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Typology of eco-innovation

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PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
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1. Eco-innovation

Eco-innovation is a recent concept. One of the first appearances of the concept of eco-innovation in the literature is in the book by Claude Fussler and Peter James (1996). In a subsequent article, Peter James defines eco-innovation as 'new products and processes which provide customer and business value but significantly decrease environmental impacts' (James 1997).

Denmark's government defines eco-innovation as innovation leading to an eco-efficient technology in the white paper "Promoting Eco-efficient Technology - The Road to a Better Environment". Eco-efficient technology means all technologies which directly or indirectly improve the environment. It includes technologies to limit pollution, more environmentally friendly products and production processes, more effective resource management, and technological systems to reduce environmental impacts. Reduced environmental impacts must not necessarily be the primary objective of an eco-efficient technology.

Other labels are environment-friendly, environment-saving, eco-friendly or eco-intelligent.

Often eco-innovation is used as shorthand for environmental innovation (Rennings, 2000; Europe Innova). There exist various definitions of environmental innovation. One such definition says that environmental innovations are new and modified processes, equipment, products, techniques and management systems that avoid or reduce harmful environmental impacts (Kemp and Arundel, 1998, Rennings and Zwick, 2003). There is no reference to novelty in this definition. **The distinguishing feature is environmental gain** (compared to relevant alternatives), which is also the defining feature of the concept of environmental technologies that is used in ETAP (the European Commission's Environmental Technologies Action Plan).

According to ETAP, *environmental technologies encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies).* Environmental technologies are technologies whose use is less environmental harmful that relevant alternatives.

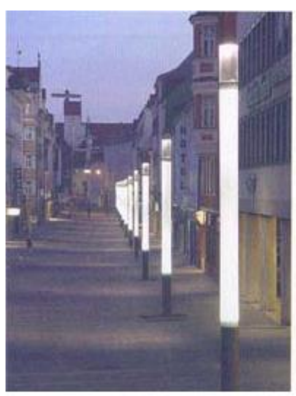
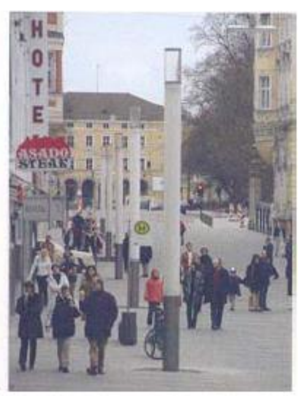
In environmental technologies themselves, we have innovation. The innovation may do one or two things: it may lower the costs of achieving an environmental improvement or it may offer a greater environmental gain than an old model. It may also be new technology for a new environmental problem. **The term eco-innovation is sometimes equated with environmental technologies. This in itself is a source of confusion** because environmental technologies themselves experience innovation (which could be called eco-innovation but is commonly referred to as normal innovation) and because the term eco-innovation is generally viewed as comprising more than the class of environmental technologies (as noted above).

It is important to note that the **widespread use of eco-innovations does not guarantee overall improvements in environmental quality**. Cost-saving technologies give rise to increases in real wealth that will translate in extra consumption and associated emissions and resource use (rebound effect).

In the text of the call on which the project is based, the term eco-innovation is used: eco-innovation is the production, assimilation or exploitation of a novelty in products, production processes, services or in management and business methods, which aims, throughout its life cycle, to prevent or substantially reduce environmental risk, pollution and other negative impacts of resources use (including energy use). Novelty and environmental aim are the two distinguishing features.[1]

This definition perhaps unwillingly limits eco-innovations to innovations whose *aim* is to reduce environmental harm, thus excluding those innovations that are environmentally friendly but that are not specially designed to reduce pollution and waste. The latter category might reasonably be called "environmental friendly normal innovations". The environmental gains of normal innovations have never been the object of systematic study. It is being estimated however that 60% of the innovations of the Dynamo Database in the Netherlands offer environmental benefits. It also was found that 55% of the innovations supported by a general innovation scheme for research cooperation (IS) offered "sustainability benefits". These two figures coming from the Netherlands suggest that the majority of technological innovations offer environmental benefits.

LED lamps are a mixed case. They have been developed for reasons of better light quality, longer lifetime and energy-efficiency.

[1] The restriction of the term innovation to those changes that involve novelty seems useful and there are good reasons for following that convention. It should be pointed out that the use of the term innovation-as-novelty (as is being done in ETAP) departs from the Oslo Manual (OECD 2005) about innovation which states that innovation does not require in-house investment in creative activities such as R&D. Firms can innovate by adopting technology developed by other firms or organizations. The Oslo manual is in line with company views about innovation: From a company point of view the adoption of a technology to replace an existing technology is an innovation, even when it involves technology that has been around from some time and is not leading edge.

When talking about innovations with an environmental benefit, we may want to make a distinction between technologies designed for special environmental purpose, such as to reduce the environmental harm, and those that produce environmental gains as a gratis side-effect. The first category may be called "environmentally motivated innovations" and the second category could be called "environmentally beneficial normal innovations".

The term eco-innovation could be used for all innovations that are less environmental harmful than relevant alternatives or it could be reserved strictly to those innovations whose purpose is to reduce environmental harm.

We propose to not restrict eco-innovations to those innovations whose purpose is to reduce environmental harm. This then leads to the **following working definition of eco-innovation**:

> **Eco-innovation is the production, application or exploitation of a good, service, production process, organisational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resources use (including energy use) compared to relevant alternatives.**

It should be noted that this definition is based on the definition in the call but no longer requires that the innovation be aimed at reducing environmental harm

In seeking to develop a typology of eco-innovation, we argue that it may **be useful to distinguish** between environmental technologies, organisational innovation, product and service innovation with environmental benefits, and green systems changes.

