Integrating resource efficiency, greening of industrial production and green industries – scoping of and recommendations for effective indicators

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About this study

This study was undertaken for United Nations Industrial Development Organization (UNIDO) as a scoping of existing resource indicators to assess their potential applicability for measuring progress towards the greening of industries and fostering green industries. In the context of UNIDO's process to establish a Green Industry Platform in 2012, this study's purpose is to provide analytical support and to contribute to discussions on potentially relevant indicators for sustainable industries within the to be established Platform.

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Table of Contents

List of Tables

List of Figures

1 Background

Increasing resource efficiency is one of the core themes of sustainable development, facilitating the improvement of socio-economic well-being while reducing resource use and its associated environmental impacts. Sustainable resource management is one of the main objectives of Agenda 21, adopted at the Earth Summit (United Nations Conference on Environment and Development) in Rio de Janeiro in 1992. Without a doubt, Agenda 21 is a milestone and trigger for the intensifying debate and progress on resource efficiency. Nonetheless, its focus on sustainable resource management is restricted primarily to the consumption side of resource use, devoting much less attention to industries and industrial development.[1] Although the Plan of Implementation of the World Summit on Sustainable Development in Johannesburg in 2002 puts greater emphasis on industries (Changing unsustainable patterns of consumption and production),[2] the political debate in recent years seems to have shifted away from industries and industrial development yet again.[3]

This is reflected, for instance, in the discussions towards supplementing and integrating the United Nations Millennium Development Goals (MDGs), adopted in 2000, with Sustainable Development Goals (SDGs), such as those proposed by the governments of Colombia and Guatemala, to be defined and agreed on within the Rio+20 process.[4] Both initiatives appear to lack specific targets for industries and industrial development.

While the MDGs outline concrete, partly quantifiable objectives to drastically reduce extreme poverty by 2015, they do not provide guidance or indicators on improving resource efficiency and in particular do not address the industrial sector.[5] For example, Goal 7 calls to "[i]ntegrate the principles of sustainable development into country policies and programmes [and] reverse loss of environmental resources" but does not provide any specific targets related to industry. Furthermore, they also do not specifically address resource efficiency. Although MDG 7 does include indicators for emissions intensity and per capita emissions, the targeted resources (e.g., forests, biodiversity, and water) do not include many of the key inputs in industrial production, such as metals or fossil fuels. Though the SDGs proposed by the governments of Colombia and Guatemala include resources relevant to industries and industrial development, in particular water resources and energy, they make no reference to industries or industrial development.

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[1] See section II CONSERVATION AND MANAGEMENT OF RESOURCES FOR DEVELOPMENT, http://www.un.org/esa/dsd/agenda21/res_agenda21_00.shtml.

[2] See section III, Changing unsustainable patterns of consumption and production, http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf.

[3] UNIDO 2011. Green Industry: A key pillar of a Green Economy. Policy Brief for the Ministerial Meeting on Energy and Green Industry, Vienna, 21 and 22 July 2011. See http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Renewable_Energy/VEF_2011/Green%20industry%20policy%20brief_Final.pdf.

[4] See the proposal by the Governments of Colombia and Guatemala; RIO + 20: Sustainable Development Goals (SDGs), http://www.uncsd2012.org/rio20/content/documents/colombiasdgs.pdf.

[5] UNMDG (2011): The Millenium Development Goals Report 2011. http://www.un.org/millenniumgoals/pdf/(2011_E)%20MDG%20Report%202011_Book%20LR.pdf

Achieving both the MDGs and the SDGs requires integrating industries and industrial development. On the one hand, industrial development plays a key role in alleviating poverty, but at the same time sustainable development on a global level can only be achieved when industries commit themselves to sustainable resource management and greater resource efficiency, for instance, by improving resource efficiency in the consumption of natural resources for production processes.[6] This in turn calls for a greening of industries as well as a fostering of green industries[7] and the environmental goods and services sector.[8] Accordingly, in the upcoming Rio +20 summit in Rio de Janeiro in June 2012, the Secretary-General's Report on Objectives and Themes of the United Nations Conference (UNDESA)[9] sets "green economy" in the context of sustainable development and poverty eradication as a key objective and main theme of the summit. However, in order to monitor and measure the progress towards sustainable industry—as an integral part of achieving both the MDGs and the proposed SDGs—effective indicators are necessary. In this context, the scope of sustainable development requires indicators to cover the environmental, social, and economic dimensions.

Concerning the environmental dimension, a broad variety of well-developed resource use indicators exist both at product and country level[10] and can be used to measure the degree of "decoupling"[11] of resource use and economic growth and the associated environmental benefits.[12]

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[6] UNEP 2011. Towards a Green Economy. Pathways to Sustainable Development and Poverty Eradication. A Synthesis for Policy Makers, www.unep.org/greeneconomy.

[7] UNIDO 2010. A Greener Footprint for Industry. Opportunities and challenges of sustainable industrial development. http://www.unep.or.jp/ietc/spc/news-nov09/UNIDO_GreenIndustryConceptEbook.pdf.

[8] Eurostat 2009. The environmental goods and services sector. Methodologies and Working Papers. European Communities, Luxembourg and OECD 1999. The Environmental Goods & Services Industry. Manual for Data Collection and Analysis, Paris.

[9] UNDESA 2011. Objective and themes of the United Nations Conference on Sustainable Development. Report of the Secretary-General. See http://www.uncsd2012.org/rio20/content/documents/N1070657.pdf

[10] Giljum, S. et al. 2011. A comprehensive set of resource use indicators from the micro to the macro level. Resources, Conservation and Recycling 55 (3): 300 – 308; Giljum, S. et al. 2009. How to measure Europe's resource use. An analysis for Friends of the Earth Europe. Vienna: SERI.

[11] One typically distinguishes between resource decoupling and impact decoupling as well as between relative decoupling (where resource use and/or impacts grow at a slower rate than economic growth), and absolute decoupling (where resource use and/or impacts stagnate or decrease). See JRC and IES 2010. Monitoring progress in Sustainable Consumption and Production in the EU. Decoupling indicators; van der Voet, E. et al. 2005. Policy review on decoupling: development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries. Brussels: EU Commission, DG ENV, as well as UNEP 2011. Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel. Fischer-Kowalski, M., Swilling, M., von Weizsäcker, E.U., Ren, Y., Moriguchi, Y., Crane, W., Krausmann, F., Eisenmenger, N., Giljum, S., Hennicke, P., Romero Lankao, P., Siriban Manalang, A.

[12] JRC and IES 2010. Monitoring progress in Sustainable Consumption and Production in the EU. Decoupling indicators; van der Voet, E. et al. 2005. Policy review on decoupling: development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries. Brussels: EU Commission, DG ENV

To a lesser extent, indicators for resource efficiency have also been discussed,[13] but according to recent evaluations[14] and key European policies on resource efficiency (in particular, the Roadmap to a Resource Efficient Europe[15], the Europe2020 Strategy,[16] and the Flagship Initiative "A resource-efficient Europe" [17] under the Europe2020 strategy), not in sufficient detail to measure effectively progress towards greater resource efficiency.[18] Altogether, there appears to be a gap concerning indicators for measuring progress towards sustainable industries and sustainable industrial development (including the greening of industries, progress achieved in green industries, and greater resource efficiency in industrial production). In addition, data availability, especially regarding life cycle resource use of products and services, proves to be a severe limiting factor for establishing relevant resource indicators.

According to reports by the European Commission on the Progress of the Thematic Strategy on the Sustainable Use of Natural Resources,[14] as well as by BIOIS, IFF, and VITO,[19] ongoing work concerning the identification of a headline indicator for resource efficiency has as of yet produced no recommended set of indicators.

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[13] UNESCAP 2009. Eco-efficiency Indicators: Measuring Resource-use Efficiency and the Impact of Economic Activities on the Environment. See http://www.unescap.org/esd/environment/publications/EEI/ESCAP_EEI%20Publication%202561.pdf

[14] European Commission 2011. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on the Progress of the Thematic Strategy on the Sustainable Use of Natural Resources. SEC(2011) 1068 final. Available at http://ec.europa.eu/environment/resource_efficiency/pdf/sec2011_1068_final.pdf.

[15] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

[16] European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.

[17] European Commission 2011. Resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy. COM(2011) 21, see http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf.

[18] Therefore, they call for the development of indicators to measure progress towards resource efficiency – to this end, an EU FP7 call for tender has been issued in 2011.

[19] BIOIS, IFF and VITO 2011. Analysis of the key contributions to resource efficiency. Final Report, March 2011. Available at http://ec.europa.eu/environment/natres/pdf/Resource_Efficiency_Final.pdf.

2 Methodological framework

2.1 Selecting the organizing framework

The organizing framework to be selected will help structure the analysis and ensure that the ecological, economic, and social dimensions are integrated. Thus, the framework is selected to enable this study to investigate indicators for sustainable industries and sustainable industrial development. Two approaches, Life Cycle Assessment (LCA) and Material Flow Analysis (MFA), are the primary methodological tools to gather, organize, and analyze information regarding the flow of natural resources through the economy, their use in products and services, as well as the types, amounts, and sinks of by-products such as pollution and waste. We will therefore compare these two approaches with the goal of selecting the more suitable one for measuring resource efficiency and the environmental impact of industries. This chapter is organized as follows: We begin with a description of the two approaches. Then, based on their respective strengths and weaknesses, we will select an approach to use as the organizing framework in this study.

2.1.1 Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA), which is also known under the terms Life Cycle Analysis, Eco-balance, and cradle-to-grave or cradle-to-cradle analysis, is a suite of methods designed to assess the environmental impacts resulting from a product's entire lifetime (or specified portion thereof).[20] This includes the impacts originating from the sources of the raw materials (e.g., mining, catching, harvesting), material processing (e.g., refining, separation, smelting), the manufacturing process (e.g., assembly, welding), distribution (e.g., transportation and storage), use, and finally either disposal or recycling and reuse.

LCA is an important tool for product management because it expands the narrow focus of a product's impacts resulting from its use (e.g., CO_2 emissions of operating an airplane) to the full set of emissions, pollution, resource use, and waste generated to make, use, and dispose of the product.[21]

The information needed to conduct LCAs is substantial. It includes compiling inventories of relevant energy and materials as well as pollutants, toxics, and other substances released at each step of the LCA chain and then evaluating their potential impacts with respect to environmental characteristics such as air and water quality, climate, habitat, biodiversity, etc. But it is precisely this level of detail and comprehensiveness that makes LCA such a powerful technique for evaluating products and allowing manufacturers, users, and others concerned with environmental impacts make more informed decisions.

LCA is not limited strictly to individual products. In fact, conducting LCA on all existing and newly created products would be infeasible, not the least because of the accelerating

[20] Hendrickson, C. T., Lave, L. B., and Matthews, H. S. (2005). Environmental Life Cycle Assessment of Goods and Services: An Input–Output Approach, Resources for the Future Press.
[21] ibid.

innovation cycle, which makes it more difficult to use data that are only a few years old for analyzing today's production environment. Therefore, LCA has been expanded to be useful for evaluating product categories (e.g., passenger cars) as well as services (e.g., banking) and industries (e.g., the cement industry). Nonetheless, the full advantage of LCA is only then harnessed when the data are (a) accurate, (b) complete, and (c) comparable. Basing decisions on LCAs that differ in these aspects is unreasonable and may have led to poor decision making in the past.

LCA in Environmental Management:

Several LCA methods have been officially accredited as part of the ISO 14000 environmental management standards, specifically, ISO 14040 (2006) and 14044 (2006), which replaced the earlier versions of ISO 14041 to ISO 14043.[22] This means that LCA has gained a widely accepted basis for theoretical and practical soundness and applicability and that environmental planning and management decisions can be made using standardized and hence legitimate procedures.

The LCA Process:[23]

LCA generally consists of four distinct but interdependent phases.

1. Goal and Scope Definition
2. Inventory Preparation and Analysis
3. Impact Assessment
4. Interpretation of the Results

While parts 1-3 are conducted sequentially, the fourth part is connected to and feeds back into all of them. An illustration of the steps is shown in Figure 1.

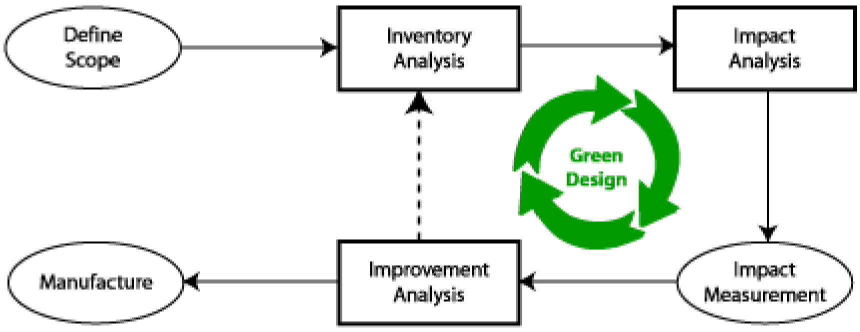

Figure 1: LCA phases (Source: Graedel and Alleby, 1995[24])

There are a number of variants of the conventional LCA methodology that have been developed to serve specific needs and purposes.[25] Three examples are energy LCA, cradle-to-gate LCA, and economic input-output LCA. Energy LCA is focused entirely on tracking

[22] ISO 14044 (2006): Environmental management – Life cycle assessment – Requirements and guidelines, International Organisation for Standardisation (ISO), Geneva.
[23] Hendrickson, C. T., Lave, L. B., and Matthews, H. S. (2005). Environmental Life Cycle Assessment of Goods and Services: An Input–Output Approach, Resources for the Future Press.
[24] Graedel TE, Allenby BR (1995). Industrial Ecology. AT&T: New Jersey.ISBN-10: 0131252380
[25] US EPA (2011). Life Cycle Assessment. http://www.epa.gov/nrmrl/lcaccess/

and analyzing the amount and types of energy used in the life cycle of products or services. Cradle-to-gate LCA, on the other hand, comprehensively identifies the types of impacts considered but is limited to assessing environmental impacts resulting up until the product leaves the factory. This is useful for preparing production—not use or disposal—information that can be published in Environmental Product Declarations. Economic input-output LCA uses accounting principles to translate physical flows of materials, pollution, and waste into monetary accounts. It generally uses aggregate sector-level data to determine the environmental impact attributable to different sectors of the economy and how much each sector purchases from others. These examples demonstrate that LCA is a flexible tool that can be adapted to a broad range of user needs.

Strengths

LCA has a number of advantages that have contributed to making it one of the most widely used assessment tools for gauging the environmental impacts of products, services, and industries.

First of all, LCA is an internally consistent and comprehensive assessment framework that allows a robust assessment of all the environmental impacts caused by a production process. It can give very detailed information on the (environmental or monetary) value of material, emissions, and waste flows that in turn can feed into environmental management decisions to improve resource efficiency or accomplish other goals (e.g., climate change mitigation).

At the same time, the diversity of methods that have been developed to date under the umbrella of the LCA framework provide substantial flexibility and offer tailored methods for a broad range of applications. These range from sector or product-cycle-specific LCAs to monetary and ecological LCAs.

As a result, LCA methods are able to guide policy decisions by using consistent, fact-based information that can help improve the environmental performance of specific products, services, and industries or simply by allowing a complete comparison of products with respect to their total environmental impacts.

Using LCA as the guiding and organizing framework for industrial data can yield effective indicators for monitoring, setting targets and benchmarks, and comparing products and sectors.

Furthermore, the development of LCA is ongoing. Social LCA, for example, is a relatively new expansion of the traditionally environmental focus of LCA. Consideration of the social impacts of resource extraction, production, use, and disposal are, however, becoming increasingly important and social LCA can inform stakeholders on issues relating to social and environmental justice.

Criticism

Aside from the above favorable properties, LCA has also had a number of critiques leveled against it.

It is a very data-intensive framework, and, although the amount and types of data collected can be tailored to the purpose of the study, it requires a comparatively large amount of human and financial resources because LCA is typically not part of routine data collection activities in the corporate and public sectors. Most businesses will know what and how many inputs are needed and where they come from, but generally less is known about the environmentally relevant by-products generated during the production process and even less is known about the environmental impacts involved in using the product or service. Waste management, reuse, and recycling statistics are notoriously difficult to obtain. This means that LCA often has to rely on assumptions, industry or product averages, conversion and equivalency values to fill data gaps. Some of these assumptions are unavoidably subjective in nature, which may undermine the objectivity of the LCA results.

The lack of readily available, routinely collected data is related to another potential shortcoming of LCA, namely its timeliness and utility to draw comparisons across products and/or over time. Assessing two or more products with respect to their environmental impacts can only be done justly if data quality, completeness, and timeliness are comparable. In addition, differences in individual, regional, and national business processes, including climatic and other contextual aspects mean that LCA-based comparisons may be limited. LCAs for products made in highly dynamic sectors may be outdated before the LCA is completed. All of these challenges can be addressed in some form or another, but they must be made transparent, and, when warranted, LCAs should be subjected to a sensitivity analysis.

To reap the most from an LCA, the data and results should also not be boiled down to a single number representing the total environmental impact as may be tempting to do. Instead, the power of LCA is derived from its level of detail and systematic, process-oriented information.

2.1.2 Material Flow Analysis (MFA)

Material Flow Analysis presumes to measure the material flows in an economic region, a factory, a production process, or an industry on the basis of mass balances. By measuring the economic processes and the associated material flows, Material Flow Indicators can, for example, provide information on how much wood is used within an industry or a region. The central assumption of the analysis is the mass balance approach. Material Flow Indicators show that materials often are used several times over (for example, wood can first be used in a furniture plant and then the waste wood in a power plant). Another example of a production process without losses could be the use of water to wash paper and then to cool or heat the plant. The mass balance of an industry therefore does show how much of the wood is used “for the last time” in an industry and thus withheld from further use in the value chain. Figure 2 shows a schematic economy-wide MFA.

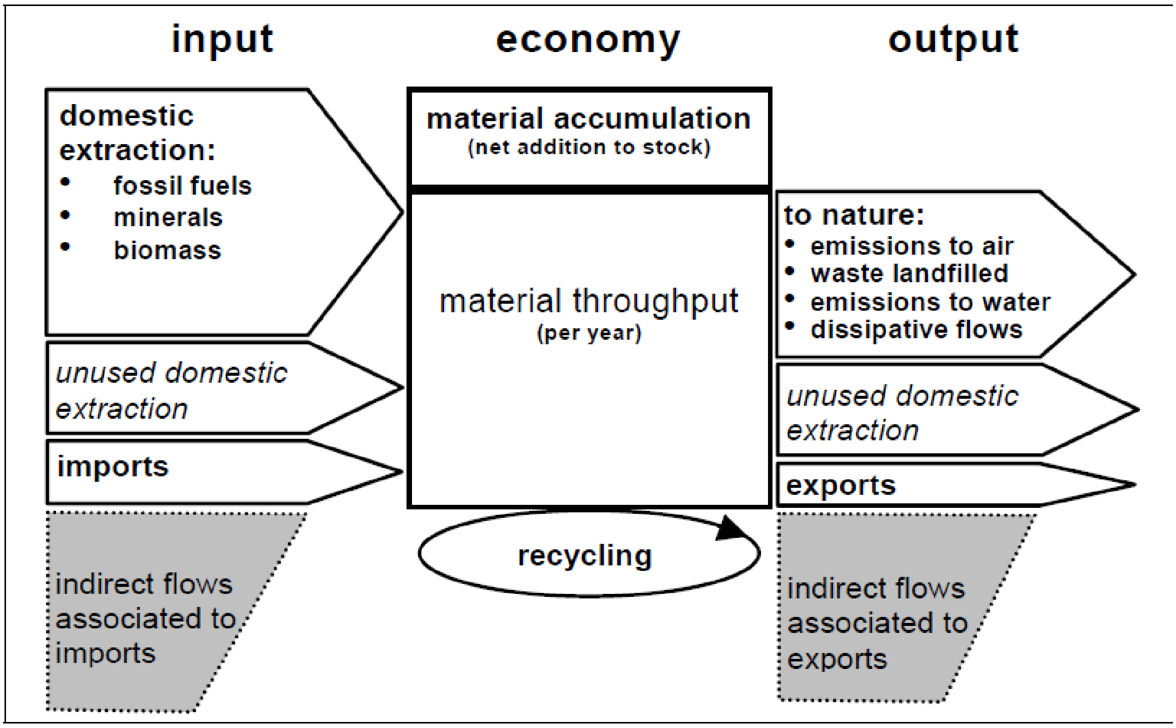

Figure 2: Economy-wide MFA scheme, excluding air and water

Source: Eurostat 2001[26], p. 16

The most used indicator created with this methodology is the Domestic Material Consumption Indicator. Domestic Material Consumption measures the overall use of material in an economy and aggregates the different materials used ton by ton. The definition of the material use is thereby based on the material balance definition used above.

Strengths

A substantial strength of Material Flow Analysis and indicators developed on this basis is that the indicators can give a very good overview as well as detailed information on what kinds of materials and how much of them pass through an economy or an industry. A detailed MFA can be used to identify the major users of a certain material or resource (including energy), where most of it is stored or discarded, and where the largest environmental impacts can be expected as a result.

In addition, the requirement to clearly identify the boundaries of the system being analyzed ensures that the analysis can be extended in a modular fashion. This is particularly useful when the initial data basis is weak. For example, an initial MFA could cover the copper flow by main use, i.e., the electrical industry, construction, and transport, which together account for 97% of copper use in industrialized countries[27] and for which relatively good data tend to

[26] Eurostat 2001. Economy-wide material flow accounts and derived indicators. A methodological guide. European Communities, Luxembourg. Available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF

[27] http://www.copperinfo.co.uk/applications.shtml (accessed 29 November 2011)

be available. This can then be expanded over time to cover the remaining users as well as other countries or regions.

The ability of MFA to generate information and indicators at various levels of aggregation, from detailed material- and industry-level information to a national DMC is advantageous for policy making and planning. It provides important information for the development of policy options, targets, interventions, and other policy recommendations. Material can be traced in the economic cycle and with that it is possible to target with policy measures the processes where the most improvements in absolute as well as cost-standardized terms can be identified.

Criticism

On the other hand, the biggest weakness of indicators based on material flow is that they cannot describe the relative importance of savings in material flows. Resource efficiency is an objective that is not pursued for its own sake but rather in order to diminish the negative environmental, economic, and social impacts caused by that resource use. This environmental (or social) damage is not strictly related to the mass extracted or used. For some materials (for example, sand) the environmental damage per ton might be relatively small, while for others it is far more significant. This means that any aggregated material flow indicators will always focus the attention of policy makers on relatively low value but heavy materials such as building materials which may not be appropriate in reflecting the relative environmental damage that the extraction and use of these materials may cause. Although this challenge only applies for aggregated indicators, it is important for all resource efficiency questions because very often the use of one resource is reduced by increased use of another resource, and only disaggregated indicators can highlight such developments.

Another reason for improving resource efficiency is the scarcity of resources, which also differs from material to material. Again, a ton-by-ton aggregation of resources does not take account of those differences. This factor is especially important for renewable resources as material consumption within the boundaries set by the carrying capacity has no scarcity implication at all. One of the arguably most important resources, water, is therefore omitted from most aggregate indicators as its use figures would overshadow any other resource use.

This means that a focusing and targeting of policies on the basis of Material Flow indicators will not necessarily lead to a sustainable use as sustainable resource use has to take account of the environmental damage it causes and potential availability limits for future generations.

2.1.3 Organizing framework selected for this study

The previous sections described the two main approaches, LCA and MFA, that are used to measure and characterize the environmental impacts and resource use intensities of industry and therefore the 'greenness' of industrial sectors and product streams. For the present study, a single organizing framework will be selected that will inform the selection of indicators to be used to measure these impacts and resource efficiencies. Table 1 below contrasts the strengths and weaknesses of LCA and MFA. Using a simple scoring mechanism that tallies the pros and cons on a point-by-point basis, we determined that LCA is more suited to achieve the objectives of this study. This does not preclude the fact that some of the indicators that will be recommended by the study also have a foundation in a MFA framework or that MFA is the framework of choice for future indicator developments and uses.

Table 1: Comparison of LCA and MFA according to their strengths and weaknesses

Characteristics	Strength (++, +) / Weakness (-, --)	
	LCA	MFA
Measures the environmental impact of product(s), service(s), industry	++	-
Flexible and adaptable to specific impact areas and/or steps in the life cycle chain	+	+
Internally consistent	++	++
Provides information on resource scarcity	+	-
Data readily and routinely available	--	--
Small amounts of data required	--	--
No or only negligible assumptions needed	--*	--*
No testing of robustness or sensitivity needed	--	--
Ties to economic analysis using input-output accounting principles	++	+
Can be used to set useful policy or management targets, benchmarks and to monitor progress	++	+
Supported by ISO standards	++	-
Can be used to calculate highly aggregated indicators of resource efficiency or environmental impacts	-	+

Note: ++ means that the characteristic is strongly supported by the approach, + means that it is supported, - means that it is not recommended and -- means that it is not supported* means it depends on the material and/or product.

Contrasting LCA and MFA reveals a major difference in the coverage of the two frameworks, with LCA allowing for a consideration of environmental impacts associated with the different stages of resource use. Thus, choosing LCA as an organizing framework for this study enables a more relevant perspective by fostering the inclusion of the ecological dimension. While resource efficiency decoupled from the environmental consequences of resource use is an important aspect in its own right—most resources are finite after all—viewing efficiency only from a mass perspective is incomplete and, worse, can be misleading. Thus, using a framework such as LCA appears crucial in order to investigate indicators for sustainable industries and sustainable industrial development.

Therefore, whether or not an indicator is able to measure different aspects of the life cycle chain and the associated environmental impacts is one important criterion for indicator selection but not the only one. The following section therefore deals with the criteria applied for selecting indicators for analysis.

2.2 List of criteria for indicator selection

In order to identify indicators that are promising for this study, existing resource indicators will be measured against a set of criteria. This set builds upon criteria developed in prior research projects[28] as well as upon the existing EEA framework[29] and the RACER framework.[30] Accordingly, criteria with relevance for the selection of resource indicators to be analyzed should include:

Table 2: Initial list of criteria relevant for selecting resource indicators

Criterion	Question to be answered by the criterion
LCA compatibility	Is the indicator able to measure different life cycle stages? What aspects of the LCA chain does the indicator measure?
Coverage of industries and industrial development	Is the indicator product-specific, or can it capture the performance of specific industries sectors, and industrial development?
Sustainability impacts coverage	Is the indicator able to measure environmental, economic, or social impacts?
Required data efforts	How much data is required to establish the indicator? How much effort is needed to collect, prepare, and use the data?
Data availability	Is the data required for the indicator readily available? At which level (global, per country, etc.) and at which time intervals (routinely, as necessary, etc.) is it collected?
Consistency	Does the indicator actually measure what it is intended to measure?
Avoiding double-counting	Does the indicator preclude double-counting of resource use?
Compatibility	Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?

[28] Giljum, S. et al. 2011. A comprehensive set of resource use indicators from the micro to the macro level. Resources, Conservation and Recycling 55 (3): 300 – 308; Grünig, M. et al. 2011. Plakative und schnelle Umweltinformation mittels hochaggregierter Kenngrößen zur nachhaltigen Entwicklung. UFOPLAN 3710 12 160. German Federal Environment Agency, Dessau.

[29] http://projects.cba.muni.cz/indikatory/documents/metodiky/metodika_EEA.pdf (accessed 26 November 2011)

[30] The RACER methodology was recommended by the European Commission in its publication "Impact assessment guidelines." SEC2005 (791), available at http://www.mfcr.cz/cps/rde/xbcr/mfcr/SEC_2005_791_Impact_Assessment_Guidelines_2006update.pdf. RACER is a generic evaluation framework applied to assess the value of scientific tools for use in policy making. RACER embraces the five criteria Relevant, Accepted, Credible, Easy to interpret and Robust.

Criterion	Question to be answered by the criterion
Uncertainties and data imputation	How are uncertainties about data reflected in the indicator and how are missing data imputed? What errors of interpretation can be caused by the imputation method? Is the indicator robust against manipulation?
Scientifically verified	Is the methodology for the indicator backed by scientific research and debate? Is it well documented?
Understanding and Acceptance	Is the information directionally safe? Is comprehension of the indicator intuitive? Is the indicator accepted and used by different experts and non experts?
Policy relevance	Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds? Does the indicator measure aspects which can be influenced by policy makers? Does it provide disaggregated information allowing analysis of causal effects? Is it available to policy makers in short time frames?
Communication	Can the indicator be visually illustrated?

3 Methodological framework for indicator review

This task deals with the systematic evaluation of existing resource indicators with respect to the objectives of the study, i.e., their utility for assessing the performance of industry and industrial development in becoming more sustainable in terms of resource use and associated environmental impacts.

To do so, each criterion is evaluated qualitatively by assessing whether different aspects are matched (☺), partially matched (😐), or not matched (☹), based on existing literature. These are summed up qualitatively by assigning an overall score per criterion. To this end, a template for an evaluation factsheet was developed and applied to evaluating the resource indicators specified above (see Table 3). Given that data availability also largely determines how effective an indicator can be, an entire chapter is dedicated to analyzing this criterion (see Task 3). Therefore, in order to avoid redundancies, data availability is not evaluated in the factsheets.

Resource Indicator:
Brief description:
Source/reference(s):

Table 3: Template for the evaluation factsheet for the existing resource indicators

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)***
LCA compatibility	*Is the indicator able to measure different life cycle stages? What aspects of the LCA chain does the indicator measure?*	
Coverage of industries and industrial development	*Is the indicator product-specific, or can it capture the performance of specific industries, sectors, and industrial development?*	
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic, or social impacts?*	
Required data efforts	*How much data is required to establish the indicator? How much effort is needed to collect, prepare and use the data?*	
Consistency	*Does the indicator actually measure what it is intended to measure?*	
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?*	
Compatibility	*Is the indicator derivable from existing measurement frameworks such as the System of Environmental-Economic Accounts (SEEA) or the Dutch National Accounting Matrix including Environmental Accounts (NAMEA)?*	
Uncertainties and data imputation	*How are uncertainties about data reflected in the indicator and how are missing data imputed? What errors of interpretation can be caused by the imputation method? Is the indicator robust against manipulation?*	
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?*	
Understanding and Acceptance	*Is the information directionally safe? Is comprehension of the indicator intuitive? Is the indicator accepted and used by different experts and non experts?*	
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds? Does the indicator measure aspects which can be influenced by policy makers? Does it provide disaggregated information allowing the analysis of causal effects? Is it available to policy makers in short time frames?*	
Communication	*Can the indicator be visually illustrated?*	

* ☹ not matching the criterion   😐 partially matching the criterion   ☺ matching the criterion

3.1 Selection of indicator for further analysis

Evaluating the criteria for all indicators proposed above, the factsheets are then used for ranking the indicators to identify the 10 most promising indicators for further analysis. Since not all criteria are equally relevant in the context of this study's objectives, the following five criteria are considered as equally weighted core criteria for guiding the indicator selection:

- LCA compatibility
- Coverage of industries and industrial development
- Sustainability impacts coverage
- Required data efforts
- Policy relevance

Table 4 shows the template for ranking of the indicators.

