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Estimating electric two-wheeler costs in India to 2030 and beyond

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This paper considers costs for high-speed battery electric two-wheelers (E2Ws) in India through 2030 and beyond. We estimate both upfront costs and the 5- and 10-year total cost of ownership (TCO) for E2Ws. In addition, we project the timing for price parity for representative battery electric scooters and motorcycles as compared to their gasoline counterparts.

Electrification of the 2W segment is important for India, the world's largest 2W market. Due to the nature of an electric drive, an E2W has better performance characteristics than a conventional 2W and reduced maintenance and operating costs. As 2Ws are significantly simpler and lighter than other vehicle types, they also have the potential to be electrified very cost-effectively because their motor power requirements and battery size are much lower than for other vehicles.

Background

E2Ws comprised 30% of global 2W unit sales in 2019, and the majority of those sales were in China.[1] Given their high sales volumes, E2Ws make up more than half of all electric vehicle (EV) energy demand worldwide.[2] With more than 80% of the 2W market in China electrified, E2W sales in China are now plateauing, and other markets are poised to drive future global growth.[3]

India's current 2W fleet consumes 65% of all gasoline fuel in the country.[4] With more than 20 million 2Ws produced each year since 2017, 2W production capacity far exceeds any other mode of transportation in India.[5] By 2026, 2W production capacity could more than double to 50.6 million units annually.[6] Given such dramatic growth potential, rapid 2W electrification in India could make it *the* global leader in E2W. Furthermore,

1 BloombergNEF, "Electric Vehicle Outlook 2020" (May 2019), https://about.bnef.com/electric-vehicle-outlook/.

2 International Energy Agency, "Global EV Outlook 2019" (Paris: IEA, 2019), https://www.iea.org/reports/global-ev-outlook-2019.

3 Patrick Hertzke et al., "Global emergence of electrified small-format mobility" McKinsey & Company, 2020, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/global-emergence-of-electrified-small-format-mobility.

4 K. K. Gandhi, "How India can drive towards an emission-free future," *Autocar Professional*, November 13, 2018, https://www.autocarpro.in/opinion-column/how-india-can-drive-towards-an-emissionfree-future-41288.

5 "Performance of Auto Industry during 2018-19," Society of Indian Automobile Manufacturers (SIAM), n.d., accessed June 3, 2021, https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=13.

6 "Indian Two-Wheeler Production and Plant Capacity Analysis," MarkLines, June 11, 2019, https://www.marklines.com/en/report/rep1872_201906.

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electrifying the 2W fleet would offer large potential reductions in carbon dioxide (CO_2) emissions, exhaust pollutant emissions, gasoline consumption,[7] and vehicular noise.

In India, as in most markets around the world, the upfront cost of an E2W is significantly higher than that of its conventional internal combustion engine (ICE) counterpart. This cost difference strongly limits the attractiveness of electric drive options. Government initiatives such as the National Mission on Transformative Mobility and Battery Storage and the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme create a foundation on which the domestic E2W industry can grow. Additionally, incentives with localization criteria can shift production of critical electric drive components (e.g., high-quality batteries, e-motors, controllers) into India from abroad. Domestic manufacturing of key battery and non-battery components will improve economies of scale and will strongly influence the pace of cost reduction in this segment. Thus, there is serious policy interest in 2W electrification.

In this paper, we first apportion the 2020 upfront costs of top-selling conventional 2W and E2Ws into component-level direct manufacturing costs (DMC) and indirect costs including manufacturer and dealer margins. Then we project all costs into the future to estimate full-vehicle upfront costs to the consumer beyond 2020. Notably, for the same real-world vehicle range, we assume technology costs for EVs will decline as batteries become smaller (i.e., more efficient) and as domestic manufacturing scales; we assume ICE costs, meanwhile, will increase on account of efficiency improvements. Similarly, we also assess total cost of ownership (TCO) parameters for both E2W and conventional models in 2020 and apply assumptions to project them beyond 2020. Through this exercise, we estimate the timing of both upfront and TCO price parity of E2Ws with conventional models under different electrification scenarios. We also examine the impact of incentives available from the central government and state-level governments on cost-parity timing, using Delhi as a model. We end with conclusions and policy implications.

Cost estimates

Representative models

Scooters constitute 29% of all 2W production in India, and motorcycles make up 67%.[8] Mopeds make up the remaining share and are not considered in our analysis.

Nearly 97% of all conventional scooters produced in India have engines between 90 cubic centimeters (cc) and 125 cc. The Honda Activa is the best-selling scooter model, with more than 3.8 million units sold in Fiscal Year (FY) 2019–20.[9] Due to its popularity, we chose the Activa as the representative conventional scooter. The claimed fuel efficiency for the Bharat Stage (BS) VI variant of the Activa is about 10% higher than the BS IV variant and is around 60 kilometers per liter (km/L).[10]

The motorcycle market is slightly more diverse than the scooter market. Sixty percent of conventional motorcycles produced have engines between 75 cc and 110 cc. The best-selling model is the Hero Splendor Plus, with more than 3.5 million units sold in FY 2019–20.[11] The most widely sold variant of the Hero Splendor Plus is the 97 cc engine. (The next best-selling motorcycle, the Hero HF Deluxe, also has a 97 cc engine.) Thus, we take the Hero Splendor Plus to be representative of conventional motorcycles. The

7 Sunitha Anup and Ashok Deo, *Fuel consumption reduction technologies for the two-wheeler fleet in India* (ICCT: Washington, DC, 2021), https://theicct.org/publications/2w-fuel-reduction-india-mar2021.

8 Sunitha Anup and Zifei Yang, *New two-wheeler fleet in India for fiscal year 2017-18* (ICCT: Washington, DC, 2020), https://theicct.org/publications/new-two-wheeler-fleet-india-2017-18.

9 Sales data from Segment Y Automotive Intelligence.

10 "Activa 6G," Honda, accessed June 3rd, 2021, https://www.honda2wheelersindia.com/assets/pdf/Activa6GBrochure.pdf.

11 Sales data from Segment Y Automotive Intelligence.

claimed fuel efficiency for the BS VI variant of the Hero Splendor Plus is about 9% higher than the BS IV variant and is around 73 km/L.[12]

Currently, only a limited number of E2Ws for sale in India have power, top speed, and range comparable to conventional 2Ws. We selected the RV400, an e-motorcycle, and the Ather 450X, an e-scooter, as the representative E2Ws in this analysis because their performance specifications are comparable to their conventional counterparts. While several other e-scooter models are available, including the Okinawa iPraise+, Hero Photon, and TVS iQube, which offer similar or greater range than the Ather 450X and are slightly more energy efficient, they do not compare as closely on performance specifications to top-selling conventional scooters. These e-scooter models are significantly cheaper than the Ather 450X, and our results are conservative to that extent.

Table 1 details key characteristics of each representative model. For illustrative purposes, we include the characteristics of other e-scooter models. For the conventional ICE vehicles, we assume that real-world fuel consumption is 20% higher than corresponding test values. For electric scooters, we used the middle performance mode and corresponding battery range reported by the manufacturer for the mode to represent real-world battery range (note that this range value is significantly lower than the certified test range value). This practice closely approximates user-reported values for the representative model. Since electric motorcycles currently have limited penetration in the Indian market, insights on their real-world range are scant; for the purpose of this analysis, we assume that the marketed range by the manufacturer is the real-world range and not the certified test range.

Table 1. Key characteristics of representative 2W models.

	Motorcycle		Scooter				
	Best-selling conventional model	Representative electric model	Best-selling conventional model	Representative electric model	Alternative electric models		
Make and model	Hero Splendor+[a]	RV400[b]	Honda Activa[c]	Ather 450X[d]	Okinawa iPraise+[e]	Hero Photon LP	TVS iQube[f]
2020 base price (INR) pre-tax and pre-subsidy	47,148	141,905	51,109	179,048	132,122	85,705	146,264
Goods and Services Tax (GST)	28%	5%	28%	5%	5%	5%	5%
FAME-II subsidy (INR)	N/A	30,000	N/A	29,000	30,000	17,000	22,500
Ex-showroom price after GST and FAME-II subsidy (INR)	60,350	119,900	65,419	159,000	102,728	72,990	131,077
Rated battery or tank capacity (kWh or L)	9.8 L	3.24 kWh (72V)	5.3 L	2.90 kWh (51.1V)	3.3 kWh	1.44 kWh (72V)	2.25 kWh
Certified fuel economy (km/L)	73	n/a	60	n/a	n/a	n/a	n/a
Certified e-range (km)	n/a	156	n/a	116	139	80	86.1
Real world range (km)	598	100	263	85	No data	60	75
Real world fuel efficiency (kWh/km)[g]	0.15	0.03	0.19	0.03	No data	0.02	0.03
Top speed (km/h)	87	85	83	80	51.2	45	78
Peak power (kW)	5.9	3.0	5.7	6.0	2.5	1.8	4.4

[a] "Hero Splendor Plus," Zigwheels.com, 2020, https://www.zigwheels.com/newbikes/Hero-Moto-Corp/Splendor-Plus/specifications.
[b] "RV400", Revolt Motors, 2021, https://www.revoltmotors.com/rv400.
[c] "Honda Activa 6G," Zigwheel.com, 2020, https://www.zigwheels.com/newbikes/Honda/activa-6g.
[d] "Ather 450X," Ather Energy, 2021, https://www.atherenergy.com/.
[e] "Okinawa iPraise+," Okinawa Autotech, 2020, https://okinawascooters.com/buy-now/buy-now/ipraiseplus/ipraiseplus/.
[f] "TVS iQube Disclaimers," TVS Motor, 2020, https://www.tvsmotor.com/iqube/disclaimer.
[g] For conventional models, we assume real world fuel consumption values to be 20% higher than corresponding test values.

12 "Splendor+ BS6," Hero, accessed June 3rd, 2021, https://www.heromotocorp.com/en-in/the-bike/splendor-bs6-98.html#features.

Despite having among the longest ranges of all E2Ws available today, the driving ranges for the representative electric models are substantially shorter than those of ICE models. However, a year's worth of data collected by Ather indicates that 90% of daily driving totaled less than 34 kilometers (km), and more than 50% of daily driving totaled less than 16 km.[13] A survey for the city of Pune showed similar utilization patterns: Ninety-one percent of prospective 2W buyers traveled less than 30 km per day.[14] Consequently, the battery ranges that the Ather 450X and RV400 provide are more than enough for multiple days of urban driving. To provide at least one week's worth of driving on a single charge, real-world battery range would need to be between 100 km and 250 km. At that range, an E2W would have similar real-world range to today's conventional ICE 2Ws and would surpass them on performance characteristics.

E2W upfront prices are significantly higher than conventional 2W prices. At an estimated ex-showroom price of Rs 1.19 lakh after the FAME-II incentive, the RV400 is almost 97% more expensive than the Hero Splendor+.[15] The Ather 450X is 143% more expensive (ex-showroom) than the Honda Activa 6G even after FAME-II subsidies and a preferential GST rate. State policies, including one in Delhi, offer additional attractive purchase and scrapping incentives for E2Ws. However, even after these incentives, the 450X is still 106% more costly than the Activa 6G.

