European Platform on Sustainable Urban Mobility Plans

Evidence Measure Review No.2
Cleaner Vehicles

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Measure No.2: Cleaner Vehicles

Innovations or interventions that aim to improve the environmental performance of vehicles – such as enhancements to engine and vehicle technologies or improved fuels.

Cities have opportunities to improve the environmental performance of fleets of vehicles involved in municipal services – waste collection, public transport etc. They can also encourage moves to more efficient commercial and private vehicles through regulatory and fiscal measures in a city.

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Key messages:

- ✓ Policy measures such as fleet emission regulations foster economies of scale, and thereby contribute to reducing the production cost of new technologies. This, in turn, supports the consumer's decision to purchase these technologies.
- ✓ For public bodies, implementation of regulatory measures is cost-effective, whereas upfront investments for the purchase of new public transport fleets may exceed direct cost savings occurring over the lifetime of that asset.
- ✓ From the perspective of the owner and transport operator, enhancements are cost-effective only under specific conditions, dependent on retail and fuel costs.
- ✓ From a societal perspective, the health, built environment and ecosystems benefits of investments into air quality abatement technologies (such as engine enhancements) should outweigh the economic costs. However, such benefits tend to be excluded from benefit–cost calculations of individual users.

2.1 Context and background

The existing vehicles in any city will reflect a range of efficiency and pollution levels. Some of these vehicles, particularly diesel vehicles used in confined inner-city areas may present particular problems in respect of localised air quality problems, and steps to improve their performance could be of particular benefit for a city.

Potential interventions

- Introducing new municipal or public transport vehicles using cleaner fuel (CNG, Biogas)
- Retrofitting existing fleets of vehicles with more efficient and / or less polluting types of motive power, or other vehicle enhancements (for example energy-efficient tyres)
- Encouragement to other transport owners (commercial and individuals) to improve the efficiency of their vehicles (Note: Additional supporting measures for this such as Low Emission Zones are covered under Measure No.6, Environmental Zones).

Whilst cities have the opportunity to address these sorts of interventions specifically in respect of their own fleets of vehicles, it is acknowledged that there will also be significant steps being undertaken at national and international levels to improve the environmental performance of the automotive fleet in general. Accepting and acknowledging this wider impetus, action at a local level to move to more efficient / less polluting vehicles is still seen to have the potential to generate significant improvements on local air quality in a city.

2.2 Extent and Sources of Evidence

As technology continuously advances, and as there are significant and immediate climate change mitigation potentials inherent to such schemes, the implementation of this type of transport intervention (often related to fleet emission regulations) is an area that receives on-going scrutiny.

The selected sources review the costs and benefits of different technologies. As enhancements of engine technologies tend not to be tied on a certain place, many of the sources do not consider local circumstances. The quality of these studies is high, including peer-reviewed articles and studies from independent research institutions, which used appropriate techniques to validate the results. In order to also discuss application on the local level and in SUMPs, the general evidence has been complemented by location specific studies, e.g. CIVITAS evaluation reports. These latter reports are not peer-reviewed.

The selected high quality evidence considers actual data alongside ex ante assessments of manufacturing cost, vehicle lifetimes, and benefits. The results of the selected local ex post evaluations confirm the more general results. The results also fit very well with pure ex ante studies (e.g. cost-abatement assessments), which include a longer time horizon and a wider set of assumptions. However, these pure ex ante studies were not selected for the review, even if their methodology was solid.

The process of evidence collection revealed that the number of pure ex post studies is limited. A reason for this may be that the effects of technologies are of potential interest when they are new. At that point, potential application at a larger scale is of interest, but expected lifetimes of the technology are not yet confirmed.

2.3 What the Evidence Claims

The results of the evidence can be boiled down to a simple message: the less energy consumed per km, the better the vehicle's environmental performance especially in terms of carbon emissions and health damaging air pollutants.

Further development of engines, chassis, and other vehicle component technologies leads to lower CO_2-emisssions, less local pollutants (including black carbon) and less noise. Enhancements of fuels may increase benefits accordingly. Technologies reducing braking distances can also contribute to reducing societal costs by reducing injuries and fatalities. However, energy efficiency improvements for vehicles do not address wider externalities from road traffic such as congestion, consumption of urban space or traffic accidents. In comparison, a shift of short distance trips to walking and cycling or a move to public transport may not only reduce emissions, but also capture wider sustainability benefits.

