these regulations could be incorporated into new regulations in India.

PERFORMANCE-BASED STANDARDS

Performance-based standards require manufacturers to sell vehicles that are more efficient and less polluting by specifying targets for key performance metrics like greenhouse gas (GHG) emissions or fuel consumption. This type of standard is technology-neutral, meaning that manufacturers can use a mix of strategies to comply: They can increase the efficiency of internal combustion engines (ICEs), sell hybrids, sell EVs, or pursue a combination of these strategies. This gives manufacturers flexibility to meet targets in a way that leverages their own strengths, particularly in the near term, but still encourages ZEVs as an attractive compliance option. India's existing and proposed fuel consumption standards fall into this category of SSR, although they lack some elements of leading global examples, as discussed below.

Table 2 compares the common types of performance-based standards: CO_2/GHG, fuel efficiency, and fuel consumption standards. In practice, these approaches have a similar effect, as a vehicle's direct CO_2 emissions are proportional to the amount of fuel that it burns. In some markets, such as the United States, GHG and fuel efficiency standards are enforced simultaneously by different government agencies. Fuel consumption targets can be converted into g CO_2/km targets, enabling easier comparison across different markets (ICCT, n.d.).

Table 2

Comparison of performance-based standard designs

	Type of standard		
	CO_2/GHG	**Fuel efficiency**	**Fuel consumption**
Metric	Grams of CO_2 per kilometer (g CO_2/km)	Kilometers per liter (km/L)	Liters per 100 kilometers (L/100 km)
Treatment of electric vehicles	Typically counted as 0 g CO_2/km	Equivalent energy consumption	Can be counted as 0 L/100km or based on equivalent energy consumption
Examples (cars)	European Union, Mexico, United States	Chile	India
Examples (HDVs)	European Union, United States		China, India

As noted above, performance-based standards allow manufacturers to use a mix of technologies to comply. This may be advantageous for manufacturers' planning and near-term costs, but it also means that there is less certainty about how many EVs will be sold as a result of the standard. The more stringent the fuel consumption standard, the more attractive manufacturing and selling ZEVs will be for manufacturers, since ZEVs are by far the most efficient powertrain and count as zero fuel consumption or CO_2 in many standards worldwide.[4] Indeed, beyond a certain stringency level, ZEVs become the lowest-cost compliance pathway, and a certain share of ZEVs may be necessary to comply with stringent standards. On the other hand, a weak fuel consumption standard may not drive any increased ZEV uptake at all. It is thus important to ensure that any standard is stringent enough to achieve the targeted level of ZEV uptake (Lutsey, 2018).

SUPER CREDITS

Performance-based standards in most light- and heavy-duty vehicle markets have included super credits (also known as multipliers) to encourage specific low- and zero-

4 In India's existing Phase 2 standards, EVs do not count as 0 g CO_2/km fuel consumption; a typical EV has a rating equivalent to about 25 g CO_2/km, compared with roughly 150 g CO_2/km for an average gasoline car.

emission vehicle technologies. With super credits in place, certain vehicles—usually EVs and sometimes plug-in hybrids (PHEVs)—are given a higher weight when each manufacturer's average fuel consumption or CO_2 value is calculated.

Super credits make ZEVs a more compelling pathway for complying with the standards, encouraging manufacturers to develop and sell ZEVs when they might otherwise find it more profitable to comply with incremental improvements to ICE vehicles. However, super credits also reward ZEVs for more emissions reductions than they deliver, meaning they enable manufacturers to comply with fewer ZEVs. In other words, for a given fuel consumption target, a larger super credit will result in lower emissions reductions.

The benefit of super credits thus depends on the market phase and the strength of the standard. At limited levels of EV penetration and low stringency, super credits can help spur increased EV adoption. This was evident with the fiscal year 2022–23 implementation of the Phase 2 CAFE norms in India: Tata and MG sharply increased their battery electric vehicle (BEV) sales share to 9% and 12%, respectively, and comfortably achieved compliance, whereas most manufacturers that sold no BEVs in that year struggled to comply (Deo & Kaur, 2024).

In contrast, with a stringent standard under which ZEVs are required for compliance, a larger super credit would result in fewer ZEV sales. For this reason, super credits are most effective when ZEV sales shares are low but are ideally eliminated as the market takes off. Illustrating this tradeoff, an ICCT analysis of India's light-duty fuel consumption standards assessed that super credits would encourage manufacturers to invest more quickly in BEVs, but under the proposed next phase of standards, ZEV sales in 2030 would be 50% higher if super credits are phased out than if they remain in place at a factor of 3 (Deo & German, 2023).

China, the European Union, and the United States, among others, have ended super credits for LDVs as ZEVs have achieved 3%–8% sales shares (ICCT, n.d.). Super credits will also be phased out in Canada after 2025 and in South Korea after 2026. To align with international best practice, India could follow a similar trajectory and phase out super credits for four-wheelers over the remainder of the decade. Performance-based standards for HDVs in leading markets have retained super credits for a longer period, as electric trucks are relatively more expensive and their adoption remains low, but such credits are still phased down over time: In the United States, for example, super credits for electric trucks end after 2027 (Xie, 2025).

CONSIDERATIONS FOR LDVS

Performance-based regulations have an extensive track record. Fuel consumption standards for cars were first adopted by the United States in 1975 to address energy security concerns. Many major vehicle markets have since implemented such standards to meet climate or energy security objectives, with India commencing its first fuel consumption standards for cars in 2017 and a second phase in 2022.

Updated fuel consumption standards in India would likely be met through a mix of improvements to ICE vehicles, hybrids, and EV sales. A recent ICCT study found that for most four-wheeler segments, gasoline vehicle efficiency can be improved by roughly 25% at a lower compliance cost than shifting to BEVs, although the percentage is lower if super credits are awarded for BEVs (Deo & German, 2023). Based on historical evidence, fuel consumption standards can drive improvements in ICE vehicle efficiency of about 3% annually (Hall et al., 2024). Therefore, to ensure ZEV uptake aligned with India's intended trajectory, standards would have to be much stronger than 3% per year; otherwise, manufacturers may comply without selling ZEVs, or

manufacturers that do sell ZEVs could reduce the efficiency of their ICE vehicles. A previous ICCT analysis found that a fleet-average CO_2 target would likely need to be lower than 90 g CO_2/km to produce a 30% ZEV sales share given the cost-effective ICE efficiency improvements that many manufacturers would deploy to meet compliance (Deo & Kaur, 2024).

