

# Comparison of two models of environmental valuation – Application to a particular case study (alternative vehicles)

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## Abstract

The final purpose of this paper is to show how two different methods of environmental impact assessment (ExternE and Eco-Indicator 99) can be used in order to determine the advantages and disadvantages of a particular product. An environmental comparison of several vehicles (petrol, diesel, electric, hybrid, LPG and CNG) is considered on the basis of each model.

The results obtained highlight the limitations of both theoretical models. In fact, it seems that EI99 is simpler to use than ExternE. However, the ExternE application is extended to more environmental impacts (accidents, nuclear, etc.). Furthermore, it allows the monetarisation of the damages (expressed in EURO). One of our conclusions is that the results mainly depend on the damages studied, but also on the weight attributed to them. In this way, the global environmental impact calculated is very related to the model of environmental valuation which tends to prove that environmental labeling on the basis of a global LCA is often not as easy as it seems...

## Goal and scope of the study

### Goal of the study

To evaluate the environmental impact of the human activities, numerous methods have been elaborated these last years. These decision tools propose criterions varying from a method to the other. This is why a comparison of two methods will be achieved on basis of the concrete case of the automotive vehicles.

The goal of this study is to show how two different methods of environmental impact assessment (ExternE and Eco-Indicator 99) can be used in order to compare on an environmental basis several vehicles (petrol, diesel, electric, hybrid, LPG and CNG). The main technical characteristics of the six vehicles are described in table 1.

	<b>Honda Civic 1.6 i</b>	<b>VW Golf 1.9 TDI</b>	<b>Opel Astra 1.6 i</b>	<b>Honda Civic 1.6 i</b>	<b>Peugeot 106</b>	<b>Toyota Prius</b>
<b>Energy Supply</b>	Petrol	Diesel	LPG	CNG	Electricity	Hybrid : Petrol
<b>Max. Power</b>	80,9 kW	66 kW	74 kW	84,6 kW	20 kW	75 kW
<b>Catalyst</b>	3 ways catalyst	Oxydation catalyst	3 ways catalyst	3 ways catalyst	-	3 ways catalyst
<b>Battery</b>	Lead-Acid	Lead-Acid	Lead-Acid	Lead-Acid	Ni-Cd	Ni-MH

*Table 1 – Main technical characteristics of the six vehicles studied.*

### Function and Functional Unit

For the comparison of the vehicles, the function is the capacity to move from one point to another by mean of each vehicle studied. This function is specified while considering a identical number of passengers and a real haulage cycle for every vehicle.

The functional unit (FU) is defined in the ISO standard as a “quantified performance of a product system for use as a reference unit in a life cycle assessment”. In this study, “1 kilometer” is chosen as the FU.

## System boundaries

The system boundaries correspond to the whole energy supply chain from cradle (extraction of primary energy) to gate (moving vehicle). These limits include :

1. For petrol, diesel, LPG and hybrid vehicles : oil extraction, oil treatment, oil transport to Belgium, refining, different fuels transported by pipeline to intermediate stocks, storage, transport by lorries to refueling station, refueling (which involves losses) and finally vehicle use phase but also vehicle construction.
2. For CNG vehicle : natural gas extraction, natural gas treatment, natural gas transport to Belgium, dispatching, compression at the station, and finally vehicle use phase but also vehicle construction.
3. For electric vehicle : fuels production and preparation, electricity production in Belgium, distribution of electricity (which involves losses), and finally vehicle use phase but also vehicle construction.

Two assumptions have been considered for the electric vehicle. In the first one, electricity needed is obtained by the average Belgian production and in the second one, the same vehicle consumes an other average electricity which does not take the nuclear plants into account.

## Life cycle inventory

Evaluating each of the methodologies requires a life cycle perspective. In this study, the life cycle considered is in fact a “fuel cycle” which includes the previously defined steps.

For emissions, our study includes the major GHGs (carbon dioxide [CO<sub>2</sub>], methane [CH<sub>4</sub>] and nitrous oxide [N<sub>2</sub>O]), but also other pollutants (particulate matter [PM<sub>10</sub>], carbon monoxide, nitrogen oxide[NO<sub>x</sub>], sulphur oxide [SO<sub>2</sub>] and hydrocarbons [HC]). Unfortunately, some interesting emission data (heavy metals, PAHs, etc.) couldn't be collected for the whole “fuel cycle” and weren't therefore included in this study.

Table 2 gives an order of magnitude of the emissions related to the different “fuel cycles”.

