# Comparing Eco-innovation Indices

## : ASEM Eco-Innovation Index (ASEI) & Eco-Innovation Scoreboard (Eco-IS)

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# Executive Summary

Measuring eco-innovation helps to understand the overall trends and to raise awareness in the society, especially encouraging companies to increase eco-innovation efforts. To measure eco-innovation at the national level, two indices were developed: ASEM Eco-innovation Index (ASEI) by the ASEM SMEs Eco-Innovation Center (ASEIC) and Eco-Innovation Scoreboard (Eco-IS) by the Eco-Innovation Observatory (EIO).

To improve knowledge of two eco-innovation indices, the ASEM SMEs Eco-Innovation Center (ASEIC) and the Institute for Sustainable Resources at University College London are publishing a working paper entitled "Comparing Eco-innovation Indices" as collaborative efforts of experts in the field of eco-innovation.

This working paper aims at examining and comparing the features of the eco-innovation indices. It attempts to get insights on the strengths and weakness of two eco-innovation indices, ASEI and Eco-IS. Two eco-innovation indices were analyzed with four foci: relevance of covering areas and stakeholders, ability to indicate changes, directions towards common goals and ability to facilitate further changes. The research results are expected to contribute to developing better eco-innovation indices, extending knowledge and improving implication of eco-innovation indices to design eco-innovation strategies at the national level.

The publishers hope that the working paper will give insight of eco-innovation indices, so it could contribute to facilitating communication on eco-innovation in Asia and Europe as well as in the global society.

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# Abbreviations

| | |
|---|---|
| ASEI | ASEM Eco-Innovation Index |
| ASEIC | ASEM SMEs Eco-Innovation Center |
| ASEM | Asian-Europe Meeting |
| EcoAP | Eco-innovation Action Plan |
| Eco-IS | Eco-Innovation Scoreboard |
| EIO | Eco-Innovation Observatory |
| JPOI | Johannesburg Plan of Implementation |
| SCP | Sustainable Consumption and Production |
| SDGs | Sustainable Development Goals |

# Chapter 1. Introduction

The concept of eco-innovation has emerged as an approach fostering sustainable development for all societies globally. Eco-innovation can be defined as "all efforts from relevant actors that introduce, develop, and apply new ideas, behaviors, products and processes and contribute to reducing environmental burdens or ecologically specified sustainability targets" (Rennings, 2000). Eco-innovation plays a key role in promoting and implementing green growth because it promotes all forms of innovation that reduce environmental impacts and strengthen resilience to environmental pressures (Jang et al, 2015d).

The study on eco-innovation began around the year 2000 and the number of publications rapidly increased after 2009 (Jo et al., 2015). The researches on eco-innovation can be classified into four areas: 1) definition and concepts of eco-innovation (Rennings, 2000; Hellström, 2007, Karakaya et al., 2014), 2) types of eco-innovation (OECD and Eurostat, 2005; EIO, 2012; Levidow et al., 2016), 3) policies and governance of eco-innovation (Leitner et al., 2010; Del Rio et al, 2010; Horbach et al., 2012; Ganapathy et al., 2014; Jang et al., 2015d), and 4) measuring eco-innovation (Kemp and Pearson, 2007; Huppes et al., 2008; Arundel and Kemp, 2009; Bleischwitz et al., 2009; Jo et al., 2015). This working paper starts from works on measuring eco-innovation and aims at examining and comparing the features of eco-innovation indices. It attempts to get insights on the strengths and weakness of two eco-innovation indices, ASEM Eco-innovation Index (ASEI) developed by the ASEM SMEs Eco-Innovation Center (ASEIC)[1] and Eco-Innovation Scoreboard (Eco-IS) developed by the Eco-Innovation Observatory[2] (EIO). Those two eco-innovation indices are analyzed with four foci: relevance of covering areas and stakeholders, ability to indicate changes, directions towards common goals, and ability to facilitate changes. The research results are expected to contribute to developing better eco-innovation indices, extending knowledge on eco-innovation indices and improving

[1] "Asia-Europe Meeting (ASEM) member countries joined together to establish ASEIC as an international platform for spreading eco-innovation principles and practices among SMEs and assisting them in harnessing the new business opportunities that arise out of such principles and practices" http://aseic.org/aseic/about.do

[2] "The Eco-Innovation Observatory is a 3-year initiative financed by the European Commission's Directorate-General for the Environment from the Competitiveness and Innovation framework Programme (CIP). The Observatory is developing an integrated information source and a series of analyses on eco-innovation trends and markets, targeting business, innovation service providers, policy makers as well as researchers and analysts.". http://www.eco-innovation.eu/index.php?option=com_content&view=article&id=22&Itemid=23

implication of eco-innovation indices to design eco-innovation strategies at the national level. Understanding, analyzing and comparing such national levels is indeed important for 'national innovation systems' (Nelson, 1993) as it has been proven how much the national institutions and general contexts matter for the stimulation, the direction, and the market development of innovation in general; eco-innovation is clearly with a strong connotation on all efforts made by environmental policies within such national innovation systems.

# Chapter 2. Research Trends and Areas

## 2.1 Measuring eco-innovation

With the emerging importance of eco-innovation since the late 1990s, several scholars have paid attention to measuring eco-innovation (Kemp and Pearson, 2007; Huppes et al., 2008; Arundel and Kemp, 2009; Cheng and Shiu, 2012). In practice, it helps policy makers understand the overall trend of eco-innovation and drivers and barriers of eco-innovation and design effective policies and framework conditions for eco-innovation (Arundel and Kemp, 2009). It contributes to raising awareness of eco-innovation at the society and especially encouraging companies to increase eco-innovation efforts.

Eco-innovation can be measured directly and indirectly (Huppes et al., 2008). Kemp and Pearson (2007) classified measures into four types to quantify technological changes by considering the process of eco-innovation: input measures, intermediate output measures, direct output measures and indirect impact measures.

- Input measures include research and development (R&D) expenditures, R&D personnel and innovation expenditures.
- Intermediate output measures consist of patents and scientific publications and citations.
- Direct output measures include data on sales of new products based on product and trade information databases.
- Indirect impact measures are derived from aggregate data including resource efficiency and productivity. Indirect impacts can be measured with company information about innovation and eco-innovation performance obtained from specially designed surveys.

In order to release a measurable index, it is important to understand details of eco-innovation concepts. Based on studies completed so far, types of innovation that need to be included when measuring eco-innovation are as follows: Product Innovation, Process Innovation, Marketing Innovation, Organizational Innovation, Material Flow Innovation, and Social Innovation (OECD and Eurostat, 2005; EIO,

2012). Although OECD (2005) only considered the product innovation, process innovation, marketing innovation and organizational innovation as major types of eco-innovation, EIO (2012) stressed the significance of material flow innovation and social innovation. Thus, these two types of innovation are included in the list of relevant types of eco-innovation. As its scope has extended, eco-innovation started to catch the various environments around companies and interactions between stakeholders. This signifies that the material flows are also considered with the economic activities, both in their physical and socio-economic dimensions. In particular, the commodity price increases since the year 2000 have driven attempts to increase resource efficiency and to enhance raw material security at the levels of industries and countries, which requires indicators based on material flow analysis (Bringezu and Bleischwitz, 2009).

Eco-innovation is not a one-way-process with input-output, but is a complex process that covers many bio-physical interactions beyond firms and consumers, including regulations, surrounding environments and personnel concerned, all of which have influences on eco-innovation. Thus, establishment of an appropriate framework is essential for capturing and measuring the dynamic nature of eco-innovation.

Eco-innovation can be measured at many levels - sectoral, firm, national, regional and international. National indicators can also provide a framework for collecting and reporting within a nation and for reporting national data to international bodies and other nations (Hommond et al., 1995). Measuring eco-innovation at the national level informs which countries are leading compared to others. For example, measuring eco-innovation policies as supporting environments for eco-innovation provides us information on which countries are leaders, followers, loungers and laggards in technology push and market pull instruments (Jang et al., 2015d). Among 17 Asian countries, Japan, Singapore, the Republic of Korea and China emerged as leaders. Thailand, Indonesia, Malaysia and the Philippines follow the trend of eco-innovation policies. Pakistan, Vietnam, India, Mongolia, and Bangladesh are loungers that slowly catch up to eco-innovation approaches. Myanmar, Lao PDR, Brunei Darussalam, and Cambodia are laggards in eco-innovation.

## 2.2 Indicators

Indicators simplify, clarify and make aggregated information available to decision makers and the public (DiSano, 2002: 3). They can help measure and calibrate progress toward social, environmental and economic goals such as sustainable development. Indicators provide information in a simpler, more readily understood form than complex statistics or other kinds of primary data derived from monitoring and data analysis and imply a model or set of assumptions that relates indicators to more complex phenomena (Hammond et al., 1995: 1). They often indicate changes into a desired direction and the speed of change. Environmental indicators play a role as a useful tool in highlighting environmental conditions and trends for policy purposes and help policy-makers see larger patterns of what is happening and determine appropriate actions (Niemeijer, 2002).

Several scholars pointed out characteristics of indicators. Hollander (2002: 3) identified nine of the most common criteria for selecting indicators: 1) validity, 2) relevance, 3) consistency and reliability, 4) measurability, 5) clarity, 6) comprehensiveness, 7) cost-effectiveness, 8) comparability, and 9) attractiveness to the media. Phillips (2003: 20) added that a successful indicator should: 1) be appropriate to its political, institutional, jurisdictional, or other context, 2) be meaningful and useful to stakeholders, 3) use affordable, relevant, and accessible data sources, 4) clearly state and accurately reflect its intent, 5) result from close collaborations with stakeholders during selection, application and review process, 6) connect and be consistent with well-articulated vision statements and goals, and 7) cause a government to take action. Hommond et al. (1995) illustrated three characteristics of successful indicators. Indicators must 1) be useful to their intended audience, 2) be pertinent to policy concerns and 3) be highly aggregated.

In developing environmental indicators, there are two approaches: data-driven and theory-driven (Niemeijer, 2002). In the data-driven approach, data availability is the central criterion for indicator development. In the theory-driven approach, selection of indicators is based on a theoretical framework and data availability is regarded as only one of reasons involved. In practice, both approaches are often combined.

Several indicators which measure environmental performance have been developed including *Global Clean-tech Innovation Index*[3] by the Cleantech & World Wildlife Fund for Nature, *Environmental Performance Index*[4] by the Yale Center for Environmental Law & Center for International Earth Science Information Network and *Green Growth Indicator*[5] by OECD. The indicators include some outcomes of eco-innovation such as government's policy, green technology capacity, investment level and social recognition.

