The Comparison of two Environmental Rating Systems: BIM-EcoScore vs. EC-Cleaner Drive

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Abstract

Two environmental rating systems, based on a comparison of the damage caused by vehicle emissions, are analysed and compared with each other. Both rating systems use a Well-to-Wheel approach. The first methodology, BIM-Ecoscore, was developed for the Brussels Capital Region and the second methodology, EC-Cleaner Drive, is being developed in the framework of a 5th FP European project.
The comparison of both methodologies was made by the following five steps, which are used in a life cycle analysis: inventory, classification, characterisation, normalisation and weighting. At each step both methodologies are evaluated and advantages and draw backs are summarised. A sensitivity analysis was carried out, to determine their robustness.

Keywords: Environment, Emissions, Alternative Fuel, Powertrain, Policy

1. Introduction

The transport sector is a source of non-negligible quantities of pollutant emissions that have a direct and an indirect impact on many environmental receptors (climate, human health, ecosystems, etc.). The introduction of 'clean vehicles' is a promising solution for a significant reduction of pollutants and energy use. However the question 'what are clean vehicles?' remains a key issue. A large number of factors influence vehicle emissions, such as the driving behavior, traffic situation and vehicle technologies. In order to compare the environmental burden caused by vehicles with different drive trains and fuel use, comprehensive methodologies are developed.
Detailed description of the Ecoscore methodology can be found in references [5,6,7,8].
Additional information about the Cleaner Drive project can be found at www.cleaner-drive.com.

2. Comparison

2.1. Methodology

The assessment of both environmental rating systems, is based on a "five-step" scheme, similar to that used in a Life Cycle Assessment. These steps are in fact the answers given to the five following questions:

- "Which pollutant emissions are associated to the vehicle to assess?" (inventory)
- "Which types of damage are these emissions contributing to?" (classification)

- "Which values are to be attributed to this damage?" (characterisation)
- "Is this damage important in comparison with the damage of the reference vehicle?" (normalisation)
- "How important is a type of damage in comparison with other damages?" (weighting)

2.2. Inventory – Well-to-Wheel approach

In both methods direct (tailpipe or tank-to-wheel) emissions and indirect (fuel and/or electricity production; or well-to-tank) emissions are considered. This allows us to compare vehicles with different types of (alternative) fuels (LPG, CNG and biodiesel, etc) and drivetrains (battery electric, hybrid, fuel cell, etc.). Emissions related to the use of material for the production of the vehicle, or related to dismantling/recycling at the end of its life as well as emissions related to the required infrastructure (e.g. highways) are not considered in both methodologies due to insufficient specific data. The use of average data would not lead to further differentiation.
Also similar is the source of emission data used, namely type approval data and emissions proportional to fuel consumption. However there are some differences. In the Cleaner Drive methodology direct SO_2 and CH_4 (except for CNG vehicles) emissions are not taken into account, this opposed to the Ecoscore methodology. The reason for this is due to relatively insignificant value because of the market introduction of low sulfur fuels and respectively lack of data. In Ecoscore the zero value of the type approval is used for PM emissions of petrol vehicles.
For the indirect emissions Cleaner Drive use the data based on reference [9]. Ecoscore uses the same data, however, since this data is already out of date and since there are significant improvements in the reduction of emissions related to electricity production the last 10 years, state-of-the-art data is used when available. Because of the European application of Cleaner Drive, EU wide comparable data are necessary. Concerning bio-fuels and hydrogen production there is a lack of useful indirect emission data.
As opposed to direct emissions, indirect emissions are not produced at the place of vehicle operation. Since refinery plants and electricity production plants are mostly situated far away from densely populated areas, their effects on human health are lower than direct tailpipe emissions, because of the dispersion of these indirect emissions. To take this into account, Ecoscore introduces a weighting factor (e.g. 50%) in calculating the total emissions related to health effects. However no weighting is allowed for overall damage like global warming since every gram of CO_2 makes the same contribution to this effect. Cleaner Drive is based on External Cost (see further) and hence does not require a weighting factor for the calculation of the total emissions because external cost values for urban and extra-urban emissions are available.
Since Ecoscore was developed in the first place for a typical urban context (Brussels Capital Region), noise pollution was also taken into account. Noise is one of the main causes of annoyance for the inhabitants of Brussels [10]. In the Cleaner Drive methodology noise is not included because of the lack of data reflecting in-use noise levels.