Economies of scale are crucial to cut costs. Policy interventions such as fleet emission regulations may thus accelerate the development and increase the market share of energy efficient vehicles.

An analysis of a range of potential measures (and associated costs) to reduce CO_2 emissions from passenger cars was undertaken in 2006. According to this report[1] (using data from 2006), the costs of reaching an average CO_2 emission in new vehicles of 140 g/km by 2008 would involve additional manufacturer costs of €832 per vehicle compared to the 2002 baseline, which translated into an additional retail price of €1200 per vehicle. The manufacturer costs for reaching the 2012 target of 120 g/km were around €1700 per vehicle compared to average costs of the 2008/9 baseline vehicle emitting 140 g/km. This translated into an additional retail price of €2450 per vehicle.

From the consumer's perspective, additional upfront costs do in many cases not pay back over the vehicle's lifetime. For example, for the Toyota Prius to be attractive to US consumers, the price of gasoline would have to be more than three times greater than in 2001 (data are used from 2001)[2].

However, a smart combination of existing technologies may also be able to even reduce costs while increasing the benefits described above. For instance, a Dutch study looking at tyres[3] finds that a further penetration of so-called "A-rated" tyres (according to the eco-design directive) would bring about significant energy savings, noise reductions, and traffic safety. Assuming the characteristics of A-rated tyres could be combined into one 'Triple-A' tyre, Dutch society would benefit from annual cost savings of nearly one billion Euros (in comparison to status quo). For the end-user, annual cost savings would range from €117 for passenger cars to €2418 for long-haul vehicles.

From a societal perspective, benefit-to-cost ratios (BCR) of enhancements to engine technologies tend to be generally positive. This was also evidenced in a wider cost-benefit analysis (CBA) of the EU's thematic strategy on air pollution[4], (with supporting measures such as the EURO emissions standards for vehicles). This analysis finds strong benefits for health (mortality and morbidity), materials (buildings), crops, and ecosystems (freshwater and terrestrial, including forests), whilst macroeconomic costs in terms of reduced gross domestic product (GDP) from factors such as spending on abatement equipment are around 0.05% per annum in 2020 (modelling "current" legislation of 2005 vs. thematic strategy).

The World Bank evaluated four diesel emissions control projects (diesel retrofit in Istanbul, green freight plus retrofit in Sao Paulo, fuel and vehicle standards in Jakarta, and CNG buses in Cebu)[5]. It concludes that for 2 cases net benefits (health and climate change) were positive and for the other two cases (Cebu and Jakarta) the benefits of black carbon reductions were positive only when assuming a large benefit from black carbon control on the climate in the near term (using 20 years Global Warming Potential or GWP) and a low social cost-of-carbon discount rate.

Studies of the procurement of new engine technologies may not consider a societal perspective, but instead focus on 'financial viability'. Local project evaluations confirm societal benefits (such as lower noise and atmospheric pollution), but evidence on financial viability may be less certain, and not unambiguous.

In Brescia, the purchase of CNG buses was co-funded by CIVITAS. The report on their implementation[6] does not point to conditions, which would strengthen the economic case for the transport operator. In Barcelona, the transport operator was able to establish a strategic partnership with a natural gas company, taking over parts of the maintenance cost. The return on investment was less than 5 years[7].

Apart from the investor's financial considerations, these two local evaluations report additional benefits: for example, the ease of adjustment to the new circumstances of CNG buses in the public transport fleet[6]. Passengers also report that the perceived noise inside the vehicle is lower than before. Similarly, the extension of the CNG bus fleet in Barcelona found a high level of acceptance[7]. Both drivers and passengers highlighted the decrease in noise, fuel smell and vibrations.

Methodologies and Caveats

The analysed evidence mainly uses a combination of ex ante and ex post data. Real data is used as a basis and then complemented by assumptions on market penetrations and technical lifetimes.

Through economies of scale and learning effects, production volumes influence production costs. New technologies become cheaper as more are produced. Some studies in this field estimate costs based on data that are valid for large-scale production of the applied technologies[1]. It appears that costs for current (internal combustion) engine technologies (ICE) may be used as a valid basis to estimate costs and benefits for further short-term developments.

