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2020–2030 CO_2 standards for new cars and light-commercial vehicles in the European Union

New passenger cars and light-commercial vehicles (vans) in the European Union (EU) are currently subject to mandatory carbon dioxide (CO_2) standards up to the year 2020/21. The European Commission is preparing to extend the light-duty vehicles' CO_2 regulation out to the 2025–2030 timeframe. In that context, it is useful to review overall vehicle CO_2 emission reduction requirements, on one hand, and vehicle-specific CO_2 reduction technology potential and cost on the other. Those topics are the subject of this briefing paper.

CO_2 REDUCTION REQUIREMENTS

The EU has established a binding target for reducing its greenhouse gas emissions: 40% below 1990 levels by 2030.[1] For sectors not covered by the EU's emissions trading system, such as the transport sector, an average reduction in annual greenhouse gas emissions of 30% below a 2005 baseline is required by 2030. In the transport sector, CO_2 emissions from passenger cars, vans, and heavy-duty vehicles constitute by far the largest proportion of total greenhouse gas emissions.

Mandatory CO_2 emission standards for new vehicles have proved in practice to be an effective policy measure for controlling those emissions, but in Europe such standards are currently in place only for cars and vans. The EU is the only major vehicle market in the world without mandatory CO_2 emission standards for heavy-duty vehicles.[2]

1 European Commission, "2030 climate & energy framework," 2016, http://ec.europa.eu/clima/policies/strategies/2030/index_en.htm

2 European Commission, "A European Strategy for Low-Emission Mobility" (2016). https://ec.europa.eu/transport/sites/transport/files/themes/strategies/news/doc/2016-07-20-decarbonisation/com%282016%29501_en.pdf

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In 2014 in the EU, average new-car CO_2 emissions were 123 grams per kilometer (g/km) when measured in type-approval tests using the New European Driving Cycle (NEDC).[3] The gap between the emissions measured in laboratory-based type-approval tests on the NEDC and real-world emission levels in 2014 stood at around 38%, meaning that average CO_2 emissions under real-world driving conditions were not 123 g/km but rather 170 g/km.[4]

By 2021, average laboratory CO_2 emissions from new cars in the EU as measured on the NEDC must fall to 95 g/km.[5] Beginning in 2017, a new test procedure, the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) will be introduced to replace the NEDC. The 2021 CO_2 target of 95 g/km as measured on the NEDC is equivalent to approximately 109 g/km under the WLTP.[6] The transition to the WLTP should reduce the gap between official and real-world CO_2 emission levels to about 23%, so that the average real-world CO_2 emissions of new cars by 2021 will be around 134 g/km (Figure 1).[7]

In 2013, the European Parliament recommended an "indicative range" for a 2025 new-car CO_2 emission target of 68 to 78 g/km (in NEDC terms) and, if "duly justified," consideration of a lower target as well. [5]

If the EU set a 2025 target of 78 g/km (equivalent to approximately 90 g/km under the WLTP) and a 2030 target of 60 g/km (about 69 g/km in WLTP terms), the average real-world CO_2 emissions of new cars by 2030 would be about 90 g/km. This projection assumes that the gap between official and real-world CO_2 emission levels will increase from 23% to 31% between 2020 and 2030 as manufacturers exploit loopholes and flexibilities in the WLTP, such as those embedded in new options for determining road-load.[7] The resulting average 2014–2030 annualized CO_2 emission reduction rate for new cars would be 3.9%, and the overall reduction in annual CO_2 emissions for all passenger cars on the road between 2005 and 2030 would be 24% (Figure 1).

If the EU were to set a 2025 target for CO_2 emissions from passenger cars of 68 g/km (about 78 g/km under the WLTP) and a 2030 target of 42 g/km (about 48 g/km WLTP) and, in addition, were to complement the WLTP with a real-world testing procedure conformity factor to limit the gap between official and real-world CO_2 emissions to a maximum of 15%, the average real-world CO_2 emissions of new cars by 2030 would fall to about 55 g/km. The resulting average 2014–2030 annualized rate of reduction in CO_2 emissions from new cars would be 6.8%, and the overall reduction in annual CO_2 emissions for all passenger cars on the road between 2005 and 2030 would be 35% (Figure 1).