2.3. Characterisation, classification, normalisation and weightening of different effects and damages

The Cleaner Drive rating system considers greenhouse gas emissions and 'air quality' emissions i.e. those that are detrimental to human health, buildings and ecosystems.

In the Ecoscore methodology the following damages are considered together with their effects on a number of receptors such as people, ecosystems and buildings: ‘global warming’, ‘respiratory and cancer diseases’, ‘acidification’, ‘damage to buildings’ and ‘noise pollution’.

The Cleaner Drive system uses ‘external costs’ from the EU ‘ExternE’ project to establish the relative weight to different emissions. External costs of emissions are values expressed in monetary terms, such as €/g, that reflect the overall damage to the environment and to human health caused by emissions. The values are derived by extensive research involving environmental and health experts as well as economists. This approach allows the different emissions from vehicles to be compared on equivalent terms.
External costs measure impacts, so air quality emissions in urban areas have higher values than those in extra-urban areas. The Cleaner Drive rating methodology uses extra-urban values for well-to-tank emissions and a weighted average of urban and extra-urban values for tailpipe emissions (weighted to reflect the national average split between urban and extra urban mileage.)
External costs give an indication of the social cost of a type of damage.
To evaluate the damage rate in the Ecoscore system, the calculated level of emissions, expressed in g/km or in g/kWh, is multiplied by a damage factor expressed in specific units. For each category of damage, these factors either come straight from the Eco-Indicator 99 methodology [11], considered as a reference for effects on health and ecosystems, or from other studies such as, for example, the CEESE-ULB specific study on damage to buildings [12].
In order to measure the relative extent of the different damage, the formerly evaluated damage is “normalised” according to a specific reference value for each category of damage. In this way, it becomes possible to compare damage caused by the vehicle to be assessed, with a reference situation.
For the Ecoscore, it was decided to take as reference the damage associated with a fictive vehicle. This reference vehicle corresponds for passenger cars with the values imposed by the Standard Euro IV for petrol vehicles. As far as CO_2 emissions are concerned, the value of 120g/km is taken as reference, as this value is the objective for new car registrations, the automobile industry has accepted to aim at in the European Union. The indirect emissions can also be calculated from these target values since they are proportional to the fuel consumption and CO_2 emissions.
For SO_2 emissions, the reference level is based on the content of 50 ppm of sulphur in the petrol or diesel forecasted from 2005 on. For the sound a level of 70 dB (A) has been chosen as a reference.

The maximum tailpipe emission for each pollutant in the Cleaner Drive methodology is set at the maximum legislated Euro III (2000) emission for any fuel/car class. Maximum emissions are calculated as those resulting from the equivalent fuel consumption of a vehicle emitting 350 g CO_2/km. Minimum values are set at zero emissions for both greenhouse gas and air pollutant emissions. In the final score this can lead to possible negative values for Cleaner Drive but not for the Ecoscore.

The final stage of the assessment consists of weighting the normalised damage before adding them in order to have a final environmental score. The weighting factor applied in the Ecoscore is not only based on a scientific point of view. Policy priorities and decision-makers opinion are also very important. This is an aspect of the methodology that allows to weight the damage categories and to give more weight to issues that decision-makers decide to be more essential than others. A specific weighting system for the Brussels-Capital Region seems to be

necessary, given the specificity of this largely urbanised region where environmental priorities can differ very much from those of a country or a continent.
Since Cleaner Drive expresses all damage in external cost no weighting systems is implemented. The question is if the external cost related to global warming can be compared with the external cost related to air quality, since the first one is calculated based on damage cost and the latter on contingent valuation.
In Figure 1 an 2 the relative contribution of the different considered damages to the end score of EcoScore and of Cleaner Drive were shown.

