THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Road transport in the EU Emissions Trading System: An engineering perspective

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Executive Summary

The introduction of mandatory CO_2 standards for passenger cars in the European Union led to a significant decrease in the level of CO_2 emissions for new vehicles, as well an increased deployment of vehicle efficiency technologies. This paper assesses the effect on technology innovation and deployment if mandatory CO_2 standards in the EU were replaced by including road transport in the EU Emissions Trading System (ETS). It is concluded that to reach a similar level of technology innovation as expected for the EU's 2020/21 CO_2 target of 95 grams per kilometer a price of about €370 per ton of CO_2 would be required (current price: €5).

1. Looking back: The EU CO_2 performance standards for passenger cars

The European Union (EU), like other major vehicle markets, relies on performance standards to drive down carbon dioxide (CO_2) emissions from new passenger cars. The EU regulation, introduced in 2009, has proven effective: average new-car CO_2 emissions fell from 170 grams per kilometer (g CO_2/km) in 2001 to 127 g/km in 2013, a 25 percent reduction in 12 years, largely attributable to the existence of a mandatory limit imposed by regulation (ICCT, 2014a). The annual rate of improvement in that average increased from around 1 percent in the years leading up to 2007, before the regulation, to around 4 percent after 2008, with the result that the 2015 emission target of 130 g CO_2/km was met two years in advance (EEA, 2014).

The EU CO_2 performance standard, together with CO_2-based vehicle taxation schemes in some EU Member States, turned out to be a strong driver for technology innovation and penetration. Prominent examples include highly efficient turbocharged gasoline engines and engine stop-start technology. In both cases, the new-vehicle market penetration in 2007, before adoption of the CO_2 regulation, was around 5 percent but increased to more than 30 percent by 2013. Similarly, in 2007 only one in three new cars was equipped with an energy-saving transmission with six or more gears. By 2013, two-thirds of new cars in the EU made use of such a technology (ICCT, 2014b).

2. Looking forward: Are there any other options for the future?

Given the record of success of the current CO_2 performance standards, the European Parliament and the EU Member States in November 2013 extended the regulation, setting a new target of 95 g CO_2/km for 2020/21 (ICCT, 2014c). Moreover, by the terms of the EU 2030 climate and energy policy framework, the European Commission must submit a report to the European Parliament and Council by the end of 2015 that will set the regulatory framework for further reducing vehicle CO_2 emissions after 2020/21. In April 2013, the Environment Committee of the European Parliament voted for a 2025 CO_2 target range of 68–78 g/km, which gives an indication of the target level to be expected (Mock, 2013).

Regardless of the target level(s), the general consensus among regulators of Europe's automotive sector seems to be that the existing system of vehicle emission standards has proven effective and that it should be continued. However, recently there is some debate around replacing or supplementing these standards with a cap-and-trade system, specifically the EU Emissions Trading System (ETS)[1]. The starting point of this debate was a decision of the European Council at its October 2014 meeting, stating that "a Member State can opt to

1 In this paper we focus on a scenario where the current system of mandatory CO_2 performance standards would be replaced by ETS. If, instead, ETS would be implemented to complement a CO_2 standard, this would most likely lead to a weakening of the CO_2 target values and a shift more towards the mechanisms of an ETS system. The effects would therefore be the same as the ones described in this paper, although to a somewhat lesser extent.

include the transport sector within the framework of the ETS" (EC, 2014).

On the one hand, the proponents of including the transport sector in the ETS argue that CO_2-reduction technologies for vehicles are relatively expensive and that ETS would help to create an efficient market in which CO_2-reduction measures are implemented in other sectors, where there is more abatement potential at lower costs. The opponents, on the other hand, argue that there are a number of cost-efficient technologies and other measures to reduce CO_2 in the transport sector, but that mainstream customers severely discount the value of the future fuel savings, which prevents these measures from being implemented. CO_2 standards then are an effective way to bridge the gap between the value of future fuel savings (and the related CO_2 emissions) to society and their value to mainstream customers, whereas relying on ETS would result in a standstill of technology innovation in the automotive sector.

