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# Research Brief

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## Overview

Faced with rising costs for producing goods and managing waste products, the competitiveness of firms, countries and even regions is increasingly linked to their ability to 'eco-innovate'. However, very little is known about the growing global trade in environmentally beneficial goods and services as eco-technologies have been largely neglected in economic statistics. Nor do we know much about innovation efforts to reduce environmental impacts. This research brief reports on a recently completed European project to develop a conceptual basis for measuring eco-innovation and to propose guidelines for its practical application by researchers and policymakers.

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# *Measuring Eco-Innovation*

Policymakers are constantly searching for ways to reconcile the goals of economic growth and environmental protection. Underlying this is the belief that the introduction of cleaner technologies and more efficient environmental management processes could help reduce the costs of environmental protection and contribute to growth and jobs.

Prince Hassan of Jordan and President of the Club of Rome noted in a 2006 speech, that "… the markets of the future are green," drawing attention to the growing scarcity of oil, water and other natural resources that is causing people to place a greater value on resource efficiency and alternative resources, expanding ecological awareness beyond niche sectors.

In reality, however, a large gap exists between current practices and the eco-friendly market of the future. To successfully manage this transition, new technologies, service innovations and alternative systems of energy, mobility, agriculture and waste management are needed.

The potential market for so-called eco technologies has been variously estimated at between 500 billion euro and 1,000 billion euro in 2005, with Roland Berger Strategy Consultants predicting a global market of 2,200 billion euro by 2020. In this scenario, the importance of eco-innovation is likely to grow, including in emerging economies and developing countries.

Unfortunately the statistical basis for eco-innovation is poor. The main sources of information are sales data on environmental goods and services, case studies and one-off surveys. We lack comprehensive information about the eco-innovation behaviour of companies, the macro-effects of eco-innovation activities and the links between micro-macro level actions.

## Understanding Eco-Innovation

To address this information gap, the European Commission's Research Directorate-General recently funded two projects to explore ways of measuring eco-innovation: *Measuring Eco-Innovation* (MEI) and ECODRIVE.

This research brief reports on the findings of the MEI project, which was coordinated by UNU-MERIT. The results of ECO-DRIVE can be found at http://www.eco-innovation.eu/wiki/index.php/Ecodrive_Wiki_Mainpage

The objectives of the MEI project were threefold:

- To offer a conceptual clarification of eco-innovation (develop a typology) based on an understanding of innovation dynamics;

- To identify and discuss the main methodological challenges in developing indicators and statistics on eco-innovation and to explore how they may be overcome;
- To propose possible indicators for measuring relevant aspects of eco-innovation, taking into account data availability issues; define future research needs for addressing these methodological challenges in developing eco-innovation indicators; and to set up guidance for the most feasible route for implementation of eco-innovation indicators within the envisaged time scale.

## Defining Eco-Innovation

There are many different definitions of eco-innovation and environmental innovation that are primarily distinguished by their focus on either *motivation* or *performance*. Past studies of eco-innovation have concentrated on environmentally-motivated innovation, overlooking environmental gains arising from other technological and institutional improvements. MEI researchers therefore decided to adopt a performance based definition of eco-innovation in order to capture any positive environmental effects irrespective of the initial reasons for undertaking the innovations.

Drawing on the OECD definition of innovation, the MEI team opted for a broad definition of eco-innovation, as follows:

"The markets of the future are green" – Prince Hassan of Jordan

> "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives."

In line with this definition, a product, process or system is classified as an eco-innovation if it is more environmentally benign than the "relevant alternative". The relevant alternative may be the technology that is currently used by a firm or the most commonly used technology in a sector (for instance gas or coal fired electricity generation). It is important to note, however, that this is a relative measure; hence an eco-innovation may not necessarily be the most environmentally benign option available. The measurement of eco-innovation is therefore closely linked to an overall assessment of environmental effects and risks.

## Towards a Typology

A key challenge for MEI was to come up with a classification of eco-innovation. To assist policy and statistical data collection, the project proposed four main categories of innovative activities: environmental


Figure 1 World Market Volume of Environmental Technologies 2005
*Source:* Market studies, expert interviews, Roland Berger Strategy Consultants, 2006.

technologies, organizational innovation for the environment, product and service innovation offering environmental benefits, and green system innovations.

