EN/03

BIOSES - Results

Biofuels Sustainable End uSe

DURATION OF THE PROJECT
15/12/2006 - 31/01/2011

BUDGET
688.504 €

KEYWORDS
Biofuel policy, stakeholder consultation, transport scenarios, WTT emissions, allocation, vehicle emissions, emission measurements, life cycle analysis (LCA), impact assessment, Ecoscore, cost projections, life cycle cost (LCC), system perturbation analysis (SPA), substitution allocation, system dynamics, multi-criteria analysis (MAMCA), transport modelling, biodiesel, bio-ethanol, 2nd generation biofuels, biofuel roadmap, transport policy, electric mobility, energy saving in transport.

CONTEXT

Biofuels are today one of the only direct substitutes for oil in road transport, available on a significant scale. They can be used today, in existing vehicle engines, unmodified for low blends, or with cheap modifications to accept high blends. Biofuels are expected to represent a substantial part of the 10% target for renewable energy in transport by 2020, set by the European Commission in its Renewable Energy Directive 2009/28/EC. With biofuels reaching a visible scale at the European level, discussions have emerged about the sustainability of biofuels compared to fossil fuels. It is clear that policy should make sure that the use of biofuels in the transport sector should happen in a sustainable way that balances the main transport related challenges of greenhouse gas reduction, reducing oil dependency and improving air quality. Specifically for the Belgian situation, BIOSES is a research project assisting the Belgian government in setting a roadmap for biofuels and analysing the potential impact that biofuel introduction may have on greenhouse gas emissions, energy use and air quality.

OBJECTIVES

The project develops different scenarios for the introduction of biofuels, based on the technological evolution in vehicle models, the likely biofuel blends on the European markets, and the possible interest of certain end user groups. Based on up-to-date data (complemented with own measurements) of energy use, emissions and cost projections, the practical feasibility and the ecological and economic impact (on micro and macro level) of the introduction of biofuels in Belgium are analysed. Results are used to create a roadmap for the introduction of biofuels in Belgium.

CONCLUSIONS

The main biofuel options for Belgium on the short term are biodiesel (methyl ester) from vegetable oil, to be blended with diesel fuel (up to B7), potentially supplemented with hydro-treated vegetable oil (HVO) in the future, and bio-ethanol from sugar or starch crops, to be blended with gasoline fuel (up to E10). Next to general blending, also options of high blends or pure biofuels could be envisaged (such as E85, ED95, B30, B100, PPO, bio-methane).

On the longer term, more advanced technologies could be introduced, and feedstock can be broadened to include waste and ligno-cellulose based resources. Typical “2nd generation” fuels could be Fischer-Tropsch diesel (so-called BTL), cellulose ethanol, bio-SNG, bio-DME, etc., with their major potential roll-out after 2020. The project started with an analysis on the technological evolution in vehicle models, the likely biofuel blends on the European markets, and the possible interest of certain end user groups, to come to realistic biofuel introduction scenarios.

For the main biofuel options, the environmental impact was studied, both in terms of well-to-tank (WTT) and tank-to-wheel (TTW) emissions. For WTT level, the assessment was based on data from the Swiss Ecoinvent database, which includes complete figures on various emissions for different biofuel pathways. Comparison was also made with other methodologies, mostly focussed on greenhouse gas emissions, in particular the methodology presented in the Renewable Energy Directive. It turns out that how part of the emissions is allocated to co-products is a very important issue. This was also concluded when using the SPA (System Perturbation Analysis) tool, which was further elaborated and optimized within this project.

Another crucial parameter for the WTT greenhouse gas balance is the estimation of N_2O emissions in agriculture, which is a very powerful greenhouse gas (300 times more intensive than CO_2). According to the model of the nitrogen cycle used, estimation of N_2O emissions can differ three-fold. For some biofuels, N_2O emissions can represent up to one third of the overall WTT greenhouse gas emissions, so this certainty creates large differences between calculation methods. The Ecoinvent figures give a lower greenhouse gas performance for current biofuels when compared to the values mentioned in the Renewable Energy Directive. It should however be emphasized that Ecoinvent figures are based on average conventional agricultural practises in Europe, and complete reliance on synthetic fertilizers. The current trend towards taking more and more environmental principles into account for agricultural practices and more use of organic fertilizers will have a serious impact on improving the overall environmental impact of biofuels.