Essentially, this is another episode in a long-running debate in economics over the relative merits of market measures and mandatory standards, in particular with respect to what is known as the "energy paradox"—a situation in which apparently cost-effective energy-saving technologies either do not diffuse through society or do so only very slowly (see for example Greene et al., 2013).

In the case of the passenger car market, the EU's 2020/21 target of 95 gCO_2/km provides an excellent illustration of the energy paradox. The necessary investments in vehicle technologies to reach this target are estimated to be below €1,000 per vehicle, while the annual fuel cost savings associated with this technology deployment are as much as €450 per year or roughly €4,500 over the lifetime of a vehicle[2]. Hence, an average customer will save approximately €3,500 as a result of the 95 g/km CO_2 target. Without mandatory CO_2 standards it would be unlikely that customers would invest in energy-saving vehicle technologies to the same extent, as mainstream customers typically severely discount fuel cost savings that occur in future years, while fully valuing an increase in purchase price that is paid upfront (Greene et al., 2013). This argument, advanced by David Greene and other researchers, is supported by actual experience in the European market before and after adoption of mandatory CO_2 standards. Despite relatively high fuel taxes, the annual rate of gCO_2/km reduction was only around 1 percent in the years leading up to 2007, before the adoption of the 130 gCO_2/km regulation. The rate of CO_2 reduction jumped after adoption of the CO_2 standards to around 4 percent after 2008, with the result that the 2015 emission target of 130 g CO_2/km has already been met two years in advance.

There are societal benefits in addition to the €3,500 savings for an individual customer: reducing the CO_2 emission level of new passenger cars to 95 g/km avoids emissions of about 0.7 tons of CO_2 per vehicle per year, or about 7 tons of CO_2 over the lifetime of a vehicle, i.e. the calculated abatement cost is -€500/ton. One could therefore conclude that the societal *benefit* of going from 140 g/km to 95 g/km is around €500 for each ton of CO_2 avoided (see Figure 1). In addition, these fuel savings also reduce oil imports into the EU—by about 25 million tons annually in the case of the 95 g/km standard. This strongly simplified calculation illustrates why the opponents of the ETS for the transport sector argue that there are abundant cost-effective measures within the sector and that an additional market-based price signal like the ETS is not enough to leverage the existing potentials.

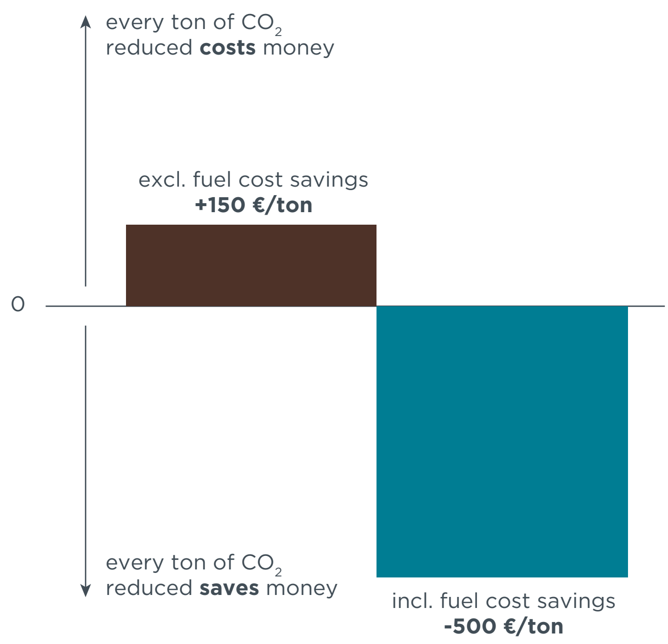

Figure 1. CO_2 abatement cost for applying passenger car technologies for reaching 95 g/km by 2020—without and with fuel cost savings taken into account (time horizon considered here: 10 years vehicle lifetime).

2 CO_2 emissions are linked to fuel consumption: reduce CO_2 emissions, and fuel consumption falls in direct proportion. All values in comparison to a 2010 baseline of 140 g/km and assuming an average annual mileage of 15,000 km. For more details, see (ICCT, 2013a). For simplification, no discounting of fuel cost savings over time was applied and no vehicle price mark-up was assumed. At the same time, average vehicle lifetime is higher than 10 years, i.e. total fuel savings are higher than assumed here.

