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Working Party on National Environmental Policies

Indicators of Innovation and Transfer in Environmentally Sound Technologies: Methodological Issues

This report is a contribution to the OECD Environment Directorate's work on environmental policy and technological innovation (www.oecd.org/environment/innovation). It summarises recent progress in the development of indicators of innovation and transfer in environmentally sound technologies (EST). A number of alternative measures are discussed, and the methodology for the development of indicators based on patent data is presented.

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INDICATORS OF INNOVATION AND TRANSFER IN ENVIRONMENTALLY SOUND TECHNOLOGIES: METHODOLOGICAL ISSUES

1. Introduction

- 1. The development of a set of indicators of environmentally sound technology innovation ('EST innovation')¹ is one of the key elements of the 2009-2010 Programme of Work of the Working Party on National Environmental Policies. In the Programme, work on 'analysis of the determinants of environment-related innovation' and 'diffusion of EST innovation in the global economy' has been foreseen. Both of these objectives require development of appropriate indicators. There are two parts envisaged for the development of such indicators:
 - The first element is to develop thematic and aggregate <u>indicators of EST innovation</u>, in which
 patterns of EST-innovation can be compared in a consistent manner across countries and
 through time.
 - The second element of the work involves developing <u>indicators of international transfer of</u> <u>EST</u>, which are also comparable through time and across countries.
- 2. The aggregate indicator of EST-innovation should be comparable to those indicators which have earlier been developed by the OECD Science, Technology and Industry Directorate in the areas of Information and Communications Technologies, Biotechnology, or Nanotechnology and which have been used widely by the OECD Secretariat and others.²
- 3. This report summarizes the preliminary work conducted previously and expands on recent progress in developing indicators of innovation and transfer in environmentally sound technologies. A number of alternative measures are discussed, and the methodology for the development of indicators based on patent data is presented.³
- 4. In addition to the value of the indicators as consistent measures of innovation and transfer in the environmental sphere, it is important to draw policy implications from this work. Therefore, the Secretariat has conducted work with the objective of assessing the relative importance of different factors (policy measures, market conditions, scientific capacity, etc.) on the rate and pattern of innovation and their transfer internationally. The document is intended to serve as a reference document for papers arising out of this work.
- 5. Hence, while the focus of this report is strictly technical in nature, devoted to methodological aspects of developing indicators of innovation and transfer that are of universal value, reports in the following 'thematic' areas have been prepared:

¹ In this report, the term 'environmentally sound technologies' (EST) will be used instead of 'EST innovation'. This is consistent with the terminology employed by a number of other international organisations, including UNEP, UNFCCC, UNIDO, WIPO, ICTSD, etc. See below for a discussion of the definitions.

² See OECD (2009). The data is available at http://dotstat.oecd.org/wbos/Index.aspx .

³ This work would not have been possible without collaboration with the Economic Analysis and Statistics Division of the OECD Directorate for Science, Technology and Industry. In addition, much of the groundwork on developing the indicators has benefited from collaboration with researchers at universities and research institutes elsewhere. Acknowledgement is provided in the relevant 'thematic' reports.

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- General environmental technologies (air, water, waste) [ENV/EPOC/WPNEP(2009)2]
- Energy sector and climate change mitigation [ENV/EPOC/WPNEP(2009)3]
- 6. In addition, it is envisaged that in the course of 2009-2010 reports in the following areas will be prepared:
 - Energy efficiency and pollution abatement in the transport sector
 - Green (sustainable) chemistry.
- 7. Both strands of work development of indicators of 'EST innovation' and the related 'thematic' analyses play a direct and important role in the OECD policy discussions surrounding 'EST innovation'. This, in turn, will provide a valuable input to the development of an OECD Innovation Strategy [see SG/INNOV(2008)2]. A publication bringing together this work is foreseen for 2010.

2. Indicators of EST innovation

8. There are a number of candidates for the measurement of innovation (see OECD *Main Science and Technology Indicators* 2008). Most commonly, **R&D expenditures or the number of scientific personnel** in different sectors are frequently used as indicators. However, a sub-set of OECD and non-OECD countries have also begun to collect data on *government budget appropriations and outlays for R&D* (GBAORD) by socio-economic objective, including 'control and care for the environment'. Figure 1 provides some evidence for countries for which this data is relatively complete in recent years. For most countries, the data indicate that between 0.5% and 4% of GBAORD is specifically targeted at environmental objectives. While in large economies such as Germany, Japan and the US this share has remained relatively stable, there seems to have been a large degree of variation across countries and over time.

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⁴ The distribution of R&D expenditures is set out in the OECD Frascati Manual: The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys on Research and Experimental Development (Paris: OECD, 2002. The definition of the socio-economic objective (SEO) for 'control and care for the environment' covers research into the control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal in the environment and the effects on man, species (fauna, flora, micro-organisms) and the biosphere. Development of monitoring facilities for the measurement of all kinds of pollution is also included. The same is valid for the elimination and prevention of all forms of pollution in all types of environment.'

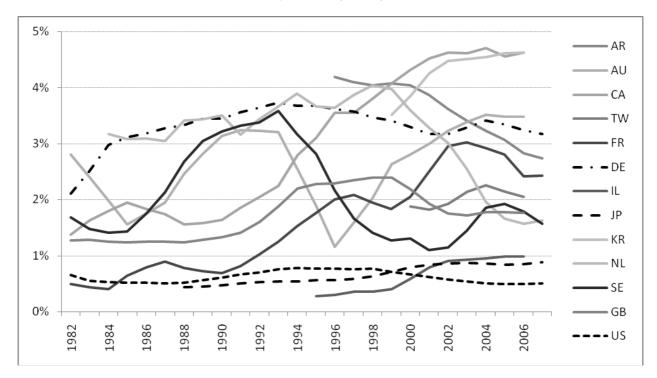


Figure 1. Percentage of GBAORD Expenditures Directed at 'Control and Care for the Environment" (3-year moving average)

Source of data: OECDSTAT (www.oecd.org/statistics) Research and Development Statistics.

9. However, there has been much greater uniformity among countries in GBAORD expenditures directed at 'rational utilisation of energy'. For most countries, the data indicate that up to 5% of GBAORD is specifically targeted at energy objectives, although this share was higher in the early 1980s. (See Figure 2.)

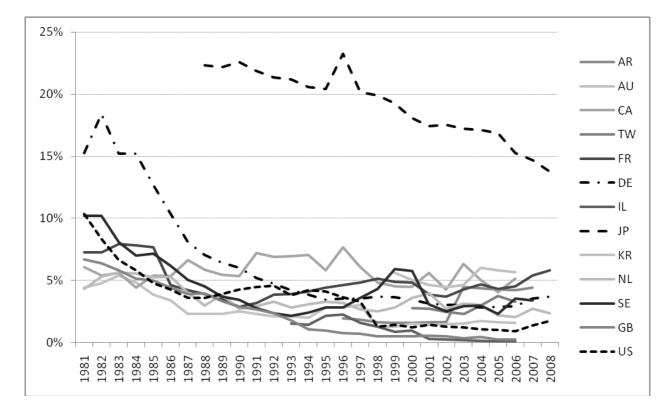


Figure 2. Percentage of GBAORD Expenditures Directed at 'Rational Utilisation of Energy"

 $Source\ of\ data:\ OECDSTAT\ (\underline{www.oecd.org/statistics})\ Research\ and\ Development\ Statistics.$

10. Finally, data are also available on government R&D spending in the energy sector (see OECD/IEA Energy Technology R&D Statistics). The data include expenditures directed at energy generation from fossil fuels, nuclear energy, and renewable energy, hydrogen and fuel cells, energy storage, as well as measures directed at improving energy efficiency in industry, residential and commercial uses, and transportation. Figure 3 gives the proportion of total energy technology R&D directed at renewable energy and energy efficiency measures. On the one hand, countries such as Finland, Denmark, Sweden, Austria, Ireland and Hungary, devote a relatively high share of their budgets to such aims. On the other hand, this share is much lower for countries such as France, Japan, Germany, Australia, Korea, Canada and the US, often as a consequence of higher levels of spending on nuclear energy sources.

