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Designing a zero-emission vehicle sales regulation for two-wheelers in India

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INTRODUCTION

A recent ICCT life-cycle analysis found that electric motorcycles and scooters in India emit 33%–50% lower greenhouse gas emissions than average new gasoline models.[1] Internal combustion engines (ICEs) continue to dominate the market, however: as of fiscal year 2022-2023, 95% of new two-wheelers sold in India were ICE vehicles—with 92% of total market share held between five manufacturers—while only 5% were electric vehicles.[2] This latter share is far lower than the target set by the Government of India that 80% of new two- and three- wheelers sold be electric by 2030.[3]

To significantly increase the share of electric two-wheelers in this short time frame, there is a need for policy intervention. Globally, governments in leading auto markets are deploying two key regulatory pathways to promote electrification across various vehicle segments: setting stringent limits on carbon dioxide (CO_2) emissions from the fleet through fuel consumption or CO_2 emission standards,[4] and zero-emission vehicle (ZEV) sales regulations that require manufacturers to sell a minimum percentage of ZEVs. These pathways need not be mutually exclusive and can be designed to have complementary effects in achieving emission reductions from the segment. To date, India has not adopted a fuel consumption standard nor a ZEV regulation for two-wheelers.

1 Georg Bieker, *Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars and Two-wheelers in India* (Washington, DC: ICCT, 2021), https://theicct.org/publication/life-cycle-greenhouse-gas-emissions-of-combustion-engine-and-electric-passenger-cars-and-two-wheelers-in-india/.

2 "Vahan Dashboard," Government of India, accessed August 2023, https://vahan.parivahan.gov.in/vahan4dashboard/vahan/vahan/view/reportview.xhtml.

3 "Govt Intends to Have EV Sales Penetration of 30% for Private Cars by 2030: Nitin Gadkari," *The Economic Times*, October 8, 2021, https://economictimes.indiatimes.com/industry/renewables/govt-intends-to-have-ev-sales-penetration-of-30-for-private-cars-by-2030-nitin-gadkari/articleshow/86864936.cms?from=mdr.

4 In this paper, the terms "CO_2 emissions" and "fuel consumption" are used interchangeably.

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To comply with fuel consumption standards, manufacturers are free to choose the most cost-effective technology packages at their discretion. However, as standards become more stringent, introducing more ZEVs into the fleet can be a more cost-effective option than investing in incremental technological advancements to improve ICE fuel efficiency. For example, a 2021 ICCT study found that setting a fleet-average standard of 20.5 gCO_2/km for two-wheelers in India would have the potential to electrify about 60% of the sector by 2030.[5] On the other hand, a ZEV regulation is the most direct way to ensure the growth of ZEVs in a market over time, because it requires that manufacturers earn a minimum number of credits proportional to their ZEV sales each year.

Building on the ICCT's previous study of the potential for bringing more electric two-wheelers to the market in India through fuel consumption standards, this paper analyzes the role that ZEV sales regulations can play in increasing sales shares. The research questions and structure of this paper are as follows:

1. What are the impacts of ZEV sales regulations based on international practices?
2. Could the existing institutional framework in India support the adoption of ZEV sales regulations?
3. What are the important elements to consider when designing a ZEV sales regulation, and what are the emerging best practices?

We assume that all zero-emission two-wheelers in India will be fully battery-electric vehicles (BEVs). While hydrogen fuel-cell electric vehicles also produce zero tailpipe emissions, their deployment in the two-wheeler segment is not anticipated in India in the near term due to their greater cost, lack of refueling infrastructure, and model availability.[6]

INTERNATIONAL BEST PRACTICES FOR ZEV SALES REGULATIONS

California has been a pioneer in ZEV sales regulations, which were first introduced in the state in the 1990s as part of vehicle exhaust standards for light-duty vehicles. Its program has evolved significantly since then, and ZEV sales requirements were included as part of the Advanced Clean Cars (ACC) regulation for model years 2015–2025 and the Advanced Clean Cars II (ACC II) regulation for model years 2026-2035.[7] Several other states have adopted California's sales requirements under ACC and ACC II.[8]

China has implemented a modified version of California's program for passenger cars as part of the country's Parallel Management Regulation for Corporate Average Fuel Consumption and New Energy Vehicle Credits, referred to as the dual-credit policy. Phase I of China's policy set ZEV sales requirements for 2019–2020,[9] Phase II for

5 Sunitha Anup, Ashok Deo, and Anup Bandivadekar, *Fuel Consumption Reduction Technologies for the Two-Wheeler Fleet in India* (Washington, DC: ICCT, 2021), https://theicct.org/publication/fuel-consumption-reduction-technologies-for-the-two-wheeler-fleet-in-india/.

6 Ashok Deo and Sunitha Anup, "What to Know About the Potential of Hybrid Technology in Two-Wheelers in India?" ICCT Staff Blog, August 25, 2021, https://theicct.org/what-to-know-about-the-potential-of-hybrid-technology-in-two-wheelers-in-india/.

7 Anh Bui, Dale Hall, and Stephanie Searle, *Advanced Clean Cars II: The Next Phase of California's Zero-Emission Vehicle and Low-Emission Vehicle Regulations* (Washington, DC: ICCT, 2022), https://theicct.org/publication/accii-zev-lez-reg-update-nov22/.

8 "Clean Vehicle Programs: State Tracker," Sierra Club, accessed March 7, 2024, https://www.sierraclub.org/transportation/clean-vehicle-programs-state-tracker.

9 Hongyang Cui, *China's New Energy Vehicle Mandate Policy (Final Rule)* (Washington, DC: ICCT, 2018), https://theicct.org/publication/chinas-new-energy-vehicle-mandate-policy-final-rule/.

2020–2023,[10] and Phase III for 2024–2025.[11] The United Kingdom has finalized ZEV sales requirements for passenger cars and vans from 2024 to 2035.[12] In Canada, where provincial sales requirements for light-duty vehicles are already in effect in Quebec and British Columbia, the government has finalized a national ZEV sales regulation, the Electric Vehicle Availability Standard, due to come into effect in 2026 and set annual sales requirements through 2035 and beyond.[13] The sales regulations adopted by California, the United Kingdom, and Canada are legally binding mandates towards ensuring 100% electrification of new sales of light-duty vehicles by 2035.

Amid growing adoption of sales regulations in the light-duty segment, California was also the first jurisdiction in the world to adopt sales requirements for medium- and heavy-duty vehicles under the Advanced Clean Trucks (ACT) regulation.[14] The ACT regulation comes into effect in 2024 and requires up to 75% new ZEV sales in the segment by 2035. As with sales regulations in the light-duty segment, several other U.S. states have also adopted California's sales requirements under ACT.

CONCEPT OF ZEV CREDITS AND TARGETS

As ZEVs can vary significantly in terms of market price and technical parameters such as range and electrical energy consumption, governments globally have used a credit-based regulatory design to achieve sales goals. In a credit-based ZEV regulation, manufacturers are obligated to acquire a minimum threshold value of credits annually, referred to as their annual credit targets.[15] For example, assuming a credit value of 1 is assigned to each ZEV sale, a manufacturer who sells 100,000 total vehicles in a given compliance period would need to sell at least 5,000 ZEVs to comply with a ZEV credit target of 5% for that period (see Text Box).