3 Peter Mock (ed.), *European Vehicle Market Statistics Pocketbook* (International Council on Clean Transportation: Berlin, 2015), http://eupocketbook.theicct.org.
4 Uwe Tietge et al., "From laboratory to road: A 2015 update" (International Council on Clean Transportation, TNO, and Institut für Energie- und Umweltforschung Heidelberg: Berlin, 2015), http://www.theicct.org/laboratory-road-2015-update
5 Peter Mock, "EU CO_2 standards for passenger cars and light-commercial vehicles" (International Council on Clean Transportation: Berlin, 2014), http://theicct.org/eu-co2-standards-passenger-cars-and-lcvs
6 Assuming an average conversion factor of 1.15, as explained in more detail in Joshua Miller. "Reducing CO_2 emissions from road transport in the European Union: An evaluation of policy options" (International Council on Clean Transportation: Washington DC, 2016), http://theicct.org/evaluating-policy-options-reducing-CO2-from-transport-EU
7 Alex Stewart et al., "Impact of real-world driving on emissions from UK cars and vans" (ElementEnergy and International Council on Clean Transportation, 2015) https://www.theccc.org.uk/publication/impact-of-real-world-driving-emissions/

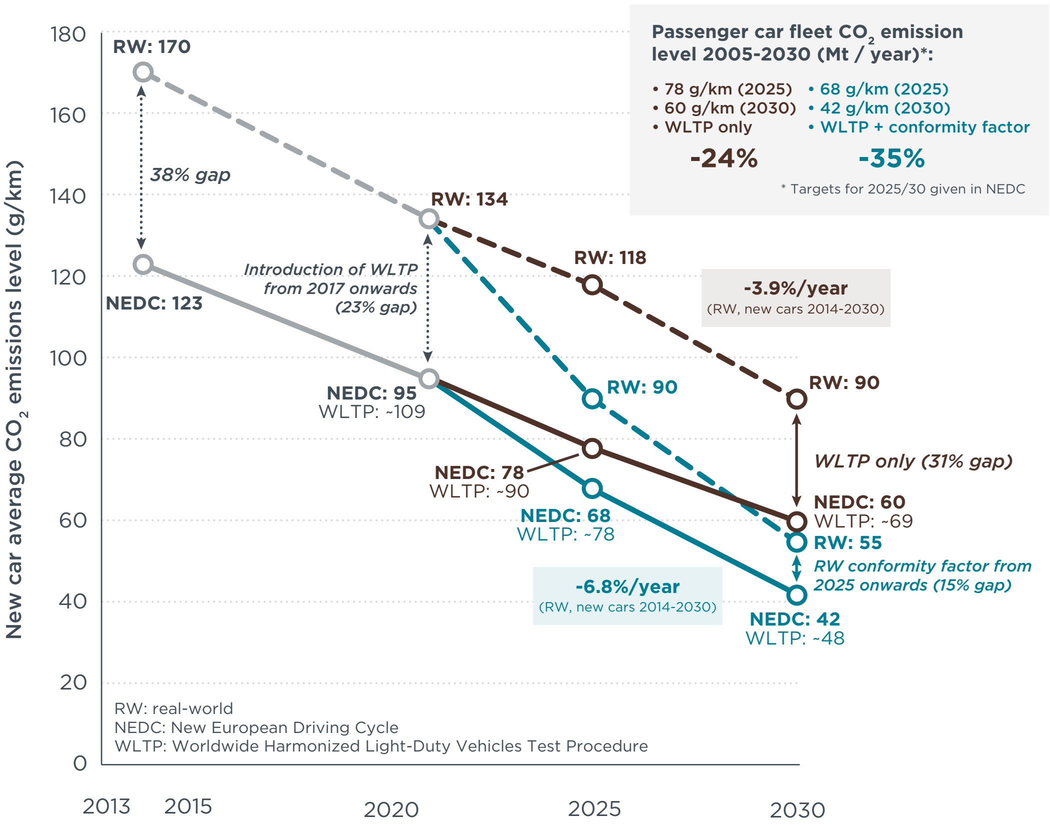

Figure 1. Schematic illustration of new car average CO_2 emission levels in the EU in the 2014–2030 timeframe, assuming a 3.9% per year and a 6.8% per year CO_2 reduction scenario.