Table 4: Template for ranking of the resource indicators reviewed

Indicator	LCA compatibility	Coverage of industries and industrial development	Sustainability impacts coverage	Required data efforts	Policy Relevance	Relevance*	Ranking
…	☺ / 😐 / ☹	☺ / 😐 / ☹	☺ / 😐 / ☹	☺ / 😐 / ☹	☺ / 😐 / ☹	very high to very low	1 to 10

☹ not matching the criterion 😐 partially matching the criterion ☺ matching the criterion

* The scale for relevance ranges is in decreasing order: very high, high, medium, low, very low. The relevance is arrived at by the following matrix:

Relevance =	**the following combination of evaluations**
very high =	☺☺☺☺☺ ☺☺☺☺ + ☹ / 😐
high =	☺☺☺ + 2😐 ☺☺☺ + 😐 + ☹
medium =	☺☺☺ + 2 ☹ ☺☺ + 3😐 / 2😐 + ☹
low =	☺☺ + 😐 + 2☹ ☺ + 2😐 + 2☹
very low =	☹☹☹ + every combination of ☺ and 😐

The ten indicators with the highest qualitative overall score on these core criteria will then be pursued for further analysis: investigating data availability in Task 3, as well as discussing and deriving recommendations in Task 4.

The filled-in factsheets for the top ten indicators are provided under (6.1), while the remaining ones are provided in the Annex.

3.2 Evaluation of data availability

In order to assess the availability of the required data for the selected indicators, the following evaluation template is used for each of the ten indicators.

Table 5: Data availability of the indicators reviewed

Indicator:	**Evaluation: ☺ / 😐 / ☹***
Data Requirements:	
Relevant Databases:	
Data Availability:	
Data sets available:	
Level of data:	
Time period:	

* ☺ good data availability   😐 medium data availability   ☹ weak data availability

4 Review of existing relevant resource indicators

We focused on key existing indicators measuring resource use, environmental impacts and progress achieved in green industries. The following list originates from previous project experiences at Ecologic Institute[31] and an additional literature search on the World Wide Web through Google scholar (http://scholar.google.com) using as key words, in combination, the terms *indicator, resource, efficiency, industry, sustainability*. An article was considered promising based on its link to the study's objectives, the title, and the summary or abstract. We also checked the references cited in each article to identify additional relevant material. The final list of indicators that were reviewed is:

- Energy
    - Energy intensity by sector,
    - Energy productivity,
    - Share of renewables in total primary energy supply (TPES),
    - Share of renewable power in total electricity
    - Share of renewable power in total final energy consumption,
    - Generation capacity for renewable power generation,

[31] The following projects may serve as examples: Environmental Pressure index (http://ecologic.eu/4202), Potential of the Ecological Footprint for monitoring environmental impact from natural resource use (http://ecologic.eu/2367), Indicator-based environmental reporting (http://ecologic.eu/3862), Establishing thresholds for environmental sustainability and a related set of indicators (http://ecologic.eu/3604), One Planet Economy Network: Europe (OPEN: EU) (http://ecologic.eu/3380).

    - Production based CO_2 productivity (GDP per unit of energy-related CO_2 emitted),
- Employment
    - Employment in environmental goods and services sector,
    - Employment in the renewable energy sector,
- Business performance
    - Corporations' turnover, value added and exports of the environmental goods and services sector,
    - Eco-labels on products and services (EU eco-label), and
    - Number of companies using EMAS or other environmental management schemes (e.g., ISO 14000 and 14001),
    - Investment in Research & Development
- Water
    - Water consumption by sector,
    - Industry water productivity by sector,
    - Water abstraction rates and water stress
- Material use
    - Total Material Consumption (TMC)
    - Total Material Requirements (TMR)
    - Resource Productivity / Material Productivity,
    - Material Intensity of the Economy,
    - Domestic Material Consumption (DMC),
    - Direct Material Input (DMI)
    - Domestic Extraction Used (DEU),
    - Environmentally weighted material consumption (EMC)
- Ecological Footprint,
- Sustainable Process Index,
- Multifactor productivity,
- Mining and Minerals Extraction
    - Available (global) stocks or reserves of selected minerals
- Fisheries
    - Proportion of fish stocks within safe biological limits (global)
- Forestry
    - Area of forest and wooded land,
    - Volume of forest resource stocks
- Agriculture
    - Share of agricultural area occupied by organic farming.

4.1 Selection of indicators for further analysis

Table 6 on the following page provides a preliminary ranking of the indicators identified above according to the five core criteria specified in 3 Methodological framework for indicator review. The ten most promising indicators according to this ranking will be presented in factsheets under 4.2 The remaining indicators are provided in the Annex.

Table 6: Preliminary ranking of indicators according to core criteria to pursue for further analysis

Indicator	LCA compatibility	Coverage of industries and industrial development	Sustainability impacts coverage	Required data efforts	Policy Relevance	Relevance*	Ranking
Environmentally weighted material consumption	☺	☺	☺	😐	☺	very high	1
Energy intensity by sector	😐	☺	☺	☺	☺	very high	2
Production based CO_2 productivity	😐	☺	☺	☺	☺	very high	3
Water consumption by sector	☺	☺	☹	😐	☺	high	4
Sustainable Process Index	☺	☺	😐	☹	☺	high	5
Water abstraction rates and water stress	☹	😐	☺	☺	☺	high	6
Corporations' turnover, value added and exports of the environmental goods and services sector	☹	☺	☺	😐	☺	high	7
Resource Productivity / Material Productivity	😐	☺	☹	😐	☺	medium	8
Total Material Consumption	😐	☺	😐	☹	☺	medium	9
Ecological Footprint	☹	☺	😐	☺	😐	medium	10
Total Material Requirement	😐	☺	😐	☹	☺	medium	
Domestic Material Consumption	☹	☺	☹	☺	☺	medium	
Proportion of fish stocks within safe biological limits (global)	☹	😐	☺	☺	☺	medium	
Share of agricultural area occupied by organic farming	☹	😐	😐	☺	☺	medium	
Energy productivity	😐	😐	☺	☺	😐	medium	
Industry water productivity by sector	☹	☺	😐	☹	☺	low	
Material Intensity of the Economy	😐	☺	☹	☹	☺	low	
Direct Material Input	😐	☺	☹	☹	😐	low	
Domestic Extraction Used	😐	☺	☹	☹	😐	low	
Share of renewables in total primary energy supply	☹	☹	😐	☺	☺	low	
Area of forest and wooded land	☹	😐	☺	😐	☺	low	

Indicator	LCA compatibility	Coverage of industries and industrial development	Sustainability impacts coverage	Required data efforts	Policy Relevance	Relevance*	Ranking
Volume of forest resource stocks	☹	😐	😐	☺	☺	low	
Share of renewable power in total electricity	☹	☹	😐	☺	☺	low	
Share of renewable power in total final energy consumption	☹	☹	😐	☺	☺	low	
Energy productivity	😐	😐	☺	☺	😐	medium	
Multifactor productivity	☹	😐	☹	-	☺	very low	
Number of companies using environmental management schemes	😐	☺	😐	-	☹	very low	
Employment in environmental goods and services sector	☹	☺	😐	😐	😐	very low	
Employment in the renewable energy sector	☹	☺	😐	☹	😐	very low	
Investment in Research & Development	☹	☺	😐	😐	☹	very low	
Available (global) stocks or reserves of selected minerals	☹	☹	😐	😐	-	very low	
Generation capacity for renewable power generation	☹	☹	☹	☺	☺	very low	
Eco-labels on products and services	😐	☹	😐	-	-	very low	

☹ not matching the criterion 😐 partially matching the criterion ☺ matching the criterion - no statement possible according to the literature reviewed

* The scale for relevance ranges is in decreasing order: very high, high, medium, low, very low. The relevance is arrived at by the following matrix:

Relevance =	**the following combination of evaluations**
very high =	☺☺☺☺☺ ☺☺☺☺ + ☹ / 😐
high =	☺☺☺ + 2😐 ☺☺☺ + 😐 + ☹
medium =	☺☺☺ + 2 ☹ ☺☺ + 3😐 / 2😐 + ☹

low = ☺☺ + 😐 + 2☹
☺ + 2😐 + 2☹

very low = ☹☹☹ + every combination of ☺ and 😐

NB: - (no statement possible…) was considered as not matching the criterion ☹ in order to accommodate the worst case.

4.2 Evaluation factsheets for indicators selected for further analysis

Thus, the 10 most promising indicators are:

1. Environmentally weighted material consumption (EWC)
2. Energy intensity by sector
3. Production based CO_2 productivity
4. Water consumption by sector
5. Sustainable Process Index (SPI)
6. Water abstraction rates and water stress
7. Corporations' turnover, value added and exports of the environmental goods and services sector
8. Resource Productivity / Material Productivity
9. Total Material Consumption (TMC)
10. Ecological Footprint (EF)

In the following, the individual evaluation factsheets for these ten indicators are presented.

Table 7: Evaluation factsheet for the indicator: environmentally weighted material consumption

Resource Indicator: Environmentally weighted material consumption (EMC)
Brief description: Environmentally weighted material flow indicators integrate the environmental impacts associated with materials extraction and use into the calculation of the indicator. To this end, EMC combines data from economy-wide material flow accounts such as DMC (based on apparent consumption = domestic production plus import minus exports) with data from LCA by multiplying the mass of selected base materials with the LCA impact coefficients. The impacts relate to the 13 different impact categories of LCA (global warming, stratospheric ozone depletion, acidification, eutrophication, photochemical ozone formation, abiotic resource depletion, human toxicity, aquatic ecotoxicity, terrestrial ecotoxicity, marine ecotoxicity, final soild waste generation, radiation, land competition) and have to be aggregated by weighting to arrive at one score. Therefore, environmental impacts throughout the materials' entire life cycle are taken into consideration.
Source/reference(s): European Commision 2007. Progress report on the European Union Sustainable Development Strategy 2007. Accompanying document to the Communication from the Commission to the Council and the European Parliament. Commission staff working document. SEC(2007) 1416. Brussels, 22.10.2007. Van der Voet, E, van Oers,L., Moll, S., Schütz, H., Bringezu, S., de Bruyn, S., Sevenster, M., Warringa, G. (2005): Policy Review on Decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries. CML report 166, Leiden: Institute of environmental sciences (CML), Leiden: Leiden University, Department Industrial Ecology, 2005 available at http://www.leidenuniv.nl/cml/ssp/projects/dematerialisation/policy_review_on_decoupling.pdf EEA 2010. The European Environment State and Outlook 2010 – Material Resources and Waste, available at http://www.eea.europa.eu/soer/europe/material-resources-and-waste Eurostat 2001. Economy-wide material flow accounts and derived indicators – A methodological guide, available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF JRC and IES 2010. Decoupling indicators, Basket-of-products indicators, Waste management indicators – Framework, methodology, data basis and updating procedures. Draft for public consultation, available at http://lct.jrc.ec.europa.eu/pdf-directory/Indicators-framework-for-public-consultation-16082010.pdf OECD 2008a. Measuring Material Flows and Resource Productivity – Synthesis report, available at http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD 2008b. Measuring Material Flows and Resource Productivity – Volume I. The OECD Guide, available at http://www.oecd.org/dataoecd/46/48/40485853.pdf

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* LCA provides a considerable amount of information for calculating the EMC indicator, which is a highly aggregated composite indicator derived from LCA. EMC is strongly based on LCA impact coefficients, so that for each material looked at a score is obtained on the LCA impact categories, such as global warming, acidification or human toxicity.	☺
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* Since EMC is based on DMC, which is material specific and also linked to semi-manufactured or finished products, but in particular for complex products requires aggregation to material categories, also for EMC this may facilitate generalization to product categories or industry sectors. Furthermore, because the three main categories fossil fuels, minerals and biomass are addressed in DMC, also EMC may be applied to capturing specific industries or sectors within these categories.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* EMC includes the environmental impacts of different base materials according to their respective LCA impacts coefficients for 13 impact categories. The impacts covered encompass, inter alia, - the impacts related to the material itself, - the impacts of auxiliary materials, - the energy used for extracting and producing the material[32] - the emissions of pollutants included in the material released during use or waste treatment. Thus, EMC shows the overall environmental impacts associated with material consumption throughout the materials' entire life cycle regardless of where and when they occur (e.g. on the domestic territory or abroad up- or downstream through imports and exports, now or in future). In order to calculate the EMC, data for the 13 impact categories per unit of material or energy carrier used are first normalized with data on status quo of a reference year on the global level to generate normalized impact coefficients, which are then multiplied with the apparent consumption (e.g. DMC) of the selected materials and energy carriers. In order to arrive at one score across the 13 impact categories, weighting has to be used for aggregation. Thus, on the downside, EMC covers only the environmental impacts of the materials selected and therefore does not capture the impacts of materials not accounted for. In addition, EMC is neither specific for one year nor for country of origin of imports. Furthermore, EMC does not take into account technological development over time, nor establishes a link to	☺

[32] The energy used during consumption is allocated to the product used, since it is very difficult to separate the data for the consumption of different materials of a (complex) product. However, energy used for consumption is reflected in the EMC through the life cycle chain of fossil fuels

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	products as underlying drivers behind the impacts and only covers the use phase via consumption/incineration of fossil fuels. Nonetheless, EMC is considered an important advancement in particular in comparison to DMC and TMC.	
Required data efforts	*Which data is required to establish the indicator?* Data are required on material flows and DMC, as well as LCA data. *How much effort is needed to collect, prepare and use the data?* Because EMC measures the cradle-to-grave impacts, which refer to finished materials, calculating raw materials imported or extracted requires their conversion into finished materials. Though this necessitates additional information about the material composition of products imported or exported and of the associated impacts, the error linked to this conversion is considered to be rather minor. However, for some smaller-scale materials with a potentially very high environmental impact per weight, arriving at credible materials balances is almost impossible (European Commission 2005).	😐
Consistency	*Does the indicator actually measure what it is intended to measure?* Yes, EMC measures the environmental impacts of different materials per tonnage across their entire life cycle.	☺
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* Since the LCA impact factor relates to life cycle chains, double-counting of different materials may occur. For instance, while the cradle-to-grave analysis of a crop accounts both for the impact of the crop harvested and of any fertilizer used for the crop, calculating both separately would lead to double-counting the impacts of the fertilizer. Therefore, double-counting is precluded by excluding materials that are only used for producing other materials already covered by the DMC while including their impacts through LCA.	☺
Uncertainties and data imputation	*How are uncertainties about data reflected in the indicator and how are missing data imputed?* Material flow and DMC data, as well as LCA data carry with them uncertainties. For instance, LCA process data is based on averages for the whole of Western Europe causing neglect of existing differences between countries and rendering efficiency improvements over time which lower material consumption invisible. Furthermore, the quality of the LCA impact assessment data largely differs for the impact categories (e.g. with global warming potentials based on internationally agreed studies, whereas toxicity categories remain very uncertain and depletion of biotic, natural resources such as wood and fish, is not included at all).	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see European Commission 2005)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* EMC is possibly the most relevant highly aggregate composite indicator for assessing the combined environmental impact of industry. EMC is able to measure the environmental impacts of material use from cradle to grave. Thus, EMC is of high	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	value to indicate the progress towards decoupling of economic growth from the use of natural resources and associated environmental impacts. Decoupling is an increasingly import policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These are core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020 Strategy[33] or the Roadmap to a Resource Efficient Europe[34]. EMC is thus considered highly policy relevant both internationally and nationally.	
Communication	*Can the indicator be visually illustrated?* The indicator is frequently is visually illustrated, for instance by the European Topic Centre for Sustainable Consumption and Production (see http://scp.eionet.europa.eu/themes/resource_use).	☺

[33] European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.
[34] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Table 8: Evaluation factsheet for the indicator: energy intensity by sector

Resource Indicator: Energy intensity by sector
Brief description: Energy intensity is the energy used per unit of value added, or the inverse of energy productivity, and is a relatively common indicator used to measure resource efficiency and sustainability. In the context of the recent OECD (2011) report monitoring progress toward green growth, energy intensity by end-use or sector is calculated differently for each sector: manufacturing (megajoule (MJ) per USD of value added), passenger transport (MJ per passenger-km), and freight transport (MJ per tonne-km). Under the theme “Socioeconomic Development”, Eurostat includes energy intensity as a key measure of progress and innovation, eco-competitiveness and eco-efficiency. Eurostat measures energy intensity as the ratio between the Gross Inland Consumption of Energy (coal, electricity, oil, natural gas and renewable energy sources – available for consumption) and GDP calculated for a calendar year and expressed in Millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)[35]. Increasing energy intensity by sector may indicate efforts to improve energy efficiency and to reduce greenhouse gases (GHGs) and other harmful emissions. This in turn is a key factor in improving environmental performance and ensuring sustainable development. However, these indicators also reflect structural and climatic factors; thus, they cannot be used as a standalone measure of the efficiency of energy use in a country or industry. Other significant factors include the structure of the economy; the size of the country; and the climate[36].
Source/reference(s): OECD 2011a. Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing. http://dx.doi.org/10.1787/9789264111356-en Eurostat 2009. Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg Eurostat 2010. Eurostat quality profile on the energy intensity of the economy. Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/files/Energy%20intensity%20of%20the%20economy).pdf

[35] Eurostat 2010
[36] OECD 2011

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Although the typical usage of this indicator does not reflect different life cycle stages, it is theoretically LCA compatible. *What aspects of the LCA chain does the indicator measure?* By incorporating different life cycle stages into the energy input for intensity, this indicator could theoretically reflect all life cycle stages. Related LCA methods: energy LCA by product, firm or sector using energy input-output tables and coupled with cost and production volume data to obtain intensity ratios. The indicator can be used to estimate GHG emissions. It is possible to distinguish by energy type and quality (coal, oil, thermal energy content or exergy). However, the indicator – as used in current sustainability indicator sets – does not incorporate life cycle stages, and this would require significant additional effort from the perspective of data collection, preparation and use.	😐
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* It could be product specific (i.e., the amount of energy used to produce inputs, transportation energy, direct manufacturing of the product, disposal, etc.) or could be calculated for different sectors, as demonstrated by the OECD (2011).	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* This indicator does not directly measure environmental and social impacts, but it does provide a direct measure of economic impacts. There are obvious economic benefits to using less energy to derive a unit of revenue, which encourages economic growth and can in turn have positive second order effects on society. On the other hand, environmental impacts are not measured relative to GDP and so the development of the indicator can mask increasing environmental impacts. Improving energy intensity can enhance environmental performance in a number of ways, including lowering GHG and other emissions. However, in order to fully understand and quantify the environmental benefits, this indicator must be used in conjunction with a measure of the energy mix (i.e., the share of renewable energy versus fossil resources, etc.).	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
Required data efforts	*Which data is required to establish the indicator?* Energy consumption by sector, revenue by sector, total energy supply/consumption (gross inland energy consumption or TPES), and GDP. *How much effort is needed to collect, prepare and use the data?* At the national or sectoral level, this data is relatively easy to obtain. However, at the product level or with the inclusion of more life cycle stages, the effort required to collect the data would be significant.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Energy is the vital input to all of human activity and the primary anthropogenic driver of climate change. Therefore, reducing energy consumption and switching to renewable, climate neutral energy sources are two key components for greening industry. Energy intensity of the economy is a key indicator for measuring the Lisbon Process and its successor Europe 2020. Other relevant European legislation includes Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on Energy Statistics; Regulation No 1392/2007 of the European Parliament and of the Council of 13 November 2007 amending Council Regulation (EC) No 2223/96 with respect to the transmission of national accounts data"[37]. Other relevant agreements and initiatives include the Kyoto protocol (Article 2); the Barcelona European Council (2002); and the Brussels European Council (2003)[38]. *Does the indicator measure aspects which can be influenced by policy makers?* Yes. *Does it provide disaggregated information allowing to analyze causal effects?* No *Is it available to policy makers in short time frames?* Yes	☺
Communication	*Can the indicator be visually illustrated?* Visual depictions of the indicator are available in the OECD (2011) report monitoring progress toward greening, as well as Eurostat's report (2009) monitoring the EU sustainable development strategy.	☺

[37] Eurostat 2011
[38] Eurostat 2010

Table 9: Evaluation factsheet for the indicator: production-based CO_2 productivity

Resource Indicator: Production-based CO_2 Productivity
Brief description: This indicator provides information about the relative decoupling between domestic production and carbon inputs. It can also provide information about other environmental issues such as the emissions of greenhouse gases and air pollution that are correlated with the carbon intensity of economic production. The indicator is calculated as GDP generated per unit of energy-related CO_2 emitted.
Source/reference(s): OECD 2011a. Towards Green Growth: Monitoring Progress – OECD Indicators. Available at http://www.oecd.org/document/56/0,3746,en_2649_37465_48033720_1_1_1_37465,00.html

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Energy LCA could be combined with monetary data on value added or contribution to GDP.	😐
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* Yes, it can measure their performance over time in reducing emissions emitted from energy use in production.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The indicator can measure the environmental impact of energy-related CO_2 emissions, assuming that these are a main cause of climate change and related impacts. In order to provide an overall picture this indicator should be read in connection with other indicators, in particular, energy intensity and efficiency, use of renewable energy, energy prices and taxes, and carbon pricing. The indicator does not directly measure the impact of CO_2 emissions on the economy, but it does provide information on the extent to which economic growth and CO_2 emissions are interlinked. The indicator does not directly measure social impacts.	☺
Required data efforts	*Which data is required to establish the indicator?* GHG emissions at the national level and by sector, energy use, and GDP growth. *How much effort is needed to collect, prepare and use the data?* Small effort, because data on GHG emissions are reported to the Secretariat of the UNFCC using 1990 as the base year. There has been good progress on developing national GHG inventories.	☺
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* Comprehension of the indicator is not intuitive, but neither is it very difficult to understand, especially when graphically	☺

Criteria	Qualitative assessment: Question(s) to be answered by the criterion	Qualitative assessment: score for criterion match (☺/😐/☹)
	represented. Some prior knowledge of productivity and decoupling emissions from GDP growth is assumed. *Is the indicator accepted and used by different experts and non experts?* The indicator is mostly used by policy makers, policy analysts and economists to measure progress towards CO_2 reduction targets and to shape strategies accordingly. Similarly, industry experts use the indicator to measure their own performance in achieving said goals.	
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The indicator can be used to measure progress on decoupling CO_2 emissions from GDP growth. It is also helpful in comparing CO_2 emissions from energy used across individual sectors, countries and regions. Moreover, this indicator measures progress towards national or international commitments to reduce GHG emissions. *Does the indicator measure aspects which can be influenced by policy makers?* Yes, as it can measure progress towards stabilizing the concentration of GHGs in the atmosphere. This goal can only be achieved globally by developing national and international policy strategies to further decouple CO_2 from economic growth.	☺

Table 10: Evaluation factsheet for the indicator: water consumption by sector

Resource Indicator: Water consumption by sector
Brief description: Water consumption per sector is defined as the annual water consumption for domestic use, industrial use, agricultural use and other sectors expressed in cubic meters per year or as a percentage of total water consumption. These indicators can be used for water resources management by identifying crucial sectors of consumption in which specific future plans have to be developed. Usually, the heaviest water uses are domestic, industrial, and agriculture in ascending order. The amount of water consumption in the agricultural sector is a crucial factor for desertification vulnerability of areas facing water scarcity problems. The calculation of the percentage for each sector has been defined by dividing the consumption of each sector by the total water consumption.
Source/reference(s): UNSTATS 2011a. Millennium Development Goals Indicators, available at http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=768, accessed 5th December 2011 UNWATER 2009. Water in a changing world. The United Nations World Water Development Report 3, available at http://unesdoc.unesco.org/images/0018/001819/181993e.pdf#page=324, accessed 5th December 2011

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* LCA for products, services and sectors can measure the consumption of water at various steps in the extraction-production-disposal chain.	☺
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* The indicator measures the performance of specific sectors in terms of water consumption.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The indicator does not measure impacts, but only pressures (water abstraction). Pressures can be linked to impacts. As the indicator does not match abstraction with availability, there is no indication as to water scarcity at all. Therefore, more information would be necessary in order to evaluate whether the water consumption measured is sustainable and whether it fosters sustainable development.	☹

Criteria	Qualitative assessment: Question(s) to be answered by the criterion	Qualitative assessment: score for criterion match (☺/😐/☹)
Required data efforts	*Which data is required to establish the indicator?* Water withdrawal by major sector (agriculture, industry and domestic), as well as total water withdrawal. *How much effort is needed to collect, prepare and use the data?* Countries with environmental accounts usually have the information required available and it does not need much effort to calculate the indicator. However, this also depends on the willingness of the different sectors to monitor and provide data on their water use. Low willingness among many industries to do so is often reported.	😐
Consistency	*Does the indicator actually measure what it is intended to measure?* The indicator does measure water consumption, although there is the differentiation between withdrawal and consumption.	☺
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* Because it measures withdrawal and not consumption, double counting is avoided.	☺
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* The indicator is easy to understand. *Is the indicator accepted and used by different experts and non experts?* The indicator is used by a wide range of experts.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Freshwater is a critical resource for life and our economic system and is becoming increasingly scarce in many parts of the world. Increasing industrial water efficiency is an important contributor to managing this resource within its replenishment rates. The indicator thus helps highlighting the importance of a sector in the total demand for water. This in turn provides an indication of how vulnerable the sector—and the economy—will be in case of decreasing water supplies. It is also a useful tool for policy makers to evaluate productivity and behavior in water consumption by key sectors over time. *Does the indicator measure aspects which can be influenced by policy makers?* This indicator informs policy to the extent that policy makers can influence how much water different sectors may consume. As an information tool, it is also useful to show which sectors are consuming the most water, especially in water scarce areas where plans need to be developed to improve access to water. Such information is particularly useful for policy makers who set the price structure of water. *Does it provide disaggregated information allowing to analyze causal effects?* Not for Water use by major sector, but for SEEAW Standard physical supply and use tables for water. *Is it available to policy makers in short time frames?* No, timeframe for AQUASTAT is approximately 10 years at the moment.	☺
Communication	*Can the indicator be visually illustrated?* Water consumption by sector can be visually represented with the use of bar graphs or pie charts.	☺

Table 11: Evaluation factsheet for the Sustainable Process Index

Resource Indicator: Sustainable Process Index (SPI)
Brief description: The Sustainable Process Index (SPI) was developed by Christian Krotscheck and Michael Narodoslawsky in 1995. It is based on the assumption that a sustainable economy is completely comprised of "solar exergy"—that is, all natural and anthropogenic activities compete for surface area to utilize the limited supply of solar energy that they need for sustaining themselves. The SPI therefore calculates which surface area, a limited resource, is needed for the conversion of energy into products and services. Accordingly, the foundation of the SPI is surface area: the more area needed to convert a process into a service, the more it "costs" in terms of sustainability. More specifically, the SPI measures the fraction of the area per inhabitant related to the delivery of a certain product or service unit. In this sense, it is a type of "ecological footprint" indicator.
Source/reference(s): Krotscheck, C. and Narodoslawsky, M. (1996): "The Sustainable Process Index – A new dimension in ecological evaluation," Institute of Chemical Engineering, Graz University of Technology, Austria. Available at http://spionexcel.tugraz.at/index.php?option=com_content&task=view&id=14&Itemid=28

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* SPI is used to measure the environmental impacts within LCA, therefore it is compatible with LCA. It is similar to the Ecological Footprint in its use of area as the metric to calculate resource use in, but the SPI is better suited at covering life cycle stages because it looks at processes and not end-user consumption.	☺
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* It can be used at different levels: process, product, and even at the regional level. It can also compare widely different technologies. The indicator does capture different sectors' performance in terms of the land used in a process and makes different technologies comparable. It can provide a basis for different industries to seek more sustainable methods, which would be measured by a reduction in land used in a process compared to current use.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* The indicator measures environmental and economic pressures of processes in terms of land use. The social impacts of said land use are not self-evident and more information would be required to draw conclusions.	😐

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
Required data efforts	*Which data is required to establish the indicator?* Renewable raw material area, non-renewable raw material area, the price of the raw material, the price of one kilowatt-hour (kWh) of energy, the area needed to provide the installation for a process, the number of workers N s cap/yr in a factory is allocated to an area (the more staff a process requires the bigger the pressure on the environment), the area allocated to dissipation. *How much effort is needed to collect, prepare and use the data?* Calculating the SPI is a very complex matter. Therefore, the SPI is used more among universities and research institutions and hardly within businesses or industry.	☹
Consistency	*Does the indicator actually measure what it is intended to measure?* The SPI is an even more abstract measurement approach than the ecological footprint. It is not entirely clear where the added value is and how this should contribute to sustainable development.	😐
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* Just as with the Ecological Footprint, double counting is difficult to avoid due to the abstract nature of the approach.	☹
Compatibility	*Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?* No.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* The SPI is not considered a relevant and feasible approach by many stakeholders. *Is it well documented?* It is documented, but there has not been much progress since 2002.	☹
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* The SPI is not easily understandable to the general public or even experts. *Is the indicator accepted and used by different experts and non experts?* The SPI is used more among universities and research institutions and hardly within businesses or industry.	☹

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The SPI allows for valuations at different levels (of processes, products, and regions) to be comparable, because it calculates the total area needed for raw materials, energy, process installation, staff and product dissipation. This may help policy makers evaluate changes in consumption patterns, organization or technology use and base future plans on the information. However, since SPI cannot be used to analyze past processes, it is not adequate for political monitoring. *Does the indicator measure aspects which can be influenced by policy makers?* To some extent, policy makers can influence adoption of more efficient technologies or steer consumption patterns towards those that have a lower footprint in terms of land use because each process and product can be converted into land area. *Is it available to policy makers in short time frames?* The SPI is not readily available.	☺
Communication	*Can the indicator be visually illustrated?* Due to the concept of the SPI it is difficult to visually illustrate it.	😐

Table 12: Evaluation factsheet for the indicator: water abstraction rates and water stress

Resource Indicator: Water abstraction rates and water stress
Brief description: Water abstraction rates and water stress reflect the intensity of use of freshwater resources. Water abstraction rates are expressed as gross abstractions per capita, as a percentage of total available renewable freshwater resources (including inflows from neighboring countries) and as a percentage of internal resources[39]. Water stress is expressed as gross abstractions in a percentage of total available renewable freshwater resources (including inflows from neighboring countries), or in a percentage of internal resources (i.e. precipitations - evapotranspiration). The OECD ranks water stress on the following scale: • Low (less than 10%): generally there is no major stress on the available resources. • Moderate (10 to 20%): indicates that water availability is becoming a constraint on development and significant investments are needed to provide adequate supplies. • Medium-high (20 to 40%): implies the management of both supply and demand, and conflicts among competing uses need to be resolved. • High (more than 40%): indicates serious scarcity, and usually shows unsustainable water use, which can become a limiting factor in social and economic development. Total freshwater resources refer to internal flow (equal to precipitation less evapotranspiration, representing the total volume of river run-off and groundwater generated, in natural conditions, exclusively by precipitation into a territory) plus actual external inflow (the total volume of the flow of rivers and groundwater coming from neighboring territories)[40]. The UN Water Task Force also monitors progress in the water sector using a set of indicators, including the intensity of use of water resources, taken as total water withdrawals over total actual renewable water resources (TARWR). However, debate exists regarding whether TARWR should be broken into its subcomponents of surface and groundwater, or only the internal renewable water resource component (more reliable), or broken down into water demand by water source type. Therefore, water intensity may reflect different information depending on context. This indicator is also included in the Millennium Development Goals, as a part of Goal 7 (ensure environmental sustainability). In addition, the European Environment Agency tracks water usage as a percentage of total freshwater resources in their Water Exploitation Index, including a sectoral breakdown[41].

