INTEGRATED PRODUCT POLICY AND THE PRODUCT IMPACT MODEL (PIM)

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EXTENDED ABSTRACT

Integrated product policy (IPP) is an initiative at the European Union (EU) level aimed at reducing the environmental burden of products and services throughout their life cycles by using a toolbox of policy instruments to ‘green’ markets through ‘greening’ both the demand side (consumption) and the supply side (product development). IPP is part of a growing trend within environmentally advanced countries in Europe towards product-oriented environmental policies. As such, it represents a new shift in thinking towards ‘front-of-pipe’ solutions (e.g. the greening of product development and design). By focusing on the product development and design phase, IPP aims to tackle the stage at which many of the environmental burdens of products are determined, thus reducing non-point source problems further in the lifecycle. IPP also aims to green the consumption side of the market by focusing on the way that customers (individual, business-to-business, distributors and governmental) choose, use and discard products and services. The aim here is to reduce the environmental impact of products during their use and to ensure their appropriate disposal at the end of their life.

The objective of this work is the development of a methodology for identifying “environmentally damaging” products. More specifically a frame was defined to rank the impacts of products or product categories, based on certain simplified indicators. This ranking includes two steps:

1. In the first step (economic assessment) the product categories will be identified according to their contribution to the Gross national product (GNP) at a national level. Moreover, a cut off rule will be defined to take into account only products with a significant impact to the GNP. In this way the methodology takes into account a regional approach.

2. In the second step (environmental assessment), the products will be ranked according to the impacts they cause to the environment, based on environmental indicators that will be set by the application of the Life Cycle Assessment (LCA) methodology (ISO 14040, 2006, ISO 14044, 2006). Data mainly from literature or LCA databases will be used as a preliminary way in determining the most damaging to the environment products.

In this work, the basic methodology is presented. Future steps include the full development of the “Product - Impact Model” (PIM), as well as its application at a macro level, for various countries.

Keywords: Integrated Product Policy, Life Cycle Assessment, Modelling, Sustainable Development, Green Products, Gross national product, Resource Intensive Products
1. INTRODUCTION

1.1. Integrated product policy
Integrated product policy (IPP) is an initiative at the European Union (EU) level aimed at reducing the environmental burden of products and services throughout their life cycles by using a toolbox of policy instruments to ‘green’ markets through ‘greening’ both the demand side (consumption) and the supply side (product development). IPP is part of a growing trend within environmentally advanced countries in Europe towards product-oriented environmental policies and it represents a new shift in thinking towards ‘front-of-pipe’ solutions, e.g. the greening of product development and design. In this way, IPP aims to tackle the stage at which many of the environmental burdens of products are determined, thus reducing non-point source problems further in the life cycle. Furthermore, IPP also aims to green the consumption side of the market by focusing on the way that customers (individual, business-to-business, distributors and governmental) choose, use and discard products and services. The aim here is to reduce the environmental impact of products during their use and to ensure their appropriate disposal at the end of their life.

1.2. Background Research
Research, carried out as a pilot study for Germany (Moll et al., 2004), identified eight ‘final-demand’ product groups with large life-cycle-wide resource use and environmental impact potentials, i.e. 1) Construction, 2) Food products and beverages, 3) Motor vehicles, trailers and semi-trailers, 4) Electricity, gas, steam, and hot water supply, 5) Basic metals, 6) Agricultural products, 7) Chemicals and chemical products and 8) Machinery equipment. Concerning materials, preliminary research for the EU-25 and the remaining three accession countries (Bulgaria, Romania and Turkey) as a whole listed the ten material categories with the highest environmental impacts (van der Voet et al., 2004), i.e. 1) Animal products, 2) Crops, 3) Plastics, 4) Oil for heating and transport, 5) Concrete, 6) Hard coal for electricity, 7) Brown coal for electricity, 8) Iron and steel, 9) Gas for heating, and 10) Paper and board. The next material categories on the priority list were: glass; oil for electricity; aluminium; ceramics; gas for electricity; clay; lead; nickel; hard coal for heating; and zinc. For the identification of these materials, both mass flows and impacts per unit weight were taken into account by combining information on material flows and life cycle impact assessment. Moreover, the 2004 report on the environmental impact of resource use by the Joint Research Centre (CEC, 2003) identified eight ‘core activities’ as the cause of the largest share of major environmental pressures from human activities, namely Combustion processes, Solvent use, Agriculture, Metal extraction and refining, Dissipative uses of heavy metals, Housing and infrastructure, Marine activities, Chemical industry.

1.3. Objectives
The main objective of this study is the development of a methodology and finally a “Product - IPP Model” (PIM) for identifying “environmentally damaging” products. This methodology will incorporate the results for the studies on the most “environmentally damaging products”, but taking a regional approach. In this way a prioritisation process will result in a preliminary list of the most important products or product groups for IPP in each country. Taking into account the list of products with significant application potential resulted from the application of PIM, a preliminary list of important product groups will be defined, that ultimately could be evaluated against national and European legislation, as well as sustainable development strategy and other environmentally related action plans.
In this work, the basic methodology is presented. Future steps include the full development of the “Product - Impact Model” (PIM), as well as its application at a macro level, for various countries.