[3] http://www.cleantech.com/indexes/the-global-cleantech-innovation-index/

[4] http://epi.yale.edu/

[5] http://www.oecd.org/greengrowth/greengrowthindicators.htm

# Chapter 3. Eco-innovation Indices

## 3.1 ASEM Eco-innovation Index (ASEI)

ASEM Eco-innovation Index (ASEI) has been developed and modified since 2012 by the ASEM SMEs Eco-Innovation Center (ASEIC) based in the Republic of Korea. ASEIC was established in 2011 as a result of the endorsement accepted by the ASEM member countries at the 8th ASEM Summit in 2010. ASEIC has annually assessed eco-innovation phenomena across ASEM member countries using ASEI. The current members of ASEM consist of 31 countries from Europe and 20 countries from Asia (Table 3.1).

**Table 3.1 ASEM member countries**

| Europe (31) | Asia (20) |
|---|---|
| Romania, Bulgaria, Estonia, Slovakia, Russian Federation, Lithuania, Latvia, Poland, Hungary, Croatia, Luxembourg, Norway, Switzerland, Denmark, Sweden, Austria, Netherlands, Ireland, Finland, Belgium, Germany, France, United Kingdom, Italy, Spain, Cyprus, Slovenia, Greece, Portugal, Malta, Czech Republic | Vietnam, Lao PDR, India, Pakistan, Cambodia, Bangladesh, Myanmar, Mongolia, Philippines, Brunei Darussalam, China, Thailand, Indonesia, Malaysia, Kazakhstan, Australia, Singapore, New Zealand, Japan, Republic of Korea |

ASEI is composed of four components of 'Eco-innovation Capacity (component 1)', 'Eco-innovation Supporting Environment (component 2)', 'Eco-innovation Activity (component 3)' and 'Eco-innovation Performance (component 4)' (Table 3.2). 'Eco-innovation Capacity' includes five indicators triggering eco-innovation in a country, personnel concerned, social components, innovation abilities and capacity presented in existing research: 1.1 Nation's Economic Competitiveness, 1.2 Nation's General Innovation Capacity, 1.3 Green Technology R&D Institution Capacity, 1.4 Green Technology possessed/acquired Enterprises and 1.5 Awareness of Sustainability Management. 'Eco-innovation Supporting Environment' includes four indicators representing government's institutional support and enabling environment for eco-innovation, company responses toward regulations and supports, mutual relationships in innovation: 2.1 Government's R&D expenditure in Green Industry, 2.2 Implementation of Environmental Regulations, 2.3 Maturity of Investment

Setting for Green Technology Industry and 2.4 Investment Scale of Green Technology SMEs. 'Eco-innovation Activity' includes five indicators representing degree of advance and implementation of eco-innovation in corporates and usage of eco-resources in overall economy: 3.1 Commercialization Level of Green Technology, 3.2 Enterprises' Participation on Environmental Management System, 3.3 Economic Influence of Leading Environmentally Responsive Enterprises, 3.4 Green Patents and 3.5 Activeness of Renewable Energy Utilization. 'Eco-innovation Performance' includes six indicators representing outcomes of eco-innovation activities in economic, social and environmental area: 4.1 Level of Environmental Impact on Society, 4.2 $CO_2$ Emission Intensity, 4.3 Nation's Energy Sustainability Level, 4.4 Water Consumption Intensity, 4.5 Jobs in Green Technology Industry and 4.6 Green Industry Market Size. The total 20 indicators were originally considered from previous researches. Data were collected in 4 components with 20 indicators, among which 12 were eventually used for 2016 ASEI depending on data availability: three indicators (Indicator 1.1, 1.2 and 1.5) for "capacity", one indicator (Indicator 2.2) for "Supporting Environment", three indicators (Indicator 3.2, 3.4 and 3.5) for "activity" and five indicators (Indicator 4.1, 4.2, 4.3, 4.4 and 4.6) for "performance".

For cases with below 5% missing value ratio, the statistical method was applied to replace the missing values. To do this, Expectation-Maximization (EM) algorithm based on likelihood-based procedures was applied in the study. EM uses maximum-likelihood estimation to place missing values with highest probability for highest value based on constant repetition of estimation where Expectation (E-step) and Maximization (M-step) are repetitively placed. Moreover, multiple imputations (MI) were used to estimate missing values. The missing values estimated from 100, 500, and 1000 iterations were the same.

The same weight was applied to 12 factors based on a suggestion by OECD (2005) and EIO (2012) for measuring factors. To make the values comparable, all the extracted values were transposed to standardized values using Min-Max methodology (Jo et al., 2015).

In an empirical analysis, each eco-innovation index such as capacity, supporting environment, activities, and performance was calculated using the Min-Max rescaling method based on the Expectation-Maximization formula which provided scores that ranged from 0 to 100. Following the OECD and the Eurostat Oslo Manual for collecting and interpreting innovation data (OECD, 2005), an equivalent weight

was adopted when weighting scores for each component. The equal weighting implies that each component has the same worth but it also could be applied in the case when there is insufficient knowledge of casual relationships or lack of consensus on alternatives (OECD, 2005). Since both controlling a nation's various factors and comparing them is difficult in an equation, equal weighting was applied to estimate ASEI. The score of ASEI in each component (Eco-innovation Capacity, Supporting Environment, Activity and Performance) was calculated by the equal weight of 0.25. Each of the four components was calculated by the mean of the indicators included in the component.

**Table 3.2 Data source of ASEI**

| Component | Indicators | Obtained Data | Data Source (Year) | Measuring Element |
|---|---|---|---|---|
| Capacity | 1.1 Nation's Economic Competitiveness | Global Competitiveness Index (GCI) | World Economic Forum (2015) | Composite Index |
| | 1.2 Nation's General Innovation Capacity | Global Innovation Index (GII) | INSEAD (2015) | Composite Index |
| | 1.3 Green Technology R&D Institution Capacity | Cleantech | Cleantech group data | Number of green technology R&D institutions, centers and university |
| | 1.4 Green Technology possessed/acquired Enterprises | Cleantech | Cleantech group data | Number of green technology possessed firms |
| | 1.5 Awareness of Sustainability Management | UN Global Compact (UNGC) Business Sector participants | UNGC (2015) | Number of participating enterprise |
| Supporting Environment | 2.1 Government's R&D expenditure in Green Industry | OECD Statics | OECD (2013) | Size of expenditure |
| | 2.2 Implementation of Environmental Regulations | WEF Executive Opinion Survey | World Economic Forum (2015) | Composite Index |

| | | | | |
|---|---|---|---|---|
| | 2.3 Maturity of Investment Setting for Green Technology Industry | Cleantech | Cleantech group data | Value of investment towards green technology firms |
| | 2.4 Investment Scale of Green Technology SMEs | Cleantech | Cleantech group data | Number of venture capitals and deals made towards green technology SMEs |
| Activities | 3.1 Commercialization Level of Green Technology | Cleantech | Cleantech group data | Number of companies with green technology widely commercialized |
| | 3.2 Enterprises' Participation on Environmental Management System | ISO 14001 environmental certificates | IMF (2014) | Number of participating enterprise |
| | 3.3 Economic Influence of Leading Environmentally Responsive Enterprises | World's Greenest Companies | Trucost by Newsweek (2015) | Amount of annual sales |
| | 3.4 Green Patents | OECD Environmental technology patent statistics | OECD (2014) | Number of patent |
| | 3.5 Activeness of Renewable Energy Utilization | IEA (International Energy Agency) | IEA (2015) | Measures the contribution of renewable to total primary energy supply |
| Performance | 4.1 Level of Environmental Impact on Society | EPI (Environmental Performance index) | EPI (2015) | Composite Index |
| | 4.2 $CO_2$ Emission Intensity | Key World Energy Statistics | International Energy Agency (2015) | Amount of Carbon dioxide generated |
| | 4.3 Country's Energy Sustainability Level | ESI (Energy Sustainability Index) | World Energy Council (2015) | Composite Index |

| | | | |
|---|---|---|---|
| 4.4 Water Consumption Intensity | IMD (International Institute for Management Development) World Competitiveness Yearbook | IMD World Competitiveness Yearbook (2014) | Water withdrawal for each 1,000 USD of GDP in cubic meter |
| 4.5 Jobs in Green Technology Industry | Cleantech | Cleantech group data | Number of employees |
| 4.6 Green Industry Market Size | UK BIS (The UK Department for Business Innovation and Skills) | LCEGS (Low Carbon and Environmental Goods and Services) Country Market Size (2011-12) | Green Industry total sales |

Source: Park et al. (2016: 4)

### 3.2 Eco-Innovation Scoreboard (ECO-IS)[6]

Eco-Innovation Observatory (EIO) established in 2009 is an initiative financed by the European Commission's Directorate-General for the Environment from the Competitiveness and Innovation framework Programme (CIP) working to observe the types, degrees and impacts of eco-innovation in the EU. EIO has developed Eco-Innovation Scoreboard (Eco-IS) as a tool to assess and illustrate eco-innovation performance across the EU Member States in 2010. As of 2015, Eco-IS presents eco-innovation of 28 Member States of EU[7]. The scoreboard consists of 16 indicators grouped into five components: eco-innovation inputs (component 1), eco-innovation activities (component 2), eco-innovation outputs (component 3), resource efficiency outcomes (component 4) and socio-economic outcomes (component 5) (Table 3.3). 'Eco-innovation Input' includes three indicators triggering eco-innovation in a country, research, personnel concerned and investment: 1.1 Governments environmental and energy R&D appropriations and outlays, 1.2 Total R&D

[6] At the chapter 3.2, contents from the Technical Note of Eco-Is (Giljum et al., 2016) are summarized.

[7] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

personnel and researchers, and 1.3 Total value of green early stage investments. 'Eco-innovation activities' include three indicators representing firm's innovative activities for reducing material input and energy input per unit output and for creating environmental management system: 2.1 Firms having implemented innovation activities aiming at a reduction of material input per unit output, 2.2 Firms having implemented innovation activities aiming at a reduction of energy input per unit output, and 2.3 ISO 14001 registered organizations. 'Eco-innovation Outputs' include three indicators representing degree of advance and implementation of eco-innovation in corporates and communication by scientists and media: 3.1 Eco-innovation related patents, 3.2 Eco-innovation related academic publications, and 3.3 Eco-innovation related media coverage. 'Resource Efficiency Outcomes' includes four indicators representing outcomes of eco-innovation activities in the environmental area with the focus on productivity and intensity: 4.1 Material productivity, 4.2 Water productivity, 4.3 Energy productivity, and 4.4 GHG emissions intensity. 'Socio-Economic Outcomes' include three indicators relating to eco-industries: 5.1 Exports of products from eco-industries, 5.2 Employment in eco-industries and 5.3 Turnover in eco-industries.