CONSIDERATIONS FOR HDVS

Segmentation of the market. Compared with light-duty four-wheel vehicles, HDVs vary much more in size, weight, and engine power. As such, fuel consumption or CO_2 requirements are typically either indexed to the vehicle's GVW (e.g., in terms of grams of CO_2 per tonne-kilometer [g CO_2/t-km]), or different standards are set for many small subgroups of vehicles based on vehicle configuration and GVW. India's existing heavy-duty fuel consumption standards are divided into 10 segments based on GVW, axle configuration, and vehicle type (rigid truck, tractor trailer, or bus); within each category, the fuel consumption limit is a function of GVW. Because the market has evolved substantially since the standards were developed in 2017, it may be appropriate to re-examine the segmentation for future phases to ensure that all vehicle types are pushed to improve at adequate rates.

Corporate average versus per-vehicle limits. Unlike CAFE systems, whereby manufacturers must meet an average target across their fleet, the first fuel consumption standard for trucks in India, developed in 2017 and implemented in 2023, set per-vehicle limits based on the median performance of trucks from 2014–2015 (Sub-Committee I [Testing/Fuel Economy Parameters], 2016). This policy design can encourage improvements in the efficiency of combustion engine vehicles by deploying cost-effective technology. However, this system does not particularly incentivize the sale of zero-emission trucks, as selling some vehicles with far greater fuel efficiency, especially ZEVs, does not give a manufacturer any additional flexibility to sell less-efficient vehicles elsewhere in its product mix. While China uses a similar individual vehicle limit system, other markets, including the European Union, Japan, and the United States, use CAFE regulations for heavy-duty as well as light-duty vehicles, making electric HDVs a compelling option for compliance.

An effective CAFE regulation for HDVs would account for the difference in emissions reductions from different categories of vehicles. For example, an electric long-haul tractor-trailer truck will provide far greater fuel savings than an electric urban delivery truck, not only because of the greater energy consumption per kilometer of the former but also because long-haul trucks tend to drive more kilometers each year. The European Union's heavy-duty CO_2 standards overcome this in a novel way through their mileage and payload weighting factor, which is assigned to each vehicle group based on its annual mileage and payload capacity (Mulholland, 2024). Groups with a higher mileage and payload weighting factor count more heavily towards a manufacturer's CO_2 emissions target; this encourages manufacturers to design and sell ZEVs in all segments, rather than only those that are smaller and easier to electrify. A similar provision could be added to new heavy-duty fuel consumption regulations in India to increase flexibility in strategies for reducing fuel consumption and emissions.

Options for vehicle testing. Because of the diversity of the HDV market and the size of the vehicles, it is impractical to physically test the fuel consumption of every type of truck and bus, as is done for cars. Instead, most regulations supplement limited vehicle and component testing with simulations of vehicle variants. The United States and the European Union have developed bespoke vehicle simulation software—the Greenhouse Gas Emissions Model and the Vehicle Energy Consumption calculation TOol (VECTO), respectively—to estimate fuel consumption and emissions of HDVs in real-world conditions (Rodríguez, 2018). Such tools enable faster and more detailed enforcement

of performance-based standards but can be resource-intensive to design and require real-world monitoring for validation. As a middle ground, China conducts chassis dynamometer testing for base models of HDVs but uses simulation to evaluate model variants to reduce the testing burden (Liu & Mao, 2024).

It could be possible to adapt VECTO as a pathway for implementing a performance-based standard for trucks in India, given that the software is open-source and that the European Union and India use similar vehicle categorization schemes. A proof-of-concept VECTO tool for India has already been created, providing a blueprint for how an official tool could be designed (Sharpe et al., 2019). Many aspects of VECTO, like the overall software architecture and component testing methodologies, could be directly copied for an Indian simulation tool.

However, the process of adapting VECTO would likely add several years to the lead time for any new heavy-duty performance-based standard, as vehicle categories and drive cycles would have to be customized for the Indian market and baseline data would require extensive real-world testing. Given that zero-emission buses and trucks are rapidly approaching total cost of ownership (TCO) parity, alternative policies like ZEV sales requirements (discussed below) may be considered a more efficient, less burdensome option as they do not require simulation or dynamometer testing (Kaur et al., 2024).

ZERO-EMISSION VEHICLE SALES REQUIREMENTS

ZEV sales requirements set targets for the percentage of a manufacturer's new vehicle sales that must be electric in a given year. Unlike fuel consumption standards, ZEV sales requirements can only be satisfied by selling ZEVs; more efficient conventional vehicles like hybrids are not counted because all of their energy comes from combusting liquid fuels. In some regulations, PHEVs may earn partial credits or count for a limited share of the ZEV requirement. In California and Canada, for example, PHEVs may count for no more than 20% of the ZEV requirement each year.

ZEV sales requirements are generally implemented through a credit system. Each year, manufacturers have a credit requirement proportional to their total vehicle sales. Manufacturers earn credits primarily by selling ZEVs. These credits can be traded among manufacturers or, if manufacturers exceed their targets, retained for use in future years.

One advantage of ZEV sales requirements is that they are much simpler to design, monitor, and enforce than fuel consumption standards. To design a ZEV sales requirement, the government need not consider the cost-effectiveness and feasibility of incremental ICE efficiency improvements. To monitor compliance, regulators primarily need to know the number of ZEVs a manufacturer sells each year, rather than the technical specifications of every vehicle. This makes these regulations especially attractive for subnational jurisdictions that may not have the resources to assess and monitor vehicle fuel consumption and emissions.

CONSIDERATIONS FOR LDVS

There are several ways that ZEV sales requirements can be customized to meet the needs of India's four-wheeler market, including through market segmentation, ZEV technical requirements, and opportunities for bonus credits.

