

# Crossing the tipping point

# Electric Vehicles

# Case Study



University  
*of Exeter*



In partnership with

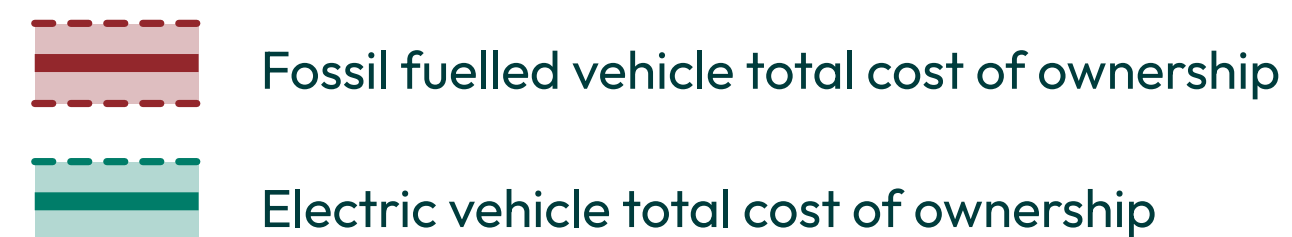
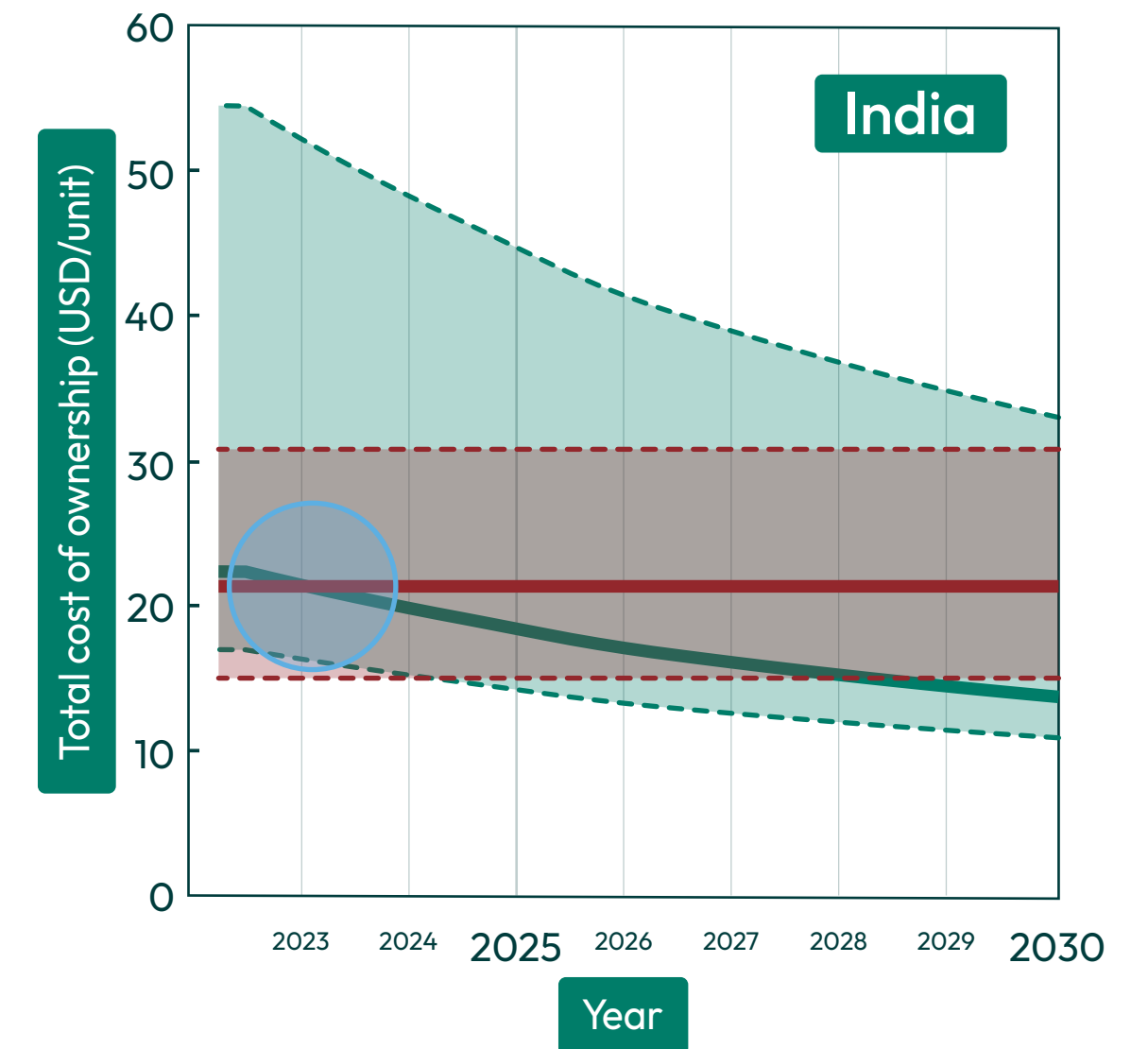
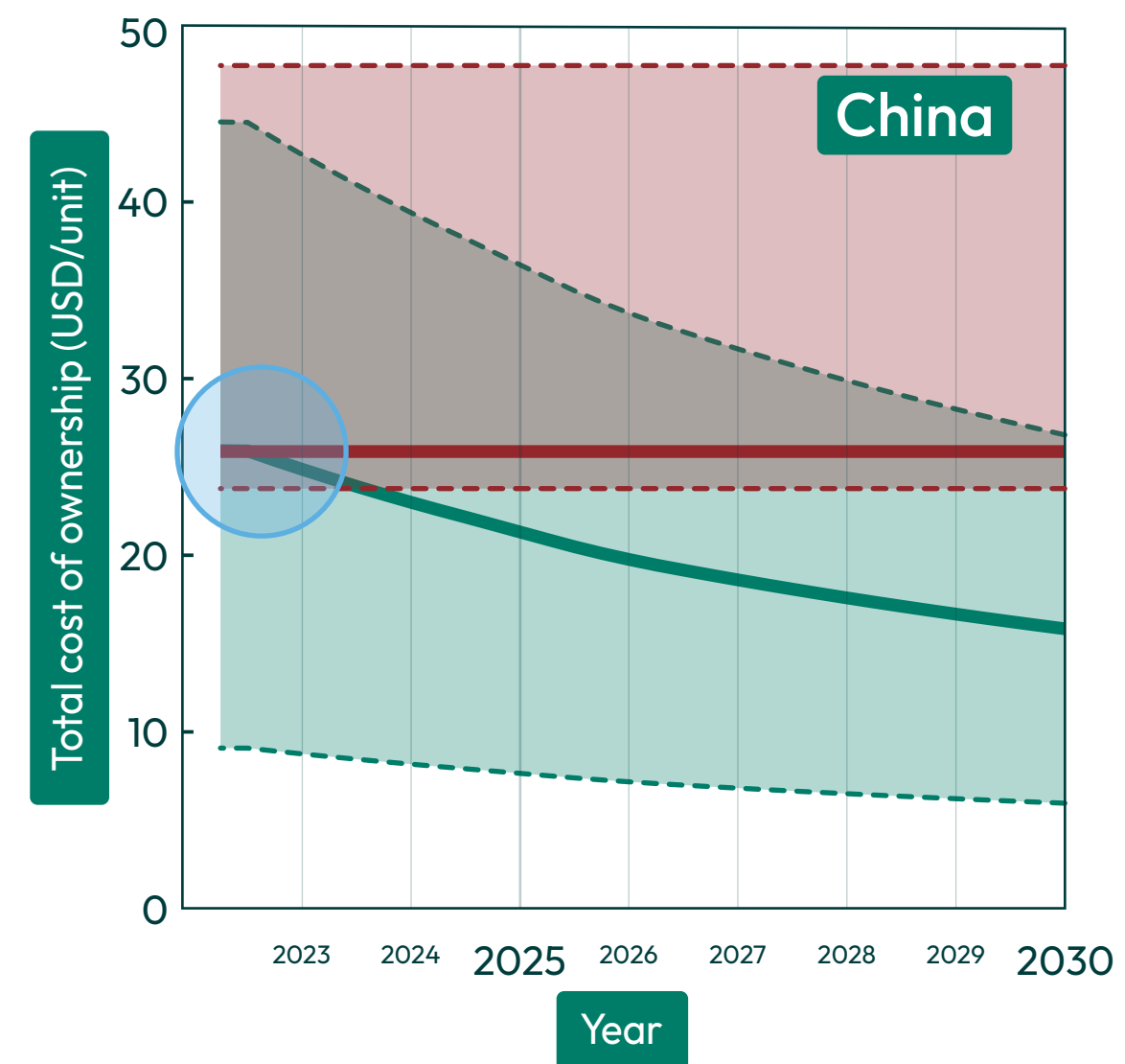
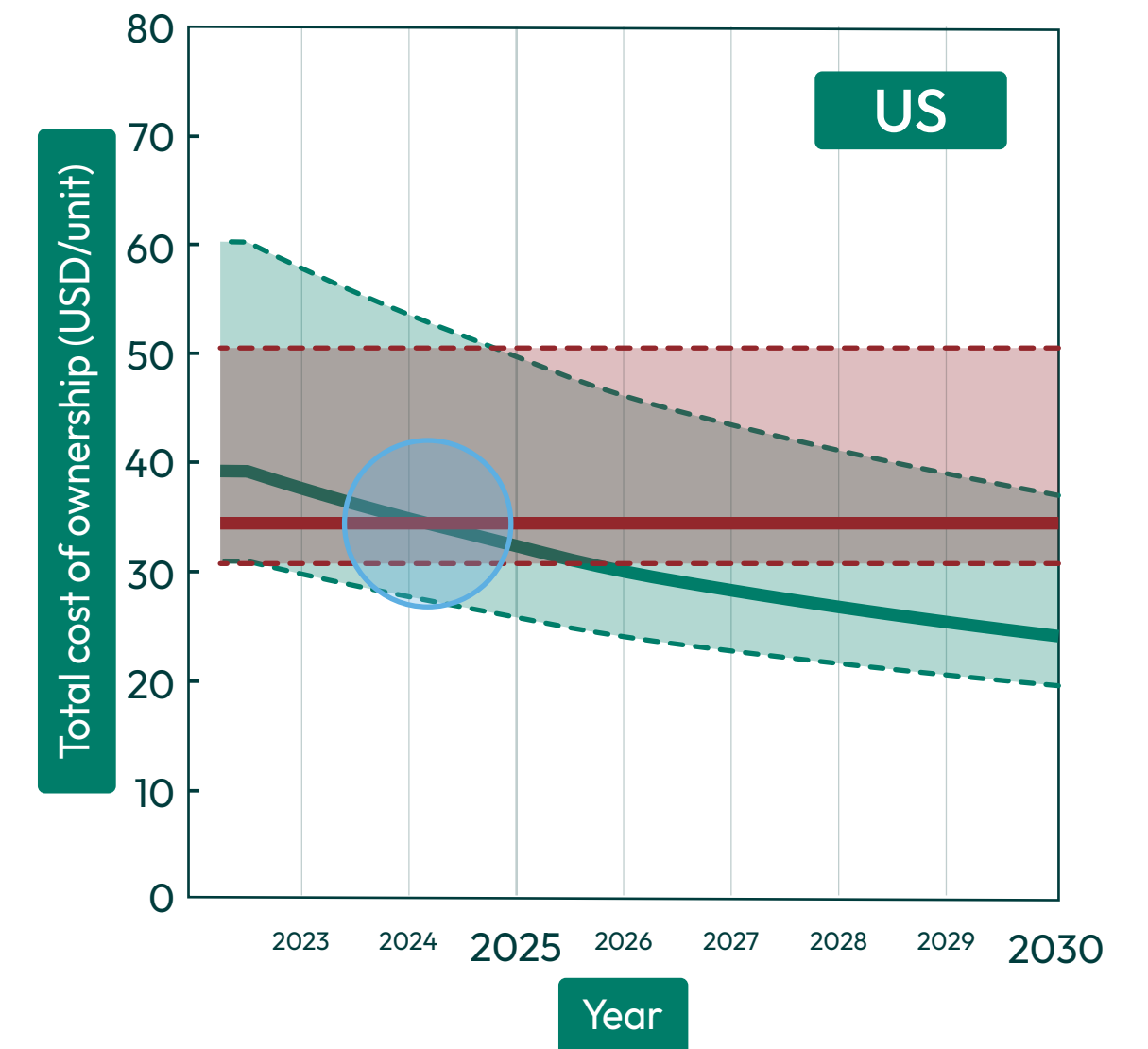
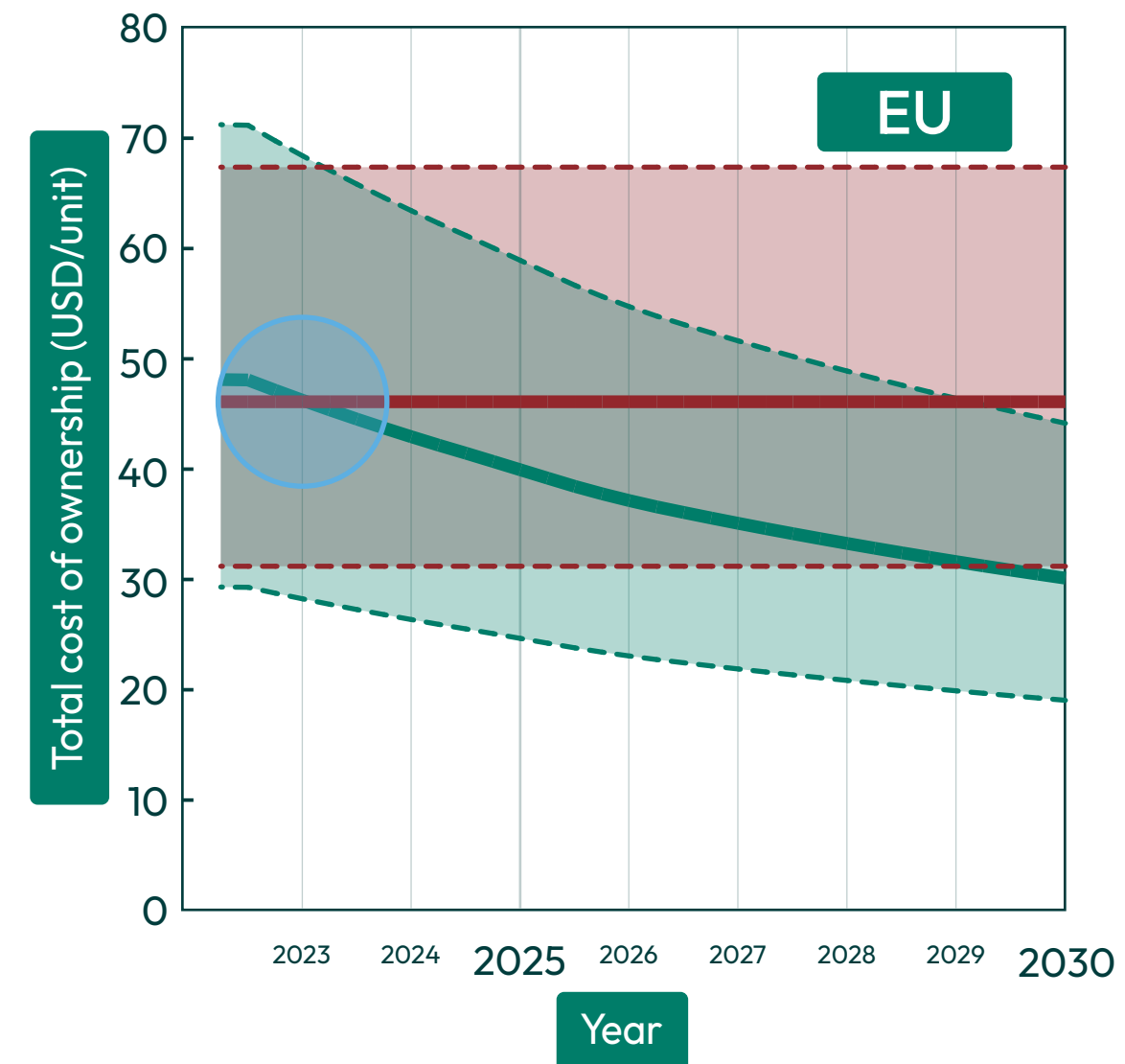