The term **environmental technologies** refers to process technologies (including energy conversion technologies) and measurement technologies used for environmental purposes (to measure pollution or to identify toxics). **Organisational eco-innovation** refers to the introduction of new organisational methods and management systems for dealing with environmental issues. and consumer products for non-productive use are not environmental technologies.

A possible taxonomy of eco-innovation is the following[2]:

[2] The classification is similar to the one proposed by Andersen (2005) who distinguishes the following five categories of eco-innovations:

1. Add-on innovations (pollution- and resource handling technologies and services)
2. Integrated innovations (cleaner technological processes and cleaner products)
3. Eco-efficient technological system innovations (new technological paths)
4. Eco-efficient organizational system innovations (new organizational structures)
5. General purpose eco-efficient innovations

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
- Waste management equipment
- Environmental monitoring and instrumentation
- Green energy technologies
- Water supply
- Noise and vibration control

B. **Organisational innovation** for the environment: The introduction of organisational methods and management systems for dealing with environmental issues in production and products. A further classification is:

- Pollution prevention schemes: aimed at prevention of pollution through input substitution, a more efficient operation of processes and small changes to production plants (avoiding or stopping leakages and the like)
- 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
- Chain management: cooperation between companies so as to close material loops and to avoid environmental damage across the value chain (from cradle to grave)

C. **Product and service innovation** offering environmental benefits: New or environmental improved products and environmentally beneficial services

- New or environmentally improved products (goods) including eco-houses and buildings
- Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, testing and analytical services
- Services that are less pollution and resource intensive. An example is car sharing.

D. **Green system innovations**

- Alternative systems of production and consumption that are more environmentally benign than existing systems: Examples are biological agriculture and a renewables-based energy system.

Perhaps the most important aspect of this classification scheme is that <u>eco-innovation is not limited to new or better environmental technologies</u>. Every environmentally improved product or service counts and organisational change for the environment as an eco-innovation.

From this follows that all new processes that are more resource efficient are eco-innovations. Wind power as a new environmental technology is to be viewed an eco-innovation because it leads to less reduction that fossil-fuel plants (being the relevant alternative) even when then exist more environmentally benign options than wind power such as concentrated solar power. Even innovations in coal burning technology qualify as eco-innovation if they reduce emissions.

What about nanotechnology, nuclear fission and biotechnology? Can they be viewed environmental technologies? In line with what has been said before, this has **to be decided on a case-by-case basis** using environmental life cycle analysis (LCA). A clear problem here is the non- commensurability of certain environmental aspects (the apples and oranges comparison problem – in Denmark, NL and Germany called the apples and pears comparison problem). There is also a problem of uncertainty. We simply do not know all relevant risks of nanotechnology, nuclear fission and biotechnology. To a certain degree this is true for all technologies. The risk issues itself should not be used as a criterion for exclusion. **One should be careful in using the label of eco-innovation for broad technology classes.** In policy this is sometimes unavoidable but is best avoided by statistical agencies and by researchers. One should use the term eco-innovation only for those innovations that have demonstrable environmental benefits.

It should be noted that the use of **the term eco-innovation crucially depends on an overall assessment of environmental effects and risks**. For this life cycle assessment based on multi-attribute value theory can be used. We should note here that this may create a problem for survey analysis: the respondents' assessment of whether an innovation is better than relevant alternatives *on a life cycle basis* need not be true. In fact, the knowledge may not be available. LCA have been done only for a handful of products and processes.

As a last remark, one may restrict the term eco-innovations for those innovations offering a **significant** (non-negligible) reduction in environmental harm. This then leads to problems of defining what is significant.

To us the above definition of eco-innovation is relevant and appears to be workable for statistical agencies and for future data collection activities from companies. There is a wide consensus in the MEI project that data collection and indicator research should not be limited to environmentally motivated innovations but also should comprise environmentally beneficial normal innovations for the reason that they constitute an important category, about which we know very little. Of course, if we do this, then almost all firms will be eco-innovators. However, this is the same 'false problem' that has been discussed in reference to the Oslo Manual on measuring innovation, with people objecting that the Manual defines innovation so broadly that almost all firms should be innovators. **The problem is not that all firms are innovators (most should be), but how we use the data to look at the different ways in which firms innovate.**