### Measurement Tools

The next step was to analyse a number of tools used to quantify technological change and innovation in order to develop a methodology for measuring eco-innovation. The project team explored four general categories of tools:

- Input measures: Research and development (R&D) expenditures, R&D personnel and innovation expenditures (including intangible investments such as design expenditures and software and marketing costs);
- Intermediate output measures: the number of patents; numbers and types of scientific publications, etc;
- Direct measures of innovative output: the number of innovations, descriptions of individual innovations, data on sales of new products, etc;
- Indirect measures derived from aggregate data: changes in resource efficiency and productivity using decomposition analysis.

Each measure has strengths and weaknesses and is subject to specific biases. Input measures such as R&D reflect only the resources devoted to producing innovative outputs, and not the amount of innovative output actually realized. R&D measures also tend to focus on formal innovation, typically within R&D laboratories. They do not sufficiently reflect R&D by smaller firms, which is often done on a more informal basis. Another disadvantage of using R&D expenditures is that they do not tell us anything about the nature of the innovations that are produced and the social value of the innovations.

MEI identified the following three methods as being the most suitable for measuring eco-innovation:

– Survey analysis
– Patent analysis
– Digital and documentary source analysis

### a) Survey analysis

Survey analysis is an important method for monitoring and understanding innovation. The results of successive Community Innovation Surveys (CIS) in Europe, for instance, have

#### Typology of Eco-Innovation

**A. Environmental technologies**

– Pollution control technologies including waste water treatment technologies
– Cleaning technologies that treat pollution released into the environment
– Cleaner process technologies: new manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives
– Waste management equipment
– Environmental monitoring and instrumentation
– Green energy technologies
– Water supply
– Noise and vibration control

**B. Organizational innovation for the environment**

– Pollution prevention schemes
– Environmental management and auditing systems: formal systems of environmental management involving measurement, reporting and responsibilities for dealing with issues of material use, energy, water and waste. Examples are EMAS and ISO 14001.
– Chain management: cooperation between companies so as to close material loops and to avoid environmental damage across the value chain

**C. Production and innovation offering environmental benefits**

– New or environmentally improved products (goods) including eco-houses and buildings
– Green financial products (such as eco-lease or climate mortgages)
– Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, other testing and analytical services
– Services that are less pollution and resource intensive (car sharing is an example)

**D. Green system innovations**

– Alternative systems of production and consumption that are more environmentally benign than existing systems: biological agriculture and renewables-based energy systems are some examples provided us with a much better idea of innovation activities in the region. Unfortunately they offer little insight on eco-innovation since, until recently, environmental technologies and processes were not specifically addressed by the Surveys.

Incorporating specific questions on environmental activities in innovation surveys would be of great benefit in understanding the nature of eco-innovation within firms, sectors and countries. When further combined with questions on organizational issues, it is possible to determine whether a company has special systems in place (such as ISO 14001).

It is important to note, however, that most surveys provide few opportunities to compare results with official statistics or other survey data. Therefore, the survey itself needs to provide additional information on the relevant control variables such as the influence of different policy instruments.

To guide future survey analysis by European agencies such as Eurostat and others, an optimal set of survey parameters was identified.

**b) Patent analysis**

Together with R&D expenditures, patents have emerged as an important indicator in measuring innovation. Patents are granted for inventions that are novel, inventive (non-obvious) and useful (have an industrial application). They bestow an exclusive right to exploit (make, use, sell or import) an invention over a limited period of time, usually 20 years from the date of filing. An advantage of patents is that they can be quantified. Since patent files contain a description of the invention, patents can further be classified according to technological sector, type of use, area of origin and technical characteristics. Furthermore, patents are publicly available for long time-series and provide detailed technological information. The cost of processing patent data is also lower than for survey-based data.

In spite of the wealth of information contained in patents, researchers should be aware of some serious weaknesses and biases when using them as innovation indicators. First, patent data capture only a small part of overall innovation. According to Crepon et al (2000), the percentage of patented innovations in the French industrial manufacturing sector is only 30%, on average, with considerable variations across sectors. A second limitation is the uneven value distribution of patents. Hence, the usefulness of simple patent counts is limited, as they place patents with a high value on an equal footing with those that are much less significant in terms of generating innovations.