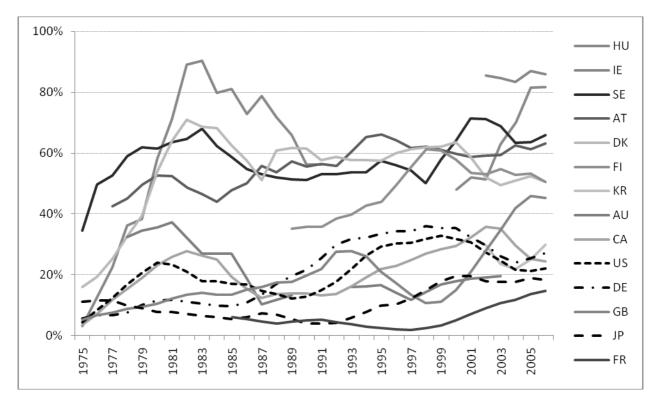


Figure 3. Percentage of Energy Technology R&D Expenditures Directed Towards 'Renewable Energy' and 'Energy Efficiency' Measures (3-year moving average)

Source of data: OECDSTAT (www.oecd.org/statistics) Energy Technology R&D Statistics.

- 11. Although such indicators do reflect an important element of the overall innovation system, there are a number of disadvantages associated with their use as indicators of innovation. For example, with respect to private R&D expenditures, the data are incomplete. Further, the data are only available at an aggregate level and (with the exception of the energy sector) they cannot be broken down by technology group. Moreover, there is no source of data for private R&D expenditures by socio-economic objective that is comparable to that used for GBAORD. Perhaps most significantly, R&D expenditures are measures of inputs to the innovation process, whereas an 'output' measure of innovation would be broadly preferable.
- 12. Given the general lack of data in this area, several *micro-level data* collection efforts have, therefore, been undertaken which have sought to measure innovation outputs. For instance, in the European Union, a small number of 'environment-related' questions have been applied as part of the *Community Innovation Survey*. Figure 4 gives the respondents' perceptions from that *Survey* of the importance of the effects of their innovation efforts. It is noticeable that 'environmental' factors rank at the bottom of this list.

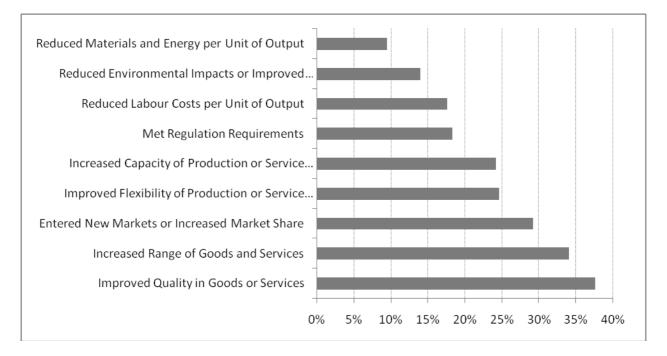


Figure 4. Motivations Identified as Highly Important for Innovation Activities (CIS 4 - EU27)

Source of data: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-07-113/EN/KS-SF-07-113-EN.PDF.

- 13. While 'environmental' concerns were only addressed tangentially in previous rounds of the CIS, considerable effort has gone into the design of the most recent CIS survey questionnaire, in order to ensure that environmental concerns are addressed in a much more systematic manner in the future (see Annex A). The OECD Secretariat plans to exploit this new data once it becomes available in 2009, in order to address policy-relevant questions.
- 14. Several of the researchers involved in the design of the environmental components of the CIS questionnaire were also involved in the (2006) OECD project on 'Environmental Policy and Firm-Level Management'. In this latter project, data was collected on *input* measures of 'EST innovation', such as expenditures on environment-related R&D, as well as on *output* measures such as 'clean production' and 'product design'. For illustration, Figure 5 provides data on the percentage of firms in that project (by industrial sector) which reported having taken environmental factors into account in *product design*.

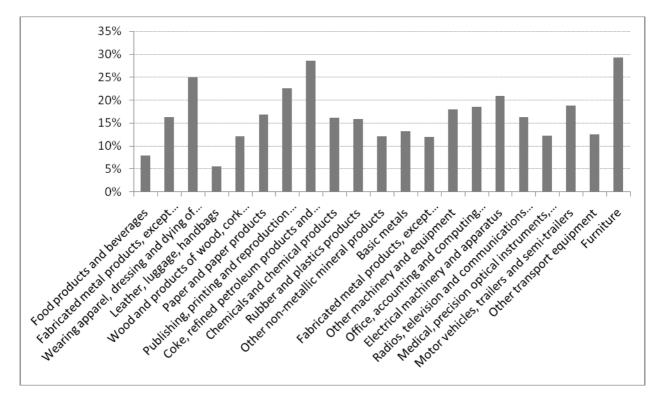


Figure 5. Percentage of Firms Which Report Having Taken Environmental Factors into Account in Product Design

Source: Johnstone (2007).

- 15. The main shortcoming with such exercises is their cost. A dedicated industrial survey which addresses environmental concerns on a periodic basis would be prohibitively expensive. While some countries do have 'environmental' components in their standard industrial censuses or innovation surveys (e.g. Canada, Norway, Japan), these data are not comparable across countries, and therefore cannot be used to develop indicators across countries.
- 16. It is therefore necessary to look elsewhere for sources of information/data which can be used to derive indicators. One possibility would, of course, be the development of indicators based upon existing **sectoral and commodity classifications** which have been developed to measure the output of goods and services. To the extent that new technologies are contained in direct (embodied) form in goods and services that are produced, such forms of innovation would be reflected in the base data. However, this would first require identification of sector or commodity classifications which represent 'environmental' technologies.
- 17. The OECD/Eurostat Informal Working Group on the Environment Industry has developed a Manual (OECD 1999) which provides a framework for the definition and classification of 'environmental industry activities'. This *Manual* identifies three broad 'environmental segments', each of which includes a large range of business activities:
 - Pollution management, including goods that help control air pollution, manage wastewater and solid waste, clean up soil, surface water and groundwater, reduce noise and vibrations, and facilitate environmental monitoring, analysis and assessment.

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⁵ See Sinclair-Desgagne (2008) for a recent discussion.

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- Cleaner technologies and products, including goods that are intrinsically cleaner or more resource-efficient than available alternatives. For example, a solar photovoltaic power plant is cleaner than a coal-fired one.
- Resource management, including goods used to control indoor pollution, supply water, or help to
 manage farms, forests or fisheries sustainably. Also included are goods used to conserve energy
 and goods that help prevent or reduce environmental impacts of natural disasters, such as firefighting equipment.
- 18. However, and as pointed out in the Manual itself, standard sectoral codes (*e.g.* ISIC, NACE, NAICS) do *not* lend themselves to such a breakdown, except in very specific areas such as water supply, wastewater treatment, and solid waste treatment and disposal. Moreover, such categories relate primarily to 'end-of-pipe' solutions to environmental concerns, areas where innovation is likely to be increasingly less beneficial overall.
- 19. On the basis of commodity classifications (the Harmonised Commodity Description and Coding System), the OECD has developed an illustrative list of 'environmental goods' (see OECD 2001) broken down into the following broad headings:

A. Pollution management

- Air pollution control
- Wastewater management
- o Solid waste management
- o Remediation and clean-up of soil and water
- Noise and vibration abatement
- o Environmental monitoring analysis and assessment

B. Cleaner technologies and products

- o Cleaner/resource-efficient technologies and processes
- o Cleaner/resource-efficient products

C. Resource management group

- o Indoor air pollution control
- Water supply
- o Recycled materials
- o Renewable energy plant
- o Heat/energy saving and management
- o Sustainable agriculture and fisheries
- Sustainable forestry
- o Natural risk management
- Eco-tourism
- 20. This list has since informed discussions about tariff arrangements related to 'environmental goods and services' at the World Trade Organization (WTO), in the context of the Doha Round of multilateral trade negotiations which calls *inter alia* for the liberalization of trade in 'environmental goods' (and services).