3. A hypothetical world with ETS for the road transport sector

Setting aside, for the moment, the question of what ETS in the transport sector could mean from an economics point of view, it is revealing to assess what the ETS would mean from an engineering point of view in terms of technology innovation and market penetration.

Again, we take the example of the 95 g/km target for 2020/21 to see what would likely have happened if the EU had relied on ETS instead of vehicle CO_2 emission targets. For this, we assume that consumers would act as they have consistently done for decades—strongly discounting future fuel cost savings—and that ETS had been introduced instead of a mandatory emission target.

At today's ETS market price for carbon (about €5/ton CO_2) and an average annual mileage of 15,000 km, the total price signal from ETS for an average customer (with a 140 g/km vehicle) would be about €10 per year[3]. If we assume that a typical customer would take into account the ETS certificate costs over a four year time horizon[4], the overall ETS price signal would amount to €40. In other words, by including the transport sector in the ETS, we would create an incentive for customers to consider purchasing a vehicle that has €40 worth of additional CO_2 reducing technologies installed.

Looking at the technology cost curve in Figure 2, these €40 would translate into approximately 8 g/km of CO_2 reduction or reaching a target level of 132 g/km. A vehicle with 132 g/km would be subject to ETS certificates worth about €9.90. Hence, by investing €40 in CO_2 reduction technologies, the customer would hardly gain any benefit and would therefore opt to not invest in new technologies. Instead, the customer would have to accept that he is required to pay an additional €10 per year to offset the CO_2 emissions of his vehicle by purchasing ETS certificates. These €10 may potentially lead to CO_2 reductions in other sectors (if the ETS system works as intended—a debate into which we will not get here), but the effect in terms of vehicle technology innovation and penetration would be zero. The same would be true for ETS certificate prices much higher than the current level of €5 per ton.

Conversely, we may ask: what is the ETS price level theoretically needed in order to provide a sufficient price signal to incentivize the additional technology required to meet 95 g/km? Looking at the technology cost curve, the signal would have to be about €1,000 over a four-year time period, or about €250 per year. A back-of-the-envelope calculation[5] shows that this translates into a carbon price in the range of €370 per ton of CO_2. In other words, only if the ETS certificate price increased to a level of €370 per ton would it would trigger the same level of technology innovation and penetration as the current 2020/21 CO_2 regulation will do. It is important to note that this high price level does *not* stem from the fact that vehicle technologies are an especially expensive means of reducing CO_2 (Figure 2 shows that the opposite is true). Instead, the high price signal is due to the fact that mainstream customers strongly discount future savings or costs. This is why a market-based price signal (be it ETS, vehicle taxes, or fuel taxes) in this case needs to be very high to generate any measureable effect. While these estimates neglect more complex economic and behavioral aspects of the vehicle market (Cambridge Econometrics, 2014), it is clear that in the foreseeable future it is highly unlikely that the ETS certificate prices will reach a level close to the above mentioned €370 per ton.

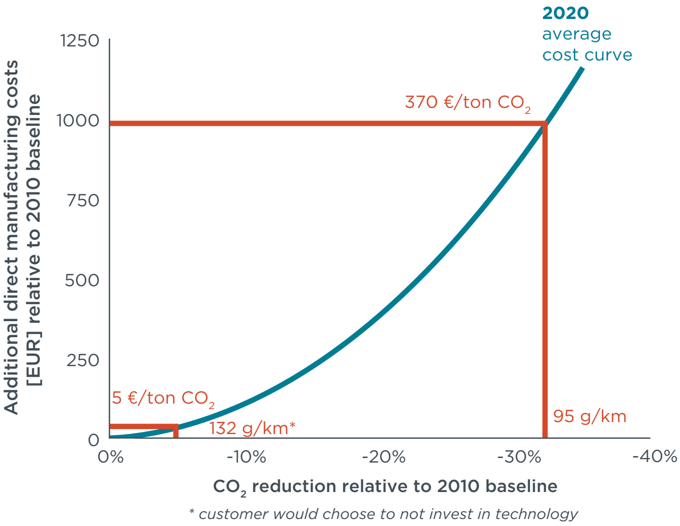

Figure 2. Technology cost curve for 2020 with an indication of the technology penetration incentive provided at today's ETS certificate price of €5/ton and at the price level required to reach the same level of technology penetration as triggered by the EU's 2020/21 target of 95 g/km[6] (time horizon considered here: four years customer payback period).