Table 2 lists the technical specifications for the ICE and electric 2Ws in both 2020 and 2030. The specifications in year 2020 are the current characteristics of today's models listed in Table 1. To project to 2030, we assume conventional vehicle (real-world) efficiency will improve at an annual rate of a 1% reduction in CO_2 emissions due to likely fuel consumption regulations for the segment and technological progress driven by ICE developers' need to compete with EVs. We also assume EV efficiency will improve at a rate of 0.65% per year, driven mainly by technology enhancements and increases in battery range.

We subdivide E2Ws into three categories based on battery range: "short," "mid," and "long." The models available on the market in 2020 were all short-range models, but as battery technology improves and manufacturing indigenizes, mid- and long-range models can be expected to enter the market. As an illustration, we extrapolate short-range costs, keeping performance constant, and include specifications for hypothetical mid- and long-range options in the table. Still, shorter range models will likely continue to be popular, as they are a lower-cost option than higher range models. Additionally, despite the difference in battery range, all E2Ws modeled are anticipated to provide enough range to cover most daily usage needs.

13 Jehan Adil Darukhanawala, "Learnings from Ather's First Year of Operations," ZigWheels.com (blog), June 13, 2019, https://www.zigwheels.com/news-features/news/ather-450-scooters-clock-over-600000km/34150/.

14 UNEP-DTU Partnership, "Study of EV charging in Pune city: survey analysis report," August 2018.

15 "Tork T6x", ZigWheels.com, 2020, https://www.zigwheels.com/newbikes/Tork/t6x.

Table 2. Technical specifications for conventional and battery electric 2Ws in 2020 and projected in 2030.

		Conventional				Electric			
		Motorcycle		Scooter		Motorcycle		Scooter	
		2020	2030	2020	2030	2020	2030	2020	2030
Power (kW)		5.9	5.9	5.7	5.7	3.0	3.0	6.0	6.0
Real-world efficiency (kWh/km)		0.152	0.114	0.187	0.154	0.032	0.030	0.034	0.032
Real-world range (km)	**Short**	598	728	263	321	100	100	75	75
	Mid					150	150	125	125
	Long					250	250	200	200
Pack capacity(kWh)[a]	**Short**	n/a	n/a	n/a	n/a	3.2	3.0	2.6	2.4
	Mid					4.9	4.6	4.3	4.0
	Long					8.1	7.6	6.8	6.4

[a] Capacity requirement to deliver the specified vehicle range reduces over time as a result of efficiency improvements.

The ex-showroom price provided by manufacturers contains either 28% GST for conventional 2Ws or 5% GST for E2Ws, and we assume these rates will continue beyond 2020.

We consider vehicle base price to be the ex-showroom listed price before GST and any subsidy. The base price comprises powertrain direct costs; other direct costs, like warranty, assembly, and non-powertrain components; and indirect costs, such as for administrative expenses and research and development, manufacturer profit, and dealer markup. Below, we describe the assumptions used to project component costs after 2020.

Battery cost projections

ICCT previously assessed battery cell and pack cost reductions in a paper examining electric cars in the United States.[16] That assessment assumed battery cell costs would decrease by 7% each year—a slightly more conservative decrease than the trend that BloombergNEF projected.[17]

Costs for both raw minerals and the synthesized active materials set the price floor for battery cells and packs. Currently, manufacturing constitutes around 15% of cell cost, while raw material costs account for the rest.[18] There is likely significant opportunity for manufacturing cost reduction, particularly as production scales. Additional cost reductions are possible through novel chemistries and incremental improvements. However, for any given battery chemistry, costs will eventually cease to drop further.[19]

Some benefits of E2Ws over electric cars further reduce costs. Battery packaging and cooling costs for 2W packs are significantly lower than for four-wheeled vehicles on a kWh basis, as the battery capacity is 10–20 times smaller and power is 25 times lower. Current E2Ws use much lower voltages than electric cars, and thus power distribution, control, and inverter/converter modules are cheaper and much more similar to those widely available in low voltage applications. E2Ws can also benefit more readily than cars from novel electricity storage devices, such as ultracapacitors. These storage

16 Nic Lutsey and Michael Nicholas, *Update on Electric Vehicle Costs in the United States through 2030* (ICCT: Washington, DC, 2019), https://theicct.org/publications/update-US-2030-electric-vehicle-cost.

17 "Battery Pack Prices Fall as Market Ramps up with Market Average at $156/KWh in 2019," *BloombergNEF* (blog), December 3, 2019, https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/.

18 I-Yun Lisa Hsieh et al., "Learning Only Buys You so Much: Practical Limits on Battery Price Reduction," *Applied Energy* 239 (April 2019): 218–24, https://doi.org/10.1016/j.apenergy.2019.01.138.

19 "Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh" (BloombergNEF, December 16, 2020), https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/.

devices allow for rapid recharging and greatly enhance the regenerative braking capacity for E2Ws, possibly doubling driving range.[20]

To realize globally cost-competitive battery pack and EV-component prices, India must simultaneously indigenize manufacturing and incentivize consumption. To ensure indigenization, the Government of India already has in place the Phased Manufacturing Programme, which has requirements for FAME-II eligibility and increased tariffs on imported parts.

For this analysis, we assume that battery cell costs in India will be globally competitive once the scale of domestic battery cell production at least matches that of the United States in 2018. This implies a cell cost of INR 9,052/kWh (US$128/kWh) once 4.5 gigawatt-hours (GWh) per year production is reached, equivalent to 100,000 battery pack units per year at 45 kWh per pack in the United States.[21] After reaching that production-driven milestone, we assume cell costs to decrease at 7% per year. We use a second milestone of 22.5 GWh per year, matching expected U.S. production in 2025, as a proxy for how well the market can maintain its competitiveness.

We developed two scenarios to project the rate of 2W electrification. In the first scenario, we assume that 100% of new 2W sales will be electric by 2035. In the second scenario, we assume 100% electrification of these sales occurring by 2047. Electric 2W sales as a fraction of total 2W sales and total sales under these scenarios are depicted in Figure 1.

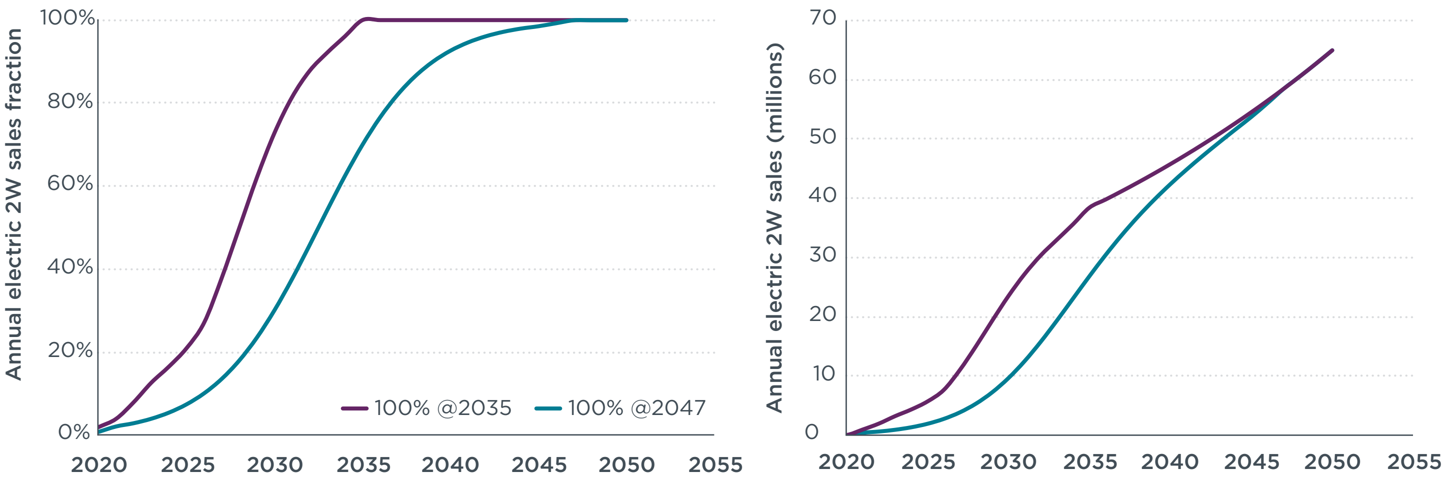

Figure 1. Projected annual new electric 2W sales under two electrification scenarios.

With the battery pack sizes of today's representative models, the 100% by 2035 scenario reaches our assumed global cost-competitiveness threshold corresponding to production of 4.5 GWh per year around 2022, about a 4-year lag from when the United States reaches it. This milestone is crossed by 2025 in the 100% by 2047 scenario. The second production milestone of 22.5 GWh per year is crossed by 2026 (a 1-year lag from the United States) in the 100% by 2035 scenario and by 2030 (a 5-year lag from the United States) in the 100% by 2047 scenario. These production milestones determine the schedule for battery cost reductions described in the preceding paragraphs.

The rates of battery capacity fabrication could increase with innovations in chemistry and manufacturing. For this reason, basing battery cell cost on the production scale of today's battery energy densities may underestimate future cost reductions and is conservative.

20 "NAWA Technologies Unveils Hybrid Battery-Powered Electric Motorbike Concept Designed for CES 2020," NAWA Technologies, December 19, 2019, http://www.nawatechnologies.com/wp-content/uploads/2019/12/NAWA-Technologies_NAWA-Racer_FINAL.pdf.

21 Lutsey and Nicholas, "Update on Electric Vehicle Costs."

Pack costs depend on battery cell production volume and pack size. These costs decrease as production increases over time. We calculate pack costs from cell costs according to a trend identified in a recent study of pack-to-cell cost ratio as a function of battery capacity, which found that the larger the pack, the lower the ratio of pack-to-cell cost.[22] The study examined battery packs for cars, which, as mentioned, are 10 to 20 times larger in capacity compared to the E2Ws on the market today and must provide about 25 times more power. The smaller E2W pack poses fewer assembly challenges (fewer cells and simpler, lighter hardware) and may therefore buck the trend of increasing cost with decreasing pack capacity. This uncertainty may further contribute to a conservative estimate of battery costs in this analysis. As an assumption, we limited the pack-to-cell cost ratio at a value of 1.6 for battery packs smaller than 10 kilowatt-hours (kWh). Figure 2 shows pack-level cost reductions that our study projects under the two model scenarios.