[39] OECD 2011
[40] OECD 2011
[41] EEA 2010

Source/reference(s):
EEA 2010. Use of freshwater resources (CSI 018) - Assessment published Dec 2010. Available online: http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources/use-of-freshwater-resources-assessment-2
OECD 2011a. Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing.
http://dx.doi.org/10.1787/9789264111356-en
UNSTATS 2011b. Millennium Development Goals Indicators: 7.5 Proportion of total water resources used. Available at: http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=768
UNSTATS 2011c. SEEA – Water Accounts. Available at: http://unstats.un.org/unsd/envaccounting/water.asp
UNWATER 2010. Monitoring progress in the water sector: A selected set of indicators, United Nations Water Task Force. http://www.unwater.org/downloads/TFIMR_FinalReport.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* As this indicator refers to total abstractions, and is not industry or sector specific, LCA is not relevant.	☹
Coverage of industries and industrial development	*Can the indicator capture the performance of specific industries or sectors and industrial development?* The UN estimates water withdrawal for the agricultural sector, municipalities (including domestic water withdrawal) and industries, as well as at the country and regional level. The EEA compares irrigation, manufacturing industry, energy cooling and Public Water Supply usage in the Water Exploitation Index. However, "estimation of water withdrawal by sector is the main limitation to the computation of the indicator"[42].	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Freshwater resources are of significant environmental and economic importance, with resources and pressures varying widely both within and between countries. Thus, higher water abstraction rates and water stress can significantly impact all sustainability pillars – economic, environmental and social. Specific impacts include low river flows, water shortages, salinization of freshwater bodies in coastal areas, human health problems, loss of wetlands, desertification and reduced food production[43].	☺

[42] UN Statistics MDG Indicators
[43] OECD 2011

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	However, this indicator does not directly measure these impacts, instead providing information regarding pressures on water resources, which is nonetheless valuable information regarding sustainability.	
Required data efforts	*Which data is required to establish the indicator?* gross abstractions; population; total available renewable freshwater resources (including inflows from neighboring countries); total internal water resources *How much effort is needed to collect, prepare and use the data?* Preparation and usage at a country level should also be straightforward, although the challenges regarding data consistency and missing values should be taken into account. Collecting data at sub-national or sectoral level would be more challenging.	☺
Consistency	*Does the indicator actually measure what it is intended to measure?* Due to the challenge of accurately accounting return flow in the computation of water resources and use, as well as the lack of a consistent method to measure incoming flows originating outside of countries, there are discrepancies between global and national data[44].	😐
Compatibility	*Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?* SEEA-Water, which is compatible with the broader SEEA, provides concepts, definitions, classifications, tables, and accounts for water and water-related emission accounts, expanding on the International Recommendations for Water Statistics (IRWS)[45].	☺
Uncertainties and data imputation	*How are uncertainties about data reflected in the indicator and how are missing data imputed?* When data is unavailable, AQUASTAT, the primary database for water-related statistics, estimates water use by sector, based on unit water use figures available for each sector, and submitted to countries for endorsement[46].	😐
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* AQUASTAT systematically reviews data obtained from national sources to ensure consistency. UN FAO has published guidance documents regarding methodology for computing the different elements of national water balances[47].	☺

[44] UN Statistics MDG Indicators
[45] UN Statistics SEEA-Water
[46] UN Statistics MDG Indicators; See the following site for more information on estimation methodology http://www.fao.org/nr/water/aquastat/water_use/index.stm.
[47] See Margat et al. (2005): *Key water resources statistics in AQUASTAT*. Conference Paper for the International Work Session on Water Statistics, Vienna, June 20-22 2005. Available at //ftp.fao.org/agl/aglw/docs/PaperVienna2005.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Is it well documented? The indicator is used by both the OECD and the UN, and is routinely included in countries' water accounting.	
Understanding and Acceptance	*Is the information directionally safe?* Trends in water withdrawal show relatively slow patterns of change, and it is unlikely that the indicator would show meaningful variations from one year to the other[48]. *Is comprehension of the indicator intuitive?* Yes *Is the indicator accepted and used by different experts and non experts?* Yes	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Related policies and initiatives include Agenda 21 (UNCED, Rio de Janeiro, 1992), which explicitly considered the protection and preservation of freshwater resources and the World Summit on Sustainable Development (Johannesburg, 2002)[49]. In addition, ensuring that rates of extraction are sustainable over the long term is objective of the EU's Sixth Environment Action Programme[50]. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing analysis of causal effects?* No *Is it available to policy makers in short time frames?* No. According to the UN, "trends in water withdrawal show relatively slow patterns of change, and it is unlikely that the indicator would show meaningful variations from one year to the other. Three years are a minimum frequency to be able to detect significant changes"[51]. Moreover, country surveys currently take place every 10 years.	☺
Communication	*Can the indicator be visually illustrated?* Maps with color codes are one example, as well as graphs showing trends over time. See, for example, OECD 2011.	☺

[48] UN Statistics MDG Indicators
[49] OECD 2011
[50] EEA Indicators 2010
[51] UN Statistics MDG Indicators

Table 13: Evaluation factsheet for the indicator: corporations' turnover, value added and exports of the environmental goods and services sector

Resource Indicator: Corporations' turnover, value added and exports of the environmental goods and services sector
Brief description: In 2009, Eurostat published a handbook regarding how to collect, interpret and present data on the environmental goods and services sector (EGSS)[52][53]. The four variables identified as the key indicators for the EGSS are turnover, value added, employment (see indicator table for employment in EGSS) and exports. According to Eurostat[54]: • "*Turnover* is defined as the totals invoiced by the observation unit during the reference period, and this corresponds to the market sales of goods or services supplied to third parties. For general government non-market production, the turnover is equal to the cost of production, i.e. the sum of personnel costs, intermediate consumption, taxes on production and consumption of fixed capital. • *Value added* of environmental protection activities represents the contribution made by these activities towards the income measure of gross domestic product (GDP). It is the difference between the value of output (turnover) and of intermediate consumption. • *Exports* of goods and services consist of sales, barter, or gifts or grants, of goods and services from residents to non-residents." One of the challenges in assessing this indicator is the lack of an internationally agreed upon classification for the environmental sector, although efforts to define these categories are underway at both the European level as well as the international level through the UN System of Environmental Economic Accounting[55]. In addition, most entrepreneurial activities that might be classified as green are currently not captured[56].

[52] Eurostat 2009

[53] Eurostat (2009) defines EGSS as "a heterogeneous set of producers of technologies, goods and services that:

- Measure, control, restore, prevent, treat, minimise, research and sensitise environmental damages to air, water and soil as well as problems related to waste, noise, biodiversity and landscapes. This includes 'cleaner' technologies, goods and services that prevent or minimise pollution.
- Measure, control, restore, prevent, minimise, research and sensitise resource depletion. This results mainly in resource-efficient technologies, goods and services that minimise the use of natural resources.

These technologies and products (i.e. goods and services) must satisfy the end purpose criterion, i.e. they must have an environmental protection or resource management purpose (hereinafter 'environmental purpose') as their prime objective."

[54] Eurostat Website

[55] OECD 2011

[56] OECD 2011

Source/reference(s):
Eurostat 2009. Environmental goods and services sector handbook
Eurostat 2011. Environmental goods and services sector¸ Available at:
http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Environmental_goods_and_services_sector
OECD 2011a. Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing.
http://dx.doi.org/10.1787/9789264111356-en

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Turnover and value added data are not captured by LCA methods. A product, service or sector should only be labeled environmentally friendly if an LCA or other evaluation indicates that its environmental impacts are indeed small (or smaller than for products, services and sectors not labeled environmentally friendly). Then capturing their monetary value added and export value can be used to evaluate the size and growth of these products, goods and sectors relative to the economy at large *What aspects of the LCA chain does the indicator measure?* N/A	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* This indicator relates directly to EGSS, capturing trends in industries specifically within the environmental goods and services sector.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Turnover, value added, and exports all provide information regarding economic trends in EGSS, such as its overall size and growth, and how that growth related to the economy as a whole. In addition, complementary data can provide other insights regarding the economic pillar of sustainability. For example, assessments of trade agreements, taxes, market shares (foreign vs. domestic, public vs. private) can provide insight into barriers and drivers of international competition. Reviews of government regulations such as subsidies, taxes, or command and control regulation offer information regarding the role of government in EGSS. However, despite the fact that this indicator is a measure of the environmental sector, it is largely an economic indicator. Although products and services in EGSS “must have an environmental protection or	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	resource management purpose (…) as their prime objective"[57], this is not a measure of those impacts. Moreover, while economic growth in EGSS may lead to additional jobs and thus social impacts, this is measured directly by the related indicator measuring employment in EGSS.	
Required data efforts	*Which data is required to establish the indicator?* Turnover: totals invoiced by the observation unit during the reference period; for general government non-market production: the cost of production Value added: value of output (turnover); intermediate consumption. Exports: exports *How much effort is needed to collect, prepare and use the data?* Turnover and employment data are widely available and commonly used in assessments of performance and growth and the economic sector overall. Value added is also available, often used to compare income added by the EGSS to the national income. Export data is also widely available and in frequent usage[58]. However, as previously stated, the definition of environmental goods and services may change depending on which data source is used. Therefore, it could be challenging to collect harmonized data. In addition, if the desired statistics are not already compiled by Eurostat or a similar entity, the preparation and use of the data could require significant effort, as each separate statistic in the indicator requires a specific methodology. Detail regarding methodology is available in the Eurostat handbook (2009). Therefore, due to the emerging nature of this indicator, there could be moderate to significant challenges in collecting, preparing, and using data in a meaningful way, although these challenges will most likely be eliminated in the near future.	😐
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* Eurostat draws attention to issues related to double counting. First, "turnover does not indicate the most important sector in terms of contribution to the gross domestic product (GDP). The sum of all the turnovers is therefore not representative of the importance of the sector from an economic point of view. In effect, there are double-counting problems, which mean that production of environmental technologies, goods or services that are intermediate consumption for the production of other environmental technologies, goods or services are also taken into account. For this reason, turnover can be considered as an indirect indicator of the size of the sector"[59].	☹

[57] Eurostat 2009
[58] Eurostat 2009
[59] Eurostat 2009

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Compatibility	*Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?* Eurostat developed a classification of EGSS activities which is consistent with the SERIEE and SEEA frameworks[60].	☺
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* The comprehension of this indicator is intuitive for those within the finance industry or with an economic background, although may provide challenges to policymakers without a similar background. In addition, the incorporation of three separate statistics provides an overview regarding performance in the EGSS, but makes it more challenging to derive a clear message. In addition, it is not immediately clear from the indicator which industries are including in the EGSS.	😐
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The performance of the EGSS is related to a number of policy priorities and initiatives, including the Gothenburg strategy for a sustainable Europe and the Lisbon strategy for a competitive, dynamic and inclusive Europe. In 2004, the Environmental Technologies Action Plan (ETAP) was launched. ETAP is a new initiative aimed at encouraging European industry to exploit its potential for green innovation and increase its share of the market for goods and services[61]. The value added and export level of environmentally friendly goods and services can be compared with total value added and total exports and hence give an idea of the extent to which the economy has transitioned to low-impact production methods and industrial composition. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing analysis of causal effects?* Somewhat. *Is it available to policy makers in short time frames?* Yes, depending on data available (i.e. data for certain countries may not be available at this time)	☺
Communication	*Can the indicator be visually illustrated?* The indicator involved three separate statistics which could be separately graphically illustrated.	😐

[60] Eurostat 2009
[61] Eurostat 2009

Table 14: Evaluation factsheet for the Resource Productivity / Material Productivity indicator

Resource Indicator: Resource Productivity / Material Productivity
Brief description: Resource productivity measures the total amount of materials directly used by an economy (DMC) in relation to the economic activity (GDP) through dividing GDP (at constant prices) by DMC (GDP/DMC) or by TMC (GDP/TMC). Thus, Resource Productivity enables aggregate measuring of the material efficiency of an economy. Overall, material productivity describes how much product is obtained per tonne of material input into the production.[62] Thus, it refers to the efficiency with which an economy or a production process uses materials extracted from natural resources. Total material productivity "(GDP/TMR) is defined as the ratio between gross value added and the total material requirements of a country" (OECD 2008: p. 8). Therefore, it relates each unit of GDP generated to the associated necessary total amount of materials extracted, moved or used (TMR = total material requirement[63]). Domestic material productivity, referring to the amount of materials consumed nationally for a generated unit of output, is indicated by GDP/DMC– therefore, domestic material productivity equals resource productivity as described above. Direct materials productivity measures the amount of materials input into the economy to generate one unit of gross domestic product, hence it is measured as GDP/DMI. Resource productivity and material productivity are frequently used as synonyms, even though resource productivity would ideally encompass all resources covered by the broadest definition of resources[64]. Since both resource productivity and material productivity measure the material efficiency of an economy, they can be used to evaluate decoupling between economic growth and use of natural resources (they are hence also proposed as decoupling indicators).

[62] Or as put by OECD "material productivity is defined as the quantity of output produced per unit of materials inputs used in the production of the output." OECD 2008a. Measuring Material Flows and Resource Productivity – Synthesis report, p. 27. Available at http://www.oecd.org/dataoecd/55/12/40464014.pdf.

[63] TMR measures the total material base of an economy and to this end also includes (indirect) material flows generated up- and downstream of material requirement associated with imports and exports. TMR equals the used and unused domestic extraction plus imports plus indirect flows imported (Eurostat 2001). TMR differs from Total Material Consumption (TMC) in that TMC focuses less on exports than TMR (OECD 2008a). According to Eurostat (2001) TMC equals TMR minus exports minus indirect flows associated with exports.

[64] See for instance the definition from the Thematic Strategy on the sustainable use of natural resources (European Commission, COM(2005) 670 final, p. 3, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0670:FIN:EN:PDF) which covers "raw materials such as minerals, biomass and biological resources; environmental media such as air, water and soil; flow resources such as wind, geothermal, tidal and solar energy; and space (land area)."

Source/reference(s):
European Commission, 2007. Progress report on the European Union Sustainable Development Strategy 2007. Accompanying document to the Communication from the Commission to the Council and the European Parliament. Commission staff working document. SEC(2007) 1416. Brussels, 22.10.2007
Eurostat 2009. Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg
Eurostat 2001. Economy-wide material flow accounts and derived indicators – A methodological guide, available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF
OECD 2008a. Measuring Material Flows and Resource Productivity – Synthesis report, available at http://www.oecd.org/dataoecd/55/12/40464014.pdf
OECD 2008b. Measuring Material Flows and Resource Productivity – Volume I, The OECD Guide, available at http://www.oecd.org/dataoecd/46/48/40485853.pdf
OECD 2008c. Resource Productivity in the G8 and the OECD – A Report in the Framework of the Kobe 3R Action Plan, available at http://www.oecd.org/dataoecd/18/20/47944428.pdf

Criteria	**Qualitative assessment[65]**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Both Resource and Material Productivity include materials input into the economy for further processing and consumption, so that different life cycle stages (from extraction to disposal) can be addressed. Furthermore, both are based on DMC, which is able to measure materials extracted, used and also disposed of, again enabling Resource and Material Productivity to address different life cycle stages. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, and because hidden flows are not included, Resource and Material Productivity are only of limited suitability for measuring impacts from a life cycle perspective.	😐
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* Resource and Material Productivity can capture the performance of industries or sectors for two reasons. First, it is based on DMC, which - in particular for complex products - requires aggregation to material categories thus facilitating generalization to	☺

[65] Since both Resource Productivity and Material Productivity relate to DMC, the qualitative assessment uses sections from the DMC template.

Criteria	Qualitative assessment[65]	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	product categories or industry sectors. Furthermore, DMC addresses the three main categories fossil fuels, minerals and biomass, so that it may be applied to capturing specific industries or sectors within these categories.	
Sustainability impacts coverage	*Is the indicator able to measure environmental impacts (directly, indirectly)?* Since Resource and Material Productivity are based on DMC, which is not able to reflect the environmental impacts of the materials used, both do not sufficiently cover the environmental dimension of resource and material consumption. In this context, it is recommended to foster research and development in order to identify indicators that can measure the environmental impacts of material consumption. Therefore, it indicates whether more value can be generated per unit of inputs, but it does not address resource scarcity or efficiency nor environmental impacts. In this regard, it is proposed to redefine Resource Productivity as GDP by Total Material Consumption (TMC), as well as to focus on Total Material Productivity (GDP/TMR), because TMC and TMR allow integrating environmental impacts associated with indirect flows of imports and exports. TMC is currently under development within the European Statistical System. Concerning economic performance, using the ratio of DMC per GDP might be misleading in that GDP growth is often linked to using small quantities of high-value materials (e.g. rare earths), whereas DMC in many cases is dominated by construction materials in terms of masses, with a rather low contribution to GDP. Therefore, both aspects could be presented separately so that analysis of their respective evolution is facilitated in comparison to simply providing an aggregate number.	☹
Required data efforts	*Which data is required to establish the indicator?* Derives from MFA and data on value added/contribution to GDP, therefore data on DMC and GDP at constant prices are required. Furthermore, also data on TMC and TMR would be required. *How much effort is needed to collect, prepare and use the data?* In order to calculate the DMC for complex manufactured product (e.g. consisting of a mix of materials), the product needs to be attributed to the "dominant" material category. This likely requires more efforts to set up conversion tables to arrive at a well-founded attribution of products and imports. Though TMR and TMC would allow for the most complete integration of environmental impacts, it is very difficult to include indirect upstream and downstream flows, therefore rendering both very difficult to measure.	😐
Consistency	*Does the indicator actually measure what it is intended to measure?* Resource and Material Productivity are intended to measure the efficiency with which materials are used. By linking the unit of GDP or product generated to the materials required to do so, they allow to measure efficiency.	☺
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. OECD 2008b)	☺

Criteria	Qualitative assessment[65]	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
Understanding and Acceptance	*Is the information directionally safe?* Yes. *Is comprehension of the indicator intuitive?* Yes. *Is the indicator accepted and used by different experts and non experts?* Not yet.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Resource and material productivity can be used to indicate the progress towards decoupling of economic growth from the use of natural resources. Decoupling is an increasingly important policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These are core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020 Strategy[66] or the Roadmap to a Resource Efficient Europe[67]. Resource and Material Productivity are, hence, of high policy relevance internationally as well as nationally. In the Roadmap to a Resource Efficient Europe, Resource Productivity is even proposed as a provisional lead indicator. *Does the indicator measure aspects which can be influenced by policy makers?* Likely yes, because it is related to imports and exports *Is it available to policy makers in short time frames?* Not very likely.	☺
Communication	*Can the indicator be visually illustrated?* Resource Productivity and Material Productivity can be and frequently are visually illustrated in percentage over time, for instance by Eurostat (see http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Material_flow_accounts), FAO (see http://www.fao.org/docrep/meeting/003/Y0006E/Y0006E00.htm) or in the Sustainable Development Strategy of the German Government from 2002 (see http://www.bmu.de/files/pdfs/allgemein/application/pdf/nachhaltigkeit_strategie.pdf, p. 94).	☺

[66] European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.
[67] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Table 15: Evaluation factsheet for the Total Material Consumption indicator

Resource Indicator: Total Material Consumption (TMC)
Brief description: Similar to Domestic Material Consumption, TMC measures the total amount of materials directly used by an economy (i.e. associated with domestic production and consumption activities), but it furthermore accounts for the effects of upstream hidden flows linked to imports of raw materials, semi-manufactured and finished products. TMC equals Total Material Requirement (TMR) minus exports minus indirect flows associated with exports. TMC differs from Total Material Requirement (TMR) in that TMC focuses also on indirect flows associated with exports.
Source/reference(s): EEA 2010. The European Environment State and Outlook 2010 – Material Resources and Waste, available at http://www.eea.europa.eu/soer/europe/material-resources-and-waste Eurostat 2009. Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg Eurostat 2001. Economy-wide material flow accounts and derived indicators – A methodological guide, available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF OECD 2008b. Measuring Material Flows and Resource Productivity – Volume I. The OECD Guide, available at http://www.oecd.org/dataoecd/46/48/40485853.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* This indicator derives from MFA type assessments. TMC is able to measure materials extracted, used (production and consumption) and also disposed of, therefore different life cycle stages can be addressed. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, TMC is not well-suited to measure impacts from a life cycle perspective.	😐
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* Similar to Domestic Material Consumption DMC, TMC is also material specific and linked to semi-manufactured or finished products. Thus, in particular for complex products TMC also requires aggregation to material categories. This may facilitate generalization to product categories or industry sectors.	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Furthermore, because the three main categories fossil fuels, minerals and biomass are addressed, TMC may be applied to capturing specific industries or sectors within these categories. However, in many cases, TMC is a highly aggregated economy-wide indicator.	
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Because TMC also covers the hidden flows of imports, it enables to measure the “real” environmental impact (through indirect flows) of materials used for production and consumption. Thus, TMC also allows to measure the associated ecological burden in upstream or downstream countries and hence the outsourcing of "dirty" production/extraction to other countries. However, though TMC thus provides a more representative picture of the environmental impacts of materials used than DMC, it may still only serve as a proxy for measuring the overall environmental pressure of resource use because different materials cause very different impacts on the environment (for instance, the impacts of 1 metric ton of mercury are doubtless much greater than those of 1 metric ton of gravel). Furthermore, the impacts linked to indirect flow associated with exports are not taken into consideration.	😐
Required data efforts	*Which data is required to establish the indicator?* TMC requires data on consumption and trade of all materials flowing in and out of an economy as well as upstream and downstream data for the countries importing from or exporting to. *How much effort is needed to collect, prepare and use the data?* TMC is still not yet fully developed, because calculating indirect flows poses great difficulties from a practical perspective.	☹
Consistency	*Does the indicator actually measure what it is intended to measure?* TMC measures overall consumption of materials within an economy/nation including indirect flows and therefore is able to measure its absolute level of resource use and associated impacts.	☺
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. OECD 2008b and Eurostat 2001).	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* TMC is able to measure the absolute level of resources used within an economy and its associated upstream resource flows. Therefore, TMC could be used to indicate the progress towards decoupling of economic growth from the use of natural resources (but not on decoupling of associated environmental impacts due to focusing on materials' weight and therefore neglecting the environmental impacts of different materials). Decoupling is an increasingly important policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These are core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020 Strategy[68] or the Roadmap to a Resource Efficient Europe[69]. TMC is, hence, of high policy relevance internationally as well as nationally. This is reflected for instance in the ongoing development efforts within the EU. *Does the indicator measure aspects which can be influenced by policy makers?* Yes. *Is it available to policy makers in short time frames?* Not currently available.	☺
Communication	*Can the indicator be visually illustrated?* It can be and frequently is visually illustrated in tonnes or in tonnes per capita, for instance by the German Federal Environment Agency (see http://www.umweltdaten.de/publikationen/fpdf-l/3426.pdf, p. 42).	☺

[68] European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.

[69] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Table 16: Evaluation factsheet for the Ecological Footprint

Resource Indicator: Ecological Footprint (EF)
Brief description: The Ecological Footprint measures how much biologically productive land and water area is required to a) provide the resources consumed and b) absorb the wastes generated by a human population, taking into account current technology. The methodology also includes a measurement of the annual production of biologically provided resources – called biocapacity. The Ecological Footprint and biocapacity are each measured in global hectares, a standardised unit of measurement equal to 1 hectare with global average productivity (yield obtained in a particular year from any land class with the locally prevailing technologies).
Source/reference(s): Best, Aaron, Stefan Giljum, Craig Simmons, Daniel Blobel, Kevin Lewis, Mark Hammer, Sandra Cavalieri, Stephan Lutter and Cathy Maguire. 2008. Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use: Analysis of the potential of the Ecological Footprint and related assessment tools for use in the EU's Thematic Strategy on the Sustainable Use of Natural Resources. Report to the European Commission, DG Environment. OECD 2002. Sustainable Development – Indicators to measure decoupling of environmental pressure from economic growth. SG/SD(2002)1/FINAL, available at http://www.oecd.org/officialdocuments/displaydocumentpdf/?cote=sg/sd%282002%291/final&doclanguage=en

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* The EF can be applied to single activities, products, persons, enterprises or industries. However, National Footprint Accounts can reflect life cycle aspects only to a limited extent. For example, energy use will be monitored as such, but not attributed to any particular energy-using products. Furthermore, the EF does not capture most of the impact categories usually applied in life cycle analysis, such as ecotoxicity, acidification, ionizing radiation. Thus, the Ecological Footprint is not well-suited at covering life cycle stages because it looks only at end-user consumption.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of specific industries or sectors and industrial development?* The EF can be applied to studying the performance of specific industries. This has been done for instance by WWF concerning	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	fine paper manufacturing (see http://wwf.panda.org/what_we_do/how_we_work/conservation/forests/news/?uNewsID=194141) or by SERI focusing on the raw-materials producing industry in Austria (see http://seri.at/projects/completed-projects/ecological-footprint-industry/) or by Chen and Hsieh (2011)[70]as regards the hotel industry. .	
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* The EF measures primarily resource consumption. However, EF accounts do not contain spatially disaggregated data on actual land use and do not provide precise information on ecosystem impacts. Furthermore, the effects of resource consumption on climate change are not directly included in the analysis; neither do EF calculations explicitly address biodiversity or impact on ecosystems. The EF does not explicitly measure social or economic impacts. In fact, the EF was not designed to comprehensively measure overall sustainability. Many aspects of sustainability are missing from the calculation and need to be covered by complementary indicators. On the other hand the Environmental footprint is one of the most ambitious attempts to provide one composite indicator that would measure the entire spectrum of sustainability.	😐
Required data efforts	*Which data is required to establish the indicator?* EF and biocapacity calculation covers six land use types: cropland, grazing land, fishing ground, forest land, built-up land, and the uptake of land to accommodate the carbon Footprint. The calculations in the National Footprint Accounts are based primarily on international data sets published by the Food and Agriculture Organization of the United Nations (FAOSTAT, 2010), the UN Statistics Division (UN Commodity Trade Statistics Database – UN Comtrade 2010), and the International Energy Agency (IEA 2010).[71] *How much effort is needed to collect, prepare and use the data?* No primary data collection is required. Sufficient data has been available to calculate National EF accounts since 1961 for more than 150 countries.	☺
Consistency	*Does the indicator actually measure what it is intended to measure?* Yes, the EF measures resource use and compares it to the earth's carrying capacity. Its main strength is that it links resource use to final consumption at the level of the consumer country rather than the producer country.	☺
Efficiency	*Does the indicator express the desired information with the least variation?* Results may sometimes be distorted because EF results are affected by data sources, choice of input variables and the	☹

[70] Chen, Han-Shen and Hsieh, Tsuifang 2011. An environmental performance assessment of the hotel industry using an ecological footprint. Journal of Hospitality Management and Tourism 2 (1): 1 – 11. Available at http://www.academicjournals.org/JHMT/PDF/Pdf2011/Jan/Chen%20and%20Hsieh%20pdf.pdf.

[71] Global Footprint Network (2010): Calculation methodology for the national Footprint accounts, 2010 EditIon. Availabe at: http://www.footprintnetwork.org/images/uploads/National_Footprint_Accounts_Method_Paper_2010.pdf

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	methodologies chosen for calculating certain conversion factors assigned to them – particularly for the equivalence factors.	
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* The EF avoids double counting by using the compound method (a top-down approach), which is the standard method for National Footprint Accounts. One problem with counting is that land use forms are taken as mutually exclusive, while in reality an area of land may fulfill several functions at the same time.	😐
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* There are stakeholders involved in refining the methodology and opportunities are provided to do so. The basic principles of EF calculation are publicly available and are standardized for national EF accounts. There are difficulties regarding the lack of scientifically established relationships (e.g. between biocapacity and greenhouse gases other than CO_2, or biocapacity and nuclear energy). Further improvements in data quality, methodologies and assumptions are required. There remains a lack of transparency regarding certain aspects of the methodology. For instance, some groups of stakeholders, in particular representatives from statistical offices, have criticized the accounting framework as being over-reliant on conversion factors and imputations of missing data, some of which are not documented in a way that can be independently reviewed. As for all composite indices which cover many different environmental impacts the conversion (normalization) and aggregation methods are hotly disputed. Any method of normalization and aggregation is fully scientifically objective and the subjectivity involved is often criticized. Not all calculation steps and underlying assumptions are sufficiently documented.	😐
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* Yes, it is an intuitively appealing indicator because it is easy to communicate and understand with a strong conservation message. *Is the indicator accepted and used by different experts and non experts?* One of the main strengths of the EF is its easy communication of a complex matter and it has made the EF widely popular across a broad public.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The EF is useful for assessing progress on the EU's resource policies; it is uniquely able to relate resource use to carrying capacity. *Does the indicator measure aspects which can be influenced by policy makers?* Yes, but the EF does not lead to immediate policy conclusions.	😐
Communication	*Can the indicator be visually illustrated?* EF can be and frequently is visually illustrated, for instance in WWF's 2010 Living Planet Report (see http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/).	☺

5 Review of the data availability for the indicators identified

In order to recommend effective indicators for sustainable industry and sustainable industrial development, the respective data availability for the 10 indicators selected in the previous analytical step needs to be taken into account. Therefore, we provide an overview of data availability for the selected indicators based on the literature reviewed under Task 2. We assessed data availability first by considering the data sources described in the literature for the selected indicators and second by conducting our own data search that included the aforementioned sources as well as a general data search. The most relevant databases that we identified are:

- Eurostat, i.e. ComExt trade database,
- OECD material flows database, national accounts, environmental data,
- FAO FAOSTAT,
- World Bank WDI,
- UNEP GEO Data Portal
- UNEP GEMS/Water including the GEMStat database,
- EU KLEMS database on industry competitiveness,
- SERI's materialflows.net,
- World Resources Institute Earth Trends Database (one-stop portal for data from other sources as well as WRI calculations),
- Global Reporting Initiative, Sustainability Disclosure Database,
- UN COMTRADE commodities trade database,
- International Energy Agency statistics, and
- World Bureau of Metal Statistics, Metallstatistik and other databases.