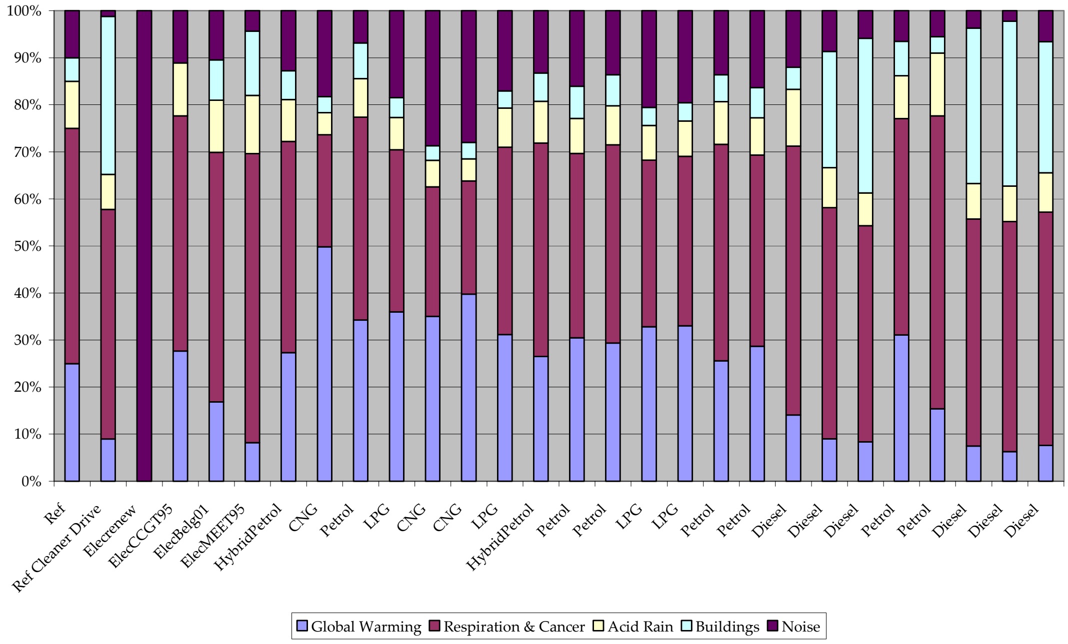

Figure 2: The relative contribution of the different considered damages to the end score of EcoScore

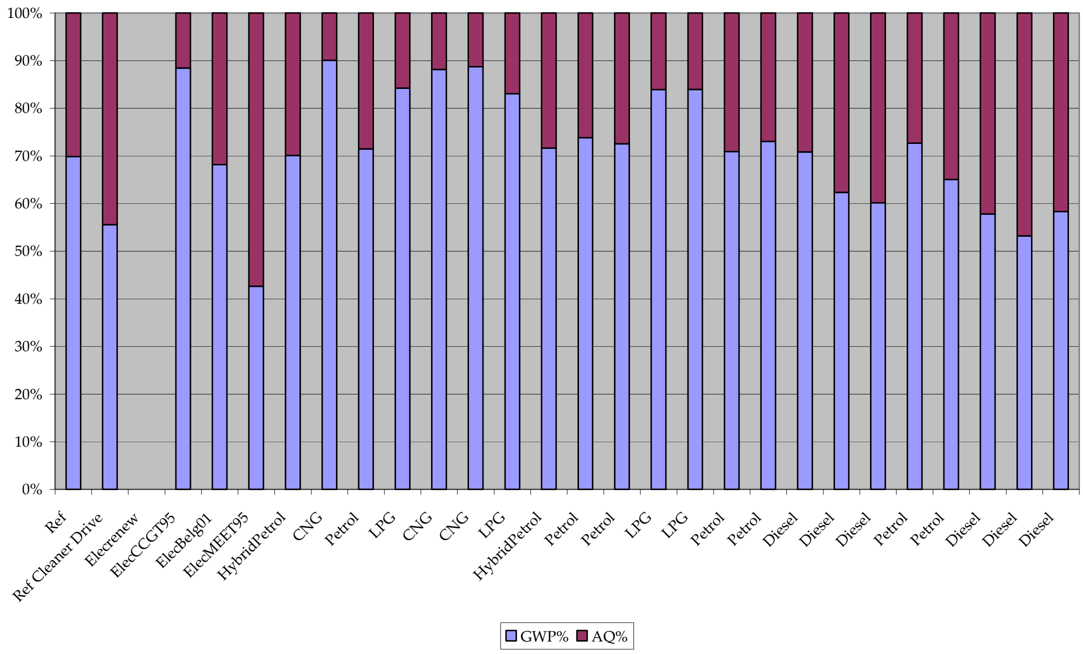

Figure 3: The relative contribution of the different considered damages to the end score of Cleaner Drive

2.4. Summary of both methodologies

Table 1 and Table 2 summarize the BIM - Ecoscore methodology. Table 3 and Table 4 summarize the Cleaner Drive system. The data are valid for the Belgium situation. Although both methodologies started from a different viewpoint and where developed in a different context, it is now possible to compare them with each other.