On TTW level, public data was collected on the effect of biofuel blends on vehicle emissions and energy consumption. While there is quite some information and test data available for older types of vehicles and engines (especially for biodiesel), the effect on new engine types, in combination with modern emission control systems, is not well documented in literature. This is why extra measurements on the effect of biofuel blends on new types of vehicles were performed within the project. Four diesel vehicles were tested on biodiesel blends, one of these also on HVO blends, three gasoline type vehicles on ethanol blends, and four converted diesel vehicles on PPO. Results are documented in a dedicated public report.

WTT and TTW data were then combined to derive Ecoscore figures for vehicles driving on biofuel blends. The Ecoscore methodology includes a combination of greenhouse gas emissions, emission related to air quality, and noise of the vehicle. Greenhouse gases and other emissions are considered on well-to-wheel (WTW) basis. The main advantage of biofuels is in the reduction of greenhouse gas emissions and a reduction of fossil energy in the pathway. On the other hand, harmful emissions – in particular particulate mass (PM) - are in some cases substantially increased through inclusion of the feedstock and fuel production pathway. All together the Ecoscore performance of vehicles running on biofuels is generally in the same order as for fossil fuel. In that sense, new technologies like electric or hybrid vehicles perform much better.

The emission data were also used to calculate overall emissions of the Belgian transport system, when shifting part of the fuel to biofuels. Distinction is made between direct emissions in transport (vehicle emissions), and indirect emissions related to the production pathway of the fuel. One clear observation is that energy saving in the transport system could have much more impact on greenhouse gas and other emissions than biofuel introduction. So energy saving should have first priority and it requires much efforts and substantial changes in our habits and energy system. Next to that, biofuels can lead to some additional greenhouse gas savings, also including indirect emissions.

For NO_x emissions, the direct impact of biofuel blending is negligible, while there is some increase through the biofuel production pathway. The effect of these indirect NO_x emissions is however rather small. The situation for PM emissions is different as indirect emission are in the same order as direct emissions, and there is an overall increase of PM emissions when introducing biofuels.

When looking at the practical feasibility of biofuel introduction for end users, cost is of course a major factor. In terms of vehicle purchase cost, the impact of low biofuel blending creates no additional cost. Fuel flexibility to be able to drive on higher blends may create some costs, although the additional cost is generally quite modest. Pure biofuels like ED95, bio-methane of PPO require substantial changes in the engine, and the additional cost of the conversion or of the dedicated technology may be substantial. In terms of fuel cost it is clear that biofuels are more expensive than fossil fuels and it is anticipated that this will remain the case in the following decade (the only exception is Brazilian ethanol). So policy (tax reductions or mandates) is needed to overcome this cost disadvantage. Only after 2020 biofuels may become competitive with fossil fuels. It should however be stressed that the project looked at long term trends. In practise high short term fluctuations may be expected, both in fossil fuel prices and on biofuel feedstock prices.

Ligno-cellulose based biofuels at least have the potential to compete with fossil fuels by 2020 as they are based on more abundant and cheaper feedstock than current biofuels. However there is still a lot of uncertainty in the technology cost and it is most probable that 2nd generation biofuels will still need policy support after 2020.