Data availability for the selected indicators is evaluated according to whether the data required for calculating and using the indicator is readily available, both in terms of access to data, as well as level of detail (countries, sectors, mineral, ground- and freshwater, etc.) and the time intervals covered.

The results of this evaluation are shown in the following tables for the ten indicators selected.

Table 17: Data availability of the indicator: environmentally weighted material consumption

Indicator: Environmentally weighted material consumption (EMC) **Evaluation:** 😐

Data Requirements: Data on material flows and DMC, as well as LCA data

Relevant Databases:

- National statistical offices (for example, Germany: DESTATIS;[72] Estonia: Environment Database;[73] US: WRI[74])
- Eurostat Environment Database
- OECD Environmental Data Compendium
- SERI (materialflows.net)
- National and regional LCI databases

Data Availability:

Data sets available: Countries that have already established Material Flow Accounts provide data on material flows through their national statistical offices. For EU15 and EU27 level, including associated countries, Eurostat has collected data on material flows in the Environment database.[75] SERI provides access to global material extraction data at the national level at http://www.materialflows.net/. OECD provides data on material resources for the OECD countries in its Environmental Data Compendium.[76]

Flows are tracked by material category, such as agricultural commodity flows, forestry commodity flows, metal and mineral flows, non-renewable resource flows, and infrastructure and earth moving flows.[77]

Approximately two thirds of OECD countries have economy-wide time series data on selected material flows available. Of these, 19 countries are EU Member States and their data are available from Eurostat and national MF databases. Additionally, data are available for Japan, Korea, and the United States. As is typical for resource flows, the data situation is generally best for input (material extraction) and consumption (imports and exports) and less well developed for outputs, where data collection is often less important and where methodological issues also must be resolved (e.g., how to measure the material content of a product, catch intermediate waste, deal with recycling of materials into the same or other production processes). The primary data sources for output data are waste statistics and emission inventories, but they often do not correspond to the strict rules imposed by material flow and LCA accounting. Little coherent information is available on flows of secondary raw materials (recycled materials) and almost no information is available on recyclable materials.

[72] Available at: http://www.destatis.de/jetspeed/portal/cms/
[73] Available at: http://pub.stat.ee/px-web.2001/I_Databas/Environment/03Material_flow_accounts/03Material_flow_accounts.asp
[74] Available at: http://www.wri.org/publication/material-flow-accounts#database
[75] See under environmental account, physical flows and hybrid accounts
[76] Available at: http://www.oecd.org/dataoecd/22/36/41878252.pdf
[77] WRI Material Flow Accounts. Available at: http://www.wri.org/publication/material-flow-accounts#database

Efforts are further hindered by the lack of ackowledged principles and methodologies for converting available data and collecting the required information. Overall, in most OECD countries physical stock data for timber, freshwater, and energy are available and well developed. Frequently these data are collected in concordance with the methods laid out in the System of Environmental and Economic Accounting (SEEA). Physical flow information on other material resources or residuals such as minerals and selected metals, fish resources, and greenhouse gases, is available in several countries, but the methods, completeness, and level of detail vary across these countries.[78]

It is predicted that the data needed to calculate the EMC will be available in the longer term, if only because it is collected as part of other indicator initiatives.

LCA data is available through Life Cycle Inventory (LCI) databases on the national and regional level,[79] on European level through the European Commission's Joint Research Centre,[80] and on the international level through UNEP/SETAC.[81]

For Europe, LCA process data is based on averages for the entirety of Western Europe, causing neglect of existing differences between countries and rendering efficiency improvements over time, which lower material consumption, invisible. Furthermore, the quality of the LCA impact assessment data largely differs for the impact categories (e.g., with global warming potentials based on internationally agreed studies, whereas toxicity categories remain very uncertain and depletion of biotic, natural resources such as wood and fish, is not included at all).[82]

EMC is currently under revision, and the European Commission proposed an overall environmental impact indicator trying to alleviate the shortcomings addressed here.

Level of data: national level, regional (European)

Time period: LCA database is updated approximately every 10 years, leading to challenges regarding analysis of trends over time.

* ☺ good data availability ☹ medium data availability ☹ weak data availability

[78] http://www.oecd.org/dataoecd/47/28/40486068.pdf

[79] See the overview by a study prepared for UNEP/SETAC. Available at: http://www.epa.gov/nrmrl/lcaccess/pdfs/summary_of_global_lci_data_resources.pdf

[80] Available at: http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm

[81] Available at: http://lca-data.org:8080/LCASearch

[82] JRC and IES 2010. Decoupling indicators, Basket-of-products indicators, Waste management indicators – Framework, methodology, data basis and updating procedures. Draft for public consultation, available at http://lct.jrc.ec.europa.eu/pdf-directory/Indicators-framework-for-public-consultation-16082010.pdf.

Table 18: Data availability of the indicator: energy intensity by sector

Indicator: Energy intensity by sector	**Evaluation:** ☺
Data Requirements: energy consumption by sector; revenue by sector	

Relevant Databases:

- IEA Energy Balances Database (OECD and Non-OECD)
- IEA Indicators Database
- Eurostat Energy Statistics
- Eurostat Structural Business Statistics
- UN Energy Statistics Database
- UNIDO INDSTAT Database

Data Availability:

Data sets available: Data on final energy consumption is available for OECD countries as well as many other countries from the IEA and is further broken down into the following categories: industries, transport, commercial and public services, agriculture, and fishing, as well as sub-categories based on the International Standard for Industrial Classification[83] (ISIC). Industry subcategories include iron and steel, chemical and petrochemical, non-ferrous metals, non-metallic minerals, transport equipment, machinery, mining and quarrying, food and tobacco, paper, pulp and print, wood and wood products, construction, textile and leather, and non-specified industries.[84]

Data availability varies, although in general more detailed data is available from 1990[85] onward. The IEA is working on further energy efficiency measures as well as improving the mandatory reporting of energy efficiency-related data.[86]

In Eurostat, final energy consumption by sector is currently available from 1990-2009.[87] Structural business statistics are also available from Eurostat for industry, construction, trade, and services according to the NACE activity classification. Data are available for the EU-27 and for the Member States.

UNIDO also collects statistics on industrial performance in the INDSTAT database, which contains time series data for the period covering 2004 to 2008.[88]

Level of data: regional, national, sectoral

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[83] IEA (2011): Energy balances of OECD countries: Documentation for beyond 2020 files. Available at: http://wds.iea.org/wds/pdf/documentation_OECDBAL_2011.pdf
[84] IEA 2011
[85] IEA 2011
[86] OECD 2011
[87] Eurostat. Statistical Database – Energy – Final Energy Consumption by Sector. Available at: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdpc320&plugin=1
[88] UN Statistics, INDSTAT Metadata. Available at: http://data.un.org/DataMartInfo.aspx

Time period: annual

* ☺ good data availability ☺ medium data availability ☹ weak data availability

Table 19: Data availability of the indicator: production-based CO_2 productivity

Indicator: Production based CO_2 productivity **Evaluation:** ☺

Data Requirements: GHG emissions at the national level and by sector; energy use; GDP growth

Relevant Databases:

- IEA Energy Balances Database (OECD and Non-OECD)
- UNFCCC, GHG inventory data
- OECD Statistics
- World Development Indicators

Data Availability:

Data sets available: Data on GHG emissions are reported annually to the Secretariat of the UNFCCC with 1990 as a base year (Annex I countries), and national GHG inventories have significantly progressed.[89]

Beginning in 1997, the IEA has published annual statistics on CO2 emissions from fuel combustion, including data from 1971 to 2008, for more than 140 countries and regions by sector and by fuel.[90] Emissions were calculated using IEA energy databases and the default methods and emission factors from the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. Data is included for the following sectors: industry, electricity and heat generation, transport, commercial and public services, agriculture and forestry, fishing, and energy industries.

GDP data is readily available for many countries, provided by national statistical offices as well as by European (e.g., Eurostat) and international databases (e.g., WorldBank, OECD).

Level of data: national, sectoral

Time period: annual

* ☺ good data availability ☺ medium data availability ☹ weak data availability

[89] OECD 2011

[90] IEA (2010): CO_2Emissions from Fuel Combustion 2011 – Highlights. Available at: http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2450

Table 20: Data availability of the indicator: water consumption by sector

Indicator: Water consumption by sector	**Evaluation:** 😐

Data Requirements: water withdrawal by major sector; total water withdrawal

Relevant Databases:

- WRI
- World Development Indicators
- AQUASTAT

Data Availability:

Data sets available: Data is available from the World Resources Institute (WRI), the World Bank World Development Indicators (data is patchy for certain countries and available up to 2006 only), OECD Environment Data, FAO's AQUASTAT (available up to 2006), UNIDO (available up to 2007), and country accounts.

According to UN FAO, which has been collecting and analyzing data on water resources and their use through its AQUASTAT country surveys since 1992, data is available for almost all countries, by continent, and by region.[91] In AQUASTAT, water withdrawal is separated into the following sectors: agricultural, municipal (including domestic), and self-abstracted industrial water withdrawal.[92] AQUASTAT data sources include ministries or other government agencies such as national statistical services (Africa, Asia, Latin America and the Caribbean), UNSTATS, Eurostat, and OECD Statistics. Data is available at the national level and sometimes at the basin level. Data for developing countries is sometimes of lower quality or has gaps. Data on withdrawals, especially in developing countries, is largely incomplete, particularly for agriculture. In many developing countries, water use is only metered within urban areas, leaving gaps in the data regarding rural use.

Where data are incomplete or unavailable, water use is estimated based on unit water use figures available for each sector, and estimates are submitted to countries for endorsement.[93] Data on water resources and water use by sector and country are available for all countries for the reference year 2000 and 2005, using 2000 values as baseline data. However, models exist which provide estimates of water use by sector and by country since 1961.[94]

Therefore, while data is available, the time interval between data collection as well as incomplete data for many countries leads to challenges in accurate analysis of trends and comparability between countries.

GDP data is readily available for many countries, provided by national statistical offices as well as by European (e.g., Eurostat) and international databases (e.g., WorldBank, OECD).

[91] UNSTATS MDG Indicators
[92] AQUASTAT, Water Use Webpage. Available at: http://www.fao.org/nr/water/AQUASTAT/water_use/index.stm
[93] UNSTATS MDG Indicators, Millennium Development Goals Indicators: 7.5 Proportion of total water resources used. Available at: http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=768
[94] UNSTATS MDG Indicators

Level of data: Data is at the national level and can cover all countries for which data is available. However, the quality of data on industrial water use is limited because often industries do not report on their water use.

Time period: Country surveys for water withdrawal take place every 10 years, although modeled results are sometimes available at greater frequency.[95] Moreover, according to UNSTATS, it is unlikely that the indicator could indicate meaningful variations from one year to the other—in fact, three years is considered the minimum frequency required to be able to detect significant changes.[96]

[*] ☺ good data availability   😐 medium data availability   ☹ weak data availability

[95] UNSTATS MDG Indicators
[96] UNSTATS MDG Indicators

Table 21: Data availability of the indicator: Sustainable Process Index

Indicator: Sustainable Process Index (SPI)	**Evaluation:** 😐
Data Requirements: renewable raw material area; non-renewable raw material area; the price of the raw material; the price of one kilowatt-hour (kWh) of energy; the area needed to provide the installation for a process; the number of workers (cap/yr) in a factory allocated to an area; the area allocated to dissipation	
Relevant Databases: • SPIonExcel Databases[97] • Eurostat • EC-DG VI (1997) • BEW's Life Cycle Inventories of Energy Systems (Ökoinventare von Energiesystemen)	
Data Availability: ***Data sets available:*** The SPIonExcel databases from the Graz University of Technology compiles data from a variety of sources, such as Eurostat data (for 2002), EC-DG VI (for 1997), "Life Cycle Inventories of Energy Systems" BEW (for 1996), Graz University of Technology, and others.[98] The SPIonExcel databases include a "Basic" database, as well as detailed data for the processes included in the Basic database. For the Basic database, as well as most of the process databases, the last update took place in 2006. Detailed process databases include Agricultural Downstream Processing (DP), Biofuels DP, Chemicals and Base Substances DP, Electricity DP, Fertilizers and Pesticides DP, Metals DP, Polymers DP, Renewable Energy DP, Toxicity, Value Chain Coal DP, Value Chain Crude Oil DP, Value Chain Fission Material DP, Value Chain Natural Gas DP, Vehicles Transport and Machinery DP, and Water Provision and Waste Processes DP. ***Level of data:*** process ***Time period:*** SPI is not published routinely; the latest available data stems from 2002.	

* ☺ good data availability   😐 medium data availability   ☹ weak data availability

[97] Available at: http://spionexcel.tugraz.at/index.php?option=com_content&task=blogcategory&id=13&Itemid=34

[98] Grünig et al. (2011): Plakative und schnelle Umweltinformation mittels hochaggregierter Kenngrößen zur nachhaltigen Entwicklung. Report written by Ecologic Institut and Bosch & Partner for the German Environmental Ministry.

Table 22: Data availability of the indicator: water abstraction and water stress

Indicator: Water abstraction rates and water stress	**Evaluation:** 😐
Data Requirements: gross abstractions; population; total available renewable freshwater resources (including inflows from neighboring countries); total internal water resources	
Relevant Databases: • AQUASTAT • WRI • World Development Indicators • OECD Environment Data • national accounts	
Data Availability: See Water consumption by sector data availability table for details.	

* ☺ good data availability ☺ medium data availability ☹ weak data availability

Table 23: Data availability of the indicator: corporations' turnover

Indicator: Corporations' turnover, value added, and exports of the environmental goods and services sector	**Evaluation:** 😐
Data Requirements: • *Turnover:* totals invoiced by the observation unit during the reference period; for general government non-market production, the cost of production • *Value added:* value of output (turnover); intermediate consumption • *Exports:* exports	
Relevant Databases: • Eurostat (COMEXT) • UN Comtrade • National statistical offices (for example, Statistics Netherlands and Statistics Austria) • National accounts • Business and VAT registers • Company annual reports • INDSTAT	
Data Availability: ***Data sets available:*** Data on the environmental goods and services sector (EGSS) is challenging to collect, due to ambiguity regarding the specific definition of EGSS and what activities should be formally considered "environmental." In the future, as EGSS is formally	

defined (a process which is already taking place[99]) and this indicator is further developed, related data will most likely be more readily available and easier to use.

Using the Classification of Environmental Protection Activities (CEPA) as well as the Classification of Resources Management Activities (CReMA), Eurostat's pilot data collection initiative provides statistics for select EU member states and Norway.[100] Two countries (Romania, Sweden) reported data for the year 2006, four countries (Germany, Netherlands, Portugal, and France) reported data for the year 2007, two (Latvia and Austria) for 2008, Belgium reported data for 2004, Romania also provided data for 2005, and Norway reported data for 2004 and/or 2006 and/or 2007, depending on the variables.[101] Eurostat does not currently provide estimates for aggregates such as EU27 or EU15.

The United Nations Commodity Trade Statistics Database (UN Comtrade) includes trade data for over 140 countries since 1962.[102]

UNIDO also collects statistics on industrial performance in the INDSTAT database, which contains time series data for the period covering 2004 to 2008.[103]

However, in many cases, data must be collected at the level of national accounts or national statistical offices, presenting challenges regarding data collection, use, and comparability.

Level of data: national, sectoral

Time period: Every other year starting from 2010 on a voluntary basis.[104]

[*] ☺ good data availability ☺ medium data availability ☹ weak data availability

[99] See Eurostat's Handbook on EGSS for more information. Available at: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-012/EN/KS-RA-09-012-EN.PDF

[100] Eurostat, Metadata on turnover, value added, and exports of the environmental goods and services sector. Available at: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/env_ac_egss2_esms.htm

[101] Eurostat Metadata for EGSS

[102] UNSTATS Comtrade Metadata. Available at: http://data.un.org/DataMartInfo.aspx

[103] UNSTATS INDSTAT Metadata. Available at: http://data.un.org/DataMartInfo.aspx

[104] Eurostat, Metadata on turnover, value added, and exports of the environmental goods and services sector.

Table 24: Data availability of the indicator: resource productivity / material productivity

Indicator: Resource Productivity / Material Productivity	**Evaluation:** ☺
Data Requirements: data on DMC and GDP at constant prices; for further development of the indicator, data on TMC and TMR	
Relevant Databases: See EMC for material flows databases • Eurostat • World Development Indicators • OECD Statistics	
Data Availability: ***Data sets available:*** See EMC data availability table regarding material flows for details. GDP data is readily available for many countries, provided by national statistical offices as well as by European (e.g., Eurostat) and international databases (e.g., WorldBank, OECD). Data on TMC or TMR is much more difficult to generate and collect because of the coverage of indirect/hidden flows. ***Level of data:*** national, regional (European) ***Time period:*** annual, quarterly (GDP)	

* ☺ good data availability   😐 medium data availability   ☹ weak data availability

Table 25: Data availability of the indicator: Total Material Consumption

Indicator: Total Material Consumption (TMC)	**Evaluation:** ☹
Data Requirements: consumption and trade of all materials flowing in and out of an economy; upstream and downstream data for countries importing from or exporting to an economy	
Relevant Databases: • National statistical offices (for example, Germany: DESTATIS;[105] Estonia: Environment Database;[106] US: WRI[107]) • Eurostat Environment Database • OECD Environmental Data Compendium • SERI (materialflows.net) • National and regional LCI databases	
Data Availability: ***Data sets available:*** See EMC data availability table regarding material flows for details. Because of the data requirements for indirect flows, data on TMC is much more difficult to collect and to compile and hence less readily available. ***Level of data:*** national ***Time period:*** annual	

* ☺ good data availability ☹ medium data availability ☹ weak data availability

105 Available at: http://www.destatis.de/jetspeed/portal/cms/

106 Available at: http://pub.stat.ee/px-web.2001/I_Databas/Environment/03Material_flow_accounts/03Material_flow_accounts.asp,

107 Available at: http://www.wri.org/publication/material-flow-accounts#database

Table 26: Data availability of the indicator: Ecological Footprint

Indicator: Ecological Footprint (EF) **Evaluation:** ☺

Data Requirements: EF and bio-capacity calculation covering six land use types: cropland, grazing land, fishing ground, forest land, built-up land, and the uptake land

Relevant Databases:

- National Footprint Accounts (Global Footprint Network)
- FAOSTAT
- UN Comtrade
- IEA Statistics

Data Availability:

The Ecological Footprint is currently coordinated by the Global Footprint Network.[108] The calculations in the National Footprint Accounts are based primarily on international data sets published by UN FAO (FAOSTAT, 2010), the UN Statistics Division (UN Commodity Trade Statistics Database – UN Comtrade 2010), and the International Energy Agency (IEA 2010).[109]

No primary data collection is required. Sufficient data has been available to calculate National EF accounts since 1961 for more than 150 countries. The quality of the data is usually a greater problem than actual availability of data, especially outside OECD. There are also certain data gaps, e.g., related to trade flows. Imputation techniques have to be used where data are missing.

In 2007, the Global Footprint Network launched the National Accounts Improvement project, an initiative designed to improve the accuracy, transparency, and applicability of the accounts.[110]

Level of data: national

Time period: National Footprint Accounts are updated annually. Most underlying data are updated on a regular basis.

* ☺ good data availability ☺ medium data availability ☹ weak data availability

[108] http://www.footprintnetwork.org

[109] Global Footprint Network (2010): Calculation methodology for the national Footprint accounts, 2010 EditIon. Availabe at: http://www.footprintnetwork.org/images/uploads/National_Footprint_Accounts_Method_Paper_2010.pdf

[110] Global Footprint Network (2010)

6 Discussion of and recommendations for sustainable industry indicators

6.1 Discussion of the top ten indicators

The selected indicators have been shown to meet the primary criteria for evaluating industry's efforts to reduce its resource consumption and environmental impacts. Since Life Cycle Assessment was identified as a suitable methodological framework for evaluating the resource efficiency and environmental impacts of not only products and services but also, albeit requiring greater generalization, that of industrial sectors and even countries, the indicators also met the requirement of being largely compatible with LCA. A third desirable property of the selected indicators is that they are, for the most part, based on available data and data collection protocols. The actual data availability may vary by industrial sector, country to country, and over time, and it can certainly be said that in general and for various reasons the environmental impacts of industrial production are not yet sufficiently traced throughout the entire economy. Therefore, in addition to surveying the field of available indicators, this study serves to highlight data gaps.

The following paragraphs discuss the selected indicators in more detail and derive suggestions for their further distinction into those that are presently the best available, most effective indicators for tracking industrial resource efficiency and environmental impacts.

The discussion is organized by indicator and addresses further methodological and data-specific issues. It also gauges the current and likely future acceptance of the indicator within political circles and decision-making processes as well as the ease with which the indicator's concept and findings can be interpreted and explained to different audiences.

6.1.1 Environmentally weighted material consumption (EMC)

The EMC indicator is selected because it combines information on the flow of materials from the environment through the economy and back to the environment with informed estimates on their environmental impacts along this chain. It is based on the accounting principles of MFA and adds to it the step of associating impact factors to different material types and quantities. Thus, the EMC indicator evolves from the DMC indicator and adds the impact factors. LCA is applied to determine the specific environmental impacts of a material. For every material included in the EMC indicator, an estimate is made of its contribution to environmental problems throughout its life cycle. This includes the impacts related to the material itself, but also the impacts of auxiliary materials, the energy used during the production process, and the emissions of undesired by-products and pollutants as well as the impacts originating from waste treatment.[111] A further advantage of the EMC is the inclusion

[111] Van der Voet, E, van Oers,L., Moll, S., Schütz, H., Bringezu, S., de Bruyn, S., Sevenster, M., Warringa, G. (2005): Policy Review on Decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries. CML report

of imported materials and foreign impacts,[112] thus giving a more accurate picture of total environmental impacts and decoupling than an indicator placed solely within domestic boundaries.

This makes the EMC indicator uniquely suited to determine material-, industry-, and even country-level environmental impacts resulting from resource use in economic production and waste treatment. The EMC considered here covers 32 base materials and is weighted based on 13 quantifiable categories of impacts.[113] The shares of each country are normalized against the global impact of each equally weighted impact category. It is therefore ranked highest in our list of potential indicators for gauging resource efficiency and 'greenness' of industries, in particular within the context of decoupling economic growth and development from resource use.

However, the EMC is not yet widely adopted and its database is incomplete. A consortium consisting of CML Netherlands, CE Delft, Science Centre North-Rhine Westphalia and the Wuppertal Institute published a study in 2005 that developed the EMC and gathered data for the EU25 for 1990-2000 and for three EU Candidate Countries for 1992-2000. More recent data and studies on the EMC are scarce. The JRC-IES (Joint Research Centre – Institute for Environment and Sustainability) has developed life cycle-based environmental indicators for decoupling, set out in the Thematic Strategy on Natural Resources, including:[114]

- resource indicators comprising:
  - overall EU eco-efficiency indicator
  - resource productivity indicators
  - resource specific impact indicators
- products' environmental impact indicators—for a basket of key product groups consumed or used in EU-27; and
- waste environmental indicators—for key waste types generated and treated in EU-27.

In a draft consultation document from 2010, JRS-IES outline some relevant shortcomings of the EMC and propose to develop and overall environmental impact indicator.[115] According to this document, on the downside EMC covers only the environmental impacts of the materials selected and therefore does not capture the impacts of materials not accounted for. In addition, EMC is neither specific for one year nor for country of origin of imports.

166, Leiden: Institute of environmental sciences (CML), Leiden: Leiden University, Department Industrial Ecology, 2005 available at http://www.leidenuniv.nl/cml/ssp/projects/dematerialisation/policy_review_on_decoupling.pdf.

112 http://www.leidenuniv.nl/cml/ssp/publications/eurostat_indicators_final_report_version_141009.pdf.

113 http://scp.eionet.europa.eu/themes/resource_use

114 Pretato, U, et al. (2009): Life Cycle indicators for the Data Centres on resources, products and waste. Presentation at the IMEA Workshop, 20 March 2009, Paris

115 JRC and IES 2010. Decoupling indicators, Basket-of-products indicators, Waste management indicators – Framework, methodology, data basis and updating procedures. Draft for public consultation, available at http://lct.jrc.ec.europa.eu/pdf-directory/Indicators-framework-for-public-consultation-16082010.pdf.

Furthermore, EMC does not take into account technological development over time, does not establish a link to products as underlying drivers behind the impacts, and only covers the use phase via consumption/incineration of fossil fuels. Nonetheless, EMC is considered an important advancement in particular in comparison to DMC and TMC.

A recent study[116] about the possibility of calculating the EMC indicator directly using EU statistics found that "… in principle, suitable databases are available: Europroms and the Agricultural Balances at Eurostat, to calculate apparent material consumption, and the ILCD database at JRC, to calculate the impact factors. However the gaps in these databases are presently so large that no meaningful result can be obtained. When EMC has to be calculated and published on short notice, it will have to rely on other databases, such as FAOSTAT, the MFA accounts and available LCA databases such as Ecoinvent 2.0."[117] However, data availability can be expected to continue to improve as resource efficiency, decoupling, and the reduction of environmental pressures and impacts continue to receive political attention and are the subject of ongoing work at the EU Commission and at the national level.

Applicability to measuring progress towards sustainable industries

From the point of view of measuring progress towards sustainable industrial production and the use of indicators to track this process and make it amenable to policy intervention, the EMC has several advantages and drawbacks. It offers a consistent methodology and high level of detail, can be expanded and subjected to robustness analysis (e.g., for testing the impact weights) and can also be used to set targets and to project trajectories. However, the EMC is data intensive and does not differentiate by country of origin. It is not necessarily specific for a given year, and does not allow the segregation of changes in industrial process efficiency from technological innovation over time. An additional effect of the EMC methodology is that the EMC is not linked to consumer behavior as an important driver behind the impacts and therefore misses this important area of policy.

Nonetheless, the EMC has been—together with other indicators—the subject of a study commissioned by DG ENV of the European Commission to compare different options for decoupling indicators based on available methods.[118]

In the study, the EMC has been recommended as one of the four indicators in a "basket of 8 indicators" supporting resource policy, to be compiled on a regular basis in the Data Centre on Natural Resources (managed by Eurostat). Thus, there is continued political and policy interest in using or further developing the EMC and other indicators with the potential to define a set or basket of indicators for tracking the multiple goals of reducing overall resource

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[116] Van der Voet, E., L. van Oers, S. de Bruyn, F. de Jong and A. Tukker (2009) Environmental Impact of the use of Natural Resources and Products. CML report 184. Department Industrial Ecology. 186p.

[117] http://www.leidenuniv.nl/cml/ssp/publications/eurostat_indicators_final_report_version_141009.pdf page 15.

[118] Best, A., Blobel, D., Cavalieri, S., Giljum, S., Hammer, M., Lutter, S., Simmons, C. & 31 Lewis, K. (2008), Potential of the Ecological Footprint for monitoring environmental 32 impacts from natural resource use: Analysis of the potential of the Ecological Footprint 33 and related assessment tools for use in the EU's Thematic Strategy on the Sustainable 34 Use of Natural Resources, Report to the European commission, DG Environment

use, promoting industrial resource efficiency, and reducing environmental impacts in all stages of resource extraction, production, use, and disposal.

We therefore conclude that EMC is a potential candidate indicator for policy use as it relates to the EU interests and policies to improve the environmental performance of the economy and specific sectors thereof within the context of existing activities in the fields of resource efficiency, green economy, decoupling, beyond GDP, and the MDG review.

6.1.2 Energy intensity by sector

Energy is a key resource in economic activity. At the same time, while the magnitude and type of impacts differ based on the energy mix of an economy, energy production is currently dominated by fossil fuels, which are in turn associated with significant GHG emissions, air and water pollution, habitat destruction, soil acidification, and other adverse environmental and health effects. In addition, fossil fuels are a finite resource, and even the use of renewable energy sources demand considerable resources. Thus, not only transitioning from fossil fuels to renewable ones but also reducing the energy required for a given unit of economic output is beneficial from a number of perspectives.

Although many countries or regions (such as the EU27) have seen a decline in their energy intensity, i.e., the amount of energy required to produce one unit of economic output, total energy consumption is still on the rise. Historically there has been a strong relationship between economic growth and increasing energy consumption in the end-use sectors of transport, industry, and services.[119] Moreover, energy consumption is projected to continue to increase, especially in developing and emerging economies. As an indicator, energy intensity by sector can measure progress (if any) toward relative decoupling — when the level of resource use or environmental impact grows at a slower rate than economic output — of energy consumption from economic growth within key sectors. High levels of energy intensity indicate a high cost of converting energy to economic output while low values reflect a low cost of energy conversion to economic value. That is, energy intensity is the inverse of energy productivity, which measures the value of economic output per unit of energy consumed.

While many factors — some of which are difficult to control such as weather and available energy resources — influence the energy efficiency of a country, industrial sector, or other type of energy user, decreasing energy intensity by sector improves energy efficiency and reduces GHGs and other harmful emissions while also providing significant economic benefits. This in turn is a key factor in improving environmental performance and ensuring sustainable development. However, it should be noted that energy intensity is not a measure of environmental impacts; in order to fully understand and quantify these effects, this indicator must be used in conjunction with a measure of the energy mix (i.e., the share of renewable energy versus fossil resources, etc.). In addition, despite its frequent and increasing use as a measure of energy efficiency and as an indicator for sustainable resource use, energy use relative to overall GDP is subject to limitations. According to the

[119] European Environment Agency (EN21 Final energy consumption intensity

UN, this economy-wide indicator is not an ideal measure of "energy efficiency, sustainability of energy use, or technological development."[120] In particular, this aggregate, made up of the energy intensity of various sectors, depends not only on the independent energy intensities of each sector, but is obviously heavily influenced by the structure of the economy.[121] Therefore, energy intensity by sector is selected not only based on its applicability to industry, as individual sectoral trends are observable, but also due to the fact that as an indicator, it is subject to fewer limitations and fewer errors in interpretation.