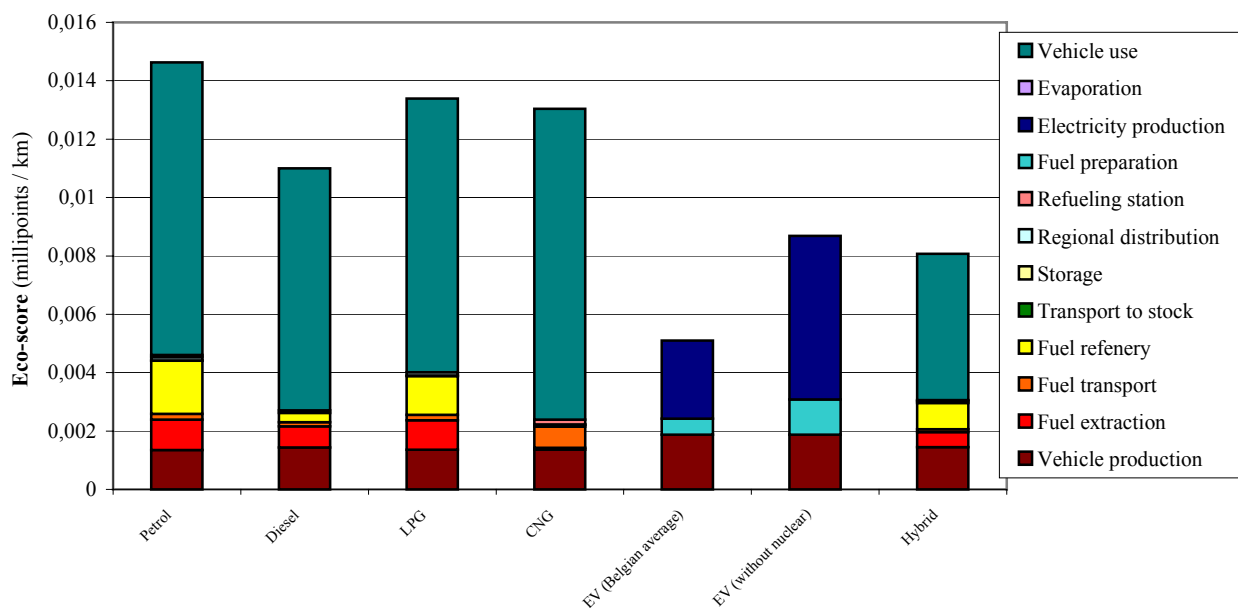
	Petrol (g/km)	Diesel (g/km)	LPG (g/km)	CNG (g/km)	Electric vehicle (average production) (g/km)	Electric vehicle (without nuclear) (g/km)	Hybride (g/km)
CO <sub>2</sub>	249	178	202	184	94	183	135
SO <sub>2</sub>	0,218	0,159	0,178	0,080	0,212	0,384	0,149
NO <sub>x</sub>	0,244	0,480	0,195	0,076	0,211	0,366	0,162
PM <sub>10</sub>	0,031	0,055	0,030	0,017	0,050	0,090	0,023
HC	0,497	0,065	0,139	0,007	0,011	0,025	0,242
N <sub>2</sub> O	0,003	0,004	0,003	0,003	0,002	0,003	0,003
CH <sub>4</sub>	0,215	0,131	0,189	0,506	0,160	0,378	0,099
CO	1,320	0,149	0,080	0,127	0,027	0,035	0,581

*Table 2 – Inventory of the global emissions related to the different “fuel cycles”.*

## Impact assessment

### Eco-Indicator 99

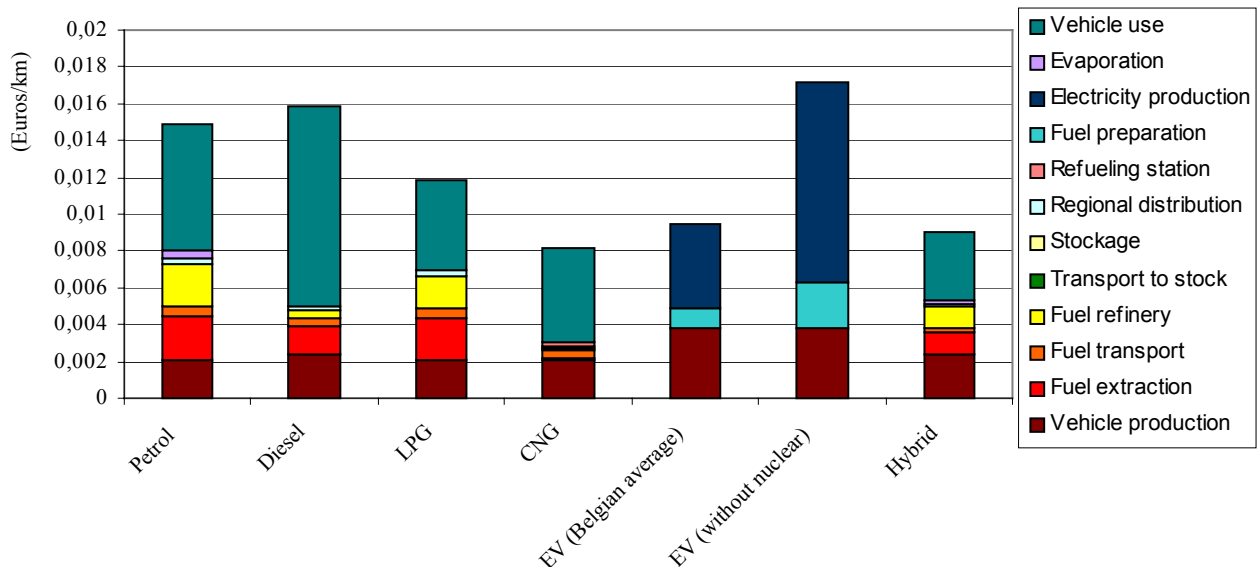
In this case study, the EI 99 method is applied with the hierarchist perspective (H,A).



