BRIEFING

JANUARY 2013

Reducing CO_2 and fuel consumption from new cars: Assessing the near-term technology potential in the EU

1. EFFECT OF THE EU-CO_2 REGULATION

The average CO_2 emissions level of new cars in the EU (as reported by car manufacturers) decreased from 170 grams per kilometer (g CO_2/km) in 2001 to 136 g/km in 2011—a 20 percent reduction in 10 years (Fig. 1) [1]. As CO_2 emissions and fuel consumption are directly related to each other, this CO_2 emissions reduction can be expressed as a reduction in fuel consumption from roughly 7.0 litres per 100 kilometre (l/100km) to 5.6 l/100km.

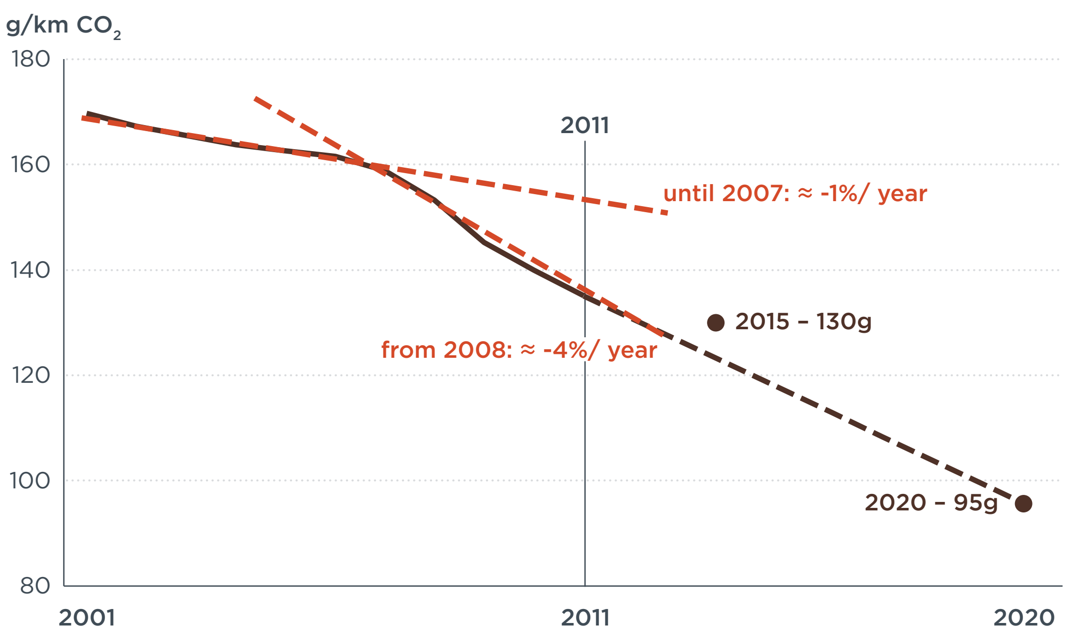

Fig 1: Average CO_2 emission levels for new passenger cars in the EU.

1 http://www.eea.europa.eu/publications/monitoring-co2-emissions-from-new

When looking closer, two distinct periods can be identified: Up until about 2007—under the industry's voluntary reduction agreement—the annual reduction rate was about one percent per year. From 2008 to 2011, the rate of reduction increased significantly, to about four percent per year. A similar trend can also be found for the individual vehicle segments, indicating that the EU-wide mandatory CO_2 regulation—that was agreed in 2008 - is a key driver behind these developments and is proving to be an effective instrument to increase vehicle efficiency.

EU Member States differ greatly in emissions reductions. This is effectively shown by the example of the Netherlands and Germany: in 2003, both countries' average car emissions were at a similar level of 174 and 176 g/km respectively. Since 2007, however, emissions in the Netherlands have been reducing much faster than in Germany, decreasing to 126 g/km in 2011 compared to Germany's 146 g/km, making cars in the Netherlands amongst the most efficient in the EU. Furthermore, around ten times as many hybrids are registered in the Netherlands as in any other EU Member State[2]. This can be primarily attributed to the reorganization of the vehicle tax system to one based upon CO_2 emissions, along with the granting of tax-breaks to alternative powertrains, both of which have changed Dutch purchasing habits.