Nevertheless, energy intensity by sector is also subject to shortfalls. Measurement and interpretation are impacted by the type of products within each category based on size, features and utilization.[122] Each sectoral intensity statistic reflects structural differences in the sub-sectors from which it is comprised, giving rise to similar interpretation challenges as an aggregate indicator, as described above. Moreover, comparison between sectors is not necessarily possible, as the definition of energy intensity within each sector is not identical.[123] Beyond structural discrepancies, energy consumption also reflects climatic factors.[124] Thus, this indicator cannot be used as a standalone measure of the efficiency of energy use in a country or industry.

In order to address these challenges, energy intensity indicators can be constructed to account for structural changes through decomposition of effects. According to the U.S. Department of Energy, "advances have been made recently that allow for this decomposition so that many of the attributes of an "ideal index" are captured", such as "perfect aggregation," in which all higher level indexes are constructed to include information available at lower levels.[125] Unfortunately, this methodology leads to results that differ from publicly available figures. To address this challenge, the U.S. has adopted "almost perfect aggregation."[126] Therefore, while there are advanced methodologies for addressing identified limitations, they are often not in common usage and thus not reflected in many published and widely available sets of indicators.

Despite these limitations, energy intensity by sector is a valid indicator to measure resource efficiency but not absolute energy use. First, despite challenges regarding differing structures at the sectoral level, energy intensity provides a relatively intuitive and clear snapshot of sectoral performance and trends over time. Data is readily available and publicly accessible from a number of sources, and the indicator is published in a variety of national, regional, and global indicator sets, such as OECD indicators for monitoring "green growth," the UN Sustainable Development Indicators, and Eurostat's indicators monitoring sustainable

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[120] UN CSD, Indicators of sustainable development: Guidelines and methodologies – Third edition Methodology sheets. Available at:
[121] UN CSD
[122] UN CSD
[123] European Environment Agency (EN21 Final energy consumption intensity
[124] OECD 2011
[125] U.S. DOE. Energy efficiency and renewable energy, Planning, budget and analysis website. U.S. Energy Indicators. Accessed on 15 December 2011. Available at: http://www1.eere.energy.gov/ba/pba/intensityindicators/methodology.html
[126] U.S. DOE

development in the European Union. In addition, improving energy intensity can be tied to several major political strategies, such as the Europe 2020 Strategy for smart, sustainable and inclusive growth,[127] the recently adopted Roadmap to a Resource Efficient Europe,[128] initiatives of the UNFCCC (such as the Kyoto Protocol) calling for limitations on total greenhouse gas emissions, and other sustainable development strategies at the local, national, regional, and global level.

Applicability to measuring progress towards sustainable industries

As a measure of progress towards sustainable industrial production, energy intensity by sector has both benefits and disadvantages. Most indicator sets break down trends into broad categories. For example, the recent OECD (2011) report monitoring progress toward green growth provides energy intensity by end-use or sector for manufacturing, passenger transport, and freight transport. The European Environmental Agency provides an energy intensity indicator for the following sectors: households; transport; services, agriculture, and other; and industry. However, at the national level, energy intensity is often presented for industry sub-sectors, providing additional detail for analyzing the industrial sector. Data on final energy consumption is available for OECD countries as well as many other countries from the IEA and is further broken down into the following categories: industries, transport, commercial and public services, agriculture, and fishing, as well as sub-categories based on the International Standard for Industrial Classification[129] (ISIC). Industry subcategories include iron and steel, chemical and petrochemical, non-ferrous metals, non-metallic minerals, transport equipment, machinery, mining and quarrying, food and tobacco, paper, pulp and print, wood and wood products, construction, textile and leather, and non-specified industries.[130]

Although energy intensity by sector is subject to the limitations described above, it provides a good overview of relative energy efficiency in different industries and trends over time. While it does not provide information regarding environmental impacts related to resource use, it shows trends in the efficiency of a sector or economy to produce value added compared to energy input over time, and can be supplemented with other indicators for additional analysis. For example, when used in conjunction with other indicators such as on energy use (e.g., total primary energy consumption), CO_2 productivity/intensity, R&D and patents related to energy efficiency and renewable energy, energy prices and taxes for households and industry, and carbon pricing, this indicator could provide a more complete picture of energy use and related impacts.[131]

[127] European Commission (2010): Europe 2020. A European strategy for smart, sustainable and inclusive growth. COM(2010)2020, 3 March 2010. Under the Europe 2020 Strategy seven flagship initiatives were proposed out of which the Resource Efficiency Flagship initiative is most relevant to the project's scope - European Commission (2010) A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy. COM(2011) 21, 26 January 2011.

[128] European Commission (2010): Roadmap to a Resource Efficient Europe. COM(2011) 571 final. 20 September 2011.

[129] IEA (2011): Energy balances of OECD countries: Documentation for beyond 2020 files. Available at: http://wds.iea.org/wds/pdf/documentation_OECDBAL_2011.pdf

[130] IEA 2011

[131] OECD 2011.

In addition, although typical usage does not reflect LCA methodology, by incorporating different life cycle stages into the energy input for intensity, this indicator could theoretically reflect different life cycles. Related LCA methods include Energy LCA by product, firm, or sector using energy input-output tables and coupled with cost and production volume data to obtain intensity ratios.

Therefore, we recommend energy intensity by sector for inclusion as an indicator for sustainable developments of industries.

6.1.3 Production-based CO2 productivity

Production-based CO_2 productivity is an important indicator for measuring the environmental performance of production processes in terms of GDP generated per unit of energy use-related CO_2 emitted. Thus, it is a means to assess the carbon efficiency with which energy resources are used and hence to measure decoupling of economic growth from carbon inputs required for growth. Since the indicator only captures production-based emissions, obtaining a complete picture of the CO_2 performance would require supplementing this with demand-based CO_2 productivity in order to account for movements in production-based measures.

Though this indicator is suitable for capturing the environmental impacts of CO_2 emissions associated with energy use, it should be used in combination with indicators on energy intensity in order to provide a clear message about the magnitude of the impacts. Furthermore, since other, partially more climate change-relevant greenhouse gases are not covered, this indicator cannot convey a message on the overall climate change effect of GDP generation—though CO_2-emissions do account for approximately 80% of total greenhouse gas emissions.[132]

Since, under the UNFCCC agreements, CO_2-data has to be reported annually to the UNFCCC secretariat, comprehensive greenhouse gas inventories exist and data availability for this indicator overall is good.

Applicability to measuring progress towards sustainable industries

In general, this indicator is fit for measuring the performance of industries in reducing emissions over time associated with energy use in production. However, it alone does not suffice to indicate the sustainability performance of industries, because neither are other greenhouse gases accounted for, nor are demand-side effects or the magnitude of energy use taken into account. Therefore, in order to be a recommendable indicator, it must be integrated within a suit of indicators addressing the limitations addressed above.

Furthermore, here coverage of this indicator under the MDG7 indicators (there named Indicator 7.2 Carbon dioxide emissions, total, per capita and per $1 GDP, see http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=752) must be taken into account. Thus, this indicator has been integrated into the development of Sustainable Development Goals, which will have to be coordinated with the MDGs. Therefore, altogether

[132] Ibid.

we do not recommend this indicator for a suit of indicators to bring forward to capture progress towards sustainable industries.

6.1.4 Water consumption by sector

Water is by far the most used resource and for human survival the most critical one. Due to the large quantities of water used, most composite resource indicators do not include water use as its use would dwarf the use of all other material resources. The inclusion of one or several water indicators into the indicator set is therefore absolutely crucial.

The water consumption indicator per sector is a suitable indicator to measure the resource efficiency of sectors. With the possible exemption of agriculture (where climate plays a defining role for the extent of water use), a comparison of the water use in sectors will enable us to identify progress or lack thereof in resource efficiency and will mark out the areas where the biggest improvements can be made.

Nonetheless the indicator has an important limitation in respect to measuring sustainability. Water availability differs significantly from country to country and the consumption of water is more harmful in some countries than in others. Water use in itself is not harmful to the environment if the water systems are not polluted when water is used and if, overall, the water is only extracted in quantities which can be replenished. Thus, the indicator should be complemented by an indicator measuring the overall size of consumption compared to availability of water.

Nonetheless, in the context of the study this flaw might be an asset. Whether a country as a whole is living within its means in respect to water consumption is not necessarily within the powers of industry as other factors play a role too. Overall, water consumption can nonetheless tell you whether industries undertake efforts to reduce their part of the water use.

The data is collected by AQUASTAT and is based on surveys conducted every 10 years. Based on modeling, results are available in shorter time periods. Data is generally regarded as good aside from some developing countries, and especially for agriculture in those countries significant gaps exist.

Applicability to measuring progress towards sustainable industries

From the point of view of measuring progress towards sustainable industrial production, the water consumption indictor is an important ingredient of a balanced indicator set. The indicator will enable the tracking of water use in an economy and in different sectors. Especially complemented by indicators which track the water use in comparison to its local availability, the indicator will be able to track the successes and failures of resource efficiency policies.

6.1.5 Sustainable Process Index (SPI)

The great strength of the Sustainable Process Index (SPI) is that it provides a measurement for the total resource efficiency of a production process and is therefore well suited to monitor the effectiveness of industrial processes. The methodology to aggregate different resource uses is important. Since in production processes very often the reduction in the use of one resource use can cause an increase in the use of another, a robust methodology to compare and aggregate the use of different resources is necessary for a robust indicator on resource efficiency.

Additionally, it should be mentioned that the methodology for aggregation does not provide an estimate of the environmental impacts of the resource uses.

Data availability is a problem, as the database is not updated regularly and the last update was done in 2006. The data is compiled from various sources, such as Eurostat data (for 2002), EC-DG VI (for 1997), "Life Cycle Inventories of Energy Systems" BEW (for 1996), Graz University of Technology, and others.[133]

Applicability to measuring progress towards sustainable industries

The SPI is similar to the Ecological Footprint indicator, but with a greater focus on products and processes. Therefore, the environmental footprint can be calculated through the SPI methodology, which appears more appropriate for measuring industrial processes (for instance the sugar industry[134] or transportation[135]) than the Ecological Footprint as such.

Overall, the SPI is an indicator for the future as currently the data availability is not good enough for policy use. On the other hand, the methodology used is better suited than most other indicators to really understand the overall implications of changes to production processes in respect to resource efficiency, and if data availability concerns are resolved it would be a useful addition to the indicator set.

6.1.6 Water abstraction rates and water stress

Water is an essential resource in any society, not only vital for maintaining health and sanitation but also as a factor input for many economic activities and industrial processes. There are various indicators related to different aspects of water and its usage, such as overall consumption, productivity, or quality. However, in order to gain insight into the key question—is usage sustainable—water stress is an ideal indicator, as it takes into account water resources available and the pressures specific to an individual country or watershed. For example, a country with significant freshwater resources may have a high level of usage per capita, but the abstraction rate may be sustainable. By expanding this indicator to identify water stress based on different sectors, this indicator provides—to a certain extent—disaggregated information regarding water consumption trends in specific industries. This in

[133] Grünig et al. (2011): Plakative und schnelle Umweltinformation mittels hochaggregierter Kenngrößen zur nachhaltigen Entwicklung. Report written by Ecologic Institut and Bosch & Partner for the German Environmental Ministry.

[134] Gwehenberger, G and Narodoslawsky, M. 2007. The Sustainable Process Index SPI as an engineer's tool for environmental impact assessment of processes: the sugar industry as a case study. In: Kungolos, A.G., Brebbia, C.A. and Beriatos, E. (Eds.). Sustainable Development and Planning III - Volume 1, WIT Press 333 – 340.

[135] See for instance Kettl, K.H. 2011. Ecological Footprint comparison of different means of transportation based on Sustainable Process Index (SPI) methodology. 1st International Conference on Sustainable Intelligent Manufacturing, Leiria, Portugal, June 28-July 1, 2011. URL https://online.tugraz.at/tug_online/voe_main2.getVollText?pDocumentNr=193596&pCurrPk=58387

turn allows policymakers to identify potential areas of resource competition and conflict between different sectors and users and craft policies that can address current and emerging scarcity.[136]

However, despite its applicability to resource use and efficiency, one of the challenges regarding the usage of this indicator is related to data quality and availability. Beginning in 1992, the UN FAO has been collecting and analyzing data on water resources and their use through its AQUASTAT country surveys. To a certain extent, data is available for "almost all countries, by continent, and by region."[137] However, the periodicity and quality of this data creates limitations for its usage. For instance, data for developing countries is sometimes of lower quality or has gaps, and in many cases water use is only metered within urban areas, leaving gaps in the data regarding rural use. Data on withdrawals, especially in developing countries, is largely incomplete, particularly for agriculture.[138] Moreover, the UN FAO currently undertakes country surveys for water withdrawal every 10 years and additional data on water uses and resources are also published every 3 years through the United Nations World Water Development Report.[139] Where data are incomplete or unavailable, water use is estimated based on unit water use figures available for each sector, and estimates are submitted to countries for endorsement.[140] Therefore, while data is available, the time interval between data collection as well as incomplete data for many countries leads to challenges in accurate analysis of trends and comparability between countries.

The lack of common definitions and procedures for calculating water abstraction and freshwater resources further complicates usage and comparability across borders, although efforts are currently being made to standardize definitions and methodologies.[141] For example, according to UNSTATS, "there is no universally agreed method for the computation of incoming flows originating outside of countries."[142] There is also no satisfactory method for taking into account return flow in the computation of water resources and use, leading to overestimation of total water withdrawal for countries where return flow represents a significant part of withdrawal.[143] There is also no consensus regarding the critical thresholds, leading to ambiguity regarding the actual level of water exploitation.[144]

Another limitation relates to the level of the data. This indicator is typically based on country data, which may not reflect uneven spatial distribution of resources and thus mask water stress situations at the regional or local level.[145]

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[136] UNSTATS MDG Indicators
[137] UNSTATS MDG Indicators
[138] UNESCO, "Water Use by Major Sector." Available at http://www.unesco.org/new/en/natural-sciences/environment/water/, accessed 5th December 2011
[139] UNSTATS MDG Indicators
[140] UNSTATS MDG Indicators, Millennium Development Goals Indicators: 7.5 Proportion of total water resources used. Available at: http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=768
[141] EEA Indicators 2010
[142] UNSTATS MDG Indicators
[143] ibid
[144] ibid
[145] EEA Indicators 2010

Improvements in data collection as well as conforming methodologies would strengthen this indicator. In addition, the water abstraction rate and water stress are only a partial measure of sustainable water management. Complementary indicators could provide a comprehensive perspective on the multiple dimensions of water usage and management, such as data on water demand management practices, behavioral changes related to water usage, climatic variations and environments, as well as progress in improving water usage efficiency.[146]

Nonetheless, water abstraction rates and water stress are valuable indicators for measuring the sustainability of resource use and have been included in several major indicator sets and sustainable development strategies, including the Millennium Development Goals. Other initiatives include Agenda 21 (UNCED, Rio de Janeiro, 1992), which explicitly considered the protection and preservation of freshwater resources, the World Summit on Sustainable Development (Johannesburg, 2002),[147] and the EU's Sixth Environment Action Programme.[148]

Applicability to measuring progress towards sustainable industries

From the perspective of a policy maker, the indicator is intuitive and provides a snapshot of trends over time at both the national and sectoral level. Major sectors included in the UN Millennium Development Goals include agricultural, municipal, and industrial sectors. However, water usage patterns vary significantly depending on the structure of the industrial sector, as different processes have vastly different resource requirements. In order to enhance applicability to industry, measuring water withdrawals by industry sub-sector would provide detail regarding which industries to target in campaigns to improve water efficiency.

Other indicators, such as industrial water productivity, have been considered for inclusion in a set of indicators measuring sustainable industries. Although industrial water productivity can provide valuable information regarding trends in efficient water use over time, it does not provide information regarding the available water resource. In some areas, it may make sense to use more water for certain processes, as water abstraction is not unsustainable and this is the most cost-effective method. This limits the relevance of this indicator for an assessment of sustainability, and thus water stress was chosen as a more appropriate measure within the realm of water usage.

However, despite its applicability to sustainable water usage within the industrial sector, we are not recommending this indicator due to its inclusion in the MDGs.

6.1.7 Corporations' turnover, value added, and exports of the environmental goods and services sector

The turnover, also known as revenue or sales, of the environmental goods and services sector is a good indicator for measuring the strength of the environmental goods and services sector. The indicator can be used to compare the size of the sector producing

[146] UNSTATS MDG Indicators
[147] OECD 2011
[148] EEA Indicators 2010

environmental goods and sectors relative to that of other sectors in terms of revenue. Moreover, temporal comparisons allow for mapping the development of the sector over time. Other indicators, such as staff working in the environmental goods and services sector, can be used to further describe the sector.

After years of standardization, the definition of the environmental goods and services sector is now fairly established and will be rolled out in the future. As the data collection is based on sectoral codes (NACE[149] rev.2 for the EU and ISIC[150] rev.4 at the international level), data can be compared across countries and over time.

While the indicator gives an important view on the development of the green sectors of an economy, it concentrates on the sectors defined as environmental goods sector. This implies that any movement towards more green practices in all other sectors is ignored. Critics would claim that minimizing the negative environmental impacts of non-green sectors might be even more important than the size of the green sector.

Another important limitation is that changes in the environmental sector are not properly accounted for. If, for example, the industry for solar panels and photovoltaic systems is booming but uses lots of energy and produces substantial environmentally harmful byproducts, this would not be reflected in the indicator. In that sense, the indicator is purely quantitative and has no qualitative message. Therefore, the indicator has only limited relevance if not accompanied by additional information.

Data availability is generally good as it can be derived from national accounts.

Applicability to measuring progress towards sustainable industries

Overall, the turnover of the green sector is a useful indicator for measuring relevance of green industries. However, the indicator should be complemented by other indicators that show the development of the overall economy towards environmental sustainability, but, as part of a basket or set of indicators, it provides an important dimension of sustainability as the size of the green sector can be seen as a proxy for the importance of the “stakeholders” in the green revolution.

6.1.8 Resource Productivity and Material Productivity

Resource Productivity and Material Productivity both link the GDP generated to the amount of resources or material used for its generation, generally based on Domestic Material Consumption (DMC). Literature on Material Flows shows a wide variety of input, consumption, and output indicators (see, for instance, OECD 2007a or Eurostat 2001). For the purpose of measuring resource use and resource efficiency, both the total quantity used and the efficiency in use should be taken into account, which capture both absolute and relative decoupling of economic output from resource use, respectively. Therefore, according to Eurostat (2001), out of the many material flow indicators, a few promising core indicators

[149] Nomenclature statistique des activités économiques dans la Communauté européenne

[150] International Standard Industrial Classification of All Economic Activities

should be selected, for instance, the consumption indicators DMC and Total Material Consumption (TMC).

Recent EU policy documents, in particular the Roadmap to a Resource Efficient Europe,[151] recommend Resource Productivity as a provisional lead indicator for measuring Resource Efficiency. Resource productivity and material productivity are frequently used as synonyms, even though resource productivity would ideally encompass all resources covered by the broadest definition of resources.[152] Since Resource Productivity is linked to Material Productivity because Material Productivity equals GDP/DMC (Domestic Material Productivity) and likewise GDP/TMC (Total Material Productivity), which in turn equals Resource Productivity, even the most recent call for resource efficiency indicators includes Resource Productivity and TMC. This also highlights the policy relevance, both of Resource Productivity and TMC, in terms of indicating the productivity and efficiency with which natural resources are used. Overall, these indicators allow us to make statements on the progress towards the decoupling of economic growth from resource use.

Applicability to measuring progress towards sustainable industries

In general, the indicator can capture the performance of industries or sectors because, for one thing, being based on DMC, materials used may need to be aggregated into material categories, thus facilitating generalization to product categories or industry sectors. Thus, resource productivity and material productivity can measure the resource efficiency of industries and industrial sectors.

However, in order to be an effective policy target, decoupling must not only focus on resource efficiency in terms of breaking the link between economic growth and resource use (so-called resource decoupling). It must also cover decoupling of economic growth from the environmental impacts linked to resource use (impact decoupling). Both resource productivity and material productivity aggregate the material flows measured by weight thereby not accounting for the considerably different environmental impacts of different materials. Furthermore, as long as GDP is put in relation to DMC, neither unused domestic extraction (i.e., materials not fit or intended for use) nor the indirect upstream flows and impacts of imports and exports are reflected in the indicator.

While the latter criticism is addressed by redefining resource productivity as GDP/TMC, with TMC able to cover the hidden flows linked to materials used for imports and associated with exports, the main challenge remains in the aggregation of the materials by weight. In addition, replacing DMC by TMC in measuring resource productivity is challenging because collecting and calculating data on the hidden flows is currently meeting substantial difficulties from a practical perspective.

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[151] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

[152] See for instance the definition from the Thematic Strategy on the sustainable use of natural resources (European Commission, COM(2005) 670 final, p. 3, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0670:FIN:EN:PDF) which covers "raw materials such as minerals, biomass and biological resources; environmental media such as air, water and soil; flow resources such as wind, geothermal, tidal and solar energy; and space (land area)."

Therefore, altogether resource productivity and material productivity are important indicators for indicating efficient resource use within industries and industrial development, but in order to measure progress towards sustainable industries, the environmental impacts should be supplemented through other adequate indicators, such as the EMC.

6.1.9 Total Material Consumption (TMC)

Much of what has been discussed under 6.1.8, Resource Productivity and Material Productivity, also applies to the TMC indicator.

Applicability to measuring progress towards sustainable industries

Nonetheless, the TMC indicator in general can capture the performance of industries or sectors and thus measure the absolute efficiency of materials used in industrial sectors. However, although TMC is a definitive improvement versus DMC because it includes hidden flows or materials use associated with imports and exports, up to now it remains very difficult to measure. Furthermore, the main criticism is the aggregation of the materials by weight, which does not allow for differentiation by environmental impact.

Furthermore, since development is underway to calculate resource productivity as GDP/TMC, there is no need to include TMC separately into a set of proposed indicators for indicating efficient resource use within industries and industrial development.

6.1.10 Ecological Footprint (EF)

The EF has experienced a substantial rise in popularity among a wide audience, including public policy makers, environmental managers, environmental activists, scientists, the media, and the general public. The primary appeal of the EF lies in its intuitive interpretation as a measure of the use of natural resources to satisfy human consumption in relation to the available amount of resources that can be provided in the long-term. It represents the amount of biologically productive land and sea area necessary to supply the resources a human population consumes and mitigate associated waste.

Calculating consumption and use of natural resources, including the extraction of minerals, plants and fiber, the assimilation of waste products, and the dissipation of pollutants, poses a considerable challenge, and the EF relies on established and innovative accounting principles to perform these calculations. Using the concept of a ‘global hectare’ the EF converts resource consumption, waste, and pollution to a globally comparable metric and compares the global hectares used by a region, country, world, etc. to the available biocapacity. Footprint values are calculated for carbon, food, housing, and goods and services using prevailing technology.

These calculations require a number of assumptions and generalizations that may affect the accuracy of the estimates (e.g., with respect to technological innovation, omission of a number of ecosystem products and services, simplification of complicated network structures, and application of a weak sustainability paradigm that allows for substitution of critical natural capital and ecosystem services with other forms of capital).

Applicability to measuring progress towards sustainable industries

On the other hand, the EF can be applied to a process such as the manufacturing of a product. This resource accounting is similar to LCA wherein the consumption of energy, biomass (food, fiber), building material, water, and other resources are converted into a normalized measure of land area called 'global hectares' (gha). Yet it is not designed to evaluate the resource efficiency or sustainability of industry but rather that of the end user, the consumer. The EF measures to what extent current consumption patterns undermine the ability of natural ecosystems to provide the resources and services to meet future consumption needs. It is a measure of overshooting regenerative capacity, similar to drawing down a bank account without adequate provisions to replenish it. As such, the EF can indicate unsustainable consumption, but it is difficult to establish the direct link to the contribution of industry to the EF value.

Nonetheless, the accounting tables developed for the EF can, in theory, be extended to include country- or region-specific information on resource efficiency in the production process. Currently, the EF only differentiates according to the varying productive capacity of five types of land and water (also across regions). If geographically varying and industry-specific efficiency factors were to be taken into account, the available biocapacity per geographical unit could be estimated more accurately (e.g., a ton of coal in China produces a different amount of food or fiber than one used in Germany due to different energy efficiencies in the countries' respective energy and manufacturing industries).

The data basis for the EF has improved substantially since the EF's initial launch in the 1990s. This is in part due to the extensive work done by the Global Footprint Network (GFN) to compile data tables for nearly all countries and regions in the world and in part because resource use data have themselves become more widely available. This trend can be expected to continue, especially since the EF has reached a fairly high level of acceptance among environmental policy makers.

Methodological development also continues for the EF and it is noted that the GFN has initiated a Committee on EF methodological development and standards that aims to facilitate the proper application of EF accounting principles and thereby further advance its uptake globally. It is not anticipated, however, that industrial efficiency and resource use intensity factors will be added in the near future.

In conclusion, the EF is a very prominent resource efficiency indicator focused on the consumer side and hence is at present of very limited use for measuring resource efficiency and sustainability of industries.

6.2 The MDG 7 Goal and recommendations for sustainable industry indicators

The MDG 7 goal includes a number of indicators aimed at tracking progress towards reducing or even halting the loss of biodiversity as well as improving human health by removing environmentally mediated infections through improved drinking water and sanitation. Specifically, the indicators are:

- Target 7a: Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
- Target 7b: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss
  - 7.1 Proportion of land area covered by forest
  - 7.2 CO_2 emissions, total, per capita and per $1 GDP (PPP)
  - 7.3 Consumption of ozone-depleting substances
  - 7.4 Proportion of fish stocks within safe biological limits
  - 7.5 Proportion of total water resources used
  - 7.6 Proportion of terrestrial and marine areas protected
  - 7.7 Proportion of species threatened with extinction
- Target 7c: Reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation
  - 7.8 Proportion of population using an improved drinking water source
  - 7.9 Proportion of population using an improved sanitation facility
- Target 7d: Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020
  - 7.10 Proportion of urban population living in slums

As can be seen, none of these indicators addresses industries specifically or with the detail necessary to gain a complete and differentiated picture of the contributions of industry to resource extraction, use, waste, pollution, and environmental impacts.

Specifically, while the MDGs contain a number of indicators measuring resource stock (7.1, 7.6), resource use (7.4, 7.5, 7.7), and pollution (7.2, 7.3), there is no indicator for raw materials scarcity or efficient use and management of the waste and pollution that accompany industrial production. Thus, the indicators proposed in this study aim to fill these important gaps from the policy perspective of greening industry and making it more accountable for resource depletion and pollution.

Following the collective review of the literature, data sources, and selected indicators, we recommend the following set of indicators to be integrated into the MDGs:

6.2.1 Indicators for measuring resource efficiency of industries and industrial development

Based on the discussion, resource productivity and material productivity are important indicators for measuring efficient resource use within industries and industrial development. In particular, resource productivity receives great attention on a European level, where it is recommended as a headline indicator to monitor progress on decoupling as a critical element of sustainable development in the EU. Therefore, we recommend putting forward resource productivity as a relevant indicator for measuring SDGs relating to sustainable industries.

Since resource productivity can only serve as a measure for relative resource decoupling, but not for impact decoupling, the environmental impacts should be captured with other adequate indicators in order to measure progress towards sustainable industries. Hence, we recommend using resource productivity for measuring resource consumption as part of a basket of indicators which can adequately account for environmental impacts.

In addition, the Sustainable Process Index (SPI) as well as the sector-specific or resource-specific indicators (a) energy intensity by sector, (b) water consumption by sector, (c) water abstraction and stress, and (d) CO_2 productivity provide additional, specific, and detailed information about the use of key natural resources across the spectrum of industrial sectors. This information is needed to identify the main users of scarce or impact-intensive resources and to tailor policy instruments to increase resource efficiency and reduce environmental impacts. While informative regarding the general industrial composition and shift towards the market for environmental goods and services, the indicator measuring turnover in environmental goods and services does not address either aspect unequivocally and hence is not recommended to be selected as a single indicator or member of a set of indicators.

6.2.2 Indicators for measuring the environmental impacts associated with different life cycle stages of industrial production

Though EMC has been identified as the most appropriate indicator established for measuring environmental impacts of resource use, the discussion of its limitations above shows a clear need to consider further indicators that are currently under development. These are, in particular, the overall environmental impact indicator and the eco-efficiency indicator.

Overall environmental impact indicator

According to JRC-IES (2010), the overall environmental impact indicator will need to capture environmental impacts and include the shifting of ecological burdens related to imports and exports. Methodologically, this is achieved by combining "territorial macro statistics regarding emissions, resource extraction and related LCI data for imports and exports [which is] essential to effectively monitor the decoupling, and reveal – otherwise unaccounted for – outsourcing of energy, resource and emission intensive industry production from the EU27 territory."[153] Concerning impact categories, the overall environmental impact ranking considers the following 12 categories: toxicity, radiation, carcinogens, respiratory inorganics, climate change, ozone layer, acidification, eutrophication, ecotoxicity, summer smog, land use (through global agricultural land use data), and resource depletion. The impacts looked at cover damages to human health and ecosystem diversity and resource scarcity.

One advantage of the overall environmental impact indicator over the EMC is that the former captures all goods and services consumed within one year, while the latter only accounts for the environmental impacts of the materials selected.

Eco-efficiency indicator

The eco-efficiency indicator is meant to measure impact decoupling, i.e., the decoupling of economic growth from the overall environmental impacts linked to apparent consumption and related use of natural resources.[154] It is calculated as economic performance in € (usually measured as GDP) in relation to the environmental impact associated with the resource use (as measured through the overall environmental impact indicator). The overall environmental impact will be a single score arrived at by weighting the impact scores across all impact categories.

Both indicators furthermore essentially cover all life cycle stages of products and are therefore very relevant to measuring progress towards sustainable industries. Nonetheless, as EMC, at present knowledge, constitutes also an important element of measuring environmental impacts of resource use, it should be part of the basket of indicators until eco-efficiency and the overall environmental impact indicator are fully established and readily usable.

CO_2 emissions are almost always collected through an emissions inventory or an Energy LCA and should therefore be available for different LCA stages.

