

ECO-EFFICIENCY INDICATORS: CONCEPT, TYPES AND APPLICABILITY

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Abstract

The importance of eco-efficiency has been gaining momentum for the last years. This concept crystalized in the 1990s as a result of multi-layer and multi-aspect tendencies that were taking place in different parts of the world since the beginning of the 1960s.

The major step which has been done is reaching the point of wide societal consensus that if quality of life and economic output is to continue to grow, ways need to be found that the economies produce more with less. This is the kernel of the eco-efficiency concept. In order progress to be made towards it, however, pertinent indicators need to be identified and supported both at organizational and at county level.

The current paper aims at presenting the concept of eco-efficiency and some of the widely used indicators to date – those defined during the Round Table on Eco-efficiency organized by the Government of Canada, the ones proposed by the UNESCAP and the ones put forward by Muller and Strum. After that their applicability is being discussed in view of their practical usage.

Key words: *eco-efficiency, eco-efficiency indicators, circular economy*

1. INTRODUCTION

The importance of eco-efficiency has been gaining momentum for the last years. This concept crystalized in the 1990s as a result of multi-layer and multi-aspect tendencies that were taking place in different parts of the world since the beginning of the 1960s.

Industrialization brought tremendous benefits to humankind; great achievements in all spheres of life were brought to light. At the same time, in many cases these achievements happened at the expense of the balance in nature, since in order to be reached, increasing and extensive use of natural resources was needed. Fascination from the growth needed to give some way to contemplation on the consequences for the ecosystems and finally to prosperity of humanity. This contemplation was to take many years, and, as we can see today, it still continues. The major step which has been done is reaching the point of wide societal consensus that, if quality of life and economic output is to continue to grow, ways need to be found that the economies produce more with less, despite the fact that “in many cases sustainability measures are considered expensive and inadequate in the process of adding value” (Dobрева 2015 p. 582). This is the kernel of the eco-efficiency concept and today it has been adopted as governmental policy in many countries and as a strategy to be pursued by many companies around the world.

In order progress to be made towards it, however, pertinent indicators need to be identified and supported both at organizational and at county level. The current paper aims at presenting the concept of eco-efficiency and some of the widely used indicators to date. After that their applicability is being discussed in view of their practical usage.

2. THE CONCEPT OF ECO-EFFICIENCY: ROOTS, DEVELOPMENT, CONTEMPORARY ASPECTS

Eco-efficiency is a comparatively new concept which has increasingly been discussed in view of the efforts of many countries in the world to shift their economic model from linear to circular. Eco-efficiency can be briefly defined as a way of production which achieves bigger output with fewer resources. Eco-efficiency is often used interchangeably with another term – “ecological efficiency”.

The difference between them is that “ecological efficiency” is used in a wider sense and in various scientific fields such as ecology, biology, physics, etc., while eco-efficiency is rather used to denote qualities of production processes within the economy.

From a historic point of view, the concept of eco-efficiency can be traced back to the beginning of the 70s in the XX century. At that time in the literature the term which is used is “ecological efficiency”. This period of time is marked by certain significant scientific discoveries which provoke the popular opinion, the corporate world and the governments to start considering the side effects of industrialization in all its aspects.

2.1. Carson’s “Silent Spring”

One of the events that played an important role in this direction is the issuing of “Silent Spring” in 1962, a book written by the American biologist Rachel Carson. In this book, Carson investigates the impact of the use of pesticides particularly on birds and reaches the conclusion that there are many negative effects from their use in agriculture. In the USA, the book provoked a wide public discussion and sharp and mixed public reactions. The society and the academics were scandalized by the fact that important information related to the adverse effects of pesticides had not been publicly revealed. At the same time, the chemical industry reacted negatively seeing in the book direct accusations against themselves.

Nonetheless, Carson’s book played a significant and very important role for the popularization of the negative consequences of the use of pesticides and actually instigated a much wider debate – the one related to the effects of human activities as a whole on the environment.

2.2. The Limits to Growth

The already existing debate was accelerated after another book – “The Limits to Growth” of Donella Meadows, Dennis Meadows, Jørgen Randers, and William W. Behrens III was presented in 1972 (Donella H. Meadows et al. 1972). This book was commissioned by the Club of Rome and was funded by the Volkswagen Foundation. The aim of the research presented in it was to show what would happen if the world economy continued to develop with the existing pace and using the resources in the usual for that time way. For the purpose of the analysis, simulation was used. The results were stunning, they revealed that there are limits to the growth of the economy, and that, if no measures are taken to change the way the economy used resources, these limits would be reached within the next 100 years and this would seriously threaten the prosperity of humankind. The model applied in the research was widely debated and criticized by a number of influential economists. Among the most fervent were Henry C. Wallich of Yale University, Robert Sollow of Massachusetts Institute of Technology and Allen Kneese from “Resources for the Future” foundation. While Wallic criticized the conclusions in the book, according to which growth would be impeded at some point in time, Sollow and Kneese debated on the characteristics of the model and the data used for the analysis and contained that it had a number of serious flaws and disadvantages.