A comprehensive set of policy measures including mandatory CO_2 standards for cars and vans, mandatory CO_2 standards for heavy-duty vehicles that require a 3.0% per year reduction rate beginning in 2020, and an increase in fuel taxes of 20 cents per liter in all EU member states would, we estimate, produce an overall annual CO_2 reduction of 14% by 2030 compared to a 2005 baseline, assuming a 2025 CO_2 standard for cars equivalent to 78 g/km as measured on the NEDC (about 3.9% annualized CO_2 reduction).[8] This would be about half of the required overall 30% reduction for the transport sector by 2030. If the 2025 CO_2 standard for new cars were set at 68 g/km (about 6.8% annualized CO_2 reduction), an overall reduction in annual CO_2 emissions from the transport sector of 22% could be achieved by 2030. This would be significantly closer to the 30% reduction from transport required to reach the EU's binding overall target, but still insufficient. Additional measures, such as a modal shift from road to rail, will be required (Figure 2).

8 Miller, "Reducing CO_2 emissions from road transport in the European Union: An evaluation of policy options," (n. 6).

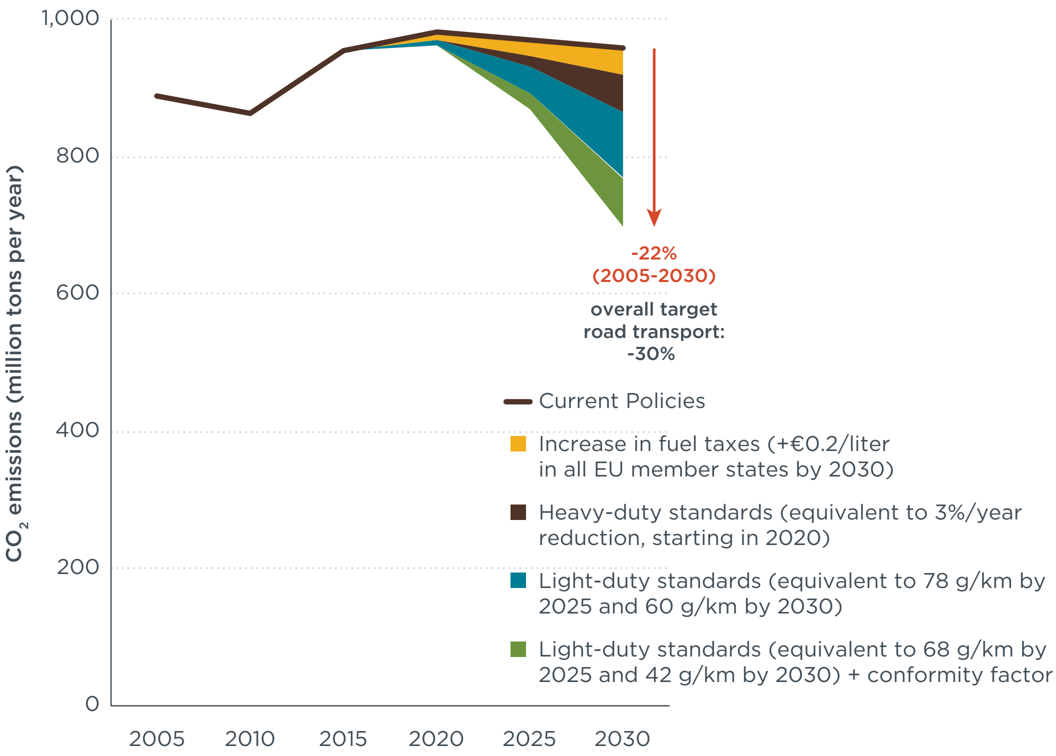

Figure 2. Annual CO_2 emissions from passenger cars, light-commercial and heavy-duty vehicles in the EU.

TECHNOLOGY CO_2 REDUCTION POTENTIAL AND COST

Mandatory CO_2 standards have stimulated the diffusion of innovative vehicle efficiency technologies and designs in the EU as in other markets. However, the extent to which the most advanced vehicle technologies, especially the most costly technologies, are needed for manufacturers to reach their CO_2 emission targets has been systematically overestimated, as have the final per-vehicle costs of meeting standards. For example, industry studies in 2003 and 2009 estimated that reducing average new-car CO_2 emissions to 120 g/km in the EU would cost €1,000-3,900 per vehicle and require hybrid-electric vehicles to exceed 20% of new vehicle sales. In reality, when officially measured new car CO_2 emissions fell to 123 g/km in 2014, the hybrid market share was below 3% and the average additional cost per vehicle was €200 (Figure 3).[9]