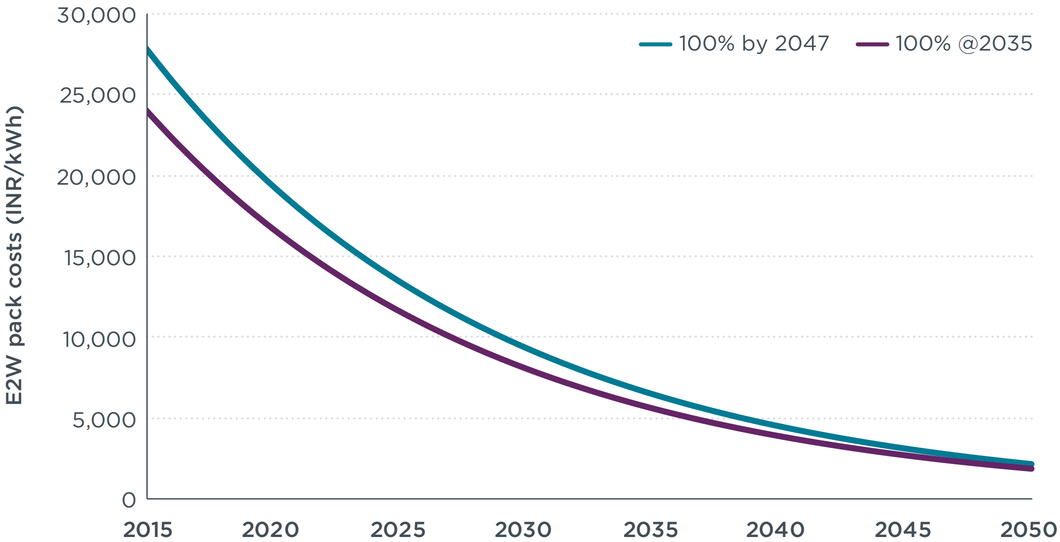

Figure 2. Modeled E2W battery pack cost in US$ per kWh.

Direct and indirect cost projections

Direct costs include powertrain, non-powertrain components, warranty, and assembly costs. For EVs, powertrain costs include the battery pack and several non-battery powertrain components; for conventional vehicles, main powertrain costs include the engine, transmission, and exhaust. Indirect costs pertaining to manufacturing include depreciation, amortization, research and development, and other administrative expenses. Other indirect costs include original equipment manufacturer (OEM) and dealer profits. The total of all direct and indirect costs results in a pre-tax and pre-subsidy base price of the vehicle for the consumer.

A detailed description of the assumptions applied to project direct and indirect costs, including battery costs as described in the preceding section, is included as an appendix. We estimate conventional 2W powertrain and non-battery E2W powertrain costs from a teardown analysis of cars manufactured in the United States in 2017 by scaling to lower power ratings for 2Ws.[23] For E2W, both battery and non-battery price reduction schedules are linked to production scale. Future costs in India follow a time-lag from production-linked costs achieved in the United States in 2018. Thus,

22 See Figure 4: Michael Safoutin, Joseph McDonald, and Ben Ellies, "Predicting the Future Manufacturing Cost of Batteries for Plug-In Vehicles for the U.S. Environmental Protection Agency (EPA) 2017–2025 Light-Duty Greenhouse Gas Standards," *World Electric Vehicle Journal* 9, no. 3 (October 6, 2018): 42, https://doi.org/10.3390/wevj9030042.

23 "UBS Evidence Lab Electric Car Teardown: Disruption Ahead?" UBS Q-Series, May 18, 2017, https://neo.ubs.com/shared/d1ZTxnvF2k/.

this time-lag is wider under slower electrification scenarios. Further, it is possible that as EV and battery production in India starts to scale, a corrective factor will show up on the assumed costs as a result of lower-cost battery chemistries. That corrective factor could be the domination of lithium iron phosphate batteries the Indian market, or changing Indian manufacturing conditions, such as lower labor or capital costs.[24] For now, since E2W production in India is essentially negligible, we base our model on data available from the United States and extrapolate these costs to India. To that extent, our results are conservative.

Results – Purchase costs

Table 3 details costs in 2020 and projections in 2030. These prices assume an electrification scenario of 100% E2W by 2035. Values are based on 2020 costs for conventional 2Ws, 75-km range e-scooters, and 100-km range e-motorcycles. Longer range E2Ws are not yet available; their costs are hypothetical and based on battery cost estimates. All projections for 2030 are nominal costs based on 2020 values.

Table 3. Cost projections for 2030 in the 100% electric 2W by 2035 scenario (all values in INR).

Component cost projections in INR			ICE powertrain	Battery	Non-battery[a]	Assembly	Indirect cost	Profit	Dealer markup	Total base price (pre-tax and pre-subsidy)
2020	Motorcycle	ICE	22,341	N/A		11,532	6,948	4,082	2,245	47,148
		BEV100	N/A	54,257	4,958		61,750	2,650	6,757	141,905
		BEV150		81,386				3,193	8,141	170,960
		BEV250		135,644				4,278	10,908	229,069
	Scooter	ICE	21698	N/A		15,020	7,532	4,425	2,434	51,109
		BEV75	N/A	45,862	9,916		96,380	3,344	8,526	179,048
		BEV125		75,174				3,930	10,021	210,441
		BEV200		117,459				4,776	12,178	255,729
2030	Motorcycle	ICE	27357	N/A		11,930	7,188	4,388	2,413	50,683
		BEV100	N/A	24,602	4,215	10,736	13,725	2,918	2,810	59,007
		BEV150		36,903				3,592	3,459	72,630
		BEV250		61,505				4,939	4,756	99,877
	Scooter	ICE	26713	N/A		15,539	7,792	4,749	2,612	54,847
		BEV75	N/A	20,828	8,431	13,985	21,422	3,542	3,410	71,618
		BEV125		34,174				4,273	4,114	86,399
		BEV200		53,467				5,330	5,1323	107,766

[a] These costs are scaled down from non-battery costs from electric cars. However, they could be lower for smaller range vehicles such as E2Ws. To that extent, these assumptions are conservative.

As seen in Table 3, by 2030, as sales volumes grow and manufacturing becomes cheaper, both battery costs and indirect costs decrease substantially for E2Ws. The cost of battery packs nearly halves from the range of INR 17,000/kWh to about INR 8,000/kWh, and E2W indirect costs experience a net decrease of 78%. These reductions are independent of any incentives available to auto, battery, and other component manufacturers. The Government of India has proposed a production-linked subsidy ranging from US$27/kWh to US$56/kWh for manufacturers who set up advanced

24 James Firth, "BNEF Talk: Lithium-ion battery costs, getting to $100/kWh," video, accessed April 13, 2021, on about.bnef.com.

chemistry cell (ACC) production units with a minimum capacity of 5 GWh.[25] These incentives are being considered to support up to 50 GWh of production capacity.[26] With well-designed production-linked incentive schemes across the value-chain, costs can decrease even further.

Figure 3 illustrates the impact of existing subsidies on the projected base prices of E2W in 2030. We assume a FAME-II incentive equal to the lower of INR 10,000/kWh or 20% of ex-showroom price and a preferential GST advantage of 23% for electric models versus conventional ones. Further, states such as Delhi have announced progressive policies for EV adoption, with additional direct incentives to bring down the upfront costs of vehicles. For E2W, Delhi offers a purchase subsidy of INR 5,000/kWh capped at INR 30,000 and a scrapping incentive that can subtract an additional INR 10,000 from the upfront price.[27] The hashed portions in the figure represent the cost reductions attributed to various incentive schemes, and total column height is the cost without any incentives.

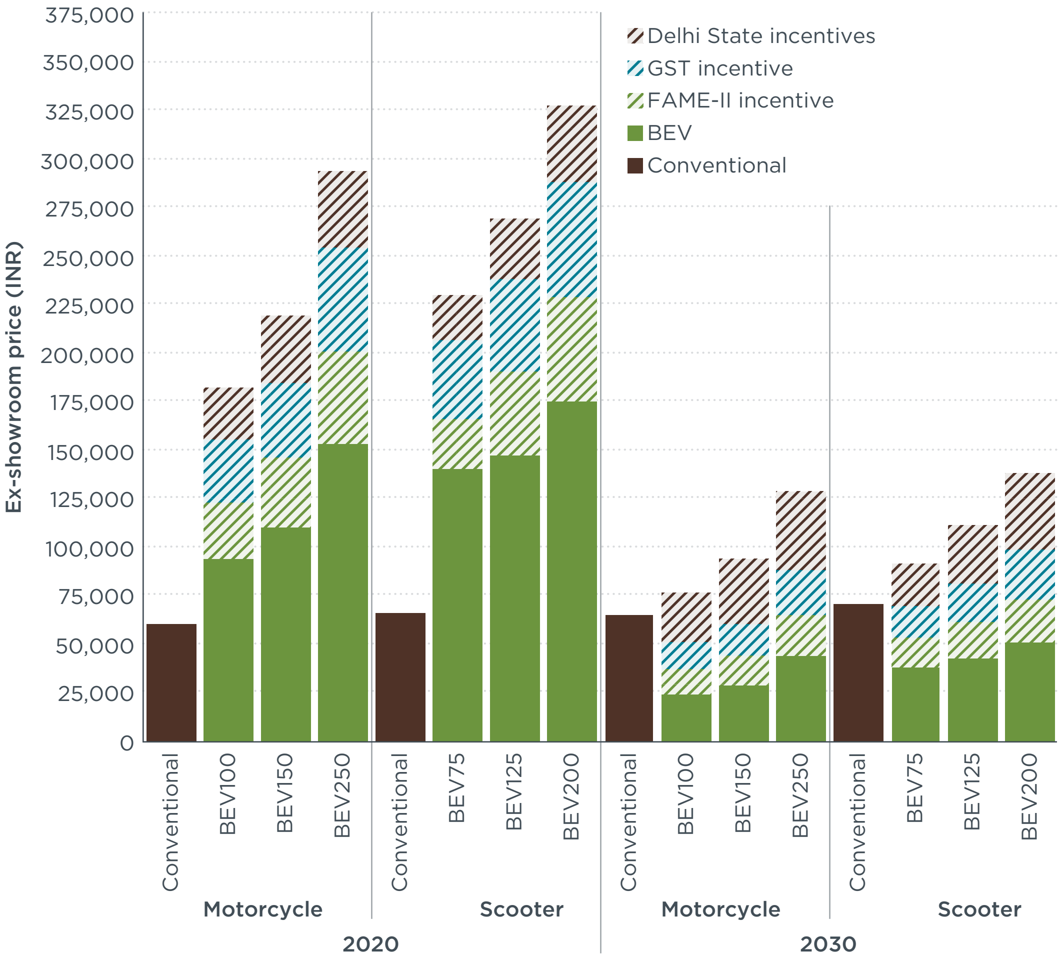

Figure 3. 2020 upfront price of 2Ws and projected 2030 price under 100% E2W by 2035 scenario.

As seen in Figure 3, despite all of the anticipated advancements in EV technology and manufacturing, by 2030, conventional 2Ws will likely be slightly cheaper than the shortest range, least expensive E2Ws, without subsidies in 2030. And without state-level subsidy packages like Delhi's, conventional 2Ws will still be less expensive than the longest range, most expensive E2Ws in 2030.

25 We used US$1 = INR 74 as the exchange rate for this paper.

26 NITI Aayog, Government of India, "Draft Model Bid Documents – National Program on Advanced Chemistry Cell Battery Storage", accessed June 3rd, 2021, on http://www.niti.gov.in/index.php/node/1360.