Table 1: Emission levels of Ecoscore reference vehicle

	Noise [dB(A)]	CO_2 [g/km]	N_20 [g/km]	CH_4 [g/km]	CO [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	SO_2 [g/km]
Direct	70	120.0	0.048	0.012	1.00	0.10	0.08	0.00	0.0038
Indirect		15.3	-	0.029	0.008	0.351	0.070	0.004	0.109

Table 2: Summary of Ecoscore

Damage	*Weighting*	*Emission*	*Unit*	*Contribution*
Global Warming	25	CO_2	GWP	1
		CH_4	GWP	23
		N2O	GWP	296
Human health Respiration & Cancer	50	HC	Daly/kg	6.46E-07
		NOx	Daly/kg	8.87E-05
		CO	Daly/kg	7.31E-07
		PM	Daly/kg	9.78E-06
Eco-systems Acidification	10	NOx	PDF.m^2.y/kg	5.713
		SO_2	PDF.m^2.y/kg	1.04
Buildings	5	SO_2	€/kg	8.3
		PM	€/kg	259
Noise	10	Noise	dB(A)	1

Table 3: Emission levels of Cleaner Drive reference vehicle

	CO_2 [g/km]	N_20 [g/km]	CH_4 [g/km[	CO [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	SO_2 [g/km]
Direct	350,0	0.141	0.232	5.22	0.29	0.78	0.10	-
Indirect	49.8	-	1.372	0.027	1.14	0.227	0.013	0.354

Table 4: Summary of Cleaner Drive

Damage	*Weighting*	*Emission*	*Unit*	*Contribution*	
				W-t-T	*T-t-W*
Global Warming	Not used	CO_2	€/g	0.000046	0.000046
		CH4	€/g	0.000966	0.000966
		N_2O	€/g	-	0.01426
Air Quality	Not used	KWS	€/g	0.003	0.003
		NOx	€/g	0.0047	0.0047
		CO	€/g	5.0E-07	1.35E-06
		SO_2	€/g	0.0079	-
		PM	€/g	0.0198	0.0505

3. Results and Sensitivity Analysis

The methodologies have been used to calculate some examples [6]. These examples are only indicative and serve to evaluate the applicability of the methodologies. Different fuel types and drive trains were selected. Various engine capacities and vehicle sizes were taken to include a broad range of vehicle types.

Figure 3 illustrates a comparison of the results of Ecoscore and Cleaner Drive. Since Cleaner Drive classifies the emissions to less types of damage, an additional exercise was demonstrated. Therefore the Ecoscore model was adapted as to consider only global warming and health effects.

As can be observed both methodologies indicate similar trends: electric vehicles[1] seem to be the cleanest followed by hybrids, CNG, LPG and some small petrol vehicles. Diesel vehicles score poorly, however this is less significant in the Cleaner Drive methodology than in the Ecoscore system.