The automobile industry as a whole had nearly reached its target of 130 g/km in 2011, four years ahead of the 2015 target-date, while some manufacturers (e.g. Toyota & Peugeot-Citroën) have already met their target. Others have announced their plan to meet or even (voluntarily) exceed their 2015 targets ahead of time (e.g. Daimler & VW)[3]. Assuming the current trend of annual CO_2 emissions reductions of 4 percent or more continues, the proposed 2020 target of 95 g/km will be reached on schedule. This reduction would also comply with long-term CO_2 emissions reductions goals in the transport sector as proposed in the *EU Transport White Paper*[4].

2. TECHNOLOGY POTENTIAL ASSESSMENT

Only around 15-20 percent of the energy in fuels is used to drive a car. The rest is rejected unused into the car's surroundings as waste heat or other losses. Thanks to advanced technologies, these losses are being reduced, step by step. Many already existing technologies, along with technologies that are not yet in mass production, are available to further improve the efficiency of cars.

In recent years, we have seen a leap forward in assessing the future CO_2 emission reduction potential of vehicle technologies, and with assessing the investment costs associated with these new technologies. In the US, ICCT, together with the Federal Environmental Protection Agency (EPA) and the California Air Resources Board (CARB), has been working on a large research program to estimate the potential of various technologies in reducing CO_2 emissions using extensive computer siumulations along with *tear-down* cost studies on real vehicles.

For the *tear-down* cost studies, established vehicle technologies are compared to innovative technologies and both are broken down to the individual parts level (Fig. 2). In most cases, the innovative technologies differ from their standard predecessors

2 http://www.theicct.org/european-vehicle-market-statistics-2012
3 http://www.theicct.org/blogs/staff/eu-car-manufacturers-likely-meet-2015-co2-target-early
4 http://ec.europa.eu/transport/themes/strategies/

in only a relatively few components. For the additional or revised components, a detailed physical and chemical analysis is then carried out to determine any necessary changes to materials and production processes. This approach allows for a thorough and transparent assessment of the cost of a technology when being produced in high volume. It mirrors a similar approach generally used by manufacturers and suppliers in the automotive industry and delivers much more reliable results than earlier cost-estimation methods based upon surveying experts.

Fig. 2: Example of a tear-down cost analysis of a transmission system.

Building on the results of the US analyses, ICCT commissioned additional studies specifically for the European vehicle market, carried out by the engineering consultants Ricardo Inc., FEV Inc. and the University of Aachen, using European baseline vehicles and European vehicle technologies. It was assumed for the cost study that all new technologies would be produced in Germany at typical German materials and labour costs[5].

The results of the study show that to reach the 95 g/km target by 2020, an investment in new technology of less than €1000 per vehicle is necessary (Fig. 3). These cost estimates are expected to be conservative, as they assume German labor cost rates and do not incorporate any further technology improvements beyond what is known today.