Market segmentation. In contrast to HDVs, discussed below, most light-duty ZEV segments face similar prospects in terms of technical readiness and timelines for reaching TCO parity with ICE vehicles (Bhosale et al., 2022). It may therefore be appropriate to set ZEV sales requirements for all LDVs and allow manufacturers to determine which types of ZEVs to bring to market first. However, setting different trajectories that must be met for different market segments can encourage manufacturers to develop products across their entire portfolio, bolstering competition and helping to ensure that there are options for all consumers. The United Kingdom took this approach with separate targets for cars and vans in its ZEV mandate, setting slightly lower annual targets for vans to reflect the less developed state of the electric van market.

ZEV technical requirements. ZEV sales requirements typically provide credits for vehicles that do not emit any GHGs or air pollution, which include BEVs and hydrogen fuel-cell vehicles. Beyond this criterion, governments can impose additional requirements to encourage manufacturers to design more capable vehicles that better serve customers' needs. These could include, for example, a minimum range, specific charging standards and minimum charging power, and guarantees on battery durability and recyclability. California and the United Kingdom have both imposed standards for these characteristics as part of their ZEV sales requirements (Bui et al., 2022; Department for Transport, 2024b).

Bonus credits. Beyond selling ZEVs, some standards provide an opportunity to earn limited credits through other actions that advance the ZEV market. In California, manufacturers can earn "environmental justice" credits for actions like selling low-price ZEVs, reselling ZEVs after they end their initial lease, or selling ZEVs at a discount

for use in community mobility programs (Bui et al., 2022). In Canada, manufacturers can earn credits for investing in public direct current fast charging infrastructure (Environment and Climate Change Canada, 2023). In the United Kingdom, manufacturers can earn partial credits for selling wheelchair-accessible ZEVs or selling ZEVs for use in car-sharing programs (Department for Transport, 2024b). In all cases, the value of these bonus credits and their contribution as a share of compliance are limited to ensure that actual ZEV sales do not fall too far below the targets. For example, California's environmental justice credits range from 0.1–0.5 credits and cannot account for more than 5% of compliance, while in the United Kingdom, ZEVs used for car-sharing earn an additional 0.5 credits, and these are capped at 5% of a manufacturer's total sales.

CONSIDERATIONS FOR HDVS

Because of the diversity of vehicle types and use cases, some classes of HDVs can transition much more quickly than others to zero emissions. Certain segments, like transit buses, already offer a lower TCO than ICE equivalents, while most classes of trucks are expected to reach TCO parity by 2030 (Kaur et al., 2024; Vijaykumar et al., 2021). Rapidly deploying ZEVs in the most cost-effective applications can help to build economies of scale, encourage the growth of charging infrastructure, and promote familiarity with the technology so that more challenging heavy-duty market segments can quickly transition to zero-emissions as technology improves (CALSTART, 2022).

Setting ZEV sales requirements separately for different categories of HDVs can encourage manufacturers to develop ZEVs across all categories of heavy vehicles while recognizing that near-term ZEV sales will mostly be in specific segments with less demanding duty cycles. This is the approach taken by California in the Advanced Clean Trucks regulation, with separate trajectories for medium pickup trucks and vans, medium and heavy rigid trucks, and heavy tractor trailers. This is also the approach of the European Union, which imposed a ZEV sales requirement only for transit buses (Mulholland, 2024).

Monitoring and administrative burden. Monitoring and enforcement for a heavy-duty ZEV sales requirement is far simpler than for a performance-based standard as it requires only verifying what powertrain a vehicle has rather than measuring vehicle efficiency. This difference is even more pronounced for HDVs than for cars given the wide variety of models and variants and larger vehicle sizes, and ZEV sales requirements do not require heavy-duty testing facilities or vehicle simulation models like VECTO. Therefore, ZEV sales requirements can be implemented more quickly than performance-based standards and may be especially appealing for governments that are resource constrained, such as state and union territory governments.

BEST PRACTICES FOR SSRS

Although the design of SSRs varies significantly depending on policy type (e.g., fuel consumption standard vs. ZEV sales requirement), vehicle type, and jurisdiction (e.g., national vs. state level), there are several design principles that are applicable to almost any policy. This section offers considerations based on international experience that can be applied to any new SSRs in India regardless of policy type, vehicle segment, or jurisdiction.

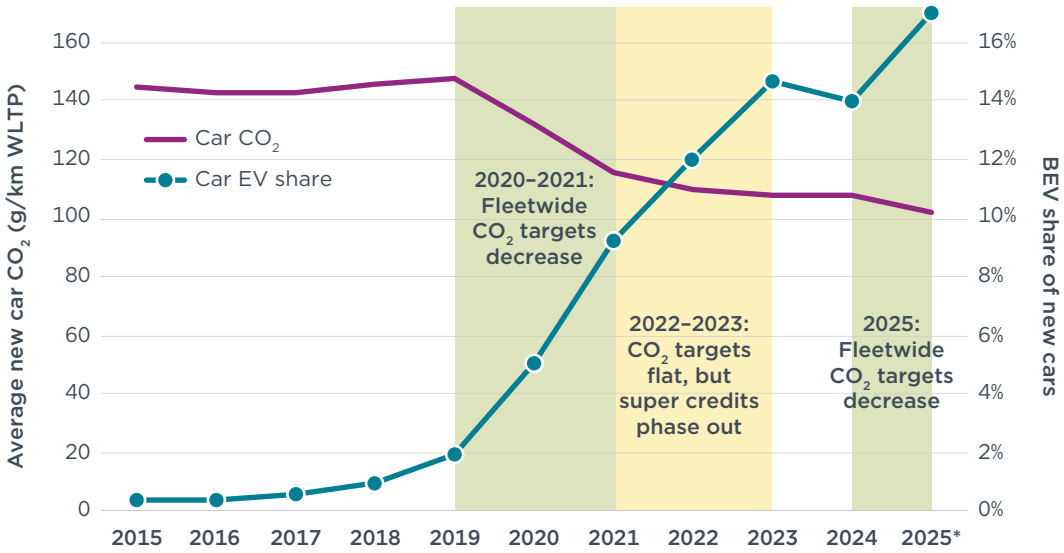
Annual versus 5-year targets. Regulations can be designed to tighten at different intervals. Many standards, including those in Australia, China, and the United States, require stricter targets every year; others, like those in the European Union and India's Phase 2 fuel consumption standards, require increases only every 5 years. Longer intervals are common for standards with per-vehicle limits, like those regulating nitrous oxides (NO_x) and particulate matter (PM), because these are met primarily by designing new components, which typically takes several years. In contrast, for standards that measure emissions on a fleetwide average basis, manufacturers can comply not only by improving vehicle design but also by changing the mix of vehicles sold each year, as well as applying flexibilities. Almost all ZEV sales requirements as of 2025 include annual targets.