However, it is important to note that even if vehicle technologies are getting more energy-efficient, these effects may be neutralised be growing size and power of vehicles.

Adopting a societal CBA approach, the cost of climate change rather than the oil price may be the crucial factor for the economic viability of ICE enhancements, because in the past, reductions in fuel consumption and increases in fuel prices tended to neutralise each other. A 2007 study[8] found that even in a scenario of high demand and significant supply constraints (growth of 2008 fuel prices by 50%), the fuel consumption component of benefits in a CBA would only increase from 26% to 30%, assuming that fuel consumption remains constant. In turn, the effect of technological change on economic evaluation largely depends on the unit value of GHG emissions.

As the studies have shown, the BCR of ICE enhancement is positive from a societal perspective. However, as the technological improvements are not able to capture wider externalities from individual motorized transport, measures that reduce car traffic may yield much higher BCRs. The costs for sustaining car-based mobility can be enormous for a city, although the cost of transport for the community decreases with rising proportion of trips made by public transport or non-motorized modes[9].

The factors included in a CBA and the choice of alternatives that are compared can largely influence the results. The reviewed studies do not compare vehicle technology improvements with other measures that aim at reducing individual motorized trips.

2.4 Lessons for Successful Deployment of this measure

The results explored in this review are mainly transferable because of the technical character of the options to enhance ICE technologies. For instance, the city of Brescia (Italy) calculated the costs and benefits of investing into a new bus fleet (CNG buses). From the city's perspective, upfront costs were too high to pay back over the buses' lifetimes. CIVITAS funding was able to close the gap. Monitoring of the operation revealed presumed benefits such as reductions of local air pollution. This case confirms other studies, which did not consider local conditions.

The 2014 World Bank study[5] summarizes a wide range of black carbon emissions control strategies in OECD countries in North America, East Asia, and Europe from technology (e.g., diesel particulate filters and refinery upgrades) to policy measures (e.g., vehicle emission standards, fuel quality standards, scrappage programs, and tax incentives). These strategies provide a menu of options that could be considered by developing countries and tailored to the national context. A key characteristic (and lesson) of the programmes implemented in the OECD is the value of national policy road maps for cleaner vehicles and fuels that provide a clear and predictable course for technology and fuel adoption by private and public stakeholders.

The local incentive to implement policy measures fostering the enhancement of ICE technologies may be the reduction of local emissions (noise, NOx, etc.). From a societal perspective, benefits should outweigh the respective cost. Regulative measures such as a low emission zone do not impose significant cost for the public bodies.

2.5 Additional benefits

As well as the evidence of economic and financial benefits of interventions discussed above, there are a number of additional benefits that are claimed for policies promoting cleaner vehicles:

- **Environmental improvements:** Enhancements to vehicles which improve energy-efficiency can help to reduce local air pollution, noise levels and CO_2 emissions, with consequent benefits for human health and the urban environment.
- **Road safety:** Technologies improving safety (e.g. braking distance) also offer benefits in the form of fewer road casualties.
- **Passenger satisfaction:** Another benefit experienced in one study here was that the journey experience improved for passengers on public transport that was converted from diesel to compressed natural gas (CNG) in urban buses. Passengers reporting that the perceived noise inside the vehicle was lower than before. Both drivers and passengers highlighted the decrease in noise, fuel smell and vibrations. Such enhancements could then help encourage increased patronage levels.

2.6 Summary

Whilst it is clear that national (and international) policy, and to an extent consumer demand, is mainly responsible for the longer term enhancements of ICE technologies, local measures stipulated in a SUMP are of supportive character. Through the use of (public) procurement and other local policy measures such as low emission zones (see Measure No.6) it is possible to significantly improve the local air quality as well as contributing to wider uptake of the technologies delivering cleaner vehicles. Cities have a range of options available to them in respect of the interventions they can make to encourage change, and it may be that implementation of regulative measures is a more cost-effective route to pursue initially. On a simple analysis, the expense of investments into new fleets may exceed cost savings occurring over their lifetime, but the local social and environmental benefits for doing so make it worthwhile.

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