Different methodologies have been proposed to evaluate the value of patents. For example, one may ask patent owners about profits made from commercializing a patent, or check the renewal records of a patent and the number of citations. Here the development of the OECD Triadic Patent Family database is of great interest since it provides a database of "high quality" inventions.

In using patent data to measure eco-innovation, a number of limitations need to be taken into account.

First, not all eco-innovations can be usefully quantified through patent analysis. Eco-patents mainly measure inventions that underlie green *product* innovations and *end of pipe technologies*, whose environmental impacts are the specific aims and motivations of the inventions. For these kinds of innovations it is acceptable to use patent analysis, provided they are carefully screened (for which one may use the four-step method described below). For other types of innovation, such as organizational innovation and process changes, patent analysis does not appear very suited. Second, patent classification systems do not provide specific categories for environmental patents and there is also no widely accepted agreement in the literature as to what constitutes an environmental technology. A practical solution is to use relevant search terms, bearing in mind that terms such as "environmental" or "environment" are not helpful because they may be overly broad.

For patent analysis the project proposed the following four-step method:

- Step 1: Choice of relevant parameters (could be the pollutant under consideration, for example, $SO_2$).
- Step 2. Patent search using keywords – based upon relevant environmental technology aspects – in order to generate a set of *potentially* relevant patents
- Step 3. Screening of the abstracts of the patents generated in order to determine whether it indeed was a relevant patent. Irrelevant patents are excluded.
- Step 4. Retrieval of patent families. These are the patent applications the inventor filed in the countries other than the home country. This helps to exclude patents of minor importance.

## The growing attention paid to eco-innovation should be backed up with support for data collection and research

### c) Digital and documentary source analysis

Innovation may also be measured using documentary and digital sources, such as innovation announcement sections in trade journals and product information databases. An example is the green car database established by Yahoo. A major advantage of this tool is that it is a measure of innovation *output* rather than *inputs* (such as R&D expenditures) or intermediary output measures (such as patent grants).

Unfortunately, there are currently very few product databases that contain environmental information. For specific products, a database of eco-innovation output may be created by sampling the 'new product announcement' sections of technical and trade journals or by examining product information provided by producers. The strengths of the product announcements sampling method are that:

- The indicator is timely: announcement times are close to the date of commercialization.
- It is relatively cheap and easy to collect the data since direct contact with firms is not necessary and firms are not burdened with time-consuming questionnaires.
- From the product description, it is possible to infer information about the innovation, for instance whether it is a radical innovation, and what its performance characteristics are.

Some limitations are:

- Adequate journal selection is a necessary precondition to measure innovations in a comprehensive way.
- In-house process innovations are rarely reflected in technical and trade journals. Direct innovation surveys and patent data are probably better indicators for this type of process innovation.
- While objective results can be derived from literature sources, determining the relative importance of each innovation is a subjective process.

**About the MEI Project:**

This Brief summarizes the findings and conclusions of the Measuring Eco-Innovation (MEI) project, funded by the Research Directorate-General of the European Commission (Call FP6-2005-SSP-5A, Area B, 1.6, Task 1). The project was carried out in collaboration with Eurostat, the European Environment Agency (EEA) and the Joint Research Center (JRC) of the European Commission.

The research partners were:

- UNU-MERIT (Project Coordinator)
- Centre for European Economic Research (ZEW, Germany)
- Risø DTU (Denmark)
- Imperial College London (UK)
- LEIA Technological Centre (Spain)

**Project officer:** Dr Michele Galatola, Research Directorate-General, European Commission

**More information** about the MEI project can be found at http://www.merit.unu.edu/MEI or obtained from the project leader, Dr René Kemp.
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Information from trade journals may be available digitally. Digital information about products may also be available from the Internet – allowing researchers to track the evolution of performance characteristics for selected products.

Digital announcements and consumer information databases are largely neglected sources of innovation output indicators. An added advantage of this tool is the enactment of product disclosure requirements in the EU, which makes such data widely available. The systematic and selective exploitation of these sources could further contribute to comparative monitoring of eco-innovation at the European and global levels.

