

IDENTIFICATION OF KEY ENVIRONMENTAL LOADS USING A LIFE CYCLE APPROACH

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ABSTRACT

Input Output Analysis will be used to identify sectors with the highest environmental impact and will make a significant contribution in advancing Integrated Product Policy measures. It will identify which parts of the UK economy are putting most stress on the environment both globally and domestically and enable the Environment Agency for England and Wales to take informed policy decisions on these issues based on sound science.

The UK National Accounts Matrix including Environmental Accounts (NAMEA) is reviewed together with a thorough literature review to develop a solid methodology to calculate the environmental impacts of sectors.

The outcome of the study is a prioritised list of sectors with high environmental impacts.

Keywords: Integrated Product Policy, Input Output Analysis, National Accounts, Environmental Accounts, Life Cycle Assessment, UK economy

1. INTRODUCTION

In 2003, the European Commission adopted a Communication on Integrated Product Policy (IPP) with the aim of improving the environmental performance of products throughout their life cycles. Furthermore, the Commission has announced measures to address individual product groups. These include a commitment to address those product groups that have the greatest potential for environmental improvement.

In effect, these developments require looking at environmental policy through the 'lens' of each product sector, selecting priority areas for improvement, and deciding on the policy and market measures best suited to deliver the improvement. The process involved here is inherently more complex than some of the traditional policy approaches that focus on the control of sites and materials, because its application ranges across whole product sectors.

As a step towards identifying the potential for improvement, it is essential that those product sectors with the highest environmental impact are identified.

The UK input/output (I/O) tables display the transactions of goods and services in the UK economy for a single year in matrix form. When I/O tables are supplemented with environmental data for each sector, ie resource consumption and emissions per £ produced, total environmental exchanges can be calculated for each sector. I/O tables supplemented by environmental data are also known as National Accounting Matrices including Environmental Accounts (NAMEAs).

The UK NAMEA is currently used to inform sustainable development policy by measuring environmental impact of different sectors in the economy.

The specific objectives of the study are:

- to review the current UK NAMEA and related studies and literature sources; and
- to carry out an assessment using the current NAMEA supplemented by specific literature and input-output data to establish those activities that have the greatest impact (resource use, global climate environmental impacts etc) on the environment.

The study is ongoing and is conducted by the LCA team at Environmental Resources Management Limited who were commissioned by the Environment Agency for England and Wales.

2. METHODOLOGY

The goal of the study is to create a consistent and structured method to select sectors in the UK economy with the greatest environmental impact and subsequently the largest potential for improvement. The method will be based on the current NAMEA, extended to cover more environmental exchanges and more economic sectors.

The method results in a list of sectors with the highest environmental impact or with the greatest potential for improvement.

Since the NAMEA trace economic flows up to the point the consumer purchases from the sector, it will not always cover the environmental impact after purchase. However, some use phases are included in the current NAMEA, eg electricity use, since the consumer buys electricity. Similarly the impact from the production of fuel for driving is included but the exhaust gases will not be included.

The current study focuses on the environmental impact of the production of goods and services taking place in the different sectors that define the UK economy in the I/O table. This is in contrast to 'classic' environmental I/O analysis where the life cycle impacts from a change in final demand (household consumption, export etc.) are calculated. Instead the environmental I/O analysis is utilised to identify the sectors in the UK economy with high environmental impacts and high impact intensities ie environmental impact per added value contribution to the economy.

For a sector to produce a unit of output it needs input of other sectors. In Fig. 1, starting from the purchase of a product worth £X from industry, the lines can be followed upstream of the production process (to the right in the figure) as it affect all other sectors, which again affects all other sectors. Thus, when an industry purchases from another industry sector, it also purchases the resulting proportion of the environmental impact generated in that sector, and so on. It is common for manufacturing sectors for the impact to reduce the further we move to the right in Fig. 1, illustrated by the impact circles at the top of the diagram.