Environmental technologies

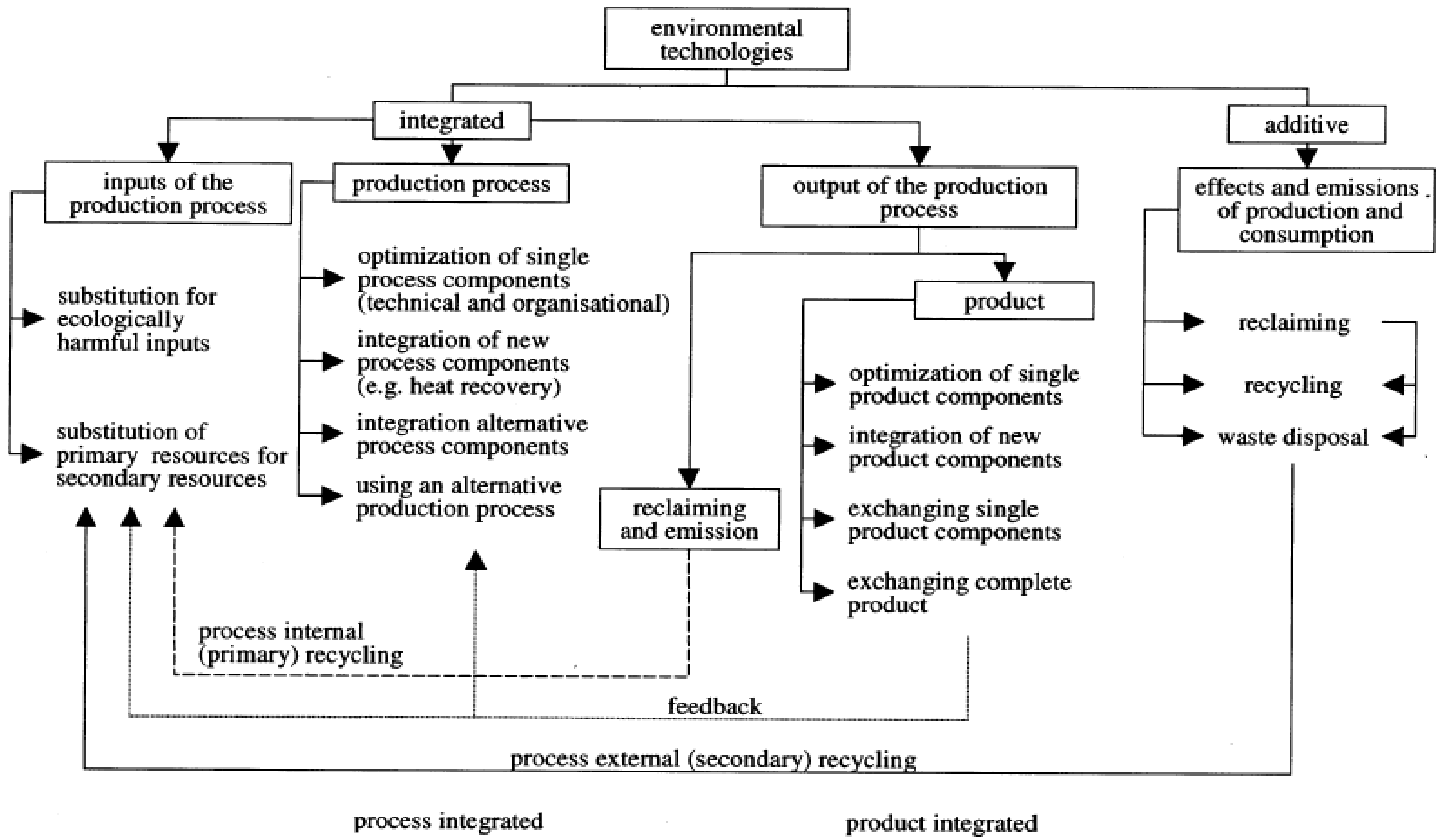
We prefer to restrict the term environmental technologies to technologies that are more environmentally benign. Environmentally improved products fall into a category of their own (together with services innovations) and other innovations for which technology is not the primary thing. Examples of environmental technologies are given in Table 2.

Table 2. Examples of environmental technologies

Pollution control technology	Small-scale biological water treatment (for homes or industry) Waste separation for recycling Wet scrubbers for waste incineration
Cleaning technology	Bioremediation for polluted soils
Clean production processes	White biotechnology or biocatalysis Nanotechnology Membrane technology for chlor-alkali
Process internal recycling	Re-use of waste materials, water and heat
Measurement technologies	Biomarkers

A common distinction of environmental technologies is between integrated solutions and additive solutions. Additive solutions are pollution treatment technology and systems of <u>external</u> recycling and waste disposal. A taxonomy of environmental technologies is being offered by Hohmeyer and Koschel (1995) (Figure 1). They included product changes in the list of environmental technologies, something we will not do.

Figure 1. A taxonomy of environmental technologies



Source: Hohmeyer and Koschel (1995) (quoted in Rennings, (2000, p.323)

Organisational innovation for the environment
This consists of the introduction of organisational methods and management systems for dealing with environmental issues in production and products. A further classification is:

- Pollution prevention schemes: aimed at prevention of pollution through input substitution, a more efficient operation of processes and small changes to production plants (avoiding or stopping leakages and the like)
- 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
- Chain management: cooperation between companies so as to close material loops and to avoid environmental damage

Product and service innovation offering environmental benefits
This consists of new or environmental improved products and environmentally beneficial services

- New or environmentally improved products (goods) including eco-houses and buildings, phosphate-free detergents, water-based paints and so on.
- Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, testing and analytical services.
- Services that are less pollution and resource intensive. An example is car sharing.

Green system innovation
These are new technology systems that are more environment-friendly that the existing systems. System innovations involve a wide array of changes in production technologies, knowledge, organisation, institutions and infrastructures and possibly changes in consumer behaviour.

General purpose technologies (GPT) are not included in the list. They may be incorporated in environmental technologies, in products and used as part of new technology systems (as in the case of biotechnology). Financial schemes for end-of-life treatment are viewed as being part of chain management. New non-tangible products such as green leasing are a product innovation.

General purpose technologies
GPT are an important part of the technological landscape, often to the extent that they give their name to an era. We had a steam engine era, the steel era and now we have an information and communication era. Perhaps the next era is the era of nanotechnology or biotechnology. The following general purpose technologies are often mentioned as offering great opportunities for environmental protection:

1. Biotechnology
2. ICT
3. energy technology (renewables, heat exchangers and fuel cells)
4. new materials

As a rule, the development of these GPT is *not* driven by environmental considerations. It is driven by commercial interests and by science. They may produce environmental benefits as a side effect but also may also cause environmental harm. ICT is a good example. Sensors linked to computer systems allow companies to identify leakages and optimise production processes for resource efficiency. It may allow for less use of paper. However this view of ICT being inherently green is far too optimistic. We did not get a paperless office; ICT facilitates long-range air travel and ICT-based manufacturing methods lead to shorter production cycles (Sonntag, 2003). Table 3 shows that there are both positive and negative impacts (direct ones and indirect ones and behavioural and structural effects).