Evidence from the European Union suggests that annual targets spur more consistent reductions in CO_2 emissions and increased ZEV sales shares compared with targets that increase only every 5 years. Figure 1 charts average new car CO_2 emissions and ZEV sales shares in the European Union between 2015 and 2025, with shading to indicate periods in which CO_2 targets tightened (green) or super credits were phased out (yellow). The figure illustrates how the use of 5-year targets in the European Union's car CO_2 standards has led to inconsistent progress in CO_2 reduction and ZEV sales. Prior to the standards taking effect, there was no reduction in new car CO_2 and only gradual growth in ZEV sales. Vehicle emissions declined significantly in years where new targets came into effect—2020, 2021,[5] and, based on early data, 2025—but emissions reductions were not realized in other years (Mock, 2021; Monteforte & Díaz, 2025). In fact, average emissions rose in 2019 and were flat in 2024, the years before new targets took effect, and in 2024, ZEV sales in the European Union fell for the first time since at least 2015 (ICCT, 2022; Monteforte et al., 2025). When new standards took effect in 2025, average CO_2 immediately began to drop, and ZEV sales shares hit record highs (Monteforte & Díaz, 2025). This suggests that in the absence of a requirement to sell cleaner vehicles, manufacturers choose to sell higher-margin, more polluting vehicles.

5 Although the numerical target did not change from 2020 to 2021, manufacturers were allowed to exclude the 5% of their vehicles with the highest emissions from the CO_2 standard in 2020. In 2021, 100% of vehicles were required to comply, effectively requiring reduced CO_2 across the fleet.

Figure 1

Average new car CO_2 and ZEV sales share in the European Union, 2015–2025



Note: Data for 2025 are for January–July. WLTP = Worldwide Harmonised Light Vehicles Test Procedure.

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Even in systems where fleetwide CO_2 or fuel consumption targets tighten every 5 years, consistent progress can be encouraged by reducing super credits and tightening other flexibilities. From 2020 to 2023, super credits for EVs and PHEVs in the EU light-duty standard were phased down from two to one, leading to sustained CO_2 reductions and ZEV sales share increases in 2022 and 2023 even while CO_2 targets remained flat (ICCT, n.d.). India could opt for a similar approach and phase down super credits over the 2027–2032 period ahead of the implementation of stricter Phase 4 fuel consumption targets.

Banking. Although SSRs specify targets to be met in certain years, manufacturers have different product planning cycles, and their product mixes may change from year to year. Such regulations, particularly those with annual targets, may be designed to offer flexibilities to manufacturers by allowing them to over-comply with their targets (by selling cleaner vehicles and more ZEVs) in some years and under-comply in other years. This most commonly takes the form of banking, also known as carry-forward, where manufacturers that over-comply in one year can apply the excess credits toward ZEV sales or CO_2 savings in future years.

Banking encourages manufacturers to expedite the sale of ZEVs rather than withholding such sales for compliance in a future year; this accelerates CO_2 and fuel savings. Nonetheless, excess banking could mean that manufacturers sell fewer ZEVs than expected in future years, reducing certainty for charge point operators and supply chains. For example, in California, most manufacturers had banked enough credits through 2023 to comply with at least 2 years of ZEV sales requirements without selling any additional ZEVs (California Air Resources Board, n.d.). To mitigate this risk, credits may be designed to have an expiration date, such that they may only be banked for a certain number of years after they are earned. In most regulations, banking is limited to 3 or 5 years (ICCT, n.d.).

Non-compliance penalties or payments. For SSRs to instill confidence in the growth of the ZEV market, they must be binding. In almost all SSRs, this is most often enforced via fees assessed on manufacturers that miss their targets, with the amount proportional to the number of vehicles sold and the gap between the target and a manufacturer's

performance. In China, the only exception among major markets, type approval of new models may be withheld, prohibiting their sale, if a manufacturer consistently misses requirements. China's approach could be considered as a backup option in India for manufacturers that fail to pay required penalties or consistently miss targets.

The optimal level of a penalty is determined by several factors. First, it should account for the cost of the additional climate and air pollution that results from selling dirtier ICE vehicles. Second, it should be high enough so that manufacturers find it more costly to miss compliance and pay the penalty than to comply, which might include additional investment and lower profit margins in the near term. Finally, if a regulation allows trading, the penalty acts as a ceiling on the price at which credits may be traded, influencing how much benefit could result for manufacturers leading in the transition to ZEVs (discussed below).

Table 3 compares the non-compliance penalties or payments for fuel economy and CO_2 standards in selected global LDV markets. All rates were converted to rupees for the purpose of comparison, using exchange rates as of February 21, 2025.

Table 3

Non-compliance penalty rates across global light-duty vehicle markets

Market	Penalty rate in original currency	Equivalent INR per g CO_2/km per vehicle
India	Up to 0.2 L/100km: ₹25,000 per vehicle Over 0.2 L/100km: ₹50,000 per vehicle	₹2,135–₹10,416
Chile	0.2 UF per 0.1 km/L per vehicle	₹515
Australia	AU$100 per g CO_2/km per vehicle	₹5,510
European Union	€95 per g CO_2/km per vehicle	₹8,607
New Zealand	NZ$67.5 per g CO_2/km per vehicle	₹3,355
United Kingdom[a]	£86 per g CO_2/km per vehicle	₹9,417
United States[b]	US$16 per 0.1 miles per gallon per vehicle	₹509

[a] The UK CO_2 standard and these payments apply only to non-ZEVs; a separate payment scheme applies for the country's ZEV sales requirement.
[b] Inflation-adjusted rate under the U.S. CAFE standard for 2023 model year vehicles. The U.S. Environmental Protection Agency also penalizes manufacturers that miss their greenhouse gas standards, which are generally aligned with the CAFE standard in stringency.