Example: Manufacturer A

Total sales in compliance year: 100,000 units

Credit target for compliance year: 5%

Minimum credits to acquire from ZEV sales: 5% * 100,000 = 5,000 credits

Minimum ZEV sales to meet credit target: 5,000 credits / 1 credit per ZEV = 5,000 ZEVs

While this example assumes that each ZEV sale counts as one credit, in practice, each jurisdiction's regulation sets out criteria for the number of credits that can be allocated depending on a ZEV's technical specifications and/or market parameters. Technical

10 Zhinan Chen and Hui He, *The Second Phase of China's New Energy Vehicle Mandate Policy for Passenger Cars* (Washington, DC: ICCT, 2021), https://theicct.org/publication/the-second-phase-of-chinas-new-energy-vehicle-mandate-policy-for-passenger-cars/.

11 Ministry of Industry and Information Technology Equipment Industry Development Center, "Notice of the Ministry of Industry and Information Technology on Matters Related to the Average Fuel Consumption of Passenger Vehicle Enterprises and the Point Management of New Energy Vehicles in 2024–2025," December 28, 2023, http://www.miit-eidc.org.cn/art/2023/12/28/art_1657_10272.html.

12 UK Department of Transport, *Consultation on a Zero Emission Vehicle (ZEV) Mandate and CO2 Emissions Regulation for New Cars and Vans in the UK* (London: Department of Transport, March 2023), https://assets.publishing.service.gov.uk/media/64537b0ffaf4aa0012e132a8/zev-mandate-co2-emissions-regulation-consultation-document.pdf.

13 Government of Canada, "Canada's Electric Vehicle Availability Standard (Regulated Targets for Zero Emission Vehicles)," December 19, 2023, https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-electric-vehicle-availability-standard-regulated-targets-for-zero-emission-vehicles.html.

14 Claire Buysse and Benjamin Sharpe, *California's Advanced Clean Trucks Regulation: Sales Requirements for Zero-Emission Heavy-Duty Trucks* (Washington, DC: ICCT, 2020), https://theicct.org/publication/californias-advanced-clean-trucks-regulation-sales-requirements-for-zero-emission-heavy-duty-trucks/.

15 We use the term "credit" to refer generally to the unit of compliance accounting under various global regulations, though terminology may differ between jurisdictions. In ACC-II, for instance, these are referred to as "values." In the United Kingdom, the term "credit" is used in reference to earning credits or avoiding the use of allowances for non-ZEV sales, which is equivalent to earning compliance.

specifications might include electric range, electrical energy consumption, and battery energy density, while market parameters may emphasize low cost-pricing, equitable access to ZEVs, and shared mobility business models.

Each regulation also sets eligibility criteria for determining if a ZEV qualifies for credit allocation. Most policies have a range-based cutoff for eligibility. Regulations such as ACC II also define additional assurance criteria involving durability, warranty, and charging requirements, which apply to all ZEVs sold in the jurisdiction. Manufacturers must meet these assurance criteria regardless of whether the ZEV can earn credits. This regulatory approach serves to help ensure that high-quality ZEVs enter the market.

The following sections review the eligibility, assurance, and credit allocation methods adopted under ZEV regulations for light-duty vehicles in California, China, and the United Kingdom.

ELIGIBILITY AND ASSURANCE CRITERIA

Table 1 presents the credit eligibility criteria for ZEV models, including minimum range based on laboratory testing, along with other assurance criteria such as warranty and charging requirements.

Table 1
Comparison of eligibility and assurance criteria adopted under global ZEV regulations

Jurisdiction	Minimum ZEV range	Other criteria
California ACC	50 miles (two-cycle test) [a]	
California ACC II	200 miles (Urban Dynamometer Driving Schedule, UDDS)	• A durability requirement of 70% of certified range value for 10 years or 150,000 miles for model years 2026–2029, and 80% of certified range value for 10 years or 150,000 miles for model year 2030 onwards. • A battery warranty requirement of 8 years or 100,000 miles, with 70% battery state of health for model years 2026–2030 or 75% for model year 2031 onwards. • A propulsion-related parts warranty of 3 years or 50,000 miles, or 7 years or 70,000 miles for high-priced parts. • Service information disclosure to independent repair shops and battery labeling for recyclability and repurposing. • On-board charger of at least 5.76 kW, 20-feet certified charging cord and connector.
China	100 km (China Light-Duty Vehicle Test Cycle, CLTC)[b]	
United Kingdom	100 miles (Worldwide harmonized Light vehicles Test Procedure, WLTP)	• Battery warranty of 3 years or 60,000 miles for the full vehicle and 8 years or 100,000 miles for traction batteries, hydrogen fuel cells, and hydrogen tanks. • The battery warranty must provide for replacement of the traction battery if it falls below 70% capacity for cars or 65% for vans during the covered period.

[a] Two-cycle tests include the UDDS test and the first 505 seconds of the U.S. Environmental Protection Agency (EPA) Federal Test Procedure (FTP-75).
[b] The CLTC was developed by China Automotive Technology & Research Centre.

CREDIT ALLOCATION METHODS

Credit allocation mechanisms under California's ACC regulation and China's dual-credit policy have evolved significantly since their inception. This evolution is also seen in how the United Kingdom defines its ZEV mandate's credit allocation system.

Earlier policies emphasized driving range, such that long-range models could earn significantly more credits than lower-range models. With rapid advancements in technology, subsequent policy phases have moved away from such range-based distinctions in their approaches to credit allocation. For example, while ACC II and the United Kingdom allocate all eligible ZEVs with a single baseline credit,[16] China's Phase II policy was amended in July 2023 to significantly reduce the weightage allocated to electric range in the base credit formula. For example, a 300 km range ZEV in China would qualify for 4.4 base credits under Phase I, 2.08 under Phase II pre-amendment, and 1.22 post-amendment. China's Phase III policy retains the same amended credits as in Phase II.

Each jurisdiction also adopts different approaches to allowing manufacturers to claim additional credits for a given ZEV. For example, beyond the single credit that is allocated to all eligible ZEVs under ACC II, additional partial credit values are available based on three different environmental justice pathways. Similarly, under UK regulations, additional partial credits are available for wheelchair accessible ZEVs and ZEVs deployed in car clubs.

China's Phase II policy specifies three separate multipliers or adjustment coefficients on the base credit value based on electric range, power consumption, and battery energy density. An additional range-based multiplier (over and above range factoring in the base-credit function) implies that range has a compounding effect under the Phase II policy in China. Notably, China's multiplier system allows the possibility of both increasing and decreasing the original base-credit value, depending on whether vehicles meet set thresholds for the given parameters. For example, under the Phase III policy, energy consumption multipliers vary between 0.5 to 1.5, while the battery energy density multiplier ranges between a value of 0 to 1, acting as a deterrent for batteries below a threshold density.

Table 2 summarizes the evolution of credit allocation mechanisms for ZEVs in California, China, and the United Kingdom.[17]

16 We use the term "baseline credit" broadly, though this term is not used in any of the regulations. China's regulations, for instance, refer to such credits as a base credit value.

17 This table summarizes credit allocation mechanisms for battery-electric vehicles only. Plug-in hybrid electric vehicles and other transitional technologies are not included under the scope of the review.