27 INR 5,000 from the state, provided there is a matching contribution from dealer or OEM.

It is worth noting that the FAME-II and GST incentives decrease in the depicted electrification scenario by more than 50% from 2020 in 2030, mainly due to battery cost reductions and the downsizing of battery packs from efficiency gains.[28] Under slower E2W market penetration (the 100% by 2047 scenario in Figure 1), battery costs decrease less, leading to higher government outlays for FAME-II as well as GST revenue losses. Conversely, faster E2W adoption decreases the incentive outlays more quickly as battery costs fall further.

By examining the faster 100% E2W by 2035 scenario, we can see the years in which E2Ws reach price parity with conventional 2Ws. As shown in Figure 4, with continued FAME-II and GST incentives, 100-km motorcycles reach upfront cost parity in 2027, 150-km motorcycles reach it around 2030, and 250-km motorcycles reach it around 2034. 75-km scooters reach parity around 2028, 125-km scooters around 2031, and 200-km scooters by 2034. The solid lines in Figure 4 indicate the cost-parity timelines with central government preferential support for E2W in the form of FAME-II and the GST incentive. The dotted lines indicate the accelerated timelines with additional state incentives at the level offered by Delhi. **State-level direct incentives can play a big role in bridging purchase cost gaps at a faster rate.** For example, adding the purchase incentive and scrapping incentive as announced by Delhi to FAME-II and GST benefits accelerates upfront parity to the 2023–2025 time frame for short-range models. For mid- and long-range models, Delhi's incentives can accelerate upfront parity by 4 to 7 years.

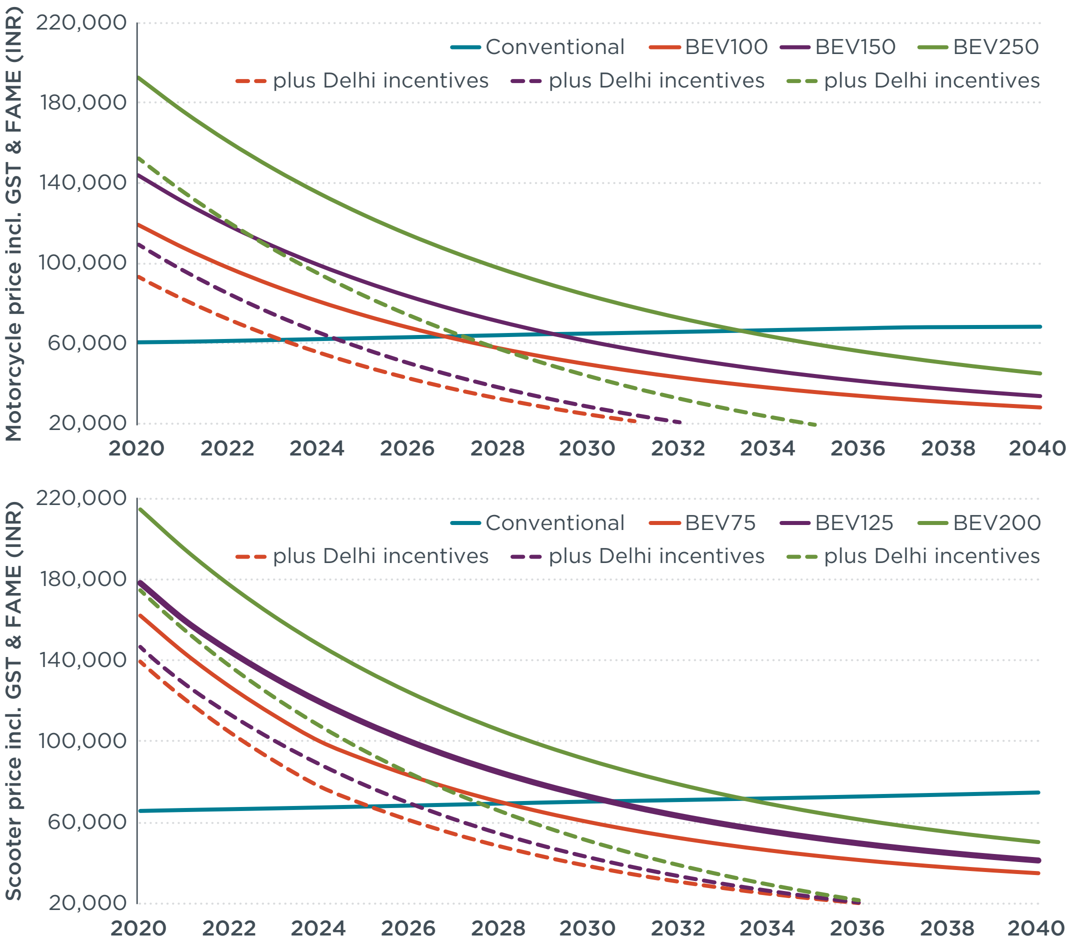

Figure 4. Upfront price of conventional and electric 2Ws from 2020 to 2040 in a 100% E2W by 2035 scenario with incentives.

28 The role of subsidy design is also interesting here. The FAME-II incentive burden decreases substantially by 2030 in this scenario because the 10,000 INR/kWh subsidy is capped at 20% of ex-showroom price. If the 20% cap is removed, the subsidy burden does not reduce so drastically from reductions in the size and cost of battery packs alone.

Figure 5 indicates how, in the absence of incentives, upfront cost parity takes 20 or more years for long-range models. This gap is largely due to higher powertrain cost for EVs compared to conventional models and is too wide to be bridged by battery cost reduction alone. Removing incentives also pushes cost parity farther behind by 5 to 9 years for short- and mid-range models.

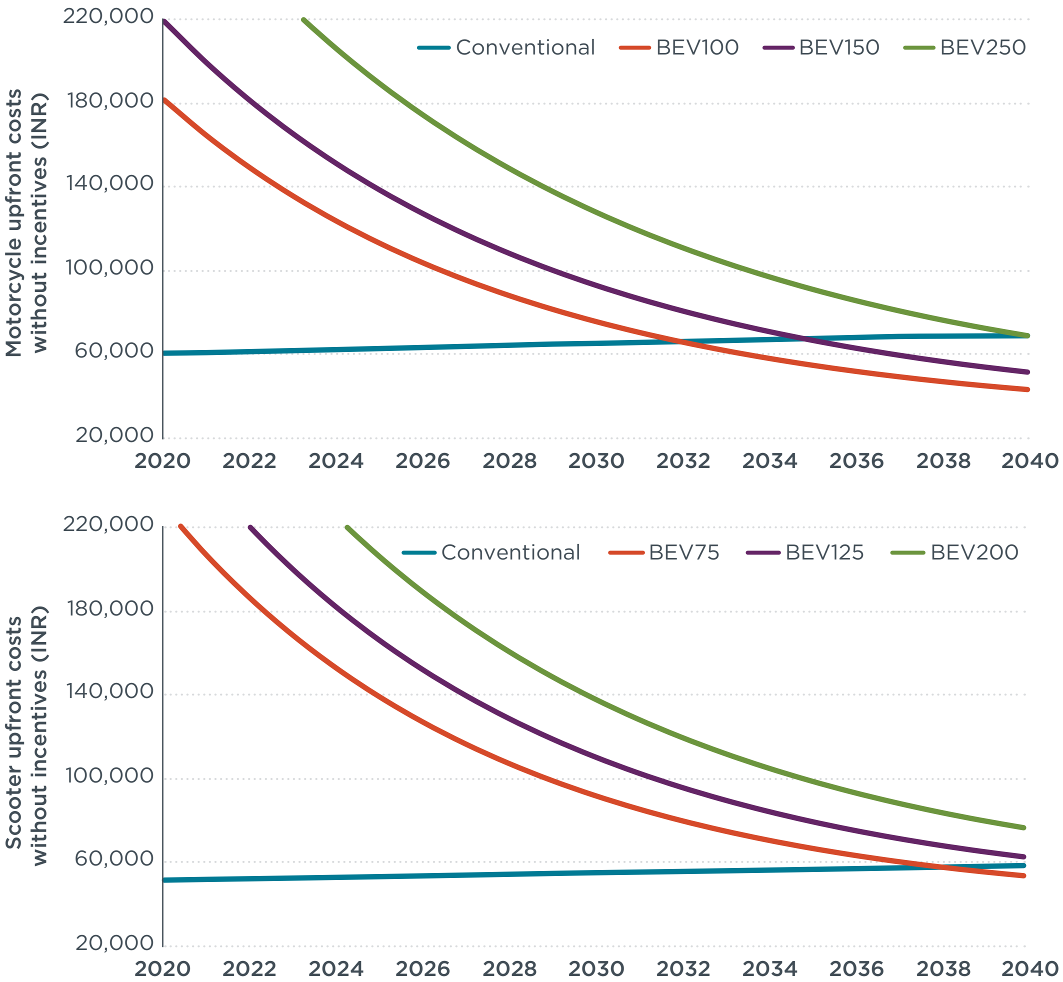

Figure 5. Upfront price of conventional and electric 2Ws from 2020 to 2040 in a 100% E2W by 2035 scenario without incentives.

Results – TCO

The year in which the upfront prices of E2Ws match conventional 2W prices is not the same as the year in which the total costs to own and operate the vehicles match. TCO parity occurs much earlier for E2Ws, and they are a far more cost-effective option over 5 and 10 years of ownership than gasoline 2Ws well before 2030. While our assumptions regarding fuel and energy consumption and pricing, maintenance and battery replacement costs, interest, depreciation, and taxes and incentives are described here, all key parameter values are included in a table in the appendix.

Conventional 2Ws are assumed to improve efficiency by 1% per year in CO_2 emissions reduction, and E2Ws become more efficient at a rate of 0.65% per year. Gasoline prices start at INR 83/L, equivalent to about INR 9/kWh. We model electricity prices to start at INR 7/kWh and assume both gasoline and electricity costs will increase at 5% per year. As the price of energy is in a comparable range for both types of propulsion, it is the efficiency advantage of E2Ws that plays the biggest role in reducing overall operating costs.

Maintenance and repair costs include the costs of maintaining or replacing parts that wear, of which there are significantly more in gasoline 2Ws than E2Ws.[29] However, at the 6th year of ownership, the battery in an E2W may need replacement, and this can be a large cost—possibly larger than the entire cost of fuel. Replacement batteries are currently taxed at an 18% GST rate, which is significantly higher than the tax rate for original vehicle-fitted batteries, which are absorbed under the 5% preferential GST rate applied to the EV.[30] Domestically manufactured replacement batteries could also be preferentially taxed at the same rate as factory-fitted batteries to improve TCO parity. As mentioned above, we assume battery cell costs will decline at around 7% per year. Factoring in efficiency improvements in battery packs, pack-level costs decline around 8% per year.

Insurance costs are based on purchase price, and E2W insurance is higher than gasoline 2W insurance in 2020. However, as the E2W fleet grows and prices decline, insurance premiums may fall to approximately the level of gasoline 2Ws.