- 21. However, it is important to note that these headings do not feature in the Harmonized System. The commodity codes themselves refer to generic commodity classifications. Indeed, many of the codes included in the list encompass goods and services which have a range of uses besides environmental protection.⁶ For instance, the list includes 'air compressors mounted on a wheeled chassis for towing' (8414.40) or 'articles of cast iron' (7325.10). More significantly, 'environmental' goods are often designated as such in relation to a conventional alternative, which may well be included in the very same commodity classification *i.e.* 'parts for spark-ignition internal combustion piston engines' (8409.91).
- 22. And finally, classification of a good as being 'environmental' does not provide any particular indication of the amount of 'innovation' it represents although production of goods and services is an important determinant and consequence of innovation, clearly only a small percentage of production can be considered to constitute 'technological innovation'.
- 23. In sum, commodity classifications cannot be used to develop indicators of 'EST innovation', for two key reasons:
 - The commodity classifications do not lend themselves to the identification of goods and services with beneficial environmental consequences. In most cases, the classes used are much broader than the intended 'target', including goods which have no specific environmental implications. Worse, the classifications are sufficiently broad that they include goods which may well be the 'dirty' substitutes for 'EST innovations'.
 - The commodity classifications do not allow for the distinction between standardized goods and services which have been on the market for some time, and those goods and services which represent real technological innovations.
- 24. Fortunately, there are other possible 'output' indicators which address both of these concerns: bibliometric data (scientific publications) and technometric data (patent publications). The use of *bibliometric data* as a measure of innovation has been given renewed impetus with the growth of the Internet, combined with increasingly efficient search engines. Using keywords and indexing codes, searches of relevant databases (*e.g.* the Science Citation Expanded Index) are typically undertaken here. Data on author, affiliation, date of publication, etc. can be extracted, and counts can be developed to assess the relative innovative activity (see Meyer, 2002).
- 25. This kind of indicator is particularly useful for analyzing the diffusion of knowledge among inventors (and between countries), based on co-publications and citations. However, there are also some shortcomings associated with the use of bibliometric data. In particular, while such data is indeed an 'output' indicator of innovation, it is only an indirect indicator of a market output. Publication in a peer-reviewed journal reflects a scientific advance, but not necessarily one which has commercial applications. It is therefore difficult to use citations even as an index of quality, let alone of actual economic importance.
- As an alternative, *patent data* have often been used as a measure of technological innovation because they focus on outputs of the inventive process (Griliches 1990, OECD 2009). Patent data provide a wealth of information on the nature of the invention and the applicant, the data is readily available (if not always in a convenient format), discrete (and thus easily subject to the development of indicators). Significantly, there are very few examples of economically significant inventions which have not been patented (Dernis and Guellec 2001).

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⁶ See OECD (2007) for a discussion of this issue.

- 27. Most importantly, the application-based nature of the patent classification systems allows for a richer characterisation of relevant technologies. Since the International Patent Classification (IPC) system includes over 70,000 separate classification codes, it is possible to identify very precise technological fields. In the area of 'EST-innovation', some examples of relevant codes include:
 - B60L 7/10: Electrodynamic brake systems for vehicles dynamic electric regenerative braking for vehicle;
 - C02F 3/28: Biological treatment of water, waste water or sewage using anaerobic digestion processes;
 - F03D 3/02: Wind motors with rotation axis substantially at right angle to wind direction having a plurality of rotors.
- 28. Consequently, patent data *can be disaggregated to specific technological areas*, as was done in previous OECD work in this area, which examined the cases of renewable energy, wastewater effluent and motor vehicle emissions (OECD, 2008). This study drew on data from the OECD Triadic Patent Family database and a commercial provider. However, recent developments in the EPO/OECD PATSTAT database have enabled the implementation of search strategies which provide broader coverage of the data and (most significantly) allow for the possibility to undertake much more refined and accurate searches of innovations in different spheres.
- 29. In the environmental sphere, this allows for the identification of more 'integrated' technological innovations (which are virtually impossible to identify using the other data sources discussed earlier). Further details on the development of indicators of innovation based on patent data are presented in Section 4.

3. Indicators of international EST transfer

- 30. Technology transfer can be either 'embodied' or 'disembodied', and take place either through market or non-market means. A possible taxonomy might take the following form (see Maskus 2004 and World Bank 2006):
 - Market-mediated transfer:
 - o Trade in goods and services
 - Foreign direct investment
 - Licensing
 - Joint ventures
 - o Cross-border movement of personnel
 - Non-market transfer:
 - o Imitation and reverse engineering
 - o Employee turnover
 - o Published information (journals, test data, patent applications)
- Available empirical evidence strongly supports the finding that the bulk of technology transfer takes place via (i) trade, (ii) foreign direct investment (FDI) and (iii) licensing (Maskus 2004). Precisely which channel is most important depends in part upon the characteristics of the 'recipient country' (i.e. domestic research capacity, strength of intellectual property rights regimes, etc.) and the nature of the technology being transferred (i.e. the potential for imitation and reverse engineering).

- When seeking to assess the spatial patterns and rates of international technology transfer, it is therefore important to focus on measures which reflect potential transfer through these primary channels. Since technologies may be transferred in direct (embodied) form through trade in goods and services, such forms of transfer would be reflected in *trade* data. However, this would necessitate the identification of relevant sector or commodity classifications which represent 'environmental' technologies.
- 33. As noted above the OECD has developed an illustrative list of 'environmental goods' (see OECD 2001). This list has since informed discussions about environmental goods and services at the World Trade Organization (WTO), in the context of the Doha Round of multilateral trade negotiations which calls for the liberalization of 'environmental goods' (and services). In principle, based upon this list, it is possible to examine recent trends in the export of 'environmental goods and services'.
- 34. For instance, according to figures published in OECD *Indicators of Globalisation* in 2006, exports of environmental goods in the OECD area reached USD 370 billion (1% of its GDP and nearly 6% of its merchandise exports). In the same year, BRICS countries (Brazil, Russian Federation, India, China and South Africa) exported USD 43 billion, which accounted for almost 1% of their GDP and 2.7% of their total merchandise exports. Over the last four years, trade in 'environmental goods' also pursued a dynamic pattern of growth, increasing faster than total merchandise trade particularly in the BRICS (where exports have been growing at an annual average rate of 35%). More than 25% of exports of 'environmental goods' are for wastewater treatment equipment, which is also the fastest growing segment of the market. This is followed by air pollution control, waste management and environmental monitoring equipment.
- 35. However, and as noted above, the list of commodity classes used to extract the data used in these figures while undoubtedly valuable for negotiating purposes cannot be used credibly for statistical purposes. This is because a large number of the classes involved are only peripherally related to environmental concerns, and in some cases may even relate primarily to the 'brown' substitutes for 'green' alternatives (*e.g.* 'parts for spark-ignition internal combustion piston engines' HS 8409.91).
- 36. The implications that this has for the assessment of the development of indicators of international technology transfer can be seen with reference to renewable power. HS 8541.40 is proposed as a measure of solar power technologies and Figure 6 gives the trend in exports for the G7 countries, as well as for China and Spain. The remarkable level and growth rate of exports from China is certainly attributable to the breadth of the definition applied, which includes not only photovoltaic devices but also light-emitting diodes and semiconductor devices. Indeed, Hong Kong is the world's fifth largest exporter of this commodity class. Presumably, this is due to a high proportion of re-exports from other countries through Hong Kong. However, due to missing data on re-exports for most top exporting countries it is not possible to calculate *net* exports.