Despite the criticism, the Club of Rome took a decision to revisit the model and to run the simulations every five years in order to be seen whether the forecasts were valid or not. Thus in 2008 Graham Turner wrote about the outcome of one such exercise and according to his statements, the initial forecasts were to a large extent validated (Turner 2008). In 2014 the British newspaper Guardian published the inferences from a research aiming at revealing the outcome of an exercise made of updated Turner data which again verified the validity of the initial forecasts announced in “The Limits to Growth” (The Guardian, 2014).

2.3. The UN Conference on Environment in 1972

The UN Conference on Environment which took place in 1972 in Stockholm was another event that accelerated the already ongoing debate on the efficiency of use of resources for the purpose of economic development. During this conference an important subject was discussed – the definition of the rights of existence in healthy environment. By that time, society was viewing the need to respect the environment just as a necessity coming from the obligation to operate within the legal framework of that time.

Only three years after the conference – in 1975 the understanding that preservation of environment was important and ensured higher economic efficacy started to become US state policy. As adverse effects from human activity started to become evident, it became more and more clear that it would be much better for the producers of various goods to consider and apply technologies and processes that were structured around care for the environment rather than not do it and need to bear the negative and costly consequences in the future.

2.4. The Work of the Brundtland Commission

In the 1980s the movement for the protection of the environment has already gained pace. The year 1987 was marked by the publishing of the report of the Brundtland Commission with the title “Our Common Future”. The aim of the report was the perspectives in front of humanity given the circumstances existing at that time to be reviewed, and new solutions and new models for its development to be proposed. The connection between growth and environmental protection has already been widely understood and accepted. One of the important legacies of the Brundtland Commission was the formulation of sustainable development as a term, the definition provided by the commission becoming the most widely used to date: “Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Environment Magazine n.d.). The Brundtland Commission underlines that sustainable development does not imply absolute limits but such that exist on environment in view of the current state of technology (UN, 1987).

2.5. Stephen Schmidheiny and “Changing Course”

Stephen Schmidheiny is the person who has coined the term eco-efficiency and who has maybe the strongest contribution to its development and wide use. A Swiss businessman, Schmidheiny inherited the company Eternit from his father. Eternit used to use asbestos in the production of construction materials, and soon after undertaking control over the company, in 1976 Schmidheiny embarked on denouncing the use of asbestos due to its extremely harmful qualities for human health. Not only that, but he led a number of debates and actions in this direction so that he actually largely contributed to the discontinuation of the use of asbestos worldwide. Eventually in 1981 Eternit stopped using asbestos being one of the first companies in the world to take such a decision (Industrial Heritage n.d.).

Schmidheiny is among the first who realizes that the future belongs to those companies which manage to alter their production processes so that they produce more output with less input, and which find ways to accommodate the needs of nature and human capital in their operations. Thus eco-efficiency concept was born and was first presented at the Earth Summit in 1991 in Rio de Janeiro. During the Earth Summit, eco-efficiency was adopted as the new leading business model for the private sector which would facilitate reaching the goals set out in Agenda 21. This same year Schmidheiny together with the World Business Council for Sustainable Development published a book titled “Changing Course” in which the concept of eco-efficiency was presented and discussed in detail.

3. ECO-EFFICIENCY INDICATORS

3.1. Challenges ahead of defining eco-efficiency indicators. Elements of eco-efficiency

The enthusiasm proclaimed during the Earth Summit retreated in the next years due to numerous factors, including the globalization euphoria, and then the terrorist attacks in 2001 which drew attention to the importance of security matters (Assenov, 2006, p. 43).

Despite this, eco-efficiency as a concept has been already been widely understood and more and more companies have started initiating actions towards achieving it in their operations. One of the most important challenges in this process turns out to be related to the difficulties of measuring the progress to it. Eco-efficiency in itself implies multi-aspect approach to deploying efforts for its achievement. This is so because eco-efficiency is not one-aspect way of production or of doing business. It has implications in all aspects of the way organizations operate. If eco-efficiency is to be reached, many changes need to take place within the organizations, and these changes are related not only to the types of resources that are used, to the way they are processed, to the paths through which they are sent to the consumers, but also to the culture of the organization, to the whole philosophy of doing business.

It is clear that without pertinent, concrete and universally applied indicators that show what is the status quo and what is the progress of each and every organization towards eco-efficiency, progress is difficult to measure, outcomes of the efforts placed in it are rather hard to quantify, and ultimately coordination of efforts at macro level and reaching the goals as set out by the governments in that direction are practically impossible to happen (for more on governmental financial instruments for ensuring sustainable development, see Kitanov 2012).

Eco-efficiency indicators to date are created in order to track two dimensions of eco-efficiency – the one specific to economic growth in terms of production and consumption units, and the other one, pertinent to the impact production and consumption have on environment.

The main challenges ahead of the preparation of eco-efficiency indicators have been outlined in a concise way by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP 2009, p. 1, 2). According to it, they need to be sought in four main directions.