India's existing penalty structure accounts for some of these factors and is generally in the range of other strong performance-based standards. The BEE issued penalties to seven manufacturers based on excess fuel consumption against the 2022–2023 standards, up to ₹373 crore, while most manufacturers complied and faced no penalties (Doval, 2023). Information on whether these penalties have been paid is not publicly available.

In India, the use of thresholds rather than a linear scale results in a comparatively harsher penalty for manufacturers that miss their targets by only a small amount (e.g., at 0.1 L/km, the penalty would be ₹10,416 per g CO_2/km per vehicle), whereas the penalty does not grow for a manufacturer that misses compliance by a large margin (e.g., at 1 L/km, it would be ₹2,135 per g CO_2/km per vehicle). As a result, if a manufacturer knows that it will be non-compliant, it may choose to withhold ZEVs for a future year, given that greater non-compliance would not result in a greater penalty above the 0.2 L/100km threshold.

COMPARISON OF REGULATORY DESIGNS

Table 4 summarizes important characteristics of performance-based standards and ZEV sales requirements relevant to the Indian market. Unless otherwise noted, these characteristics apply both to LDVs and HDVs.

It should be noted that both kinds of standards could be implemented simultaneously, as they were in China and the United Kingdom. While more administratively complex, pairing both types of standards can lead to the greatest emissions reductions and fuel savings by ensuring a shift to ZEVs as well as the deployment of cost-effective ICE efficiency technologies and hybrids. This option is shown in the right-most column.

Table 4

Key characteristics of performance-based standards and ZEV sales requirements

	Performance-based standards	ZEV sales requirement	Combination
Metric	Average fuel consumption (e.g., L/100 km) or CO_2 emissions (g CO_2/km) of new vehicles sold	Percentage of new vehicles sold that are ZEVs	Percentage of new vehicles sold that are ZEVs, plus fuel consumption or CO_2 standards for non-ZEV vehicles or whole fleet
Ways to meet compliance	More efficient ICE vehicles, hybrids, and increased ZEV sales	Increased ZEV sales shares, potentially including limited PHEVs	Increased ZEV sales and more efficient ICE vehicles (including hybrids)
Certification required	Light-duty: Testing and type approval of each model variant Heavy-duty: Combination of vehicle/component testing and simulation	Powertrain only; including PHEVs may require emissions or range certification by model	Light-duty: Testing and type approval of each model variant Heavy-duty: Combination of vehicle/component testing and simulation
Typically implemented by	National governments	National or state/regional governments	National governments
Certainty for ZEV supply chains and infrastructure	Moderate	High	High
Certainty of meeting ZEV targets	Moderate	High	High
Encourages ICE vehicle efficiency improvements	Yes	No	Yes
Can allow trading among manufacturers	Yes	Yes	Yes
Administrative resources	Moderate (four-wheeler) to high (HDV)	Low	High
Regions with policy in place for passenger cars	Australia, Brazil, Canada, Chile, European Union, India, Japan, Mexico, New Zealand, South Korea, United States	California and 17 other U.S. states,[b] Canada, India National Capital Region	China, United Kingdom[a]
Regions with policy in place for heavy-duty vehicles	China, India, Japan, European Union, United States	California and 10 other U.S. states,[b] European Union (transit buses)	None

[a] The United Kingdom supplements its ZEV sales requirements with a fuel consumption standard for non-ZEV cars (including PHEVs) that prevents backsliding on ICE efficiency.
[b] California Air Resources Board (2025)

IMPACTS OF SUPPLY-SIDE REGULATIONS GLOBALLY

SSRs are being increasingly adopted globally, not only in advanced economies but also in emerging markets like Chile and Mexico. As of 2024, 73% of global LDV sales were in jurisdictions that had SSRs, although in several of these markets, including India, the existing regulations were not strong enough to help achieve stated ZEV targets (Hall, 2024).

The experience of California, which has had some of the longest-running SSRs to promote ZEV adoption, illustrates the potential of these regulations to meet long-term targets. In 2012, the state's governor finalized the state's ZEV sales requirements while also setting a target for 1.5 million ZEVs to be on California's roads by 2025; these were criticized as too ambitious by manufacturers and dealerships (Gallucci, 2012). The 1.5 million ZEV target was surpassed in early 2023, 2 years ahead of schedule (Governor of California, 2023). In 2018, the California Air Resources Board (2018) projected that ZEVs would account for 8% of new vehicle sales in the state in 2025, yet by 2024, California's ZEV sales share had already surpassed 25% (California Energy Commission, n.d.).