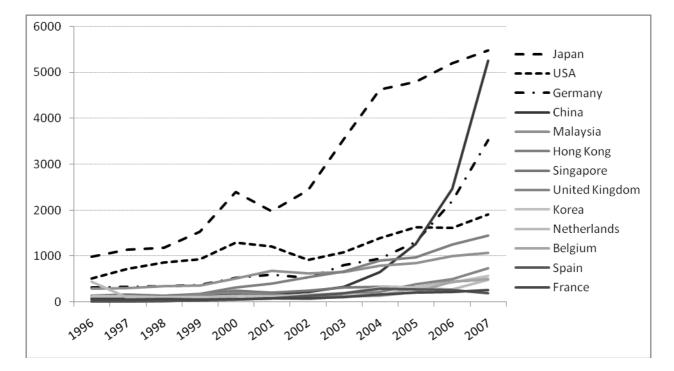


Figure 6. 'Solar Power' Technology Exports (based on COMTRADE data) (million USD)

- 37. And finally, and of even more relevance to *this* paper, trade in an 'environmental' good need not actually constitute 'technology transfer' although trade is an important channel of international technology transfer, not all trade can be considered to be technology transfer. In particular, trade in standardised goods and services can hardly be considered technology transfer. For several reasons, therefore, trade data is *not* an appropriate means by which to examine the transfer of environmental technologies.
- 38. Technology can also be transferred through *foreign direct investment*. If a subsidiary of a multinational corporation is established, the parent company may transfer advanced technologies directly to the subsidiary. This may diffuse more widely in the economy by different channels *e.g.* local employees of the subsidiary taking up employment in domestic firms, and carrying knowledge about the technology with them. However, it is even more difficult in this case (than it was in the trade case examined above) to identify potential transfers which are directly relevant to environmental concerns. FDI data is not available at a level of disaggregation that would allow for an assessment of 'environment-related' trends.
- 39. And finally, technologies can be transferred through *explicit licensing of specific technologies*. However, data on licensing is very sparse, and to the authors' knowledge, no effort has yet been made to assess licensing in any sector (or with respect to any particular good or service) which might be considered to be 'environmental'.
- 40. The idea of using *patent data* to measure international technology transfers arises from the fact that there will be a partial 'trace' of all three of the above-noted channels of transfer in patent applications. If there is any potential for reverse engineering, exporters, investors and licensors will each have an incentive to protect their intellectual property when it goes overseas. Although it cannot capture the full extent of the transfers which eventually take place, patent data *can* provide robust indicators of trends in both the direction and the extent of international transfer. Patent data has already been used extensively for this purpose, although not in the environmental sphere (see Eaton and Kortum 1996 for the seminal study.)

- Moreover, relative to measures which rely on commodity and sectoral classifications, patent data has the great advantage that the International Patent Classification system (the IPC) is 'technological' by nature. This allows for the identification of very specific 'environmental' technologies *i.e.* a distinction can be drawn between air pollution control devices designed to reduce NO_X emissions and devices designed to control SO₂ emissions (see *e.g.* Popp, 2005). In addition, each application can list multiple codes (unlike commodity or sectoral classifications), which allows for refined searches when innovations are horizontal in nature (*i.e.* the development of fuel cells for mobile uses). And finally, unlike other data, keyword searches can be used to refine the data.
- 42. The potential to use patent data as the base from which to develop a proxy measure of technology transfer arises from the fact that *a single invention may be patented in a number of countries*. While the vast majority of inventions are only patented in one country (often that of the inventor, particularly for large countries), some are patented in several countries (*i.e.* the 'international patent family size' is greater than one). Such 'duplicate' applications can then be used to develop indicators of technology transfer.
- 43. A patent only gives the applicant protection from potential imitators. It does not reflect actual transfer of technologies. If applying for protection did not cost anything, inventors might patent widely and indiscriminately. However, patenting is costly both in terms of the costs of preparation of the application and in terms of the administrative costs and fees associated with the approval procedure. (See Helfgott 1993 for some comparative data. Van Pottelsberghe and Francois (2006) also provide more recent data for European Patent Office applications). If enforcement is weak, the publication of the patent in a local language can also increase vulnerability to imitation (see Eaton and Kortum 1996 and 1999). As such, inventors are unlikely to apply for patent protection in a second country unless they are relatively certain of the potential market for the technology that the patent covers.
- 44. The increased reliability of the use of duplicate patent applications as a measure of technology transfer can be seen through a comparison of one particular area in which trade and patent classifications are similar wind power. Using data from the UN COMTRADE database (http://comtrade.un.org), it is possible to compare exports of 'wind-powered electric generating equipment' (HS 850231) with the count of duplicate patent applications by priority office for 'wind motors' (IPC F03D 1-11). Figure 7 provides data for the main inventing countries for the period 1996-2003 the only years for which the trade data is also available.

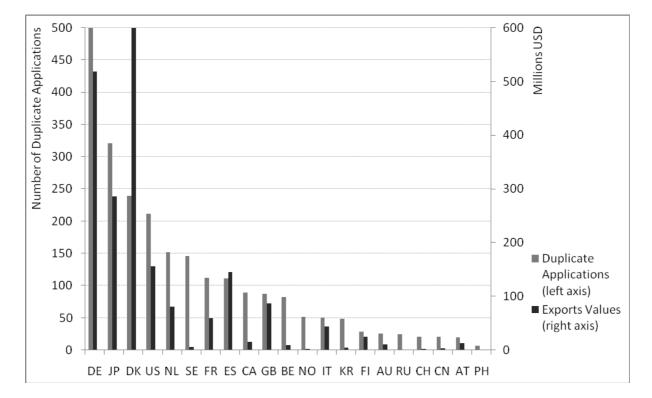


Figure 7. Number of Duplicate Patent Applications and Export of Wind Power Technologies

- While the correlation is not perfect, it is positive and significant. Indeed the top four exporters are also the top four priority patenting offices, and the Spearman rank correlation coefficient for the top 30 countries by trade is 0.68. Some of the observed discrepancies between the two data sets may also be attributable to shortcomings in COMTRADE's coverage. For instance, for reasons of commercial confidentiality, trade figures for low-level HS classifications may be significantly downward-biased. This would explain the number of countries with no apparent exports who are known to be active in the field (e.g. Sweden, Canada, Norway, and Switzerland).
- 46. Another area in which there is a close 'marriage' between IPC and HS classifications relates to the manufacture of motor vehicles. In this case, the correlation between bilateral exports and duplicate patent applications over the period 1988-2005 is approximately 0.74 when a small number of outliers (two of 825 observations) are removed. While this has little to do with environmental technologies per se, it gives a good indication of the value of duplicate patent applications as a measure of transfer.
- 47. Evidence on the extent of globalisation of the environmental technology sector can be developed on the basis of extractions of data on 'priority' (the first patent office at which an application for a particular invention is filed) and 'duplicate' (all subsequent patent offices at which protection for the same invention is sought) applications from the PATSTAT database. Further details are presented in section 4.

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See http://comtrade.un.org/kb/attachments/1.%20UN%20Comtrade%20Coverage%20and%20Limitations-GUIDbecc0aa5044f44b5a048a8b45bce6d19.pdf

4. Development of EST indicators of innovation and transfer based on patent data

48. In this section the general approach to the development of indicators of EST innovation is discussed. This is the approach that has been adopted by the OECD Secretariat for those areas for which indicators have already been developed (*e.g.* air pollution control, renewable energy).