According to the Technical Note of Eco-IS (Giljum et al., 2016: 4), country specific figures of the single indicator are weighted with the share of population in order to calculate an EU average which corrects for the bias of smaller Member States. Therefore the EU average of a sub-indicator presents the weighted mean of all country specific data of the EU Member States. The EU average of indicators that display absolute numbers is built directly by summing up the underlying data.

In order to exclude statistical outliers, the 5 % and the 95 % Quantile are introduced as thresholds. Values above/below the thresholds are replaced by the corresponding threshold value. The EU average is calculated with the data corrected by the thresholds. To normalize the various indicators, a "Distance-to-reference[8]" method, with the EU average defined as the reference, is used and a value of 100 is set. Countries with higher figures than the EU average obtain a higher score than 100 and countries with lower figures achieve less, depending on the deviation from the

[8] "Distance to a reference measures the relative position of a given indicator vis-à-vis a reference point. This could be a target to be reached in a given time frame. (ellipsis) The reference country could be the average country of the group and would be assigned a value of 1, while other countries would receive scores depending on their distance from the average. Hence, standardised indicators that are higher than 1 indicate countries with above-average performance" (OECD, 2005: 28).

EU average.

Unlike ASEI, missing data are not replaced by estimations. Countries for which data is not available do not get a result for the respective indicator. The score of the index in each of the five components is calculated by the unweighted mean of the underlying indicators. Consequently, each indicator has the same weighting in the five components. The overall scoreboard of an EU Member State is calculated by the unweighted mean of the 16 sub-indicators in order to avoid bias by components of the scoreboard which consist only of a few indicators.

**Table 3.3 Data source of Eco-IS**

| Component | Factors | Data Source (Year) | Measuring Element |
|---|---|---|---|
| 1. Eco-innovation inputs | 1.1 Governments environmental and energy R&D appropriations and outlays | EUROSTAT (2014) | Governments budget appropriations and outlays (% of GDP) |
| | 1.2 Total R&D personnel and researchers | EUROSTAT (2014) | Number of R&D personnel and researchers (% of total employment) |
| | 1.3 Total value of green early stage investments | Cleantech (2012-2015) | Total value of investments (USD/capita) |
| 2. Eco-innovation activities | 2.1 Firms having implemented innovation activities aiming at a reduction of material input per unit output | EUROSTAT (2008) | Number of firms having implemented innovation activities for material efficient (% of total firms) |
| | 2.2 Firms having implemented innovation activities aiming at a reduction of energy input per unit output | EUROSTAT (2008) | Number of firms having implemented innovation activities for energy efficiency (% of total firms) |
| | 2.3 ISO 14001 registered organizations | ISO Survey of Certifications (2014) | Number of ISO 14001 registered organizations (per mln population) |

| | | | |
|---|---|---|---|
| 3. Eco-innovation outputs | 3.1 Eco-innovation related patents | Patstat (2012) | Number of patents (per mln population) |
| | 3.2 Eco-innovation related academic publications | Scopus (2014) | Number of publications (per mln population) |
| | 3.3 Eco-innovation related media coverage | Meltwater (2015) | per number of electronic media |
| 4. Environmental outcomes | 4.1 Material productivity | EUROSTAT (2007) | Direct material productivity (GDP/Domestic material Consumption) |
| | 4.2 Water productivity | Water Footprint Network (1996-2005) | GDP/Water footprint |
| | 4.3 Energy Productivity | EUROSTAT (2013) | Energy productivity (GDP/gross inland energy consumption)) |
| | 4.4 GHG emissions intensity | EEA (2013) | $CO_2e$/GDP |
| 5. Socio-economic outcomes | 5.1 Exports of products from eco-industries | EUROSTAT (2014) | % of total exports |
| | 5.2 Employment in eco-industries and circular economy | Orbis (2014) | % of total employment across all companies |
| | 5.3 Revenue in eco-industries and circular economy | Orbis (2014) | % of total revenue across all companies |

Source: Giljum and Lieber (2016: 3)

# Chapter 4. Analysis Method

We analyze two eco-innovation indices –ASEI and Eco-IS - with following four foci: 1) Relevance of covering areas and stakeholders, 2) Ability to indicate changes, 3) Directions towards common goals and 4) Ability to facilitate further changes (Table 4.1). Strength and weakness is described with the above four foci.

**Table 4.1 Four foci for analyzing eco-innovation indices**

| Analysis foci | Description |
|---|---|
| Relevance of covering areas and stakeholders | Appropriateness of priority issues, consideration of stakeholders |
| Ability to indicate changes | Validity, consistency, reliability, measurability, cost-effectiveness |
| Directions towards common goals | Linkage with well-articulated visions and social, environmental and economic goals |
| Ability to facilitate further changes | Encouragement to governmental action and enterprises' strategies, foresight on future action |

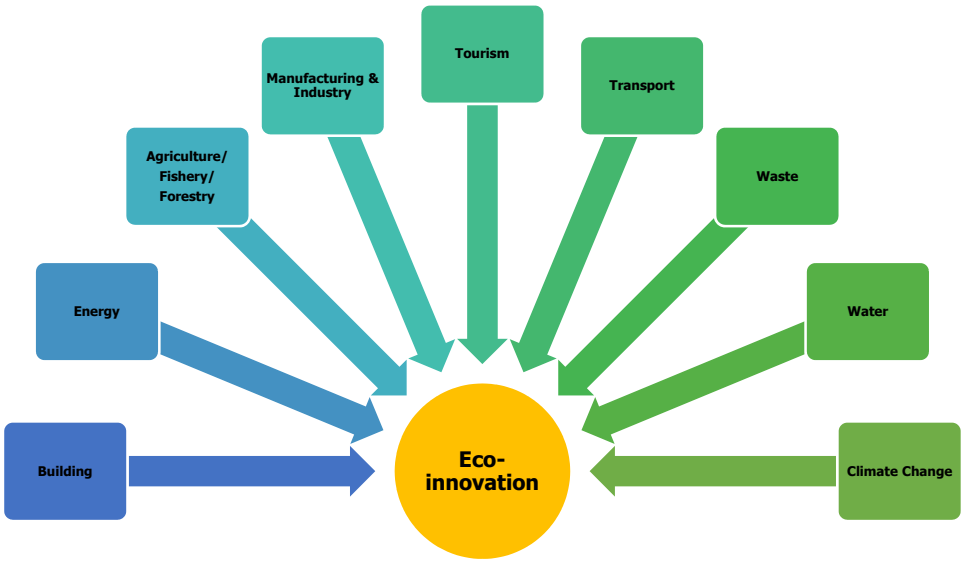
***Relevance of covering areas and stakeholders***

Index should present priority issues of eco-innovation appropriately (Hollander 2002). We analyze to what extent the index covers relevant issues of eco-innovation. As relevant issues of eco-innovation, nine sectors of green economy (UNEP, 2011) are considered; building, energy, agriculture/fishery/forestry, manufacturing & industry, tourism, transport, waste, water, and climate change (Figure 4.1).

Various stakeholders including governments, enterprises, investors, NGOs etc. exist in the field of eco-innovation. Index can be meaningful and useful to multiple stakeholders (Phillips, 2003). It is also important to address actors outside the usual suspicious and go beyond eco-industries, for others to undertake relevant activities too and to need to be covered as well as enabled. The role of the government is crucial for implementing and diffusing eco-innovation at the national level. Governments can develop a national system that enables producing eco-friendly goods and services. Governments can establish and implement policy instruments for eco-innovation, such as environmental regulations, financial schemes, and programs for supporting R&D and fostering eco-markets (Jang et al., 2015d).

Business and industry play a crucial role in reducing impacts on resource use and the environment through more efficient production processes, preventive strategies, and cleaner production technologies and procedures. Citizens as consumers have demands on eco-products, and may become involved in innovation activities. Consumers' behavior contributes to building green markets. NGOs set the environmental issues at the society and collaborate with other actors to create sustainable life. Investors can influence eco-innovation through green investment (Inderst et al., 2012). Therefore, eco-innovation index can be used by multiple stakeholders. It shall also provide useful information for stakeholders in order to encourage further action.

Figure 4.1 Sectors of eco-innovation




***Ability to indicate changes***

The index should present changes of phenomena in the certain area. Here validity, reliability, measurability, comprehensiveness, cost-effectiveness, comparability and accessibility of data can be considered (Table 4.2). Validity means that data is well-grounded and accurately depict a real situation of eco-innovation. It can be evaluated by a way to build a logical structure of index and to collect and handle data. Consistency and reliability can be judged if indicators can be reliable for a period of time. In particular, transparency and quality of data are significant.

Measurability of indices will be assessed if data can be obtained for a community, especially in a nation level. It is related to defining indicators and clarifying measurement tools. Comprehensiveness can be judged by covering parts of eco-innovation. Cost-effectiveness can be assessed with costs of data collection. For example, free data by international organizations has high cost-effectiveness. Comparability is checked if indicators can be compared with other communities. It is related to geographic areas covered by the index, such as cities, countries and regions. Accessibility of data means affordable, and open-access data is preferable.

**Table 4.2. Meaning of analysis categories of ability to indicate changes**

| Category | Meaning |
|---|---|
| Validity | well-grounded in data and accurately depicting a real situation |
| Consistency and reliability | can be researched reliably over a period of time |
| Measurability | data can be obtained for a community |
| Comprehensiveness | represents many parts of an issue and reduces the need for excessive number of indicators |
| Cost-effectiveness | data collection is not overly expensive |
| Comparability | sufficiently general that it can be compared with other communities |
| Accessibility | Use affordable, relevant, and accessible data sources |

[Source] Hollander (2002) & Phillips (2003)

### *Directions towards common goals*

The index can have an orientation towards common goals. The index should clearly state and accurately reflect its intent and be consistent with well-articulated vision statements and goals (Phillips, 2003). Indicators can inform via time series about a direction of changes, and thus if the activities come closer to common goals. Eco-innovation is a means to achieve sustainable development. Therefore, in principle, an eco-innovation index should be connected with sustainable development. Here it will be measured how the index is connected with sustainable development goals (SDGs). On 25$^{th}$ September 2015, the United Nations General Assembly formally adopted the universal, integrated and transformative 2030 Agenda for Sustainable Development, along with a set of 17 Sustainable Development Goals and 169 associated targets. SDGs address the multiple interlinked global challenges of eradicating poverty, ensuring environmental sustainability, achieving economic equity, ensuring gender equality, tackling climate change, building resilience,

managing equitable distribution of natural resources, realizing human rights, and reducing inequality between and within populations.