Table 3. ICT impacts on the environment

Table 2. ICT impacts on the environment		
	Positive impacts	**Negative impacts**
Direct effects of ICT	Environmental monitoring, *e.g. remote sensing*	Environmental impacts of production, use and disposal of ICTs, *e.g. electronic waste*
Indirect effects of ICT	Improved efficiency, dematerialisation and virtualisation, *e.g. intelligent logistics, electronic directories*	Proliferation of electronic devices, partial substitution, e.g., e-shopping as well as private shopping trips
Structural and behavioural effects of ICT	Structural and life style transitions *e.g. growth of light industries, green consumerism*	Stimulating growth and re-materialisation, *e.g. growth of long-distance travel*

This suggest that it is wrong to label certain general purpose technologies altogether as green. Neither ICT, nor biotechnology or nanotechnology are inherently green. Only certain configurations with particular types of use are more green.

The time scale and target points for decision-making in relation to environmental technologies, organizational measures and systems changes are given in Tables 4, 5, and 6:

Table 4. The time scale of environmental technologies and point at which targeted decision are made

	Targeted decisions	**Time Scales**
Pollution control technologies	Treatment of pollution before release into environmental media through special devices (usually end-of-pipe).	Short-term One time
Cleaning technology	Treatment of pollution within the environment (receiving water, soil, or air). An example is remediation of polluted soils	Short-term to medium term One time

Cleaner technology: integrated process changes	New technology investment	Medium or long-term New investment cycle
Waste management equipment	Plant design or redesign	Short-term to long-term
Environmental monitoring and instrumentation	Equipment and processes	Day-to-day continuous
Green energy technology	Energy production Strategic decision based on long-term considerations	Short-term to medium term Periodic
Water supply	Connection to water supply systems Or own water treatment works	Short-term to long-term One time
Noise and vibration control	Production equipment and other equipment	Short-term to long-term One time

Table 5. The time scale of organisational innovations and supra-organisational changes for the environment and point at which targeted decision are made

	Targeted decisions	**Time Scales**
Pollution prevention schemes	Plant operations and maintenance, small changes in the existing production lines, input substitution	Short to medium-term Any time
Environmental management systems	Decision-making for reducing environmental impacts of products and processes	Short-term to medium-term Continuous
Greening of production chain through coordinated, deliberate action	Production chains: resource extraction, processing, manufacturing, final product and end-of-life use or care through design for recycling etc.	Medium to long-term Continuous

Table 6. The time scale of environmentally improved products, environmental services and new technology systems and point at which targeted decision are made

	Targeted decisions	**Time Scales**
Environmentally improved products	Product features of material use, energy use, durability and reusability thanks to design for the environment and re-use	Long term Continuous
Environmental services	Environmental choices of other companies	Small-medium term One-of or continuous
Services that are less pollution and resource intensive	The features of final services and the way in which they are provided	Small-medium term One-of or continuous
New technology systems	New product-service systems (for example, customized mobility or decentralized systems of energy)	Long-term Continuous

2. Eco-efficiency

A broader notion than cleaner production and integrated production is the notion of eco-efficiency: "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing ecological impacts and resource intensity, through the life cycle, to a level at least in line with the earth's estimated carrier capacity" (World Business Council for Sustainable Development, 2000).

Eco-efficiency is a broad concept that is usually measured at the product or service level. Eco-efficiency means *less environmental impact per unit of product or service value* (WBCSD, 2000).

$$\textit{Eco-efficiency} = \frac{\textit{product or service value}}{\textit{environmental impact}}$$

For product and service value, we may use value added figures (even when those figures do not include consumer surplus). Environmental impact is more difficult to measure. The environmental impact is measured on the basis of both resource use (the source side) as well as emissions to air, soil and water (the sink side) per produced unit/activity. Toxicity of resources may be taken into account. In so doing, it differs from material intensity per service (MIPS) which only looks at kilotons. In actual practice, eco-efficiency is not so easy to measure but the WBCSD has identified seven strategies to improve eco-efficiency:

- Reduce material intensity
- Reduce energy intensity
- Reduce dispersion of toxic substances
- Enhance recyclability
- Maximize use of renewables
- Extend product durability
- Increase service intensity

Product durability can only be calculated at the product level. Material intensity and energy intensity can be calculated at the firm, product, sector, region, and supraregion (national and international) level.

The eco-efficiency approach offers a different in-road into the issue of eco-innovation, followed in the ECO-DRIVE project where innovation could be conceptualised and measured as a change in resource productivity or eco-efficiency. This may be done in several ways. One approach to operationalising this is through the use of aggregate indicators for resource use of an economy. Indicators for measuring resource use and material flows have been developed largely by the Wuppertal Institute in Germany and are shown in Table 6. It has been argued that these indicators could form a useful way of establishing targets and indicators for the EU's Thematic Strategy on Sustainable Use of Natural Resources (Wuppertal, 2006).