One reason for the discrepancy between ex-ante and ex-post technology assessments in the past has been the extensive reliance on industry stakeholder surveys to estimate technology potential and future costs. In setting its 2017–2025 light-duty vehicle CO_2 targets, the U.S. Environmental Protection Agency (EPA) instead used detailed computer simulation of CO_2 reduction technologies and bottom-up "tear-down" cost assessments of individual parts. This assessment method is more transparent and robust, though also more expensive and time-consuming.[10]

9 Paul Wolfram et al., "Deployment of passenger car technology in Europe and the United States" (International Council on Clean Transportation: Berlin, 2016) http://www.theicct.org/EU-and-US-PV-technology-deployment
10 U.S. Environmental Protection Agency, "Light-Duty Technology Cost Analysis Pilot Study – Peer Review Report" (2009), https://www3.epa.gov/otaq/climate/fev-peerreview-rpt.pdf

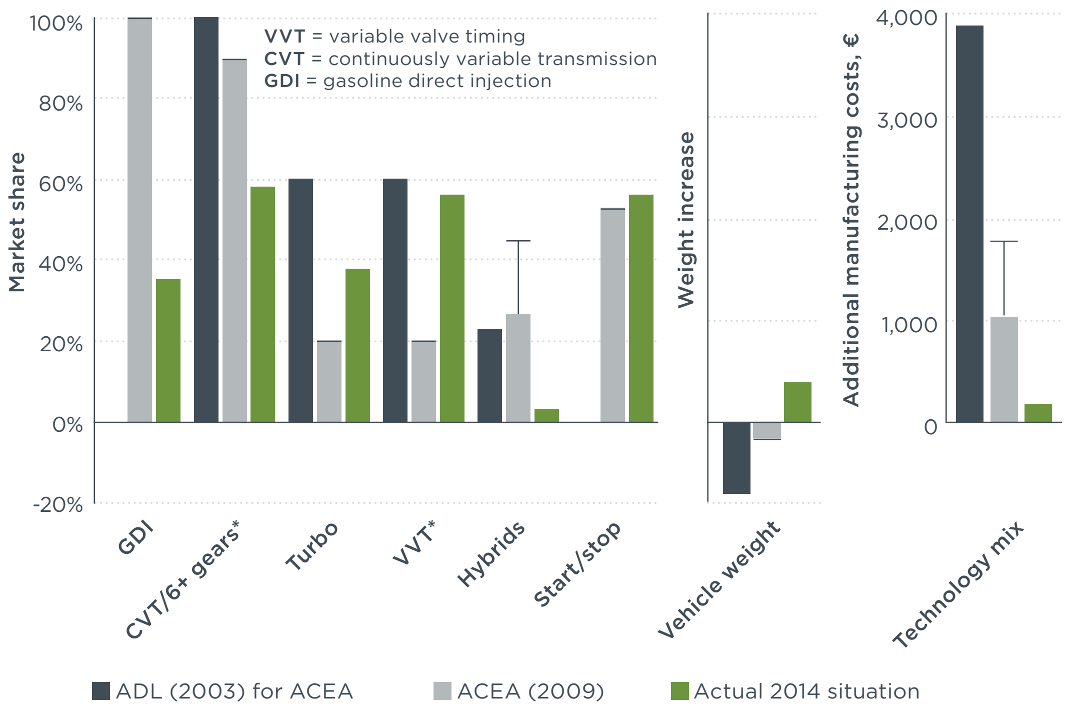

Figure 3. Comparison of ex-ante industry studies and actual ex-post assessment for meeting an average car CO_2 level of 120 g/km.[9] *Actual share for 2013.

The ICCT commissioned the German engineering services provider FEV to carry out similar detailed computer simulations and bottom-up cost estimates for individual technologies and technology packages that can help to reduce CO_2 emissions of European passenger cars and vans in the 2025 timeframe.[11] ICCT supplemented the raw powertrain data results provided by FEV with estimates of the cost-benefit effects of improvements in road-load reduction (reducing vehicle weight plus rolling resistance and aerodynamic resistance), indirect costs and learning out to 2030, type-approval test procedure flexibilities and performance-based adjustments (for a lower-bound scenario only), off-cycle technologies (lower-bound scenario only), and electric vehicles.[12] This section encapsulates that analysis.