***SDGs as common goals***

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure *sustainable consumption and production* patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainable use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably mange forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

### *Ability to facilitate further changes*

The index presents the situation of eco-innovation at the national level. The value of index can influence decision-making in the field of eco-innovation. Here applicability of the index will be considered. Index could facilitate countries' changes through assessing strengths and weakness and learning lessons from others. Index can become a part of scenarios and modelling, ideally co-produced with stakeholders. Eco-innovation index influences public awareness of eco-innovation. It

is necessary to interpret how the index is unambiguous and understandable to diverse audiences (Phillips, 2003). Index can be used in establishing and implementing eco-innovation strategies by governments, enterprises and investors. Also, the attractiveness of the index to the media will be reviewed (Hollander, 2002).

# Chapter 5. Analysis Results of Eco-innovation Indices

## 5.1 ASEI

### *5.1.1 Relevance of covering areas and stakeholders*

ASEI was developed to measure eco-innovation at the country level. It informs the national state related to eco-innovation in 51 ASEM member countries, covering both Europe and Asia. ASEI measures four components consisting of capacity, supporting environment, activity and performance. The components cover a complex process of eco-innovation including input, output and impact of eco-innovation.

In general, ASEI uses overarching indicators covering various sectors within a country. In particular, as a composite index, economic competitiveness (1.1) and general innovation capacity (1.2) indicate eco-innovation capacity. Green patent (3.4) and green market (4.6) present eco-innovation activities and performance across sectors. In addition, ASEI presents eco-innovation in the specific sectors. It includes indicators regarding the specific issues of eco-innovation such as climate change, water and energy. $CO_2$ emission density (4.2) and Green Industry Market Size (4.6) regarding low carbon goods and services are related to the sector of climate change. Two indicators including activeness of renewable energy utilization (3.5) and country's energy sustainability level (4.3) present the energy sector. Water consumption density (4.4) indicates an eco-innovation performance. Many indicators of ASEI use the term of 'green technology (indicator 1.3, 1.4, 2.1, 2.3, 2.4 and 3.1)' and 'green industry (indicator 4.5 and 4.6)'. The indicators on green technology and green industry present capacity, support environment and performance of eco-innovation.

ASEI has indicators covering performances by different stakeholders including government, industries and society. Some indicators present governmental capacities and policies including nation's economic competitiveness (1.1), nation's general innovation capacity (1.2) governmental expenditure on green R&D (2.1) and implementation of environmental regulations (2.2). Other indicators of ASEI present eco-innovation supporting environment and activities by enterprises such as commercialization level of green technology firms (3.1), environmental management (3.2), economic influence of leading environmentally responsive firms (3.3), and

green patents (3.4). Finally other indicators are related to performance by investors including investment setting for green technology industry (2.3) and investment scale towards green technology SMEs (2.4).

ASEI is oriented at green technology and green industry. Eight indicators regarding green technology and green industry present all four components of ASEI. Seven indicators related to green technology and green industry have not been measured due to data accessibility. Related data were not available in all target countries, especially in Asian countries. For keeping these indicators, it is necessary to build a database covering all target countries.

Therefore ASEI covers performances by different stakeholders and sets green technology and green industry as high priority issues.

### *5.1.2 Ability to indicate changes*

ASEI implies a country level status on eco-innovation, based on an analytical framework of eco-innovation (Jo et al., 2015). The indicators have clear definition on measuring factors, measuring elements and measuring procedures so data can be properly collected. The index adopted composite indicators which would cost much if measured. Most indicators of ASEI are measured with public and free data which were offered by international organizations such as International Energy Agency, OECD, World Economic Forum etc. However, six indicators are established depending on the data of *Cleantech*. The data of *Cleantech* has some limitation due to its accessibility, cost-effectiveness and comparability. The data covers just EU member countries, and the subscription cost is 10,000 USD per annum. In addition, there is no consistency in measuring the indicators. To keep the indicators, an alternative data source is required. Moreover, for some countries, the statistical method (EM algorithm) was applied to replace the missing values due to absence of data. Therefore, the scores could not present a real situation of eco-innovation.

As mentioned above, to measure indicators regularly in all target countries, it is necessary to build a system on collecting indicators data covering Asian countries in an effective and timely manner.

The index pursuits to present a general situation of eco-innovation of a country by

combining sub-categories measuring each development procedure of eco-innovation. Also, without in-depth research on validity, it is not guaranteed whether the index reflects general situation properly. Therefore, conducting national case studies can help interpret eco-innovation situation. National reports on eco-innovation in Vietnam (Jang et al., 2015c), Republic of Korea (Jang et al., 2015b), Myanmar (Jang et al., 2015a), Japan (Jang et al., 2015e), Singapore (Choi et al., 2016) and Thailand (Han et al., 2016) published by ASEIC support interpretation of ASEI scores of those countries liking with national contexts and instruments for eco-innovation policies.

### *5.1.3 Directions towards common goals*

ASEI indicators are logically related to SDGs. Seven indicators among all indicators of ASEI are created for measuring capacity, supporting environment, activity and performance of green technology and green industry: Indicator 1.3 Green Technology R&D Institution Capacity, Indicator 1.4 Green Technology possessed/acquired Enterprises, Indicator 2.1 Government's R&D expenditure in Green Industry, Indicator 2.3 Maturity of Investment Setting for Green Technology Industry, Indicator 2.4 Investment Scale of Green Technology SMEs, Indicator 3.1 Commercialization Level of Green Technology and Indicator 4.5 Jobs in Green Technology Industry. Eco-innovation is closely related to the development and use of environmental or green technologies as well as the concepts of eco-efficiency and green industry (Sarkar, 2013). Green technology which reduces environmental burdens can facilitate sustainable and resilient infrastructure development at a society and enterprise. It creates and develops new and more sustainable industries by preventing or reducing negative impacts or optimizing the use of natural resources. Therefore, green technology and green industry which ASEI focuses can contribute to building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation (Goal 9 Industry and infrastructure). Consequently, green technology and green industry facilitates sustainable production process through increasing material efficiency and enables sustainable consumption through creating eco-markets (Goal 12 Sustainable Consumption and Production).

Eco-innovation is used in conjunction with eco-efficiency (Jo et al., 2015). The

component of eco-innovation performances of ASEI is measured focusing on resource use efficiency including Indicator 4.2 $CO_2$ Emission Intensity, Indicator 4.3 Nation's Energy sustainability level and Indicator 4.4 Water Consumption Intensity. Therefore, these indicators are related to Goal 13 Climate Action, Goal 7 Clean Energy and Goal 6 Clean Water. In the future material flow analysis – based indicators can be developed, e.g. carbon footprint and water footprint.

Eco-innovation pursues green growth to prevent further environmental risks and to find new opportunities (OECD, 2011). The component of eco-innovation capacity of ASEI includes nation's economic competitiveness (Indicator 1.1) from the Global Competitiveness Index 2015-2016 and general innovation capacity (Indicator 1.2) from the Global Innovation Index 2015. Economic competitiveness and innovation capacity can indicate possibility for promoting sustained, inclusive and sustainable economic growth (Goal 8). Jobs in green technology industry (Indicator 4.5) and green industry market size (Indicator 4.6) as indicators of eco-innovation performance present the status of employment related to the Goal 8 Good jobs and economic growth. In conclusion, ASEI is closely linked with the Goal 8 Good jobs and economic growth, the Goal 9 sustainable industrialization and Goal 12 sustainable consumption and production.

**Table 5.1 ASEI indicators and SDGs**

| Component | Indicator | SDGs |
|---|---|---|
| 1. Eco-Innovation Capacity | 1.1. Nation's Economic Competitiveness | G. 8 Good jobs and economic growth<br>G.12 Responsible consumption and production |
| | 1.2. Nation's General Innovation Capacity | G. 8 Good jobs and economic growth<br>G.12 Responsible consumption and production |
| | 1.3. Green Technology R&D Institution Capacity | G. 9 Industry and infrastructure |
| | 1.4. Green Technology possessed/acquired Enterprises | G. 9 Industry and infrastructure |
| | 1.5. Awareness of Sustainability Management | G.12 Responsible consumption and production |
| 2. Eco-Innovation | 2.1. Government's R&D expenditure in Green Industry | G. 9 Industry and infrastructure<br>G.12 Responsible consumption and production |

| | | |
|---|---|---|
| Supporting Environment | 2.2. Implementation of Environmental Regulations | G. 16 Peace, justice and strong institutions |
| | 2.3. Maturity of Investment Setting for Green Technology Industry | G. 9 Industry and infrastructure |
| | 2.4. Investment Scale of Green Technology SMEs | G. 9 Industry and infrastructure |
| 3. Eco-Innovation Activities | 3.1. Commercialization Level of Green Technology | G.12 Responsible consumption and production |
| | 3.2. Enterprises' Participation on Environmental Management System | G.12 Responsible consumption and production |
| | 3.3. Economic Influence of Leading Environmentally Responsive Enterprises | G. 9 Industry and infrastructure |
| | 3.4. Green Patents | G.12 Responsible consumption and production |
| | 3.5. Activeness of Renewable Energy Utilization | G. 7 Clean energy |
| 4. Eco-Innovation Performances | 4.1. Level of Environmental Impact on Society | G. 3 Good health<br>G.12 Responsible consumption and production |
| | 4.2. $CO_2$ Emission Intensity | G. 13 Climate action |
| | 4.3. Nation's Energy sustainability level | G. 7 Clean energy |
| | 4.4. Water Consumption Intensity | G. 6 Clean water |
| | 4.5. Jobs in Green Technology Industry | G. 8 Good jobs and economic growth<br>G. 9 Industry and infrastructure |
| | 4.6. Green Industry Market Size | G. 8 Good jobs and economic growth<br>G. 9 Industry and infrastructure |

Note: Indicators in the blue cells were measured in 2015 and 2016.

### *5.1.4 Ability to facilitate further changes*

ASEI provides information on the status of national eco-innovation of the target countries in Asia and Europe. ASEI can play a role as a basic source with numeric values for understanding the status of national eco-innovation in the target countries in Asia and Europe. Dividing the index into the sub-categories can give useful implications to policy makers on where their country is and what they should do

considering eco-innovation. By comparing scores of the index and each component with other countries, policy makers can benchmark policy measures of other countries. The index is attractive as it gives country specific scores for ASEM member countries which can show countries' competitiveness on recently highlighted environmental issues at country level. It can also show ASEM's efforts, compared to other developed countries outside ASEM, to move forward to environmental friendly industries.