6.2.3 Indicators capturing the social and economic dimension of industries and industrial development

Sustainability requires not only the generation and maintenance of sufficient economic activity within the ecological limits of the planet but also the consideration of social aspects such as equity, cohesion, and participation in decision-making.

None of the selected 10 indicators is particularly well suited to reflect on the social dimension of industry. This is due to the focus on indicators for measuring the 'greening' of industry.

From an economic point of view, the transition to a 'green economy' should not undermine the capacity of an economy to continue to provide its citizens with a high standard of living. Indicators that measure aspects of the economic dimension of industrial development are the turnover in the environmental goods and services industries, at least insofar as it has been

[153] JRC and IES 2010, p. 17.
[154] JRC and IES 2010.

shown to create value added and jobs, as well as indicators measuring resource productivity such as resource use per unit GDP. Becoming more productive with respect to the use of natural resources not only extends and protects the availability of such resources in the future, but it also saves money and may generate innovative capital and hence increased competitiveness.

The favored indicator for assessing environmental impacts, the EMC, can also be counted here because it reduces costs for remediation, rehabilitation, and other 'defensive' expenditures that would occur without the reduction of environmental impacts.

On the other hand, there are, so far, no readily available indicators to assess the distributive impacts of the greening of industries other than basic indicators to reflect the distribution of income such as the GINI coefficient.

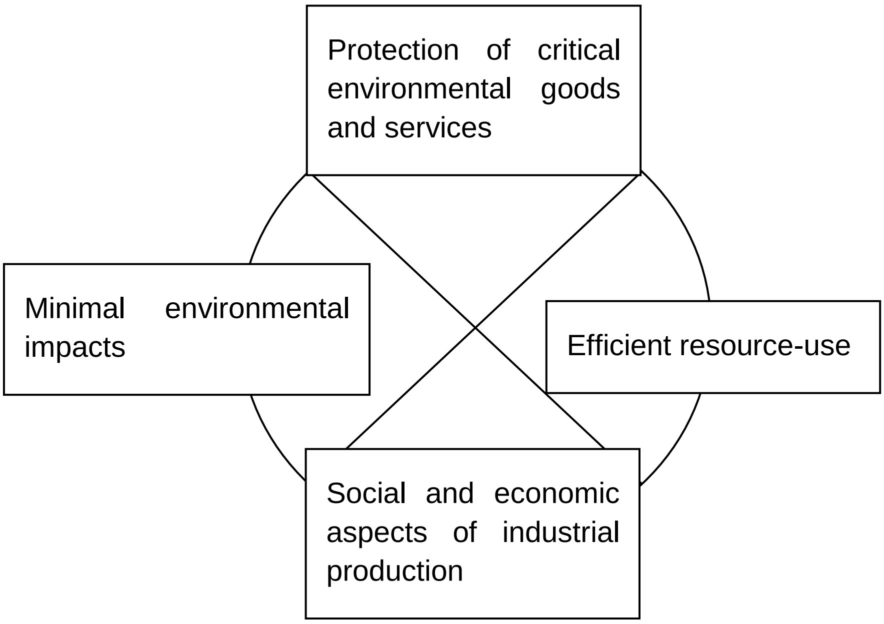
The social dimension of sustainable industrial development has not been the focus of this scoping study, but could be further developed in subsequent research.

6.2.4 Basket / Set of indicators

Considering the different aspects of industrial production and the environmental impacts covered by the ten indicators, it is only logical to consider building a basket of indicators that jointly give a more comprehensive picture than any of the indicators could give alone.

Figure 3 shows how the different dimensions of sustainable industry could be visualized. An indicator basket should then be built to cover these dimensions with the minimal number of indicators.

Figure 3: Different dimensions of sustainable industrial development



Based on the reviews conducted in the previous chapters, the following indicators are proposed to be included in the basket:

- **EMC** (or eco-efficiency or overall environmental impact indicator) to capture *environmental impacts;*
- **Energy intensity by sector and production-based CO_2 productivity** to cover the *critical environmental areas* energy and climate change;
- **Water productivity by sector and water stress** to capture resource efficiency for a second *critical environmental resource; and*
- **Resource productivity (or TMC over GDP)** to capture *resource efficiency.*

As shown, the social aspects of sustainable industry have not been within the scope of this analysis.

6.3 Outlook

The findings in this draft reflect the best knowledge and peer-reviewed research available to the team at Ecologic Institute. Special care was taken to ensure a high level of quality in this draft report. Still errors and mistakes cannot be completely ruled out, but will gladly be corrected.

This scoping study did not provide the necessary frame to develop a fully fledged analysis or road-test the proposed indicator basket. Such research tasks should be undertaken in follow-up projects under the auspices of UNIDO.

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8 Annex

Evaluation factsheets for resource indicators not selected for further analysis

Table 27: Evaluation factsheet for the Direct Material Input indicator

Resource Indicator: Direct Material Input (DMI)
Brief description: DMI is an input indicator which measures the direct flows of materials input into the economy for use in production and consumption. Hence, DMI relates to the material supply. It equals domestic (used) extraction (fossil fuels, minerals and biomass) plus physical imports (mass weight of imported goods). Total Material Input (TMI) equals DMI (DEU plus imports) plus unused domestic extraction (UDE[155]).
Source/reference(s): Bringezu, S., Schütz, H., Moll, S. (2003): Rationale for and interpretation of economy-wide Material Flow Analysis and derived indicators, Journal of Industrial Ecology, Vol. 7, no. 2, p. 43-64 EEA (2003): Indicator fact sheet Direct Material Input (DMI), http://eea.eionet.europa.eu/Public/irc/eionet-circle/etc_waste/library?l=/core_indicators_wmf/fact_sheets/indicator_dmipdf/_EN_1.0_&a=d Eurostat (2001): Economy-wide material flow accounts and derived indicators – A methodological guide OECD (2008a): Measuring material flows and resource productivity – Synthesis report, http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD (2008b): Measuring material flows and resource productivity – Volume I, The OECD Guide, http://www.oecd.org/dataoecd/46/48/40485853.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* DMI is related to materials extracted, input into production and consumption processes and also disposed of through waste, therefore different life cycle stages can be addressed. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, and because hidden flows (e.g. raw materials extracted in foreign countries to produce the products traded and thereby impacting on the environment) are not included, DMI is not well-suited to measure impacts from a life cycle perspective.	😐

[155] Unused domestic extraction (UDE, i.e. raw materials not fit or intended for use) relates to three main groups: mining and quarrying (associated extraction wastes, e.g. overburden materials), biomass harvest (e.g. discarded by-catch or losses during wood harvesting) and soil excavation (materials accumulating during construction or dredging activities) (Eurostat 2001).

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* DMI addresses the three main categories fossil fuels, minerals and biomass are addressed, therefore it may be applied to capturing specific industries or sectors within these categories.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* DMI does not include hidden flows, i.e. unused domestic extraction or indirect flows linked to imported goods. Therefore, similar to DMC, DMI does not reflect the range of environmental impacts associated with the materials input. Therefore, using DMI may actually convey a wrong message on the environmental performance of a country's material use: if a country is replacing domestic resource extraction by increasing import of raw materials, DMI may signal lowered environmental impacts within the domestic territory, because parts of the ecological burden of extraction is shifted to the exporting countries. Furthermore, DMI aggregates materials by their weight, regardless of their environmental impact. However, DMI constitutes a proxy for potential environmental pressures – hence for a generic environmental pressure – associated with the materials input into a national economy, because all materials eventually are turned into emissions or waste with associated environmental impacts. Therefore, DMI could be used in a complementary way to existing environmental pressure indicators to cover the quantity dimension.	☹
Required data efforts	*Which data is required to establish the indicator?* Calculating DMI requires compiling data from different statistical sources in order to cover the material input considered (e.g. energy balances, extraction and production statistics, foreign trade statistics and agriculture statistics). *How much effort is needed to collect, prepare and use the data?* Because material flow accounts are not available for all countries and because some information is only of limited availability (such as data for domestic mineral extraction), DMI will also have to be based on certain estimations. Since DMI integrates data from different statistical sources (e.g. energy, minerals and agriculture), which are collected and prepared by different international (such as International Energy Agency or FAO) and national institutions, reliability and robustness of the data differ – in particular as regards domestic mineral extraction for which data is based on different international source with differing reporting categories and periods.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. Eurostat 2001)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* In how far DMI is policy relevant and of how much use the information provided is for assessing the sustainability of resource use and resource management is still subject to debate. However, as part of the calculation of DMC, also DMI is a relevant measure in the discussion of decoupling economic growth from resource use and associated environmental impacts.	😐
Communication	*Can the indicator be visually illustrated?* It can be and frequently is visually illustrated, usually as input of different materials in metric tonnes (see e.g. EEA 2003).	☺

Table 28: Evaluation factsheet for the Domestic Extraction Used indicator

Resource Indicator: Domestic Extraction Used (DEU)
Brief description: DEU measures the input of raw materials annually extracted from the natural environment and physically entered into the economic system to be further processed or directly consumed, hence DEU is an input indicator. The materials are usually converted into or components of products and thus are of economic value. Similar to DMC raw materials do not cover water and air, but fossil fuels, minerals and biomass. DEU plus imports equals DMI. Unused domestic extraction (UDE, i.e. raw materials not fit or intended for use) is related to three main groups: mining and quarrying (associated extraction wastes, e.g. overburden materials), biomass harvest (e.g. discarded by-catch or losses during wood harvesting) and soil excavation (materials accumulating during construction or dredging activities) (Eurostat 2001).
Source/reference(s): European Commission (2007): Progress report on the European Union Sustainable Development Strategy 2007. Accompanying document to the Communication from the Commission to the Council and the European Parliament, Commission staff working document, SEC(2007) 1416. Brussels, 22.10.2007. EEA (2010): The European environment state and outlook 2010. Material resources and waste, http://www.eea.europa.eu/soer/europe/material-resources-and-waste Eurostat (2001): Economy-wide material flow accounts and derived indicators – A methodological guide, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF OECD (2008a): Measuring material flows and resource productivity – Synthesis report, http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD (2008b): Measuring material flows and resource productivity – Volume I. The OECD Guide, http://www.oecd.org/dataoecd/46/48/40485853.pdf

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* DEU is related to materials extracted, input into production and consumption processes and also disposed of through waste, therefore different life cycle stages can be addressed. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, and because hidden flows (e.g. raw materials extracted in foreign countries to produce the products traded and thereby impacting on the environment), as well as unused extraction are not included, DEU is not well-suited to measure impacts from a life cycle perspective.	😐

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* DEU addresses the three main categories fossil fuels, minerals and biomass are addressed, therefore it may be applied to capturing specific industries or sectors within these categories.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* Because DEU does neither account for unused domestic extraction (i.e. not fit or intended for use), nor the indirect upstream flows and impacts of imports (for instance, raw materials which are extracted abroad for import not as priced goods), DEU is only able to reflect some of the environmental impacts associated with the use of different materials (i.e. the materials actually used). It order to fully cover environmental impacts, DEU would need to be supplemented with the impacts of unused domestic extraction (UDE).	☹
Required data efforts	*Which data is required to establish the indicator?* As part of DMI, also calculating DEU requires to compile data from different statistical sources in order to cover the material input considered (e.g. energy balances, extraction and production statistics, foreign trade statistics and agriculture statistics). *How much effort is needed to collect, prepare and use the data?* Because material flow accounts are not available for all countries and because some information is only of limited availability (such as data for domestic mineral extraction), also DEU will have to be based partially on certain estimations. Since DEU integrates data from different statistical sources (e.g. energy, minerals and agriculture), which are collected and prepared by different international (such as International Energy Agency or FAO) and national institutions, reliability and robustness of the data differ – in particular as regards domestic mineral extraction for which data is based on different international source with differing reporting categories and periods.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. Eurostat 2001)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* In how far DEU is policy relevant and of how much use the information provided is for assessing the sustainability of resource use and resource management is still subject to debate. However, as part of the calculation of DMC, also DEU is a relevant measure in the discussion of decoupling economic growth from resource use and associated environmental impacts.	😐
Communication	*Can the indicator be visually illustrated?* It can be and frequently is visually illustrated, for instance in UNEP's Global Environment Outlook 4 (see http://maps.grida.no/go/graphic/domestic-extraction-used-in-eu-15-compared-to-imports-of-industrial-minerals-and-ores).	☺

Table 29: Evaluation factsheet for the Domestic Material Consumption indicator

Resource Indicator: Domestic Material Consumption (DMC)
Brief description: DMC measures the total amount of materials directly used by an economy, relating to apparent consumption, not to final consumption. DMC thus is a consumption indicator, it is measured in metric tons. According to Eurostat, DMC can be defined as "the annual quantity of raw materials extracted from the domestic territory of an economy, plus all physical imports minus all physical exports." (Eurostat 2009: p. 128) The materials directly used encompass "all solid, liquid and gaseous materials that enter the economy for further use in production and consumption processes." (Eurostat 2009:, p. 145). However, air consumption and water consumption, other than the water content of the materials used, are excluded. Therefore, materials directly used mainly cover raw materials domestically extracted (Domestic Extraction Used, DEU) and imports, the sum of which constitutes the direct material input (DMI). DMC is then obtained by deducting exports from DMI. Domestic raw materials are assigned to three main categories: fossil fuels (e.g. hard coals and crude oil), minerals (e.g. construction minerals, metal ores) and biomass (e.g. from harvesting, grazing or fishing). Imports and exports are clustered according to their level of manufacturing into: raw materials, semi-manufactured product, finished products, other products (predominantly relating to products of the nutrition industry), packaging material of imported products, and waste imported for final treatment and disposal (Eurostat 2001).
Source/reference(s): European Commission (2007): Progress report on the European Union Sustainable Development Strategy 2007. Accompanying document to the Communication, Commission staff working document, SEC(2007) 1416. Brussels, 22.10.2007. European Commission (2005): Policy review on decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries, CML report 166, http://www.leidenuniv.nl/cml/ssp/projects/dematerialisation/policy_review_on_decoupling.pdf EEA (2010): The European environment state and outlook 2010 – Material resources and waste, http://www.eea.europa.eu/soer/europe/material-resources-and-waste Eurostat (2009): Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg Eurostat (2001): Economy-wide material flow accounts and derived indicators – A methodological guide OECD (2008a): Measuring material flows and resource productivity – Synthesis report, http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD (2008b): Measuring material flows and resource productivity – Volume I. The OECD Guide, http://www.oecd.org/dataoecd/46/48/40485853.pdf UNDESA (Division for Sustainable Development): Methodology sheets for the theme consumption and production patterns. Subtheme material consumption: Domestic Material Consumption, http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/consumption_production/domestic_material_consumption.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* DMC is able to measure materials extracted, used (production and consumption) and also disposed of through waste, therefore different life cycle stages can be addressed. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, and because hidden flows (e.g. raw materials extracted in foreign countries to produce the products traded and thereby impacting on the environment) are not included, DMC is not well-suited to measure impacts from a life cycle perspective.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* DMC is material specific and also linked to semi-manufactured or finished products, but in particular for complex products requires aggregation to material categories. This may facilitate generalization to product categories or industry sectors. Furthermore, because the three main categories fossil fuels, minerals and biomass are addressed, DMC may be applied to capturing specific industries or sectors within these categories.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* Because DMC does neither account for unused domestic extraction (i.e. materials not fit or intended for use), nor the indirect upstream flows and impacts of imports and exports, DMC does not reflect the range of environmental impacts associated with the use of different materials. For Europe, this is aggravated by the fact that many resources used are substituted by imports, which shifts the associated impacts elsewhere (ecological burden shifting). Though DMC helps to assess the absolute level of resource use reflecting all material emitted from or accumulated in a given region, it only gives an indication towards the emission and waste potential linked to resources consumed. Therefore, DMC is not able to measure the true environmental impact of material consumption – in particular because upstream and downstream impacts of imports and exports are neglected, but also because this mass-based approach does not account for the different environmental impacts that different materials have (for instance, the impacts of 1 metric ton of mercury are doubtless much greater than those of 1 metric ton of gravel). Hence further research and development for refined indicators are needed.	☹
Required data efforts	*Which data is required to establish the indicator?* DMC requires data on consumption and trade of all materials flowing in and out of an economy. Furthermore, in order to measure progress towards decoupling of economic growth from resource use GDP data is needed place. When country comparisons shall be made, than national population data would be necessary to calculate GDP per capita. *How much effort is needed to collect, prepare and use the data?* In order to calculate the DMC for complex manufactured product (e.g. consisting of a mix of materials), the product needs to be attributed to the "dominant" material category. This likely requires more efforts to set up conversion tables to arrive at a well-founded attribution of products and imports.	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Uncertainties and data imputation	*How are uncertainties about data reflected in the indicator and how are missing data imputed?* There are uncertainties linked to using DMC, mainly concerning the calculation. This applies to - standardizing the water contents of domestic harvest and grazing of biomass used as fodder for ruminants, - often insufficient statistical data on bulk minerals for construction, and - the very limited availability of gross weight data for ores concerning the domestic extraction of metallic minerals, so that usually net metal contents have to be used instead.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. Eurostat 2001)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* DMC is able to measure the absolute level of resources used within an economy. Furthermore, DMC can be used to indicate the progress towards decoupling of economic growth from the use of natural (but less so on decoupling of associated environmental impacts due to focusing on materials' weight and therefore neglecting the environmental impacts of different materials). Decoupling is an increasingly important policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These being core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020 Strategy[156] or the Roadmap to a Resource Efficient Europe[157], DMC is of high policy relevance internationally as well as nationally. *Does the indicator measure aspects which can be influenced by policy makers?* Because DMC measures the materials, which physically remain on the territory of a country in the form of additional material stock or as emissions or waste, DMC is particularly relevant from the national perspective. Thus, it is not only relevant to policy makers as regards the national economy, but it very likely can and will be influenced by policy makers, for instance through regulating imports and addressing consumption (patterns).	☺
Communication	*Can the indicator be visually illustrated?* It can be and frequently is visually illustrated, in particular concerning the progress towards decoupling by displaying DMC against GDP (see for instance OECD 2008b).	☺

[156] European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.

[157] European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Table 30: Evaluation factsheet for the Eco-Labels on products and services indicator

Resource Indicator: Eco-Labels on products and services (EU Eco Label)
Brief description: The European Ecolabel, a voluntary scheme introduced in 1992, provides easy identification of products and services which comply with specific environmental criteria. Product groups include cleaning products, appliances, paper products, textile and home and garden products, lubricants and services such as tourist accommodation[158] In addition to the EU Ecolabel, many countries have adopted similar schemes which comply with Ecolabel standards, including the German Blue Angel or the Nordic Swan[159][160]. There are currently 26 product groups covering twelve major areas of manufacturing and one service activity[161]. The related indicator, integrated into Eurostat's monitoring framework for the EU sustainable development strategy, measures the success of the EU Ecolabel based on the number of eco-label or 'EU flower' awards in EU Member States[162].
Source/reference(s): Eurostat (2009): Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg European Commission 2011c. EC Environment Website, Industry and Technology – EU Ecolabel, http://ec.europa.eu/environment/ecolabel/index_en.htm

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/☺/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Eco-label assessments are based on studies which analyse the impact of the product or service on the environment throughout its life-cycle as part of Environmental Product Statements (EPS), starting from raw	☺

[158] EC Website, Ecolabels

[159] Eurostat 2009

[160] A list of related indicators can be found at the following site: http://ec.europa.eu/environment/ecolabel/useful_links/other_ecolabels_en.htm

[161] Eurostat 2009

[162] Eurostat 2009

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	material extraction in the pre-production stage, through to production, distribution and disposal[163].	
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The indicator assesses a variety of products and services, but is not broken down by category	☹
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Ecolabels provide an overview of the growth in environmental products, but the indicator, which tracks the success of the labeling program, does not provide information regarding specific environmental impacts. The Ecolabel itself "is an important tool in terms of corporate social responsibility, contributing to sustainable development at both business and consumer level. It also encourages the manufacturing of products and services with reduced impact on the environment by providing consumers with information on the consequences of their consumption"[164].	😐
Communication	*Can the indicator be visually illustrated?* Yes. See, for example, Eurostat 2009	☺

[163] EC Website, Ecolabels

[164] Eurostat 2009

Table 31: Evaluation factsheet for the Employment in environmental goods and services sector indicator

Resource Indicator: Employment in environmental goods and services sector
Brief description: In 2009, Eurostat published a handbook regarding how to collect, interpret and present data on the environmental goods and services sector (EGSS)[165][166], in which employment is one of four key indicators (for other indicators, see table on turnover, value added, and exports). According to Eurostat[167], employment in EGSS is measured by the “full-time equivalent employment which is the number of full-time equivalent jobs, defined as total hours worked divided by average annual hours worked in full-time jobs.” The OECD also measures employment in the environmental products sector (for selected countries), including the following sectors: recycling (ISIC 37); collection, purification and distribution of water (ISIC 41); sewage and refuse disposal, sanitation and similar activities (ISIC 90). The indicator is expressed a percentage of total employment[168]. In addition, the *Green Economy Initiative*, launched in 2008 and led by the UNEP, provides analysis and guidance regarding policies and investments to achieve a green transformation and includes a framework for green economy indicators to assess progress. One of the focus areas for the initiative is “Green transformation of key sectors and the economy” focusing on investments in a green transformation of various sectors of the economy, and their associated share in output and employment.”[169] One of the challenges in assessing this indicator is the lack of an internationally agreed upon classification, although as shown above, efforts to define these categories are underway at both the European level as well as the international level through the UN System of Environmental Economic Accounting[170]. In addition, most entrepreneurial activities that might be classified as green are currently not captured.

[165] Eurostat 2009

[166] Eurostat (2009) defines EGSS as “a heterogeneous set of producers of technologies, goods and services that:

- Measure, control, restore, prevent, treat, minimise, research and sensitise environmental damages to air, water and soil as well as problems related to waste, noise, biodiversity and landscapes. This includes ‘cleaner’ technologies, goods and services that prevent or minimise pollution.
- Measure, control, restore, prevent, minimise, research and sensitise resource depletion. This results mainly in resource-efficient technologies, goods and services that minimise the use of natural resources.

These technologies and products (i.e. goods and services) must satisfy the end purpose criterion, i.e. they must have an environmental protection or resource management purpose (hereinafter ‘environmental purpose’) as their prime objective.”

[167] Eurostat Website

[168] OECD 2011

[169] OECD Green Growth Indicators Website

[170] OECD 2011

Source/reference(s):
Eurostat 2009. Environmental goods and services sector handbook
Eurostat 2011. Environmental goods and services sector¸ http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Environmental_goods_and_services_sector
OECD 2011a. Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing. http://dx.doi.org/10.1787/9789264111356-en
OECD 2011b. OECD Green Growth Indicators Website, http://www.oecd.org/document/58/0,3746,en_2649_37425_48303098_1_1_1_37425,00.html

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Employment data are not captured by LCA methods. *What aspects of the LCA chain does the indicator measure?* N/A	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* This indicator relates directly to EGSS, capturing trends in employment in industries specifically within the environmental goods and services sector.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* As a measure of employment, this indicator directly quantifies social impacts. Growth in EGSS has the potential for job creation, a significant social benefit, although the outcome of this indicator depends on the definition of EGSS, which is currently being refined at both the European and international level. In addition, policies that promote growth in green industries may also impact other industries. Thus, growth in employment in EGSS may result in job losses in other sectors or may create jobs in other sectors via spillovers. An ideal sustainability indicator would measure the net effect of environmental policies on employment. A similar challenge applies regarding environmental objectives. Increased employment in recycling can point to increased recycling efforts or to an increased waste generation which are very different from a sustainability point of view.	😐

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Data regarding overall employment as well as a review of existing policies which may impact EGSS provide complementary information regarding overall social impacts related to EGSS. Eurostat also notes that data on gender and education level could enhance the value of this indicator[171]. Although this indicator provides indirect information regarding growth in EGSS, it does not provide any information regarding environmental impacts or economic impacts.	
Required data efforts	*Which data is required to establish the indicator?* Employment data for classes of industry defined by Eurostat as environmental (or according to another framework); public sector employment in environmental initiatives Complementary data: employment by gender in EGSS; educational level of employees in EEGS; overall employment/unemployment data *How much effort is needed to collect, prepare and use the data?* Data are available from both Eurostat (for many European countries) and the OECD, although as previously stated, the definition of environmental goods and services may change depending on which data source is used. Therefore, it could be challenging to collect harmonized data. In addition, if the desired statistics are not already compiled by Eurostat or a similar entity, the preparation and use of the data could require significant effort. For example, although classes of the industries defined by Eurostat as “environmental” are available in NACE (Nomenclature of Activities in the European Union), if the NACE class is not 100% environmental, then this industry must be appropriately scaled[172]. Detail regarding methodology is available in the Eurostat handbook (2009). Therefore, due to the emerging nature of this indicator, there could be moderate to significant challenges in collecting, preparing, and using data in a meaningful way, although these challenges will most likely be eliminated in the near future.	😐
Compatibility	*Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?* Eurostat developed a classification of EGSS activities which is consistent with the SERIEE and SEEA frameworks[173].	☺

[171] Eurostat 2009

[172] Eurostat 2009

[173] Eurostat 2009

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Employment in EGSS is related to a number of policy priorities and initiatives, including the Gothenburg strategy for a sustainable Europe and the Lisbon strategy for a competitive, dynamic and inclusive Europe. In 2004, the Environmental Technologies Action Plan (ETAP) was launched. ETAP is a new initiative aimed at encouraging European industry to exploit its potential for green innovation and increase its share of the market for goods and services[174]. However, typically these initiatives are based on growth, not employment specifically, and thus this is an indirect measure. Therefore, this indicator is at best a proxy for comparing the size of the environmentally friendly industrial base to that of conventional production and manufacturing *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Yes, depending on data available (ie. data for certain countries may not be available at this time)	😐
Communication	*Can the indicator be visually illustrated?* Yes. See, for example, OECD 2011a.	☺

[174] Eurostat 2009

Table 32: Evaluation factsheet for the Employment in the renewable energy sector indicator

Resource Indicator:
Employment in the renewable energy sector

Brief description:
Prepared by the WorldWatch Institute, the Renewables 2005 Global Status Report includes a "jobs from renewable energy" indicator, measured based on the following methodology: "We conducted a literature review of analytical factors for jobs-per-existing-capacity and jobs-per-unit of produced capacity…We then totalled the jobs based on existing installed capacity in 2004 and new manufactured/installed capacity in 2004… The simplified alternative adopted here is to use analytical approaches to define employment coefficients, generally based on (a) information on labor time needed for a unit of power (i.e. person-years per MW), or (b) data on expenditure necessary to support a full-time job annually (person-years/USD invested)."[175]. This methodology is based on the premise that it is currently challenging to measure employment impacts of renewable energy development. However, a more valid approach, often challenging based on data limitations, would be to build input-output analysis models[176].

Although some countries, such as Germany and the Netherlands, provide this data and incorporate it into assessments on the performance of the renewable energy sector, this indicator is currently not widely used as a part of recognized sustainability frameworks. Instead, employment within the environmental goods and services industry is a more common indicator.

Source/reference(s):
Beurskens, L.W.M. and P. Lako (2010): Socio-economic indicators of renewable energy in 2009: Update of data of turnover and employment of renewable energy companies in the Netherlands.
Martinot et al (2005): Renewables 2005: Global status report, Paper prepared for the REn21 Network by the WorldWatch Institute
IEA 2011. IEA Statistical Databases, http://www.iea.org/stats/index.asp

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* This information is not typically collected in LCA.	☹

[175] Martinot 2005

[176] Martinot 2005

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	What aspects of the LCA chain does the indicator measure? N/A	
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* This indicator captures performance in the renewable energy industry.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* As a measure of employment, this indicator directly quantifies social impacts. However, this indicator only provides a gross view on employment in the renewable energy sector. If the renewable energy sector is subsidized the net gain in employment might be smaller as the investment in renewable energy crowds out other investment. Data regarding overall employment as well as a review of related policies provide complementary information regarding overall social impact. It is important to note that this indicator gives a gross view on employment in the renewable energy sector. If the renewable energy sector is subsidized the net gain in employment might be smaller as the investment in renewable energy crowds out other investment. From a social perspective this indicator might also hide important developments, as the new jobs created will often go to highly educated people with good job prospects. This indicator does not provide any information regarding environmental impacts or economic impacts.	😐
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* The methodology for this indicator is just emerging and differs based on the country or the particular analysis.	☹
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* This indicator can be used as a proxy for the size of the renewable energy industry relative to others, but with the caveat that employment figures do not measure environmental impacts. *Does the indicator measure aspects which can be influenced by policy makers?* Indirectly, as policy makers can influence growth in the renewable energy sector. As the indicator is only providing gross employment figures it may well give misleading messages. *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Due to the current lack of data or a defined methodology, this is typically not available in a short time frame.	😐
Communication	*Can the indicator be visually illustrated?* Yes, for instance as a graph showing trends over time.	☺

Table 33: Evaluation factsheet for the energy productivity indicator

Resource Indicator:

Energy productivity

Brief description:

Energy productivity is expressed as the amount of revenue generated per unit of energy used. In the context of the recent OECD (2011) report monitoring progress toward green growth, energy productivity is calculated as the amount of GDP generated per unit of total primary energy supply (TPES), which equals production plus imports minus exports minus international marine and aviation bunkers plus or minus stock changes.

Increasing energy productivity by sector may indicate efforts to improve energy efficiency and to reduce greenhouse gases (GHGs) and other harmful emissions. This in turn is a key factor in improving environmental performance and ensuring sustainable development. However, these indicators also reflect structural and climatic factors; thus, it cannot be used as a standalone measure of the efficiency of energy use in a country or industry. Other significant factors include the structure of the economy; the size of the country; and the climate[177].