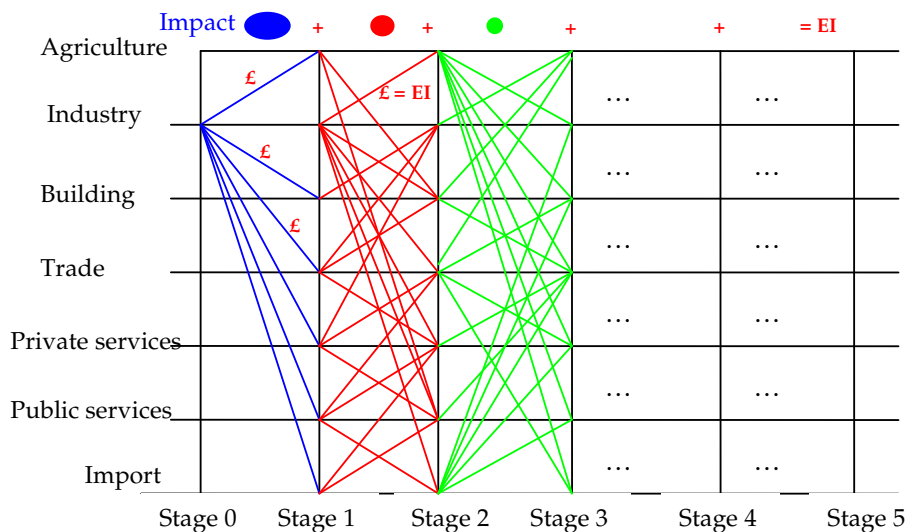


Fig. 1 The flow of environmental impact through the economy

As a second step in the project, a number of existing studies using environmental I/O analysis or other approaches to identify the environmental impacts from different sectors/product groups were reviewed.

The review serves several purposes:

- to check important environmental impacts to guide the collection of data in expanding the current NAMEA;
- to assist in filling data gaps which will allow better prioritisation of extended sectors/product groups;
- to allow a thorough understanding of the method used in the study;
- to draw upon experiences from other studies; and
- to prevent duplication of work.

The following studies were analysed:

- [1] Palm V et. al. Swedish Experience Using Environmental Accounts Data for Integrated Product Policy Issues;
- [2] Tukker A, et al. Environmental impact of products (EIPRO);
- [3] Weidema B.P, et al. Prioritisation within the Integrated Product Policy Danish Environmental Protection Agency;
- [4] Nijdam DS ; Wilting. Environmental load due to private consumption;
- [5] Labouze et al., Study on external environmental effects related to the lifecycle of products and services;
- [6] Moll et al. Environmental implications of resource use – insights from input-output analyses;
- [7] Hertwich Edgar G. Consumption and the Rebound effect;
- [8] Clift R. and Wright L. Relationships Between Environmental Impacts and Added Value Along the Supply Chain;
- [9] Goedkoop M.J et. al. Environmental Load from Private Dutch Consumption; and
- [10] Suh S. and Huppes G., Missing Inventory Estimation Tool Using Extended Input Output Analysis.

Each study was assessed based on reliability, data quality, age and suitability for the current project. Furthermore, the analysis will identify unique approaches of the existing studies which can be relevant for the present study or any future work using the I/O methodology.

The literature review provided a comprehensive overview of the methods and data used in the most up to date studies using NAMEAs. The experiences of the previous studies were used in the review and extension of the current UK NAMEA.

Besides comparing the methodologies with existing studies, the literature review provides results that are used to quality check the results of the study. This is used to validate the I/O model and the matrix calculation routines.

The review of the existing NAMEA identified the following issues:

- what sector it covers;
- what environmental issues it addresses; and
- how it addresses environmental issues.

A NAMEA normally consists of two separates matrices ie a matrix with the economic transaction between the sectors of the economy and a matrix with the environmental interventions of the sectors. In the present study, we have named them the ‘economic matrix’ and the ‘environmental matrix’.

The existing NAMEA has been expanded in two stages:

- extension of the economic matrix, and
- extension of the environmental matrix.

The review and analysis of the NAMEA resulted in a 129x129 economic matrix and an 129 sector environmental matrix consisting of the following emissions and consumption of resources:

Emission	Emission	Emission	Raw material
CO ₂	SF ₆	Hg	Coal use
NO _x	CO	As	Natural Gas use
SO _x	PM10	Cr	Oil use
CH ₄	NMVOC	Cu	Water use
N ₂ O	Benzene	Ni	Solid waste
NH ₃	1-3 butadiene	Se	
HFC's	Pb	Zn	
PFCs	Cd	V	

Table 1 Emissions and raw materials included in the NAMEA.

The emissions and resource consumptions from the extended NAMEA are interpreted using the CML LCIA method [11]. The CML method is comprehensive, well-established and used world-wide to interpret LCA results. Furthermore, the CML method includes the impact categories utilised in the other studies examined in the literature review ie:

- climate change;
- acidification;
- abiotic depletion;
- photochemical oxidation;
- ozone depletion;
- eutrophication;
- ecotoxicity; and

- human toxicity.

The impact categories will be extended with other environmental indicators, including direct consumption of water and energy and waste generation, because these indicators are easier to communicate, and have been shown to attract attention in other studies.

3. EXAMPLE OF RESULTS

Global warming potential is used below as an example to show the results of the I/O analysis. The environmental impacts per sector are presented in two ways ie overall environmental impact and environmental impact per added value.