2. METHODOLOGY FOR THE PIM

2.1. General Approach
As previously stated, the main objective of this work is the development of a methodology for identifying “environmentally damaging” products. More specifically a frame will be defined to rank the impacts of products or product categories, based on certain simplified indicators. This ranking includes two steps:

1. In the first step (economic assessment) the product categories will be identified according to their contribution to the Gross national product (GNP) at a national level. Moreover, a cut off rule will be defined to take into account only products with a significant impact to the GNP. In this way the methodology takes into account a regional approach. The total GNP will be the summation of the relative contribution of all economic sectors:

   \[ \text{GNP} = \sum \text{GNPi} \]

   For each product or product category (i) an indicator (pi) will be assigned from 0 to 1.0 according to the contribution to the GNP:

   \[ p_i = 0 \ldots 1.0 \]

   For each case, a relevant cut off rule will be defined to take into account only products with a significant impact to the GNP, and thus only products whose contribution exceeds the limit will be taken accounted for the environmental impact assessment.

2. In the second step (environmental assessment), the products will be ranked according to the impacts they cause to the environment, based on environmental indicators that will be set by the application of the Life Cycle Assessment (LCA) methodology. Data mainly from literature or LCA databases will be used as a preliminary way in determining the most damaging to the environment products.

   For each product or product category (i) two indicators (ri and fi) will be assigned according to the environmental impact they cause. The value of ei will range from 0 to 1.0:

   \[ r_i = 0 \ldots 1.0 \text{ and } f_i = 0 \ldots 1.0 \]

3. Finally, an algorithm will select all products that exceed certain limits that will be set:

   \[ p_i \geq a \text{ and } r_i \geq b \text{ and } f_i \geq b \]

   Then the product will be further assessed where a, b and c will be determined based on national and global criteria.

Environmental assessment will be made in two distinctive steps:

- Firstly products will be ranked according to their raw material input needs, which will reveal the "most resource intensive products" (MRIP).
- Secondly, those most resource intensive products will be ranked according both the input and output flows. From this ranking, the "highest impact products" will be derived, namely those products having the highest impact on
the environment. The Life Cycle Assessment methodology will be used during this phase (Figure 1).

**Figure 1:** From the LCA framework to the Product IPP Model

Next, the environmental assessment stage of the methodology is further analysed.

### 2.2. Environmental Assessment

As previously stated, this stage will be based on Life Cycle Assessment. LCA involves the evaluation of some aspects - often the environmental aspects - of a product system through all stages of its life cycle. Simply stated, the life cycle of a product embraces all of the activities (subsystems) that go into making, transporting, using and disposing of that product. The typical life cycle consists of a series of stages running from extraction of raw materials, through design and formulation, processing, manufacturing, packaging, distribution, use, re-use, recycling and, ultimately, waste disposal. Furthermore, each subsystem requires inputs of materials and energy, transportation of product produced and has outputs of products, co-products, atmospheric emissions waterborne wastes, solid wastes and possibly other releases.

The **resources** and **environmental fluxes** (energy, waste, emissions etc) that occur over the entire life cycle of one product are the sum of the environmental fluxes occurring during the different life cycle stages. The product life cycle stages accounted are:

- **Production of materials** from primary and/or secondary resources. This stage includes the raw materials acquisition, material manufacture and the product fabrication stage. The manufacturing stage includes activities required to process a raw material into a form that can be used to fabricate a particular product or package. Normally, the production of many intermediate chemicals or materials is included in this category. Transport of intermediate materials is also included. Product fabrication is the process step that uses raw or manufactured materials to fabricate a product ready to be filled or packaged.

- **Product distribution.** These include processes that prepare the final products for shipment and that transport the products to retail outlets. Although these activities may commonly require a change in the location or physical configuration of a product, they do not involve a transformation of materials.

- **Product use:** Begins after the distribution of products or materials for intended use and includes any activity in which the product or package may be reconditioned, maintained or serviced to extend its useful life.

- **Product disposal:** This stage begins after the product, has served its intended
purpose and either will enter a new system through recycling or will enter the environment through the waste management system.