3 For our analysis, we assume that road transport would be integrated into the EU ETS in form of an *up-stream* approach (see Annex I for details). Although this approach seems the least problematic one in terms of practicability, other approaches are possible in theory as well. Nevertheless, the price implications and thereby the resulting effects on technology penetration are the same as described for the *up-stream* approach.

4 See for example Greene at al. (2013) for a description of typical payback period times for customer purchase decision calculations.

5 Reducing CO_2 emissions from 140 g/km to 95 g/km saves 45 g/km or about 0.7 tons of CO_2 per year. At technology costs of €250 this corresponds to about €370 per ton of CO_2 reduced.

6 It should be noted that technology costs are shown here. Resulting technology prices (including indirect cost) are likely to be higher, thereby requiring higher ETS price levels than shown here to reach the respective CO_2 emission levels.

Looking further into the future, the role of mandatory CO_2 standards in terms of technology innovation becomes even more evident. There is common agreement that, in order to avoid dramatic consequences of climate change by limiting the expected temperature increase to 2°C, today's CO_2 emission levels in the EU have to be reduced by about 95 percent by 2050 (EC, 2013). The three key sectors (industry, households, transport) each account for about one-third of total energy consumption in the EU, and the transport sector accounts for about 22 percent of CO_2 emissions. To be in line with the 2050 objective, *all* sectors will have to drastically decrease their CO_2 emissions—including the transport sector.

As a consequence, it is unavoidable that the transport sector essentially needs to be de-carbonized by 2050. Furthermore, as it takes about 10–15 years for the full vehicle stock to get replaced, it has to be ensured that by about 2035 all new cars coming to the market emit close to zero CO_2 emissions. The technologies to reach this objective already exist today. However, they are currently sold only in small volumes and at relatively high prices. Turning those technologies from today's niches into mainstream applications will require time—time to build up infrastructure, time for customers to get familiar with the new technologies, and time to increase production volumes and drive down costs.

The EU CO_2 standard allows for this lead-time. Another advantage of standards is that future target values can be set well in advance and allow vehicle manufacturers to develop and deploy the technologies needed to meet the respective target level. The standards thereby provide a *continuous* push for new technologies, driving innovation in the automotive sector. An ETS-based system, on the other hand, would imply that for many years relatively little CO_2 reduction would prove lucrative in the automotive sector and only a few new technologies would be developed (see Figure 3). Then, when presumably more attractive mitigation opportunities in other sectors have been exhausted, larger-scale mitigation efforts would be required in the transport sector, leaving little time for technology innovation and market roll-out. In addition, the price volatility of emission permits would increase the economic risk for car manufacturers investing in new technologies. The net result would be the opposite of planning security for vehicle manufacturers.