Table 7: Macro-indicators for material flows

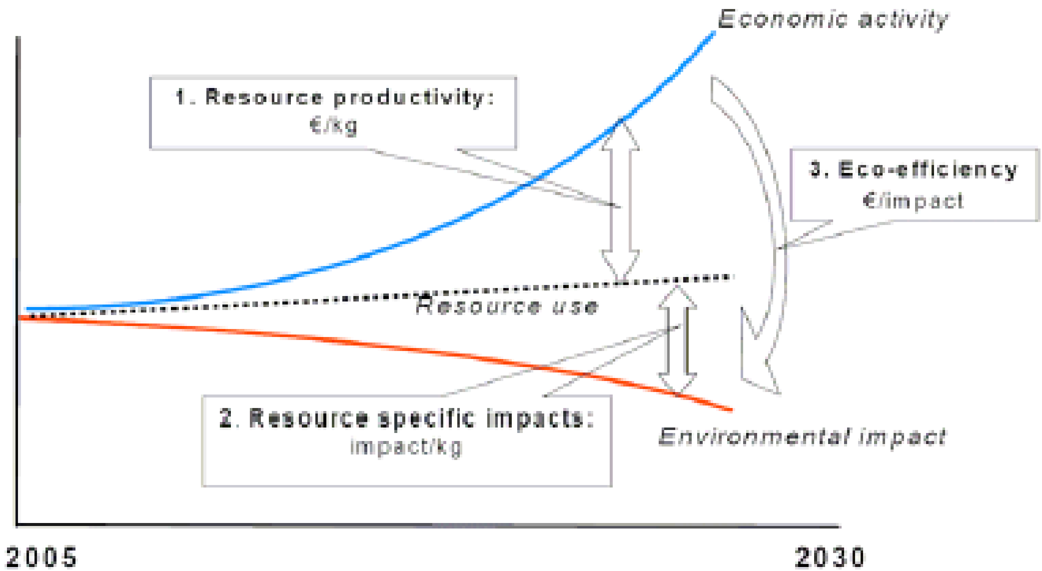
Indicator	Formula	Subject
Total Material Requirement (TMR)	DMI + indirect flows	Domestic and imported resources including their ecological rucksacks, which are required for domestic production and consumption.
Total Material Consumption (TMC)	TMR – (exports + indirect flows of exports)	Domestic and imported resources including their ecological rucksacks, which are required for domestic consumption only (excluding exports).
Domestic Material Input (DMI)	domestic material used + imports	Domestic and imported resources without ecological rucksacks, which are used for domestic production and consumption.
Domestic Material Consumption (DMC)	DMI - exports	Domestic and imported resources without ecological rucksacks, which are used for domestic consumption only (excluding exports).

Note: 'Ecological rucksacks' refer to materials which are extracted or otherwise moved by economic activities but which are not used in domestic production or consumption (mining waste such as overburden, erosion in agriculture etc.). These flows are not further processed and have no economic value, but impact on the environment.

For example, Resource Productivity and Material Productivity of a National or the European economy could be measured by GDP/TMR or GDP/DMI. These measures show that resource and material productivity of the EU-25 has increased over the last 10 years, as TMR and DMI have remained roughly constant. However, absolute reductions in TMR and DMI would be required to reduce overall environmental impacts.

The EU's Thematic Strategy on Sustainable Use of Natural Resources goes further than simply arguing for decoupling of resource use from GDP by proposing a 'double decoupling' of environmental impacts of resource use from economic growth.

Figure 2: Decoupling economic activity, resource use and environmental impact

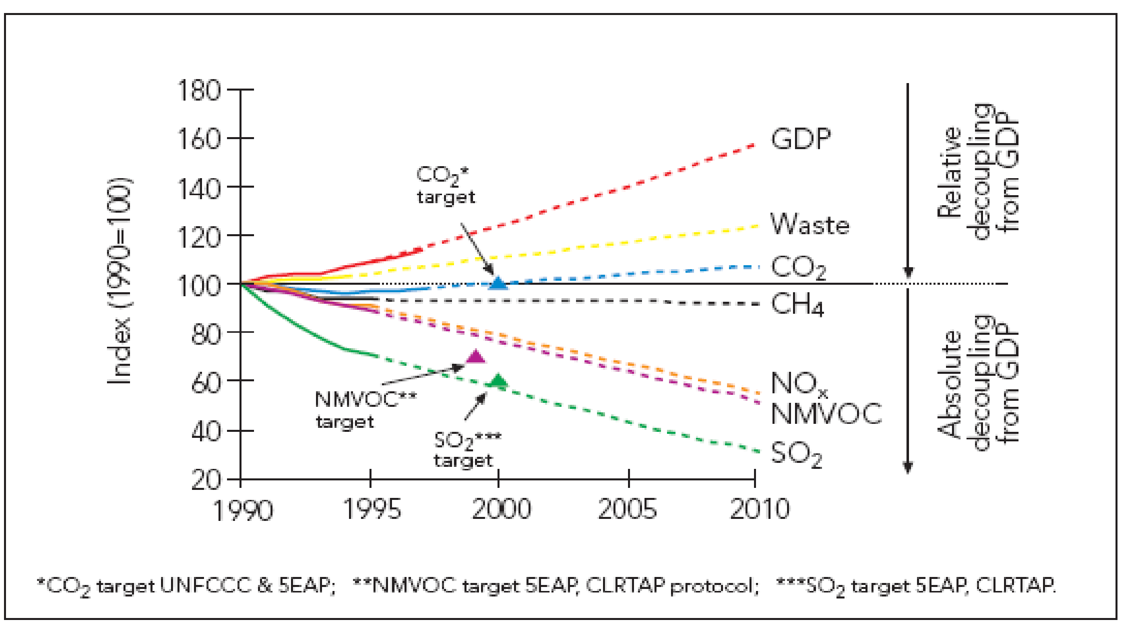


Source: COM (2005) 670

Instead of looking at resource productivity, one may look at the development of emissions and waste vis-à-vis GDP.

Figure 3: Absolute and relative decoupling

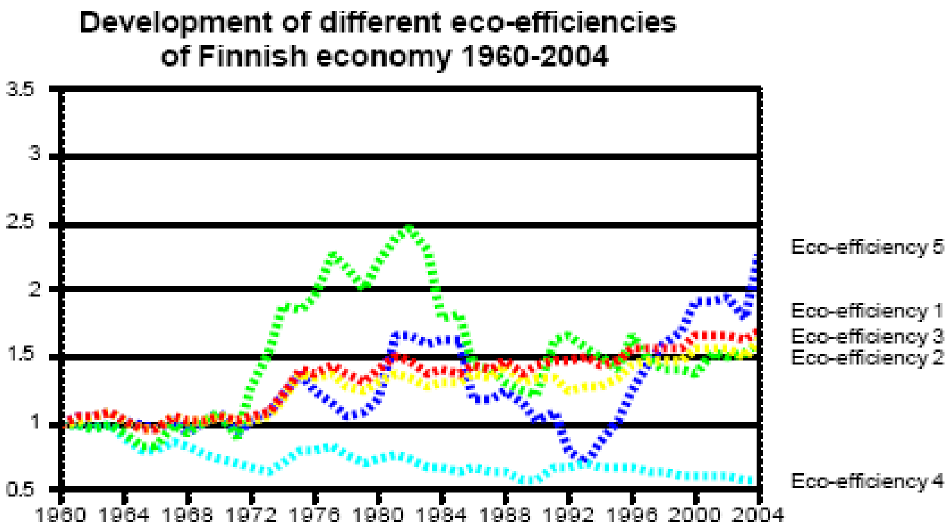
Economic developments and trends in pressures in EU (1990-2010)
in relation to environmental targets