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# Tipping point: current status

**A first tipping point has been crossed: in leading markets, electric vehicles are already cheaper to own than fossil fuelled cars**

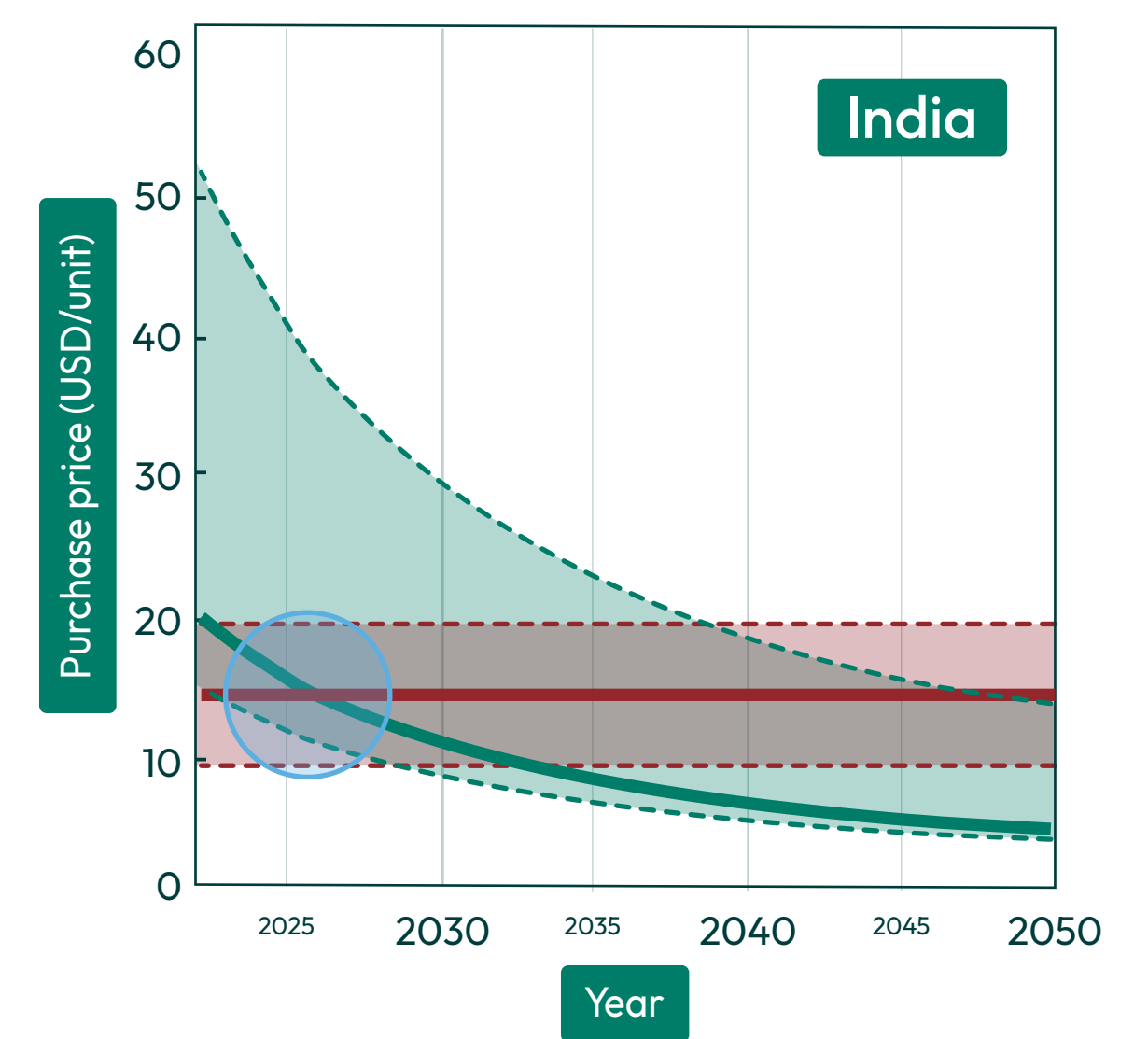
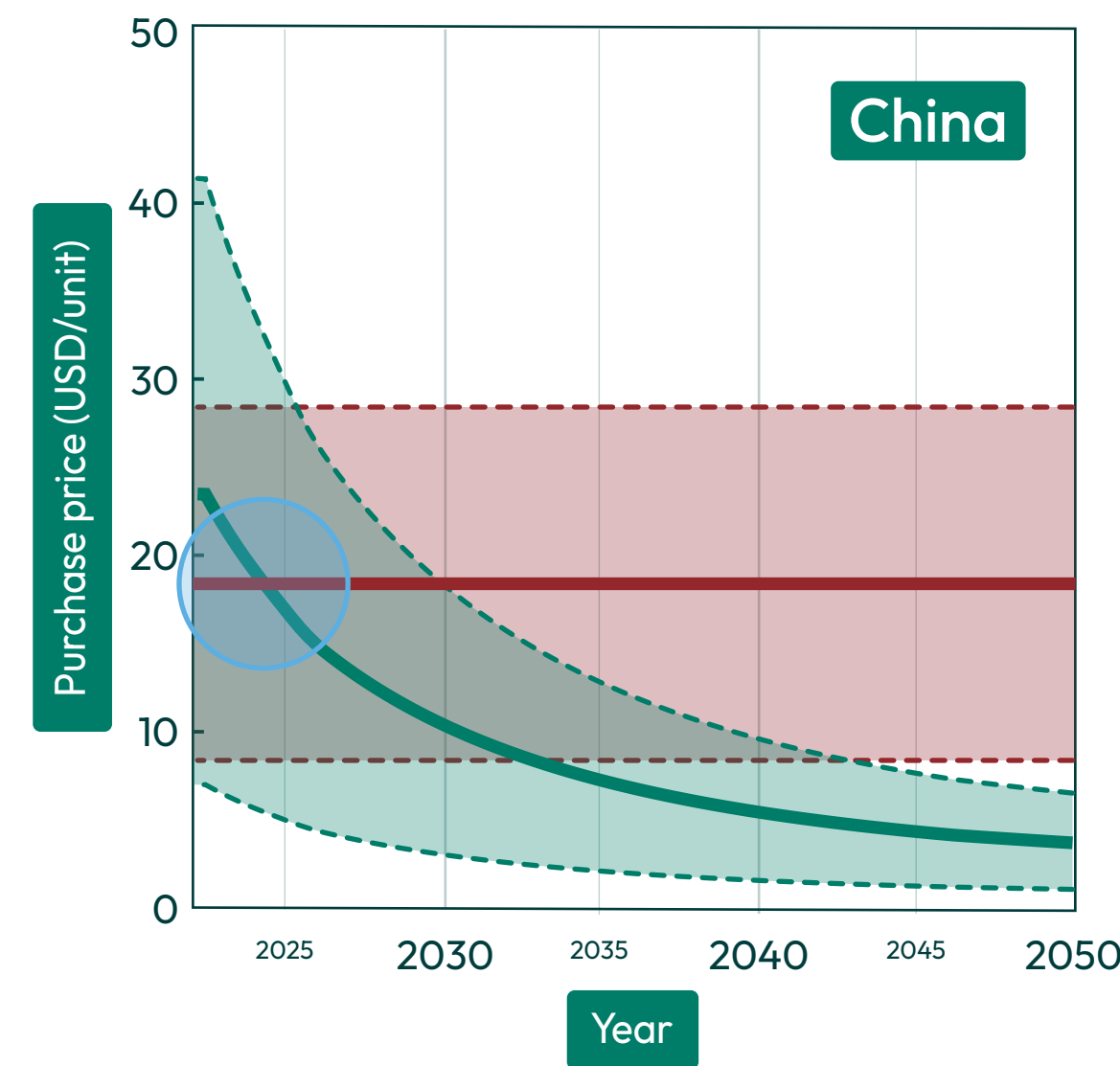
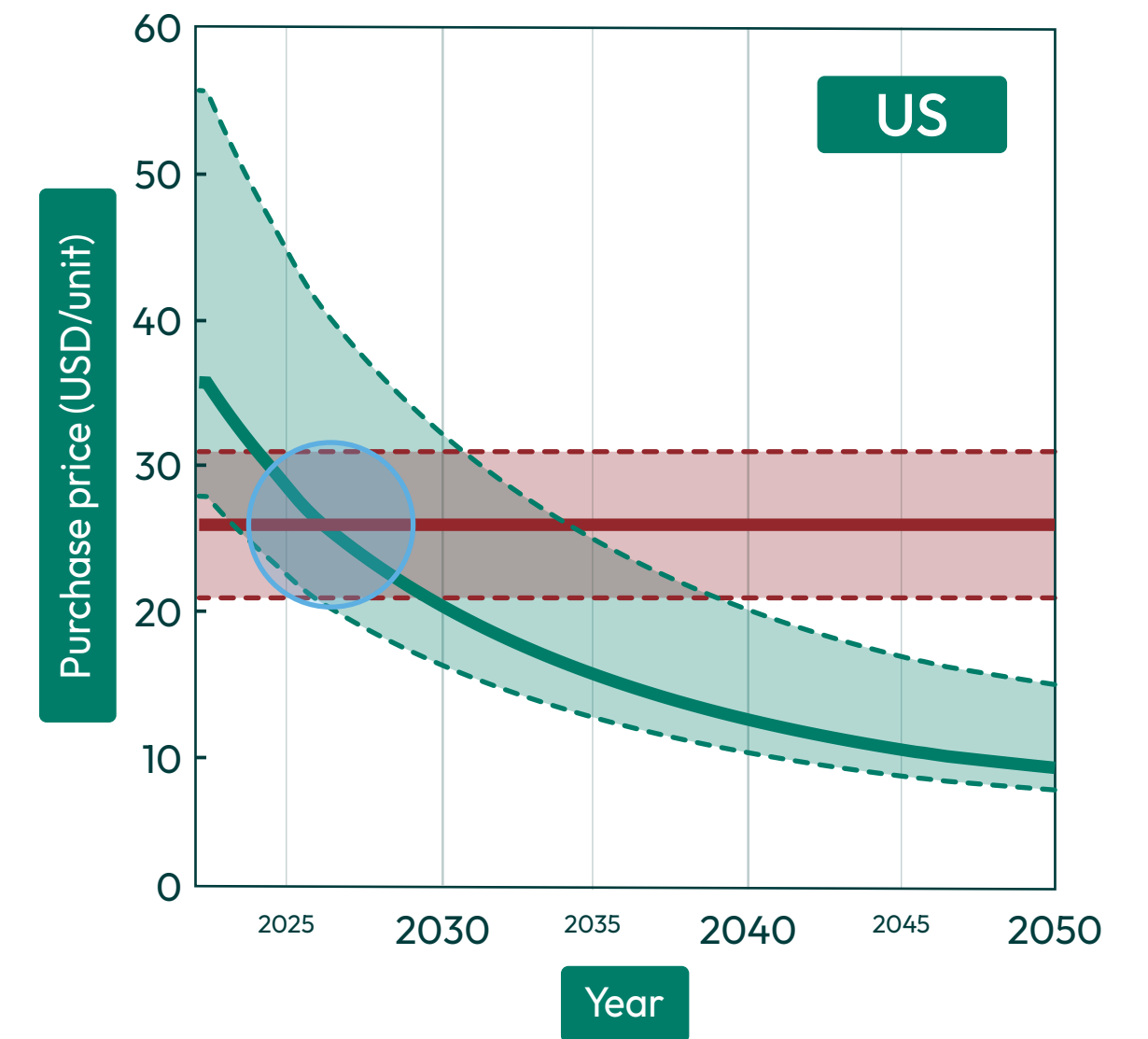
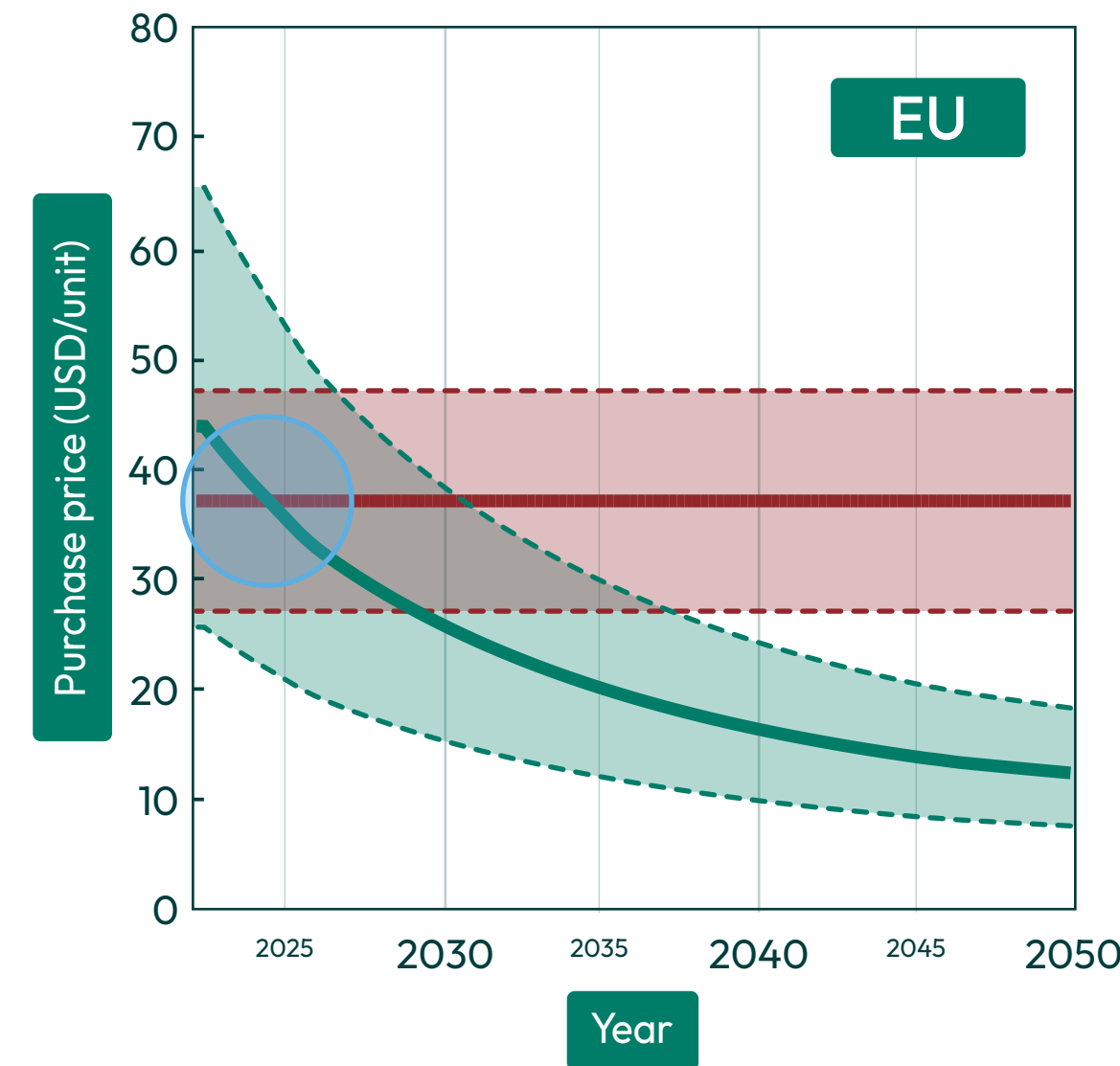
- **A rapid shift to battery electric vehicles (BEVs)** is the most cost-effective way to decarbonise passenger road transport [1].
- **This shift will accelerate as BEVs cross ‘tipping points’** where they outcompete fossil fuel cars first on the cost of ownership, then on purchase price [2].
- **In the EU and China, the first tipping point has already been crossed:** BEVs are already cheaper to own than petrol and diesel cars, in the small and medium-sized car segments, when both the purchase price and the cost of use are accounted for. In the US, this tipping point is likely to be crossed in 2024-5 [3].
- **These three markets have global impact,** accounting for 60% of the global car market. Their progress greatly increases economies of scale in battery production, bringing down the cost of electric vehicles for the rest of the world [4].



Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

# A second tipping point is imminent: in leading markets, electric vehicles will be cheaper to buy than fossil fuelled cars within the next one to three years

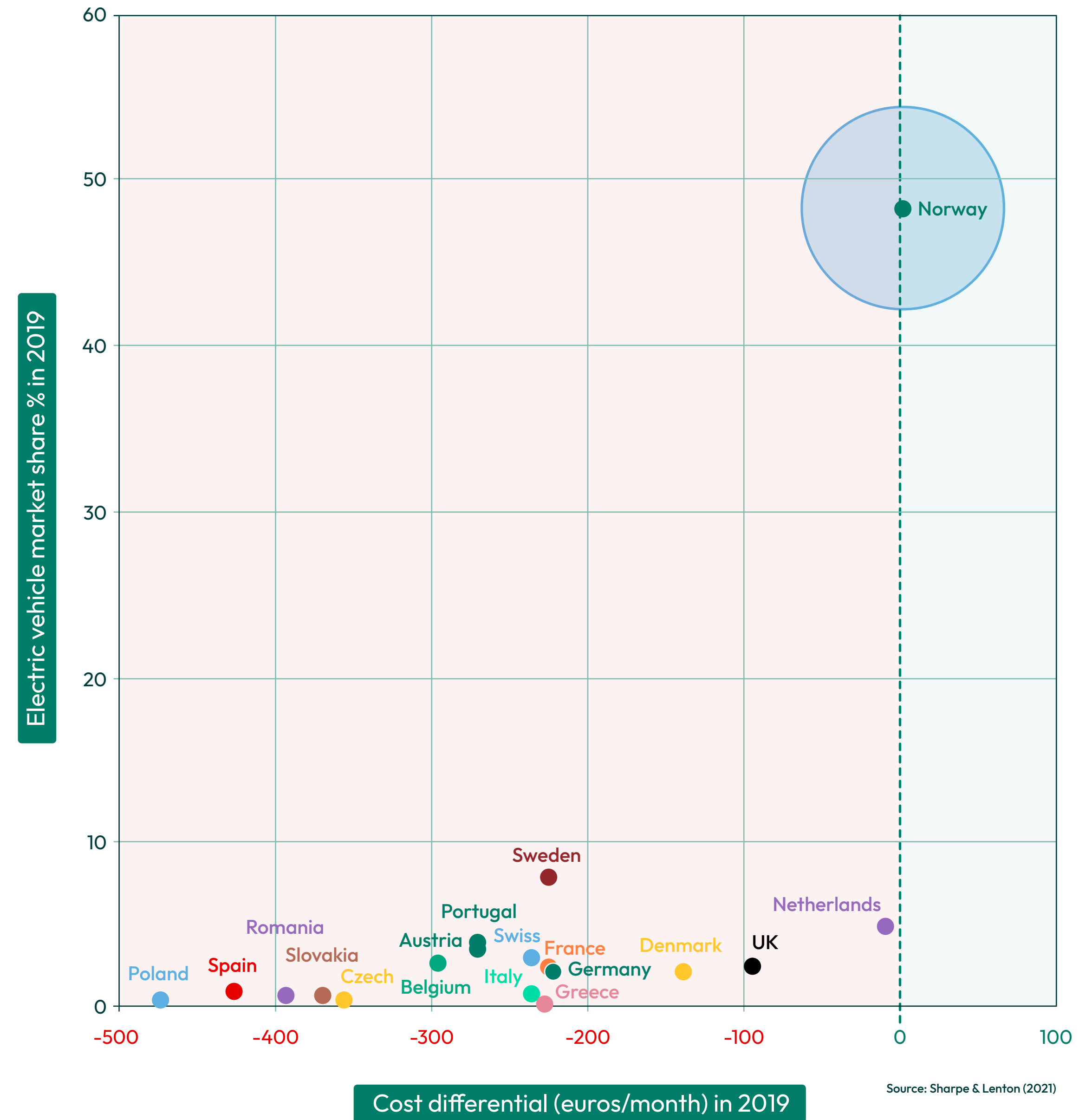
- The shift in consumer preference towards battery electric vehicles (BEVs) is likely to accelerate once upfront purchase price parity is achieved, while range, model availability and charging infrastructure continue to improve [1].
- This tipping point is expected as early as 2024 in Europe, 2025 in China, and 2026 in the US for medium-sized cars, and even sooner for smaller vehicles [2]. It has already been achieved for some models – in China, the two best-selling BEVs in 2022 were priced at under \$6,500 and \$16,000, less than the equivalent fossil fuelled cars [3].
- In other countries the tipping point is later, but still likely this decade – in India it may occur around 2027 [4]. In Japan, it is likely to occur after 2030 given strong policy favouring hybrid vehicles [2].
- These tipping point forecasts exclude subsidies, so the tipping point for the consumer will be even earlier where governments provide them.



Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

# Strong policy can bring forward tipping points by years

- **Norway achieved ownership cost parity in 2012, a decade ahead of the largest markets, and achieved purchase price parity in 2021.** Its policies included a combination of subsidies and taxes that made electric vehicles (EVs) cheaper to buy than fossil fuelled cars, preferential treatment for electric vehicles (access to bus lanes, and free parking) and investment in charging stations. This led to a tipping point in price, accessibility and attractiveness. Norway's EV share of car sales reached 18% in 2015, then 79% by 2022 (5 times the global average).
- **China crossed the price parity tipping point for small cars before any other large market,** through a combination of regulations to shift industry investment, subsidies for electric vehicle production and purchase, and public investment in charging infrastructure [2].
- **California is ahead of the rest of the USA, thanks to purchase subsidies and regulatory policy.** Its EV share of car sales stood at 25% in the first quarter of 2023, 3-4 times the level of the rest of the USA, and EVs are now its largest export [3]. The Inflation Reduction Act should help the rest of the USA catch up: it is expected to cut the purchase price of electric cars by \$3,000 to \$9,000 [4], accelerating adoption and bringing forward the price-parity tipping point.



Source: Sharpe & Lenton (2021)

Sources: [1] Bkerkan et al (2016); Figenbaum (2017); Norwegian EV Association (2023) [2] Anadon et al (2022) [3] CEC (2023); Reuters (2023); Utility Dive (2021) [4] ICCT (2023)



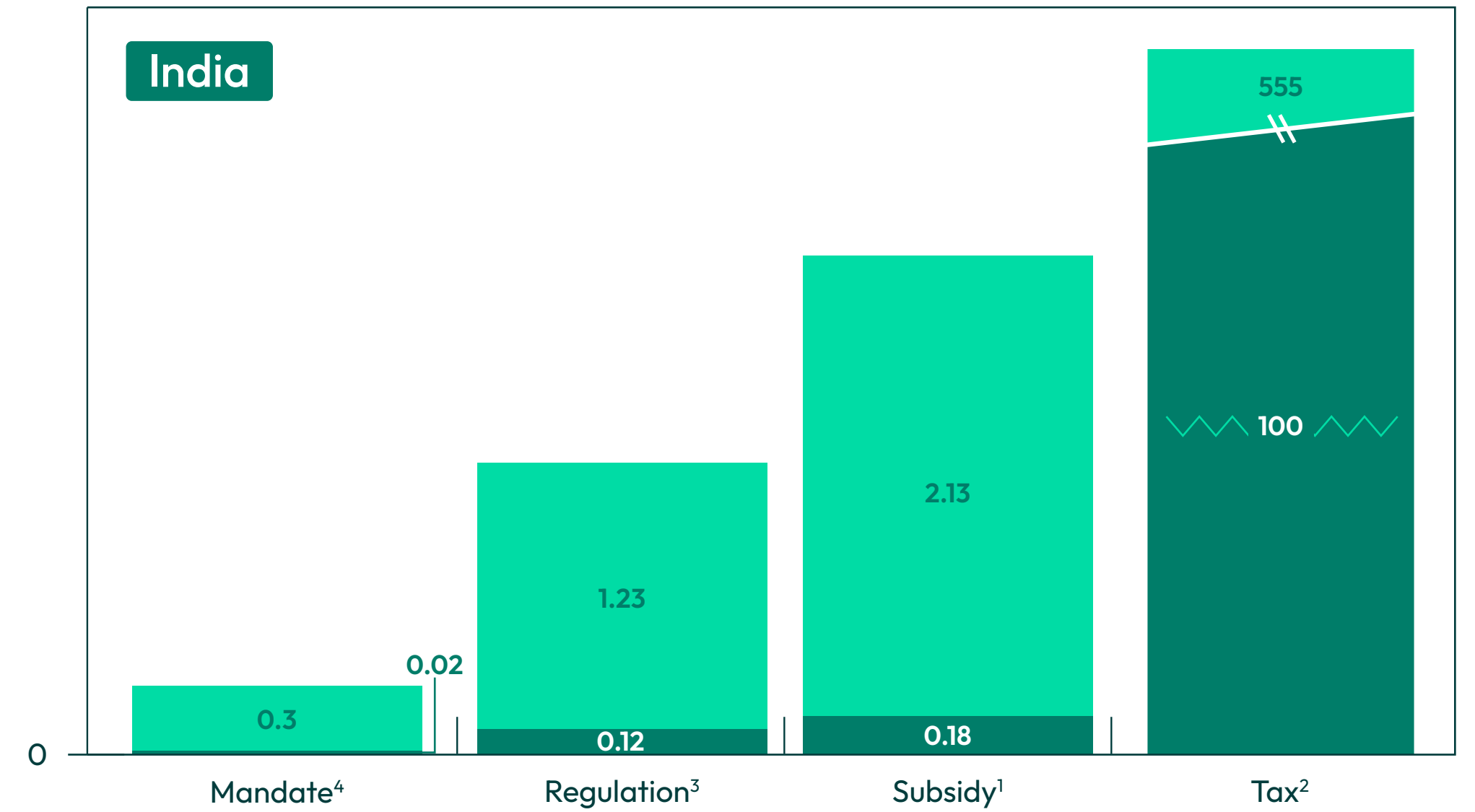
# National policy recommendations

## Zero emission vehicle mandates are the single most effective policy to drive the transition

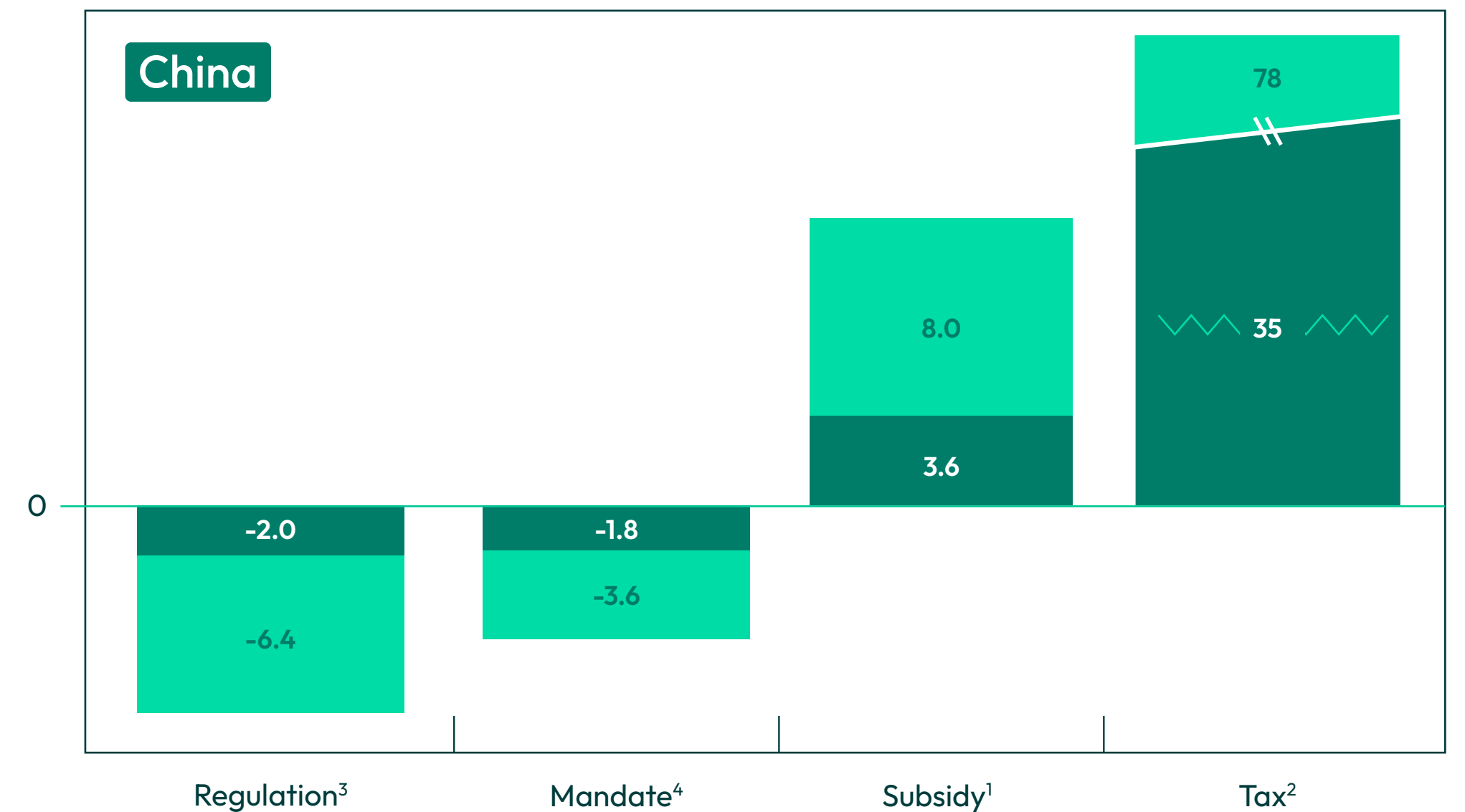
- **Zero emission vehicle (ZEV) mandates ensure a complete shift to the new technology by requiring an increasing proportion of cars sold to be zero emissions.** This ensures a complete elimination of emissions, leaving nothing to chance [1].
- **ZEV mandates do the most to accelerate electric vehicle cost declines:** by ensuring the largest deployment of EVs in a given time period, they push the technology furthest down the learning curve.
- **ZEV mandates and efficiency regulations are both highly cost-effective approaches to increasing the uptake of electric vehicles.** They are considerably more cost effective as individual policies than subsidies and taxes, and have been central to the successes achieved by the leading markets of the EU, China, and California [2].
- **Contrary to traditional economic advice on carbon pricing, taxes used alone are the least cost-effective way to drive the transition.** However, they can be useful as part of a package of policies [3].

Sources: [1-3] Barbrook-Johnson et al (2023)

Cost of EV deployment (Billion USD/percentage point increase in EV share)



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<sup>1</sup>Subsidy: an EV purchase subsidy set at the level required to achieve ownership cost parity with an equivalent fossil fuelled car in 2022

<sup>2</sup>Tax: a tax on fossil-fuelled vehicles set at the level required to achieve ownership cost parity with an equivalent EV in 2022

<sup>3</sup>Regulation: requires the carbon intensity of new vehicles to reduce linearly from its level in 2022 to zero by 2035.

<sup>4</sup>Mandate: requires all new vehicles to be zero emission by 2035.

2030

2050

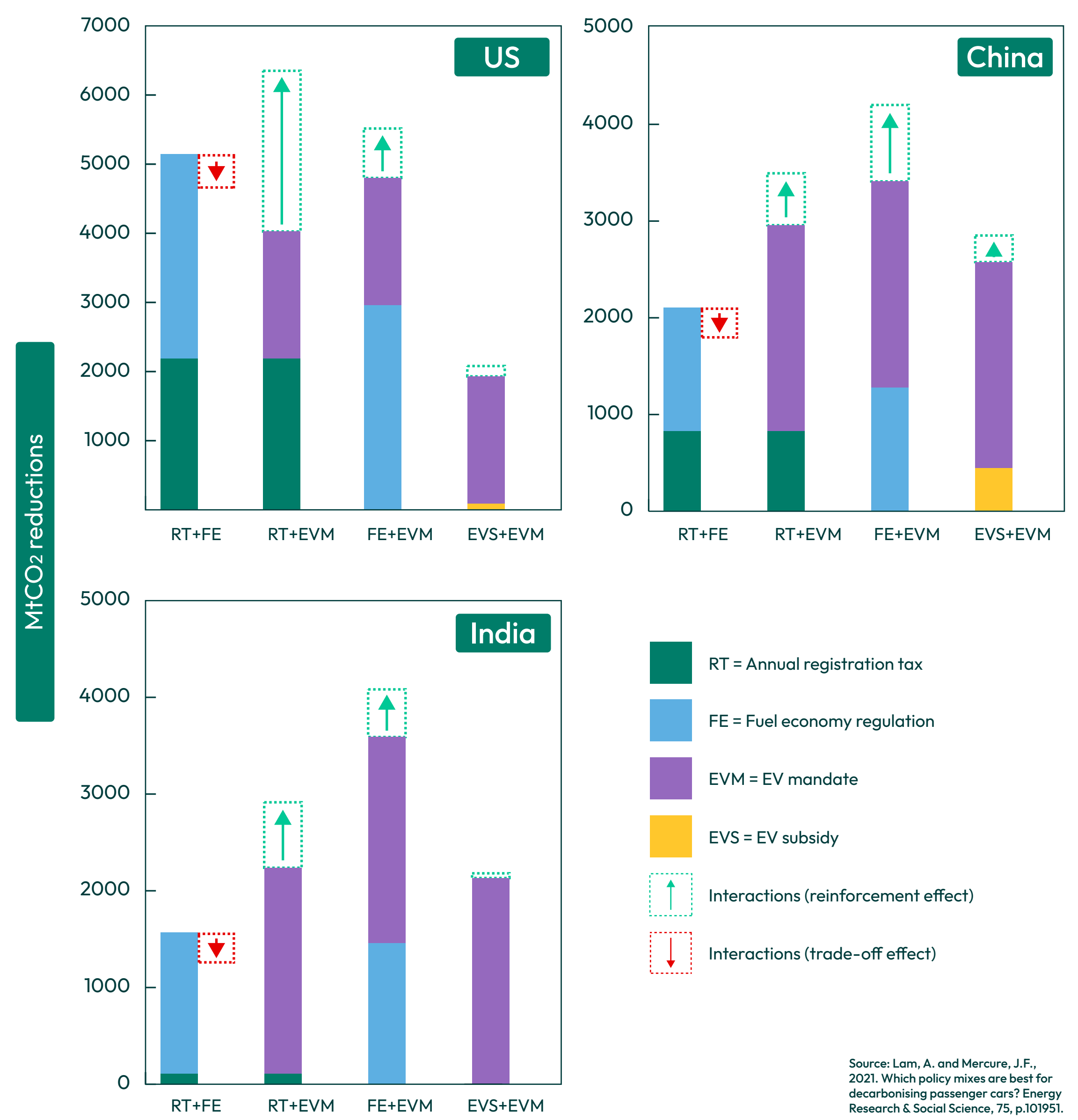
Source: Lam, Vercoulen, Mercure & Sharpe, in Barbrook-Johnson, P. et al (2023). New economic models of energy innovation and transition

# Policy combinations can achieve more than the sum of their parts

- **The right policies used in combination can achieve more than the sum of their parts** – resulting in additional cost and emissions savings [1].
- **The greatest gains occur from combining electric vehicle (EV) mandates with other policies**, including efficiency regulations, road taxes, and purchase subsidies [2]. In all cases, infrastructure investment will be needed too.
- **Policy combinations have driven the growth of electric vehicle sales in the markets leading the transition**, including Norway, California, China, the EU, Canada and the UK [3].
- **Tax and subsidy combinations can cross the tipping point without needing government spending:** a small tax on each fossil fuelled car sale can fund a large subsidy for each electric vehicle, because electric vehicles are still a small share of the market. This is a revenue-neutral way to cross the cost parity tipping point [4].
- **Some policy combinations achieve less than the sum of their parts**, for example when efficiency regulations are combined with taxes [2].

Sources: [1] Lam & Mercure (2021) [2] Barbrook-Johnson et al (2023) & EEIST modelling [3] CSE India (2023); Canadian Climate Institute (2022) [4] EEIST (2023)

Combining certain policies creates additional CO2 emissions reductions



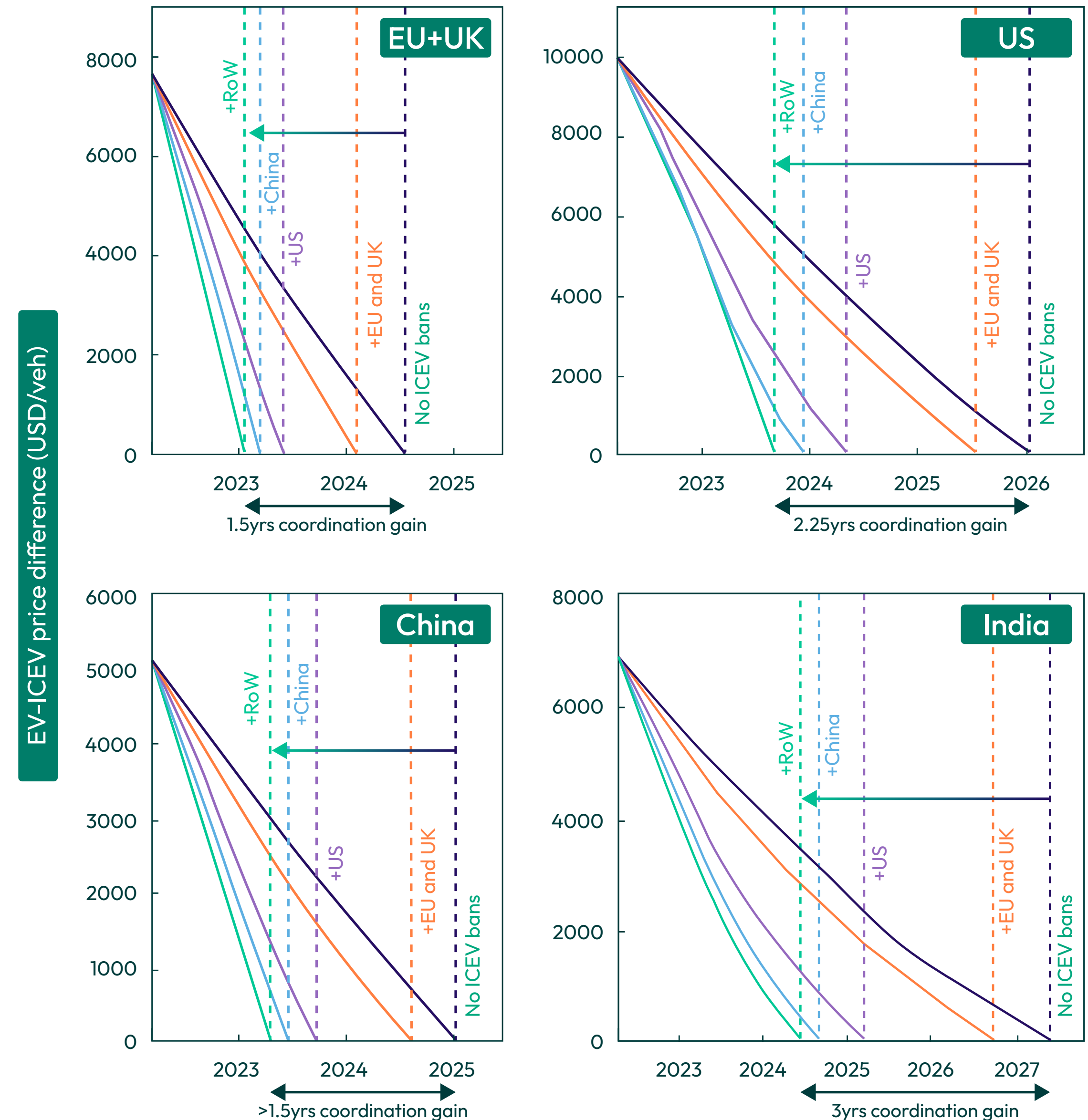
Source: Lam, A. and Mercure, J.F., 2021. Which policy mixes are best for decarbonising passenger cars? Energy Research & Social Science, 75, p.101951.

# International action

## Coordinated action among the largest markets can bring electric vehicle costs down faster than any country can achieve alone

- If the EU, US, and China align their regulatory trajectories towards all new car sales being zero emission by 2035, this can bring forward national price parity tipping points by several years. This happens because a faster transition in the largest markets scales up production, which drives faster innovation and lower costs [1].
- **This benefits all countries.** For example, coordinated action between Europe, the US and China could bring forward the electric vehicle (EV) / fossil fuelled vehicle price-parity tipping point in India by nearly 3 years [1].
- **Coordinated international action would have a greater impact now than later,** as price declines are steeper earlier in the transition [1].
- **Other forms of international cooperation that can accelerate the transition to EVs** include financial and technical assistance for emerging economies, particularly to facilitate investment in charging infrastructure, and harmonising standards for battery sustainability [2].

International coordination can bring forward price-parity tipping points



Sources: [1] Barbrook-Johnson et al (2023) ; Lam & Mercure (2022) & EEIST modelling [2] Breakthrough Agenda (2022)

Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

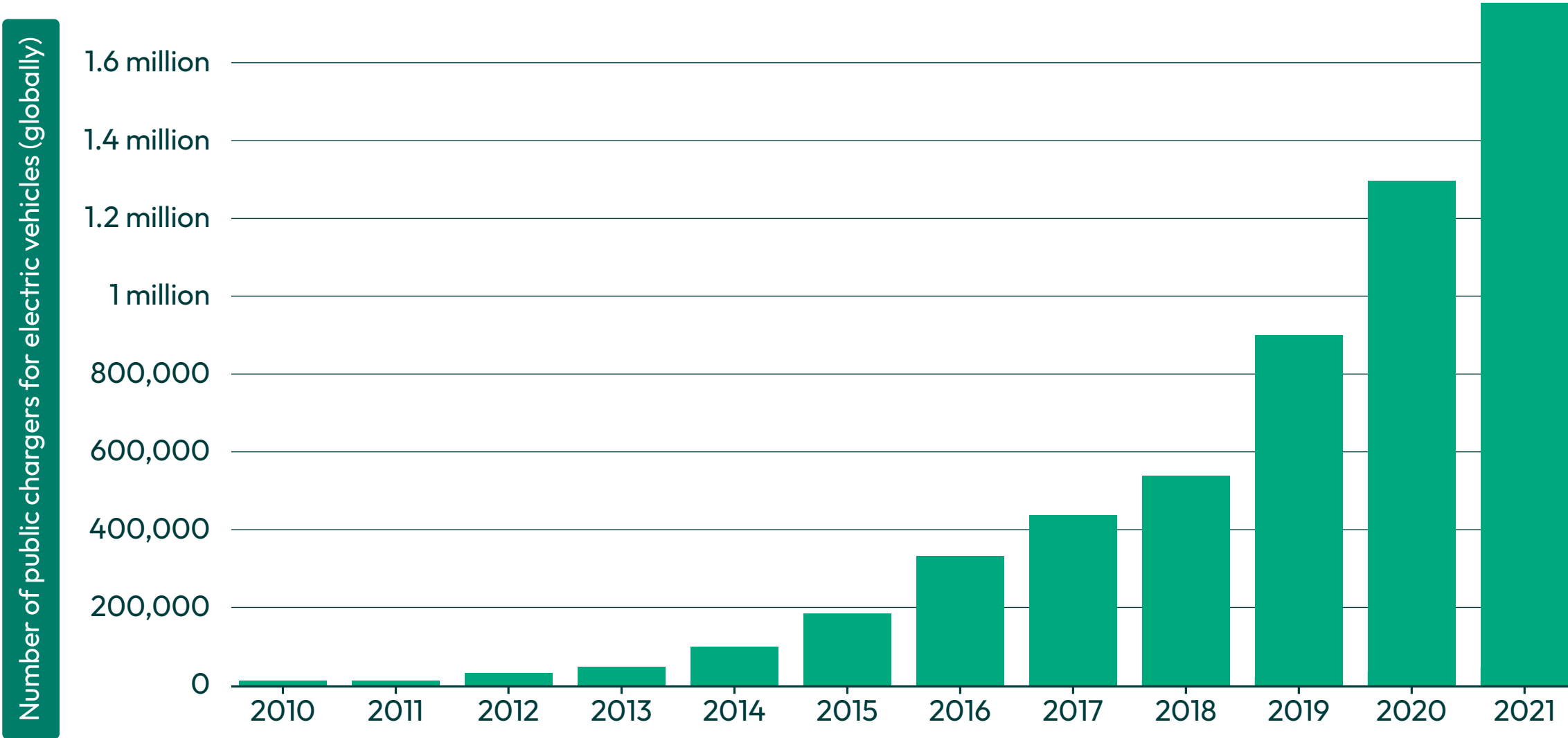


# The challenges of charging infrastructure and material supply can be overcome, with proactive policy

- **Globally, the global deployment of public chargers has roughly kept pace with the rise of electric vehicles (EVs) over the past five years, staying at about 8-10 EVs per public charger.** This indicates that charging infrastructure can keep up with EV deployment [1].
- **Proactive policy such as financial subsidies and incentives can accelerate charging infrastructure deployment.** With these policies, China became the largest charging infrastructure network in the world (now with only 7 EVs per charger), and the Netherlands built its total public charging points to 10 times the EU average [2].
- **There are enough mineral reserves** for the transition, and solutions are emerging to ease supply constraints and reduce prices. New lithium mines are rapidly starting production, near-total recycling of batteries has become technically feasible, and recycling policies are increasing in key markets [3].

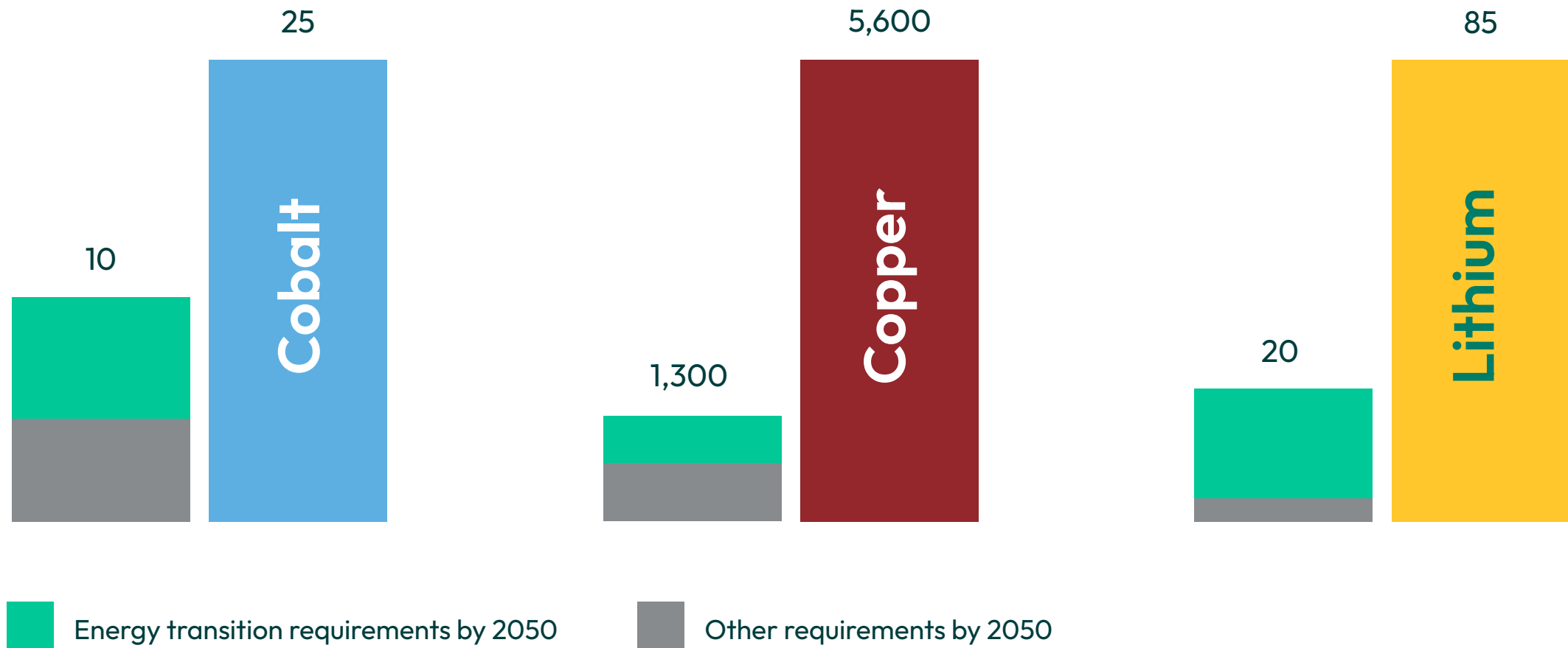
Sources: [1] Ritchie (2023); IEA (2023) [2] Anadon et al (2022); ChargeUp Europe (2022) [3] Fast Company (2023); ETC (2023)

Public chargers are growing exponentially



Sources: International Energy Agency

There are sufficient materials (Global reserves, million metric tonnes)