4.1. Search strategy

- 49. Since EST innovation only represents one small aspect of innovation in general, prior to data retrieval from a patent database a *search strategy* must be developed that identifies the relevant patent documents using alphanumeric codes of the International Patent Classification (IPC) system, developed at the World Intellectual Property Organization (WIPO). For example, all patent documents with the code 'B01D 53/50 Chemical or biological purification of waste gases; Removing sulfur oxides' could be categorized as 'SO_x end-of-pipe pollution abatement".
- Development of a *search strategy* is thus based on identification of relevant patent classes that correspond to the selected 'environmental' technology field. As a first step this involves a review of internationally-accepted definitions and classification schemes for environmental technologies, expenditures and commodities, including but not restricted to: the UNECE/Eurostat Classification of Environmental Protection Activities (http://europa.eu.int/comm/eurostat/ramon); UNEP's Agenda 21 (http://europa.eu.int/comm/eurostat/ramon); the UNFCCC's classification scheme for environmentally sound technologies (http://unfccc.int/resource/docs/2006/sbsta/eng/inf01.pdf). This is followed by an extensive review of the trade and academic literature which relates to a specific technological field.
- 51. The relevant IPC classes which correspond to the different fields are then identified in two alternative ways: First, we review closely the descriptions of the classes online to find those which are appropriate (www.wipo.int/classifications/ipc/ipc8/?lang=en). Second, using the online world patent search engine maintained by the European Patent Office (www.espacenet.com), we search patent titles and abstracts for relevant keywords. The IPC classes corresponding to the patents that emerge are included, provided their description confirms their relevance.
- 52. However, in some cases, it may not be possible to identify IPC classes that alone represent the 'environmental' field of interest. Possible solutions include (i) combining multiple 'co-classes' using logical operators (that is, IPC classes whose intersection or negation yields the desired outcome); or (ii) relevant patent classes may need to be combined with the use of keywords within the search algorithm. As part of the extraction, abstracts of patent documents with the relevant IPC classes would then be searched for the keywords identified. In some cases this would involve the exclusion of patent documents which include a particular word. However, availability of English abstracts limits the practicality of this approach when pooling data from multiple patent offices, unless the propensity to include English abstracts can be corrected for reliably.
- When applying the *search strategy*, two possible types of error may arise: irrelevant patents may be included or relevant ones left out. The first error happens if an IPC class includes patents that do not bear the desired 'environmental' focus. In order to avoid this problem, we carefully examine a sample of patent abstracts for every IPC class considered for inclusion, and exclude those classes that do not consist only of patents related to 'environment'. The second error relevant inventions are left out is less problematic. We can reasonably assume that all innovation in a given field behaves in a similar way and hence our extracted datasets can be seen at worst as good proxies of innovative activity in the field being considered. However, overall innovative activity may be underestimated, and the totals may be less reliable than trends

54. The search algorithms developed for selected areas of environmental policy concern are discussed next. Table 1 gives the 'thematic' areas covered by the different indicators under development in this project, together with an indication of the status of development of the corresponding search strategy. A document presenting detailed descriptions of the search algorithms will be completed by mid-2009.

Table 1. 'Thematic' areas for the indicator of environmentally sound technologies

Thematic areas for EST-innovation indicator	Status of the work
Pollution Abatement, Control, Prevention and Monitoring	1
Air pollution control from stationary sources	
\circ SO _x	Completed
\circ NO _x	Completed
o PM	Completed
o VOCs	Underway
o ODS	Underway
Air pollution from mobile sources	
o CO	Completed
o HC	Completed
\circ NO _x	Completed
o PM,	Completed
\circ SO _{x,}	Underway
o Lead	Underway
Water & wastewater pollution abatement	
 Water and wastewater treatment 	Completed
 Oil spill remediation 	Completed
 Fertiliser production (using wastewater) 	Completed
Solid waste management	
 Disposal and landfilling 	Completed
Incineration	Underway
 Waste material reuse and recycling 	Underway
 Waste prevention 	Underway
Land decontamination and remediation	Underway
Noise protection and control	Completed
Environmental monitoring equipment	Underway
Green (sustainable) chemistry	Underway
nergy Efficiency and Climate Change Technologies	
Renewable energy generation	Completed
Wind power	•
o Solar energy	
 Ocean energy 	
o Geothermal energy	
Hydropower	
 Biomass and waste-to-energy 	
Fossil-fuel energy-efficient electricity generation	Completed
 Oil and gas conversion and combustion 	
 Coal conversion and combustion (incl. IGCC, FBC) 	
 Combined heat & power 	

 Technologies specific to climate change mitigation CO₂ capture and storage (CCS) Methane capture Energy efficiency/conservation measures in the residential, commercial and industrial sectors Buildings energy efficiency (insulation, double-glazing) Building material energy efficiency (e.g. cement) Completed Lighting Water heating Space heating and cooling; Air conditioning Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Alternative fuelled vehicles (electric, hybrid) 	Underway
 Methane capture Energy efficiency/conservation measures in the residential, commercial and industrial sectors Buildings energy efficiency (insulation, double-glazing) Building material energy efficiency (e.g. cement) Lighting Water heating Space heating and cooling; Air conditioning Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Completed Underway Completed Completed Completed Completed Completed 	
commercial and industrial sectors O Buildings energy efficiency (insulation, double-glazing) O Building material energy efficiency (e.g. cement) O Lighting O Water heating O Space heating and cooling; Air conditioning • Energy efficiency and fuel choice in transportation O Motor vehicle fuel efficiency Completed Underway Underway Completed	
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 Lighting Water heating Space heating and cooling; Air conditioning Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Completed 	2)
 Water heating Space heating and cooling; Air conditioning Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Completed 	
 Space heating and cooling; Air conditioning Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Completed 	
 Energy efficiency and fuel choice in transportation Motor vehicle fuel efficiency Completed	
o Motor vehicle fuel efficiency Completed	Underway
o Alternative fuelled vehicles (electric, hybrid) Completed	
	Completed
Energy storage	
 Secondary cells (batteries) Underway 	Underway
o Other (super-capacitors; superconducting magnetic; water Foreseen	ic; water Foreseen
heat storage; sensible/latent heat storage; photochemical	hemical
storage; kinetic energy storage)	
Hydrogen and fuel cells	
 Hydrogen production, storage, combustion Underway 	Underway
o Fuel cells Completed	Completed
Intersection with other advanced technologies	
Nanotechnology and EST Foreseen	Foreseen
o ICT and EST (e.g. energy efficiency and distribution) Foreseen	tion) Foreseen
o Biotech and EST Foreseen	Foreseen

4.2. Patent database

Over the last several years, the OECD Directorate for Science, Technology and Industry, jointly with other members of the OECD Patent Statistics Taskforce, have developed a patent database that is suitable for statistical analysis – the OECD Patent Statistics Database. Further work has recently been undertaken by the Taskforce members towards developing a world-wide patent database – *The EPO/OECD Worldwide Patent Statistical Database (PATSTAT)*. The European Patent Office (EPO) has taken over responsibility for development and management of the database.

56. The PATSTAT database is drawn directly from the EPO's master database (Rollinson and Lingua 2007). It has been developed specifically for use by governmental/intergovernmental organisations and academic institutions, and optimised for use in the statistical analysis of patent data. It has become a primary source of patent data information for statisticians, academics, and policy advisors (Rollinson and Heijnar 2006).

⁸ Other Taskforce members include the European Patent Office (EPO), Japan Patent Office (JPO), United States Patent and Trademark Office (USPTO), World Intellectual Property Organisation (WIPO), National Science Foundation (NSF), EUROSTAT, and DG Research.