Added value measures the contribution to the economy of each individual producer, industry or sector in the UK. It refers to the resources used in the production of goods and services usually split up in land (rent), labour (wages) and capital goods (interests).

Added value is chosen above production value since it better represents the activities taking place in the sector, eg an industry that imports semi-finished products will achieve a high production value but will not add much value to the product since the production, and thereby the environmental impact, has taken place in another industry or even abroad.

The comparison of environmental impact per £ added value is especially relevant when discussing decoupling of welfare and environmental impact, ie how environmental improvement can be achieved without necessarily reducing the total level of production.

To be relevant for product orientated environmental policy, a sector must have both a high total impact and high impact intensity (impact per £). The sectors with high impact intensity indicate where it would be desirable to search for substitutions. The UK economy would not necessarily be affected by this change, as in some cases, high intensity is a function of relatively low added value.

Fig 2. shows the 15 sectors with the highest overall global warming potential for the UK in 2002.

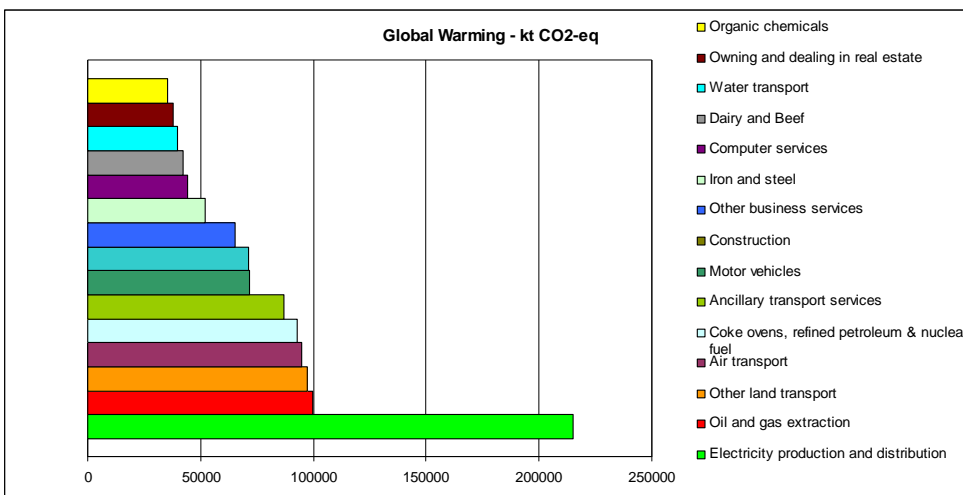
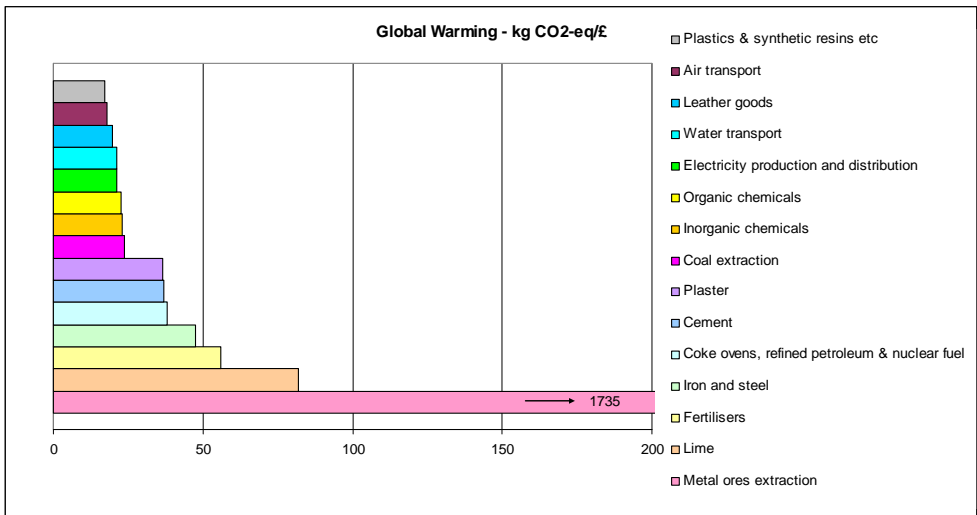
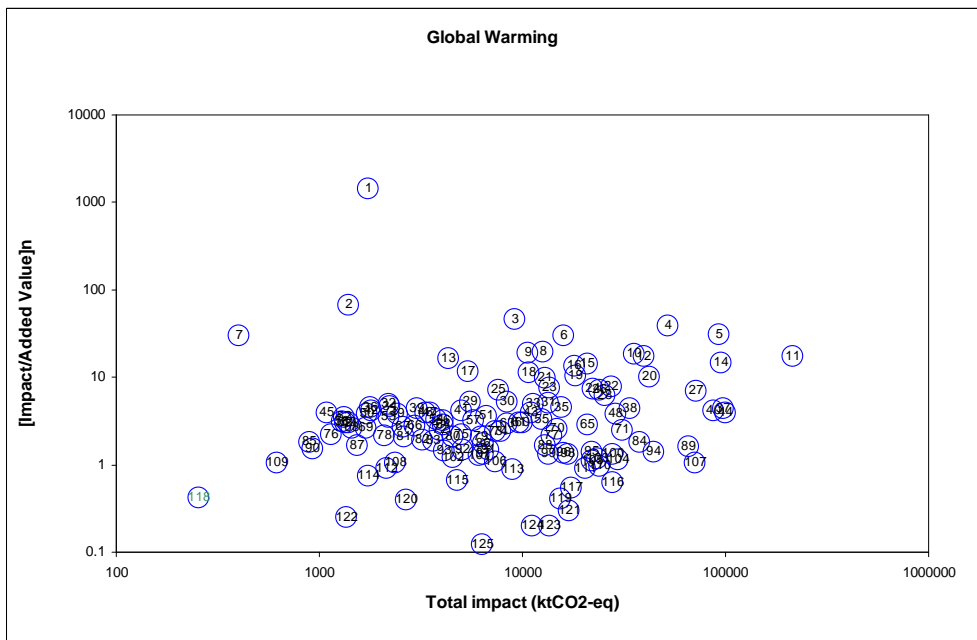


