“ARE WE MOVING IN THE RIGHT DIRECTION?” TRANSPORT’S ENVIRONMENTAL IMPACT ASSESSMENT WITH ELECTRE III

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Abstract. “Are we moving in the right direction?” is TERM’s key question on the environmental performance of transport in Europe. Here, we apply ELECTRE III to answer this question, that has been left open ever since. Indicator weights are transferred from Life Cycle Assessment methodology and proposed for discussion. Judging from the indicators provided, the environmental performance from the road vehicles in EU15 may become better if transport’s increasing land take and fragmentation can be halted. Otherwise, improvements do not seem enough to balance the increasing energy consumption and carbon dioxide emissions.

1. Strategic environmental assessment of the transport sector

“Are we moving in the right direction?” is TERM’s key question on the environmental performance of transport in Europe and, consequently, of European transport policy. However, a comprehensive answer has been missing since the first publication of the ‘Transport and Environment Reporting Mechanism (TERM)’ by the European Environment Agency in the year 1999 (EEA 1999). There are the fundamental problems, if, how and by whom a relative importance of the different environmental impact categories is assigned, and if a positive performance in one category can compensate for a negative performance of another? Second, the environmental impacts are by their very nature heterogeneous and therefore hard to compare. A third, technical problem is simply lack or poor quality of data.

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2. Methodological approach

2.1. ELECTRE III for ranking

Conventional assessment methods usually need homogeneous, quantitative and crisp values and assume an unlimited compensation between impact categories. Therefore this research applied a multi-criteria method that has been established in France for two decades, though rarely on transport issues. The ELECTRE method follows an ordinal assessment logic, based on outranking pairs of alternatives, without compensation between impact categories (Roy and Bouyssou 1993). It can furthermore cope with heterogeneous, qualitative as well as quantitative data, treat uncertainty formally and include a veto mechanism if a certain under-performance is judged unacceptable. We have thus been able to give a methodologically sound answer to the original TERM question.

2.2. Criteria weights transferred from Life Cycle Assessment methodology

The German Federal Environmental Agency developed an environmental impact assessment method for use in their Life Cycle Assessments (UBA 1999). The Agency proposed a set of criteria in order to derive a ranking of the overall ecological importance of the various impact categories, then summarised its knowledge and passed its own authoritative judgement on the ecological importance of each impact.
The Federal Environment Agency proposes three criteria for pertinence:

A. The ecological hazard for the impact category[2],

B. the distance between the actual state and the target for each impact category, and

C. the system's specific contribution to the impact category.

The first two criteria reflect the environmental context in general, largely in terms of severity and probability of an incidence. The third criterion focuses on the relative weight of the system under study.

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[2] An impact category regroups similar environmental effects. Life Cycle Assessment generally considers ten to fourteen environmental impact categories: Greenhouse effect, acidification, eutrophication, photosmog etc. for the impact categories used by the German Federal Environment Agency, and Pennington et al. (2004) and references therein for slightly different categories. The overall protection targets are 'Human health', 'Structure and Function of Ecosystems', and 'Natural Resources'. These ultimate targets have been set – here: for Germany – by the Federal Environment Agency based on the analysis of the pertinent laws (UBA 1999, p.12).

Indicator	Energy consumpt.	GHG-emission	Fatalities	Fragmen-tation	Land take	Noise	Particles (pot.)
Ecolog. hazard	3	5	4	5	5	3	4
Distance to target	4	5	3	4	4	4	4
Spec. contribution	3,2	2,1	4,0	5,0	4,0	5,0	3,8
Weight	**10,2**	**12,1**	**11,0**	**14,0**	**13,0**	**12,0**	**11,8**
Share	**12%**	**14%**	**13%**	**17%**	**15%**	**14%**	**14%**

Tab 1: Weights on a scale from 5 (highest) to 1 (lowest) transferred from Life Cycle Assessment to the environmental impact categories of transport (Borken 2005).

While Life Cycle Assessment according to the International Standardisation Organisation (ISO 14040ff) applies to products or processes, this analysis envisages a potential application within Strategic Environmental Assessment e.g. for transport (infrastructure) plans or programmes.

2.3. TERM-indicators as data source

We use the TERM-indicators as the central data source. However they are by no means ready for use: They are far from being homogeneous, they are redundant and in most cases not relevant. Hence a careful selection and homogenisation comes first. Full details can be found in Borken (2005). The result is anyway a concentration on seven impact categories that can indeed be represented by seven indicators

Indi-cator Year	Energy consumpt. EU 15	GHG-emissions EU 15	Fatalities EU 15	Fragmen-tation EU 15	Land take EU 15	Noise EU 15	Particulates (pot.) EU 15
1990	100%	100%	100%	100%	100%	100%	100%
1995	109%	108%	80%	76%	75%	92%	93%
2000	126%	119%	73%	32%	32%	84%	79%
2005	139%	129%	67%	17%	17%	79%	62%
2010	151%	139%	63%	13%	12%	75%	44%

Tab. 2: Performance table for the environmental impact of transport in Europe, based on a minimally selected set of TERM indicators (EEA 2001). Data for 2005 and 2010 from Samaras et al. *2002) or trend extra-polation (Borken 2005).