57. The PATSTAT database has a world-wide coverage (over 80 patent offices), spanning a time period stretching back to 1880 for some countries. It contains over 70 million patent documents. It is updated on a regular basis biannually. Patent documents are categorised using the international patent classification (IPC) and some national classification systems. In addition to the basic bibliometric and legal data, the database also includes patent descriptions (abstracts), applicant and inventor names, as well as citation data. The PATSTAT database is thus an ideal source of patent data information for the purposes of this report.

4.3. Construction of indicators of EST innovation

- 58. Indicators of innovation are constructed as frequency counts of patent applications. They are disaggregated by:
 - Technological field (based on a search strategy using IPC classes¹⁰);
 - Priority date¹¹ (based on the first application filing date world-wide);
 - *Inventor country* (country of residence of the inventors¹², generated as fractional counts¹³);
 - Application authority¹⁴; and possibly also,
 - Document type (based on patent family data¹⁵).
- 59. There are several alternative approaches that could be used to construct the statistics:
 - Count of all patent applications deposited at a single patent office (e.g. the EPO);
 - Count of claimed priorities (CPs) deposited at any office world-wide;

⁹ This includes patent documents from the EPO, USPTO, JPO, and other national and regional patent offices, as well as international patent applications filed under the Patent Co-operation Treaty (PCT).

¹⁰ For a list of International Patent Classification (IPC) codes developed by the World Intellectual Property Organisation (WIPO), see http://www.wipo.int/classifications/ipc/ipc8/?lang=en. Note that an cooperative agreement has been struck with the European Patent Office whereby more fine-grained ECLA codes would be included in future versions of PATSTAT. This would allow for further refinement of the search algorithms in a number of areas (e.g. clean coal).

¹¹ 'Priority date' indicates the earliest application date worldwide (within a given patent family).

¹² For a list of two-digit abbreviations of country names, developed by the International Organisation for Standardisation, see http://www.iso.org/iso/country_codes.htm; The relevant WIPO document is available at http://www.wipo.int/standards/en/pdf/03-03-01.pdf

¹³ Generating the counts as 'fractional' means that if inventors from two (or three, or more) different countries are involved, only a fraction of 0.5 (0.33, etc.) will be counted for a given patent application.

For a list of application authorities (patent offices) included, and their abbreviations used, see http://documents.epo.org/projects/babylon/eponet.nsf/0/2464E1CD907399E0C12572D50031B5DD/\$File/global_patent_data_coverage_0708.pdf. See also http://www.wipo.int/standards/en/pdf/03-03-01.pdf

¹⁵ Using data on patent family, the following types of documents are distinguished: *Singular* is patent applied for at a single office, with no subsequent filings elsewhere (*i.e.* patent family size=1); *Claimed priority* (CP) is patent for which an application is filed at an additional office to that of the 'priority office"; these are inventions that have been applied for protection in multiple countries (patent family size>1); Finally, *duplicate* is the additional application.

- Count of all patent applications deposited at any office world-wide.
- 60. In the first case, the statistic would include all three types of patent documents (singulars, claimed priorities, and duplicates). Alternatively, only claimed priorities and duplicates would be included because, other things being equal, these should be the inventions of higher value. While it may be useful to examine patenting activity in other countries, frequently activity at the European Patent Office (EPO) is studied because (a) the data is most complete and of best quality, and (b) being one of the triadic offices, the statistics should reflect well the 'global' trends in patenting.
- 61. The second case focuses specifically on 'claimed priorities' (*i.e.* patent applications that have subsequently been claimed as priority elsewhere in the world). For the purpose of international comparisons, this statistic may be preferable for several reasons: (i) considering only priority applications (and not their duplicates) avoids double-counting which would occur if data from multiple patent offices were pooled. The data is thus better suited for cross-country analysis; (ii) considering only 'claimed priorities' provides a quality threshold as priority applications which have never been claimed are excluded. This helps contain any concerns over strategic patenting; and finally, (iii) the data are truly world-wide in their coverage, because the entire stock of patent priorities is considered. It follows that patent counts are attributed geographically solely to the inventors' country, independently of the priority filing office. In the third case, again all three types of patent documents singulars, claimed priorities, and duplicates could be included. Since data from multiple patent offices would be pooled.
- 62. Care needs to be taken when conducting descriptive and econometric analyses. In particular, comparisons across inventor countries should take into account the potential 'home bias' of domestic inventors. In addition, the propensity of inventors to patent, the breadth of invention claims covered by a patent, as well as the scope of patent protection, each vary over time and across countries. In order to account for these differences, the patent counts representing 'environmental' innovations should therefore be expressed as a share of, or otherwise controlled for (econometrically), using data on patenting activity overall.
- And finally, given the comprehensive coverage of thematic areas for which it has been possible to develop specific indicators of EST innovation (see Table 1), the aggregate indicator of EST innovation will be based upon a simple summation of the counts in the different areas. The implications of various means of weighting the different thematic indicators will be examined in order to test for the robustness of the aggregate indicator(s).

4.4. Construction of indicators of international EST transfer

- 64. An indicator of transfer is constructed using counts of **duplicate patent applications**, disaggregated by
 - Technological field (thematic sub-area);
 - Time (based on priority date or application date);
 - Source country of the invention (based on inventor country or priority office); and
 - Recipient country (based on priority office or duplicate office).
- 65. Other types of indicators of 'globalisation' can be derived from data on international patent families. These include:

- The **proportion of international families** *i.e.* the share of inventions that are patented in at least two countries. This indicator reveals the degree of internalization of markets for technology in a particular field. At the country-level, a high share of international families among inventions developed by domestic inventors denotes 'good' performance in terms of technology exports.
- The average size of international families this indicator provides information on the size of the markets targeted by patent owners. This can be measured either in terms of number of countries or in GDP of the countries where patent protection is asked for.
- 66. Finally, patent data can be used to develop indicators of international knowledge spillovers and cooperation. On the one hand co-invention data (*i.e.* inventions for which there are multiple inventor countries) can be used to examine **international research collaboration**. On the other hand, citation data can be used to examine **international knowledge flow**. Such measures have been applied in the areas of biotechnology, nanotechnology and ICT (OECD 2008), and could also be applied to EST innovation.

5. Final remarks and future work

- Work undertaken in this project thus far has allowed for the development of robust search algorithms to develop indicators of EST innovation. This work will continue through the rest of 2009-2010. In addition to refinement of the indicators developed in the areas examined thus far (climate change mitigation, motor vehicle emissions), a number of new areas are being explored, with the ultimate objective of developing a general indicator of 'EST innovation', as well as a suite of subsidiary indicators in specific fields. Collaboration with the European Patent Office should allow for the refinement of the indicators developed since it has been agreed that the more fine-grained ECLA patent classifications will be included in PATSTAT.
- 68. It is envisaged that efforts to develop a general indicator of innovation in environmentally sound technologies will result in including the indicator on OECDSTAT. This would involve adding a 'tag' (ENV-tech) which would complement the already existing indicators of innovation in ICT, BIO-, and NANO-technologies. As with these cases, the methodology for the development of the indicators and the list of relevant classes will be presented to the OECD Patent Statistics Taskforce for approval by written procedure. Inputs from delegates to the WPNEP and the Working Group on Environmental Information and Outlooks will also be sought.
- 69. However, progress made thus far has already generated wide interest in the OECD and elsewhere. This has resulted in a number of strands of work in which the indicators are being applied to document and understand trends and assess policy interventions. For example, the work on climate change mitigation will be co-ordinated with the work of the Climate Change, Biodiversity, and Outlooks (CBO) Division, particularly in the area of international transfer of climate change mitigation technologies. In addition, this work is providing inputs to the Joint Meetings of Tax and Environment Experts' work on taxation, innovation and the environment (*i.e.* motor vehicle fuel efficiency and emissions abatement, SOx and NOx abatement, etc.). And finally, work on innovation in 'sustainable chemistry' is being overseen by the Joint Meeting of the Chemicals Committee and the Working party on Chemicals, Pesticides and Biotechnology.
- 70. And finally, use will be made of other data sources to measure and analyse environmentally sound technology development and diffusion. The *Community Innovation Survey* has been mentioned above, and discussions are underway to assess how data from this source might be usefully exploited. The Secretariat is also involved in discussions at the OECD Directorate for Science, Technology and Industry about the use of the *SCOPUS database*, the largest abstract and citation database of scientific publications.