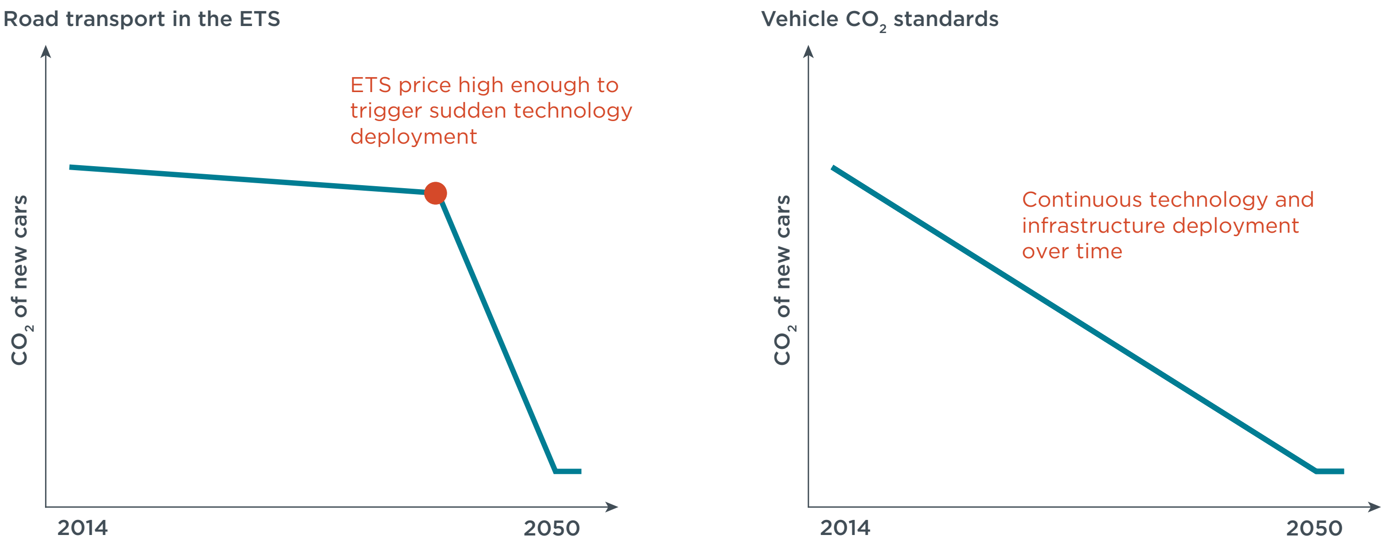

Figure 3. Schematic illustration of vehicle CO_2 emission reductions over time in a) an ETS-based system and b) a vehicle standards based system.

4. What a comprehensive EU policy framework could look like

CO_2 performance standards for new vehicles are often referred to as an instrument to *push* technology, providing a requirement for manufacturers to develop and offer new technologies on the market (see for example CARB, 2014; Grubb, 2004; Lee, 2011). In an ideal policy framework (Figure 4), this *technology push* is complemented by a *technology pull*, i.e., customers asking for and purchasing these new technologies for their vehicles. This customer demand can be stimulated by an adequate vehicle taxation system, for example in the form of a revenue-neutral *feebate* system, in which vehicles with low CO_2 emissions pay no vehicle tax or even receive a rebate, while vehicles with high emissions pay a fee (German, 2010). Similarly, it has been demonstrated that in the Netherlands, where high vehicle taxes are based on CO_2 emissions, emission levels fell quicker than in other EU Member States and a significant proportion of this decrease was due precisely to that vehicle taxation system (Cambridge Econometrics, 2013). For most other EU Member States, current vehicle taxation levels are too low to have any measurable effect on CO_2 emissions[7].

On top of vehicle standards and vehicle taxation, fuel taxation can address the driving behavior of customers and can help to prevent a *rebound effect*, i.e., customers driving more as their vehicles become more efficient (Ajanovic et al., 2012). Instead, vehicle efficiency gains can be balanced by increasing fuel taxes, so that the overall annual mileage remains constant[8]. This last element, addressing a potential rebound effect, is where the ETS could indeed play a role in the future: in addition to increasing fuel taxes directly, ETS certificates could be required to be purchased. Fuel prices would increase and consumers would have an incentive to not drive more than they did before their vehicles' efficiency increased.

However, even for addressing rebound effects, ETS certificate prices are too low at the moment: the current level of €5 per ton of CO_2 translates into a fuel price increase of only 1 cent per liter—less than the daily fluctuations in fuel prices and thereby too low to be noticeable to most customers.

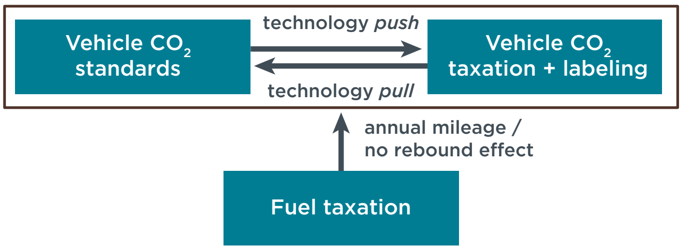

Figure 4. Illustration of a comprehensive policy framework for reducing CO_2 emissions in the road transport sector.