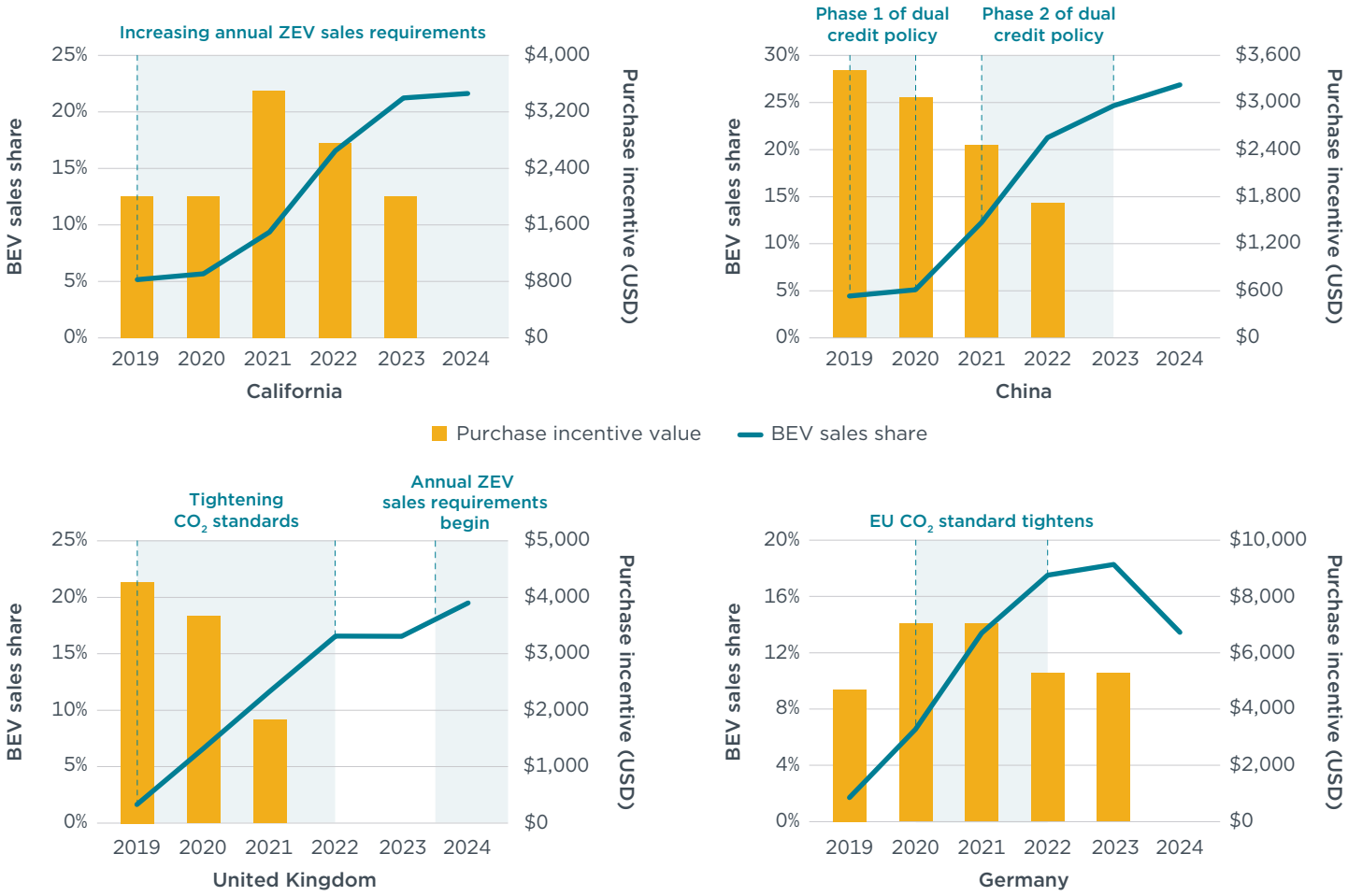
SUSTAINED MARKET GROWTH WITHOUT INCENTIVES

SSRs, particularly ZEV sales requirements, have also sustained ZEV market growth even in markets where vehicle purchase incentives have been reduced or ended. This is evidenced by data from California, China, Germany, and the United Kingdom, as shown in Figure 2. The figure shows that even as purchase incentives were reduced and eventually ended in California, China, and the United Kingdom,[6] BEV sales shares continued to increase over the 2019–2024 period. SSRs in all three markets continued to increase in stringency during this period, spurring increased ZEV sales despite reductions in incentives. In contrast, Germany illustrates a case where incentives were withdrawn and SSRs were not in place or their stringency remained flat; as a result, ZEV sales fell sharply in 2024. While subsidies can be useful to complement SSRs when ZEV sales are low, SSRs provide confidence in the long-term market trajectory to phase out incentives in a predictable way (Tankou et al., 2024).

6 This includes only those incentive programs available to mainstream private vehicle purchasers: the Clean Vehicle Rebate Program and Clean Fuel Reward in California, the Central New Energy Vehicle Subsidy in China, the Environmental Bonus in Germany, and the Plug-In Car Grant in the United Kingdom.

Figure 2

ZEV sales shares, purchase incentives, and SSR developments in California, China, Germany, and the United Kingdom



ECONOMIC BENEFITS OF SUPPLY-SIDE REGULATIONS

SSRs not only offer environmental benefits in the form of reduced emissions but also set the stage for increased investment that can create jobs and promote innovation. Moreover, they can make the transition to ZEVs more efficient and affordable by spurring the development of charging infrastructure, which also leads to job creation, and encouraging automakers to bring more affordable ZEVs to the market. This section outlines some of these benefits based on the experience of other markets that have adopted SSRs.

Encourage investment in ZEV supply chains

Robust SSRs encourage investments in the ZEV supply chain. Original equipment manufacturers (OEMs) are likely to invest in setting up or expanding ZEV manufacturing in markets where demand is expected to grow due to such regulations. Additionally, import tariffs and localization requirements for availing incentives are increasingly becoming the norm in vehicle manufacturing countries; these measures further encourage OEMs and upstream manufacturers in the ZEV supply chain to co-locate their investments in markets governed by SSRs to meet demand. Import tariffs alone do not guarantee investments in ZEVs as they typically do not make a distinction between ICE vehicles and ZEVs. Announcements of investments in electric vehicle and battery manufacturing within the United States, the European Union, and the United Kingdom surrounding the adoption or strengthening of SSRs support this logic, although we acknowledge that upstream investments are based on several factors and

that setting up new manufacturing plants and drafting and finalizing regulations are both multi-year processes, making timelines challenging to compare.

More broadly, outside of China, no car manufacturing country currently has both ZEV and battery manufacturing industries operating at scale. In this context, the ZEV transition offers India a pathway to capture a higher share of global vehicle production than it has achieved in the case of ICE vehicles since economic liberalization in 1991. In China, strong SSRs pushed the development of competitive and affordable ZEVs; coupled with industrial policies supporting battery and vehicle manufacturing, these regulations were a critical factor behind the transformation of the country's automotive sector from building low-cost ICE vehicles for a purely domestic market to becoming a major exporter of premium and affordable ZEVs (Alochet, 2023). India may be in a similar position to substantially increase its manufacturing gross domestic product and employment in the auto manufacturing sector.

European Union. The EU LDV CO_2 standards, which were introduced for consideration by the European Commission in 2021 and adopted by the European Union in 2023, set a binding requirement to reduce average emissions from new cars by 55% by 2030 and 100% by 2035, relative to 2021 (Dornoff, 2023). Deliberations on the standards and their subsequent adoption were followed by a flurry of announcements of investments in EVs, including by the BMW Group, Stellantis, and CATL.

United States. In August 2022, California adopted the Advanced Clean Cars II regulations; over the subsequent years, this policy was also adopted by 12 other states and Washington, DC (Miller & Sen, 2023). In March 2024, the U.S. Environmental Protection Agency notified its revised LDV GHG standards (Scott, 2024). Between 2023 and 2024, multiple investments were announced to set up or scale up ZEV and battery component manufacturing in the United States by Stellantis, LG Energy Solution (LGES), Honda, and Hyundai.