With respect to EST innovation, possible application could include closer examination of fields where patent searches have proven difficult so far (e.g. CCS) and possibly corroborating data on EST innovation.

71. In addition, the ORBIS micro-database, recently acquired by five OECD Directorates (DAF, STD, STI, ELS, and TAD), will be explored for new research opportunities. For example, by 'marrying' assignees in PATSTAT to the firm identifiers in ORBIS, it will be possible to assess the links between EST innovation and profitability, employment, etc. This work will serve as a contribution to the Environment Directorate's work on the environment and competitiveness. Finally, relevant insights from the methodological work arising out of the Measuring **Eco-Innovation** project (http://www.merit.unu.edu/MEI/) will be examined.

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ANNEX A. 'Environmental' Section of CIS 5

Innovations with environmental benefits

An environmental innovation is a new or significantly improved product (good or service), process, organizational method or marketing method that creates environmental benefits compared to alternatives.

- The environmental benefits can be the primary objective of the innovation or the result of other innovation objectives.
- The environmental benefits of an innovation can occur during the production of a good or service, or during the after sales use of a good or service by the customer.
- 1. During the three years 2006 to 2008, did your enterprise introduce a product (good or service), process, organisational or marketing innovation with any of the following environmental benefits?

	Yes	No
Reduced material use per unit output Reduced energy use per unit output Reduced CO ₂ footprint for your enterprise Replaced materials with less polluting or hazardous substitutes Reduced soil, water, or air pollution Recycled waste, water, or materials		
Environmental benefits from the after sales use of a good or service by the customer Reduced energy use Reduced air, water, soil or noise pollution Improved recycling of product after use		
2. During 2006 to 2008, did your enterprise introduce an environmental innovation in re	esponse	to:
Need to comply with existing environmental regulations Environmental regulations that you expected to be introduced in the future Availability of government grants, subsidies or other financial incentives for environmental innovation	Yes	No
Market demand from your customers for environmental innovations Voluntary codes for environmental good practice within your sector		
3. Does your enterprise have procedures in place to regularly identify and reduce your environmental impacts? (For example preparing environmental audits, setting environmental goals, ISO 14001 certification, etc).		
☐ Yes: implemented before January 2006 ☐ Yes: Implemented or significantly improved after January 2006 ☐ No		

ANNEX B. Glossary of Relevant Patent and Related Terms

Adoption: The point at which a technology is selected for use by an individual or an organization.

Applicant: The person or company that applies for the patent and intends to 'work' the invention (*i.e.* to manufacture or license the technology). In most countries the inventor(s) does not necessarily have to be the applicant.

Application (or filing) date: The patent application date is the date on which the patent office received the patent application.

Application for a patent: To obtain a patent, an application must be filed with the authorised body (Patent Office) with all the necessary documents and fees. The patent office will conduct an examination to decide whether to grant or reject the application.

Assignee: The person(s) or corporate body to whom all or limited rights under a patent are legally transferred. Assignment of all or limited rights under a patent.

Bibliometrics: Study of the quantitative data of the publication patterns of individual articles, journals, and books in order to analyze trends and make comparisons within a body of literature.

Breadth (or scope): A measure of the extent of the invention covered by a single patent application. For example, one patent application to the EPO would generally more claims than an application to the JPO.

Citations: They comprise a list of references that are believed to be relevant prior art and which may have contributed to the 'narrowing' of the original application. Citations may be made by the examiner or the applicant/inventor.

Claim(s): These define the invention that the applicant wishes to protect. A main claim will define the invention in its broadest form, by including its essential technical features. Further 'dependant' claims can then relate to additional features of the invention.

Copyright: The legal right granted to an author, editor or publisher of an article, chapter or complete work. Copyright applies to intellectual property in a variety of artistic fields and attempts to be format-neutral.

Design applications: Designs can be registered for a wide range of products, including computers, telephones, CD-players, textiles, jewellery and watches. Registered designs protect only the appearance of products, for example the look of a computer monitor. Registration of the design does not protect the way in which the product relating to the design works.

Designated countries: Countries in which patent applicants wish to protect their invention. This concept is specific to European patent applications and international patent applications filed under the Patent Cooperation Treaty (PCT).

Diffusion: The extent to which a technology spreads to general use and application in the economy.

Duplicate: All patents relating to the same invention and sharing the same priority, but filed at patent offices other than the priority office. The count of such patents can be considered as the size of a 'simple' patent family.

ECLA: The European Patent Office's patent classification system. It is based on the IPC Classification System, with greater disaggregation.

Equivalent: A patent that relates to the same invention and shares the same priority application as a patent from a different issuing authority.

Esp@cenet: European Patent Office web site for searching, displaying and downloading patent documents.

European Patent Convention (EPC): The Convention on the Grant of European Patents (European Patent Convention, EPC) was signed in Munich 1973 and entered into force in 1977. As a result of the EPC, the European Patent Office (EPO) was created to grant European patents.

European Patent Office (EPO): The European Patent Office (a regional patents office) was created by the EPC to grant European patents, based on a centralised examination procedure. By filing a single European patent application in one of the three official languages (English, French and German), it is possible to obtain patent rights in all the EPC member and extension countries by designating the countries in the EPO application. The EPO is not an institution of the European Union.

European patent: A European patent can be obtained for all the EPC countries by filing a single application at the EPO in one of the three official languages (English, French or German). European patents granted by the EPO have the same legal rights and are subject to the same conditions as national patents (granted by the national patent office). It is important to note that a granted European patent is a 'bundle' of national patents, which must be validated at the national patent office for it to be effective in member countries.

Examiner: An employee of a patent office to whom an application is assigned for handling prosecution.

Grant date: The date when the patent office issues a patent to the applicant. On average it takes three years for a patent to be granted at the USPTO and five years at the EPO.

Grant: A temporary right given by the authorised body for a limited time period (normally 20 years) to prevent unauthorised use of the technology outlined in the patent. A patent application does not automatically give the applicant a temporary right against infringement. A patent has to be granted for it to be effective and enforceable against infringement.

Home Bias: Propensity for the priority country to be the same as the inventor or applicant country.

Infringement: Unauthorised use of a patented invention.

Innovation: The creation or introduction of something new, especially a new product or a new way of producing something.

Intellectual property rights (IPR): IPR allows people to assert ownership rights on the outcomes of their creativity and innovative activity in the same way that they can own physical property. The four main types of intellectual property rights are: patents, trademarks, design and copyrights.

International patent application: Patent applications filed under the Patent Cooperation Treaty (PCT) are commonly referred to as international patent applications. However, an international patent (PCT) application does not result in the issuance of 'international patents', *i.e.* at present, there is no global patent system that is responsible for granting international patents. The decision of whether to grant or reject a patent application filed under the PCT rests with the national or regional (*e.g.* EPO) patent offices.