7 In addition to vehicle taxation, a comprehensive labeling system can ensure that customers are well informed about the emission level of their vehicles and the resulting operating cost, thereby leveraging the benefits of a CO_2 standard and CO_2 based vehicle taxation system.

8 It should be noted that to date fuel taxes in many cases are not adjusted to balance vehicle efficiency gains. For example, in Germany, fuel taxes for gasoline / diesel fuel have remained constant since 2003 (at 65 / 47 cents per liter of fuel), i.e. taking into account inflation, real fuel tax levels have actually decreased over time

Annex I. An overview of approaches to implement ETS road transport

In the literature, generally three different main pathways for including the road transport sector in the ETS are discussed (Table 1 and Figure 5) (see also in Creutzig, 2011).

Table 1. Summary of options for implementing emission trading in the road transport sector.

Implementation strategy	Stakeholder charged with cost of permits	Economic effect*
***down*-stream**	vehicle owners	ca. €10 per year for each vehicle owner
***mid*-stream**	car manufacturers	ca. €100 per vehicle
***up*-stream**	fuel suppliers	€0.01 per liter fuel

* Estimates based on 15,000 km mileage per year, carbon price of €5 per t CO_2, average vehicle emissions of 130 g/km, and vehicle lifetime of ten years.

The most prominently discussed system is an *open* (i.e., trading between the transport and other sectors is allowed) *up-stream* (i.e., fuel suppliers would purchase ETS permits) system. In practice this approach is equivalent to increasing the current level of fuel taxes by a certain amount. In the case of Germany, the average gasoline price in 2013 was 159.2 cent per liter (MWV, 2014). Of this price, import costs of the fuel accounted for 55.5 cent and 12.9 cent were cost and profit of the fuel supplier. Taxes accounted for the remaining 91 cent: 65.6 cent was fuel tax and 25.4 cent was value added tax. Including the transport sector in the ETS would increase this tax level by 1.2 cent, i.e. the total fuel price would have been 160.4 cent instead of 159.2 cent.

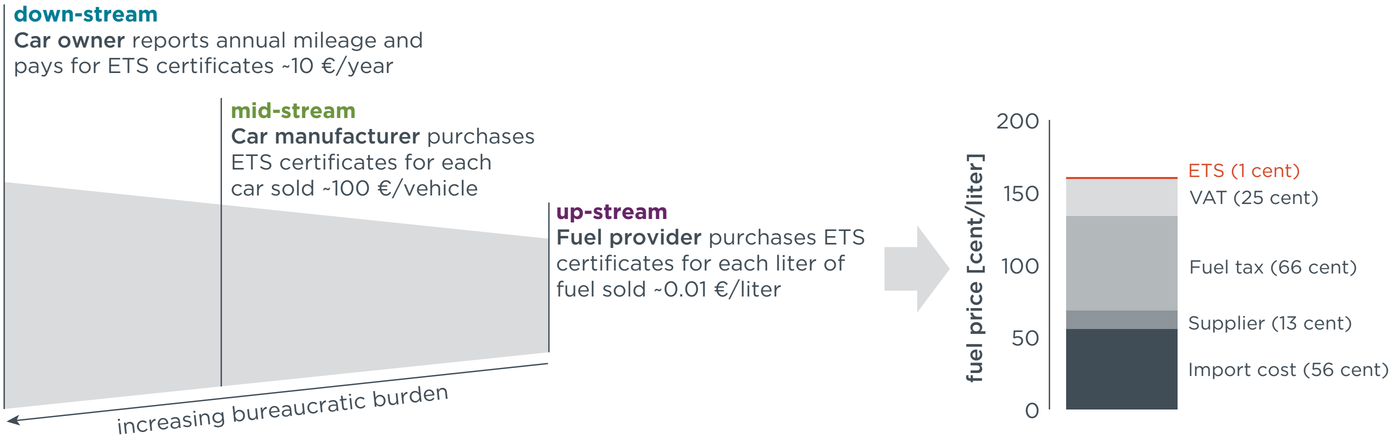

Figure 5. Schematic illustration of variations for an ETS system in the road transport sector and expected fuel price composition with ETS implemented in an *up-stream* system.

References

Ajanovic, A., Schipper, L., Haas, R. (2012). *The impact of more efficient but larger new passenger cars on energy consumption in EU-15 countries*. Energy, Volume 48, Issue 1, December 2012, Pages 346-355, ISSN 0360-5442, http://dx.doi.org/10.1016/j.energy.2012.05.039

Cambridge Econometrics (2013). *Effectiveness of CO_2-based feebate systems in the European passenger vehicle market*. Retrieved from http://www.theicct.org/effectiveness-co2-based-feebate-systems-european-passenger-vehicle-market

Cambridge Econometrics (2014). *The Impact of Including the Road Transport Sector in the EU ETS*. Retrieved from http://www.ebb-eu.org/EBBpressreleases/Cambridge_ETS_transport_Study.pdf

CARB (2014). *First Update to the Climate Change Scoping Plan*. California Air Resources Board. May 2014. Retrieved from http://www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm

Creutzig, F., et al. (2011). *Climate policies for road transport revisited (I): Evaluation of the current framework*. Energy Policy (2011). Retrieved from doi:10.1016/j.enpol.2011.01.062

European Commission (2013). *European Commission Roadmap for moving to a competitive low carbon economy in 2050.* Retrieved from http://ec.europa.eu/clima/policies/roadmap/index_en.htm

EC (2014). *European Council (23 and 24 October 2014)—Draft conclusions*. Council of the European Union. Retrieved from http://www.transportenvironment.org/sites/te/files/Council_draft_conclusions_oct_23-24_2014.pdf

EEA (2014). *Monitoring CO_2 emissions from new passenger cars in the EU: summary of data for 2013*. European Environment Agency. Retrieved from http://www.eea.europa.eu/publications/monitoring-co2-emissions-from-new-1

German, J., Meszler, D. (2010). *Best Practices for Feebate Program Design and Implementation*. The International Council on Clean Transportation. Retrieved from http://www.theicct.org/best-practices-feebate-program-design-and-implementation

Greene, D., Evans, D., Hiestand, J. (2013). *Survey evidence on the willingness of U.S. consumers to pay for automotive fuel economy*. Energy Policy, Volume 61, October 2013, Pages 1539-1550, ISSN 0301-4215, http://dx.doi.org/10.1016/j.enpol.2013.05.050

Grubb, M. (2004). *Technology innovation and climate change policy: an overview of issues and options*. Keio Economic Studies, Volume 41(2), Pages 103-132.

ICCT (2013a). *Reducing CO_2 and fuel consumption from new cars: Assessing the near-term technology potential in the EU*. The International Council on Clean Transportation. Retrieved from http://www.theicct.org/briefing-near-term-tech%20potential-new-cars-eu.

ICCT (2014a). *CO_2 emissions from new passenger cars in the EU: Car manufacturers' performance in 2013*. The International Council on Clean Transportation. Retrieved from http://www.theicct.org/co2-emissions-new-passenger-cars-eu-car-manufacturers'-performance-2013

ICCT (2014b). *European Vehicle Market Statistics Pocketbook 2014*. The International Council on Clean Transportation. Retrieved from http://www.theicct.org/european-vehicle-market-statistics-2013 (some data only available ICCT internally, not in publication)

ICCT (2014c). *EU CO_2 standards for passenger cars and light-commercial vehicles*. The International Council on Clean Transportation. Retrieved from http://theicct.org/eu-co2-standards-passenger-cars-and-lcvs

Lee, J., Veleso, F., Hounshell, D. (2011). *Linking induced technological change, and environmental regulation: Evidence from patenting in the U.S. auto industry*. Research Policy 40 (2011), 1240-1252. Retrieved from doi:10.1016/j.respol.2011.06.006

Mock, P. (2013). *EU vote on cars CO2: 95 g/km in 2020, 68-78 g/km in 2025*. The International Council on Clean Transportation. Retrieved from http://www.theicct.org/blogs/staff/eu-vote-cars-co2

MWV (2014). *Zusammensetzung des Preises für Superbenzin 1972 bis 2013*. Mineralölwirtschaftsverband. Retrieved from http://www.mwv.de/index.php/daten/statistikenpreise/?loc=10