Depreciation is a major cost for all 2Ws. We assume that conventional 2Ws lose half their value by the 5th year of ownership, and 63% of their value by the 10th year of ownership.[31] E2Ws are assumed to depreciate faster, dropping to 50% value in the 4th year, and potentially losing 95% of their value by the 10th year of ownership.[32] However, several factors may alleviate this depreciation. As E2W usage spreads, more information on real-world battery degradation will accumulate, which will shed light on how much utility is lost over time. Additionally, if battery recycling becomes a profitable industry, battery packs may retain more value, thereby reducing depreciation. For these reasons alone, additional research may be warranted into E2W depreciation. Nevertheless, the FAME-II incentive effectively reduces some of the losses from E2W depreciation by lowering the consumer purchase price.

Key taxes levied on vehicle purchases in India include GST, registration fees, road tax, and, in some cases, a municipal tax or parking fee. In the FY2019 budget, the government declared the preferential GST rate of 5% for EVs, which compares to 28% for ICE vehicles. We assume in this analysis that the same preferential advantage is maintained going forward, and that conventional ICE 2Ws will incur a registration fee of INR 1,000, while E2Ws will enjoy a waiver of registration fees, as proposed by the government. We assume this fee advantage will continue going forward. Road tax varies across states and ranges from 6% to 14% of vehicle base price. The central government has urged states to offer tax breaks on EV sales, and several states have already declared these sales exempt from road tax. In our analysis, we assume a road tax rate of 8% for ICE 2Ws and a full exemption for E2Ws and assume this tax advantage continues going forward. Municipal or local taxes such as parking fees apply in several places, and the tax structure varies across locations. On average, these tax costs are about 2% of vehicle base price for ICE vehicles. There has not been much relief for privately owned EVs from parking charges in the policy landscape in India, and we assume in this analysis that no such relief or incentive will be available to private vehicles going forward.

29 Zigwheels.com, "Ather 340 vs Honda Activa 5G DLX: A Theoretical Cost Analysis," *The Times of India*, August 9, 2018, https://timesofindia.indiatimes.com/auto/bikes/ather-340-vs-honda-activa-5g-dlx-a-theoretical-cost-analysis/articleshow/65337184.cms; "Electric Scooters," Plug In India, 2020, https://www.pluginindia.com/electricscootersbrowse.html; "Electric Motorcycles," Plug In India, 2020, https://www.pluginindia.com/electricmotorcyclesbrowse.html.

30 The Revolt RV400, an e-motorcycle comparable to the Tork T6X, has an 8-year warranty on its battery. See "RV400 User Manual," Revolt Motors, accessed June 3rd, 2021, https://cdn.revoltmotors.com/assets/doc/Revolt-UM-RV400-91219.pdf.

31 Tarun Mathur, "All You Wanted to Know about Depreciation of Two-Wheelers," *MoneyControl.com* (blog), November 2, 2017, https://www.moneycontrol.com/news/business/personal-finance/all-you-wanted-to-know-about-depreciation-of-two-wheelers-2426663.html.

32 Chris Woodyard, "Three Electrics Lead 10 Worst Cars for Depreciation," *CNBC*, November 19, 2013, https://www.cnbc.com/2013/11/19/three-electrics-lead-10-worst-cars-for-depreciation.html.

Using these TCO variables, the analysis estimates both 5-year and 10-year TCO corresponding to a 100% electrified 2W fleet (new sales) scenario by 2035. Figure 6 shows the results of the analysis for vehicles purchased in 2020 and in 2030, along with the impact of key incentives, similar to Figure 3.

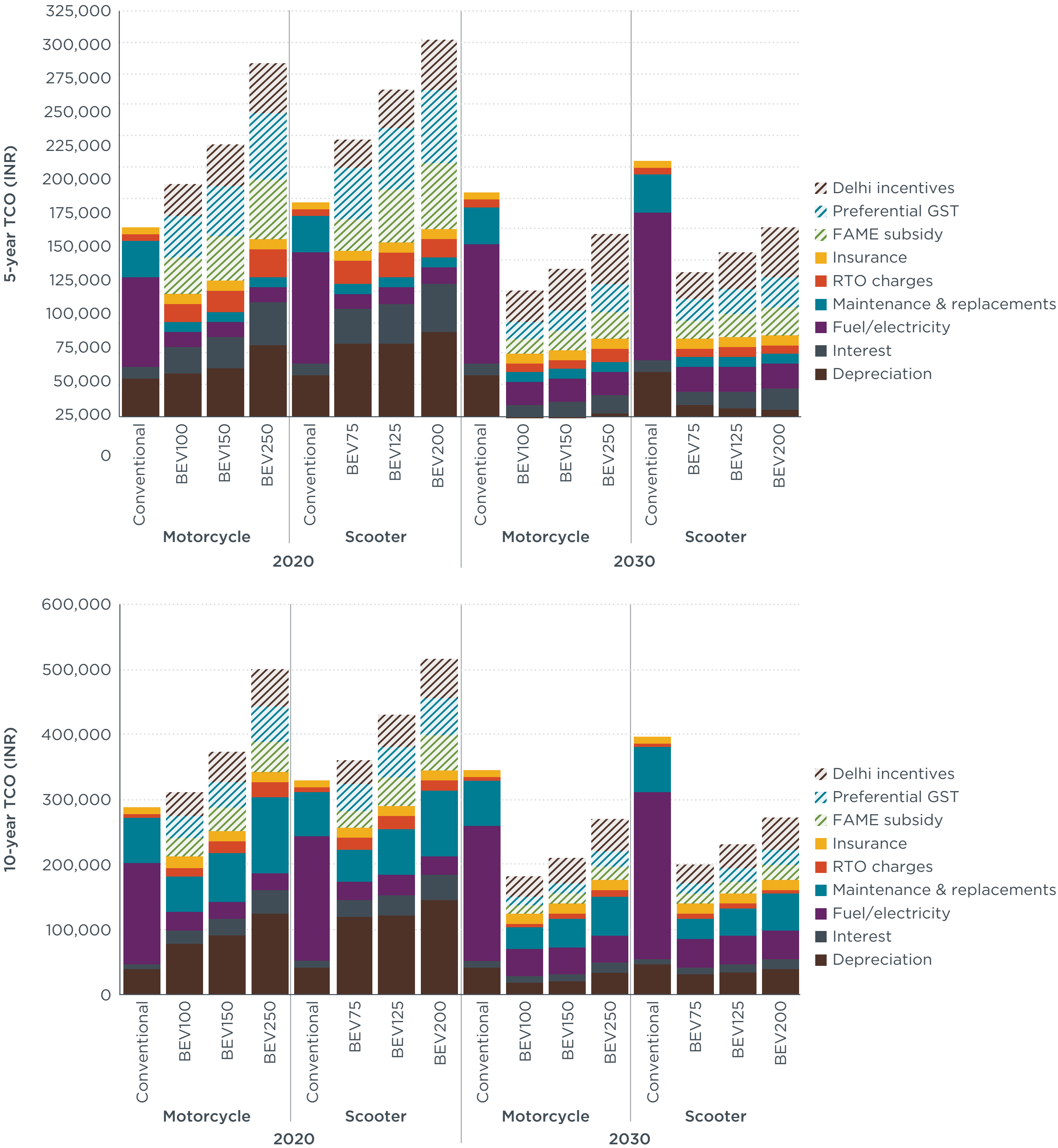

Figure 6. 5- and 10-year TCO for 2Ws purchased in 2020 and in 2030.

In Figure 6, we observe some trends. First, due to government incentives, all E2W models are already cheaper to own than ICE vehicles over a 5-year period, and for all but the most expensive/longest range model, they are also cheaper over a 10-year period. Second, by 2030, all E2Ws are significantly cheaper than conventional 2Ws even in the absence of incentives. Conventional 2Ws have high fuel costs, and these only increase as fuel prices increase. E2Ws also benefit from lower depreciation costs, which are due to lower purchase prices and much lower battery costs.

The first 5 years of ownership require very little maintenance for E2Ws, and this bolsters their cost competitiveness. Over a 10-year ownership period, however, battery replacement in the 6th year creates a jump in TCO. This cost is much larger in 2020 than in 2030, as batteries get significantly cheaper by the end of the decade. Over 10 years, the higher efficiency of E2Ws leads to quick savings and ultimately to much cheaper total ownership costs.

In contrast to the upfront price parity in Figure 5, 5-year TCO parity is already achieved for all models with central government incentive support (Figure 7).

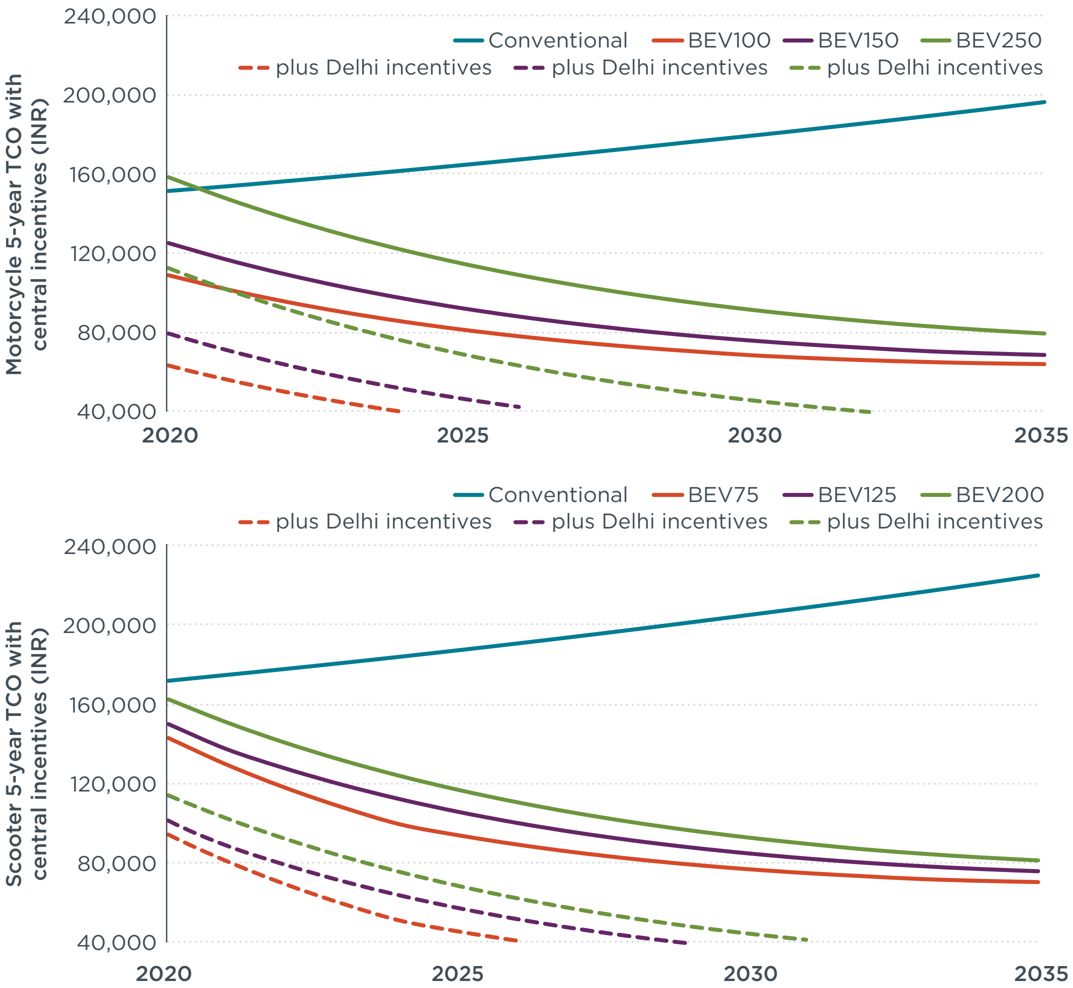

Figure 7. Total ownership cost over 5 years with incentives.