ASEI measures eco-innovation activities by enterprises such as commercialization level of green technology enterprises (3.1), environmental management by enterprises (3.2), economic influence of leading environmentally responsive firms (3.3), and green patents (3.4). Therefore ASEI can stimulate industrial activities towards eco-innovation. Also ASEI has contributed to increasing awareness of eco-innovation at the national and international society. Based on the scores of ASEI, eco-innovation issues and policies have been discussed at several global forums such as Asia-Europe Environment forum[9], in Brussels, ASEM Global Eco-Innovation Forum[10], 2015 in Seoul and the CLMV workshops on SDGs implementation[11] in Hanoi, 2016. However, it is difficult to find practical implication of ASEI to establish and implement eco-innovation strategies in target countries. Although ASEI was developed by ASEIC within the context of ASEM, few opportunities were created for sharing knowledge of ASEI in ASEM community. For target countries to use the results of ASEI, it is definitely necessary to extend communication on the scores and their interpretation of ASEI across ASEM member countries.

## 5.2 Eco-Innovation Scoreboard (Eco-IS)

### *5.2.1 Relevance of covering areas and stakeholders*

Eco-IS illustrates the overall status and performances of eco-innovation in EU countries, and rank and group regarding the overall eco-innovation performances in

[9] http://www.asef.org/projects/programmes/517-asia-europe-environment-forum-(envforum)

[10] http://aseic.org/center/forum/global_2015.do

[11] http://www.asef.org/projects/themes/sustainable-development/3837-workshop-on-sustainable-development-goals-implementations-in-clmv-countries

key areas including investments, company performance and economic and environmental outcomes (EIO, 2013: viii). Eco-IS measures five components consisting of eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency outcomes and socio-economic outcomes. The components cover a material flow innovation, process eco-innovation, product eco-innovation, organizational eco-innovation, marketing eco-innovation and social eco-innovation (EIO, 2010: 67-69).

In principle, Eco-IS covers multiple sectors in eco-innovation. Eco-IS includes indicators in the specific fields to assess environmental outcomes such as water productivity (4.2), energy productivity (4.3) and GHG emissions intensity (4.4). Especially eco-innovation is closely related to resource efficiency. Many indicators of Eco-IS connect resource efficiency focusing on productivity and intensity at the components of Eco-innovation Activities, Eco-innovation Outputs and Environmental Outcomes. For example, eco-innovation related academic publications (3.2) include the English keywords in title or abstract such as eco-innovation, energy efficient/efficiency, material efficient/efficiency, resource efficient/efficiency, energy productivity, material productivity and resource productivity (Giljum and Lieber, 2016: 10).

Eco-IS has indicators covering main stakeholders including government, industries and society. The indicators present activities by different stakeholders. Expenditure on environmental and energy R&D (1.1) presents governmental policy. Many indicators of Eco-IS present eco-innovation activities and socio-economic outcomes by enterprises such as reduction of material input (2.1) and reduction of energy input (2.2), ISO 14001 registered organizations (2.3), exports of products from eco-industries (5.1), employment in eco-industries (5.2) and revenue in eco-industries (5.3). Total value of green early stage investment (1.3) is related to performance by investors.

Eco-IS indicators include the specific sectors of climate change, water and energy at the component of Environmental Outcomes. The component of Socio-economic Outcomes use the term of 'eco-industries' including indicator 5.1, 5.2 and 5.3. Environmental industry or eco-industry is defined as "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems (OECD and Eurostat, 1999: 9)". This includes cleaner technologies,

products and services that reduce environmental risk and minimize pollution and resource use (European Commission, 2006).

### *5.2.2 Ability to indicate changes*

Eco-IS implies a country level status on eco-innovation, based on theoretical framework of eco-innovation (EIO, 2012). Several reports by EIO (2011, 2013, 2013) indicate the theory-based structure of Eco-IS. The indicators have clear definition on measuring factors, measuring elements and measuring procedures so data can be properly collected (Giljum and Lieber, 2016). Half of indicators of Eco-IS are measured with the statistical data of EUROSTAT as the statistical office of the European Union. A framework for collecting data of EUROSTAT was designed in the process of developing Eco-IS. Therefore, measuring Eco-IS depends on the stable database of EUROSTAT which covers EU countries. The rest of indicators of Eco-IS are measured with open data which are offered by international organizations such as Scopus, Patstat, Water Footprint Network and so on.

The index pursuits to present a general situation of eco-innovation of a country by combining input-output model of eco-innovation. National case reports of EU countries inform national contexts of eco-innovation and consequently help to interpret the scores of Eco-IS in each country.

### *5.2.3 Directions towards common goals*

Eco-IS is connected with sustainable development goals (SDGs). The component of Socio-economic Outcomes focus on 'eco-industries' including Indicator 5.1 Export of Products from Eco-industries, Indicator 5.2 Employment in Eco-industries and Indicator 5.3 Turnover in Eco-industries. Eco-industries can contribute to building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation (Goal 9 Industry and Infrastructure). They promote sustainable economic growth and productive employment (the Goal 8 Good Jobs and Economic Growth.

Eco-IS focuses on the resource-use aspect of eco-innovation. Resource efficiency is a core element in eco-innovation (Jo et al., 2015). The component of Eco-innovation activities is measured focusing on reducing resource use including Indicator 2.1

Reduction of Material Input and 2.2 Reduction of Energy Input. It facilitates sustainable industrialization (Goal 9 Industry and Infrastructure) and sustainable production process through increasing material efficiency and enables sustainable consumption through providing eco-products (Goal 12 Sustainable Consumption and Production). The component of Environmental Outcomes is measured increasing productivity and using resources more effectively including Indicator 4.1 Material Productivity, Indicator 4.2 Water Productivity, Indicator 4.3 Energy Productivity, and Indicator 4.4 GHG Emissions Intensity. The indicators are related to Goal 13 Climate Action, Goal 7 Clean Energy and Goal 6 Clean Water. In conclusion, Eco-IS is closely linked with the Goal 8 Good jobs and economic growth, the Goal 9 sustainable industrialization and Goal 12 sustainable consumption and production.

**Table 5.2 Eco-IS indicators and SDGs**

| Component | Indicator | SDGs |
|---|---|---|
| 1. Eco-innovation inputs | 1.1 Governments environmental and energy R&D appropriations and outlays | G. 8 Good jobs and economic growth<br>G. 9 Industry and infrastructure |
| | 1.2 Total R&D personnel and researchers | G. 8 Good jobs and economic growth |
| | 1.3 Total value of green early stage investments | G. 9 Industry and infrastructure |
| 2. Eco-innovation activities | 2.1 Firms having implemented innovation activities aiming at a reduction of material input per unit output | G. 9 Industry and infrastructure<br>G.12 Responsible consumption and production |
| | 2.2 Firms having implemented innovation activities aiming at a reduction of energy input per unit output | G. 7 Clean energy<br>G. 9 Industry and infrastructure<br>G.12 Responsible consumption and production |
| | 2.3 ISO 14001 registered organisations | G. 9 Industry and infrastructure<br>G.12 Responsible consumption and production |
| 3. Eco-innovation outputs | 3.1 Eco-innovation related patents | G. 9 Industry and infrastructure<br>G.12 Responsible consumption |

| | | |
|---|---|---|
| | | and production |
| | 3.2 Eco-innovation related academic publications | G. 9 Industry and infrastructure |
| | 3.3 Eco-innovation related media coverage | G. 9 Industry and infrastructure |
| 4. Environmental outcomes | 4.1 Material productivity | G. 9 Industry and infrastructure<br>G.12 Responsible consumption and production |
| | 4.2 Water productivity | G.6 Clean water |
| | 4.3 Energy Productivity | G. 7 Clean energy<br>G. 9 Industry and infrastructure |
| | 4.4 GHG emissions intensity | G. 13 Climate action |
| 5. Socio-economic outcomes | 5.1 Exports of products from eco-industries | G. 9 Industry and infrastructure |
| | 5.2 Employment in eco-industries | G. 8 Good jobs and economic growth<br>G. 9 Industry and infrastructure |
| | 5.3 Turnover in eco-industries | G. 9 Industry and infrastructure |

### *5.2.4 Ability to facilitate further changes*

Eco-IS illustrates eco-innovation performances of countries and industries over time. It indicates how well individual member states perform in different dimensions of eco-innovation compared to the EU average and presents their strength and weakness. No country performed well across all categories (EIO, 2011). Eco-IS has been annually measured and the country scores were announced by annual reports and internet homepage of EIO since 2010. Consequently, the measured scores of the respective indicators can be compared and present the changes over time.

Eco-IS was created and has been used within the European policies for eco-innovation. It is being referred to as political information for the EU Eco-Innovation Action Plan (EcoAP)[12] which is an important progress for Europe to promote general Eco-Innovative processes, products and services other than green technology (ASEIC, 2014: 20). EcoAP includes monitoring and reviewing eco-innovation

[12] http://ec.europa.eu/environment/ecoap/frontpage_en

measures and action taken by Member States with Eco-IS (European Commission, 2011:16). Therefore, Eco-IS is interlinked with regional and national policies on eco-innovation in Europe.

Also Eco-IS helps to raise awareness about eco-innovation at the national and international societies. The aggregated index and the country rankings of Eco-IS are frequently taken up by the media (EIO, 2013).

# Chapter 6. Discussion: Comparison between ASEI and Eco-IS

ASEI and Eco-IS have some strength and weakness (Table 6.1). Comparing between ASEI and Eco-IS, there are some similarities and differences which are worth noting. As similarities, firstly ASEI and Eco-Is illustrate the overall status and performances of eco-innovation at the national level with the systematic approach. They present conditions of national innovation system and technology innovation systems. They provide scores with multiple layers including the overall indices (one aggregated layer), indices from main components (second layer) and the single indicators in each component (third layer). They are based on the model of eco-innovation including input, output and impact of eco-innovation (Kemp and Pearson, 2007). They consist of theory-driven indicators (Niemeijer, 2002). Indicators were developed with an understanding of theories including determinants and process of eco-innovation. One of the implications is to look at innovations in a wider perspective that includes the dissemination and market development of more sustainable trajectories.

Second, two indices include proxy indicators using data regarding green technology and green industries due to a general lack of data on eco-innovation across sectors (EIO, 2013; 20). Both have a focus on the resource-use aspect of eco-innovation (EIO, 2010; ASEIC, 2014). Despite such broad approach, the more traditional indicators of green industry and eco-industry play a pivotal role in performances and impacts of eco-innovation. They contribute to job creation and the realization of environmental policy targets such as reduction of greenhouse gases, share of renewable energy and energy efficiency savings (Bilsen and Rademaekers, 2009: 22). Consequently, two indices including indicators on green industry and eco-industry have a great potential in contributing towards the SDGs, in particular the Goal 9 sustainable industrialization and Goal 12 sustainable consumption and production. Both indices try to capture the balance between the more traditional green industry, relevant efforts by others, and the overall outcomes for the economies.

Third, two indices are not static tools, but continuously improved and updated, as more recent data becomes available and new data sources are being tested (Giljum and Lieber, 2016). Replacements of underlying data sources lead to change in the country scores for the indicators and bring some limitation of the direct comparison of the scores over time.