**Raw materials**

Resource flows constitute the materials basis of the economy (Brinighu et al., 2004). **Raw materials** are extracted, transformed into products and goods, transported to other parts of the world and, sooner or later, released back to the natural environment as waste or emissions. Raw materials (including fuels) are materials directly extracted from the earth's crust (iron ore for instance) or from the biosphere (for wood for instance). Raw materials are transformed to produce semi-manufactured materials defined as any materials resulting from a more or less elaborated transformation of raw materials before casting of moulding or (metal) machining operations take place that end to a product fabrication. The Earth is a closed material system, and this sets certain limits to economic growth. These are clearly related to the availability of natural resources, where the environment plays the role of a 'source'. For some non-renewable resources, including many metals and construction minerals, security of supply does not currently give cause for concern; for others, such as fossil fuels and land, availability is already becoming a problem which is almost certain to grow. For many renewable resources, such as fish stocks, forests and water, the key challenge is to ensure their sustainable regeneration by safeguarding the reproductive capacities of ecosystems (also known as 'maintenance of natural capital'). Managing resources in a sustainable way has three different points of intervention: resource extraction or imports, production and consumption, and management of wastes and emissions (UNEP, 2010).

Although indestructible, water is a finite and precious resource essential for sustaining life, supporting economic activities, and for the environment itself. Water resources in Europe are, in many locations, under threat from a range of human activities, which lead to problems of overexploitation and low quality of inland waters.

Based on the above, three **resource consumption indicators** will be used to determine the most resource-intensive products:

1. The **Material Intensity indicator (MII)** aims to reflect the total amount of material used for the manufacturing and use (for instance, the amount of steel, plastic, glass, etc. used to assemble a car and provide spare parts over its life span) of products consumed in a year. Moreover, it can be expressed by material categories. Material intensity is linked to the production phase and, for products using consumables, to the use phase. Material intensity, which is a measure of the efficiency of an economy, can also be expressed by the amount of materials consumed (DMC) per unit of GDP. Several factors determine material intensity, including the structure of the economy (basic industry and raw material processing versus hi-tech manufacturing), share of the service sector in GDP, consumption patterns, construction activities etc.

2. The **Fuel Intensity indicator (FII)** takes into account the fuel necessary to energy process all the materials required to assemble and to use products consumed (hence excluding energy used to assemble consumables and energy used or recovered during the disposal phase). Indicators Ep and Eu were also calculated to reflect the individual energy requirement related to the production and the use phases respectively.

3. The **Water Intensity indicator (WII)** represents the water consumption during the use phase of the products consumed during the life cycle of the product.
From the above-mention indicators will derive indicator \( r_i \), and all products will be ranked based on that and national criteria. In this way the *most resource intensive products* will be revealed.

**Environmental Fluxes Assessment**

In this stage, the MRIP will be ranked according both the input and output flows. The environmental fluxes to be considered are:

**Input fluxes:**
1. Energy (\( e \))

**Output fluxes:**
1. Emissions to air (\( a \))
2. Emissions to water (\( w \))
3. Solid waste (\( sw \))

One given flux \( x \) related to the total life cycle of a final product is the sum of this fluxes occurring during all accounted life cycle stages production (\( p \)), use (\( u \)), or disposal (\( d \)):

\[
    x = x_p + L \cdot x_u + x_d
\]

where,

\( L \) represents the lifespan of the product.

For instance the energy requirement during the entire product’s life cycle is the sum of the following components:

\[
    e = e_p + L \cdot e_u + e_d
\]

where,

\( e_p \) represents the total energy input related to the raw material extraction and production processes of primary materials contained in the final product and/or the energy input related to the production of secondary materials contained in the product.

\( e_u \) represents the total energy input of the product during use per year.

\( e_d \) represents the net energy input of the product disposal processes.

From this ranking will derive indicator \( f_i \), and all products will be ranked based on that and national criteria. In this way the *highest impact products* will be derived, namely those products having the highest impact on the environment.

3. **FUTURE STEPS**

As previously described, in order to minimize the number of calculations, only the most resource-intensive products will be further analysed. Although resources depletion seems to be good predictor of the magnitude of the environmental impacts caused by a product (IPTS/ESTO, 2006), the broad validity of this hypothesis is under investigation. In cases where this approach is not applicable, a special co-efficient will be developed to balance the system.

Future steps also include the full development of the “Product - Impact Model” (PIM), as well as its application at a macro level, for various countries.

4. **CONCLUSIONS**

Human wealth is based on the use and consumption of natural resources, including materials, energy and land. Continued increase in resource use and the related
environmental impacts can have a multitude of negative effects leading to ecological crises and security threats. Integrated product policy is an initiative aiming at reducing the environmental burden of products and services throughout their life cycles by using a toolbox of policy instruments to ‘green’ markets through ‘greening’ both the demand side and the supply side (product development). By focusing on the product development and design phase, IPP aims to tackle the stage at which many of the environmental burdens of products are determined, thus reducing non-point source problems further in the lifecycle.

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Environmental assessment will be made in two distinctive steps; firstly products will be ranked according to their raw material input needs, which will reveal the “most resource intensive products”, and secondly, those most resource intensive products will be ranked according both the input and output flows. From this ranking, the “highest impact products” will be derived, namely those products having the highest impact on the environment.

Future steps include the further validation of the methodology, the full development of the “Product - Impact Model” (PIM), as well as its application at a macro level, for various countries.

REFERENCES

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