A 2014 baseline was used for the FEV/ICCT analysis, i.e., reflecting the 2014 average EU vehicle market situation as closely as possible in terms of vehicle segment and technology market shares. The analysis assumed that the split between vehicle segments and also vehicle driving performance characteristics within each segment would remain constant between 2014 and 2030, which served to exclude the impact of any potential shift in consumer preferences over time.

Vehicle technologies covered in the FEV/ICCT 2014–2030 analysis include direct injection, single-stage and two-stage turbocharging combined with engine downsizing, variable valve-lift and timing, cam-profile switching, exhaust-gas recirculation, cooled exhaust-gas recirculation, two-stage and fully variable compression ratio, Miller/Atkinson Cycle, low-friction design, 12-volt start-stop technology, 48-volt belt starter-generator, full-parallel P2 hybrid, 7-speed and 10-speed dual-clutch transmissions, vehicle mass reduction up to a maximum of 20%, 35% rolling-resistance reduction, 20% aerodynamic drag reduction, plug-in hybrid, battery electric, and fuel-cell electric

11 FEV, "2025 Passenger Car and Light Commercial Vehicle Powertrain Technology Analysis" (2015), http://www.theicct.org/2025-passenger-car-and-light-commercial-vehicle-powertrain-technology-analysis

12 Dan Meszler et al., "CO_2 reduction technologies for the European car and van fleet, a 2025-2030 assessment" (International Council on Clean Transportation: Berlin, 2016), http://www.theicct.org/co2-reduction-technologies-european-car-and-van-fleet-2025-2030-assessment

vehicles. For purposes of estimating costs, the analysis assumed for all non-electric vehicle technologies that 77% were manufactured in the Western EU countries and 23% in Eastern EU countries, a split that reflects the current production network situation in Europe. Drawing on a previous review of technology cost estimates for electric vehicles, the analysis assumed that direct manufacturing battery costs for battery electric vehicles at the battery pack level would fall to €100 per kilowatt-hour (kWh) by 2030 in a lower-bound scenario, and 160 €/kWh in an upper-bound scenario.[13]

Based on that analysis, we estimate that a passenger vehicle CO_2 standard of 70 g/km (measured on the NEDC) would require few or possibly no electric vehicle sales. The range of combustion engine technologies, including 48-volt belt starter-generator and full parallel P2 hybrid electric vehicles, is sufficient to reduce the fleet average CO_2 emissions to that level. The average per-vehicle cost increment to reach that target, including indirect costs but excluding taxes, would fall between €1,000 and €2,150 in 2025, compared to the 2014 baseline (Figure 4).

A passenger car standard of 40 g/km (in NEDC) could be achieved by 2030 at an average per-vehicle cost increment of between €1,600 and €3,000. Reaching that target would require that electric vehicles make up a large share of new-vehicle sales (Figure 4).