Source: Compiled from multiple sources

Jukka Hofrén (ref.) has used various measures to determine the eco-efficiency of the Finish economy.

Figure 4: Development of various eco-efficiency measures for Finland



Eco-efficiency formulas utilised :

$$\text{Eco-efficiency 1} = \frac{GDP}{DMF} \text{ (= Eco-efficiency of production)}$$

$$\text{Eco-efficiency 2} = \frac{EDP1}{DMF} \text{ (= Industrial eco-efficiency)}$$

$$\text{Eco-efficiency 3} = \frac{ISEW}{DMF} \text{ (= Societal eco-efficiency)}$$

$$\text{Eco-efficiency 4} = \frac{HDI}{DMF} \text{ (= Human eco-efficiency)}$$

$$\text{Eco-efficiency 5} = \frac{SBM}{DMF} \text{ (= Potential eco-efficiency)}$$

GDP = Gross Domestic Product
DMF = Direct Material Flow
EDP1 = Environmentally adjusted Domestic Product 1
ISEW = Index of Sustainable Economic Welfare
HDI = Human Development Index
SBM = Sustainable Benefit Measure

Further work is needed to understand the decomposition of these aggregate indicators. For example, resource productivity of industrialised economies improves as they move from being manufacturing to service-based economies. However, this may largely involve transfer of the manufacturing base and associated environmental impacts to developing and emerging economies from which finished goods are imported for consumption.

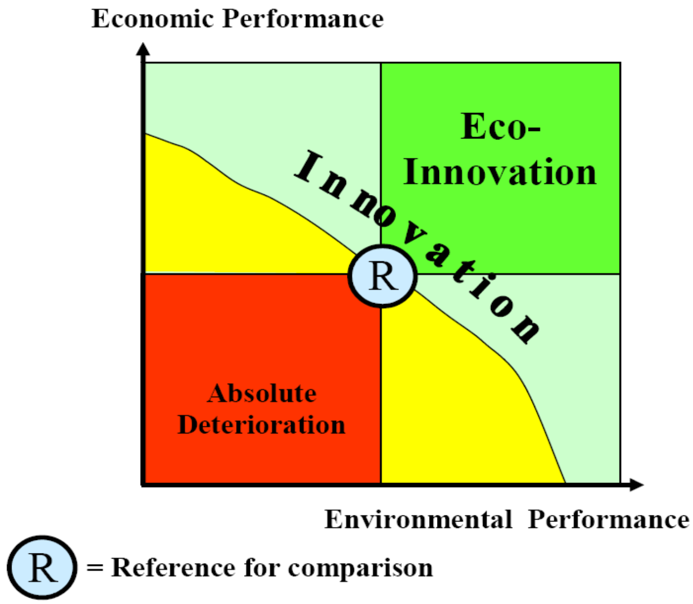
A decomposition analysis may use the identity I = PAT, where I stands for Impact, P for population, A for affluence and T for technology. The I = PAT identity is best thought of as a high-level heuristic device for decomposing the components of environmental impact. As governments are generally reluctant to act to directly address increases in population or affluence, i.e. rate of consumption per person, attention has focused on the technological factor, which measures environmental impact per unit of consumption. The term "technology" is something of a misnomer because it also picks up change in industrial structures and also organizational and behavioural changes.

The ECODRIVE project aims to analyse eco-innovation on the basis of economic and environmental performance data (at the firm, sector and national level) and proxies for innovation:

> Eco-innovation is a change in economic activities that improves both the economic performance and the environmental performance.

This definition would exclude many environmental technologies produced by the environmental goods and service sector. The criterion of economic benefits may also prove difficult to apply. For instance, the adoption of end-of-pipe technologies may lead to additional costs for the adopter but on the other hand they offer economic benefits to the suppliers and create jobs so that the net effect is undetermined. MEI wants to go beyond traditional environmental technologies but does not want to exclude them.

ECO-DRIVE view on eco-innovation



3. Eco-industry

The broad definition of eco-innovation might have implications for our understanding of the eco-industry. One could argue that the definition of eco-industry should be widened to include also companies whose innovations qualify as eco-innovations by being less environmental harmful than relevant alternatives. This would create problems for a data collection point of view as **the term eco-industry is already used for data collection activities by Eurostat and OECD** where eco-industries are "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources" (European Commission, 2006).

The study by Ernst Young for the European Commission identifies the following sectors as constituting the **Environmental Goods and Services sector** (eco-industry)[3]

- Solid Waste Management & Recycling
- Waste Water Treatment
- Air Pollution Control
- General Public Administration
- Private Environmental Management
- Remediation & Clean Up of Soil & Groundwater
- Noise & Vibration Control
- Environmental Research & Development
- Environmental Monitoring & Instrumentation
- Water Supply
- Recycled Materials
- Renewable Energy
- Nature Protection
- Eco-construction

Source: *Study on Eco-industry, its size, employment, perspectives and barriers to growth in an enlarged EU Final report, August 2006,* 17-18.

