TM/04

CLEVER - Results

Clean vehicle research: LCA (Life Cycle Analysis) and policy measures

DURATION OF THE PROJECT
01/01/2007 - 31/05/2011

BUDGET
671.155 €

KEYWORDS
Clean vehicles; Transport; Future mobility; Environmentally friendly vehicles; Alternative vehicle technologies; Life Cycle Assessment (LCA); Well-to-Wheel (WtW), Policy measures; Policy scenarios; Life Cycle Cost (LCC); Price elasticity; Consumer behaviour; External costs; Barriers; Emissions; Multi-Criteria Analysis (MCA)

CONTEXT

In a period when environmental issues on a local, regional and global scale are becoming very important, the relationship between transport and the environment needs to be clarified. The finite nature of oil resources and the associated political and economic effects presently lead to the need to assess alternative energy sources and to reduce dependency on imported oil. In addition to these energy aspects, there are important environmental, safety and economy related (e.g. congestion) reasons for changing our transport systems. In order to make transportation more sustainable, different possible options are available: controlling the need for motorised travel, land use planning, making travel safer (driving behaviour), encouraging modal shifts (walking, cycling, public transport) and technical innovation. Among these options, technical innovation of vehicles plays a key positive role.

OBJECTIVES

The objectives of the project can be described as follows, with a focus on the passenger car market:

- Create an objective image of the environmental impact of vehicles with conventional and alternative fuels and/or drive trains;
- Investigate which price instruments and other policy measures are possible to realize a sustainable vehicle choice;
- Examine the external costs and verify which barriers exist for the introduction of clean vehicle technologies on the Belgian market;
- Analyse the global environmental performances of the Belgian car fleet;
- Formulate recommendations for the Belgian government to stimulate the purchase and use of clean vehicles.

MAIN CONCLUSIONS/RECOMMENDATIONS

Life Cycle Assessment

To compare the environmental impacts of vehicles with different conventional (diesel, petrol) and alternative fuels (Liquefied Petroleum Gas (LPG), Compressed Natural Gas (CNG), alcohols, biofuels, biogas, hydrogen) and/or drive trains (internal combustion engines and battery (BEV), hybrid and fuel cell electric vehicles (FCEV)), a Life Cycle Assessment (LCA) has been performed, within a Belgian context. An LCA not only takes into account the so-called Well-to-Wheel emissions (tailpipe exhaust and emissions due to production and distribution of the fuel/electricity), but also the pollutants which are emitted during the production, maintenance and end-of-life phase of the vehicle. Because of the large variety of environmental impact categories, it is almost impossible and sometimes misleading to claim that a vehicle is better than the others from all viewpoints. In this project, a list of relevant environmental impact categories has been made in order to have a good appreciation of the environmental score of conventional and alternative vehicles. When dealing with climate impact, conventional vehicles have the highest impact. Battery electric vehicles (BEV) powered with the Belgian electricity supply mix, have a lower greenhouse effect than all the registered family cars in Belgium, with exception of the sugar cane based bio-ethanol E85 vehicle. For the different impact categories considered in this study, the impacts of the LPG technology are comparable to diesel. FCEV are more interesting than petrol and diesel vehicles for greenhouse effect, respiratory effect and acidification. CNG vehicles appear to be an interesting alternative for conventional vehicles. They have a low climate impact (comparable to hybrid technology) and the best score for respiratory effects and acidification. However CNG is produced from a non-renewable fossil fuel.

Life Cycle Cost Assessment (LCC)

From a user perspective, the cost-efficiency is often a crucial factor. The LCC can not only be used to examine whether clean vehicles currently are a cost-efficient alternative to conventional vehicles, but it can also be applied to investigate whether pricing measures, based on the environmental performance of vehicles, can enhance their financial attractiveness.

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Within each vehicle type, diesel vehicles represent the greatest cost-efficiency on a per kilometer basis as compared to the reference petrol vehicle, which is mainly the result of differences in fuel-efficiency (20 to 30% more efficient than petrol engines) and in fuel taxation (almost 40% less excises than on petrol fuel). Diesels are known to emit more PM and NOx emissions than petrol fuel, which implies that diesel vehicles should be subjected to a higher fuel tax per litre, given the differences in fuel use per kilometre. On the other hand, this would mean that diesel and petrol vehicles with approximately the same characteristics should be faced with equal fixed vehicle taxes, which would lead to a drastic revision of the current vehicle taxation system. No differentiation in fixed vehicle taxes is currently in place for diesel vehicles with externality reducing characteristics, such as PM-filters, facing a higher cost on a per kilometre basis than conventional diesel vehicles.