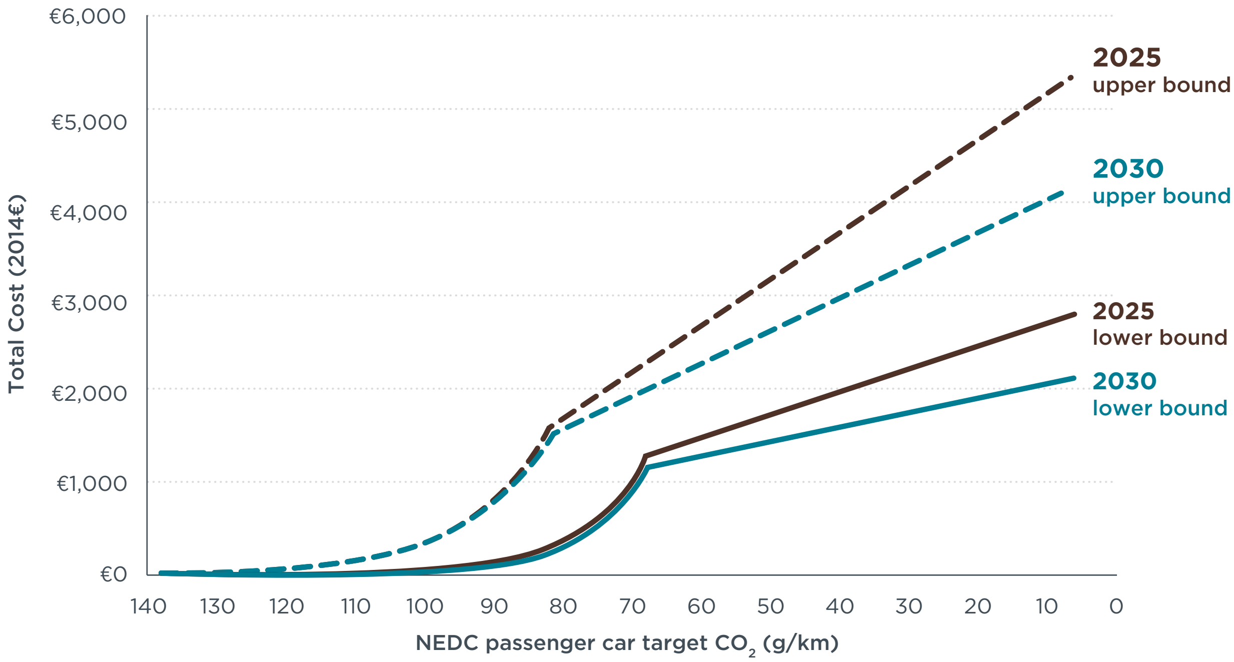

Figure 4. Total incremental cost (including indirect costs but excluding taxes) of reducing the CO_2 emissions of the average passenger car in the EU by 2025 / 2030 in an upper- and a lower-bound scenario, assuming full deployment of combustion-engine technologies before transitioning to electric vehicles.

Two manufacturer compliance strategies were analyzed. Under the first, combustion-engine technologies are deployed until (from a present-day point of view) no further reduction in CO_2 emissions can be gained and it becomes impossible to meet a declining new-car CO_2 emissions limit without abruptly shifting manufacturing focus to electric vehicles. In that case, the incremental per-vehicle technology deployment cost towards the end of the combustion engine part of the cost curve is relatively high (Figure 5). Under the second, manufacturing transitions from combustion-engine to electric

13 Paul Wolfram and Nic Lutsey, "Electric Vehicles: Literature review of technology costs and carbon emissions" (International Council on Clean Transportation: Washington DC, 2016), http://www.theicct.org/lit-review-ev-tech-costs-co2-emissions-2016

vehicles at an earlier point. This reduces the compliance cost in the intermediate time frame. The optimal transition point minimizes technology deployment cost at any time, leaving aside any potential market barriers such as availability of infrastructure and customer acceptance.

Switching to electric vehicles earlier and following a least-cost technology strategy, rather than exhausting the full potential of combustion-engine technologies, would reduce the costs of meeting a 70 g/km (NEDC) CO_2 emissions target by €200 to €500 per vehicle in 2025 (Figure 5).