Table 2

Comparison of credit allocation mechanisms under zero-emission vehicle regulations in various jurisdictions

Jurisdiction	California		China			United Kingdom
	ACC	ACC II	NEV mandate Phase I	NEV mandate Phase II	NEV mandate Phase III	ZEV mandate
Compliance period	Model year 2012–2025	Model year 2026–2035	Calendar year 2019–2020	Calendar year 2021–2023	Calendar year 2024–2025	Calendar year 2024–2035
Baseline credit (BC) system	Range- based function allowing multiple credits per eligible ZEV: • BC = 0.01 * electric range (ER) + 0.50, capped at 4	All eligible ZEVs earn 1 credit.	Range-based function allowing multiple credits per ZEV, with weightage assigned to range in the base credit function reduced over successive policy periods: • Phase I: BC = 0.012 * ER + 0.8 • Phase II: BC = 0.0056 * ER + 0.4 • Phase II: BC = 0.0034 * ER + 0.2, capped at 2.3 (Aug - Dec 2023) • Phase III: 0.0034 * ER + 0.2, capped at 2.3			All eligible ZEVs earn 1 credit.
Opportunities to earn additional credits	None	Extra credits available for: • Authorized sales of used ZEVs (up to 0.25) • ZEVs sold through community-based discount programs (0.5) • All sales of low-cost ZEVs below a given retail price (0.1)	Multipliers based on vehicle electric energy consumption (0.5 up to 1.2)	Until August 2023, multipliers based on: • Vehicle electric energy consumption (0.5 up to 1.5) • Battery energy density (0 up to 1.0) • Electric range (0 up to 3.4) Since August 2023, multipliers based on: • Vehicle electric energy consumption (0.5 up to 1.5) • Battery energy density (0 up to 1) • Electric range (0.7 up to 1)		0.5 extra credits available for: • ZEVs sold to car-clubs • Wheel-chair accessible ZEVs
Maximum credits possible per ZEV (including any additional credits)	4	1.5	6	5.1	3.45	1.5

IMPACT OF A ZEV SALES REGULATION ON THE TWO-WHEELER MARKET IN INDIA

Electric two-wheelers are gaining momentum in India and the market is well-positioned for policies to encourage faster adoption of battery-electric vehicles. We define the impact of a ZEV sales regulation on the two-wheeler market based on how it affects consumers (demand) and manufacturers (supply). Among the various factors, model availability and reductions in the price of ZEVs have an impact on consumers, and market competitiveness and investor certainty impact ZEV manufacturers.

Model availability. One of the most significant impacts of a ZEV regulation is an increase in the number of ZEV models available to consumers on the market. To comply with their ZEV sales obligations, manufacturers look for more opportunities to expand their market share and introduce a greater number of electric vehicle models to attract consumers. The ZEV market in the U.S. state of California illustrates the relationship between sales of battery-electric passenger cars and increased model availability. As of 2019, the top metropolitan areas in terms of electric vehicle sales in

the United States—Los Angeles, San Jose, San Francisco, and San Diego—each had more than 30 electric models available.[18] Other U.S. states that adopted regulations similar to California, such as New Jersey, New York, Washington, Maryland, Oregon, and Colorado, also saw growth in electric model availability.[19] ZEV sales regulations thus not only impart a sense of certainty to both the market and manufacturers, but also foster an uptick in model availability for consumers.

Price reduction of ZEVs. A ZEV sales regulation compels manufacturers to produce and sell electric two-wheeler models. With more models in the market, the volume of ZEVs would increase and, due to economies of scale, there would eventually be a reduction in the cost of batteries, ultimately leading to consumer price benefits.

For example, a 2022 ICCT analysis of light-duty vehicles in the United States estimated that an acceleration of annual reductions in battery costs from 7% to 9% expedites the path toward price parity between electric and conventional vehicles by approximately 1 to 2 years. Conversely, lowering annual battery cost reductions by 3% typically extends the timeline for parity by about 1 to 4 years.[20] For the passenger car and sports utility segments in China, the cost of battery packs is anticipated to decrease from ¥0.9 per watt-hour (Wh) in 2020 to around ¥0.4 per Wh by 2030 due to advancements in technology and production scale. Price parity between 300–400 km electric-range vehicles and conventional cars and sport utility vehicles is expected to happen between 2026 and 2029.[21]

For two-wheelers in India, projections indicate that when electric vehicle battery production and assembly cost decrease in alignment with accelerated electrification scenarios, shorter-range battery-electric vehicles covering 150–200 km can achieve price parity by 2024–2026. BEVs with 250–300 km of range are expected to follow suit around 2026–2029, with the longest-range BEVs, spanning 350 to 400 km, projected to attain price parity by 2029–2032.[22] India has an opportunity to localize the production of electric vehicles and batteries, a crucial step in cost reduction. A robust regulatory framework could instill confidence in investors and propel the electric two-wheeler market towards accelerated growth.

Market competitiveness. Manufacturers can comply with their sales obligations under ZEV mandates through the production of ZEVs or the purchase of surplus credits from other manufacturers who overachieve their ZEV sales obligations. In practice, the monetary value of ZEV credits will depend on the supply and demand of ZEVs in the market. Under such a scheme, manufacturers who are slow to embrace electrification can lose market competitiveness. This is because such manufacturers would have to buy credits and will likely distribute these costs across their ICE models. Similarly, manufacturers who gain revenue from the sale of excess credits could potentially pass on benefits across their electric models by selling them at lower cost. In leading electric vehicle markets, governments have prioritized stronger electrification policies to help manufacturers retain their positions in the market. For instance, China's New Energy

18 Anh Bui, Peter Slowik, Nic Lutsey, *Update on Electric Vehicle Adoption Across U.S. Cities* (Washington, DC: ICCT, 2020), https://theicct.org/wp-content/uploads/2021/06/EV-cities-update-aug2020.pdf.

19 Anh Bui, Peter Slowik, and Nic Lutsey, *Evaluating Electric Vehicle Market Growth Across U.S. Cities* (Washington, DC: ICCT, 2021), https://theicct.org/publication/evaluating-electric-vehicle-market-growth-across-u-s-cities/.

20 Peter Slowik, Aaron Isenstadt, Logan Pierce, and Stephanie Searle, *Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022-2035 Time Frame* (Washington, DC: ICCT, 2022), https://theicct.org/publication/ev-cost-benefits-2035-oct22/.

21 Nic Lutsey, Hongyang Cui, and Rujie Yu, *Evaluating Electric Vehicle Costs and Benefits in China in the 2020-2035 Time Frame* (Washington, DC: ICCT, 2021), https://theicct.org/publication/evaluating-electric-vehicle-costs-and-benefits-in-china-in-the-2020-2035-time-frame/.

22 Shikha Rokadiya, Anup Bandivadekar, and Aaron Isenstadt, *Estimating Electric Two-Wheeler Costs in India to 2030 and Beyond* (Washington, DC: ICCT, 2021), https://theicct.org/publication/estimating-electric-two-wheeler-costs-in-india-to-2030-and-beyond/.