The EGS may be measured on the basis of environmental protection measures or on the basis of sales, or a combination thereof. Whatever method is used, it is important to note that **eco-innovation occurs in the whole economy**. Any company adopting a good, service, production process management or business method with environmental benefit is an eco-innovator. In this respect, it appears useful **to distinguish different types of eco-innovators.**

Here we could follow the suggestion of Bruce Tether in the UK and Anthony Arundel and Hugo Hollanders at UNU-MERIT to assign all innovative firms to one of four mutually exclusive categories, depending on how each firm innovates (by developing innovations for other firms, adopting innovations developed elsewhere in a strategic or

[3] Definitions of the sectors are given in Annex 1.

passive way). Following this logic, eco-innovators could be classified in the following categories:

Strategic eco-innovators: active in eco equipment & services sectors, develop eco-innovations for sale to other firms.
Strategic eco-adopters: intentionally implement eco-innovations, either developed in-house, acquired from other firms, or both.
Passive eco-innovators: process, organisational, product innovation etc that result in environmental benefits, but no specific strategy to eco-innovate.
Non eco innovators: No activities for either intentional or unintended innovations with environmental benefits.

They may be identified in the CIS using filter questions based on those definitions.

The partitioning of the universe of firms into 4 categories based on eco-innovation activities has not been attempted by anyone but appears an interesting direction for indicator research, allowing one to study changes in company behaviour with regard to environmental issues within the economy and possible reasons for these. At this moment only comprehensive information is available only for the strategic eco-innovators belonging to the eco-equipment & services sector. Work is under way to link the OECD list of environmental technologies with NACE. [4]

Figure 5 anticipates a possible outcome of the partitioning of firms according to eco-activities. I should note that this is nothing more than a wild guess.

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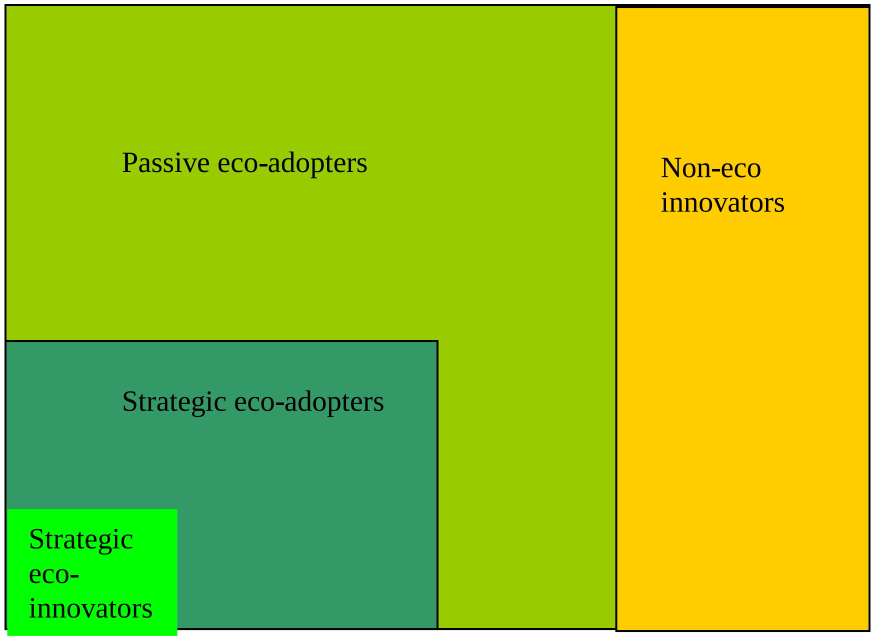
[4] Eurostat is currently drafting a compilation guide for collecting stats on the EGSS, so they are also in the process of defining the sector from the activities point of view (the NACE codes). They have defined a 'core' industry group (NACE 25.12, 37, 41, 51.57 and 90), but the much larger 'non-core' group of industries is yet to be defined.

Figure 5. Possible distribution of firms according to eco-activities



It is unclear what the economic size is of environmental beneficial innovations produced outside the eco-industry. We do know from Dutch studies that probably half of the innovations have a gratis environmental benefit but this has not been systematically studied. The size of the eco-industry narrowly defined amounts to 2.2% of GDP according to a recent study by Ernst and Young for DG Environment. The share of non-eco innovators is probably between 20-30%, based on survey information from the IMPRESS project under 1594 companies of more than 50 employees in 5 European countries (Germany, Italy, NL, CH and UK) in the 1999-2000 period and a recent OECD study under 4186 facilities in 7 OECD countries (Canada, France, Germany, Hungary, Japan, Norway, and the USA).

It is clear however that **future eco-innovation data collection should go beyond the traditional eco-business sector, which captures only a small amount of the eco-activities**. There is a big need for an assessment of the eco-activities in companies not belonging to the environmental goods and services sector as defined by the OECD.

4. Conclusion

In this report we offered a discussion of various definitions of eco-innovation. We argued for the use of a broad definition of eco-innovation to be used perhaps besides more narrow ones. Our broad definition of eco-innovation is

Eco-innovation is the production, application or exploitation of a good, service, production process, organisational structure, or management or business method that is <u>novel</u> to the firm or user and which <u>results</u>, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resources use (including energy use) <u>compared to relevant alternatives</u>.

Three key elements are that the novelty may consist of a novelty in use; there does not have to be an environmental aim (we are looking at results) and we are comparing the innovation with relevant alternatives.

The term eco-innovation crucially depends on an overall assessment of environmental effects and risks. For this life cycle assessment based on multi-attribute value theory can be used. We should note here that this may create a problem for survey analysis: the respondents' assessment of whether an innovation is better than relevant alternatives *on a life cycle basis* need not be true. In fact, the knowledge may not be available. LCA have been done only for a handful of products and processes and they do not always lead to unequivocal outcomes.