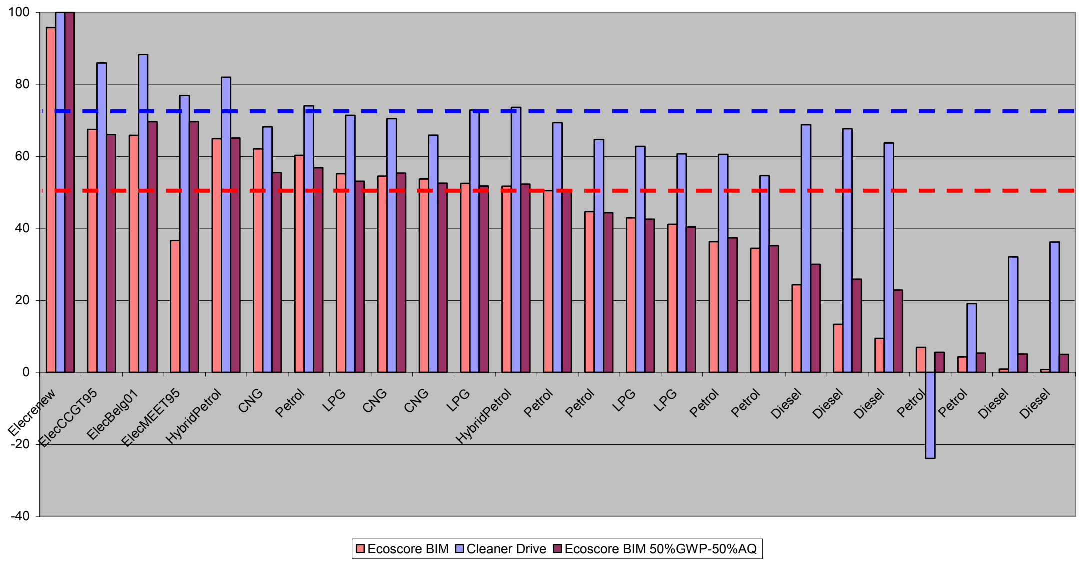

Figure 3: Comparison of the results of Ecoscore and Cleaner Drive

A closer look to the relative contribution of the various damages considered to the end-score can explain the better results for the diesel vehicle in the case of the Cleaner Drive system. In this system global warming almost contributes for 70% to the end score. Since diesel vehicles are characterized by low CO_2 emissions, they will have a low contribution to global warming. In the Cleaner Drive methodology is chosen to use a high value for the external cost of one gram of CO_2, namely 46 €/tonCO_2. In the Ecoscore methodology developed for an urban context, important weight has been contributed to emissions with impact on human health which are mainly emitted by diesel vehicles.

A sensitivity analysis of both systems is carried out. For this exercise the contribution of each pollutant to the damage is multiplied by 2. In this way the sensitivity of the environmental rating towards the emissions levels or their damage factor can be evaluated.

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[1] This result is valid independent of what kind of electricity mix is chosen (three examples are illustrated in Figure 3)

On the right axe of figure 3 the Ecoscore is marked. The left axe contains the absolute difference between the original Ecoscore and the Ecoscore calculated by doubling the damage factors. As can be noticed a maximum deviation of less than 5 on a scale of 100 is observed. A similar exercise is illustrated in figure 4 in the case of the Cleaner Drive methodology. In this system a maximum deviation of 15 on a scale of 100 can be seen. A possible conclusion could be that both methodologies are quite robust but that the Cleaner Drive system is somewhat more sensitive than the Ecoscore model.