Automobile Industry Plan (2021–2035) targets 20% of vehicle sales to be ZEVs by 2025, to achieve international competitiveness for China's ZEV industry.[23]

Investor certainty. Establishing clear quantities of ZEV two-wheelers to be sold in India each year could deliver increased confidence to investors in the market. In addition, having guaranteed numbers of ZEVs on the road would allow charge point operators to accelerate investment in charging infrastructure. A ZEV regulation coupled with EV ecosystem investment thus has the potential to deliver significantly improved consumer choice and a better user experience.

Government policies to create robust frameworks for the electric vehicle market have led to market advancements in other countries and regions, such as China and Europe.[24] Experience from these markets suggests that establishing explicit volume goals and offering financial incentives ultimately engages governments and companies in the development of an electric vehicle market and manufacturing infrastructure.[25] Countries such as Germany and the United Kingdom are formulating national-level charging roadmaps designed to establish networks with extensive geographical coverage and sufficient power capacity to meet vehicle sales targets. These mandatory installation targets offer increased legal and policy certainty, which are in turn anticipated to spur increased investment by private-sector actors.[26]

In the following sections, we discuss potential institutional frameworks and credit design approaches for adopting a ZEV sales regulation for two-wheelers in India.

VENUE AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTATION OF A ZEV CREDIT PROGRAM IN INDIA

Issuance of ZEV credit obligations on manufacturers would have to be backed by requisite legal authority, and program success would also require a well-established supporting institutional framework. In other countries and regions, ZEV regulations are authorized by legislation linked to air quality improvement, climate change mitigation, or fuel consumption reduction. China and the United Kingdom to some extent interplay ZEV regulations with fuel consumption standards.

In India, supply side regulations and market-based compliance mechanisms have been deployed in the power sector. The Renewable Purchase Obligation (RPO) stipulates that all electricity distribution licensees must acquire or generate a minimum specified quantity of their electricity needs from renewable energy sources, in accordance with the Indian Electricity Act of 2003. The Renewable Energy Certificate mechanism serves as a market-based instrument to encourage renewable energy usage and streamline compliance with RPOs. Its objective is to rectify the disparity between the availability of renewable energy resources in a state and the obligation of entities to fulfil their RPOs.[27]

23 International Energy Agency, "Global Outlook 2021: Policies to Promote Electric Vehicle Deployment" (2021), https://www.iea.org/reports/global-ev-outlook-2021/policies-to-promote-electric-vehicle-deployment.

24 Anh Bui, Peter Slowik, and Nic Lutsey, *Power Play: Evaluating the U.S. Position in the Global Electric Vehicle Transition* (Washington, DC: ICCT, 2021), https://theicct.org/publication/power-play-evaluating-the-u-s-position-in-the-global-electric-vehicle-transition/.

25 Nic Lutsey, Mikhail Grant, Sandra Wappelhorst, and Huan Zhou, *Power Play: How Governments are Spurring the Electric Vehicle Industry* (Washington, DC: ICCT, 2018), https://theicct.org/publication/power-play-how-governments-are-spurring-the-electric-vehicle-industry/.

26 Marie Rajon Bernard, Irem Kok, Tim Dallman, and Pierre-Louis Ragon, *Deploying Charging Infrastructure to Support an Accelerated Transition to Zero Emission Vehicles* (Washington, DC: ZEV Transition Council, 2022), https://theicct.org/publication/deploying-charging-infrastructure-zevtc-sep22/.

27 Ministry of Power, "Government of India, Ministry of Power Redesigns Renewable Energy Certificate Mechanism," Press release, September 29, 2021, https://pib.gov.in/PressReleasePage.aspx?PRID=1759300.

A review of major legislation related to automobiles, the environment, and energy and fuel consumption in India suggests that a ZEV credit program could be implemented at both national and state levels, under several pathways. Table 3 summarizes this assessment.[28]

Table 3
Summary of enabling statutory authority for issuance of ZEV regulation in India

Pathway	Venue	Key administrative actors	Enabling authority
Fuel/energy consumption reduction	National	Ministry of Power, Bureau of Energy Efficiency	Energy Conservation Act
Air quality improvement	National	Ministry of Road Transport and Highways	Central Motor Vehicles Act
Air quality improvement	National	Ministry of Environment, Forest, and Climate Change, Central Pollution Control Board	Environment Protection Act, Air Act
Air quality improvement	State	State Pollution Control Boards / Committees	Air Act
Air quality improvement	State (National Capital Region and Adjoining Areas)	Commission on Air Quality Management in National Capital Region and Adjoining Areas	Commission on Air Quality Management in National Capital Region and Adjoining Areas Act

In addition to the above agencies with statutory powers, it is also important to emphasize the unique roles of the National Board of Electric Mobility (NBEM) and the National Council on Electric Mobility (NCEM), two bodies formed under the National Electric Mobility Mission Plan 2020. This plan aims to address multiple strategic objectives in India, including enhancing energy security, mitigating adverse environmental impacts, and boosting domestic manufacturing of electric vehicles. The NCEM and NBEM are chaired by the heads of the Ministry of Heavy Industries and the Department of Heavy Industries, respectively. The NCEM and NBEM have been granted powers to recommend and approve broad policy frameworks in the interest of promoting electric vehicles and their manufacturing in India.[29] The bodies also possess extensive authority to suggest to the central government any new legislation, policy, or amendment to current measures that would advance the production and utilization of electric vehicles in the country. In that respect, the NCEM and NBEM could help to enable the implementation of a ZEV sales regulation in India.

Judicial intervention in the interest of the environment, air quality, and public health has also played a key role in regulating transport in India. For example, in 1998, the Supreme Court of India ordered the conversion of all public transport in Delhi to run on compressed natural gas (CNG), following a writ petition.[30] More recently, in 2015, the Supreme Court ordered that all taxis running in the National Capital region should run on CNG by early 2016; the Court also banned new sales of all diesel cars with

28 ICCT appointed a legal consultant to undertake an assessment of authorities available at the national and state level in India for the issuance of ZEV mandates, including credit programs. While this paper focuses on two-wheelers, regulatory authority discussed is independent of vehicle segment.

29 Ministry of Heavy Industries and Public Enterprises, "Notification of National Council on Electric Mobility," March 2017, https://heavyindustries.gov.in/sites/default/files/2023-09/ncem.pdf.

30 Anuj Bhuwania, "The Case that Felled a City: Examining the Politics of Indian Public Interest Litigation Through One Case," *South Asia Multidisciplinary Academic Journal* 17 (2018), https://journals.openedition.org/samaj/4469.

an engine capacity of 2,000 cc and above.[31] Businesses altered their operations to ensure compliance with these rulings. For example, following the 2015 order, transport network companies like Ola received bulk purchase discounts from manufacturers for CNG models and passed the benefits to drivers to help with cost feasibility.[32] In other words, once the Supreme Court mandate was declared, market transitions occurred via business responses, even without subsidies.

Over and above the legal authority to impose regulations on manufacturers, there are other aspects of ZEV sales regulations that require institutional coordination and action for successful implementation. One such aspect is the deployment of charging infrastructure. One of the major reasons that the ICE vehicle market is so well-established in India is its well-adapted refueling infrastructure. For electric two-wheelers to compete effectively with their ICE counterparts, their development and cost optimization must be coordinated with the deployment of adequate charging infrastructure. The government, power and utility companies, industry, and standardization organizations all will play important roles in this regard.