Fourth, two indices contribute to sharing knowledge on eco-innovation and raising awareness on eco-innovation. Annually the scores of ASEI and Eco-IS were announced by annual reports and were informed by global forums. Country reports of eco-innovation support understanding the scores of two indices. EIO reports include more multiple interpretation of the scores than ASEIC reports. Fifth, two indices present overall status of eco-innovation across sectors, while they offer few information on sectoral eco-innovation. Although they include indicators about the sector of climate change, water resources and energy within the component of Eco-innovation Performances of ASEI and Eco-innovation Outcomes of Eco-IS, they exclude other major sectors of eco-innovation such as the sector of agriculture and forestry. To sum up, the above four similarities are strengths of ASEI and Eco-IS, and the last similarity appears to be a current weakness of both ASEI and Eco-IS. Recently European Commission started to fund a project with the title of RECREATE[13] focusing on climate action, resource efficiency and raw materials. The project includes development of Green Horizons Scoreboard for assessing EU Member States' performance in several sectors of innovation system such as agriculture and soil sciences, bio-economy, climate adaption, critical raw materials, energy efficiency, environmental governance, fossil fuel efficiency, material efficiency, renewable energy, waste and recycling and water and waste water (Jordan et al., 2015). The Green Horizons Scoreboard might provide sectoral eco-innovation performances which Eco-IS do not present.

**Table 6.1 Strength and weakness of ASEI and Eco-IS**

| Index | Category | Strength | Weakness |
|---|---|---|---|
| ASEI | Covering relevant areas and stakeholders | Illustrating the country profiles in Asia and Europe<br>Measuring performances by multiple stakeholders | Limitation to measure sectoral eco-innovation |
| | Able to indicate changes | Illustrating the country profiles with multiple layers<br>Evidence-based indicators<br>Continuous modification of measurement | Lack of data<br>High costs for collecting data<br>Not entirely clear how disruptive innovations are shaped by countries, and how country changes shall be |

[13] RECREATE stands for "**RE**search network for forward looking activities and assessment of research and innovation prospects in the fields of **C**limate, **R**esource **E**fficiency and raw m**ATE**rials."

| | | | |
|---|---|---|---|
| | | | interpreted. |
| | Towards common goals | Linking with some SDGs | Not yet strong on SDGs related to food and land |
| | Facilitate further changes | Facilitating improvement of green technology and industry | Weak linkage of national eco-innovation policies with ASEI |
| Eco-IS | Covering relevant areas and stakeholders | Illustrating the country profiles in Europe<br>Measuring performances by multiple stakeholders | Limitation to measure sectoral eco-innovation |
| | Able to indicate changes | Illustrating the country profiles with multiple layers<br>Stable database system<br>Theory-based indicators<br>Continuous modification of measurement | Not entirely clear how disruptive innovations are shaped by countries, and how country changes shall be interpreted. |
| | Towards common goals | Linking with some SDGs | Not yet strong on SDGs related to food and land |
| | Facilitate further changes | Facilitating improvement of eco-industry<br>Linking with regional and national policies in Europe<br>Extending knowledge sharing and raising awareness of eco-innovation<br>Facilitating resource efficiency | Unclear to what extent it is used by stakeholders, how strongly its links with real policies play out, and how it is linked with real foresight processes. |

As regards to differences, the scope of the countries covered differs across the two indices. ASEI covers both Asian and European countries, while Eco-IS covers only EU countries. ASEI covers all EU countries of Eco-IS. Many environmental indicators inform the country profiles from developed countries including OECD countries due to lack of data from developing countries. However, ASEI informs the status of eco-innovation in developing countries in Asia.

Second, data availability of two indices is different. ASEI has limitation of measuring all indicators due to data availability. Currently, eight indicators are not measured because of lack of data from Asian developing countries. It is a huge weakness of ASEI. However Eco-IS is based on the stable database from EUROSTAT which provides proper data to assess Eco-IS. EIO has been able to define necessary data and collect them for measuring eco-innovation using the EU network. It is a

powerful strength of Eco-IS. Asia has no regional level database. To complete measuring ASEI, it is necessary for Asian countries to create a database based on ASEM.

Third, Eco-IS is closely linked with the regional and national policies for eco-innovation by European Commission such as EcoAP, while ASEI was not directly applied to national policies for eco-innovation in ASEM countries. Eco-IS was developed as a part of eco-innovation policies by the European Commission. It seeks to stimulate the establishment and implementation of national strategies – although one would need to assess how strong these links are in reality, especially at the level of member states. Comparing with Eco-IS, ASEI has not done such facilitation yet and could start support for creating national roadmaps for eco-innovation in ASEM countries. More opportunities for sharing the results of ASEI with ASEM countries are necessary. More country reports and thematic reports including the scores of ASEI and their interpretation should be published for extending communication on ASEI at the global level.

# Chapter 7. Conclusion

Both ASEI and Eco-IS as eco-innovation indices are now established and help to understand eco-innovation patterns in the countries over time. Two indices in themselves are important tools for policy-makers, R&I managers, and analysts. Both illustrate the status of national eco-innovation focusing on green technology. They are expected to contribute towards the SDGs, in particular the Goal 9 sustainable industrialization and Goal 12 sustainable consumption and production. In doing so, they can help bringing eco-innovation into the SDG debates and vice versa. What is needed is a better link from such indices to foresight processes, scenarios, and modelling. Such attempts would need to be done by research, but results and the processes themselves would be relevant for all policy makers interested in seeing how their countries come closer to delivering SDGs or similar sustainability goals.

However, ASEI has a weakness of data availability in Asian countries. For measuring ASEI completely and continuously, it is required for Asian countries to create a database on eco-innovation, and make it accessible and comparable. For the next stage, not only modifying indicators of ASEI and Eco-IS but also expanding the application of two indices towards more sectors and more countries is necessary. Again, the scores of the two indices can be utilized for future work on scenarios and modelling helping to achieve policy-relevant purposes.

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# Appendix

## Appendix 1. Characteristics of ASEI indicators and data collecting methods

Source: Park et al. (2016)

| Indicator | Country's Economic Competitiveness (1.1) |
|---|---|
| Category | Eco-innovation Capacity |
| Measuring factor | Efficiency enhancers subindex of the Global Competitiveness Index measures factors promoting economic efficiency of countries such as country's level of higher education and training, efficiency of product markets, efficiency of labor market, development of financial markets, technological foundation and market sizes. |
| Measuring element | Efficiency enhancers subindex (Pillar 5~10) of the Global Competitiveness Index 2015-2016 |
| Source | The Global Competitiveness Index 2015-2016 |
| Publisher | World Economic Forum |
| Data collection interval | Annual |
| Target | 148 countries (50 ASEM member countries are included except Brunei Darussalam) |
| Method | The World Economic Forum's Global Competitiveness Index consists of Basic requirements subindex, Efficiency enhancers subindex, and Innovation and sophistication factors subindex covering 12 Pillars<br>The Efficiency enhancers subindex consists of 53 indicators measured by number from 1 to 7 from a survey.<br>The survey was conducted in 148 countries from February to June 2014 with a target of 14,000 companies (22 countries were surveyed on-line)<br>GCI 2015-2016 is a synthesis of a survey in 2014 and 2015 |
| Remarks | - Composite index (114 indicators, ASEI uses 53 indicators)<br>- Published every year<br>- Most qualitative indicators among 20 ASEI indicators<br>- Korean partners: KDI, Seungjoo Lee, Research Associate, Public Opinion Analysis Unit, Youngho Jung, Head, Public Opinion Analysis Unit |
| References used | World Economic Forum, Executive Opinion Survey<br>World Bank/International Finance Corporation, Doing Business 2015: Going Beyond Efficiency<br>International Air Transport Association, SRS Analyser<br>International Telecommunication Union, ITU World Telecommunication/ICT Indicators Database 2015 (June 2015 edition)<br>International Monetary Fund, World Economic Outlook Database (April 2015 edition)<br>Central Intelligence Agency (CIA)<br>The World Factbook (accessed June 22, 2015)<br>The World Health Organization, World Malaria Report2013<br>United States Centers for Disease Control and Prevention (CDC)<br>Malaria Information and Prophylaxis information (accessed July 11, 2014)<br>UNESCO Institute for Statistics, Data Centre (accessedJuly 2, 2015)<br>Organisation for Economic Co-operation andDevelopment (OECD)<br>Sistemade Información de tendencias Educativas de América Latina(SITEAL) |

| | United Nations Development Programme (UNDP) |
|---|---|
| Indicator | Country's General Innovation Capacity (1.2) |
| Category | Eco-innovation Capacity |
| Measuring factor | Measuring the level of innovation capacity including status of research institutions, human capital, infrastructure, elaborateness of market and industries, outcomes of technologies |
| Measuring element | Global Innovation Index |
| Source | The Global Innovation Index 2015 |
| Publisher | INSEAD, WIPO, Cornell University |
| Data collection interval | Annual |
| Target | 143 countries (50 ASEM countries are included except Lao PDR) |
| Method | The Global Innovation Index published by INSEAD, WIPO, Cornell University consists of Innovation Input Sub-index and Innovation Output Sub-Index<br>Input Subindex consists of Institutions, Human capital and research, Infrastructure, Market sophistication and Business sophistication while Output Sub-index does Knowledge and technology outputs and Creative outputs.<br>Each subindex consists of 3 categories and each category has 3 to 5 indicators.<br>GII consists of 81 indicators |
| Remarks | - Composite index (81 indicators)<br>- Published annually<br>- A indicator called ISO 14001 environmental certificates (3.1.1) is directed related to Firms' participation on Environmental Management System of ASEI |
| References used | World Bank, World Governance Indicators 2013 update<br>The methodology was improved for Doing Business 2015<br>World Bank, Doing Business 2015: Going Beyond Efficiency<br>World Bank, Ease of Doing Business Index 2015<br>UNESCO Institute for Statistics, UIS online database (2005–13)<br>OECD Programme for International Student Assessment (PISA) (2010–12)<br>QS Quacquarelli Symonds Ltd, QS World University Ranking 2014/2015, Top Universities<br>International Telecommunication Union, Measuring the Information Society 2014, ICT Development Index 2014<br>United Nations Public Administration Network, e-Government Survey 2014<br>International Energy Agency, World Energy Balances online data service (2012–13)<br>World Bank and Turku School of Economics, Logistics Performance Index 2014<br>International Monetary Fund, World Economic Outlook 2014 database, April 2015 (PPP$ GDP)<br>Yale University and Columbia University, Environmental Performance Index 2014<br>International Organization for Standardization (ISO), The ISO Survey of Management System Standard Certifications, 1999–2013<br>Standard and Poor's and World Bank and OECD GDP estimates; extracted from the World Bank's World Development Indicators database (2006–12).<br>Microfinance Information Exchange, Mix Market database; |