Sources: Energy Transitions Commission

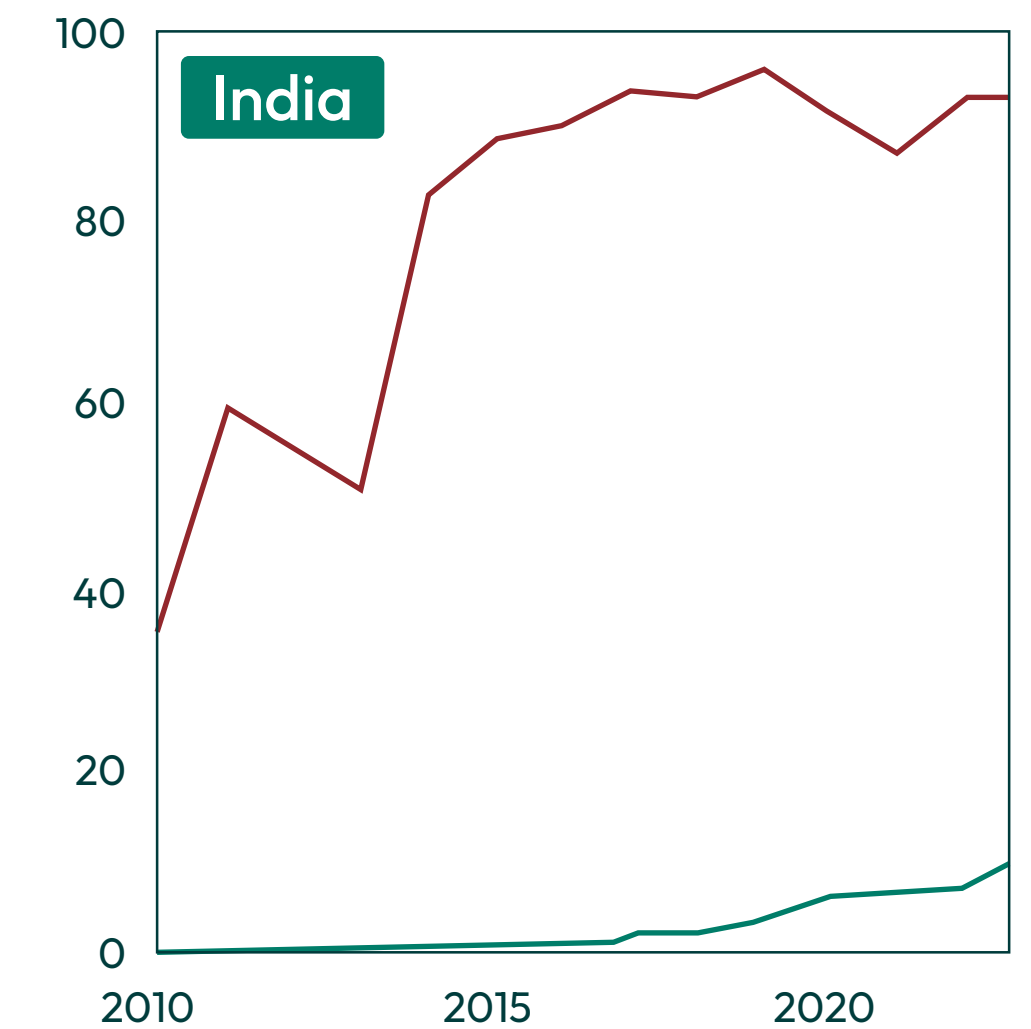
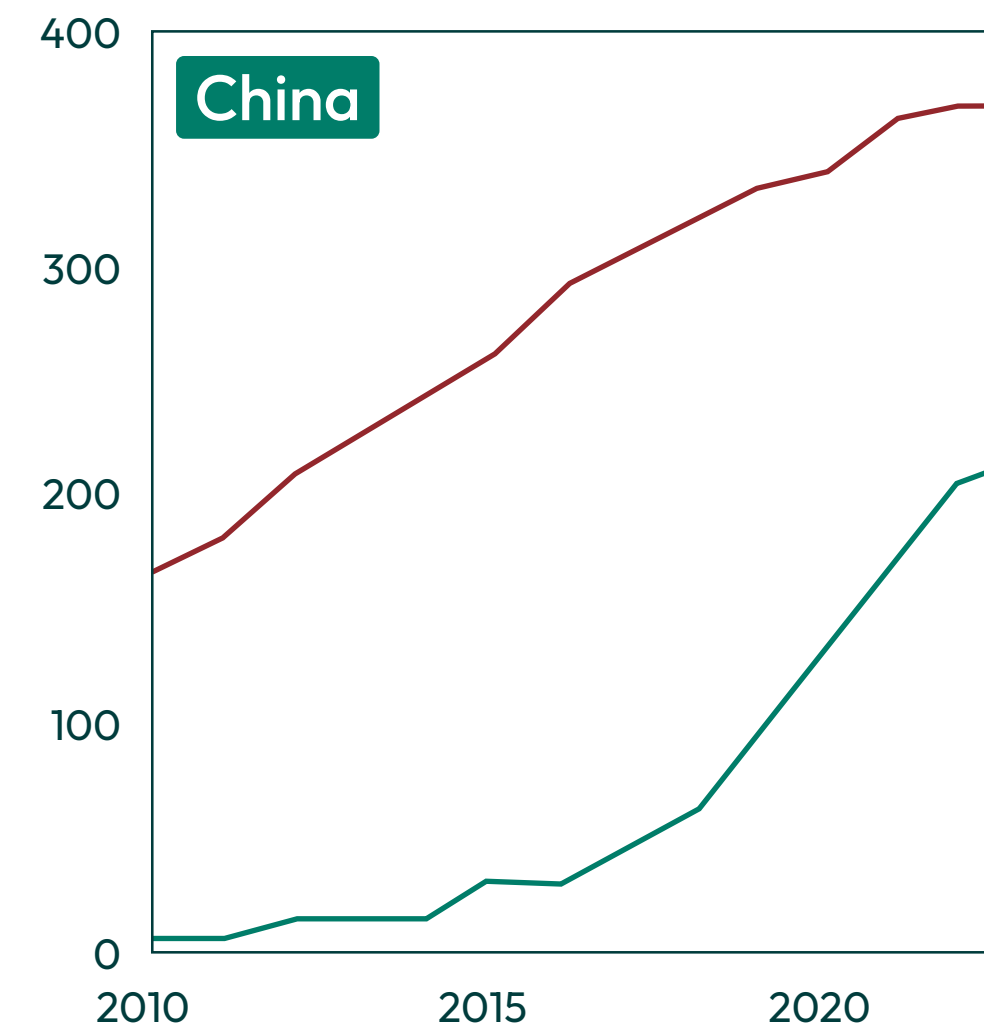
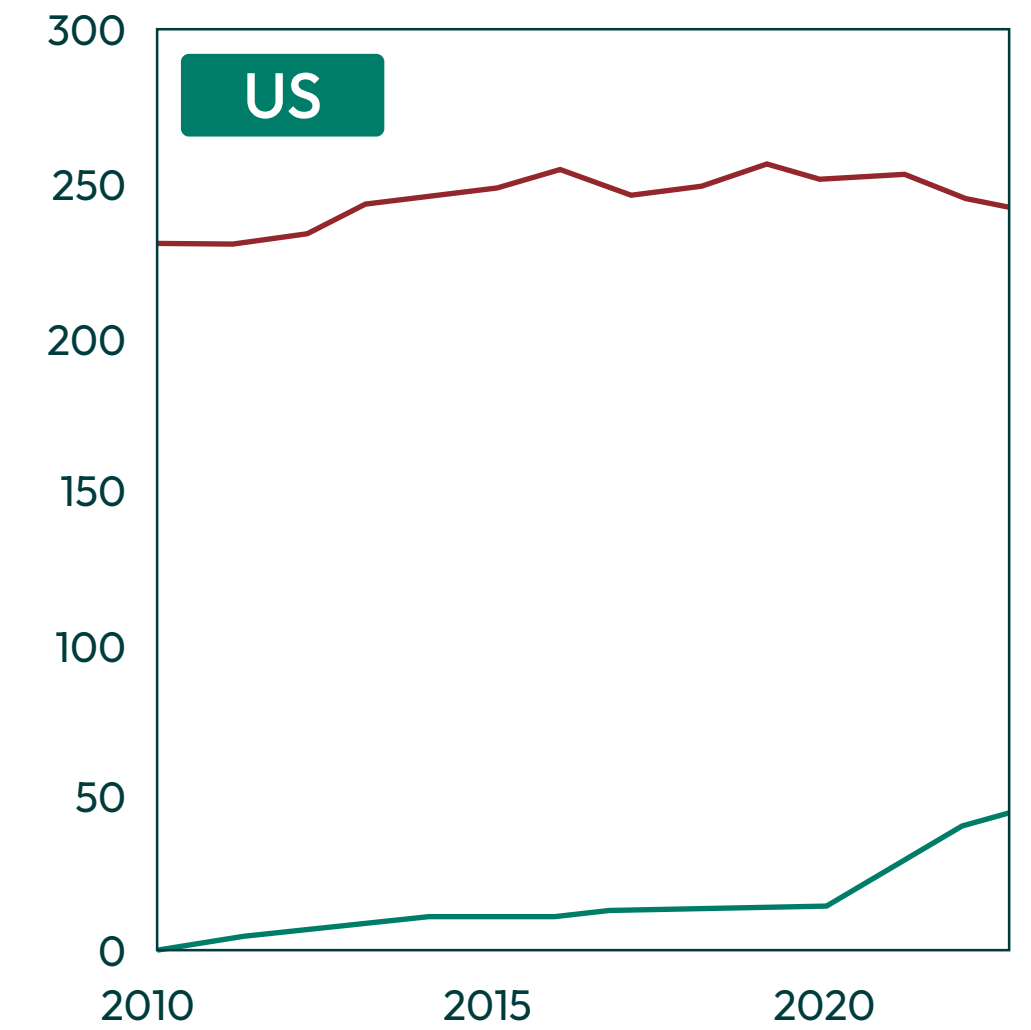
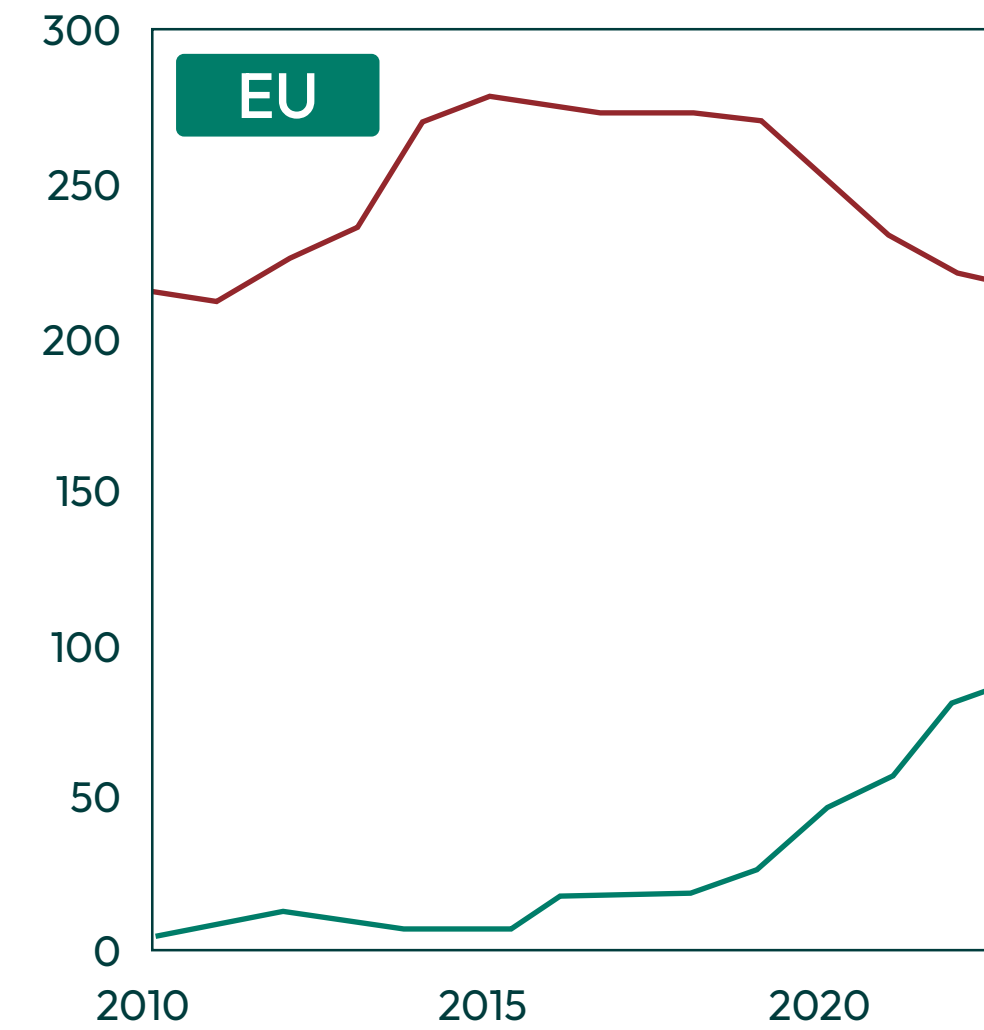


# Wider benefits

## There are many benefits of a fast electric vehicle transition: avoid expensive oil imports, create jobs and cut pollution

- **The transition can cut expensive oil imports.** Many countries spend huge sums on oil imports every year (China spent \$365bn on crude oil imports in 2022, the US \$205bn, India \$173bn, Japan \$102bn) [1]. Transport accounts for about two thirds of global oil demand [2]. The transition to electric vehicles (EVs) allows more of this money to be invested domestically instead.
- **Being a leader in the transition can be good for jobs and industrial competitiveness.** In 2022, top global automakers announced spending plans of nearly \$1.2 trillion up to 2030 to develop and produce EVs, more than doubling estimates made in 2021 [3]. The number of different fossil fuelled vehicles on sale in leading markets is declining, while the variety of EV models is rising, clearly indicating the focus of new investment [4].
- **A rapid electric vehicle transition can save lives.** Emissions from fossil fuelled vehicles were linked with around 385,000 premature deaths globally in 2015, and the shift to electric transport could cut this by 75% [5].

Number of models marketed



■ Petrol/diesel ■ EV

Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

Authors: **Anna Murphy, Aileen Lam, Jean-Francois Mercure, and Simon Sharpe**

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