Meanwhile, as Figure 8 shows, in the absence of key incentive assumptions, short- range models reach 5-year TCO parity in 2022. Without incentives, TCO parity is pushed back by 2 to 6 years for mid- and long-range models.

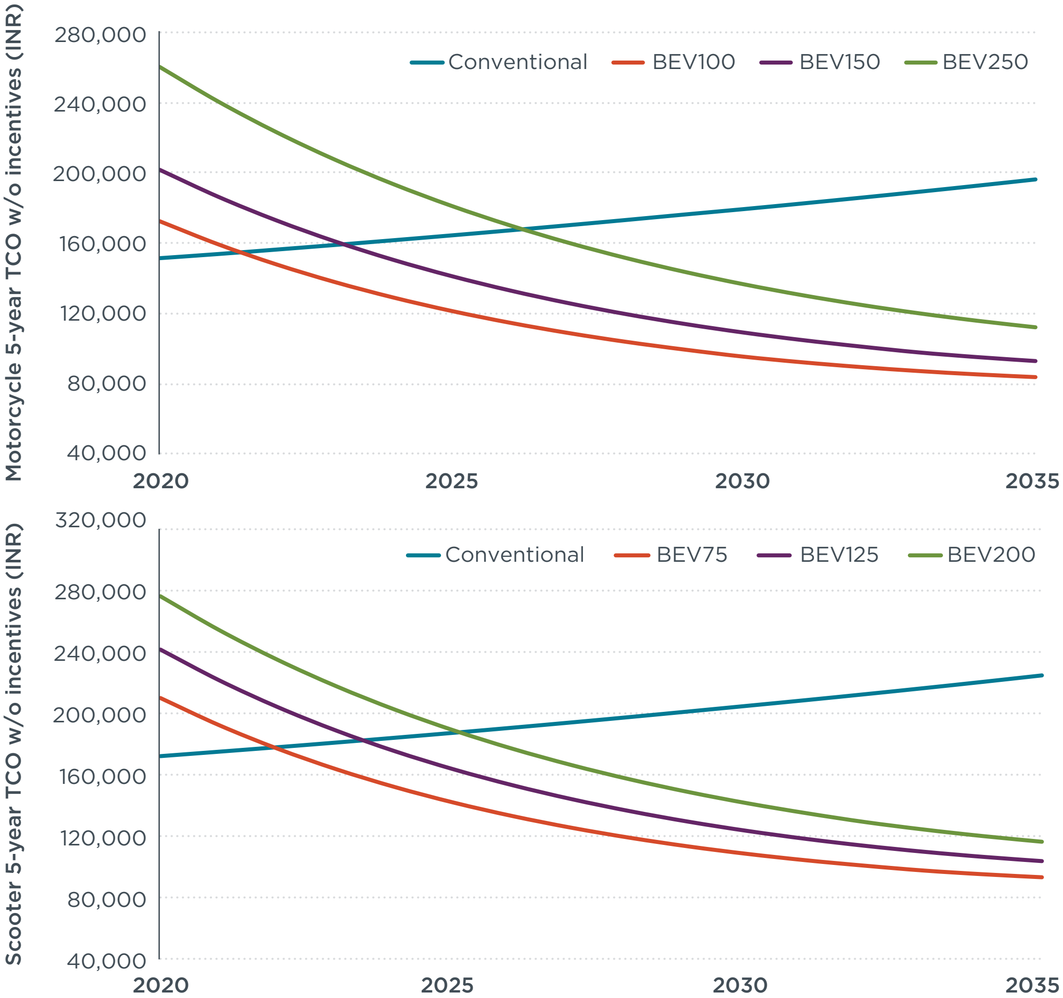

Figure 8. Total ownership cost over 5 years without incentives.

Due primarily to the need to replace the battery, over a 10-year ownership period, TCO parity is slightly later than 5-year TCO parity for the longest-range model but is still much earlier than upfront cost parity. Figure 9, below, shows the 10-year TCO curves with central government incentive structures continuing and additional state-level support considered. Short-range and mid-range models are already cheaper to own. Long-range models reach parity by 2023 - 2024, and 2 years earlier with additional state incentive support. Notably, 10-year TCO parity for long-range models is achieved almost 10 years earlier than upfront cost parity.

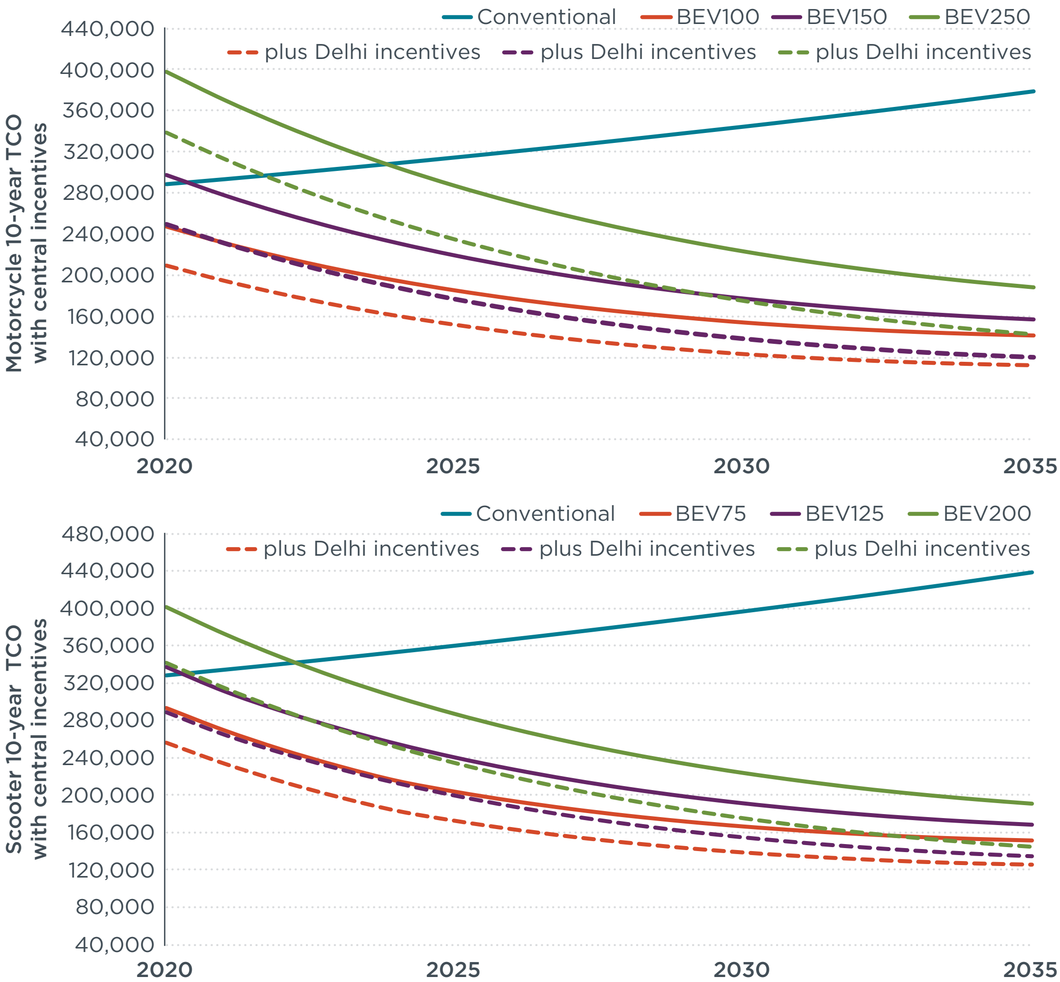

Figure 9. Total ownership cost over 10 years with incentives.

Figure 10 shows how removing central and state incentives pushes back TCO parity for mid-range models to 2023, and for long-range models to 2025-2027.

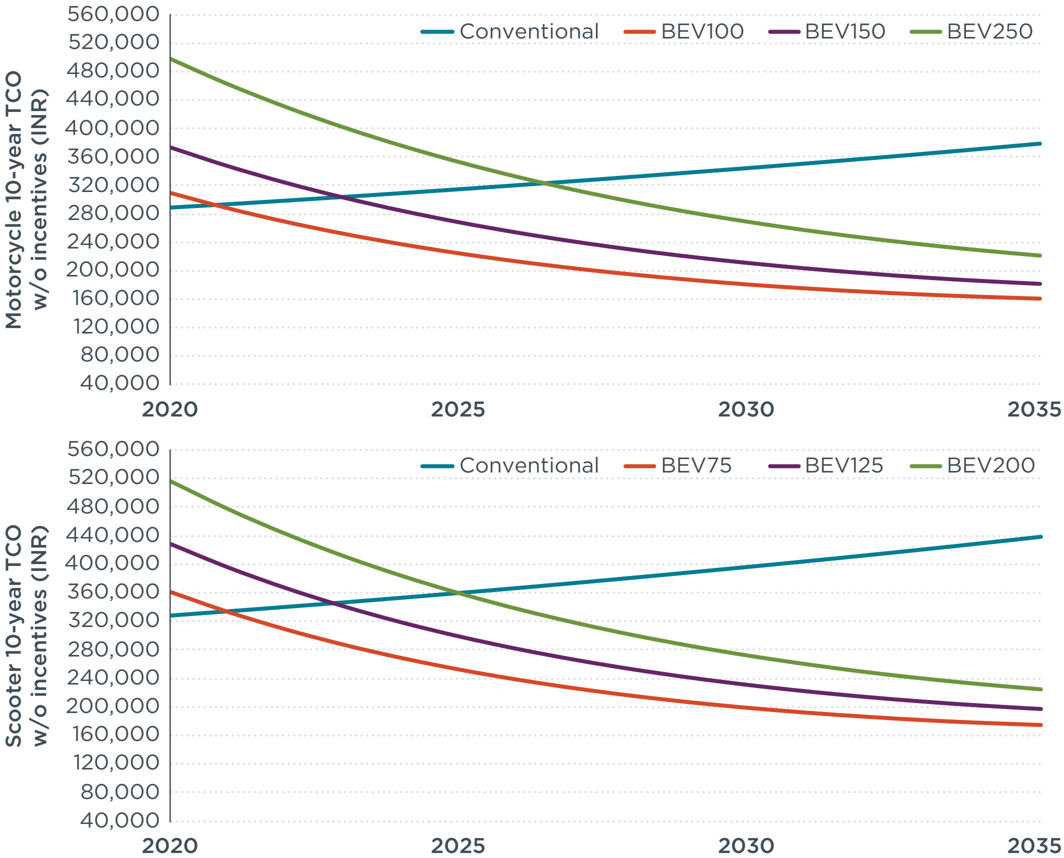

Figure 10. 10-year TCO parity without incentives

Consideration of alternative E2W sales rates

The preceding analysis considered an ambitious scenario of E2W proliferation leading to a 100% electric share of new sales by 2035. Such a sales scenario is ambitious but achievable, given technology availability and the many policy levers the central government and state-level governments have at hand. In another scenario, E2W sales growth could backslide, pushing back 100% electrification from 2035 to closer to 2050; Figure 11 shows how ex-showroom prices would differ in this case. In the figure, the actual upfront price is shown in solid columns, and two key central government incentives (FAME-II and preferential GST) and model state-level incentives (Delhi's purchase incentive and scrapping incentive) are shown as dotted columns. The combined column height signifies the full vehicle price without these subsidies.