| Indicator | Green Technology R&D Institutions Capacity (1.3) |
|---|---|
| Category | Eco-Innovation Capacity |
| Measuring element | Number of Green (Clean) Technology R&D Institutions, Centers and University |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | - Cleantech provides data to EU member countries<br>- Subscription cost is 10,000 USD per annum<br>- Cleantech covers 40 countries of which 32 countries are ASEM members.<br>- A part of the indicator is overlapped with ASEI Indicator 2.1. |

| Indicator | Green Technology possessed/acquired Firms (1.4) |
|---|---|
| Category | Eco-Innovation Capacity |
| Measuring factor | Number of companies which possess green technologies |
| Measuring element | Number of Green (Clean) Technology possessed firms (Include firms in all development stages: concept, product development, shipping product/pilot, wide commercial availability) |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | - Cleantech provides data to EU member countries<br>- Subscription cost is 10,000 USD per annum<br>- Cleantech covers 40 countries of which 32 countries are ASEM members. |

| Indicator | Awareness of Sustainability Management (1.5) |
|---|---|
| Category | Eco-innovation Capacity |
| Measuring factor | Number of United Nations Global Compact Participant Firms |
| Measuring element | Number of United Nations Global Compact Participant Firms. The UN Global Compact is the world's largest corporate citizenship and sustainability initiative, which its networks include important business associations representing leading companies from around the world. |
| Source | United Nations Global Compact |
| Publisher | UNGC |
| Data collection interval | Available on a certain date |
| Target | 199 countries including 51 ASEM members |
| Method | - https://www.unglobalcompact.org/what-is-gc/participants<br>- Data available since 2000.07<br>- Current data used for ASEI is retrieved from a range of 1st July 2000 to 20th October 2016<br>- Both business and non-business are included<br>- Data is complete for the whole ASEM member countries |

| Indicator | Government's R&D expenditure in Green Industry (2.1) |
|---|---|
| Category | Eco-Innovation Supporting Environment |
| Measuring element | Public spending in environmentally related RD, % total public spending |
| Source | OECD Green Growth Indicators |
| Publisher | OECD |
| Data collection interval | Data upto year 2014 |
| Target | 42 countries of which 24 countries are ASEM members |
| Method | - http://stats.oecd.org/<br>OECD's Environment>Green Growth>Economic opportunities and policy responses>Technology and innovation: R&D>Environmentally related government R&D budget, % total government R&D<br>- Currently 2014 data is used |
| Remarks | - Not all ASEM members are covered<br>- More investigation is needed to find out data for Non-OECD countries |

| Indicator | Implementation of Environmental Regulations (2.2) |
|---|---|
| Category | Eco-Innovation Supporting Environment |
| Measuring element | Stringency and enforcement of environmental regulation |
| Source | Sustainable Competitiveness Index |
| Publisher | World Economic Forum |
| Data collection interval | Annually |
| Target | 113 countries of which 46 countries are ASEM members except Lao PDR, Myanmar, Brunei Darussalam, Singapore and Malta |
| Method | Two indicators called "Stringency of environmental regulation" and "Enforcement of environmental regulation" from the Sustainable Competitiveness Index<br>- The data is based on survey<br>- The indicators use the results of WEF's Executive Opinion Survey |
| References used | World Economic Forum, Executive Opinion Survey<br>http://www.weforum.org/content/pages/sustainable-competitiveness/<br>Stringency: How would you assess the stringency of your country's environmental regulations? [1 = very lax, among the worst in the world; 7 = among the world's most stringent]<br>Enforcement: In your country, how would you assess the enforcement of environmental regulations? [1 = very lax, among the worst in the world; 7 = among the world's most rigorous] |
| Remarks | - Applying the average of the results from 2 surveys |

| Indicator | Maturity of Investment Setting for Green Technology Industry (2.3) |
|---|---|
| Category | Eco-Innovation Supporting Environment |
| Measuring element | Value of Investment towards Green Technology Firms |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | - Cleantech provides data to EU member countries<br>- Subscription cost is 10,000 USD per annum<br>- Cleantech covers 40 countries of which 32 countries are ASEM members. |

| Indicator | Investment Scale towards Green Technology SMEs (2.4) |
|---|---|
| Category | Eco-Innovation Supporting Environment |
| Measuring element | Number of venture capitals & deals made towards green technology SMEs |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | Cleantech provides data to EU member countries<br>Subscription cost is 10,000 USD per annum<br>Cleantech covers 40 countries of which 32 countries are ASEM members. |

| Indicator | Commercialization Level of Green Technology (3.1) |
|---|---|
| Category | Eco-Innovation Activity |
| Measuring element | Number of companies with green technology widely commercialized |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | - Cleantech provides data to EU member countries<br>- Subscription cost is 10,000 USD per annum<br>- Cleantech covers 40 countries of which 32 countries are ASEM members. |

| Indicator | Firms' Participation on Environmental Management System (3.2) |
|---|---|
| Category | Eco-Innovation Activity |
| Measuring factor | Number of firms with ISO14001 certification (per billion GDP in PPP$) |
| Measuring element | Number of firms with ISO14001 certification (per billion GDP in PPP$) |
| Source | ISO 14001 Survey |
| Publisher | ISO |
| Data collection interval | Annually (latest in 2013) |
| Target | 46 countries |
| Method | Two data sets are needed to measure: number of firms with ISO certification and GDP in PPP<br>- GCI measured for all ASEM members except 5 countries in 2012 |
| Remarks | The same indicator as an indicator called "ISO 14001 environmental certificates" (3.3.3) of the Global Competitiveness Index<br>- Updating data with the two data sets |

| Indicator | Economic Influence of Leading Environmentally Responsive Firms (3.3) |
|---|---|
| Category | Eco-Innovation Activity |
| Measuring element | Revenue of firms included in Newsweek Green Ranking. |
| Source | Newsweek Green Ranking |
| Publisher | Newsweek (Sustainalytics & Trucost) |
| Data collection interval | Every two years |
| Target | 25 countries |
| Method | - Green Ranking is derived from the results of 8 indicators.<br>It consists of three categories: environmental impacts, environmental management and environmental announcements |
| Remarks | - Sustainalytics & Trucost analyze the score<br>Majority of ASEM member countries has no firm under the World's Greenest Companies 500<br>Among ASEM countries from Asia, a few countries have such firms such as 34 firms from Japan, 34 firms from China, 9 firms from Australia, 7 firms from India, 6 firms from South Korea and 4 firms from Singapore<br>- Revenue data from firm are needed |

| Indicator | Green patents (3.4) |
|---|---|
| Category | Eco-Innovation Activity |
| Measuring element | Environmental technology patent (Patent grants by technology) / Total patent grant (direct and PCT national phase entires) |
| Source | OECD Green growth |
| Publisher | OECD |
| Data collection interval | Annually |
| Target | 32 countries |
| Method | WIPO statistics Database |
| Remarks | - Quantitative data<br>- The definiation of environmental technology is followed WIPO<br>- filling office |

| Indicator | Activeness of Renewable Energy Utilization (3.5) |
|---|---|
| Category | Eco-Innovation Activity |
| Measuring element | Measures the contribution of renewable to total primary energy supply (TPES) |
| Source | Energy Balances of OECD countries & Energy Balances of non-OECD countries |
| Publisher | International Energy Agency |
| Data collection interval | Annually |
| Target | 50 countries except Lao PDR |
| Method | - Data available in 2014 (included estimated data)<br>- OECD country report and Non-OECD country report provides data<br>- Charged data |
| Remarks | Renewable energy is defined to include hydraulic power, geothermal, solar heat, wind power, tidal power, solid bio fuel, bio gasoline, bio diesel and other liquid bio fuel and bio gas |

| Indicator | Level of Environmental impact on Society (4.1) |
|---|---|
| Category | Eco-Innovation Performance |
| Measuring factor | Environmental health including air pollution, water, access to drinking water and diseases |
| Measuring element | Measuring Environmental Health of Environmental Performance Index |
| Source | Environmental Performance Index 2015 |
| Publisher | Yale University & Columbia University & World Economic Forum |
| Data collection interval | Every two years |
| Target | 51 countries |
| Method | Environmental Health Index consists of 6 indicators |
| References used | - United Nations, Department of Economic and Social Affairs, Population Division (2014).<br>- World Population Prospects: The 2012 Revision.<br>Aerosol Optical Depth (AOD) from NASA's MODIS, SeaWiFS, and MISR satellite instruments, and the GEOSChem chemical transport model.<br>- World Health Organization's Household Energy Database (World Health Organization (2012).<br>WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation(http://www.wssinfo.org/data-.estimates/table/) |

| Indicator | $CO_2$ Emission Intensity (4.2) |
|---|---|
| Category | Eco-Innovation Performance |
| Measuring element | $CO_2$ emissions / GDP using exchange rates |
| Source | Key World Energy Statistics 2015 |
| Publisher | International Energy Agency |
| Data collection interval | Annually |
| Target | 50 countries except Lao PDR |
| Method | - $CO_2$ emissions / GDP(PPP)(2005USD)<br>- $CO_2$ emissions include fuel combustion only<br>- IPCC Guideline (1996) is applied to calculate the emissions |

| Indicator | Country's Energy Sustainability Level (4.3) |
|---|---|
| Category | Eco-Innovation Performance |
| Measuring element | Energy Performance of the Energy Sustainability Index |
| Source | Energy Sustainability Index |
| Publisher | World Energy Council |
| Data collection interval | Annually |
| Target | 48 countries except Lao PDR, Myanmar and Brunei Darussalam |
| Method | - Energy performance consists of 13 indicators<br>- It provides raw data |
| Remarks | Ranking reflecting energy security, social equity and environmental impact |

| Indicator | Water Consumption Intensity (4.4) |
|---|---|
| Category | Eco-Innovation Performance |
| Measuring element | Water withdrawal for each 1,000 US$ of GDP in cubic meters |
| Source | World Competitiveness Yearbook |
| Publisher | IMD |
| Data collection interval | Annually |
| Target | 60 countries including 39 ASEM members |
| Method | - The indicator called "4.4.15: Water Consumption Intensity" of the IMD World Competitiveness year book<br>- IMD World Competitiveness year book provides data on 60 countries. |
| Remarks | - Charged data<br>- Referred to FAO, Total water withdrawal |
| References used | - Food and Agriculture Organization of the United Nations (FAO)<br>- AQUASTAT<br>- OECD Environmental Data April 2014<br>- EUROSTAT April 2014<br>Annual quantity of freshwater withdrawn for agricultural, industrial and domestic purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and eventual use of desalinated water or treated wastewater. It does not include other categories of water use, such as for cooling of power plants, mining, recreation, navigation, fisheries, etc., which are sectors that are characterized by a very low net consumption rate. Years showed as 2009 can range from 2000 to 2010. |

| Indicator | Jobs in Green Technology Industry (4.5) |
|---|---|
| Category | Eco-Innovation Performance |
| Measuring element | Number of Employees |
| Source | Cleantech Group |
| Publisher | Cleantech |
| Data collection interval | Annually |
| Target | NA |
| Method | NA |
| Remarks | - Cleantech provides data to EU member countries<br>- Subscription cost is 10,000 USD per annum<br>- Cleantech covers 40 countries of which 32 countries are ASEM members. |
| Indicator | Green Industry Market Size (4.6) |
| Category | Eco-Innovation Performance |
| Measuring factor | Green Market Size |
| Measuring element | BIS (then BERR) commissioned Innovas/K-matrix to undertake a market assessment of the size of the UK low carbon and environmental goods and services (LCEGS) sector in 2008. The sector has been defined using 24 sub sectors (Level 2 markets). These are sub-divided into three broad categories- Environmental, Renewable Energy and Low Carbon- the addition of each broadly mapping the evolution of the current LCEGS sector definition from its environmental roots |
| Source | LOW CARBON ENVIRONMENTAL GOODS AND SERVICES (LCEGS) Report 2011/2012 |
| Publisher | UK Department for Business Innovation & Skills |
| Data collection interval | Annually |
| Target | 224 countries of which 49 countries are ASEM members |
| Method | - Total LCEGS (Low Carbon Environmental Good and Survices) Country Markets size<br>- LCEGS – underlying data |

## Appendix 2. Characteristics of Eco-IS indicators and data collecting methods

Source: Giljum and Lieber (2016)

| Indicator | 1.1 Governments environmental and energy R&D appropriations and outlays |
|---|---|
| Short description | The relative priority given by governments to investing in research and development in the areas of energy, including renewables, and environment |
| Unit of measurement | Percentage (of GDP) |
| Original data | Mln Eur |
| Data provider | EUROSTAT |
| Link to original data | http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gba_nabsfin07&lang=en |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 1.2 Total R&D personnel and researchers |
|---|---|
| Short description | Indicator of the knowledge and research capabilities of a country. Since the data for R&D personnel involved in eco-innovation or environmental or cleantech research is not available, the generic indicator in used |
| Unit of measurement | Percentage (of total employment) |
| Original data | Share of total employment |
| Data provider | EUROSTAT |
| Link to original data | http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init =1&plugin=1&language=en&pcode=tsc00025 |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 1.3 Total value of green early stage investments |
|---|---|
| Short description | The value of early stage investments in cleantech industries |
| Unit of measurement | USD/capita |
| Original data | USD per country |
| Data provider | Cleantech |
| Link to original data | www.cleantech.com, however access to data is available only upon subscription. In case of the EcoIS, the data was provided directly by Cleantech. |
| Most recent year available | 2015 |
| Frequency of updates | Quarterly & annually |
| Geographical coverage | 79% |
| Update in Scoreboard 2015 | Updated to 2015, based on cumulative indicators for 2013-2015 |

| Indicator | 2.1 Firms having implemented innovation activities aiming at a reduction of material input per unit output |
|---|---|
| Short description | Indicator of material efficiency oriented eco-innovation in companies |
| Unit of measurement | Percentage (of total firms) |
| Original data | N of companies per country |
| Data provider | EUROSTAT / Community Innovation Survey (CIS) |
| Link to original data | http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey |
| Most recent year available | 2008 |
| Frequency of updates | Not systematic. The indicator was covered only in the 2008 and 2014 surveys. |
| Geographical coverage | 79% |
| Update in Scoreboard 2015 | No update, as new data from CIS 2014 will only be available in autumn 2016. Data thus refers to the CIS 2008 version. |

| Indicator | 2.2 Firms having implemented innovation activities aiming at a reduction of energy input per unit output |
|---|---|
| Short description | Indicator of energy efficiency oriented eco-innovation in companies |
| Unit of measurement | Percentage (of total firms) |
| Original data | USD per country |
| Data provider | EUROSTAT / Community Innovation Survey (CIS) |
| Link to original data | http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey |
| Most recent year available | 2008 |
| Frequency of updates | Not systematic. The indicator was covered only in the 2008 and 2014 surveys. |
| Geographical coverage | 79% |
| Update in Scoreboard 2015 | No update, as new data from CIS 2014 will only be available in autumn 2016. Data thus refers to the CIS 2008 version. |

| Indicator | 2.3 ISO 14001 registered organisations |
|---|---|
| Short description | The importance of observing environmental management requirements for business. Can be seen as a proxy indicator for the level of environmental awareness and management capability of business. |
| Unit of measurement | Number per mln population |
| Original data | N of organisations per country |
| Data provider | ISO Survey of Certifications |
| Link to original data | http://www.iso.org/iso/home/standards/certification/iso-survey.htm |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 3.1 Eco-innovation related patents |
|---|---|
| Short description | According to OECD's scoping of patents in environmentally-related technologies: Energy generation from renewable and non-fossil sources PLUS Combustion technologies with mitigation potential PLUS Emissions abatement and fuel efficiency in transportation PLUS Energy efficiency in buildings and lighting PLUS Complementary Patstat queries conducted by EIO team |
| Unit of measurement | Number per mln population |
| Original data | N of patent per country |
| Data provider | Patstat database of European Patent Office (EPO) |
| Link to original data | No links available as Pastat database used for extracting data is offline (on CD) |
| Most recent year available | 2012 (the data for later years is available but incomplete) |
| Frequency of updates | Bi-annual |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2012 |

| Indicator | 3.2 Eco-innovation related academic publications |
|---|---|
| Short description | Institutions being involved in publications with the following list of English key-words in title and/or abstract: eco-innovation, energy efficient/efficiency, material efficient/efficiency, resource efficient/efficiency, energy productivity, material productivity, resource productivity |
| Unit of measurement | Number per mln population |
| Original data | N of publications |
| Data provider | Scopus |
| Link to original data | www.scopus.com (access is available upon subscription) |
| Most recent year available | 2014 |
| Frequency of updates | Daily |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 3.3 Eco-innovation related media coverage |
|---|---|
| Short description | Number of hits in all electronic media covered by "Meltwater News" with key-word "Eco-innovation" (translated in all EU-27 languages) |
| Unit of measurement | Number per mln population |
| Original data | Annual hits Number of electronic media sources |
| Data provider | Online media monitoring |
| Link to original data | www.meltwater.com (access is available upon subscription) |
| Most recent year available | 2015 |
| Frequency of updates | Daily |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2015 |

| Indicator | 4.1 Material productivity |
|---|---|
| Short description | Illustrates the GDP generated by material consumption of a country |
| Unit of measurement | GDP/Domestic Material Consumption |
| Original data | Domestic Material Consumption (DMC) |
| Data provider | EUROSTAT |
| Link to original data | http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_mfa&lang=en |
| Most recent year available | 2013 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2013 |

| Indicator | 4.2 Water productivity |
|---|---|
| Short description | Illustrates the GDP generated by domestic water consumption |
| Unit of measurement | GDP/Water Footprint |
| Original data | National Water Footprint |
| Data provider | Water Footprint Network |
| Link to original data | http://www.waterfootprint.org/?page=files/WaterStat-NationalWaterFootprints |
| Most recent year available | 1996-2005 |
| Frequency of updates | Next update probably in 2017 |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Not updated, as new data set is not yet available. |

| Indicator | 4.3 Energy productivity |
|---|---|
| Short description | Illustrates the GDP generated by domestic energy use |
| Unit of measurement | GDP/ gross inland energy consumption |
| Original data | Primary energy consumption |
| Data provider | EUROSTAT |
| Link to original data | http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdcc120 |
| Most recent year available | 2013 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2013 |

| Indicator | 4.4 Greenhouse gas (GHG) emission intensity |
|---|---|
| Short description | Illustrates the amounts of GHG emissions generated per unit of GDP |
| Unit of measurement | $CO_2$/GDP |
| Original data | GHG emissions |
| Data provider | EEA |
| Link to original data | http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer |
| Most recent year available | 2013 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2013 |

| Indicator | 5.1 Exports of products from eco-industries |
|---|---|
| Short description | Based on selected list of trade codes referring to "environmental goods and services" (Source: Ecorys) |
| Unit of measurement | Percentage (of total exports) |
| Original data | Eurostat COMEXT |
| Data provider | EUROSTAT |
| Link to original data | http://epp.eurostat.ec.europa.eu/newxtweb/ |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 100% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 5.2 Employment in eco-industries and circular economy |
|---|---|
| Short description | Indicates the share of employment in eco-industry and circular economy in total employment. Total employment is an aggregate employment in all companies across sectors in a specific country. Data have been sourced from the Orbis database. Eco-industry company population was selected based on NAICS codes for eco-industries, including waste treatment, water sector, environmental technologies, recycling, reuse and recovery. The selection excludes companies engaged in energy generation and storage. The scope has been defined specifically for the Eco-IS. Annex I provides the full list of NAICS codes selected for data extraction. Annex II provides additional information on how this indicator was calculated. |
| Unit of measurement | Percentage (of total employment of all companies in Orbis database) |
| Original data | Number of employees in companies in eco-industry sector in a specific country (aggregation of micro level data). |
| Data provider | Orbis database |
| Link to original data | https://orbis.bvdinfo.com (access to data is available only upon subscription) |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 89% |
| Update in Scoreboard 2015 | Updated to 2014 |

| Indicator | 5.3 Revenue in eco-industries and circular economy |
|---|---|
| Short description | Indicates the share of revenue from eco-industry in total revenue across sectors in a specific country. Total revenue is aggregate revenue in all companies across sectors in a specific country. Data have been sourced from the Orbis database. Eco-industry company population was selected based on NAICS codes for eco-industries, including waste treatment, water sector, environmental technologies, recycling, reuse and recovery. The selection excludes companies engaged in energy generation and storage. The scope has been defined specifically for the Eco-IS. Annex I provides the full list of NAICS codes selected for data extraction. Annex II provides additional information on how this indicator was calculated. |
| Unit of measurement | Percentage (of total revenue of all companies in Orbis database) |
| Original data | Annual revenue of companies in eco-industry sector in specific country (aggregation of micro level data) |
| Data provider | Orbis database |
| Link to original data | https://orbis.bvdinfo.com (access to data is available only upon subscription) |
| Most recent year available | 2014 |
| Frequency of updates | Annually |
| Geographical coverage | 93% |
| Update in Scoreboard 2015 | Updated to 2014 |


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