Source/reference(s):

OECD 2011a. Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing. http://dx.doi.org/10.1787/9789264111356-en

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Although the typical usage of this indicator does not reflect different life cycle stages, it is theoretically LCA compatible. *What aspects of the LCA chain does the indicator measure?* By incorporating different life cycle stages into the energy input, this indicator could theoretically reflect all life cycle stages. For example, the input for energy productivity is a unit of energy used. Energy use could be defined as the total energy used through the life cycle of the product or service that produced the related unit of revenue. Related LCA methods: energy LCA by product, firm or sector using energy input-output tables and coupled with cost and production volume data to obtain productivity ratios The indicator can be used to estimate GHG emissions. It is possible to distinguish by energy type and quality (coal, oil, thermal energy content or exergy). However, the indicator – as used in current sustainability indicator sets – does not incorporate life cycle stages, and this	😐

[177] OECD 2011

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	would require significant additional effort from the perspective of data collection, preparation and use.	
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* It could be product specific (ie. the amount of energy used to produce inputs, transportation energy, direct manufacturing of the product, disposal, etc.) or could be calculated for different sectors, as demonstrated by the OECD (2011). However, energy intensity by sector is a more common indicator in this context.	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* This indicator does not directly measure environmental and social impacts, but it does provide a direct measure of economic impacts. There are obvious economic benefits to using less energy to derive a unit of revenue, which encourages economic growth and can in turn have positive second order effects on society. On the other hand, environmental impacts are not measured relative to GDP and so the development of the indicator can mask increasing environmental impacts. Improving energy productivity can enhance environmental performance in a number of ways, including lowering GHG and other emissions. However, in order to fully understand and quantify the environmental benefits, this indicator must be used in conjunction with a measure of the energy mix (ie. the share of renewable energy versus fossil resources, etc.).	☺
Required data efforts	*Which data is required to establish the indicator?* total energy supply/consumption (gross inland energy consumption or TPES); GDP *How much effort is needed to collect, prepare and use the data?* At the national or sectoral level, this data is relatively easy to obtain. However, at the product level or with the inclusion of more life cycle stages, the effort required to collect the data would be significant.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Energy intensity (see energy intensity indicator evaluation), which is the inverse of energy productivity, is a key indicator for measuring the Lisbon Process and its successor Europe 2020. Other relevant European legislation includes Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on Energy Statistics; Regulation No 1392/2007 of the European Parliament and of the Council of 13 November 2007 amending Council Regulation (EC) No 2223/96 with respect to the transmission of national accounts data"[178]. Other relevant agreements and initiatives include the Kyoto protocol (Article 2); the Barcelona European Council (2002); and the Brussels European Council (2003)[179]. *Does the indicator measure aspects which can be influenced by policy makers?*	😐

[178] Eurostat 2011

[179] Eurostat 2010

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	Yes. *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Yes	
Communication	*Can the indicator be visually illustrated?* Visual depictions of the indicator are available in the OECD (2011) report monitoring progress toward greening, as well as Eurostat's report (2009) monitoring the EU sustainable development strategy.	☺

Table 34: Evaluation factsheet for the Number of companies using environmental management schemes indicator

Resource Indicator: Number of companies using environmental management schemes (e.g., EMAS, ISO 14000 and 14001)
Brief description: UNIDO prepares the related indicator, "trends in ISO 14001 certification", measuring the number of companies receiving ISO 14001 certification. In order to analyse trends, UNIDO calculates the percentage share for any country or region. The ISO 14000 family "addresses various aspects of environmental management" including ISO 14001, a standard for environmental management systems (EMS). An EMS meeting the requirements of ISO 14001:2004 is a "management tool enabling an organization of any size or type to: • identify and control the environmental impact of its activities, products or services, and to • improve its environmental performance continually, and to • implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved"[180]. As a part of Eurostat's efforts to monitor the EU sustainable development strategy, Eurostat includes an indicator as the number of EMAS-registered organisations and sites. EMAS, or "eco-management and audit scheme", is a "voluntary environmental management system implemented by companies and other organizations from all sectors of economic activity including local authorities, to evaluate, report on and improve their environmental performance"[181] Although EMAS and other schemes, such as ISO 14001, have similar objectives, they are different in a number of ways, including the addition of four additional pillars of evaluation[182]: • continual improvement of environmental performance; • compliance with environmental legislation ensured by government supervision; • public information through annual reporting; • employee involvement. Therefore, Eurostat's indicator does not take into account companies and other organisations covered under alternative frameworks. Other related indicator sets include OECD Industrial Statistics and the European Pollution Emissions Register[183].

[180] ISO Website
[181] Eurostat 2009
[182] Specific differences are outlined in the European Commission's EMAS fact sheet, available at: http://ec.europa.eu/environment/emas/pdf/factsheet/fs_iso_en.pdf

Source/reference(s):
Eurostat (2009): Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg
European Commission – EMAS Helpdesk (2011): Leaflet on EMAS and ISO 14001, *http://ec.europa.eu/environment/emas/pdf/factsheet/fs_iso_en.pdf*
European Parliament (2009): Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC, *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009R1221:EN:NOT*
ISO: ISO Website, *http://www.iso.org/iso/catalogue_detail?csnumber=37456*
ISO: ISO Website, *ISO 14000 Essentials, http://www.iso.org/iso/iso_14000_essentials*
UNIDO: Indicator Fact Sheet, *http://www.unesco.org/water/wwap/wwdr/indicators/pdf/H5_Trends_in_ISO_14001_certification.pdf*

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* According to the most recent EMAS legislation: "For non-industrial organisations, such as local authorities or financial institutions, it is essential that they also consider the environmental aspects associated with their core business. An inventory limited to the environmental aspects of an organisation's site and facilities is insufficient. These include, but are not limited to: (i) product life cycle related issues (design, development, packaging, transportation, use and waste recovery/disposal)" In terms of ISO 14001, "waste streams are managed through life cycle assessments"[184]; ISO 14040/43 relates to "Life Cycle Assessment General Principles and Practices"[185]	😐

[183] UNIDO

[184] UNIDO

[185] ISO Website

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	However, this is in and by itself not a LCA type indicator	
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The UNIDO and Eurostat indicators measure total count, and thus do not take into account the performance of specific industries, but instead industry as a whole, although sectoral or industry performance is measurable.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The indicator does not directly measure environmental, economic, or social impacts.	😐
Required data efforts	*Which data is required to establish the indicator?* Number of companies and organizations under EMAS, ISO 14001, or other schemes (by country, region and worldwide).	-
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* This indicator does not reflect by itself how green an industry really is.	☹
Communication	*Can the indicator be visually illustrated?* Yes. See, for example, UNIDO's indicator fact sheets.	☺

Table 35: Evaluation factsheet for the Proportion of fish stocks within safe biological limits Indicator

Resource Indicator: Proportion of fish stocks within safe biological limits
Brief description: The proportion of fish stocks within safe biological limits is expressed as the percentage of fish stocks exploited within their level of maximum biological productivity[186]. As a part of the OECD's indicators measuring green growth, this is a global indicator. The FAO procedure to classify the state of the stocks includes the following categories: Underexploited, Moderately exploited, Fully exploited, Overexploited, Depleted and Recovering. This indicator was also integrated into the revised Millennium Development Goals (MDG) monitoring framework in 2007, as a part of MDG 7 (ensure environmental sustainability).
Source/reference(s): OECD (2011): Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing. http://dx.doi.org/10.1787/9789264111356-en UN-Water Task Force (2010): Monitoring progress in the water sector: A selected set of indicators, United Nations Water Task Force. http://www.unwater.org/downloads/TFIMR_FinalReport.pdf UNFAO: UNFAO Website: Indicator Fact Sheets.

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* This is a measure of the fish stock exploitation and does not measure related resource use. Thus, LCA is not relevant.	☹
Coverage of industries and industrial development	*Can the indicator capture the performance of industries, specific industries or sectors and industrial development?* This is a biological indicator measuring the health of ecosystems, although to a certain extent it also provides some insight into the performance of the fishing industry in terms of sustainable harvesting. However, without complementary indicators on fish production from aquaculture compared to the production of capture fisheries, it is challenging to assess actual industry performance[187]. Moreover, fish stocks are subject to other variables, such as environmental fluctuations and climate	😐

[186] OECD, 2011

[187] OECD, 2011

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	change, predator-prey interactions, and habitat modification[188]. Therefore, although there are challenges, with complementary information on industry activities this could be a useful measure of fishing industry performance. According to the OECD, this indicator is intended for global or regional usage, and is not a good measure of country-specific performance. Although the indicator can monitor trends at the national, regional and global levels, this may not be ideal for assessing fisheries management at the national level and any cross-country comparisons may be challenging.	
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* This indicator provides a direct measure of environmental impacts by assessing ecosystem health, as well as indirect information regarding economic and social impacts. Fish resources are vital to human food supply in many societies and play a significant role in maintaining healthy aquatic ecosystems. According to the OECD, many valuable fish stocks are already fully or over-exploited, threatening societies that rely on these populations both for their food supply and economy, and have significant negative impacts on biodiversity. Conversely, sustainable fisheries preserve biodiversity, trade, fish food security and economic growth[189]. However, one limitation of the indicator is that it does not measure the impact of over exploitation for each species covered. The value of different species for the ecosystem might differ, and thus this indicator might hide serious developments for some species that are crucial for the ecosystem as a whole.	☺
Required data efforts	*Which data is required to establish the indicator?* Time series of catch and effort data for each exploited stock, including at least 10 years of data points Data on international fish populations Complementary data: Aquaculture production *How much effort is needed to collect, prepare and use the data?* Fish catch and production data are available from international sources (FAO) at significant detail and for most OECD countries. Data on the size of major fish populations exist but are scattered across national and international sources. Specific assessment data on internationally managed stocks are available from regional fisheries management organisations and from ICES[190]. As the data may come from many different databases and sources, collecting the data could present moderate challenges. However, global trends in fish stocks are available in FAO's State of the World Fisheries and Aquaculture report, so depending on requirements, collection and preparation of the data may be straightforward.	☺

188 UNFAO

189 OECD 2011

190 OECD 2011

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* This methodology is already used by FAO for describing status and trends in capture fisheries in the biannual publication SOFIA and for regular reviews of the state of the world marine fisheries.	☺
Understanding and Acceptance	*Is the indicator accepted and used by different experts and non experts?* Yes (FAO, OECD, national governments)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* There are a number of related bilateral and multilateral agreements, including the Rome Consensus on World Fisheries, the Code of Conduct for Responsible Fishing (FAO, November 1995), the UN Convention on the Law of the Sea and its implementation agreement on straddling and highly migratory fish stocks[191]. This indicator is already being used to measure progress towards these targets, and is a key indicator in the MDGs. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* Without the inclusion of complementary data that is related to fish populations, as well as trends in aquaculture, it could be challenging to analyse causal effects. *Is it available to policy makers in short time frames?* This indicator is typically available on an annual basis.	☺
Communication	*Can the indicator be visually illustrated?* Yes. For example, see OECD 2011.	☺

[191] OECD 2011

Table 36: Evaluation factsheet for the Area of forest and wooded land Indicator

Resource Indicator: Area of forest and wooded land
Brief description: This indicator measures the area of forest and wooded land, as a percentage of total land area and in km^2 per capita, and related changes since 1990. The FAO defines "forest area" as land spanning more than 0.5 hectare and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. This excludes woodland or forest predominantly under agricultural or urban land use and used only for recreation purposes. This indicator is included in the OECD's framework to monitor green growth, and is included in the Millennium Development Goals (MDG) as a part of MDG 7 (ensuring environmental sustainability). It is also an included in the Pan-European Forest Process on Criteria and Indicators for Sustainable Forest Management and the World Bank's World Development Indicators. The Food and Agriculture Association of the United Nations is the key organization responsible for defining the methodology and has been monitoring the world's forests at 5 to 10 year intervals since 1946[192].
Source/reference(s): OECD (2011): Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en UNSTATS: Millennium Development Goals Metadata, Accessed 30 Nov 2011, http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=25 UN FAO (2010): Global forest resources assessment, http://www.fao.org/forestry/fra/en/ Forest Europe: Forest Europe Website, Accessed 30 Nov 2011, http://www.foresteurope.org World Bank, World Development Indicators Webpage, Accessed 30 Nov 2011, http://data.worldbank.org/indicator/AG.LND.FRST.ZS

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* The indicator is not product related, so this criterion does not apply. *What aspects of the LCA chain does the indicator measure?* N/A	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?*	😐

192 UNFAO 2010

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	As a single statistic, this indicator does not provide direct information regarding industry performance. Changes In the percentage of forest and wooded land out of the total land area can indicate trends in deforestation and forest management practices. However, in order to capture the performance of specific industries or sectors, such as the forestry industry or other industries which engage in similar activities such as agriculture, additional information on forest management practices and protection measures would be an ideal complement.	
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Typical use of this indicator does not provide direct information regarding sustainability impacts, although with supplemental information could provide valuable evidence of sustainability impacts related to forestry. Ideally it should inform about the quality – not just quantity – of the available forest resource, such as a measure of the share of disturbed/deteriorated forests in total forest area[193]. This would in turn provide important insight regarding biodiversity, a key environmental impact. Nonetheless, the trend of the indicator gives an important insight into important environmental developments. Firstly a decrease in forest area indicates that the use of wood is higher than its capacity for renewal, as well as indicating increases in GHG emissions, more pressure on biodiversity, and more pressure on the water management system. Forests are an important resource, providing timber and other products; recreation benefits and ecosystem services such as regulation of soil, air and water; are reservoirs for biodiversity; and commonly act as carbon sinks[194]. Unless efforts are made to ensure sustainable management and extraction, industries such as agriculture, forestry, and transport infrastructure development can have serious negative impacts for the environment, economy and society. According to the OECD (2011), "main concerns relate to the impacts of human activities on forest diversity and health, on natural forest growth and regeneration, and to their consequences for the provision of economic, environmental and social forest services." Other issues impacting forest areas include air pollution, degradation, fragmentation and conversion to other types of land use[195]. In order to measure environmental impacts, expanding this indicator to reflect forest quality and providing complementary indicators such as the value of ecosystem services in forested areas or the total CO_2 released (or absorbed) as a result of deforestation (or reforestation/afforestation) could improve the value of this indicator.	☺
Required data efforts	*Which data is required to establish the indicator?* Area of forests and wooded land Complementary data: species type and distribution	😐

193 OECD 2011

194 OECD 2011

195 OECD 2011

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	How much effort is needed to collect, prepare and use the data? The data are available for many countries as a part of the Global Forest Resources Assessment (FRA). FRA 2005 contains information for 229 countries and territories on more than 40 variables related to the extent of forests, their conditions, uses and values for three points in time: 1990, 2000 and 2005[196]. The data provided by the FRA in the form of country reports undergoes a review process to ensure correct use of definitions and methodology as well as internal consistency[197]. Thus, the effort required to prepare the data is limited and usage is straightforward if FRA standards are used. However, "in regional and ecoregional criteria and indicator processes, as well as in national reports, more detailed classifications of the forest area are often used, for example, according to forest or vegetation type, age structure or diameter distribution classes. Because of the varying conditions and classification systems among countries and regions, it was not feasible to report on such classifications at the global level except for the three selected forest types listed above"[198]. In addition, "trends over longer periods often lack comparability due to continued improvements in international definitions and in national forest inventories"[199].	
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Related policies and initiatives include international principles on sustainable forest management adopted at UNCED (Rio de Janeiro, 1992) and reaffirmed at the World Summit on Sustainable Development (Johannesburg, 2002); the Pan-European Criteria and Indicators for Sustainable Forest Management, the Montreal Process on Sustainable Development of Temperate and Boreal Forests; and the UN Forum on Forests[200]. (OECD 2011) However, this indicator does not allow sufficiently comprehensive conclusions about about the forestry industry's actual efficiency or environmental impact *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* No. The data is collected at intervals of 5-10 years.	☺
Communication	*Can the indicator be visually illustrated?* Yes	☺

196 UN Statistics
197 UN Statistics
198 FAO 2010
199 OECD 2011
200 OECD 2011

Table 37: Evaluation factsheet for the volume of forest resource stocks Indicator

Resource Indicator: The volume of forest resource stocks
Brief description: This indicator measures the volume of forest resource stocks (expressed in m^3) and related changes since 1990. More specifically, “growing stock” refers to the “volume over bark of all living trees more than X cm in diameter at breast height (or above buttress if these are higher) and includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm”[201].
Source/reference(s): OECD (2011): *Towards Green Growth: Monitoring Progress: OECD Indicators*, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Not captured by LCA. *What aspects of the LCA chain does the indicator measure?* N/A	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The indicator does not provide information regarding industry or sector performance. In order to capture the performance of specific industries or sectors, such as the forestry industry or other industries which engage in similar activities such as agriculture, additional information on forest management practices and protection measures would be an ideal complement.	☹
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The indicator does not directly measure environmental, economic, or social impacts. Supplemental information could provide valuable evidence of sustainability impacts related to forestry. Ideally it should inform about the quality – not just quantity – of the available forest resource, such as species distribution, which would in turn provide	☹

[201] OECD 2011

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	important insights regarding biodiversity, a key environmental impact. Forests are an important resource, providing timber and other products; recreation benefits and ecosystem services such as regulation of soil, air and water; are reservoirs for biodiversity; and commonly act as carbon sinks[202]. Unless efforts are made to ensure sustainable management and extraction, industries such as agriculture, forestry, and transport infrastructure development can have serious negative impacts for the environment, economy and society. According to the OECD (2011), "main concerns relate to the impacts of human activities on forest diversity and health, on natural forest growth and regeneration, and to their consequences for the provision of economic, environmental and social forest services." Other issues impacting forest areas include air pollution, degradation, fragmentation and conversion to other types of land use[203]. In order to measure environmental impacts, expanding this indicator to reflect forest quality and providing complementary indicators such as the value of ecosystem services in forested areas or the total CO_2 released (or absorbed) as a result of deforestation (or reforestation/afforestation) could improve the value of this indicator.	
Required data efforts	*Which data is required to establish the indicator?* volume of forest resource stocks (expressed in m3) *How much effort is needed to collect, prepare and use the data?* For FRA 2010, information was sought on the current status and changes over time (1990, 2000, 2005 and 2010) of the standing volume of wood, i.e. the total growing stock in forests and other wooded land, and its composition. The data provided by the FRA in the form of country reports undergoes a review process to ensure correct use of definitions and methodology as well as internal consistency[204]. Thus, the effort required to prepare the data is limited and usage is straightforward if FRA standards are used. However, "in regional and ecoregional criteria and indicator processes, as well as in national reports, more detailed classifications of the forest area are often used, for example, according to forest or vegetation type, age structure or diameter distribution classes. Because of the varying conditions and classification systems among countries and regions, it was not feasible to report on such classifications at the global level except for the three selected forest types listed above"[205]. In addition, "trends over longer periods often lack comparability due to continued improvements in international definitions and in national forest inventories"[206].	☺

[202] OECD 2011

[203] OECD 2011

[204] UN Statistics

[205] FAO 2010

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Related policies and initiatives include international principles on sustainable forest management adopted at UNCED (Rio de Janeiro, 1992) and reaffirmed at the WSSD (Johannesburg, 2002); the Pan-European Criteria and Indicators for Sustainable Forest Management, the Montreal Process on Sustainable Development of Temperate and Boreal Forests; and the UN Forum on Forests[207]. (OECD 2011) However, this indicator does not capture the industry's total environmental impact, but only whether timber stocks are declining or not. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* No. The data is collected at intervals of 5-10 years.	😐
Communication	*Can the indicator be visually illustrated?* Yes	☺

[206] OECD 2011

[207] OECD 2011

Table 38: Evaluation factsheet for the Generation capacity for renewable power generation Indicator

Resource Indicator: Generation capacity for renewable power generation
Brief description: In terms of recognized indicator frameworks, indicators related to renewable energy (or electricity) consumption or production appear to be more common than the generation capacity for renewable power generation. For example, in the European Environment Agency's (EEA) collection of environmental indicators, there are a significant number of energy related indicators, yet none that relate directly to generating capacity. However, "renewable energy share in energy and electricity" is a part of a collection of *Energy Indicators for Sustainable Development* (EISD) developed by the IAEA in cooperation with UNDESA, IEA and EEA. Essentially a collection of statistics related to renewable energy use and generation, this indicator measured the share of renewable energy in total primary energy supply (TPES), total final consumption (TFC) and electricity generation and generating capacity, excluding non-commercial energy[208]. Thus, the generating capacity of renewable power generation would be one output of this indicator. In terms of generating capacity, this indicator is measured as the share of renewable energy in total energy capacity, including both combustible and non-combustible renewable energy. According to the EISD, non-combustible renewables include the following sources: geothermal, solar, wind, hydro, tide and wave energy, including direct use of geothermal and solar hear and heat from heat pumps. Combustible renewables and waste include the following sources: biomass (fuelwood, vegetal waste, ethanol) and animal products (animal materials/wastes and sulphite lyes), municipal waste (wastes produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power) and industrial waste[209]. Prepared by the WorldWatch Institute, the Renewables 2005 Global Status Report includes a "Power Generation" indicator, broken down into large hydropower, small hydropower, wind turbines, biomass power, geothermal power, solar PV (off-grid), solar PV (grid-connected), solar thermal power, ocean (tidal) power, and total renewable power capacity excluding large hydro. The indicator is measured as the existing capacity in GW. In addition, the IEA online database includes "Net Generating Capacity of Renewable and Waste Products", showing the status of net electrical capacity by type of fuel, as well as solar collectors' surface.

[208] IAEA 2005

[209] IAEA 2005

Source/reference(s):
IAEA et al. (2005): Energy indicators for sustainable development: Guidelines and methodologies, http://www.google.com/url?q=http://www.iaea.org/OurWork/ST/NE/Pess/assets/07-23753_energyindic_small.pdf&sa=U&ei=69vdTqv-A4Xn-gb3_pnaBQ&ved=0CAkQFjAC&client=internal-uds-cse&usg=AFQjCNG16vbEubgA3ggusAbZTZMkEej5Jw
European Environment Agency: EEA Indicators Webpage. Available at: http://www.eea.europa.eu/data-and-maps/indicators
Martinot et al (2005): Renewables 2005: Global status report, Paper prepared for the REn21 Network by the WorldWatch Institute
IEA Statistical Databases, http://www.oecd.org/document/30/0,3746,en_21571361_33915056_39153694_1_1_1_1,00.html

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Not captured by LCA. *What aspects of the LCA chain does the indicator measure?* N/A	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* Yes, for industries dealing with renewable energy.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The generating capacity of renewable does not directly measure environmental, economic or social impacts. Promoting energy from renewable sources has a number of sustainability benefits, including the environmental benefits of lower GHG and other emissions, job creation, and security and diversification of energy supply[210]. However, without complementary indicators regarding employment, actual production, and the overall fuel mix, it is challenging to use this indicator to measure sustainability impacts. For example, generating capacity does not actually reflect the energy produced and consumed, as many plants work below capacity, and thus is not a good measure of actual emissions reductions. One important limitation of the indicator is that the environmental and social impacts of renewable energy depend on the energy source they are replacing (GHG emissions decrease faster if coal is replaced than if natural gas is replaced) and on the type renewable energy used (eg. impact of biofuels on food markets or employment effect of investments). Overall a rising share of renewable energy has probably a positive environmental impact but the scale will vary, for social impacts not even the direction of impacts is assured.	☹
Required data efforts	*Which data is required to establish the indicator?* Renewable generating capacity	☺

[210] IAEA 2005

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Complementary data: total generating capacity; disaggregated generating capacity by fuel *How much effort is needed to collect, prepare and use the data?* Data on capacity by fuel type is available for many countries, and thus collection, preparation and use should not require significant effort.	
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* Based on the literature identified, there does not appear to be a significant amount of research and debate regarding the use of this indicator. *Is it well documented?* This indicator is used in a variety of assessments to provide a snapshot of the energy industry in a given country, but is not commonly used as a key indicator in related indicated frameworks, where consumption and production are more frequently employed.	☹
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* More than 80 countries are members of a coalition formed at the World Summit on Sustainable Development in Johannesburg in 2005, including those countries willing to set targets and timelines for increasing renewable energy sources in the energy mix. Many countries or regional bodies, such as the EU, have set targets for the percentage of electricity or energy that must come from renewable sources. For example, in 2009, the Council of the European Union adopted climate-energy legislation (CARE), designed to achieve the EU's overall environmental target of a 20% reduction in greenhouse gases and a 20% share of renewable energy in the EU's total energy consumption by 2020[211]. In addition, the indicator is related to international initiatives such as the MDGs as well as national initiatives promoting an increase in renewable and decreased GHG emissions. However, while overall generating capacity is obviously related to these initiatives, an indicator directly measuring consumption is more valuable in this context. *Does the indicator measure aspects which can be influenced by policy makers?* Yes, as demonstrated by the significant increase in renewable generating capacity in countries such as Spain and Germany with generous feed-in tariffs for renewable energy. *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Yes	😐
Communication	*Can the indicator be visually illustrated?* Yes	☺

[211] EEA 2011

Table 39: Evaluation factsheet for the Industry Water Productivity indicator

Resource Indicator: Industry water productivity by sector
Brief description: This indicator measures the productivity of water in value added (in US$) per cubic meter of water withdrawn. The rationale behind it is that water productivity will increase when industrial technology is improved and water saving measures are implemented. It can thus be interpreted as a technological response to water scarcity. Countries that have low levels of industrial water productivity are likely to undervalue water resources.
Source/reference(s): M. Mdemu, B. Lankford, R.M.J. Kadigi, J. Cour and J.J. Kashaigili (2003): Water productivity indicators in Great Ruaha River Basin. Analysis and implications for decision-making and allocating water, Research for Development, http://www.dfid.gov.uk/r4d/PDF/Outputs/Water/R8064-Ruaha10-Water_Productivity_Indicators-paper.pdf UNESCO: UNESCO Water Webpage, Accessed 21 Nov 2011, www.unesco.org/water UN-Water Task Force on Indicators, Monitoring and Reporting (2009a): Monitoring progress in the water sector: A selected set of indicators. Final report, http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/wwap_UNTF-IMR_Final_report_for_reporting_to_UNWater.pdf UN-Water Task Force on Indicators, Monitoring and Reporting (2009b): Monitoring progress in the water sector: A selected set of indicators. ANNEXES: Indicators in use, http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/wwap_UNTF-IMR_Annex_of_Final_report_for_reporting_to_UNWater_edited-221210_2_.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* LCA can be used to obtain detailed statistics of water abstraction, consumption and discharge along the production/service chain. However, the indicator as such is not fit for measuring different life cycle stages.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* Yes, the indicator shows how specific industries or sectors are performing in terms of value produced per unit of water. Over time, they can track progress made.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic or social impacts?* The indicator can measure economic impacts as water productivity is usually measured in terms of economic output per unit of water.	😐

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	In order to use this indicator to measure environmental impacts, a precise understanding of how water flows affect ecosystem functioning and its attributable benefits is necessary. However, measures that capture those impacts require quantitative data on the relationship between the ecosystem and water. The indicator does not directly measure social impacts. However, once the relationship between water flows and the ecosystem has been established, it may be possible to derive information on the social impacts.	
Required data efforts	*Which data is required to establish the indicator?* Water withdrawal in cubic meters und value added (in US$). *How much effort is needed to collect, prepare and use the data?* In many case, the water use by industry is underestimated, which renders this indicator difficult to interpret. Furthermore, since often industries do not report on their water use the quality of the data for industrial water use may be limited.	☹
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Water consumption is a critical aspect of efficient water management but abstraction and discharge also provide valuable information, e.g., in the context of scarcity at the point of abstraction and/or discharge. The indicator can measure water productivity over time and thus provide useful information on which sectors have improved their water productivity. *Does the indicator measure aspects which can be influenced by policy makers?* One view is that the indicator can be used by policy makers to direct water to those sectors in which it can generate a higher economic return per unit of water, such as industries and high value crops that use less water. That is particularly relevant in water scarce regions. At the same time, policy makers could choose to instead allocate that water to sectors where its social impact is higher even if their "water productivity" is lower. It is important to combine this indicator with "water consumption by sector" indicators so that policy makers have an overview of all major water users before they introduce measures to increase water productivity. This may help avoid shifting water resource to a productive sector at the expense of other users who depend on water heavily, namely the rural poor.	☺
Communication	*Can the indicator be visually illustrated?* Yes, the indicator can be illustrated using charts and graphs (for instance by UNESCO, see http://www.unesco.org/water/wwap/wwdr/indicators/pdf/H4_Industrial_water_productivity.pdf)	☺

Table 40: Evaluation factsheet for the Investment in Research and Development Indicator

Resource Indicator: Investment in Research & Development
Brief description: Research and development is a key indicator for a number of sustainable development or related indicator sets, although it is expressed differently depending on the source. R&D expenditure in public and business sector of importance to green growth in energy- and environment-related technologies is a key indicator used by the OECD to monitor progress toward green growth, expressed as the percentage of all-purpose R&D expenditures. Expenditures on research and development is also used as a World Development indicator, defined as “current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development”. In addition, expenditure on research and development as a percent of gross domestic product is a UN Sustainable Development Indicator.
Source/reference(s): OECD (2011): Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en UN Commission of Sustainable Development (2007): Indicators of sustainable development. Guidelines and methodologies, Third edition, http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf World Bank: World Development Indicators webpage, Expenditures on research and development, accessed on 9 Dec 2011, http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* This indicator has no links to LCA.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The OECD publishes the report *Research and Development Expenditure in Industry*, which provides statistical data on R&D expenditure broken down by industrial and service sectors.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?*	☹

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	R&D expenditures do not directly measure sustainability impacts. As noted by the OECD, “R&D expenditure is an input measure, and environmental R&D thus reflects an intent towards green growth, not a green growth outcome”[212] However, “adequate R&D funding that is commensurate with economic growth and national income is necessary for ensuring sustainable development. Scientists are improving their understanding on policy-relevant issues such as climate change, growth in resource consumption rates, demographic trends, and environmental degradation. Changes in R&D investments in these and other areas need to be taken into account in devising long-term strategies for development. Scientific knowledge should be applied to assess current conditions and future prospects in relation to sustainable development”[213].	
Required data efforts	*Which data is required to establish the indicator?* For the share of R&D out of total GDP (UN, World Bank): total domestic expenditure on R&D; GDP expressed in national currency; for R&D expenditures related to green growth: energy and environmentally-related R&D outlays (public and private sector); GDP *How much effort is needed to collect, prepare and use the data?* There may be challenges regarding data collection. According to the UN CSD, “data on R&D expenditure for 1990, or later years, are available for 46 countries only.” In addition, the OECD states that “significant gaps exist concerning harmonised data on private-sector R&D expenditures on climate change mitigation, as well as harmonised micro-data on the development and adoption of climate change mitigation technologies. Data on public-sector energy-related R&D budgets are also available from the International Energy Agency (IEA) for OECD and a small number of non-member countries. More needs to be done to mobilise data on other non-member countries and to monitor technology transfers”[214].	😐
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* This indicator is related to the following conventions or agreements[215]: The Second Conference of Ministers Responsible for the Application of Science and Technology to Development in Africa (CASTAFRICA II), 6-15 July 1987; ‘Social Development: Africa's Priorities, Audience Africa’, United Nations Educational, Scientific and Cultural Organization (UNESCO) The indicator is related to the following targets or standards: African countries should devote 1% of their GNP to R&D by 1995; each African country should allocate at least 0.4 - 0.5% of its GDP to research by 2000 However, the indicator is only of limited relevance for measuring resource use in industries, because it does not provide information on how much of R&D spending is on resource efficiency and environmentally friendly production or how much of this specific spending yields actual resource and impact reductions *Does the indicator measure aspects which can be influenced by policy makers?* Yes	☺

[212] OECD 2011.
[213] UN CSD.
[214] OECD 2011.
[215] UN CSD.