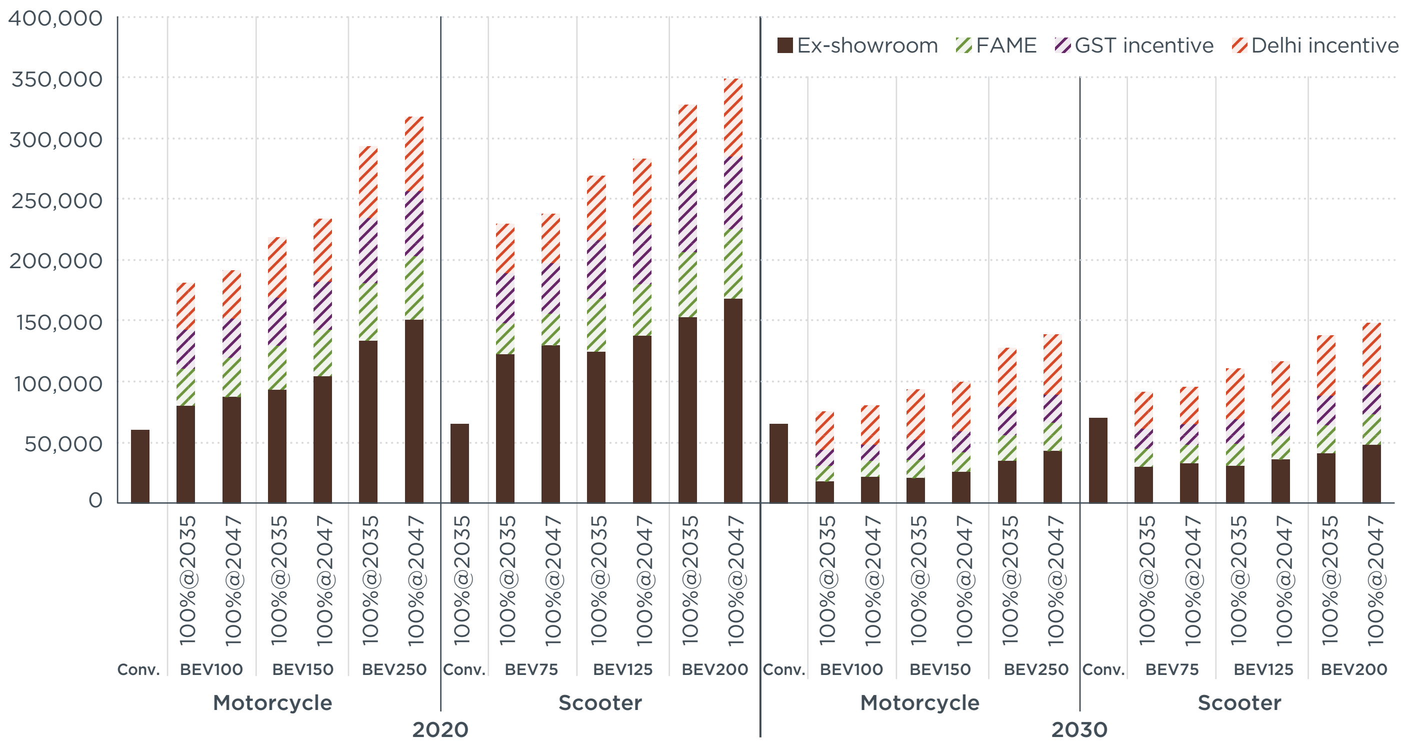

Figure 11. Comparison of vehicle price and key central government subsidies under different E2W sales scenarios.

Under a slower electrification scenario, both E2W prices and subsidies are higher. Conversely, faster E2W market penetration leads to quicker cost reductions and lower subsidies. Increases in battery production volume from higher sales drive down costs. Even with a delay of only 1 or 2 years in battery cost reductions, when coupled with price-dependent factors (see appendix Table A1 and A2, for example), these cost savings compound. As the 2030 short-range price shows, these variations could mean the difference between continued government outlays for E2W cost parity and lower government expenditures, since E2Ws are cost-competitive on their own.

Figure 12 answers the question of when cost parity occurs, assuming key central government incentive schedules continue. As expected, the faster that battery costs fall, the earlier all measures of cost parity occur. For example, over a 5-year ownership period, short- and mid-range models already achieve TCO parity.

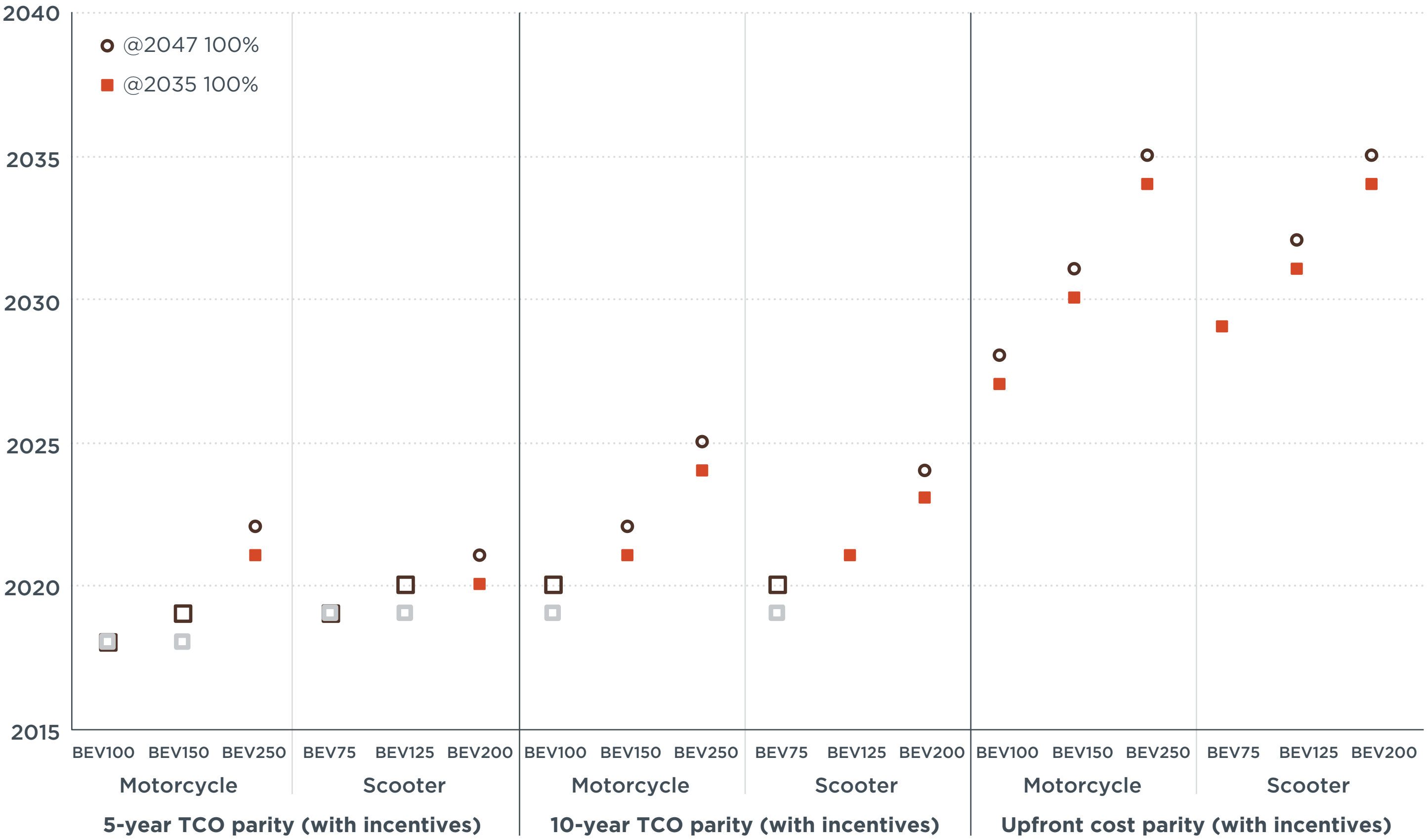

Figure 12. Comparison of upfront cost, 5-year TCO, and 10-year TCO parity years under different E2W sales scenarios with FAME-II and GST incentives.

Figure 12 also shows that the larger the battery pack (i.e., the longer the range), the later parity is reached in all three metrics (upfront cost, 5-year TCO, and 10-year TCO). For 10-year TCO, long-range E2Ws reach parity between 2023 and 2025 depending on the electrification scenario.

Lastly, upfront cost parity occurs closer to 2030 for short-range E2Ws, and at some point between 2030 and 2035 for mid- and long-range E2Ws under both scenarios considered. As the long-range E2Ws experience the highest cost for the longest period of time, continuing subsidies for at least these E2Ws will help make them more attractive to consumers. Additional state subsidies can accelerate upfront cost parity significantly by 4 to 7 years, as highlighted in earlier sections.

Conclusions

This paper builds upon previous ICCT research to analyze costs for E2Ws in India from present day to beyond 2030. We estimated the timing of upfront cost parity, 5-year TCO parity, and 10-year TCO parity for E2Ws versus conventional ICE 2Ws. We find that the battery cost reduction schedule is the main factor affecting E2W price. Even though each E2W battery pack is a fraction of the size of an electric passenger car's battery pack, anticipated 2W sales growth in India suggests that Indian kWh battery production will catch up to the global average, leading to globally competitive battery prices.

Additionally, we draw three main conclusions:

E2W upfront cost parity is expected between 2027 and 2034 in an ambitious electrification scenario, provided FAME-II and preferential GST benefits continue until that time. Short-range models achieve parity faster than long-range models, and state-level direct incentives such as in Delhi can accelerate upfront parity by 4 to 7 years.

Faster battery cost reduction and increased production of higher capacity, longer-range batteries could also reduce the time to upfront cost parity.