Technology, research, testing, and funding organizations are other key stakeholders in the rollout of a ZEV credit program. These include government and non-government think-tanks, technology and policy research organizations and institutions, industry bodies, vehicle and emission testing and certification agencies, government funding agencies, and financial institutions.

KEY DESIGN ELEMENTS FOR CONSIDERATION OF A ZEV SALES REGULATION IN INDIA

As noted above, global programs are moving away from relying heavily on electrical range as a basis for allocating ZEV credits. In the Indian context, we delve into the uncertainties associated with a credit function that largely depends on range using a hypothetical ZEV target and credit function. We base this illustration on two-wheeler sales data from Maharashtra, as the state has expressed a readiness to explore a ZEV credit program in its state electric vehicle policy, which was notified in 2021 and targets 10% ZEV penetration among new vehicle registrations by 2025.[33]

Assuming a 5% ZEV credit target for the top five manufacturers of two-wheelers in Maharashtra,[34] we calculate the ZEV credits required by such manufacturers based on their annual sales in FY 2021–2022. We assume that electric two-wheelers with a minimum range of 80 km are eligible to earn 1 credit,[35] while electric two-wheelers with a range of 300 km and above are eligible for a maximum of 4 credits. Based on this assumption, the resulting linear function for credit allocation is:

credits earned per model = 0.0136 x electric range – 0.0909.

We further assume three scenarios through which manufacturers generate credits to comply with their credit targets. In the first scenario, manufacturers sell equal numbers of both short- and long-range models. In the second, they sell only short-range 80 km models, and in the third, they sell only long-range 300 km models.

31 Sakshi Dayal, "Another Supreme Court Order 18 Years Ago and Delhi's First Brush with CNG", *India Express*, May 3, 2016, https://indianexpress.com/article/cities/delhi/supreme-court-ban-on-diesel-taxis-2781490/.

32 Press Trust of India, "Ola to Offer Rs 1 Lakh to Drivers to Move to CNG," *Times of India*, August 26, 2015, https://timesofindia.indiatimes.com/tech-news/ola-to-offer-rs-1-lakh-to-drivers-to-move-to-cng/articleshow/48684166.cms.

33 "India: State Level EV Policies," Transportpolicy.net, https://www.transportpolicy.net/standard/india-state-level-ev-policies/.

34 Collectively, these manufacturers represent 83% of the two-wheeler market in the state.

35 We assume a minimum range eligibility of 80 km in alignment with the eligibility criteria for electric two-wheelers under the Indian government's national incentive scheme, FAME-II.

As shown in Table 4, the penetration of electric two-wheeler sales varies under these scenarios between 1.3% if manufacturers choose to comply with their credit target by selling only long-range models and 5.0% if they sell only short-range models.

Table 4
Scenarios of ZEV credits earned based on electric two-wheeler range

No.	ZEV credit target	ZEV credit compliance strategy	Electric model deployment (top-5 manufacturers)	Electric model deployment (all manufacturers)
Scenario 1	5%	50% of sales are short-range models, while 50% of sales are long-range models	3.6%	3.3%
Scenario 2	5%	All sales are short-range models	5.0%	4.6%
Scenario 3	5%	All sales are long-range models	1.3%	1.1%

Based on this example, we see that the electrification target under Maharashtra's EV policy can be achieved faster under Scenario 2 than under Scenarios 1 and 3, in which longer-range models are part of the compliance strategy and result in excess credits.

Considering that petrol scooters and motorcycles in India typically deliver 300–800 km of range when fully charged, Indian consumers may prefer long-range electric models.[36] However, the market for electric two-wheelers in India is still relatively new and there are insufficient data to ascertain long-term consumer preferences regarding model range. In comparison to four-wheelers, two-wheelers travel shorter distances per trip and have lower dependence on public fast charging. Therefore, it is possible that with adequate access to residential charging points, consumers may be able to transition to lower-range models as well.

Additionally, given that the two-wheeler market in India is highly price-sensitive, long-range models may not appeal to all consumer segments until substantial reductions in battery costs take place. For perspective, in China, Indonesia, Thailand, and Vietnam, the average range of leading electric two-wheeler models is between 80 and 120 km, which is similar to the range available in the Indian market.[37] Manufacturers are best placed to recognize and respond to the range preferences of various consumer segments as the market matures.

The Indian Government's Faster Adoption and Manufacturing of Hybrid Vehicles (FAME) II scheme specifies a minimum range of 80 km, minimum top speed of 40 km/h, minimum acceleration of 0.65 m/s^2, and a maximum energy consumption of 7 kWh/100 km for electric two-wheelers to be eligible for consumer incentives. Policymakers might consider adopting the same technical specifications for eligibility in a crediting scheme for electric two-wheelers. Beyond the minimum eligible range, all ZEVs could be allowed to earn the same base credit value. This approach would have the advantage of spurring the initial market to replace combustion engine kilometers with ZEV kilometers.

36 Sunitha Anup, *Market Analysis of the New Two-Wheeler Fleet in India for Fiscal Year 2020-21* (Washington, DC: ICCT, 2021), https://theicct.org/publication/market-analysis-of-the-new-two-wheeler-fleet-in-india-for-fiscal-year-2020-21/.

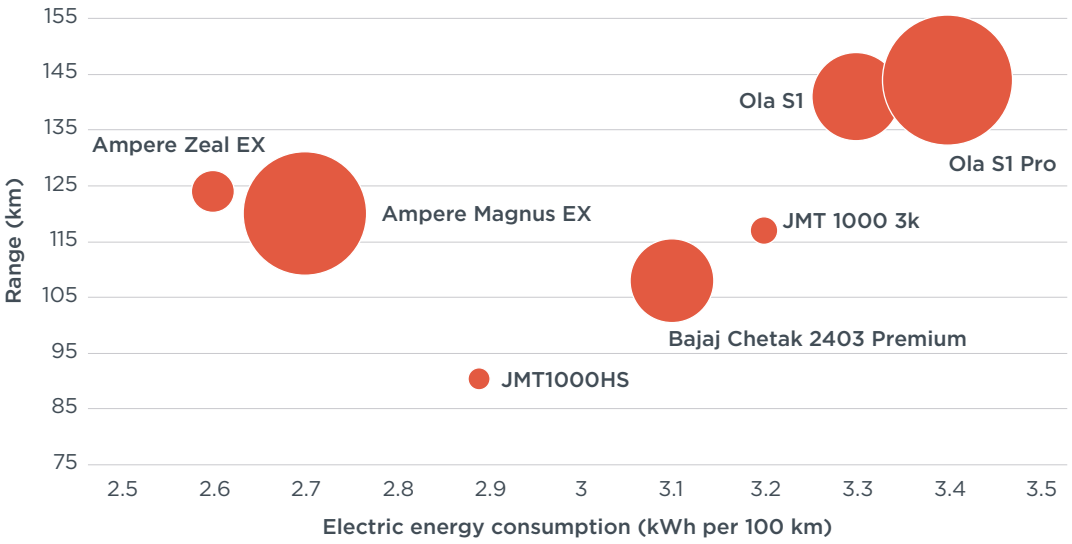
37 Houng Le, Francisco Posada, and Zifei Yang, *Electric Two-Wheeler Market Growth in Vietnam: An Overview* (Washington, DC: ICCT, 2022), https://theicct.org/publication/asia-pacific-lvs-ndc-tia-e2w-mkt-growth-vietnam-nov22/.