In order to design appropriate policies, it is important to capture the dynamics that determine the biofuel market. In the framework of the project, a 'system dynamics' (SD) model was developed to gain insight in the long-term dynamic behaviour of biodiesel over time. The model deals with internal (positive and negative) feedback loops, stocks and flows, time delays and non-linearities to describe the dynamic, long term behaviour of aggregated social systems. The purpose of the model developed in this project was rather exploratory, as a full simulation of the market would take integration of worldwide linkages with other sectors (mainly energy and agriculture), including possible uncertainties in terms of weather and climate conditions, stakeholder risk aversion and variations in the investment climate. Within this exercise the focus was restricted to the Belgian policy system. Policy should focus on overcoming the economic disadvantage of biofuels with fossil fuels before markets will take off (through tax or mandates). When demand takes off, a shock in biodiesel demand might lead to a positive shock in feedstock price, which consequently affects biodiesel prices. On the longer term, scale advantages will gain more weight.

Biofuel sectors often cope with many concerns related to economic, environmental, legal and technical issues which should be addressed to get a successful market penetration of biofuels. A common approach that integrates the stakeholders' visions into the evaluation process of biofuel options is currently lacking. In order to gain understanding in the stakeholders' point of view for several biofuel options, a multi-actor multi-criteria analysis (MAMCA) was performed within the frame of this project. The options analysed were (1) only fossil fuels, so exclusion of biofuels, (2) general blending of biodiesel (FAME & HVO) to diesel fuel, (3) general blending of bio-ethanol to gasoline fuel and in addition introduction of E85 and flexifuel vehicles, (4) bio-methane in a number of niche markets, (5) general blending of Fischer-Tropsch diesel to all diesel fuel. With insights from the MAMCA, additional policy measures can be established to tackle the barriers and disadvantages which could emerge once policy makers decide on which biofuel options to implement and for which stakeholders.

CONTRIBUTION OF THE PROJECT TO A SUSTAINABLE DEVELOPMENT POLICY

The BIOSES project has contributed actively to the elaboration of the Belgian National Renewable Action Plan (NREAP) for 2020, to be submitted to the European Commission in the frame of the Renewable Energy Directive. The consortium provided input in terms of projections of diesel and gasoline consumption in a baseline and an energy saving scenario, providing realistic biofuel introduction scenarios, and consulting, involving and informing biofuel stakeholders, of which several representatives were part of the BIOSES follow-up committee, on the potential framework of biofuel introduction in Belgium. To fulfil the 2020 targets fixed by the NREAP, policy around energy consumption in transport should be a combination of:

1. Increased general blending: general blending will play a major role in reaching the national targets. In this view, the current blending obligation of $4\%_{vol}$ should be progressively increased according to quality standard publications.
2. Promote the use of biofuels with good greenhouse gas performance: the revised Fuel Quality Directive 2009/30/EC requires fuel suppliers to reduce the life cycle greenhouse gas emissions per unit of energy from fuel and energy supplied of 6 % by 2020 compared to 2010, and biofuels with a high greenhouse gas reduction are essential in that sense.
3. Support for innovative and advanced biofuels: although the contribution of advanced biofuels to national targets is expected to reach significant volumes only after 2020, the promotion of such technologies is crucial from now on.
4. Promotion for market development of higher blends: support should be given to the deployment of high blends and pure biofuels, especially E85 and bio-methane, both in terms of compatible vehicles, fuel infrastructure and fuel price. Deployment should start in niche markets, but may widen afterwards.
5. Sustainability assurance: this is a major issue for societal acceptance of biofuels. The practical implementation of the sustainability requirements in legislations should be based on relevant, transparent and science-based data and tools.

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Regarding long term transport policy, there should be the following focus: (1) energy saving in transport and (2) introduce renewable energy in transport. Energy saving should clearly be given priority. For the second pillar there are actually two options: electric mobility and biofuels. On the long term, a balance will appear between these options. While in the next ten years current biofuels (based on agricultural crops) are still the basis in biofuel roadmaps, further growth afterwards will have to come from other feedstocks, like waste & residues, ligno-cellulose and possibly algae (long term). This opens a far higher biomass potential on a global scale as biofuel resource. Nevertheless energy efficiency & energy saving in transport remain key, in terms of limited resources of fossil resources, biomass & materials (batteries).

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