**Fig. 1 – Contribution of the different steps to the global environmental load in EI 99.**

In figure 1, the Eco-score is considered for the different steps of the life cycle for the seven systems compared. Figure 1 shows that the electric vehicle (Belgian average) has the smallest environmental impacts. However, the “Belgian average” scenario is little realistic because actual nuclear production is totally consumed by other activities and there is at this moment no policy to develop new nuclear plants. Thus, we can consider that the hybrid vehicle represents the most advantageous alternative.

### ExternE



**Fig. 2 – Contribution of the different steps to the global environmental load in ExternE.**

In figure 2, the Eco-score calculated with ExternE is considered for the different steps of the life cycle for the seven systems compared. This figure shows that the CNG vehicle has the smallest environmental impacts.

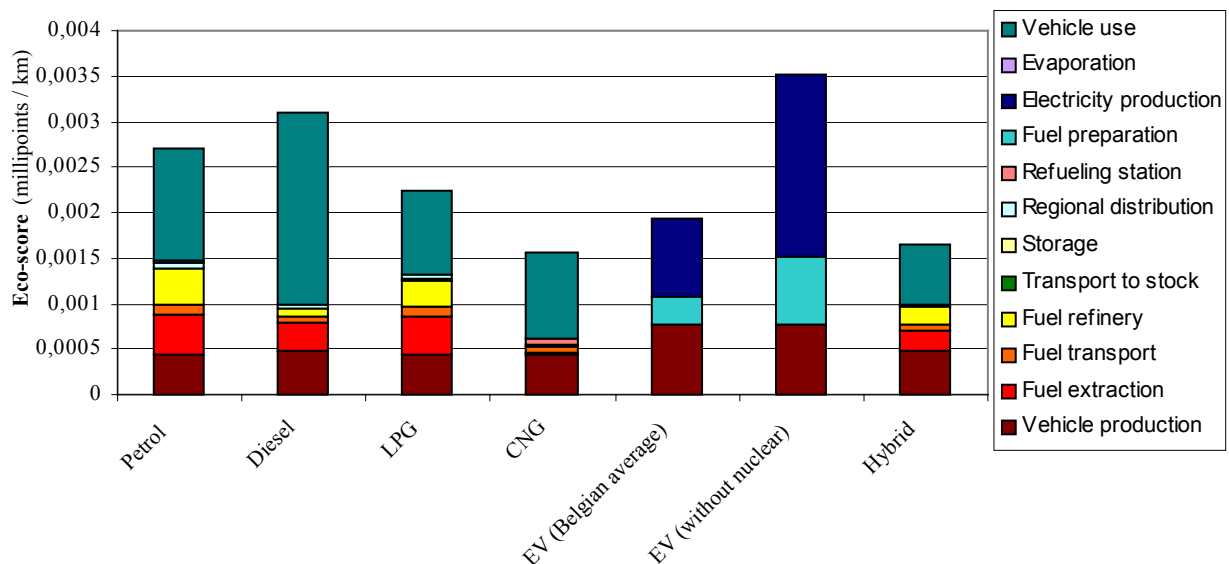
## Methods comparison

First of all, the EI 99 method is a non specific method. Damage factors of every pollutant are independent of the emission site. To the inverse, the ExternE method includes the dependence of the results in relation to the site.

Then, the EI 99 method is simpler to use than ExternE. However, the EI 99 method only takes account of three types of environmental damages : human health, ecosystem quality and resources. The ExternE application is extended to more environmental impacts (accidents, nuclear, etc.). Furthermore, it allows the monetarisation of the damages (expressed in EURO).

Finally, a certain number of differences appears in the relative importance given to each pollutant. So, in comparison with the damages allocated to the emissions of CO<sub>2</sub>, the ExternE method grants a bigger importance to the emissions of HC that the EI 99 method.

The results obtained by the two methods in the figure 1 and 2 are very different. This difference comes mainly because the ExternE method doesn't take into account the damage caused by the use of natural resources. If we don't consider this damage in the results obtained with EI 99, we get the figure 3 whose results are similar to those obtained with the ExternE method.



**Fig. 3 – Contribution of the different steps to the global environmental load in EI 99 (without damages to natural resources) .**

## Conclusions

In the setting of our study, the hybrid and CNG vehicles represents the most environmentally advantageous alternative. However, the results mainly depend on the damages studied, but also on the weight attributed to them. In this way, the global environmental impact calculated is related to the model of environmental valuation. So, the result of a comparison can be different according to the method used. It is therefore essential to analyse the assumptions considered in a particular case study but also in the calculation method. Hopefully when similar assumptions are taken into account, the results seems to be similar.

## References

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