As in other jurisdictions, other technical and consumer cost parameters beyond base credits may be considered for the purpose of awarding a reasonable amount of extra credits to eligible ZEVs. Criteria related to electrical energy consumption, battery energy density, and vehicle price may be evaluated for such purposes.

Figure 1 illustrates the variability in range versus electrical energy consumption of electric two-wheeler models on the market in 2022. Figure 2 illustrates the variability in range versus battery energy density, and Figure 3 illustrates variability in range versus price. The sizes of the bubbles in all three figures represent total annual sales for the depicted models.

Figure 1

Comparison of range and energy consumption of electric two-wheeler models in 2022

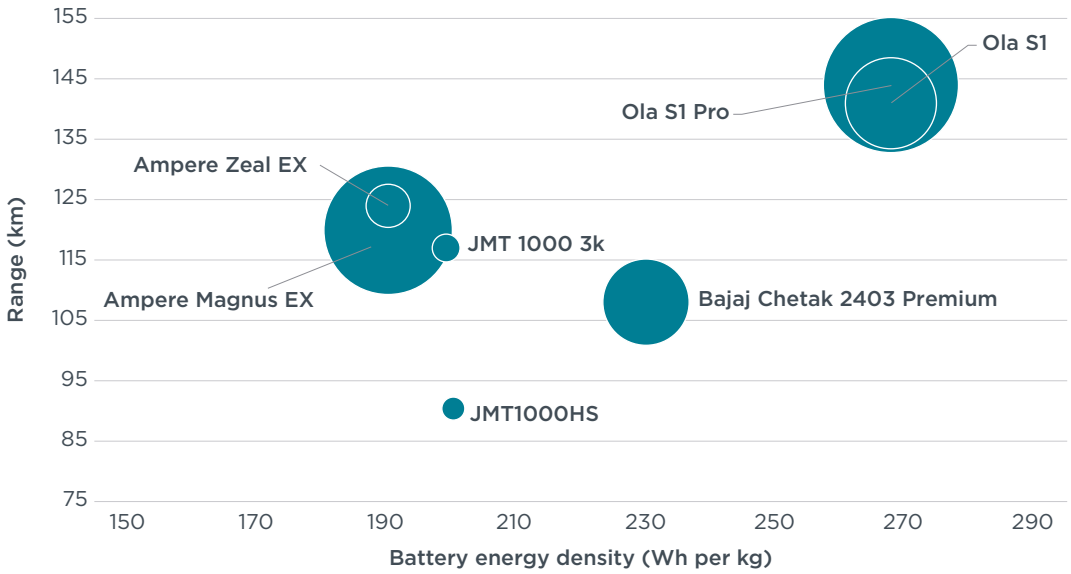


Source: "FAME India Scheme Phase II Dashboard," Government of India, Ministry of Heavy Industries, http://fame2.heavyindustries.gov.in/dashboard.aspx.

Figure 1 shows a scattered distribution and indicates the potential to incentivize more efficient models through credit multipliers for reducing electrical energy consumption. There seems to be no direct correlation between range and energy consumption, such that encouraging more efficient ZEVs would not discourage the manufacturing of models with longer ranges. Notably, all models have an electrical energy consumption well under the threshold of 7 kWh/100 km specified under the FAME II scheme to qualify for incentives.

Figure 2

Comparison of range and battery energy density of electric two-wheeler models in 2022



Source: "FAME India Scheme Phase II Dashboard," Government of India, Ministry of Heavy Industries, http://fame2.heavyindustries.gov.in/dashboard.aspx.

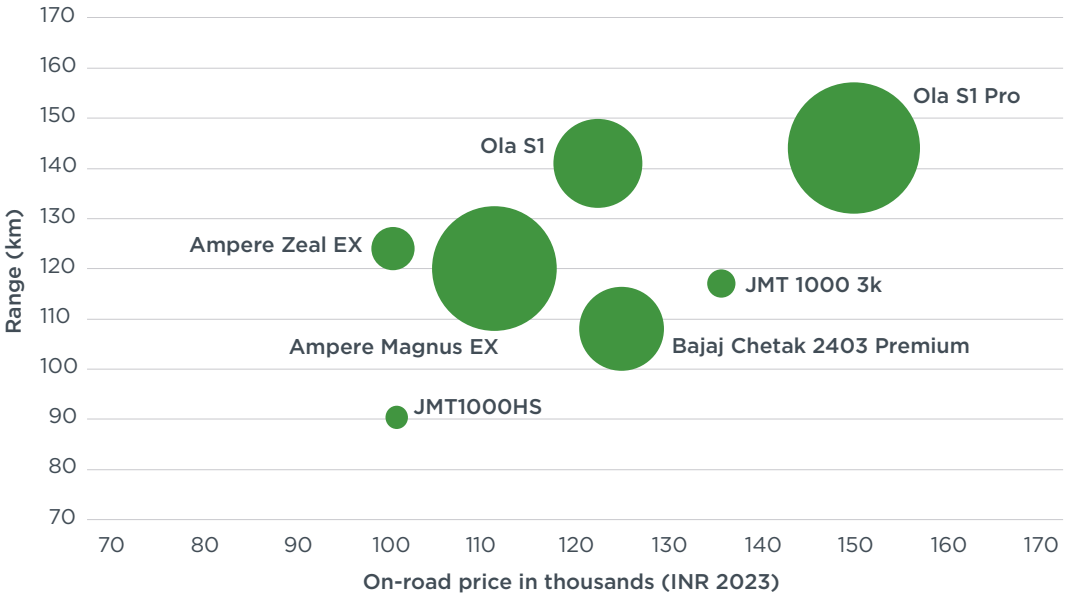
As seen in Figure 2, there is wide variation in battery energy density of models on the market. Battery energy density is also a function of battery chemistry; while FAME II only incentivizes models with advanced battery chemistries,[38] certain technologies may offer tradeoffs between energy density and safety and performance under Indian weather conditions. It is important to have adequate market consultations to understand optimal battery energy density for the Indian two-wheeler segment for the purpose of awarding any premiums on credits under a ZEV sales regulation.

As seen in Figure 3, there is also wide variability in the upfront pricing of electric two-wheeler models on the market. While price is observed to increase with range, even the lowest-cost model on the market has an upfront price 21% higher than the top-selling conventional two-wheelers. As the Indian two-wheeler market is very price-sensitive, to enable better reach of electric models among the average consumer, the production of low-cost models that meet all requisite technical and performance quality criteria could be incentivized through appropriate amounts of extra credits.

38 According to FAME, "Vehicle fitted with only advanced chemistry meeting with minimum technical criteria and registered as 'Motor Vehicle' as per Central Motor Vehicle Rules shall be eligible for incentives under the FAME-II scheme. Advanced battery represents the new generation batteries such as lithium polymer, lithium iron phosphate, lithium cobalt oxide, lithium titanate, lithium nickel manganese cobalt, lithium manganese oxide, metal hydride, zinc air, sodium air, nickel zinc, lithium air and other similar chemistry under development or under use. In addition, to this battery should have specific density of at least 70 Wh/kg and cycle life of at least 1000 cycles." Ministry of Heavy Industries and Public Enterprises, *Fame 2 Notifications and Guidelines* (2019), https://www.acma.in/uploads/doc/FAME%202%20Notifications_DHI_10th%20May%202019.pdf.

Figure 3

Comparison of range and upfront prices of electric two-wheeler models in 2022



Sources: "FAME India Scheme Phase II Dashboard," Government of India, Ministry of Heavy Industries, http://fame2.heavyindustries.gov.in/dashboard.aspx and manufacturer websites.

POLICY GOALS FOR TWO-WHEELER ZEV REGULATIONS IN INDIA

Figure 4 illustrates the electrification levels that can potentially be achieved through stringent fuel consumption standards,[39] in comparison to an indicative sales regulation that increases year-on-year sales obligations by 5%. For reference, the chart also depicts the electrification trajectory for new sales of two-wheelers under the ambitious policy scenario of ICCT's India Roadmap Model.[40] The ambitious scenario depicts electrification levels that are required to align India's road transport emissions with objectives of the Paris Agreement and India's net-zero by 2070 goal.

As shown in Figure 4, by increasing annual ZEV sales by 5% starting from 2024, only 14% electrification is reached by 2025. From a climate standpoint, targeting a 30% share for new electric two-wheelers by 2025 is better aligned to achieving 100% electrification of new sales by 2035.

Among vehicle segments, two-wheelers offer the easiest pathway for EV penetration due to their small battery pack, which is typically less than 5 kWh. Studies indicate that with central and state government subsidy support, cost parity has already been achieved for several models on the market.[41] It is therefore reasonable to assume that a ZEV regulation could target 10% annual growth in new sales of electric two-wheelers. In practice, annual sales obligations need not follow a linear path, and near-term and long-term electrification targets could be set to balance both cost feasibility and policy objectives.

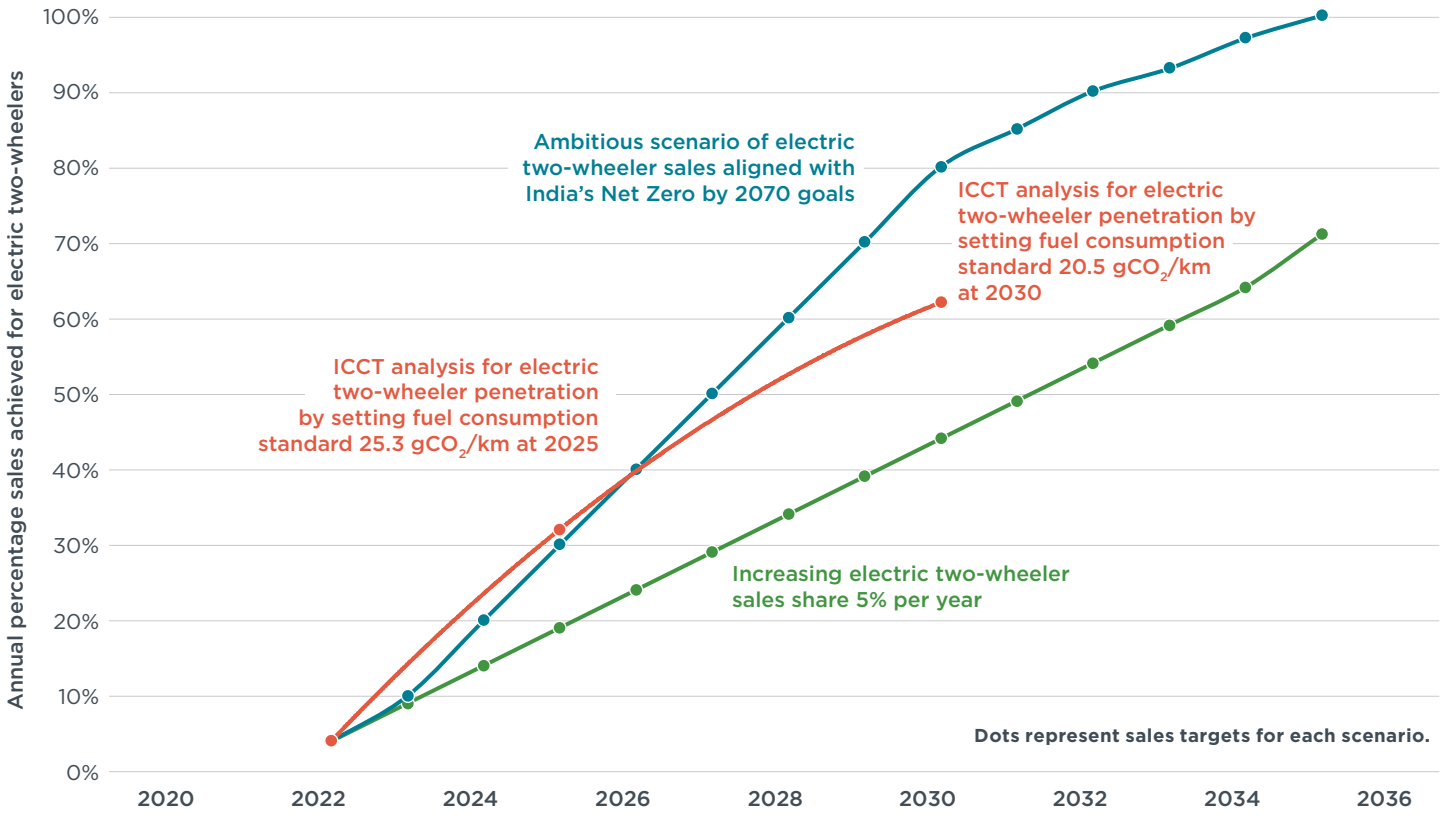
39 Sunitha Anup and Ashok Deo, *Fuel Consumption Standards for the New Two-Wheeler Fleet in India* (Washington, DC: ICCT, 2021), https://theicct.org/publication/fuel-consumption-standards-for-the-new-two-wheeler-fleet-in-india/.

40 Arijit Sen and Josh Miller, *Vision 2050: Update on the Global Zero Emission Vehicle Transition in 2023* (Washington, DC: ICCT, 2023), https://theicct.org/publication/vision-2050-global-zev-update-sept23/.

41 Shikha Rokadiya, "FAME-II Revisions Spark Hopes for a Jump in Electric Two-Wheeler Sales in India," ICCT Staff Blog, July 28, 2021, https://theicct.org/fame-ii-revisions-spark-hopes-for-a-jump-in-electric-two-wheeler-sales-in-india/.

Figure 4

Illustrative policy trajectory for new two-wheeler sales



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In this context, a ZEV credit program for two-wheelers in India could target 30% market penetration in the very near term (2025), up from a rate of 4.1% in 2022.

COMPLIANCE FLEXIBILITY AND ENFORCEMENT PATHWAYS

In this section, we briefly discuss the various compliance and enforcement pathways established under ZEV sales regulations in other countries and regions as focus areas of regulatory design. Such mechanisms can provide flexible options to manufacturers for meeting their credit targets to promote market growth in a progressive and feasible manner, while at the same time setting a strong deterrent to non-compliance.

The most direct pathway available to manufacturers for compliance with their annual credit targets is through sales of the required number of ZEVs. However, ZEV credit programs also offer options to bank and/or trade surplus credits as a compliance flexibility to manufacturers.