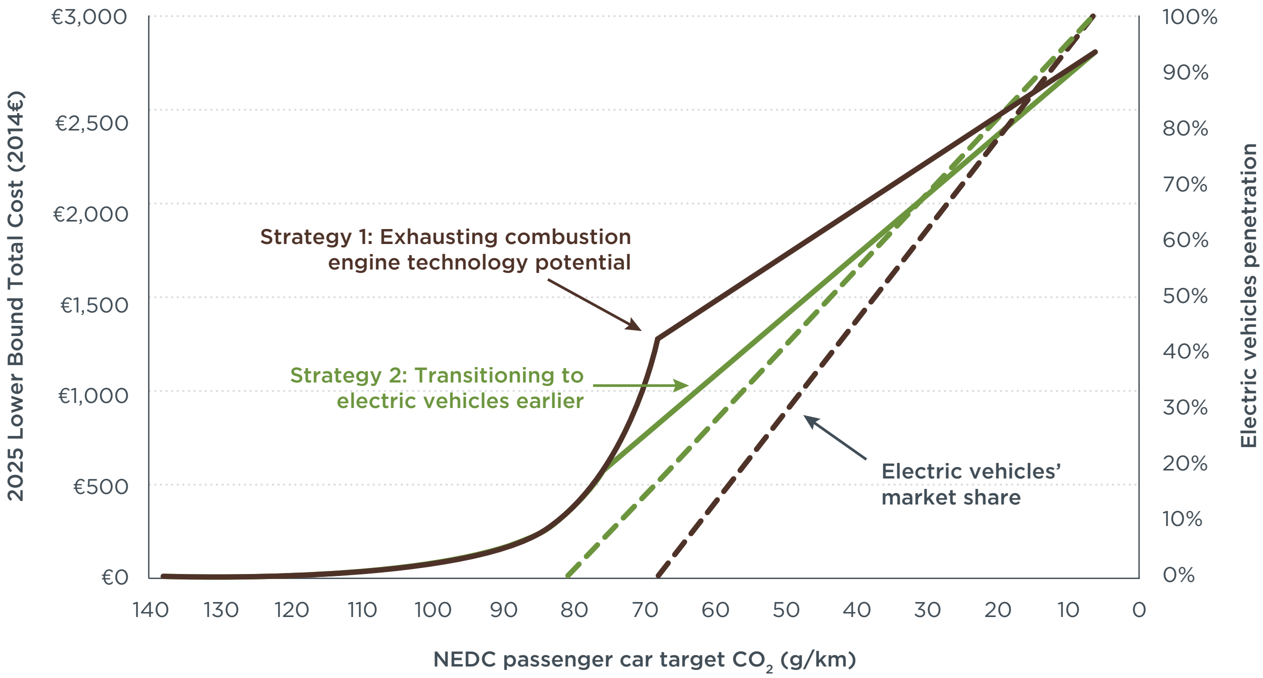

Figure 5. Total incremental cost (including indirect costs but excluding taxes) of reducing CO_2 emissions of the average passenger car in the EU by 2025 in a lower-bound scenario, comparing full deployment of combustion engine technologies before transitioning to electric vehicles to a least-cost strategy of transitioning to electric vehicles earlier.

The analysis found the average consumer-payback period (the point at which the initial cost increment of efficiency technology is offset by cumulative savings on fuel costs) of a 70 g/km (NEDC) 2025 target to be less than four years in the upper-bound scenario and less than three years in the lower-bound scenario, assuming an average fuel price of €1.50 per liter and annual vehicle distance traveled of 15,000 kilometers.

For numerically identical WLTP CO_2 standards, compliance costs will be higher than for NEDC-based type approval, but the cost difference will decline over time because electric vehicles are credited with very low CO_2 emissions under both driving cycles.

With respect to light-commercial vehicles, CO_2 standards as low as 90–100 g/km (NEDC) can be achieved with few or no electric vehicles in the new-vehicle market. A CO_2 target of 110 g/km (NEDC) in 2025 will lead to an average cost increment of €1,000 (lower bound) to €3,000 (upper bound) per vehicle, while a 90 g/km (NEDC) standard in 2025 will cost on average between €2,500 and €4,000 per vehicle. Costs would be €250 to €1,000 lower when pursuing a least-cost technology pathway and transitioning to electric vehicles earlier.

Compliance costs for individual manufacturers will differ from these average fleet values, as will the technology mix each manufacturer ultimately adopts. Also, compliance cost estimates in this analysis assumed technology neutrality of the CO_2 target system—in particular, they assume no disincentive for vehicle light-weighting, although the current vehicle mass-based CO_2 target system in the EU does in fact impose such a disincentive on manufacturers.

The analysis did not consider either genuinely new technology developments or future optimization of existing technologies through product redesigns that take advantage of evolving knowledge. Consequently, these cost curves represent conservative estimates; actual costs are likely to be lower.

A rough comparison of the FEV/ICCT cost curves for the 2025 time range (labeled [ICCT, 2016] upper/lower bound in Figure 6) to other available estimates shows them to be slightly lower than the interim results of a study for the European Commission[14] (labeled [AEA, 2015] upper/lower bound) and less than a third of the outcome of a study for the German Ministry for Economics[15] (labeled [IKA, 2015]). This is similar to earlier estimates for the 2020 time range, where the ICCT results [ICCT, 2013][16] were slightly below those of European Commission consultants' [TNO, 2011] and significantly below those obtained by a study for the German Ministry for Economics [IKA, 2012]. For 2015, the actual compliance costs [AEA, 2015] were about one-third of the original estimates for the European Commission [TNO, 2006] and about one-fifth of estimates from the European vehicle manufacturers' association [ACEA, 2009].