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Does it provide disaggregated information allowing to analyse causal effects? No *Is it available to policy makers in short time frames?* Yes	
Communication	*Can the indicator be visually illustrated?* Yes	☺

Table 41: Evaluation factsheet for the Material Intensity of the Economy Indicator

Resource Indicator: Material Intensity of the Economy
Brief description: Material intensity indicators measure the intensity with which natural resource or materials are used at national, industry or plan level. They calculate how much material is needed per unit of GDP generated or product obtained and therefore how material intense for instance a production process is. Hence, intensity indicators are the inverse of productivity indicators, which measure how many units of GDP or product are generated per ton of material input (and thus the productivity). The material intensity of an economy is measured as the ratio of DMC to GDP at constant prices (DMC/GDP, material consumption per unit of GDP) and specified as Kilograms per $1,000 of GDP.
Source/reference(s): Eurostat (2001): Economy-wide material flow accounts and derived indicators. A methodological guide, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF OECD (2008a): Measuring material flows and resource productivity – Synthesis report, http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD (2008b): Measuring material flows and resource productivity – Volume I, The OECD Guide, http://www.oecd.org/dataoecd/46/48/40485853.pdf UN Department for Economic and Social Affairs (Division for Sustainable Development): Methodology sheets for the theme consumption and production patterns. Subtheme material consumption: Domestic Material Consumption, http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/consumption_production/domestic_material_consumption.pdf

Criteria	Qualitative assessment[216]	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Similar to Resource and Material Productivity, also Material Intensity include materials input into the economy for further processing and consumption, so that different life cycle stages (from extraction to disposal) can be addressed. Furthermore, it is based on DMC, which is able to measure materials extracted, used and also disposed of, again enabling Material Intensity to address different life cycle stages.	😐

[216] Since both Resource Productivity and Material Productivity relate to DMC, the qualitative assessment uses sections from the DMC template.

Criteria	Qualitative assessment[216]	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, and because hidden flows are not included, Material Intensity is only of limited suitability for measuring impacts from a life cycle perspective.	
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* Material Intensity can capture the performance of industries or sectors for two reasons. For one thing, it is based on DMC, which in particular for complex products requires aggregation to material categories thus facilitating generalization to product categories or industry sectors. Furthermore, DMC addresses the three main categories fossil fuels, minerals and biomass are addressed, so that therefore it may be applied to capturing specific industries or sectors within these categories.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Since Material Intensity is based on DMC, which is not able to reflect the environmental impacts of the materials used, also Material Intensity does not sufficiently cover the environmental dimension of resource and material consumption. It does not contain information about resource scarcity and environmental impacts. As regards the economic performance, using the ratio of DMC per GDP might be misleading in that GDP growth is often linked to using small quantities of high-value materials (e.g. rare earths), whereas DMC in many cases is dominated by construction materials in terms of masses, with a rather low contribution to GDP. Therefore, both aspects could be presented separately so that analysis of their respective evolution is facilitated in comparison to simply providing an aggregate number.	☹
Required data efforts	*Which data is required to establish the indicator?* Data on DMC and GDP at constant prices are required. *How much effort is needed to collect, prepare and use the data?* Though total material productivity and TMC would allow for the most complete integration of environmental impacts, it is very difficult to include unused and indirect upstream and downstream flows, therefore rendering both very difficult to measure.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. Eurostat 2001)	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Alike Resource and Material Productivity, also the Material intensity indicator serves as a basis on which to assess the need for and the progress on resource efficiency. Therefore, it can also be used to indicate the progress towards decoupling of economic growth from the use of natural resources. Decoupling is an increasingly important policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These being core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020	☺

Criteria	Qualitative assessment[216]	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Strategy[217] or the Roadmap to a Resource Efficient Europe[218], Material Intensity is of high policy relevance internationally as well as nationally.	
Communication	*Can the indicator be visually illustrated?* Material Intensity can be and frequently is visually illustrated, for instance in the OECD Environmental Outlook 2001 (available at http://www.mindfully.org/Heritage/OECD-Environmental-Outlook2001.htm)	☺

217 European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.

218 European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Table 42: Evaluation factsheet for the Multifactor Productivity Indicator

Resource Indicator: Multifactor Productivity
Brief description: Multifactor productivity (MFP) is a measurement that disentangles the direct growth contributions of labor, capital, intermediate outputs and technology. In basic terms, MFP is the change in GDP that cannot be explained by changes in the quantities of capital and labor that generate GDP. The MFP changes can be the result of more efficient management of the processes of production or of a reduction in the amount of intermediate goods and services needed to produce a given amount of output. As such, MFP changes can help explain the long-term growth of real GDP; it helps review past growth patterns and assess potential for future economic growth. It is a national measure of all labor, capital and technology contributions to GDP.
Source/reference(s): OECD (2001): Measuring productivity – OECD Manual, www.oecd.org/dataoecd/59/29/2352458.pdf

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* LCA captures only material inputs not other factors of production such as labour and financial capital.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* It can evaluate their performance at the national level. MFP could evaluate sustainable development of industrial sectors if it was first explained how technological improvements, efficiency gains or reductions in inputs (MFP changes) contribute to sustainability.	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* It can measure the economic impact of technological change or changes in the intermediate goods required in a production process. More information would be required to draw a link between technological change and environmental improvements because it does not contain information about resource scarcity and environmental impacts. Finally, it offers little insight into the social impacts of production.	☹
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* Understanding is not 100% intuitive. A certain understanding of economics and production processes is assumed. *Is the indicator accepted and used by different experts and non experts?* The indicators are not widely used by non-experts. It is mostly appealing to economists and policy makers interested in increasing productivity.	😐
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* Yes, the indicator can help measure the progress of technological change and its impact on GDP. However, it is important to	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	note that, according to an OECD study, not all facets of technological change are captured by the MFP. *Does the indicator measure aspects which can be influenced by policy makers?* Yes, policy makers can influence the pace of technological change through industry incentives, for example. However, factors mentioned above such as the value of pre-efficiency improvements should also be taken into account in policy decisions.	

Table 43: Evaluation factsheet for the Share of the total agricultural area under Organic Farming Indicator

Resource Indicator: Share of the total agricultural area under Organic Farming
Brief description: According the UN ESA, the area under organic farming is defined as the "ratio of total utilized agricultural area occupied by organic farming to total utilised agricultural area"[219]. Utilised agricultural area (UAA) is further defined as "the area utilised for farming, which includes all the area of arable land, permanent meadow and pasture, and land developed to permanent crops and kitchen gardens"[220]. Organic farming is incorporated into the OECD Agri-environmental Indicators under "Farm Management and the Environment" as well as the UN Sustainable Development Indicators.
Source/reference(s): Eurostat (2009): Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg OECD (2001): Environmental Indicators for Agriculture Methods and Results, http://www.oecd.org/dataoecd/0/9/1916629.pdf UN Department for Economic and Social Affairs (UN DESA) (Division for Sustainable Development). Methodology sheets for the Theme Land, Subtheme Agriculture: Area under Organic Farming, available at http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/land/organic_farming.pdf

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Not captured by LCA.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The indicator is specific to the food and agriculture industry only.	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* This indicator does not directly measure sustainability impacts. However, growth in organic farming has to potential to provide environmental benefits, such as reduction of environmental loading on soil and water resources; reduced pressure on	😐

219 UN DESA

220 UN DESA

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	biodiversity; and reduced use of pesticides, herbicides and other chemicals[221]. In addition, it can provide economic opportunities for local populations and improve health.	
Required data efforts	*Which data is required to establish the indicator?* data on organic certified and in conversion areas; total UAA[222] *How much effort is needed to collect, prepare and use the data?* Collecting, preparing and using the data for countries with specific organic standard is not challenging, although using that data on a larger scale, for instance to compare countries, could be challenging. The definition of "organic farming" differs based on the country or region, and thus data comparability is challenging[223]. For example, in the EU level there is a European Action Plan for Organic Food and Farming (SEC(2004)739) and a Council Regulation EEC No. 2092/91; in the USA there is the National Organic Program of the USDA; in Japan there are the Japanese Organic Standards; and there are 71 countries with organic regulations at some stage of development[224].	☺
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate?* Standards are established at the global level by the Codex Alimentarius Commission Guidelines on Organically Produced Foods as well as by the International Basic Standards of the International Federation of Organic Agriculture Movements (IFOAM)[225].	☺
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* Yes, although it is not immediately clear what "organic" refers to, particularly as this definition varies depending on county or region.	😐
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* This indicator is related to the following measures: Guidelines on Organically Produced Foods (GL 32 – 1999, Rev.1 – 2001) and the Convention on Biological Diversity' Global Strategy for Plant Conservation, Target 12 for 2010. However, there are no specific targets related to the area or number of organic farms. At a general level, it is related to regional and international agreements related to sustainable development.	☺

[221] UN DESA

[222] UN DESA

[223] UN DESA

[224] UN DESA

[225] UN DESA

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Does the indicator measure aspects which can be influenced by policy makers? Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Yes	
Communication	*Can the indicator be visually illustrated?* Yes. For example, a color coded map could compare countries, or a graph could demonstrate trends over time.	☺

Table 44: Evaluation factsheet for the Available (global) stocks or reserves of selected minerals and related extraction rates Indicator

Resource Indicator: Available (global) stocks or reserves of selected minerals and related extraction rates.
Brief description: Available (global) stocks or reserves of selected minerals (metallic minerals, industrial minerals, fossil fuels, critical raw materials) and related extraction rates is a proposed indicator for the OECD to monitor progress toward green growth. However, no accompanying methodology is provided. The Handbook for Mineral and Energy Asset Accounting, created for the United Nations Framework Classification for Energy and Mineral Resources, includes proposed methodologies for calculating stocks and reserves.
Source/reference(s): European Commission (2010): Decoupling indicators, Basket-of-products indicators, Waste management indicators: Framework, methodology, data basis and updating procedures. OECD (2011): Towards Green Growth: Monitoring Progress: OECD Indicators, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en Gravgård, O. (2007): Handbook for Mineral and Energy Asset Accounting, Statistics Denmark, For presentation at the 11th London Group Meeting Pretoria, South Africa 26-30 March 2007

Criteria	**Qualitative assessment**	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Not captured by LCA.	☹
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* The indicator is not specific to industries or sectors.	☹
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* The indicator does not directly measure sustainability impacts, although it does provide valuable information regarding the status of mineral reserves as well as expectations regarding future resource availability. While it allows resource scarcity considerations it does not capture current environmental impacts resulting from their extraction and processing.	😐
Required data efforts	*Which data is required to establish the indicator?* Mineral reserves and stocks; total extractions *How much effort is needed to collect, prepare and use the data?*	😐

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	Data on minerals and metals, including consumption of primary and secondary materials, can be estimated from the UNCTAD database. Data on resource extraction can also be found at BGS and/or USGS for minerals (incl. metals), through industry associations, or Eurostat MFA tables[226]. However, no literature was identified which specifically addresses the methodology, and thus the level of effort required is unknown.	
Compatibility	*Is the indicator derivable from existing measurement frameworks such as System of Environmental-Economic Accounts (SEEA), the Dutch National Accounting Matrix including Environmental Accounts (NAMEA), or national LCA databases?* SEEA 2003 annex 1 presents a general classification regarding mineral and energy assets	☺

[226] European Commission 2010

Table 45: Evaluation factsheet for the Share of Renewables in Total Primary Energy Supply Indicator

Resource Indicator: Share of renewables in TPES
Brief description: The share of renewables in total primary energy supply (TPES) is measured as the percentage of renewable energy in TPES, which equals production plus imports minus exports minus international marine and aviation bunkers plus or minus stock changes[227]. According to the OECD, renewables include hydro, geothermal, solar, wind, tide/wave/ocean energy, as well as combustible renewables and waste. "Renewable energy share in energy and electricity" is a part of a collection of *Energy Indicators for Sustainable Development* (EISD) developed by the IAEA in cooperation with UNDESA, IEA and EEA. Essentially a collection of statistics related to renewable energy use and generation, this indicator measured the share of renewable energy in total primary energy supply (TPES), total final consumption (TFC) and electricity generation and generating capacity, excluding non-commercial energy[228].
Source/reference(s): OECD (2011): Towards green growth. Monitoring progress: OECD Indicators, OECD Publishing http://dx.doi.org/10.1787/9789264111356-en European Environment Agency (2006): EN29 Renewable Energy Factsheet, http://www.eea.europa.eu/data-and-maps/indicators/en29-renewable-energy/en29-renewable-energy/at_download/file European Environment Agency (2005): EEA core set of indicators: Guide. EEA Technical Report No 1/2005, http://www.eea.europa.eu/publications/technical_report_2005_1/at_download/file IAEA et al. (2005): Energy indicators for sustainable development: Guidelines and methodologies, http://www.iaea.org/OurWork/ST/NE/Pess/assets/07-23753_energyindic_small.pdf

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* LCA generally does not distinguish between different sources of energy but this could be added to the data collection process.	☹

[227] OECD 2011

[228] IAEA 2005

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
Coverage of industries and industrial development	*Can the indicator capture the performance of industries, specific industries or sectors and industrial development?* The indicator measures the share of renewable in TPES, and thus does not provide information for specific industries. However, in theory it is feasible to calculate the indicator for specific industries.	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* By providing information regarding the share of renewable in TPES, this indicator provides general information regarding progress toward reducing the environmental impact related to our energy supply. However, in order to understand the overall impact, additional information regarding the fuel mix, biodiversity impacts, and any pollution abatement equipment is necessary. For example, large hydropower plants can negatively impact ecosystems, and the incineration of municipal and solid waste often includes materials contaminated with heavy metals, both of which can negatively impact the environment, depending on related regulations, site selection, etc[229]. This indicator does not provide direct information regarding economic impacts or social impacts, although additional information on overall fuel mix could theoretically provide estimates of improves health related to the reduction in fossil fuels.	😐
Required data efforts	*Which data is required to establish the indicator?* TPES; renewable energy supply Complementary data: supply by fuel type *How much effort is needed to collect, prepare and use the data?* Data on energy supply is readily available from international sources, such as the IEA, for all OECD countries and many other countries in the world[230]. As the indicator is a key indicator for many high profile international indicator sets, collecting, preparing and using the data should be relatively low effort.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The indicator related to numerous policies at the local, national, regional and international level, although related indicators regarding total energy or electricity consumption may be more relevant. For example, in 2009, the Council of the European Union adopted climate-energy legislation (CARE), designed to achieve the EU's overall environmental target of a 20% reduction in greenhouse gases and a 20% share of renewable energy in the EU's total energy consumption by 2020[231]. In addition, the indicator is related to international initiatives such as the MDGs as well as national initiatives promoting an increase in renewable and decreased GHG emissions. Other related policies in the context of the EU include the Directive on GHG emissions of fuels and biofuels;	☺

[229] EEA 2005

[230] OECD 2011

[231] EEA 2011

Criteria	Qualitative assessment Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	Strategic Energy Technology Plan (SET-plan); and the Directive on Waste[232]. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Data is collected annually.	
Communication	*Can the indicator be visually illustrated?* Trends in TPES versus GDP can be illustrated graphically, as seen in the OECD's report monitoring green growth (2011).	☺

[232] EEA 2011

Table 46: Evaluation factsheet for the Share of renewable power in total final energy consumption Indicator

Resource Indicator: Share of renewable power in total final energy consumption
Brief description: The share of renewables in total final energy consumption measures the structure of the energy supply in terms of primary energy source as a percentage of total final energy consumption. According to the OECD, renewables include hydro, geothermal, solar, wind, tide/wave/ocean energy, as well as combustible renewables and waste. Eurostat adopts a similar indicator, the “share of renewables in gross inland energy consumption”, as a headline indicator to measure progress toward sustainable development in the European Union. Gross inland energy consumption is calculated as total domestic energy production plus energy imports minus energy exports (including fuel supplied to international marine bunkers). This indicator is also a part of the core set of indicators for the European Environment Agency (EEA), and the UN Commission on Sustainable Development included “share of consumption of renewable energy resources” in their core set of sustainable development indicators, developed in 2001. “Renewable energy share in energy and electricity” is a part of a collection of *Energy Indicators for Sustainable Development* (EISD) developed by the IAEA in cooperation with UNDESA, IEA and EEA. Essentially a collection of statistics related to renewable energy use and generation, this indicator measured the share of renewable energy in total primary energy supply (TPES), total final consumption (TFC) and electricity generation and generating capacity, excluding non-commercial energy[233].

[233] IAEA 2005

Source/reference(s):
OECD (2011): Towards green growth. Monitoring progress: OECD Indicators, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en
Eurostat (2009): Sustainable development in the European Union - 2009 monitoring report of the EU sustainable development strategy, European Communities, Luxembourg
European Environment Agency (2006): EN29 Renewable Energy Factsheet, http://www.eea.europa.eu/data-and-maps/indicators/en29-renewable-energy/en29-renewable-energy/at_download/file
European Environment Agency (2005): EEA core set of indicators: Guide. EEA Technical Report No 1/2005, http://www.eea.europa.eu/publications/technical_report_2005_1/at_download/file
European Environment Agency Website (2011): Renewable primary energy consumption indicator overview, http://www.eea.europa.eu/data-and-maps/indicators/renewable-primary-energy-consumption/
IAEA et al. (2005): Energy indicators for sustainable development: Guidelines and methodologies. Available at: http://www.google.com/url?q=http://www.iaea.org/OurWork/ST/NE/Pess/assets/07-23753_energyindic_small.pdf&sa=U&ei=69vdTqv-A4Xn-gb3_pnaBQ&ved=0CAkQFjAC&client=internal-uds-cse&usg=AFQjCNG16vbEubgA3ggusAbZTZMkEej5Jw

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* Not captured by LCA, but could be added as part of Energy LCAs. *What aspects of the LCA chain does the indicator measure?* N/A	😐
Coverage of industries and industrial development	*Can the indicator capture the performance of industries, specific industries or sectors and industrial development?* Typical usage of this indicator measures the share of renewables at the national or regional (or even global) level, and thus does not provide information for specific industries. However, the indicator could theoretically be adapted as share of renewable energy in total energy consumption of a specific industry or sector.	😐
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Similar to the share of renewable in TPES, this indicator provides general information regarding progress toward reducing the environmental impact of energy consumption. However, in order to understand the overall impact, additional information regarding the fuel mix, biodiversity impacts, and any pollution abatement equipment is necessary. For example, large hydropower plants can negatively impact ecosystems, and the incineration of municipal and solid waste often includes materials contaminated with heavy metals, both of which can negatively impact the environment, depending on related	☹

Criteria	Qualitative assessment: Question(s) to be answered by the criterion	score for criterion match (☺/😐/☹)
	regulations, site selection, etc[234]. This indicator does not provide direct information regarding economic impacts or social impacts, although additional information on overall fuel mix could theoretically provide estimates of improves health related to the reduction in fossil fuels.	
Required data efforts	*Which data is required to establish the indicator?* total renewable energy consumption; total energy consumption Complementary data: supply by fuel type *How much effort is needed to collect, prepare and use the data?* Data on energy consumption is readily available from international sources, such as the IEA, for all OECD countries and many other countries in the world[235]. As the indicator is a key indicator for many high profile international indicator sets, collecting, preparing and using the data should be relatively low effort in developed countries.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The indicator addresses and supports numerous policies at the local, national, regional and international level. For example, in 2009, the Council of the European Union adopted climate-energy legislation (CARE), designed to achieve the EU's overall environmental target of a 20% reduction in greenhouse gases and a 20% share of renewable energy in the EU's total energy consumption by 2020[236]. In addition, the indicator is related to international initiatives such as the MDGs as well as national initiatives promoting an increase in renewable and decreased GHG emissions. Other related policies in the context of the EU include the Directive on GHG emissions of fuels and biofuels; Strategic Energy Technology Plan (SET-plan); and the Directive on Waste[237]. *Does the indicator measure aspects which can be influenced by policy makers?* Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Data is collected annually.	☺
Communication	*Can the indicator be visually illustrated?* Trends in the share of renewables in total final energy consumption can be illustrated graphically to show progress over time.	☺

[234] EEA 2005

[235] OECD 2011

[236] EEA 2011

[237] EEA 2011

Table 47: Evaluation factsheet for the Share of renewable power in total electricity Indicator

Resource Indicator:
Share of renewable power in total electricity

Brief description:
The share of renewables in electricity production measures the structure of the energy supply in terms of primary energy source as a percentage of total electricity generation[238]. According to the OECD, renewables include hydro, geothermal, solar, wind, tide/wave/ocean energy, as well as combustible renewables and waste.
Renewable energy share in energy and electricity is a part of a collection of *Energy Indicators for Sustainable Development* (EISD) developed by the IAEA in cooperation with UNDESA, IEA and EEA. Essentially a collection of statistics related to renewable energy use and generation, this indicator measured the share of renewable energy in total primary energy supply (TPES), total final consumption (TFC) and electricity generation and generating capacity, excluding non-commercial energy[239].

Source/reference(s):
OECD (2011): Towards green growth. Monitoring progress: OECD Indicators, OECD Publishing, http://dx.doi.org/10.1787/9789264111356-en
IAEA et al. (2005): Energy indicators for sustainable development: Guidelines and methodologies, http://www.google.com/url?q=http://www.iaea.org/OurWork/ST/NE/Pess/assets/07-23753_energyindic_small.pdf&sa=U&ei=69vdTqv-A4Xn-gb3_pnaBQ&ved=0CAkQFjAC&client=internal-uds-cse&usg=AFQjCNG16vbEubgA3ggusAbZTZMkEej5Jw

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* N/A	😐
Coverage of industries and industrial development	*Can the indicator capture the performance of industries, specific industries or sectors and industrial development?* Typical usage of this indicator measures the share of renewables at the national or regional (or even global) level, and thus does not provide information for specific industries. However, the indicator could theoretically be adapted to reflect the share of renewables in electricity production in specific industries or sectors.	😐

[238] OECD 2011

[239] IAEA 2005

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Similar to the share of renewable in TPES, this indicator provides general information regarding progress toward reducing the environmental impact of energy consumption. However, in order to understand the overall impact, additional information regarding the fuel mix, biodiversity impacts, and any pollution abatement equipment is necessary. For example, large hydropower plants can negatively impact ecosystems, and the incineration of municipal and solid waste often includes materials contaminated with heavy metals, both of which can negatively impact the environment, depending on related regulations, site selection, etc[240]. This indicator does not provide direct information regarding economic impacts or social impacts, although additional information on overall fuel mix could theoretically provide estimates of improves health related to the reduction in fossil fuels.	☹
Required data efforts	*Which data is required to establish the indicator?* total renewable electricity generation; total electricity production Complementary data: supply by fuel type *How much effort is needed to collect, prepare and use the data?* Data on electricity consumption is readily available from international sources, such as the IEA, for all OECD countries and many other countries in the world[241]. As the indicator is a key indicator for many high profile international indicator sets, collecting, preparing and using the data should be relatively low effort in developed countries.	☺
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* The indicator addresses and supports numerous policies at the local, national, regional and international level. For example, in 2009, the Council of the European Union adopted climate-energy legislation (CARE), designed to achieve the EU's overall environmental target of a 20% reduction in greenhouse gases and a 20% share of renewable energy in the EU's total energy consumption by 2020[242]. In addition, the indicator is related to international initiatives such as the MDGs as well as national initiatives promoting an increase in renewable and decreased GHG emissions. Other related policies in the context of the EU include the Directive on GHG emissions of fuels and biofuels; Strategic Energy Technology Plan (SET-plan); and the Directive on Waste[243]. *Does the indicator measure aspects which can be influenced by policy makers?*	☺

[240] EEA 2005

[241] OECD 2011

[242] EEA 2011

[243] EEA 2011

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
	Yes *Does it provide disaggregated information allowing to analyse causal effects?* No *Is it available to policy makers in short time frames?* Data is collected annually.	
Communication	*Can the indicator be visually illustrated?* Trends in the share of renewables in total electricity generation can be illustrated graphically, showing progress over time.	☺

Table 48: Evaluation factsheet for the Total Material Requirement indicator

Resource Indicator: Total Material Requirement (TMR)
Brief description: TMR measures the total primary material requirements of the production activities of an economic system (not limited to a national economy) and hence its total ‘material base’. Therefore, it calculates the mass (weight) of all materials required by the economic system, regardless of whether unused or used in production or consumption activities and whatever their origin is (domestic or rest of the world).TMR equals Total Material Input (TMI = Direct Material Input DMI [Domestic Extraction Used DEU plus imports] plus Unused Domestic Extraction UDE) plus indirect (upstream) flows associated with imports). Domestic TMR therefore relates to the material flows originating from the national territory, i.e. DEU and UDE[244]. Domestic TMR equals Total Material Input (TMI) minus imports.
Source/reference(s): EEA (2010a): The European environment state and outlook 2010, http://www.eea.europa.eu/soer/ EEA (2001b): Developments in Indicators: Total material requirement (TMR), Accessed 7 December 2011, http://www.eea.europa.eu/publications/signals-2000/page017.html EEA (2001): Total material requirement of the European Union. Technical report No 55, http://www.eea.europa.eu/publications/Technical_report_No_55 Eurostat (2001): Economy-wide material flow accounts and derived indicators – A methodological guide, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-34-00-536/EN/KS-34-00-536-EN.PDF OECD (2008a): Measuring material flows and resource productivity – Synthesis report, http://www.oecd.org/dataoecd/55/12/40464014.pdf OECD (2008b): Measuring material flows and resource productivity – Volume I, The OECD Guide, http://www.oecd.org/dataoecd/46/48/40485853.pdf UN Department for Economic and Social Affairs (UN DESA) (Division for Sustainable Development): Methodology sheets for the Theme Consumption and Production Patterns: Total Material Requirement Economy, Accessed 2 Dec 2011, http://www.un.org/esa/sustdev/sdissues/consumption/cpp1224m9.htm

[244] Unused domestic extraction (UDE, i.e. raw materials not fit or intended for use) is related to three main groups: mining and quarrying (associated extraction wastes, e.g. overburden materials), biomass harvest (e.g. discarded by-catch or losses during wood harvesting) and soil excavation (materials accumulating during construction or dredging activities) (Eurostat 2001).

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
LCA compatibility	*Is the indicator able to measure different life cycle stages?* This indicator derives from MFA type assessments. TMR is related to materials unused or used for production and consumption processes and also disposed of through waste. Therefore, different life cycle stages can be addressed. However, because the different materials are calculated in terms of their weight, which does not sufficiently take into account the different environmental impacts of different materials, TMR is not well-suited to measure impacts from a life cycle perspective.	😐
Coverage of industries and industrial development	*Is the indicator product-specific or can it capture the performance of industries, specific industries or sectors and industrial development?* Because TMR also addresses the three main categories fossil fuels, minerals and biomass it may be applied to capturing specific industries or sectors within these categories. However, in many cases, TMR is a highly aggregated economy-wide indicator.	☺
Sustainability impacts coverage	*Is the indicator able to measure environmental, economic and/or social impacts?* Because TMR covers also unused extraction and the hidden flows associated with imports, it enables to measure the “real” environmental pressure (through indirect flows) of materials’ use for production and consumption. Thus, alike Total Material Consumption TMC, also TMR allows to measure the associated ecological burden in upstream countries and hence the outsourcing of "dirty" production/extraction to other countries. Thus, TMR provides a more representative picture of the environmental pressure of materials use. However, TMR does not cover exports and most importantly, by measuring all materials in mass it gives them equal weights without actually being able to indicate the severity of the environmental impacts of the different materials.	😐
Required data efforts	*Which data is required to establish the indicator?* TMR requires data on consumption and import of all materials flowing in and out of an economy as well as upstream data for the countries importing from. *How much effort is needed to collect, prepare and use the data?* Alike TMC, also calculating TMR is facing great difficulties from a practical perspective when calculating indirect flows. While TMR is not additive across countries (for example, EU totals of TMR must take into account the intra-EU trade and its indirect flows) domestic TMR is additive across countries.	☹
Avoiding double-counting	*Does the indicator preclude double-counting of resource use?* Double-counting of resource use is a problem when calculating TMR because when indirect flows associated with imports are considered, this often means that materials are counted both for the exporting and the importing country.	☹
Scientifically verified	*Is the methodology for the indicator backed by scientific research and debate? Is it well documented?* The methodology for the indicator is both backed by scientific research and well documented (see e.g. OECD 2008 and Eurostat 2001)	☺

Criteria	Qualitative assessment	
	Question(s) to be answered by the criterion	**score for criterion match (☺/😐/☹)**
Understanding and Acceptance	*Is comprehension of the indicator intuitive?* No because indirect flows are counted. *Is the indicator accepted and used by different experts and non experts?* This indicator is not yet widely used, but rather in the process of being further developed.	😐
Policy relevance	*Does the indicator address and support policy priority issues by measuring progress towards political targets or thresholds?* TMC is able to measure the absolute level of resources used within an economy and its associated upstream and downstream impacts. Therefore, TMR could be used to indicate the progress towards decoupling of economic growth from the use of natural resources. Decoupling is an increasingly important policy issue, from international to the national level, aiming at reducing environmental impacts and degradation associated with primary production, material processing, manufacturing and waste disposal. These being core issues of the Agenda 21 and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation, as well as of European policies, such as the EUROPE2020 Strategy[245] or the Roadmap to a Resource Efficient Europe[246], TMR is of high policy relevance internationally as well as nationally. This is reflected for instance in the ongoing development efforts within the EU. *Does the indicator measure aspects which can be influenced by policy makers?* Not covered by literature identified – but likely yes, because it is related to imports and resource extraction. *Is it available to policy makers in short time frames?* According to EEA (2001) the indicator is available for the EU 12 and EU 15 for the time period 1985 to 1997.	☺
Communication	*Can the indicator be visually illustrated?* It can be and frequently is visually illustrated, either in tonnes or in tones per capita (see for instance EEA 2001).	☺

245 European Commission 2010. EUROPE 2020 - A European strategy for smart, sustainable and inclusive growth. COM(2010) 2020, see http://ec.europa.eu/europe2020/index_en.htm.

246 European Commission 2011. Roadmap to a Resource Efficient Europe. COM(2011) 571 final, see http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf.