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# Does the European diesel car boom mitigate global warming?

In parallel to the adoption of the Kyoto protocol in 1997, the European Commission and Member States, together with the European car and oil industries, initiated a massive technology change from petrol towards diesel vehicles[1]. For new sales, the market share of diesel cars in Western Europe had been relatively stable at around 15% until the 1990s. It rose quickly in the late 1990s and 2000s, surpassing 50% in 2005, and stood at 53% in 2014[2].

The political motivation behind this changeover was a belief that diesel would save $CO_2$ and so help meet the Kyoto protocol's requirements to slow the greenhouse effect[1]. Put simply, the EU institutions and Europe's national governments were convinced that diesel cars represented an essential and indispensable option to reduce $CO_2$ emissions in the transport sector, something still claimed by the European car industry (ACEA) to this day[3].

In order to make diesel cars more competitive, weaker toxic emission standards were granted compared to petrol cars (e.g. for nitrogen oxides, or $NO_x$) from the mid-1990s. European emissions legislation allowed – and continues to allow – lower air pollution standards for diesel, as set out in a series of regulations known as Euro 0 to Euro 6.

Maintaining a weaker air pollution standard for diesel cars is quite astounding because such emissions are toxic regardless of their source. How did we get here? In the 1990s the political will prevailed to accept negative health outcomes in exchange for what legislators perceived would be climate gains – accepting that more is known now regarding diesel's negative impact on air quality and health.

In parallel to maintaining weaker air pollution standards, European governments continue to tax diesel fuel less than petrol, something that occurs in all Member States except the UK. Low tax rates on diesel fuel lead to lower running costs for owners of diesel cars, which in turn makes the purchase and manufacture of diesel cars more financially attractive at a European scale.

Unfortunately, the primary political target of the past two decades – to prevent the atmosphere from heating up with the help of more than 45 million newly registered diesel cars in Europe – has failed for reasons that are little acknowledged or simply not debated in Europe until now.

Reducing $CO_2$ emissions by switching to diesel passenger cars was inefficient (see figure below). $CO_2$ emissions of newly registered petrol cars in Europe decreased faster than those of diesel cars and were nominally just higher by 1.6 g/km compared to diesel cars in 2013 (see figure below), noting that diesel car sales concern bigger and heavier vehicles.

The progress diesel engines have made is largely down to the fact that over the last 20 years the European car industry has primarily focused on diesel engine advancement at the expense of the petrol engine[3]. $CO_2$ emissions of an efficient petrol hybrid car, e.g. the Prius IV, are much lower at 73g $CO_2$/km than a comparable diesel car, e.g. the Skoda Octavia Greenline, a special edition efficiency model, with 90g $CO_2$/km[4]. Even the $CO_2$ emissions of a modern car with a downsized, turbocharged (non hybrid) petrol engine are almost equal to those of an equivalent diesel[3].

While the European car industry pretends that "*diesel cars (have) significantly lower $CO_2$ emissions per kilometre [and] are essential to manufacturers' efforts to reach the EU's ... $CO_2$ fleet average targets*"[5], the reality looks completely different. Based on data for new sales, cars sold in Japan emitted 20g $CO_2$/km less than European (diesel) cars in 2013, mostly due to the high share of efficient petrol hybrid cars and almost no diesel cars (see figure below). In contrast to Europe, the Japanese car industry was forced to invest in new technology 20 years ago[6], leading to the development of the hybrid car. This technical alternative in the EU could have saved – and in the future may save - Europe a very significant amount of $CO_2$ emissions as well as toxic fine particles and $NO_x$ emissions.

$CO_2$ is the most important greenhouse gas, and is regulated by the Kyoto protocol - but $CO_2$ alone does not determine the future climate. Unfortunately, Kyoto did not consider black carbon (BC) emissions, despite BC being "*the second most important human emission in terms of its climate-forcing in the present-day atmosphere*", as world leading atmospheric researchers conclude[7].

As with other greenhouse gases, BC can be expressed in $CO_2$ equivalents. Once this conversion is made, it results in an additional 76 g $CO_2$-eq/km for a Euro 2 diesel car and an extra 38 g $CO_2$-eq/km for a Euro 3 diesel car, respectively[1]. To obtain a scientifically accurate picture of the true climate burden of Europe's embrace of diesel cars, these $CO_2$-equivalents for BC have to be added on top of the direct $CO_2$ emissions of each relevant class of diesel cars. After the period 2002 - 2005, the level of BC emitted decreased as diesel cars with particulate filters became available. (Rather than originating within the EU law reform process, stronger standards pushing carmakers to install diesel particulate filters came on foot of strong public pressure, the negative health consequences of diesel's fine particulate emissions becoming more and more obvious.)

To summarise, diesel cars emitted an average of 10 g $CO_2$/km less than petrol cars in the 2000s (see figure below), but were responsible for BC warming in the magnitude of 40 - 80g of $CO_2$-eq/km. In other words, some 20 million of the extra diesel cars in Europe since the 1990s are actually making global warming worse, and this will continue to be the case for as long as they are driven. It was due to diesel's high BC level that leading US atmospheric researchers discarded diesel cars as an option to mitigate global warming in the early 2000s, their modelling based on diesel cars with filters[8].

As mentioned, BC emissions have decreased for new diesel cars equipped with particulate filters. Provided that the filter is working properly, only a small amount of $CO_2$-eq/km emissions would have to be added to direct $CO_2$ emissions to account for BC. However, the more complex the exhaust after-treatment system is, the more it is prone to failure. Tests conducted on 168 diesel cars in France showed that 75% had one or more defect (exhaust clogging, bad fuel injection, and faulty recirculation, for example) leading to higher air pollution[3]. Even public transport vehicles show significant failure levels. Tests on approximately 350 diesel-fuelled taxis serving five German cities found that diesel particulate filters were dysfunctional in 9% of post-2005 cars[9].

Even if diesel cars were produced to the air pollution standards already in place for petrol, such vehicles would only perform to this standard for a modest period of time unless their owners undertook a comparably high level of intervention, something accompanied by higher time and cost burdens. While the emissions of petrol cars also increase over their life, today's diesel cars will later be associated by high particulate/BC emissions with the effect of endangering human health and accelerating global warming. As the figure below shows, even a small percentage of diesel cars with filter malfunctions makes average emissions from the diesel fleet surpass average petrol car emissions. While further work is required to quantify the adverse impacts regarding health and climate, it can be expected that most of the aged diesel cars in the EU will operate at significantly higher emission levels in the future.

The situation is made worse by EU emissions law which only mandates a design life of 160,000km for pollution abatement technology. In contrast, regulators in the United States insist on a design life of up to 240,000km (150,000 miles). Because the average life of cars in much of East / South-East Europe is 10 years or more (e.g. 14 years in Lithuania), it is to be expected that the greater part of the distance travelled by diesel vehicles in these countries takes place when emissions abatement technology no longer needs to work under EU law.

Finally, apart from direct driving emissions, the supply chain also contributes to climate change. The fuel supply chain usually adds some 20% to $CO_2$ levels on top of direct emissions. As diesel fuel demand in Europe has tripled over the last 20 years or so, energy use by refining companies has increased, and so too have $CO_2$ emissions. Moreover, Europe now relies heavily on imported diesel, particularly from Russia, and, unless action is taken, this import dependence is expected to grow[10]. According to preliminary data, supply chain emissions outstrip the marginal $CO_2$ advantages shown by recent registration data for diesel cars. This data shows only direct emissions - before the additional emissions of black carbon and the supply chain are added; see figure below.

**Conclusion**: Although full quantification of the above effects is not possible until more data is made available, the data that is available clearly indicates that diesel cars are intensifying rather than mitigating global warming. As the case of Japan shows, alternatives are available. Japanese carmakers are using hybrid technology to deliver average $CO_2$ levels from new cars that are already 16% lower than those sold in the EU (20g/km). The further research and development of the hybrid engine in Japan is also likely to give its carmakers a technological lead in producing fully electric cars at mass market levels. Cars powered solely by electric charge have the potential to vastly decrease carbon emissions on the road when combined with renewable electricity production.

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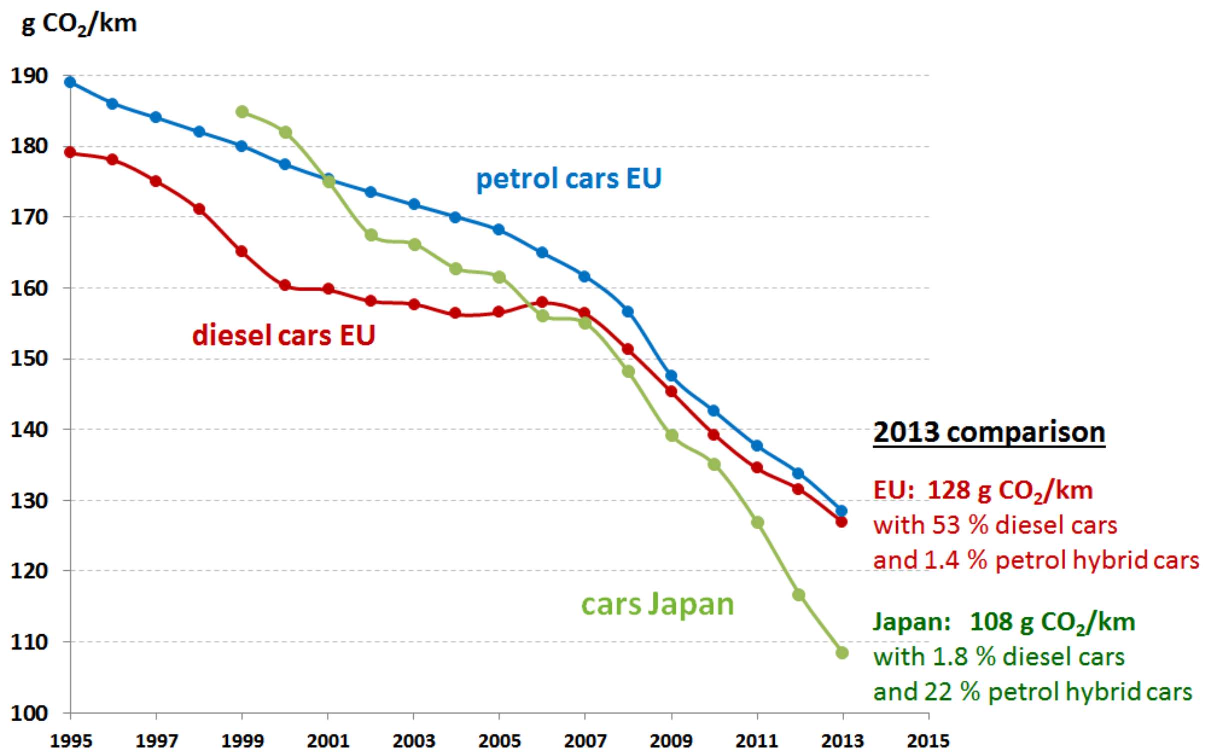
Figure: $CO_2$ emission trend of newly registered cars in Europe and Japan, 1995 – 2013




Data sources: Cames & Helmers, 2013, EEA 2014, JAMA 2015. EU data is based on NEDC testing while Japanese data is from its JC08 test. However, real-world CO2 emissions in the EU are 40% higher than its tests show, a gap that continues to grow.

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[1] Cames M. and E. Helmers 2013. Critical evaluation of the European diesel car boom - global comparisons, environmental effects and various national strategies, Environmental Sciences Europe, 25 (15), 1-22 http://www.enveurope.com/content/pdf/2190-4715-25-15.pdf

[2] http://www.acea.be/statistics/tag/category/share-of-diesel-in-new-passenger-cars

[3] The Truth about Diesel Cars: open letter to the European public and policy-makers. http://iaqm.co.uk/the-truth-about-diesel-cars-open-letter/ . Pollution abatement equipment was not working correctly in 126 out of 168 diesel cars randomly tested in France, with up to four individual problems per car: Pillot D., A. Legrand-Tiger, E. Thirapounho, P.Tassel, P.Perret (2014). Impacts of inadequate engine maintenance on diesel exhaust Emissions. Transport Research Arena 2014, Paris 4.

[4] http://www.skoda-auto.de/SiteCollectionDocuments/PDF%20Prospekte/Octavia_PuA_2016_01_06.pdf

[5] http://www.acea.be/uploads/press_releases_files/Open_Letter_to_European_Policy_Makers.pdf,

[6] In 1992 Japan imposed tighter laws on NOx emissions (compared to the EU) and Toyko reduced the tax advantages for diesel during the 1990s. There was also higher public awareness of the air pollution caused by diesel cars, something spearheaded by the Toyko mayor at the time; http://www.nytimes.com/2006/03/03/business/worldbusiness/03iht-diesel.html?_r=1&pagewanted=print

[7] NASA, 2013. http://pubs.giss.nasa.gov/abs/bo05200b.html

[8] https://web.stanford.edu/group/efmh/jacobson/PDFfiles/0710OralTestHouseBC.pdf

[9] AutoBild, 29 August 2014. Overseen by emissions expert, Axel Friedrich, the German NGO Deutsche Unwelthilfe (DUH) measured 351 diesel-fuelled taxis, finding emissions abatement equipment to be dysfunctional or removed in 31 of them. The taxis served five cities: Berlin, Frankfurt, Hamburg, Cologne and Munich.

10 https://www.fuelseurope.eu/knowledge/how-refining-works/diesel-gasoline-imbalance