Banking and trading of surplus credits

Surplus credits occur when a manufacturer holds more credits at the end of a compliance year than required. The manufacturer can *bank* the excess credits and use them to comply with next year's ZEV requirement or can *trade* the excess credits with other manufacturers who are not meeting their targets. Banking of credits is an important flexibility element for manufacturers. It not only encourages manufacturers to transition to ZEVs earlier than required but also provides flexibility and security in case market uptake does not occur exactly as anticipated. Credit banking provisions also discourage manufacturers from holding back ZEV sales if they have already met their requirement for that year. Banking also reduces the number of credits available

for trading and thereby might force manufacturers to transition to ZEVs faster than if relying on purchased credits.

Credit borrowing

In addition to banking, ZEV regulations also may include mechanisms that allow manufacturers to borrow credits from future compliance years. For example, the United Kingdom's ZEV regulation allows the borrowing of allowances in the first three years of the policy (2024–2026), with an interest rate of 3.5% annually.

Some compliance pathways also allow for limited interlinkage between manufacturer compliance towards ZEV regulations and fuel consumption or greenhouse gas standards. In China, manufacturers can offset corporate average fuel consumption deficits by using banked or traded NEV credits, in addition to the option of using their own or transferred fuel consumption credits.[42] Meanwhile, manufacturers can offset NEV deficits only by using their own NEV credits or purchasing NEV credits from other companies.[43] Phase II of China's NEV mandate policy, however, allows for a relaxation in a manufacturer's total vehicle volume on which the NEV credit requirements are calculated. This relaxation is allowed only for vehicles that either meet or exceed China's fuel consumption standards.[44]

Under California's ZEV credit provisions for model years 2018–2021, manufacturers were permitted to offset 30%–50% of their ZEV credit requirements through credits earned by over-complying with applicable greenhouse gas standards by at least 2 g CO_2/km.[45] Under the United Kingdom's ZEV mandate, manufacturers will be allowed to use excess credits (allowances) from CO_2 regulation compliance towards compliance with the ZEV mandate in the initial years. This feature was introduced primarily with the objective of providing flexibility to manufacturers to optimize costs in making CO_2 reductions across the fleet while moving towards an all-ZEV fleet in the long term. The transfer of such allowances towards ZEV compliance is capped at 65% in 2024, 45% in 2025, and 25% in 2026.

While two-wheelers in India are not subject to fuel-consumption standards, if such standards are introduced in the near future, appropriate transitional interlinkages could be considered that benefit manufacturers who may choose to make short-term investments in fuel-efficient technologies while transitioning towards electrification at scale in the long term.

Deterrents for non-compliance

If manufacturers are unable to demonstrate compliance with ZEV targets through the various compliance pathways and flexibility mechanisms available to them, credit programs specify enforcement measures to deter non-compliance. For example, under California's ACC II regulations, if a manufacturer demonstrates non-compliance, it has an additional two years to make up its ZEV deficit, beyond which it is liable for a financial penalty of $5,000 per credit deficit. Paying this penalty does not write off the credit deficit, which is accrued to future years. The United Kingdom's ZEV mandate also specifies a financial compliance payment of £15,000 per excess non-ZEV car

42 Zhinan Chen and Hui He, *The Second Phase of China's New Energy Vehicle Mandate Policy for Passenger Cars* (Washington, DC: ICCT, 2021), https://theicct.org/publication/the-second-phase-of-chinas-new-energy-vehicle-mandate-policy-for-passenger-cars/.

43 Zhinan Chen and Hui He, "How Will the Dual-Credit Policy Help China Boost New Energy Vehicle Growth?" ICCT Staff Blog, February 10, 2022, https://theicct.org/china-dual-credit-policy-feb22/.

44 Chen and He, *The Second Phase of China's New Energy Vehicle Mandate Policy.*

45 Shikha Rokadiya and Zifei Yang, *Overview of Global Zero-Emission Vehicle Mandate Programs* (Washington, DC: ICCT, 2019), https://theicct.org/publication/overview-of-global-zero-emission-vehicle-mandate-programs/; Zero-Emission Vehicle Standards for 2018 through 2025 Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Code of Regulations Section 1962.2, https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifro1962.2.pdf.

registration as a last resort for manufacturers to comply with their ZEV targets. Unlike California's penalty system, the UK's mechanism absolves manufacturers of any deficits in exchange for the payment.

CONCLUSIONS

ZEV regulations send a clear market signal towards the ZEV transition and can spur manufacturers to produce and supply ZEVs in greater numbers. ZEV regulations can also help to stimulate market competition and benefit consumers by encouraging wider model availability at competitive prices. Credit mechanisms offer added compliance flexibility for manufacturers to optimize costs in transitioning towards electric powertrains.

A mandate in the form of a ZEV regulation can provide the necessary push for manufacturers to enter the market and build capacity at scale. The two-wheeler market in India is arguably well-positioned for the issuance of such a regulation, and attractive demand-side incentives are already in place from the central government and several state governments. As noted above, the CNG transition in Delhi, which was brought about through a mandate, indicates that regulatory certainty can have powerful impacts in achieving market transformation at scale in a cost-effective manner.

Our review suggests that there are multiple enabling statutory frameworks that could provide the necessary authority for issuance of a ZEV regulation at the national or sub-national level. Such authority is derived from laws in place related to energy (fuel) consumption, air quality, environment, and vehicular transport. Key authorities include the Ministry of Power, the Bureau of Energy Efficiency, the Ministry of Road Transport and Highways, the Ministry of Environment, Forest, and Climate Change, and the Central Pollution Control Board. At the state level, they also encompass State Pollution Control Boards and Committees and State Transport Departments. Further, the National Council on Electric Mobility and National Board on Electric Mobility also have broad powers to recommend and approve policy frameworks in the interest of promoting electric vehicles and their manufacturing in India.

Under a credit-based ZEV regulation, two-wheeler manufacturers in India could be subjected to increasingly stringent credit targets over a policy period. Under ZEV regulations for light-duty vehicles in other countries and regions, a range-based sliding credit system has been used to determine the number of credits awarded to a given ZEV. However, relying heavily only on range to distinguish credit allocation can lead to excess credits and introduce uncertainty in meeting target market shares. Several jurisdictions, including California and the United Kingdom, have hence moved toward awarding credits uniformly to all eligible ZEVs, as opposed to range-based sliding credit approaches.

In the initial phases of a ZEV regulation in India, policymakers could consider allocating credits uniformly to all two-wheelers that meet a minimum range criterion for models with factory-fitted batteries with advanced chemistries. Such range criteria could be modified and or waived for swappable battery packs, which may have a lower range by design. In future years of the regulation, based on market performance and feedback, distinctions could be made to favor uptake of energy-efficient vehicles and batteries, as well as low-cost models, through multipliers on the base credit value for such parameters.

Banking provisions could be defined to allow manufacturers to hold any additional credits for future use as a compliance flexibility, alongside options to trade or sell excess credits to competitors. Further, if fuel consumption standards are also implemented for two-wheelers, appropriate near-term interlinkages could be specified

between the two regulations to enable manufacturers to make short-term investments in improving the fuel-efficiency of their ICE fleet while transitioning towards electrification over the longer term. Finally, appropriate penalties could be defined to deter non-compliance after manufacturers have exhausted all available pathways to meet their credit obligations.

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