Within each vehicle segment, alternatively fueled vehicles (LPG, CNG) and vehicles with alternative drive trains (BEV, HEV) produce competitive costs on a per kilometre basis with respect to the reference petrol vehicle, but are often not cost-efficient with respect to the comparable diesel vehicle. Although biofuels can enjoy a small excise reduction, they are faced with higher fuel taxes on a per kilometre basis as a result of their lower energy density. LPG and CNG vehicles are exempted from paying fuel taxes, but are confronted with an additional fixed tax burden. Many of these alternative technologies also cope with additional conversion costs to make them fuel compatible or with extremely high purchase prices (in case of BEVs), which add to long payback periods for these vehicles.

Overall, the LCC analysis demonstrates that (more) sustainable vehicles are at present not financially attractive for the Belgian end-user. A new fiscal system based on the environmental performance of cars, using the Ecoscore methodology, can therefore be useful to stimulate the use and purchase of clean vehicle technologies and eliminate existing tax distortions. The new system will then better reflect the cost that each vehicle imposes on the society. However, the steering effect of such a tax reform and other pricing measures should not be overestimated. Pricing measures (like taxation) only act on a small fraction of the overall vehicle costs and have a smaller weight in the purchase decision than e.g. purchase or fuel costs, so it will only indirectly affect the consumers' purchase decision. Moreover, other purchase factors, such as reliability, safety, etc., determine the purchase decision too.

Price elasticities

Policy measures will only be effective if they induce the right behavioural responses. A green vehicle demand model has been developed, which enables to estimate the distribution of respondents wiling to switch to a more environmentally friendlier car, based on different weighted pricing levels of combined policy measures.

Overall, it is shown that combined pricing measures will affect the adoption rate of clean vehicles, but to a certain extent. A possible reason for this outcome is that (1) other factors besides operating costs might be of particular relevance too in the purchase decision (such as purchase price, quality) and that (2) some pricing measures (such as congestion pricing, parking tariffs etc.) rather affect vehicle use than vehicle ownership.

This means that a further adoption of clean vehicles will depend on additional supply-sided measures and additional governmental incentives that act on the other important aspects that determine the purchase decision and this confirms the need for an entire policy package which not only consists of pricing measures (sticks), but also of subsidies (carrots) and regulations (see further).

External Costs

An external cost, also known as a negative externality, arises when the social or economic activities of one group of persons provide damage to another group and when that damage is not fully accounted, or compensated for, by the first group. The environmental cost can be integrated into the LCC analysis of new vehicles. This approach allows a complete comparison with conventional vehicles, based on a full-cost approach. Diesel cars without particulate filter are associated with the highest total external cost, reaching c€ 22,6/v.km for an SUV in the most realistic scenario. Diesel vehicles equipped with particulate filters have the second highest total external cost (up to c€ 14,39/v.km for an SUV), though they are much closer to those of the petrol, LPG, CNG, flexifuel and biofuel engines (c€ 7,23/v.km to c€ 9,87/v.km). At the opposite side, electric cars generate the lowest impacts (c€ 4,75/km). Hybrid cars also prove to have lower external costs than any other technology for vehicles of the same weight. This assessment does not allow a direct comparison of flexifuel and biofuel vehicles as the emissions have been measured according to different homologation procedures. Globally, external costs are proportional to the weight of the vehicle for a given motorisation system and are thus highly correlated with the car size. The study also clearly shows the predominance of PM_{10} related impacts in the total societal costs. More specifically, non-exhaust PM appeared to be the main cost driver. At the current state of knowledge however, non-exhaust PM_{10} emissions and their specific impacts on health and building damage are surrounded by a great deal of uncertainty.

Social barriers

While economic barriers appear to be very important, results have shown that other aspects also have a significant impact on consumer behaviour about alternative cars, sometimes more important than economic aspects. Psychological barriers have a significant impact on consumer behaviour about cars. Interviews of fleet managers have highlighted that it is the combination of several barriers (supply, economic, technical and market) that make alternative vehicles particularly unattractive for introducing them in vehicle fleets (except hybrid, for which the main barrier is economic). The lack of supply of alternative vehicles in leasing companies and also the inexistence of alternatives for intervention vehicles or vans limit greatly the development of alternative vehicles in some vehicle fleets.

An important barrier which prevents car manufacturers from developing alternative vehicles is related to the fact that they expect no (or not enough) demand for those vehicles, as they are not competitive with conventional vehicles for several reasons: economic, technical and psychological. Their current strategy is rather to focus on the improvement of conventional fossil fuel cars - diesel in particular- in terms of efficiency and reduction of emissions.

Currently, the market is “stuck” because supply-side stakeholders expect no demand and demand-side stakeholders wait for supply development. This implies a need for policy intervention to release this locking mechanism. However, there is also a lack of policy measures to promote alternative vehicles.