United Kingdom. The UK ZEV mandate, which took effect in January 2024, sets percentages of new zero-emission cars and vans that manufacturers will need to sell each year, rising to 80% for cars and 70% for vans in 2030, with the next phase planned to reach 100% by 2035 (Department for Transport, 2024a). In the lead-up to the start of the policy, Ford, Tata Group, Nissan, and JATCO announced a wide range of investments in ZEV and upstream manufacturing in the United Kingdom.

Table 5 provides a summary of some of the key investment announcements by companies in the European Union, United States, and United Kingdom.

Table 5

Key investment announcements by OEMs and battery manufacturing companies in the European Union, United States, and United Kingdom

Country/ region	Date announced	Company	Investment amount	Investment focus/purpose	Notes
European Union	March 2022	Stellantis (2022)	€50 billion	Achieving 100% BEV sales in Europe by 2030	Set out under the Dare Forward 2030 strategy
	January 2024	BMW Group (2024)	€650 million	Converting parent plant in Munich to manufacture exclusively ZEVs by 2027	
	February 2024	Stellantis (2024a)	€103 million	Production of electric drive modules at its plant in Szentgotthárd, Hungary	Includes contributions from the Hungarian government
	December 2024	Stellantis and CATL (Stellantis, 2024c)	€4.1 billion	Building a battery plant in Zaragoza, Spain	Expected to start production in 2026 and reach up to 50 GWh capacity
United States	March 2023	LGES (2023b)	$3.2 billion	27 GWh battery plant in Arizona	Expected to start production in 2026
		LGES & Honda (LGES, 2023a)	$4.4 billion	40 GWh battery plant in Ohio	Expected to create 2,200 jobs
	May 2023	LGES and Hyundai (LGES, 2023c)	$4.3 billion	30 GWh battery manufacturing plant in Georgia	Expected to start production in 2025
	September 2024	Stellantis (2024b)	$406 million	Supporting its multi-energy strategy through three facilities in Michigan	One of the facilities, Sterling Heights Assembly Plant, to be the company's first U.S. plant to build a BEV
United Kingdom	December 2022	Ford (Ford Media Center, 2022a)	£125 million	Transformation of Halewood plant into a ZEV component plant	Contributes to an overall investment in the plant to almost £380 million
	July 2023	Tata Group (2023)	£4 billion	40 GW global battery cell gigafactory	
	September 2023	BMW Group (2023)	£600 million	Transitioning the Oxford MINI plant to all-electric production by 2030	
	November 2023	Nissan (Carey, 2023)	£1.12 billion	Build electric versions of two models from its Sunderland plant	
	January 2025	JATCO, Nissan, and UK government (DBT, 2025)	£50 million	Build a new manufacturing site to supply electric powertrains for the Sunderland Nissan plant	Expected to create 183 high-value jobs in the region and support over 400 in the wider supply chain

Provide a competitive advantage for manufacturers committed to ZEVs

Supply-side regulations, if properly designed, can provide a valuable revenue stream for leading manufacturers of EVs (and, in some cases, low-emission vehicles). This revenue can be used to further expand those manufacturers' electric vehicle investments in India, creating a virtuous cycle of growth funded not by public money but via receipts from the purchase of credits by lagging, more polluting vehicle manufacturers.

To enable this dynamic, an SSR must have four features. First, it must establish targets at a fleetwide average level, rather than individual vehicle limits (this is always the

case for ZEV sales requirements). Second, it must include a credit trading mechanism. Third, it must be sufficiently stringent that some manufacturers will find it challenging to meet the requirements without purchasing credits from other manufacturers. If all manufacturers comply with the standards easily, there is no reason to trade for credits and no reward for those manufacturers that exceed the standard by the greatest margin. Fourth, there must be a penalty for non-compliance, such that manufacturers are encouraged to trade to stay compliant. India's proposed light-duty fuel consumption standards meet the first and fourth criteria, but not the second (with the third depending on how the regulation is finalized).

Table 6 presents the ZEV sales share and ZEV commitments of the leading manufacturers in India's four-wheeler market. The table shows that India-based companies Tata and Mahindra led in EV market share in 2024 and also have the most ambitious targets for electric vehicle sales share in 2030, ahead of foreign manufacturers Maruti Suzuki and Hyundai. With a regulatory framework meeting the above requirements, Tata and Mahindra could potentially sell credits to other manufacturers and accordingly earn revenue that can fund the continued growth of domestic EV supply chains.

Table 6

Market share and electric vehicle commitments of the largest four-wheeler manufacturers in India

Manufacturer	LDV market share	ZEV sales share in India (2024)	ZEV commitments	Source
Maruti Suzuki	41%	0%	Maruti Suzuki plans for 15% of 2030 sales to be electric. Maruti Suzuki's first electric four-wheeler, the e-Vitara SUV, is anticipated to launch in India in 2025.	Maruti Suzuki (2025); Suzuki Motor Corporation (2023)
Tata	13%	10.9%	At least 30% of sales planned to be electric by 2030. Tata Motors is set to introduce 10 new models.	Hsiao (2024)
Mahindra	12%	1.3%	Mahindra plans to reach 30% EVs "well before 2030." The automaker has announced that its first born-electric ZEV will be the Mahindra XUV.e8, essentially an electric version of the XUV700 SUV.	Luthra and Kapoor (2024); "Mahindra soon launch" (2024)
Hyundai	14%	0.2%	The Hyundai Creta ZEV will be Hyundai's first electric car in 2025, with the Venue EV and Grand i10 Nios EV also in the pipeline.	Express Drives Desk (2024)

A similar dynamic also could arise for HDVs, particularly buses. Tata Motors was the largest producer of buses in India in 2024 (29% of the market), and 19% of its bus sales were electric, compared with 8% of the Indian market overall (Segment Y Automotive Intelligence, 2025). A number of other Indian companies focused exclusively on electric buses also posted promising sales figures in 2024, including Olectra, PMI, and Eka. A ZEV sales requirement or strong efficiency standard for buses could provide an opportunity for these new challengers—and legacy players that have invested in ZEVs, like Tata—to further build their electric bus businesses in India.