5 http://www.theicct.org/eu-cost-curve-development-methodology

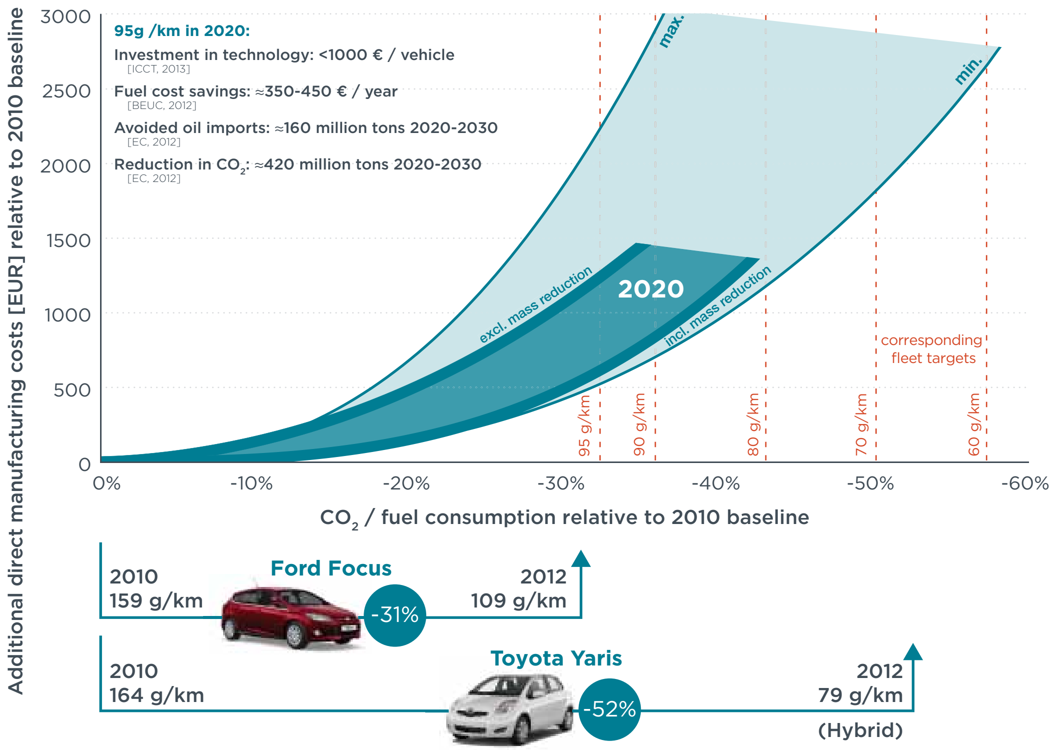

Fig. 3: CO_2 reduction cost curve for the European passenger cars market, based on vehicle computer simulation and tear-down cost assessments. Reference year is 2010—costs for reference year 2015 (130 g/km) are lower[6].

The Ford Focus, one of the top-5 most popular cars in Europe, is a real-world example for some of the technologies that will likely be used to meet the 95 g/km target by 2020. The 2012 vehicle has a smaller, turbocharged engine, makes use of Gasoline Direct Injection, and applies a Start-Stop system. The result is a vehicle that has about 30 percent lower CO_2 emissions in 2012 than it had in 2010, without any reduction in vehicle weight and while maintaining all vehicle performance characteristics. The 2012 version of the Audi A3—having the same vehicle platform as the VW Golf—emits 29 percent less CO_2 emissions than the 2010 version of the vehicle, using similar technologies plus a dual-clutch automated manual transmission. In order to reach the 95 g/km target in 2020, a 32 percent reduction compared to 2010 (27 percent compared to the 2015 target value) is required for the total vehicle fleet. This reduction has been met by both vehicles—the Ford Focus and Audi A3—already in 2012.

The Toyota Yaris hybrid is an example of the improvements possible with the application of further technologies. The 2012 Yaris hybrid emits—due to the fuel saving potential of the combination of internal combustion and electric motor—50 percent less CO_2 than its conventional counterpart from 2010. Through the application of mass reduction technologies, further improvements are possible.

Considering the entire fleet, meeting the 95 g/km target is expected to require few hybrid vehicles. Nevertheless, it is expected that some manufacturers will

6 The curve "excl. mass reduction" shows the expected compliance costs in a regulatory system that *fully* discounts mass reduction, the curve "incl. mass reduction" the costs in a technology-neutral system.

develop hybrids and other alternative powertrains according to their specific fleet composition and/or due to more long-term strategic considerations.

Taking current fuel prices and distances driven, the European consumers' organisation BEUC calculated that a target of 95 g/km would result in annual fuel-cost savings of approximately €350-450 per vehicle[7]. For the consumer, as well as for society as a whole, significant savings over the lifetime of a vehicle can therefore be expected—even taking into account indirect technology costs and vehicle taxes.

In the absence of CO_2 regulations, the necessary technical improvements are likely to be introduced at a much slower rate. This is due to the so-called *energy paradox*, a market-failure whereby car buyers—due to uncertainties with respect to in-use fuel consumption, future fuel prices and the distances they (will) drive—choose a lower-specified vehicle than that which would be economically optimal for their requirements. It is at this point that CO_2 regulations take effect, creating planning security for all manufacturers and leading to significant macroeconomic savings.

This manifests itself in negative CO_2 abatement costs, where the fuel savings more than pay for the cost of reducing CO_2. The EU Commission calculates a negative cost of -€80 to -300 per tonne of avoided CO_2 for the 95 g/km target[8]. In other words, for every tonne of CO_2 *not* emitted or every litre of fuel *not* used, the EU saves further money. Altogether, the European Commission expects avoided oil imports in the order of 160 megatons between 2020 and 2030, a saving around €70 billion Euro. Moreover, current studies show a positive effect upon employment as well[9].