Fig 3. shows the 15 sectors with the highest global warming potential per £ added value for the UK in 2002.



When comparing Fig 2. and Fig. 3 the highest overall Global Warming Potential does not correspond entirely with the highest Global Warming Potential per £. Those additional sectors that appear in the top 15 intensity ranking suggest low levels of added value and relatively high emissions.

The high Global Warming Potential per £ for ‘Metal Ore Extraction’ is a result of extremely low added value (less than 0.001% of UK economy) compared to the emissions associated with this industry. On this basis, one could consider this sector to be an outlier and worthy of no further investigation. The low added value indicates that this sector is not of substantial size. Therefore, environmental policy reducing the global warming impact from this sector will not reduce the overall global warming impact of the UK economy. Comparing the impact intensity per sector with the overall global warming potential per sector will ensure that the environmental policy is targeted at the sectors with the most impact.



Before arriving at the result presented in Fig 4., the impact intensity ($\text{CO}_2\text{-Eq}/\text{£}$) has been normalised according to the total global warming potential in the UK and the UK GDP.

Fig 4. shows global warming impact intensity and total impact for all 129 sectors in the UK economy. The sectors most relevant for environmental policy are situated in the top right corner of the figure and include:

- Sector 4. Iron and steel;
- Sector 5. Coke ovens, refined petroleum and nuclear fuel;
- Sector 10. Organic chemicals;
- Sector 11. Electricity production and distribution;
- Sector 12. Water transport;
- Sector 14. Air transport; and
- Sector 20. Dairy and Beef.

4. CONCLUSIONS

Methodologically, the project takes its starting point in the UK national accounts of economic flows between UK industries and institutions, ie their mutual purchases and sales, imports and exports and supply to final consumption. This is then combined with data from different environmental statistics, adjusted to the same level of detail as the national accounts.

The current project utilises the mutual purchases and sales between the sectors (industries and institutions) and calculates the environmental impact hereof. This is used to prioritise the sectors according to environmental impact and can be used to focus future environmental policies on sectors with high impacts.

To be relevant for environmental policy, sectors selected should have both a high total impact and high impact intensity (impact per £) value. High impact intensity and high overall impact does not correspond entirely which complicates the choice of sectors.

The extended NAMEA was used to calculate the top five sectors of the UK economy with the highest environmental impacts.

The five sectors with the highest environmental impacts are:

- Iron and Steel;
- Coke ovens, Refined petroleum and Nuclear fuel;
- Organic chemicals;
- Electricity Production and Distribution; and
- Water transport.

5. NEXT STEPS

Detailed analysis of the sectors will be carried out using LCA of representative products. This will identify where which life cycle stage contributes the most to the environmental impact.

When carrying out the LCA of the selected sectors, all sector-relevant life cycle stages will be included, ie transport and the use phase for energy-using products. Furthermore, post-consumer disposal at end of life which has been left out of the I/O model will be accounted for by sending the product to an appropriate waste treatment facility.

The LCA results will enable the Environment Agency to focus and prioritise their environmental policies on all products and services in the UK economy with high environmental impact.

6. REFERENCES

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