3. Results for the central estimate and sensitivity analyses

Judging from the indicators provided, the environmental performance of transport in EU15 becomes better, notably because of diminishing fatalities and land use pressures, though the increase in CO_2-emissions and transport energy consumption counteracts. These improvements will become more distinct for 2005 than they have been in the nineties (Figure 1 - in the representation of Pictet et al. 1994).

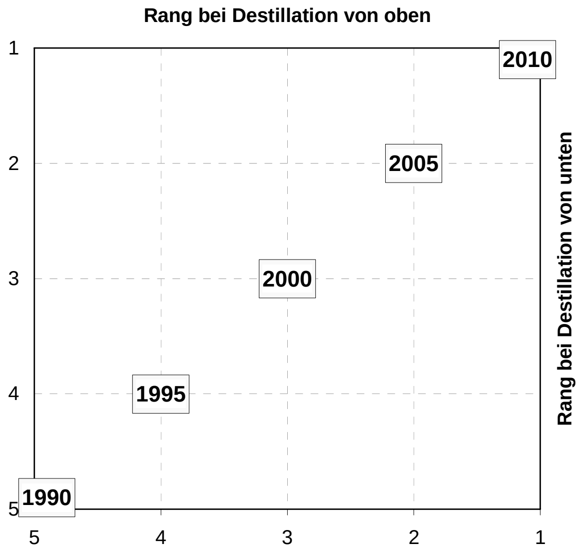

Figure 1: Unambiguous overall ranking of transport's environmental impact for different years in the base case (Borken 2005).

These conclusions remain valid for a large range of weightings and performances in the different impact categories as large uncertainties of the data significantly blur the picture (Figure 2). If notably the quality of transport's nitrous oxygen emission inventory could be reduced to less than 25% uncertainty, this would significantly sharpen the credibility, usability and efficiency of TERM: NO_x is a key substance for PM_{10} and ozone formation, and thus transport's health impacts, as well as via eutrophication for biodiversity impacts.

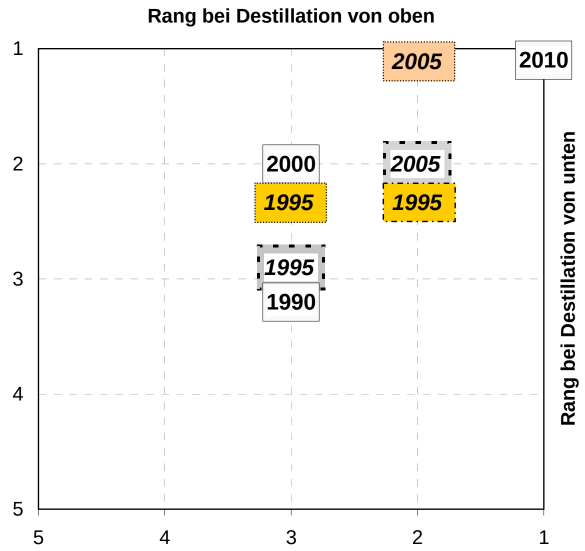

Figure 2: Sensitivity of the ranking depending on different weighting profiles: The tendency remains stable, differences between 1995 and 2000 blur (Borken 2005).

4. Conclusions

The current assessment is strongly based on indicators with more reliable data like greenhouse gas emissions and resource consumption on the one hand, and accidents and land use on the other hand. Crucial is hereby the evaluation of transport's land use: If only a reduction in absolute land take would be judged acceptable, and not already a decreasing trend, then transport's performance was to be considered significantly worse. In addition, it is far from certain that the environmental impact of transport goes down in the future as much as has be assumed from the trend extrapolation here.

Thus, the assessment presented here provides differentiated feedback on the overall success or shortcomings of European transport policy, as measured by TERM indicators. Yet, critically, most indicators put forward by the European Environment Agency are neither pertinent nor sensitive, and the set is far from describing the whole transport system: Therefore this assessment covers essentially only the impacts from road transport! A lot of improvements are needed – but also feasible.

We identify key parameters for further improvements and action in terms of policy, assessment concept and data. The methodological part of our research is intended to move the discussion on suitable and robust methods for transport impact assessment further.

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