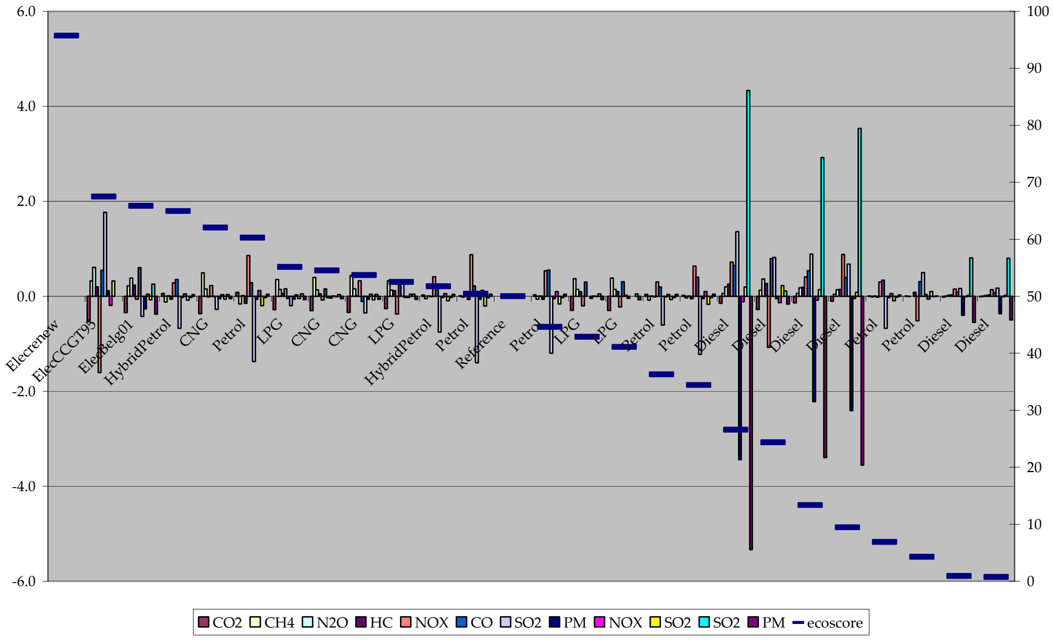

Figure 3: Sensitivity analysis of the EcoScore system

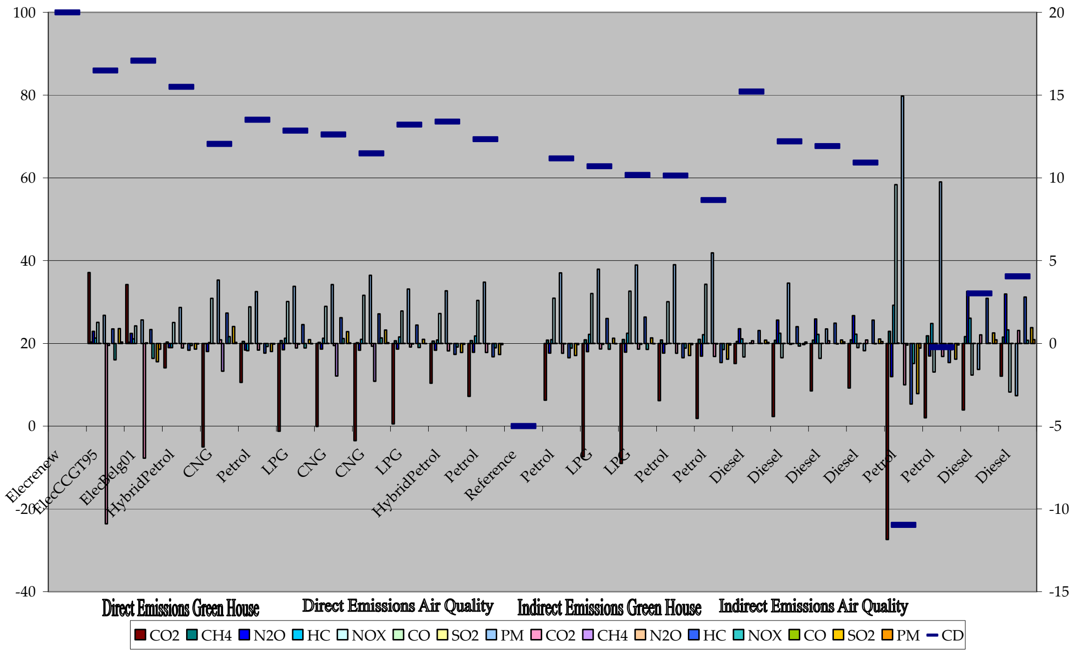

Figure 4: Sensitivity analysis of the Cleaner Drive system

4. Conclusions

In the framework of a Life Cycle Assessment approach two environmental rating systems, Cleaner Drive and Ecoscore, were compared. A comprehensive and transparent summary of both systems is highlighted.
Some results, to demonstrate the applicability of the methodologies, where calculated. Finally on the basis of a sensitivity analysis the robustness of both methodologies was evaluated.
As general conclusion one can state that, nevertheless the differences in approach and the different scopes of the environmental rating systems, they indicate similar results. Both are quite robust with a slight advantage for the Ecoscore system.
Currently a new research program, commissioned by the Flemish Government (AMINAL) is running, with the aim of comparing the EcoScore methodology with the European Cleaner Drive methodology and to evaluate the usability of a new transparent and comprehensive methodology in order to adopt policy instruments (taxation, incentives, consciousness razing campaigns etc.) in favour of cleaner vehicles.

5. Acknowledgements

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