Short-range E2Ws on the market today are already cheaper to own and operate; additionally, in an ambitious electrification scenario with central government incentives, long-range E2Ws are expected to reach 10-year TCO parity between 2023 and 2024. State-level incentives, including direct incentives and road tax waivers, can accelerate 10-year TCO parity by 2 years for long-range models. Due to fuel savings that result from E2Ws' improved efficiency, 5-year TCO parity has already arrived for E2Ws. Short-range and mid-range models have also already reached 10-year TCO parity, and longer-range models do so over the next 3 years. However, consumers do not always value or calculate future savings, and numerous factors other than total ownership costs affect consumers' willingness to buy electric, including model availability[33] and broad charging infrastructure.[34] Governments can help increase consumer awareness of the benefits of E2Ws.[35]

As the biggest factor in E2W cost, battery costs can delay or accelerate cost parity. India has an opportunity to indigenize EV and battery production, which will be necessary to reduce costs. A strong and enabling regulatory environment can signal certainty for investors and shift the E2W market from its current position of caution toward accelerated growth. Due to lack of indigenous raw materials for batteries, India could also work to become a leader in EV battery recycling. Further, establishing a strong E2W production and recycling industry would lay a foundation for expanding electrification to cars, trucks, and buses. It would also guarantee increased demand for electricity, which may spur the construction of new renewable electricity facilities.

Ultimately, battery costs, E2W sales, and policy incentives must move together.[36] As in previous analyses in other markets, cost and sales projections are based on the assumption that policies which encourage vehicle electrification will remain in place.[37] It is thus vital that India implement stringent fuel efficiency standards and/or EV mandates for 2Ws.[38]

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33 Peter Slowik and Nic Lutsey, *The Continued Transition to Electric Vehicles in U.S. Cities* (ICCT: Washington, DC, 2018), https://www.theicct.org/publications/continued-EV-transition-us-cities-2018.

34 Michael Nicholas, Dale Hall, and Nic Lutsey, *Quantifying the Electric Vehicle Charging Infrastructure Gap across U.S. Markets* (ICCT: Washington, DC, 2019), https://www.theicct.org/publications/charging-gap-US.

35 Kenneth Kurani, Nicolette Caperello, and Jennifer Tyree-Hageman, *New Car Buyers' Valuation of Zero-Emission Vehicles: California* (Institute of Transportation Studies, University of California Davis: Davis, 2016), https://its.ucdavis.edu/research/publications/.

36 Lutsey and Nicholas, "Update on Electric Vehicle Costs."

37 Pramoda Gode, *Lower the GST rate on conventional two-wheelers in India? Let's consider the impact on electric vehicle sales* (ICCT: Washington, DC, 2020), https://theicct.org/blog/staff/gst-rate-impact-ev-india-sept2020.

38 Sunitha Anup and Ashok Deo, *Fuel consumption reduction technologies for the two-wheeler fleet in India* (ICCT: Washington, DC, 2021), https://theicct.org/publications/2w-fuel-reduction-india-mar2021.

Appendix

Table A1. Conventional and electric 2W costs.[39]

Type		Component	Costs in 2020 and projections forward			Description on model assumptions
			motorcycle	scooter	Annual change	
Direct costs	Electric vehicle (EV) powertrain	Battery pack	54,257	45,862	-7%	UBS baseline cell costs of US$128/kWh are assumed when production scale reaches 4.5 GWh (U.S. production scale in 2018). Pack level costs vary with the pack-to-cell cost ratio as per Safoutin et al.,[40] which our study caps at 1.6 for pack sizes < 10 kWh.
		Thermal management	359	719	1.3%	UBS costs for cars (150 kW) are scaled down to reflect lower E2W power (6.0 kW) with corresponding annual change assumptions from the study. Non-battery costs follow the same time-lag as battery costs.
		Power distribution module	359	719	-2.1%	
		Inverter/converter	1,002	2,004	3.5%	
		Electric drive module	1,725	3,450	1.3%	
		DC converter	216	431	1.4%	
		Controller	73	147	1.3%	
		Control module	134	267	1.3%	
		High voltage cables	482	963	1.3%	
		On-board charger	392	785	3.5%	
		Charging cord	216	431	1.3%	
		Non-battery subtotal	4,958	9,916	1.6%	
	Conventional powertrain	Engine, transmission, exhaust, etc.	22,341	21,698	Cost curves developed by ICCT	UBS costs for cars are scaled down to reflect lower power of the representative 2Ws (127 kW vs. 6kW). We assume an efficiency improvement of 1% CO_2 reduction per year with cost-curves for 2W developed by ICCT.[41]
	Other direct cost	Warranty, assembly, other components	11,532	15,020	0.7%	Other direct costs are calculated by subtracting conventional powertrain costs from the base price and factoring out indirect costs (see below). We assume other direct costs for E2W to be the same as for conventional 2W and to vary annually at the same rate as UBS estimates for cars.
Indirect costs	Manufacturing	Expenses from depreciation, amortization, research and development (R&D), and administration	61,750 (EV) 6,948 (ICE)	96,380 (EV) 7,532 (ICE)	-14% (EV) 0.34% (ICE)	The same indirect manufacturing cost factor from UBS for conventional cars (20.5% of total direct costs) is used for conventional 2Ws. For E2W, indirect costs are calculated from base price without profit or markup (see below) minus powertrain and other direct costs. We assume these costs vary annually at the same rate as UBS estimates for cars.
	Profit	Manufacturer profit	2,650 (EV) 4,082 (ICE)	3,344 (EV) 4,082 (ICE)	(EV) 11% till 2040 0% (ICE)	For conventional 2W, we assume manufacturer profits at a vehicle level to be at 10% of total direct and indirect costs[42] For E2W, we assume manufacturer profits are at 2% of above costs in 2020 and increase to 15% by 2040.
	Markup	Dealer profit	6,757 (EV) 2,245 (ICE)	8,526 (EV) 2,434(ICE)	0%	We assume average dealer margins of 5% of all above costs throughout the modelled period for both EV and ICE.[43,44]

39 Costs were adapted for this study from a UBS teardown analysis for cars. All values are in INR and are representative of models on the market in 2020.

40 See Figure 4: Michael Safoutin, Joseph McDonald, and Ben Ellies, "Predicting the Future Manufacturing Cost of Batteries for Plug-In Vehicles for the U.S. Environmental Protection Agency (EPA) 2017–2025 Light-Duty Greenhouse Gas Standards," *World Electric Vehicle Journal* 9, no. 3 (October 6, 2018): 42, https://doi.org/10.3390/wevj9030042.

41 Based on cost analysis for conventional 2W less than 150 cc, as per Deo Ashok., Anup Sunitha., ICCT, (to be published).

42 Conventional 2W OEMs in India are reported to have profit margins in the range of 12% to 20%. However, this range includes substantial revenues from after-sales services, spare parts, and exports. We assume a 10% unit-level (vehicle-level) profitability for conventional 2W as an approximation.

43 Pratishtha Nangia, "Even 8% margin not enough for EV dealers to sustain: Sohinder Gill" (*ET Auto*, November 11, 2020), https://auto.economictimes.indiatimes.com/news/two-wheelers/scooters-mopeds/even-8-margin-not-enough-for-ev-dealers-to-sustain-sohinder-gill/72009471.

44 "Car Dealership Margins Explained in India: FADA Wants Manufacturers To Fix Dealer Margin," 91Wheels, June 11, 2020, https://www.91wheels.com/news/car-dealership-margins-explained.

Table A2. Factors considered in total cost of ownership (TCO) analysis.

TCO factor	Value		Year of occurrence	Annual change (%)
	Motorcycle	Scooter		
Gasoline 2W energy consumption	0.150 kWh/km	0.185 kWh/km	2020	-1%
Electric 2W energy consumption	0.035 kWh/km	0.037 kWh/km	2020	-0.65%
Gasoline price	INR 9/kWh (INR 83/L)		2020	+5%
Electricity price	INR 7/kWh		2020	+5%
Annual kilometers	10,000 km	10,000 km	2020	0%
Gasoline maintenance[a]	INR 2,800	INR 2,800	1st year of ownership	10%
Electric maintenance[b]	INR 2,000	INR 2,000	4th year of ownership	0%
Gasoline repairs[c]	INR 10,000	INR 10,000	4th year of ownership	0%
Electric repairs (battery replacement)	Varies	Varies	6th year of ownership	-8%
Preferential GST advantage for E2W	17%	17%	1st year of ownership	0%
FAME incentive for E2W	INR 10,000/kWh capped at 20% of ex-showroom price	INR 10,000/kWh capped at 20% of ex-showroom price	2020	0%
Gasoline registration	INR 1,000	INR 1,000	1st year of ownership	0%
Electric registration	INR 0	INR 0	1st year of ownership	0%
Gasoline road tax	8% of base price	8% of base price	1st year of ownership	0%
Electric road tax	0%	0%	1st year of ownership	0%
Gasoline parking fee	INR 1,000 if base price < INR 60,000 or 2% of base price	INR 1,000 if base price < INR 60,000 or 2% of base price	1st year of ownership	0%
Electric parking fee	Same rate structure as gasoline	Same rate structure as gasoline	1st year of ownership	0%
Gasoline insurance	INR 1,060	INR 1,060	Annually	0%
Electric insurance	INR 1,600	INR 1,600	Annually	0%
Gasoline depreciation[d]	50% (63%)	50% (63%)	5th year (10th year)	0%
Electric depreciation[e]	50% (95%)	50% (95%)	4th year (10th year)	0%
Gasoline down payment	15%	15%	1st year of ownership	0%
Electric down payment	15%	15%	1st year of ownership	0%
Gasoline loan term	3 years	3 years	1st year of ownership	0%
Electric loan term	3 years	3 years	1st year of ownership	0%
Gasoline interest rate	11%	11%	Annually	0%
Electric interest rate	11%	11%	Annually	0%

[a] Zigwheels.com, "Ather 340 vs Honda Activa 5G DLX: A Theoretical Cost Analysis," *The Times of India*, August 9, 2018, https://timesofindia.indiatimes.com/auto/bikes/ather-340-vs-honda-activa-5g-dlx-a-theoretical-cost-analysis/articleshow/65337184.cms.

[b] "Electric Motorcycles," Plug in India, 2020, https://www.pluginindia.com/electricmotorcyclesbrowse.html.

[c] "Electric Motorcycles"; "Electric Scooters," Plug in India, 2020, https://www.pluginindia.com/electricscootersbrowse.html.

[d] Tarun Mathur, "All You Wanted to Know about Depreciation of Two-Wheelers," *MoneyControl.com* (blog), November 2, 2017, https://www.moneycontrol.com/news/business/personal-finance/all-you-wanted-to-know-about-depreciation-of-two-wheelers-2426663.html.

[e] Chris Woodyard, "Three Electrics Lead 10 Worst Cars for Depreciation," *CNBC*, November 19, 2013, https://www.cnbc.com/2013/11/19/three-electrics-lead-10-worst-cars-for-depreciation.html.