THE ROAD AHEAD: HOW DO WE MOVE TO CLEANER CAR FLEETS?

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Climate Action Tracker

KEY MESSAGES

- Science tells us the global decarbonisation of the transport sector is key to achieving deep cuts in emissions in line with the Paris Agreement's long-term temperature goal. Fuel economy and emission standards set by a number of countries will help to deeply decarbonise their transport sector in the coming decades, but more work is needed.
- **Without swift and extensive deployment of electric vehicles powered by clean electricity, reductions from the transport sector will not be enough to meet the more stringent long-term goals of the Paris Agreement, i.e. limiting temperature rise to 1.5˚C.**
- If countries were to double fuel economy standards in new cars by 2030, and achieve 50% EV uptake by 2050, then most get close to—or even reach—the 2˚C pathway. This **suggests that for the transport sector to decarbonise sufficiently, there is no choice but to adopt zero-emission vehicles** unless major shifts take place in transport behaviour.
- To go from a 2°C to a 1.5°C trajectory, however, zero global aggregate emissions would need to be reached around 10 years earlier. [1] We calculate that the last gasoline/diesel car would have to be sold by roughly 2035, and even that could be too late to avoid the need for negative emissions. This would also have to be accompanied by a decarbonisation of the power sector.
- The deliberate manipulation of emissions tests threatens the value of vehicle emission standards, highlighting the need for stronger monitoring and verification of policy compliance. Extra measures need to be taken to account for misreporting in previous years.

THE IMPORTANCE OF VEHICLE EMISSION STANDARDS

Globally, the transport sector accounts for up to 14% of all GHG emissions.[2] Emissions from the transport sector are determined in three ways:

- activity levels (how many people and how much cargo get transported how far),
- modal share (how many private vehicles versus public transport), and
- emission intensity levels of the fuel used (how much carbon dioxide and other pollutants are emitted per kilometre driven).

In 2015, the Volkswagen scandal brought the concept of vehicle emission intensity levels under global scrutiny as the company admitted to having manipulated emissions tests.[3] The scandal sparked a debate about the trustworthiness in manufacturers' claims on vehicle standards, but also on the limited ability of the actual tests to reproduce real-world driving conditions. Ethical questions aside, such actions could have more far-reaching consequences than just a breach of trust between sellers and buyers. If emissions are so much higher on the road than what companies tell us and current test protocols suggests, what are the implications for our ability to track progress towards the decarbonisation of the transport sector needed to limit the global temperature increase to 1.5°C, as posed in the Paris Agreement?

Substantial changes in the energy system are needed to meet the 1.5°C scenario. The most current scientific knowledge finds that energy efficiency is key, especially within sectors with limited near-term availability of low-carbon technologies, such as the transport sector[4]. Some promising developments have emerged, where some countries are starting to heavily promote electric vehicles (EVs),[5] and demand for these is rapidly increasing.[6]

The Dutch parliament recently passed a motion calling for efforts to make sure all new cars sold in 2025 are zero-emission, which reportedly could result in an outright ban[7] on internal combustion engine (ICE) vehicles; Norway, despite having had to quash rumours of such a ban[8], is also putting in place a number of policies to help catalyse a phase-out of ICEs in the medium term. A new, harmonised global testing standard for determining the emissions from motor vehicles—the Worldwide Harmonized Light Vehicles Test Procedure (WLTP)—will replace existing EU[9] standards, and may help prevent discrepancies between lab and road emissions in the future.

Such endeavours contribute to the decarbonisation of the transport sector. But how far-reaching are the required changes in emissions standards (and their implementation) to limit global warming? To what extent is EV

NEW CLIMATE INSTITUTE ECOFYS CLIMATE ANALYTICS deployment needed to be in line with 1.5°C? To answer these questions, we have analysed the impact of current and planned fuel economy and emission standards in seven different countries/regions: the EU, USA, China, India, Mexico, Brazil and Japan.

WHAT PROGRESS IS THE TRANSPORT SECTOR MAKING TOWARD DECARBONISATION?

Based on the scientific literature and consensus, the Cancun Agreement's goal of holding warming below 2°C has been consistently interpreted (including in the recent IPCC AR5) as the "likely below" 2°C scenarios.[10] The Paris Agreement goes well beyond the Cancun Agreement's 2°C limit and aims to hold warming to *well* below 2°C and to pursue efforts to *limit temperature increase to 1.5°C.*

The literature evaluating the Paris temperature limit is not as broad as that looking into the "likely below" 2° C class of scenarios, especially at the sectoral level. Due to limited data availability on 1.5°C scenarios, we therefore base this analysis on the ample 2°C literature, from which we draw conclusions on the implications for limiting warming to 1.5°C.

We have analysed the emissions pathways of the light-duty vehicle (LDV) fleet in different countries, using an in-house Climate Action Tracker model (Annex A), which estimates the average LDV fleet emission intensity (tank-to-wheel, or TTW) under the implementation of specific fuel economy (in km/l) or emission (gCO_2/vkm; vkm = vehicle-kilometre) standards for vehicles with internal combustion engines (ICE), along with a specific rate of deployment of electric vehicles (EVs). We compare the model outcomes to a 2°C-compatible scenario, which gives us an indication of the direction towards limiting warming to 1.5°C.

Our analysis shows two key results for all investigated countries/regions:

- SCENARIO 1: doubling new car fuel economy standards by 2030. This scenario is in line with the Global Fuel Economy Initiative[11] target, and would significantly reduce emissions intensity. However, average emission intensities of LDV fleets would still not decrease enough to be in line with a 2°C limit, let alone in line with the 1.5°C limit adopted in Paris.
- SCENARIO 2: doubling new car fuel economy standards by 2030, plus 50% (zero emission) EV's by 2050.[12] Here, most countries get close to, or even reach, the 2°C pathway, suggesting that there is "no way around" zero-emission vehicles if the transport sector is to decarbonise sufficiently.

If we were to rely purely on stringent emission standards without EVs, we would need to reach near-zero emission standards (less than 10 gCO_2/vkm, more than 13 times lower than the current EU standards) within a few decades to get near a 2°C pathway.

SPECIFIC COUNTRY AND REGION RESULTS

Figure 1 shows the historic development of LDV fleet emission intensities (top) and LDV emissions (bottom) for the EU and China, as well as projected developments until 2030 with no new policies, and the projected outcomes until 2050 of Scenarios 1 and 2 as described above. For the other countries, see Annex B.

Most regions have already formulated fuel economy targets up to 2021. While the EU and USA have the most stringent emission standards for new cars, India and Brazil, too, could reach the 2°C pathway in Scenario 2. (Here, current emission intensities are already relatively low, due to small vehicle sizes in India and biofuel use in Brazil.) The 2°C pathway is also less stringent for these two than for other countries due to differences in load factor (the average number of passengers per vehicle). For India and Brazil, a significantly higher load factor is expected than in the other regions. This behavioural difference makes the 2°C pathway more easily attainable for India and Brazil, as the "CO_2 budget" for 2°C could be distributed over fewer vehicles to meet the demand[13] (see Figure 3).

Focusing only on emission intensity does not tell the whole story, as projected activity levels differ greatly across various countries. In most countries, activity levels are still projected to increase, and absolute emissions from LDVs would therefore still rise post-2030 in Scenario 1.

- In the EU and the USA, the increased deployment of EVs would keep overall emissions on a downward trend in line with the 2°C pathway.
- In India, the projected rise in activity levels is so high that absolute emissions from LDVs would keep rising even under Scenario 2. However, this would still be in line with the IEA's 2°C pathway for India, which foresees a similar rise in emissions, reflecting this strong expected growth.
- The situation in China, Brazil and Mexico lies between these two cases, with emissions under Scenario 2 stabilising as the effects of increased activity and reduced intensity approximately balance out.

- Overall emissions are expected to decrease most strongly in Japan (in both scenarios), due to declining activity levels.

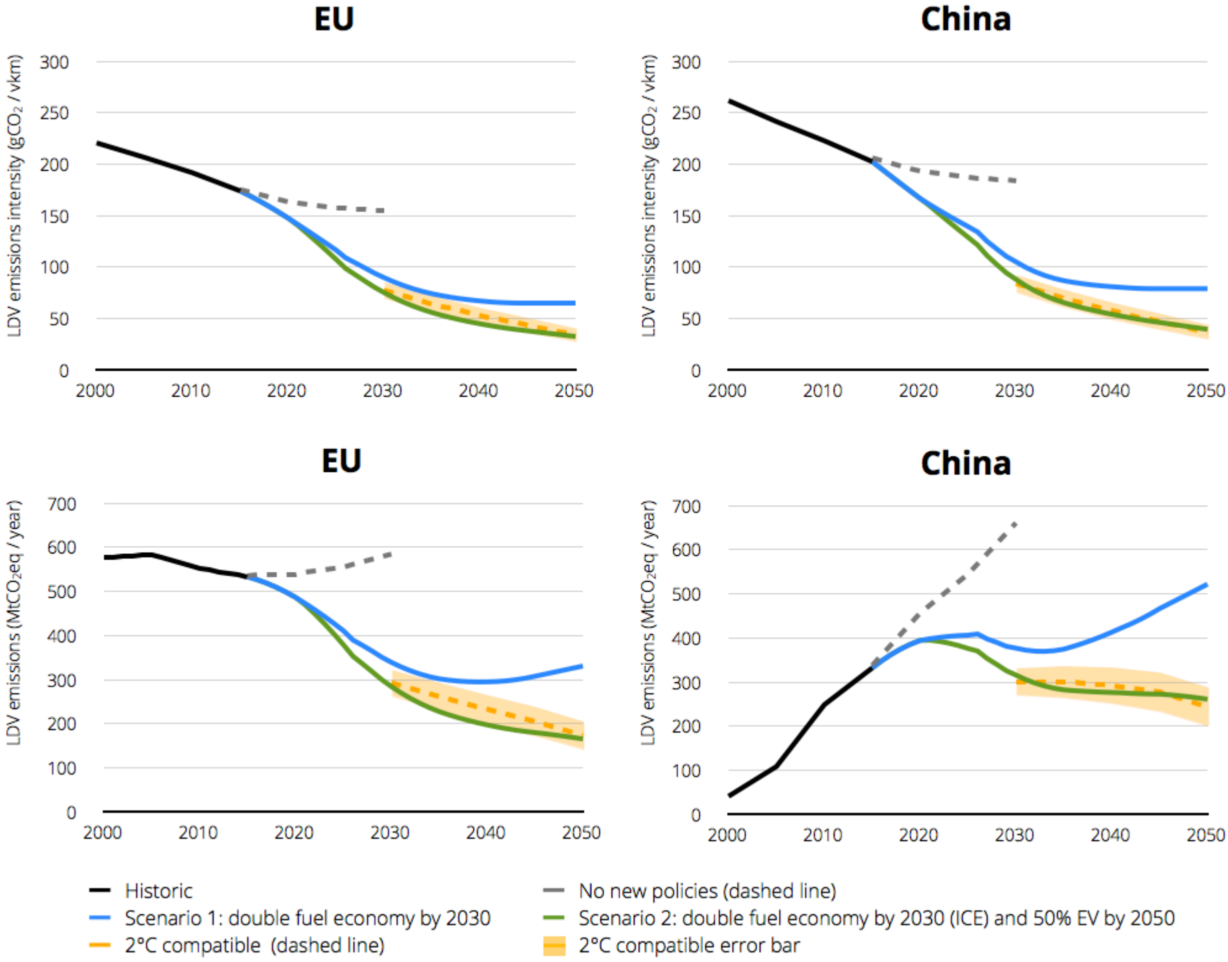

Figure 1 - Emission intensities and TTW emissions of LDVs in the EU and China under implementation of more stringent emission standards and up to 50% share of electric vehicles by 2050. Results for the US, India, Japan, Mexico and Brazil are shown in Annex B. "No new policies" corresponds to no further improvements in vehicle fuel efficiency beyond what is already mandated.

What does the Paris Agreement mean for transport?

The Paris Agreement stipulates that global mean temperature increase should be kept to "well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C." What does this imply for vehicle standards and EV deployment?

In going from a 2°C to a 1.5°C trajectory, zero global aggregate emissions would need to be reached around 10 years earlier, [14] so the timeline for phasing out ICE vehicles (and decarbonising the power sector) must be moved forward. Considering the current literature, and that a new car would stay on the road for up to 15 years (see Annex A), the last gasoline/diesel car would have to be sold by roughly 2035. The IPCC AR5 and subsequent literature clearly show that a delay in mitigation action increases the need for reliance on negative CO_2 emissions. It is therefore clear that the earlier we decarbonise, the less we will need to rely on negative emissions that largely rely on technologies still awaiting large-scale deployment. This could make even this 2035 date very late.

The ambitions of Norway and the Netherlands—already frontrunners in EV deployment[15]—to work towards stopping the sales of new gasoline and diesel cars, are a first step towards what is needed to decarbonise the transport sector in line with 1.5°C. To realise such ambitions, large investments in EV infrastructure would be necessary, as the density of charging stations is still not up to par with that of conventional filling stations, even in frontrunner regions. EVs are still more expensive to purchase than other cars,[16] and policy projections still only see a share of around 5% of EVs in the total EU, China and US fleets by 2030.[17]

The implications of deficient reporting

A report by the International Council on Clean Transportation (ICCT) estimated emissions from light duty vehicles in the EU to have been up to 36% higher (per km) recently than those reported in certification tests.[18] This implies that significant extra measures to ensure compliance and improve monitoring systems will have to be taken to stand any chance of being close to 2°C compatibility, let alone 1.5°C.

The ICCT also reported that up to a third[19] of the gap between lab and road emissions could be explained by carmakers systematically taking advantage of "technical tolerances and imprecise definitions." This means that much more stringent monitoring is needed to ensure more realistic test results. For example, on-the-road testing is much more common in the US than in the EU, leading to smaller discrepancies between lab and road emission intensities.[20]

The existing emission standards for new cars (see Annex A) are thus left to look like mere definitions that have little to do with actual developments in the transport sector. As a result, EV deployment would have to be intensified even further to stay in line with the Paris Agreement.

CONCLUSION

Our analysis brings insights into the extent of change that is necessary in the transport sector to achieve decarbonisation. While a number of major emitting countries have set ambitious fuel economy and/or emission standards that can substantially reduce emissions (especially the EU and USA), 2°C trajectories can only be reached by a massive scale-up of EVs, to around 50% by 2050. More action is needed to ensure compatibility with the 1.5°C limit agreed upon in Paris, especially considering the current practices in conscious misreporting of emission standards by car manufacturers.

Getting anywhere close to a 1.5°C compatible pathway would thus require changes on a different scale, with sales of zero-emission vehicles reaching 100% of new sales in the next two decades, combined with a completely decarbonised power sector. Some countries have made pledges in this direction, but more sustained action is needed on a global scale.

Lastly, increasing EV sales is no silver bullet for the entire transport sector. For example, in heavy freight transport over long distances, EVs currently offer no feasible alternative to standard trucks, not to mention aviation, maritime transport, and train travel, which is still often powered by diesel fuel. Here, the focus on increasing fuel efficiency and emission standards is all the more important in the near term, although zero-emission technologies are still required sector-wide in the long-term.

BOX 1 WHY FOCUSING SOLELY ON EVS MISSES THE TARGET

The increased deployment of EVs on its own does not guarantee a cleaner economy. While the tank-to-wheel-emissions of EVs are zero, charging an EV requires electricity. Increased deployment of EVs will lead to a surge in electricity demand, and if electricity generation is carbon-intensive, to higher emissions. This is shown by the graphs below, which illustrate the additional emissions per vkm that would result if we assume the electricity demand was met by an electricity mix as predicted under the IEA WEO's New Policies Scenario. Especially in China, where the power sector remains heavily fossil-based, the difference compared to a situation with 100% renewables is large, suggesting that additional action in the power sector is necessary.

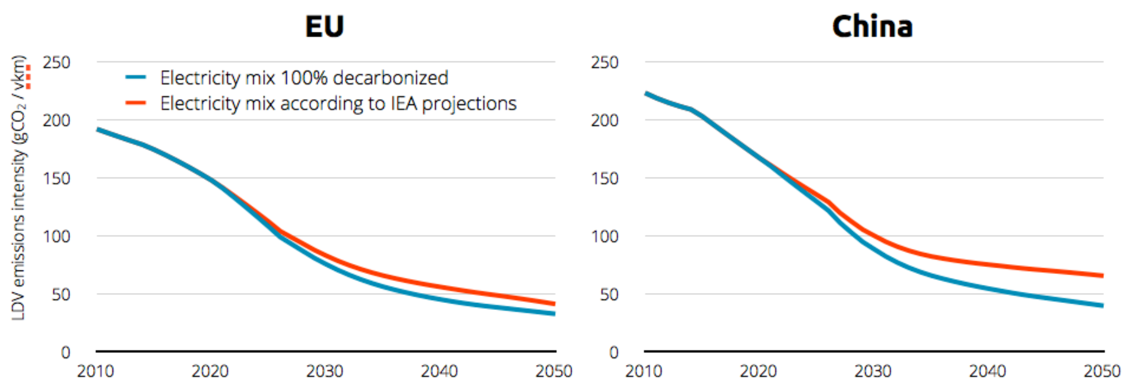

Figure 2 - Fleet-wide averages of LDV emissions intensity in the EU and China, including the emissions related to electricity generation needed for the usage of EVs, under two different developments of the electricity sector.

ANNEX A: METHODOLOGY

The basis of our model is as follows.

- Predictions of activity levels (measured in the number of vehicle-kilometres driven per year) on a country-level are obtained from the ICCT's Global Transportation Roadmap Model (GTRM)[21].
- It is assumed that new ICE cars added to the fleet in any given year conform to the national fuel economy or emission intensity standards applicable to that year, with interpolations where necessary[22]. If no standards are available in a given year, the emission intensity is assumed equal to those derived from the ICCT GTRM base case.
- The emissions of EVs (tank-to-wheel or TTW) are assumed to be zero.
- Wherever a country has not formulated explicit emission standards but instead fuel economy standards, these are converted to emission standards with an average emission factor (in gCO_2/l) based on the assumed share of gasoline, diesel and bio-ethanol in a country's total fuel use.
- It is assumed that LDVs stay on the road for an average lifetime of 15 years, after which they are replaced by new vehicles. Thus, under implementation of fuel economy / emission standards, the entire fleet's emission intensity will gradually reduce, as more efficient cars constitute an ever larger share of the fleet. However, overall emissions from the transport sector may still increase if activity levels would simultaneously increase strongly.

The following table gives an overview of the existing and planned vehicle standards considered in the analysis[23]:

Country/region	Standard (year)	Assumed share of ICE vehicles
EU	130 gCO_2/vkm (2015); 95 gCO_2/vkm (2021)	
USA	139 gCO_2/vkm (2016); 88 gCO_2/vkm (2025)	
China	6.9 l / 100 km (2015); 5 l / 100 km (2020)	99% gasoline, 1% diesel[24]
India	130 gCO_2/vkm (2016); 113 gCO_2/vkm (2021)	
Mexico	16.7 km/l (2016)	50% gasoline, 50% diesel[25]
Japan	16.8 km/l (2016); 20.3 km/l (2020)	99% gasoline, 1% diesel[26]
Brazil	17.4 km/l (2017)	73% gasoline, 27% bio-ethanol[27]

The "no new policies" scenario in the graphs is taken from the ICCT GTRM base case, which assumes no further improvement beyond already mandated vehicle fuel efficiency standards as of 2012 and no technological shifts.

2°C scenarios

We construct a 2°C scenario as follows:

- The IEA defines sectoral least-cost emissions pathways under a 2°C scenario in its Energy Technology Perspectives (ETP) 2014[28]. Krabbe et al. (2015) have used these sector-level pathways to formulate sectoral-level intensity targets that serve as proxy for 2°C compatibility[29].
- For passenger road transport, this pathway is defined in gCO_2/pkm (well-to-wheel or WTW)[30]. We have converted this pathway to the gCO_2/vkm metric using year- and country-specific load factors (pkm/vkm) from the ICCT GTRM.
- Lastly, this pathway was converted from WTW to TTW emissions using the appropriate mean global factor in the ICCT GTRM (81%) base case[31].

The uncertainty ranges of the 2°C scenario have been constructed as follows:

- The IPCC Fifth Assessment Report (AR5), WGIII, chapter 6, gives estimates (including uncertainty ranges) for the relative reduction (with respect to 2010) in final energy demand in transport necessary for 2˚C compatibility, by 2030 and 2050, based on a maximum atmospheric greenhouse concentration of around 450 ppm CO_2e by the end of this century[32].
- We have used the same relative uncertainty applied to the values of 2°C compatible scenarios in our analysis (with linear interpolation between 2030 and 2050).

Analysis

We have compared the model outcomes of the following two scenarios of development in the transport sector up to 2050:

(1) Countries aim for doubling the fuel economy of new cars by 2030 from their current values, in line with the Global Fuel Economy Initiative (GFEI) target[33], which generally translates to an emission standard of around 70 gCO_2/vkm by 2030.
(2) Equal to (1), but EV deployment starts in 2020 and reaches a share of 50% of a country's LDV fleet by 2050.

We made the calculations in Box 1 on the emission increase resulting from generation of electricity for EVs as follows:

- We calculated the emission factor of electricity (gCO_2 / kWh) from the IEA WEO 2015 New Policies Scenario[34] by year and country. This data was available until 2040 with linear interpolations being done for the years in between.
- Extrapolation to 2050 was done using the linear trend of the emission factor between 2020 and 2040. We assumed an average electricity consumption of 0.2 kWh/km for EVs[35].
- Subsequently, the total emissions resulting from the EV deployment under Scenario II were calculated and added to the total fleet emissions.

Comparison of 2°C / 1.5°C pathways

According to literature on 1.5°C pathways, such as i.e. Rogelj et al. (2015)[36], worldwide CO_2 emissions from energy and industry would have to reach zero around 2050 to stay within a 50% chance of returning warming to below 1.5°C by 2100. Assuming an average car lifetime of 15 years, this implies that the last ICE vehicle would have to be sold roughly in 2035. Note that the 2050 timeframe refers to global emissions; realistically speaking, this timeline would have to be shortened for developed countries, to give other regions more time to develop, along with financial support from developed to developing countries.

ANNEX B: OTHER COUNTRY-LEVEL RESULTS

These graphs show the results of the same model outcomes as presented in These graphs show the results of the same model outcomes as presented in Figure 3 for the EU and China for the remaining five countries analysed. It can be seen that under Scenario 1, total LDV emissions would eventually start increasing again in all countries except Japan, as activity levels are projected to keep rising. Only under Scenario 2 do they stabilise in most countries.

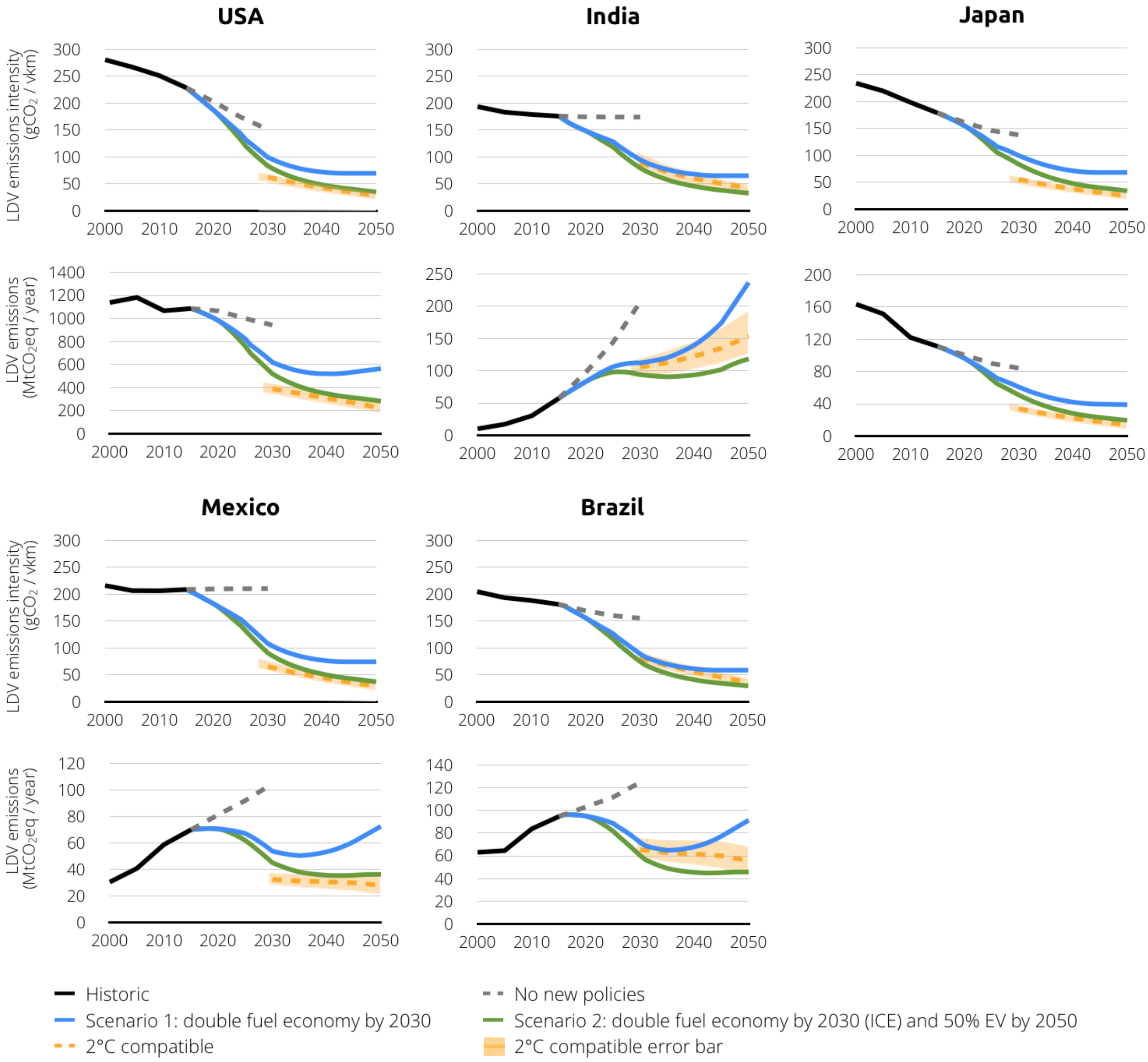

Figure 3 - Emission intensities and TTW emissions of LDVs in the US, India, Japan, Mexico and Brazil under implementation of more stringent emission standards and up to 50% share of electric vehicles by 2050.