From the international point of view, it is notable that a few years ago the EU was the clear front-runner in automobile CO_2 emissions reductions. In the meantime, all significant markets worldwide have introduced binding CO_2 targets for new cars, with converging target values. The US has recently introduced regulation dictating a reduction of approximately 50 percent compared to 2010 by 2025 (Fig. 4).

7 http://www.beuc.org/custom/2012-00461-01-E.pdf
8 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012SC0213:EN:NOT
9 http://www.daimler.com/dccom/0-5-1380319-49-1381876-1-0-0-0-0-1-8-876574-0-0-0-0-0-0-0.html, as well as Cambridge Econometrics (preliminary unpublished results)

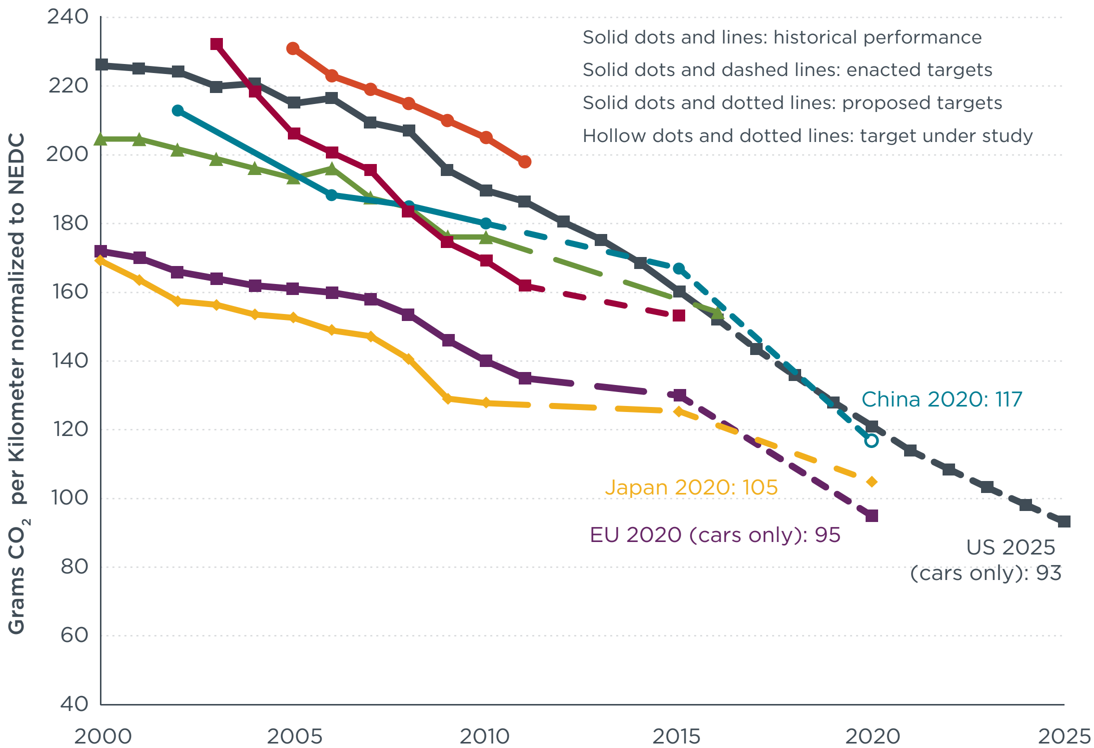

Fig. 4: Comparison of worldwide automobile CO_2 regulations.

3. CHOICE OF THE INDEX PARAMETER

The heavier a car is, the greater its fuel consumption and CO_2 emissions. Mass reduction is therefore an effective measure to reduce a car's emissions. However the current EU CO_2 target system offers little incentive to reduce the mass of vehicles: the lighter a manufacturer's fleet, the lower its assigned CO_2 target. If the manufacturer reduces the mass of its vehicles, it must then also achieve a lower g/km target. This evaporates most of the manufacturer's weight-reduction advantage, and it will usually pursue other alternatives to reduce CO_2 emissions (Fig. 5). In the last 10 years, the weight of new cars in the EU has grown by an average of 1 percent per year.

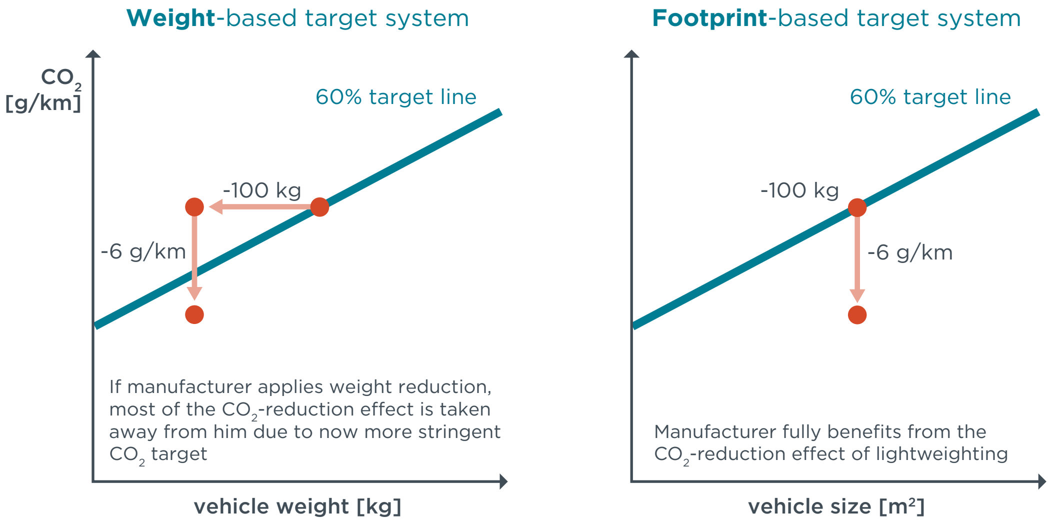

Fig. 5: Weight reduction in the current weight-based CO_2 target system (left) and in a size based system (right).

The restriction of the manufacturers' choice of technology has its price: calculations show that in a technology-neutral target-system, the investment necessary to reach the 95 g/km target is up to 40 percent lower compared to the current weight-based system[10]. The best alternative parameter is the vehicle size, defined as its *footprint*[11]. A *footprint* based CO_2 target system ensures, as per a weight-based system, that the current vehicle diversity is retained. In contrast to weight, however, *footprint* does not discriminate against weight reduction, and thus increases manufacturers' flexibility to choose appropriate measures, leading to lower costs and greater savings for customers and society.

It is expected that with improved computer simulation of crash-tests, the use of lightweight materials will become much more feasible and will be accomplished without increasing fatalities. Increased electrification of vehicles is another factor that will necessitate weight reduction, as lighter vehicles will have increased range for any given battery size.

At the same time, manufacturers need sufficient time to reconfigure their product ranges to a *footprint*-based system. A *dual-compliance* approach could provide a suitable solution: each manufacturer would be free to choose between a weight or size based target for 2020, after which—beyond 2020—they would be assigned a *footprint* based target. Unlike a few years ago, data on cars' *footprint* is now collected on a routine basis and is available in detail to allow for compliance to be based on vehicle footprint.

10 ICCT Working Paper 2013-1 to be published shortly on http://www.theicct.org/policies/eu-light-duty-vehicle-co2-regulation
11 http://www.theicct.org/evaluation-parameter-based-vehicle-emissions-targets-eu

4. FURTHER MEASURES

In a similar way, manufacturers should be given sufficient time to prepare for future CO_2 targets. Studies such as the ICCT EU cost curve work already provide the information needed to estimate technical and economically sensible CO_2 targets for 2025. These can then be evaluated for their plausibility at a later point in time in form of a *review* based upon the latest technical knowledge and economic developments.

A CO_2 regulation's effectiveness can be greatly enhanced by the introduction of a complimentary CO_2 based tax system and effective vehicle labelling. Both measures will have the effect of making it easier for manufacturers to sell more efficient cars. Such a change to a vehicle tax system has recently been successfully introduced in The Netherlands for example.

Furthermore, the test cycle and test procedure must be appropriately specified to ensure correlation between laboratory-test and real-world CO_2 values in the future[12].

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12 http://www.theicct.org/blogs/staff/eu-consumer-organizations-asking-more-realistic-vehicle-testing