Policy measures

A mix of policies which integrates carrots (incentives), sticks (disincentives) and regulations works best. This includes a mix of target audiences: industry and final consumers, both public and private. For private consumers, tax systems based on environmental performance are getting more and more common. No mandatory systems towards private fleet consumers exist yet today, but voluntary systems are in place and the market starts offering green products. Company car taxation seems the appropriate instrument to influence that market. For public consumers, mandatory targets for clean vehicles seem to have an effect on the overall market and are a suitable instrument to open the market. However, monitoring and impact assessment results from different implemented policy measures are still lacking most of the time. In order to get a better insight into the acceptance level of different policy measures, a series of stakeholder meetings was organized with industrial actors, NGOs, users and policy makers. On some measures (e.g. tax system based on CO_2 and Euro standard) stakeholders easily agreed; on others (e.g. environmental city zones) they did not. Four scenarios were conceived.

The **baseline scenario** only includes current and planned measures, for example (1) Euro 5 and Euro 6 emission standards, (2) CO_2 legislation for new passenger cars, (3) Low blends of biofuels, (4) EU directive on coolants in air conditioning and (5) Mandatory quota for green public fleets.

The **realistic scenario** includes measures that are seen as potentially having a large impact, while they are relatively easy to implement in the short term. Extra measures in this scenario (on top of the baseline scenario) are: (1) Vehicle tax system based on the CO_2 and euro standard, (2) Advantages for early-complying-Euro 6 vehicles, (3) Standardization of clean fuels (e.g. CNG and E85), (4) Higher excises for diesel, none on clean fuels, (5) Subsidies for retrofitting old diesel cars with PM filters and (6) Subsidies for cleaner fuel systems (LPG and CNG).

The **progressive scenario** includes measures that could have a high impact, but are difficult to implement. Clean vehicles are now defined based on the Ecoscore. Extra measures under the progressive scenario are: (1) Registration tax based on ecoscore combined with a time-, place- and ecoscore-dependent kilometre charge, (2) Limited access environmental city zones, (3) Mandatory green private fleet quota and (4) Scrappage scheme.

Finally, a more pragmatic **visionary scenario** has been elaborated in which the vehicle ownership is expected to evolve in the direction of transport sharing.

The results of the four scenarios were clustered in three groups: fleet composition (number of vehicles), vehicle use (number of kilometers) and environmental performance (Well-to-Tank emissions and Ecoscores). The results indicate that the benefit (compared to baseline) of implementing the realistic scenario is rather confined. It seems that the share of diesel kilometers will be even higher than under the baseline. On the other hand, the progressive scenario provides a clear benefit with regard to the number of kilometers driven, emissions and the average Ecoscore. The results obtained from the visionary scenario demonstrate that there is still room for more ambitious targets in the long run.

Multi-Criteria Analysis

For policy makers, several concerns are associated with the choice of a specific policy package to stimulate clean vehicles into the market requiring the application of a multi-criteria assessment (MCA). From a governmental point of view, it is important to know how the market will react on different measures and if it will effectively steer clean vehicles into the market and hence increase the average Ecoscore and decrease the fleet emissions of the Belgian vehicle fleet (“environmental effectiveness”). Moreover, a policy package should also perform well with respect to decreasing vehicle kilometres driven and enhancing people to use other transportation modes inducing a modal shift (“impact on mobility”). Finally, a policy package should by preference be implemented relatively easily, without major obstructions from a budgetary, technical and socio-political point of view (“feasibility”).

The overall ranking shows that for the reference year 2020, the progressive and baseline scenario almost have an equal absolute score, which means that they are both seen as scenarios that contribute the best to the different criteria for the reference year 2020. For the reference year 2030, the situation is slightly different. There, the progressive scenario clearly outranks the other scenarios. The overall ranking of the scenarios is noticeably influenced by the established weights attributed to the criteria groups. If, for example, feasibility becomes the major concern for policy makers (50%), then the progressive scenario will be outranked by respectively the baseline and the realistic scenario. More important than the absolute ranking is thus the insight in the strong and weak points of the considered scenarios. It is thus very important to take these sensitivities into consideration when deciding on which scenario to implement. It should also be noted that the overall assessment outcome not only depends on the type of measures introduced, but also on the specific levels of the simulated measures.

CONTRIBUTION OF THE PROJECT TO A SUSTAINABLE DEVELOPMENT POLICY

New clean vehicle technologies play a key role in the sustainable development because they jointly allow, on the one hand to reduce the pressure on environment and resources and on the other hand to participate in the sustainable growth by emphasising a targeted innovation. In this framework, new clean vehicle technologies contribute to the respect of the principle of precaution because they comply with those growing objectives of environmental quality. These new techniques participate also to the prevention principle for pollution that is not backed by quantified objectives yet but the negative environmental impacts of which are denounced.

The LCA methodology is inherently based on these principles since it allows integrating several environmental quality objectives. As it considers a holistic view of production and consumption cycles, the LCA methodology partly fulfills to the integration principle of sustainability. Taking into account the overcost of new transport modes and complying with stricter standards, as well as the inclusion of external costs and new fiscal policies in the methodology are elements belonging to the polluter-pays principle. Considerations on social equity are other elements that have been analysed. It includes social components like social barriers against new techniques, overcosts and fiscal incentives scenarios for developing the purchase of clean vehicles, in the short or long term.

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