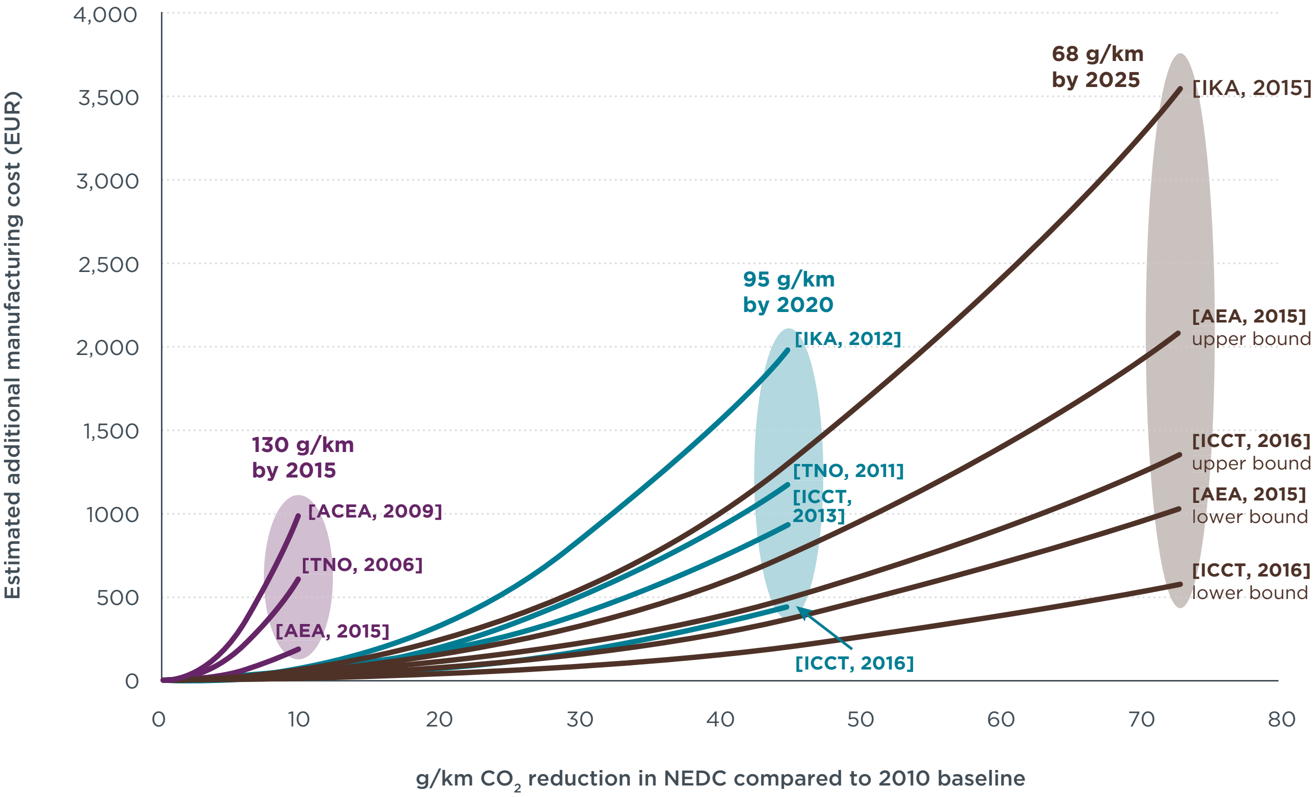

Figure 6. Schematic illustration of various technology cost curve studies for the EU's passenger vehicle fleet for the 2015, 2020 and 2025 time range.

14 Ricardo-AEA, "Improving understanding of technology and costs for CO_2 reductions from cars and LCVs in the period to 2030 and development of cost curves," 28 July 2015 draft version, distributed at a stakeholder workshop of the European Commission DG CLIMA

15 Institut für Kraftfahrzeuge, "CO_2-Emissionsreduktion bei Pkw und leichten Nutzfahrzeugen nach 2020," http://www.bmwi.de/DE/Mediathek/publikationen,did=686692.html

16 International Council on Clean Transportation, "CO_2 Reduction Technologies For The European Car And Van Fleet: A 2020–2025 Assessment" (ICCT: Washington DC, 2013), http://www.theicct.org/series/co2-reduction-technologies-european-car-and-van-fleet-2020-2025-assessment