AUTHORS

NewClimate Institute
Sebastian Sterl
Takeshi Kuramochi
Markus Hagemann
Sofia Gonzales-Zuñiga

Ecofys
Karlien Wouters
Yvonne Deng

Climate Analytics
Jasmin Cantzler
Andrzej Ancygier
Marcia Rocha
Matt Beer

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ENDNOTES

[1] Climate Analytics, http://climateanalytics.org/publications/2015/timetables-for-zero-emissions-and-2015-emissions-reductions.html

[2] US Environmental Protection Agency, https://www3.epa.gov/climatechange/ghgemissions/global.html

[3] BBC, http://www.bbc.com/news/business-34324772

4 Rogelj, J., Luderer, G., et al., 2015. Energy system transformations for limiting end-of-century warming to below 1.5°C. *Nature Climate Change,* 5, pp. 519-527.

[5] Which are zero-emission vehicles if powered by zero-emission electricity.

[6] Forbes, http://www.forbes.com/sites/brookecrothers/2016/04/15/with-tesla-model-3-orders-nearing-400000-chevy-bolt-feels-heat-of-tesla-brand/#526992665349

[7] NRC, http://www.nrc.nl/nieuws/2016/03/29/tweede-kamer-neemt-omstreden-motie-over-elektrische-autos-aan ;
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[8] Reuters, http://www.reuters.com/article/us-norway-autos-idUSKCN10R1J5

[9] EU Observer, https://euobserver.com/environment/133833

[10] 2°C scenarios that have a 66% chance, or greater, of staying below a 2°C global mean warming above pre-industrial levels throughout the 21st century

[11] GFEI, http://www.globalfueleconomy.org/. The GFEI target is doubling the fuel economy of new cars by 2030, and of the entire fleet by 2050.

[12] Roughly in line with the IEA ETP 2014's estimation of the global vehicle portfolio in their 2DS (2°C scenario). Here, EVs and FCEVs reach 40% share in the fleet by 2050, and hybrids another 35%, of which a smaller percentage could be counted as effectively EV.

[13] Along the same lines, this has implications for policymaking related to public transport: the load factor of conventional forms of public transport is much higher than for personal vehicles. In terms of the emission intensity (gCO_2/vkm) indicator, the effect of a higher load factor is thus to relax the requirements to reach a 2°C pathway, as one vehicle-kilometre from a bus will cater to a higher share of the demand for transport than one vehicle-kilometre from a personal car.

[14] Climate Analytics, http://climateanalytics.org/publications/2015/timetables-for-zero-emissions-and-2015-emissions-reductions.html

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[21] ICCT, http://www.theicct.org/global-transportation-roadmap-model

[22] For instance, cars added to the EU fleet between in 2015 are assumed to emit 130 gCO_2/vkm, the emission standard applicable from 2015 onwards. This is assumed to linearly decrease to the 2021 target of 95 gCO_2/vkm during 2015-2021.

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[29] Krabbe, O. et al., 2015. Aligning corporate greenhouse-gas emissions targets with climate goals. *Nature Climate Change*, 5(12), pp.1057–1060. Available at: http://dx.doi.org/10.1038/nclimate2770

[30] Such 2°C pathways can be based on the activity assumptions in the ETP and the ICCT, respectively. Basing it on ETP numbers is slightly more stringent taken across the period 2020-2050, which is why we use it here.

[31]This factor does not take EVs into account, where TTW emissions are, by definition, zero. In this sense, it cannot be indiscriminately used to construct a "2°C compatible pathway for any LDV "fleet" if that fleet includes EVs, as the conversion factor would be different. However, as we assume in our analysis that EVs are powered by 100% renewable electricity (i.e. their WTW emissions are zero as well), the factor of 81% *is* consistent with our Scenario 2.

[32] Clarke, L. et al., 2014. *Assessing Transformation Pathways. IPCC [Edenhofer; O.; R. Pichs-Madruga; Y. Sokona; E. Farahani; S. Kadner; K. Seyboth; A. Adler; I. Baum; S. Brunner; P. Eickemeier; B. Kriemann; J. Savolainen; S. Schlömer; C. von Stechow; T. Zwickel and J.C. Minx (eds)]*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter6.pdf

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