International Patent Classification (IPC): The International Patent Classification, which is commonly referred to as the IPC, is based on an international multilateral treaty administered by WIPO. The IPC is an internationally recognised patent classification system, which provides a common classification for patents according to technology groups. IPC is periodically revised in order to improve the system and to take account of technical development. The current (eighth) edition of the IPC entered into force on 1 January 2006.

Inventor country: Country of the residence of the inventor, which is frequently used to count patents in order to measure inventive performance.

Inventor: Inventor names are recorded for all patents. These appear in the standard last name-initial(s) format.

Japan Patent Office (JPO): The JPO administers the examination and granting of patent rights in Japan. The JPO is an agency of the Ministry of Economy, Trade and Industry (METI).

Kind Code: The letter, often with a further number, indicating the level of publication of a patent. For example DE-A1 is the German *Offenlegungsschrift* (application laid open for public inspection) while a DE-C1 is the German *Patentschrift* (first publication of the granted patent).

Lapse: The date when a patent is no longer valid in a country or system due to failure to pay renewal (maintenance) fees. Often the patent can be reinstated within a limited period.

Learning by doing: Refers to the improvement in technology that takes place in some industries, early in their history, as they learn by experience, so that average cost falls as accumulated output rises. See infant industry protection, dynamic economies of scale.

Learning curve: Relationship representing either average cost or average product as a function of the accumulated output produced. Usually reflecting learning by doing, the learning curve shows cost falling, or average product rising.

Licence: The means by which the owner of a patent gives permission to another person to carry out an action which, without such permission, would infringe on the patent. A licence can thus allow another person to legitimately manufacture, use or sell an invention protected by a patent. In return, the patent owner will usually receive royalty payments. A license, which can be exclusive or non-exclusive, does not transfer the ownership of the invention to the licensee.

Novelty: If an application for a patent is to be successful, the invention must be novel (new). The invention must never have been made public in any way, anywhere, before the date on which the application for a patent is filed (or before the priority date).

Obviousness: The concept that the claims defining an invention in a patent application must involve an inventive step if, when compared with what is already known (*i.e.* prior art), it would not be obvious to someone skilled in the art.

OECD triadic patent families: The triadic patent families are defined at the OECD as a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and the US Patent & Trademark Office (USPTO) that share one or more priorities. Triadic patent families data are consolidated to eliminate double counting of patents filed at different offices (*i.e.* regrouping all the interrelated priorities in EPO, JPO and USPTO patent documents).

Paris Convention: The Paris Convention for the Protection of Industrial Property was established in 1883 and is generally referred to the Paris Convention. The Paris Convention established the system of priority rights. Under the priority rights, applicants have up to 12 months from first filing their patent application (usually in their own country) in which to make further applications in member countries and claim the original priority date.

Patent Cooperation Treaty (PCT): Signed in 1970, the PCT entered into force in 1978. The PCT provides the possibility to seek patent rights in a large number of countries by filing a single international application (PCT application) with a single patent office (receiving office). The PCT procedure consists of two main phases: (a) an 'international phase'; and (b) a PCT 'national/regional phase'. PCT applications are administered by the World Intellectual Property Organisation (WIPO).

Patent family: A patent family is a set of individual patents granted by various countries. The patent family is all the equivalent patent applications corresponding to a single invention, covering different geographical regions. Patent family size is a measure of the geographical breadth for which protection of the invention is sought.

Patent number: A patent number is a unique identifier of a patent. Patent numbers are assigned to each patent document by the patent-issuing authority. The first two letters designate the issuing patent office *i.e.* EP for EPO patents and US for USPTO patents

Patent: A patent is an intellectual property right issued by authorized bodies to inventors to make use of, and exploit their inventions for a limited period of time (generally 20 years). The patent holder has the legal authority to exclude others from commercially exploiting the invention (for a limited time period). In

return for the ownership rights, the applicant must disclose the invention for which protection is sought. The trade-off between the granting of monopoly rights for a limited period and full disclosure of information is an important aspect of the patenting system.

Patentability: Patentability is the ability of an invention to satisfy the legal requirements for obtaining a patent. The basic conditions of patentability, which an application must meet before a patent is granted, are that the invention must be novel, contain an inventive step (or be non-obvious), be capable of industrial application and not be in certain excluded fields (*e.g.* scientific theories and mathematical methods are not regarded as inventions and cannot be patented at the EPO).

PATSTAT: The EPO's World Patent Statistical Database.

Prior Art: Previously used or published technology that may be referred to in a patent application or examination report. (a) In a broad sense, technology that is relevant to an invention and was publicly available (*e.g.* described in a publication or offered for sale) at the time an invention was made. (b) in a narrow sense, any such technology which would invalidate a patent or limit its scope. The process of prosecuting a patent or interpreting its claims largely consists of identifying relevant prior art and distinguishing the claimed invention from that prior art.

Priority country: Country where the patent is first filed before being (possibly) extended to other countries.

Priority date: The priority date is the first date of filing of a patent application, anywhere in the world (normally in the applicant's domestic patent office), to protect an invention. The priority date is used to determine the novelty of the invention, which implies that it is an important concept in patent procedures. For statistical purposes, the priority date is the closest date to the date of invention.

Publication lag: In most countries, a patent application is published 18 months after the priority date. For example, allpending EPO and JPO patent applications are published 18 months after the priority date. Prior to a change in rules under the American Inventors Protection Act of 1999, USPTO patent applications were held in confidence until a patent was granted. Patent applications filed at the USPTO on or after 29 November 2000 are required to be published 18 months after the priority date.

R&D expenditures: The basic measure of R&D expenditures is 'intramural expenditures"; *i.e.* all expenditures for R&D performed within a statistical unit or sector of the economy.

R&D: Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

Renewal fees: Once a patent is granted, annual renewal fees are payable to patent offices to keep the patent in force. In the USPTO these payments are referred to as maintenance fees.

Rent: The premium that the owner of a resource receives over and above its opportunity cost.

Reverse engineering: The process of learning how a product is made by taking it apart and examining it.

Revocation: Termination of the protection given to a patent on one or more grounds, e.g. lack of novelty.

Scientometrics: The quantitative study of the disciplines of science based on published literature and communications. This could include identifying emerging areas of scientific research, examining the development of research over time, or geographic and organizational distributions of research.

Search report: The search report is a list of citations of all published prior art documents which are relevant to the patent application. The search process, conducted by a patent examiner, seeks to identify patent and non-patent documents constituting the relevant prior art to be taken into account in determining whether the invention is novel and includes an inventive step.

Technology Transfer: The communication or transmission of a technology from one country to another. This may be accomplished in a variety of ways, ranging from deliberate licensing to reverse engineering.

Term of patent: The maximum number of years that the monopoly rights conferred by the grant of a patent may last.

Trade-Related Aspects of Intellectual Property Rights (TRIPS): Agreement on trade-related aspects of intellectual property rights requires members to comply with certain minimum standards for the protection of IPR. But members may choose to implement laws which provide more extensive protection than is required in the agreement, so long as the additional protection does not contravene the provisions of the agreement. The WTO's TRIPS agreement, negotiated in the 1986-94 Uruguay round, introduced intellectual property rules into the multilateral trading system for the first time.

United States Patent and Trademark Office (USPTO): The USPTO administers the examination and granting of patent rights in the United States. It falls under the jurisdiction of the U.S. Department of Commerce.

Utility model: Also known as 'petty patent', these are available in some countries (*e.g.* Japan). This type of patent involves a simpler inventive step than that in a traditional patent and it is valid for a shorter time period.

World Intellectual Property Organization (WIPO): An intergovernmental organisation responsible for the negotiation and administration of various multilateral treaties dealing with the legal and administrative aspects of intellectual property. In the patent area, the WIPO is notably in charge of administering the Patent Cooperation Treaty (PCT) and the International Patent Classification system (IPC).

Primary Sources:

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