To us the above definition of eco-innovation is relevant and appears workable for statistical agencies and for future data collection activities from companies. There is a wide consensus in the MEI project that data collection and **indicator research should <u>not</u> be limited to environmentally motivated innovations** but also should comprise "environmentally beneficial normal innovations" for the reason that they constitute an important category, about which we know very little. Of course, if we do this, then almost all firms will be eco-innovators, which is seen as problematic by some (what is the usefulness of the concept of eco-innovation if almost every company is an eco-innovator?). However, this is the same 'false problem' that has been discussed in reference to the Oslo Manual on measuring innovation, with people objecting that the Manual defines innovation so broadly that almost all firms should be innovators. The problem is not that all firms are innovators (most should be), but *how we use the data to look at the different ways in which firms innovate.*

We also developed a typology of eco-innovation. The typology consists of four classes which are:

1. Environmental technologies
2. Organisational innovations as facilitators of material and behavioural changes offering environmental benefits
3. New and improved products and services offering environmental benefits
4. Green system innovations

The classes are based on whether technology or organisation issues are primary. In the first category, the technological aspect is foremost. In the second category organisational aspects are primary. In the case of new products and system innovations, the technological and organisational elements are so finely meshed together that it is impossible to say what is primary - they both are.

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Annex 1.Definitions of eco-industry sectors

Solid Waste Management & Recycling is defined here as the production of equipment, technology or specific materials, or the design, operation of systems, plants and sites or provision of other services for the collection (waste and scrap), separation, sorting, handling, transport, treatment (thermal, biological and chemical), storage, disposal, recovery, recycling and management of hazardous and non-hazardous solid waste, including low level, but not high level, nuclear waste. It includes outdoor sweeping and watering of streets, paths, parking lots, etc.

Waste Water Treatment is the production of equipment, technology or specific materials, or the design, operation of systems, plants and sites or provision of other services for the collection, treatment, handling, transport, reuse and management of waste water, cooling water and sewage. The equipment includes pipes, pumps, valves, aeration, gravity sedimentation, chemical treatment and recovery, biological recovery systems, oil/water separation systems, screens and strainers, sewage treatment, waste water reuse, water purification and other water handling systems.

Air Pollution Control is the production of equipment, technology or specific materials, or the design, operation of systems or provision of other services for the treatment and/or removal of exhaust gases and particulate matter from both stationary and mobile sources. The equipment includes air-handling equipment, dust collectors, precipitators, filters, catalytic converters, chemical treatment and recovery systems, specialised stacks, incinerators, scrubbers, odour control equipment and environmentally less-damaging specialised fuels.

General Public Administration consists of national public administration teams and departments, including government departments, environmental protection agency inspection teams, environmental tax collection and administration, that bear responsibility for environmental management fields, the implementation and control of environmental regulations, monitoring of fundamental research and development efforts, reporting and follow-up on eco-industries performances and other duties.

Private Environmental Management includes all activities addressing environmental management issues within the private sector, in-house or through the provision of external assistance (expertise, consulting, etc.) including environmental management system design and operation, ISO 14 001 management and operation and environmental audit works.

Remediation & Clean Up of Soil & Groundwater is the production of equipment, technology or specific materials, or the design, operation of systems or provision of other services to reduce the quantity of polluting materials in soil and water, including surface water, groundwater and sea water. It includes absorbents, chemicals and bio-remediators for cleaning-up, as well as cleaning-up systems (in situ or installed), emergency response and spill cleanup systems, water treatment and dredging of residues.

Noise & Vibration Control is the production of equipment, technology or specific materials, or the design, operation of systems or provision of other services to reduce or eliminate the emission and propagation of noise and vibration both at source and dispersed. It includes mufflers and silencers, noise deadening material, noise control equipment and systems, vibration control equipment and systems, sound-proof screens and street covering

Environmental Research & Development is the research of environmental issues (air, soil, water, energy, waste, noise, etc.) and development of “end of pipe” pollution treatment and clean up solutions and “source prevention” solutions to prevent environmental impacts, through the development of “cleaner” technologies and the use of renewable raw materials, analyze environmental impacts (settlement of measurement and analysis instrumentation), clean up pollution (e.g. filtering or treatment processes).

Environmental Monitoring & Instrumentation includes the manufacturing, integration and distribution of components, equipment and systems for monitoring air quality, water quality, noise, industrial emissions, radioactivity levels, etc. It also includes laboratory analysis, data acquisition and management systems.

Water Supply is the production of equipment, technology or specific materials, or design, construction, installation, management or provision of other services for water supply and delivery systems (public and private) and the collection, purification and distribution of potable water to household, industrial, commercial or other users.

Recycled Materials is the production of equipment, technology or specific materials, or design, construction, installation, management or provision of other services for manufacturing new materials or products, separately identified as recycled, from recovered waste or scrap, or preparation of such materials or products for subsequent use. This category covers the production of secondary raw materials but not their subsequent use.

Renewable Energy is the production of equipment, technology or specific materials, or design, construction, installation, management or provision of other services for the generation, collection or transmission of energy from renewable sources, including biomass, solar, wind, tidal, or geothermal sources.

Nature Protection includes the administration, training, information and education activities to conserve or maintain the natural environment, and in particular, the protection and rehabilitation of fauna and flora species, ecosystems and habitats, natural and semi-natural landscapes.

Eco-construction consists of the production of equipment, technology or specific materials, or design, installation, management or provision of other services to minimize environmental impacts from building, construction and renovation, including the construction activity itself (workshop), selection of materials, consumption, emissions and other environmental impacts during use of the structure, management of construction waste. It does not include construction for an eco-activity facility.

Source: *Study on Eco-industry, its size, employment, perspectives and barriers to growth in an enlarged EU Final report, August 2006,* 17-18.