This dynamic has been observed in other markets with SSRs, most notably for all-electric manufacturer Tesla. Tesla has earned over $10 billion in U.S. dollars from selling credits related to regulations in California, Canada, and the United States, as well as pooling agreements in Europe; in total, this amounts to 25% of their total operating profits (Root, 2024). For the 2023 compliance year under California's ZEV sales requirement, three electric vehicle manufacturers with significant employment in California—Tesla, Rivian, and Lucid—sold tens of thousands of credits (estimated to be valued at thousands of dollars each) to foreign manufacturers (California Air Resources Board, n.d.).

Facilitate buildout of charging infrastructure

Charging infrastructure represents one of the greatest challenges and expenses in the transition to EVs. Past ICCT research estimated that India will need 300,000 public chargers by 2030 and that the cost of this charging infrastructure could amount to about ₹40 crore; by 2035, both the number of chargers and the associated cost will approximately triple (Rajon Bernard et al., 2022). While government support for public charging is important when ZEV uptake is low, private businesses can install most of the chargers if the proper conditions are in place and there is the potential for profitability.

To invest in building public charging, businesses must have confidence in the use of charging stations, which requires an understanding of how quickly the number of ZEVs on the roads will grow in the coming years. When the ZEV market is driven purely by customer demand and subsidies, businesses do not have this confidence and may be reluctant to invest, contributing to an inadequate public charging network that further hinders demand for EVs. SSRs can reverse this dilemma: When there is a clear, shared expectation for how quickly ZEV sales will grow, businesses can confidently invest in public charging infrastructure, growing domestic industry and reducing the need for government subsidies to build out the charging infrastructure network.

This effect is being demonstrated in markets with strong SSRs in place. The CEO of ChargeUK, a trade group for the charging industry in the United Kingdom, stated that its member companies have committed £6 billion in investments in public charging through 2030 based on the confidence provided by the ZEV mandate, which would not have occurred if only non-binding targets were in place (Read, 2024). In the same letter, the group emphasized that a strong ZEV mandate was critical to the companies' continuing investments in charging infrastructure ahead of demand.

Benefit consumers through improved competition

Supply-side regulations have proven effective not only in increasing ZEV sales in the aggregate but also in increasing consumer choice and affordability of ZEVs. This is because manufacturers are encouraged to make ZEVs more attractive for consumers to ensure they meet targets and avoid penalties; in some cases, this means they may cross-subsidize ZEVs with profits from ICE vehicles. Additionally, when manufacturers have only a limited supply of ZEVs globally as they ramp up production, they prefer to sell those ZEVs to the jurisdictions where they can earn credits for their sale.

As of 2023, California and other states that adopted ZEV sales requirements had seen 30% more electric or plug-in hybrid models available for purchase than states without such requirements, creating more competition and options for drivers (Bui & Slowik, 2024). Following the introduction of the ZEV mandate in the United Kingdom, many new models were made available, particularly more affordable options targeted toward cost-conscious consumers (Palmer, 2024). In 2023, no electric cars with a list price of £23,000 or below were sold in the United Kingdom; in 2024, two such models were introduced, and by 2027, at least 13 such cars have been promised. In the European Union, manufacturers like Volkswagen and Renault have reduced prices of ZEVs to meet stricter CO_2 standards in 2025, bringing the price of ZEVs close to the cost of ICE alternatives (Mathieu, 2024; "Renault slashes price," 2025).

CONCLUSIONS

This paper examined how the adoption of well-designed SSRs in India could help to consistently grow ZEV sales and spur the development of the country's ZEV industry at a limited cost to the government. Our analysis supports the following conclusions and policy considerations:

Although India has a comprehensive policy approach in place for promoting ZEVs, SSRs have not yet played a major role. India is quickly becoming one of the top markets for ZEV manufacturing and purchasing. This growth has been driven largely by financial subsidies for ZEV buyers, manufacturers, and charging providers, including those provided under the FAME, PM E-DRIVE, and PLI schemes. Though effective, such incentive programs would be costly to scale up. SSRs could be an effective complement to this policy mix by requiring manufacturers to sell ZEVs at increasing rates, thereby encouraging more investment and competition and providing a predictable environment for developing supply chains. These could take the form of fuel consumption standards at the national level or ZEV sales requirements at the national or state levels.

By adapting best practices from other countries, India can enact world-class regulations to realize its ZEV goals. As India develops new fuel consumption standards, it can build on lessons learned from other markets like California, China, the European Union, and the United Kingdom to maximize environmental and economic benefits. Super credits could be phased down to encourage consistent year-over-year ZEV sales growth as cost parity approaches. A trading system could enable greater flexibility for manufacturers while providing a revenue source for progressive manufacturers, including prominent Indian companies. Non-compliance penalties could be indexed to the margin of non-compliance to promote fairness and avoid perverse incentives.

Countries that adopt SSRs have an extensive track record of attracting ZEV investments, indicating a pathway for India to further grow this sector. The adoption of LDV CO_2 standards in the European Union in 2023 was followed by a series of announced investments in ZEVs and battery manufacturing by the BMW Group, Stellantis, and CATL amounting to approximately €5 billion. In the United Kingdom, Ford, Tata Group, Nissan, and JATCO announced investments in ZEV and upstream manufacturing amounting to roughly £6 billion in the lead-up to implementation of the country's ZEV mandate in 2024. Adopting SSRs may position India to similarly attract investments in ZEV manufacturing, helping it to increase output and employment in the auto manufacturing sector and to achieve a higher market share of global vehicle production.

Driven by concerted policy and innovation by Indian companies, India appears poised to become a global leader in the transition to ZEVs, promising substantial economic benefits alongside reductions in air pollution and GHG emissions. This paper has illustrated how SSRs, when properly designed, can help India to make this transition more effectively, maximizing private investments and job creation while reducing public spending. Future work could provide more detailed insights on how these policies could be administered in an efficient and transparent way. Furthermore, given the interest from Delhi and other states in adopting EV sales requirements for specific vehicle segments, future research could assess the complementarity and smooth integration of national- and state-level SSRs. As India strengthens its ZEV policy framework and its ZEV transition unfolds, it can likewise become a model for other markets.

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