### Selecting the Best Tool

Although some methods are better than others, no single method or indicator is ideal. Instead, a combination of different methods to analyze eco-innovation is likely to yield the most useful data.

In particular, more effort should be devoted to *direct* measurement of innovation output using documentary and digital sources. Innovation may also be measured by the use of indirect indicators such as changes in resource efficiency and productivity.

### Eco-Innovation and Competitiveness

Improved measurement tools are not only needed to help us better understand how eco-innovation occurs, they also help us to analyze the effects of eco-innovation on the competitiveness of nations and sectors. Such effects are likely to vary, depending on the type of innovation and context in which it is used. Eco-innovation can contribute to competitiveness and job creation by (1) helping industry to lower operational expenses due to lower resource costs; and (2) creating novel products that can be sold on the world market.

As with eco-innovation, a measurement problem exists with regard to competitiveness due to the existence of different tools and the impact of external factors on the internal capabilities of firms. Such external factors include: firm rivalry, which forces companies to innovate; demand and feedback from users; the presence of related and supporting industries; education and skill levels; and intellectual property rights protection.

A number of tools can be used to measure the competitiveness of sectors, including:

- Indicators based on trade performance
- Indicators based on costs and labour productivity
- Single indicators based on input measures for innovation
- Systems indicators based on sets of indicators

Of these, relative trade performance (one country's exports relative to another's) is the best measure. But this is not a perfect measure either because it partly reflects the comparative advantages and international specialization of each country. Germany has a flourishing solar and wind power industry, thanks to a feed-in law that establishes high prices for green electricity fed into the grid, but as a result German consumers and industry pay more for electricity than they otherwise would. Higher electricity costs may in turn hamper the competitiveness of other sectors, especially electricity-intense sectors. One should thus look beyond the revealed comparative advantage (RCA).

To assess future competitiveness data on innovation expenditures, R&D, business startups and relative patent advantages (RPA) may be used. However, none of these is a reliable predictor because future competitiveness also depends on broader factors such as institutions, infrastructure, education, the macro-economy and regulation. The results derived can be validated by comparing them with supplementary data sources such as the Global Competitiveness Index, the Business Competitiveness Index and the Competitiveness Scoreboard, provided that special attention is given to values that are especially important for eco-innovation.

### Conclusion

In general the knowledge base for eco-innovation is poor. One reason for this is that eco-innovation is currently not recognized as an official sector. As part of ongoing work to develop guidelines for collecting statistics on the Environmental Goods and Services Sector (EGSS), Eurostat has begun to categorize the various activities associated with the sector (the NACE codes). So far, a "core" industry group (NACE 25.12, 37, 41, 51.57 and 90) has been identified, but the much larger "non-core" group of industries is yet to be defined.

By proposing a methodology for categorizing and comparing eco-innovations, the typology developed by the MEI project may prove helpful in the process of creating an information base for this second category of eco-innovation activities. A key conclusion of the project is thus that eco-innovation research and data collection should not be limited to EGSS products or to environmentally-motivated innovations but it should cover all innovations that produce a net environmental benefit – throughout the life cycle of a product – when compared to relevant alternatives.

As resource scarcity and environmental degradation rise to troublesome levels, eco-innovation can no longer be seen as a luxury. Developing countries too stand to benefit from building on this foundation to create their own systems of information and intelligence to deal with pollution and use natural resources sustainably.

In doing so, it is crucial to bear in mind that eco-innovation entails much more than the adoption of environmental technologies. In developed countries it is increasingly characterized by the transition from investing in pollution control technologies to address cleaner production processes, recycling systems and new products. The intense resource pressure felt by many developing countries necessitates thinking about similar transitions, including (crucially) in the area of sustainable water management. World wide there is a need for transitions to carbon-low energy systems and sustainable mobility.

Eco-innovation could thus provide an important new entry-point for international development cooperation and capacity building.

## Eco-innovation could provide an important new entry-point for international development cooperation and capacity building

**About the Author**

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**INSIDE:**

# Research Brief

## *Measuring Eco-Innovation*

A project to develop conceptual clarification of eco-innovation and propose methodological guidelines for developing indicators and statistics on eco-innovation

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