- First when constructing the indicators, it needs to be taken into consideration what the reflection of economic activities in terms of consumption of resources, harmful emissions from production, garbage generation and storage will be on the environment.
- Secondly, answer to the question of how resource productivity impacts the economy needs to be sought.
- On the third place, what the impact of environmental degradation such as deforestation for example would be on economic productivity.
- And last but not least, on the fourth place, how certain improvements such as the achievement of higher quality of life would affect the environment.

As evident from these four main directions outlined by the UNESCAP, eco-efficiency is a complex phenomenon and achieving it implies considering the deployment of various activities in many dimensions. Also, not only the multitude of dimensions of materialization of impacts from human activities need to be investigated in order to see whether humanity is moving towards eco-efficiency or not, but this exercise needs to be done in view of different time horizons. Achieving eco-efficiency implies systematically organized efforts at multiple layers in society and in the business environment targeting long term outcomes on the basis of implementing short term actions each day.

Another important consideration when constructing eco-efficiency indicators is the one related to the goals the indicators have. UNESCAP identifies four main goals of eco-efficiency indicators (UNESCAP 2009).

First of all, these indicators need to be able to measure the level of eco-efficiency in the different economic sectors. This would provide both policy-makers and businessmen the needed initial

understanding of where the economic activities stand on their path to eco-efficiency. On this information all the efforts needed for achieving eco-efficiency would be based.

On the second place, the indicators have to be structured in such a way so as to facilitate comparative analyses across countries regarding the level of eco-efficiency achieved. This would help streamline efforts at global level and also, countries would be able to gain insights from the work done by peers.

After that, eco-efficiency indicators must be assisting the identification of particular policy measures that need to be implemented in order for eco-efficiency to be achieved. This quality is a key one for each indicator, since indicators are a tool, not a goal in themselves, and need to be able to help progress to be made in the various endeavors.

Finally, eco-efficiency indicators must make possible the follow-up of eco-efficiency outcomes as time passes. This would provide possibility for taking score of the efficiency of the efforts themselves and for taking measures for speeding up certain activities, if needed.

Another important thing when constructing eco-efficiency indicators is outlining the elements of eco-efficiency itself properly. UNESCAP provides some guidelines in this direction (UNESCAP 2009).

First of all, eco-efficiency is related to the decrease of the quantities of materials used for the production of goods and services. On the second place, eco-efficiency is in place when there is decrease in energy intensity of goods and services. Next, it exists where less toxic ingredients are being used in production. Fourthly, eco-efficiency can be identified in the cases where garbage is decreased and the amount of products which are recycled increases. Fifthly, an important element of eco-efficiency is the maximization of sustainable consumption of renewable resources. The sixth element of eco-efficiency is the expansion of the durability of products. And the seventh element of eco-efficiency is the increased intensity of use of services at the expense of products use.

3.2. Eco-efficiency indicators as defined by the Round Table on Eco-Efficiency organized by the Government of Canada in 1997

The Canadian government, recognizing the importance of eco-efficiency and the need to find solutions for practical implementation of this concept organized a round table dedicated on the matter in 1997 (Table ronde 1997). At that time many companies, some of which international corporations such as British Petroleum, Elf Atochem, Dofasco, WMS, had accumulated experience in the composition and usage of eco-efficiency indicators with the aim to be in a position to track their own performance towards achieving eco-efficiency. On the round table, three basic principles which eco-efficiency indicators needed to comply with were defined:

- they need to meet a particular goal for which they are created,
- they need to be measurable, and
- they need to be structured in a way to allow for various comparisons among countries and across industries.

A unanimous view was reached that at that time the eco-efficiency indicators are numerous, prepared for the specific needs and goals of the organizations that decide to use them and this does not facilitate aggregation of data by economic sector or by country. Unification of the indicators is needed, however the problem remains how to reach a unification for indicators given the wide diversity of industries with different characteristics. As a result of the debates during the round table conclusion is reached that there need to be at least some basic, fundamental indicators, which to be prepared for each organization and which to allow for comparison.

For the purpose three indices are proposed:

- Index of toxic emissions;
- Index of resource productivity;

- Index of product value against its durability.

The index of toxic emissions needs to show the total quantity of harmful substances, thrown into the environment in order for a particular product to be produced. It is to be calculated by subtracting the garbage thrown away from the total quantity of materials used for the production of the product. The main difficulty with this index is related to the complexity of the “garbage” thrown away and the difficulties related to its measurement.

The concept behind the index of resource productivity is to measure the quantities of materials and energy used for the production of products, sub products and usable garbage in relative terms of the total quantity of all materials and energy used in the whole production process of a certain company.

The index of product value against its durability needs to show how durable a product is and to what extent it can be recycled. This index is calculated in the following way: the value of the product is divided to its useful life, measured in terms of years. The calculation methodology of this index, however, is strongly debated. It is pointed out that it combines financial data with data on the product durability, measured in terms of years. Interpretation of the index is complicated and that is why its usefulness is under discussion.

3.3. UNESCAP Eco-efficiency Indicators

UNESCAP has been dealing extensively with the matter of eco-efficiency and as a result of detailed work two big types of indicators have been identified: scope-wide and subject-wise indicators (UNESCAP 2009).

Scope-wide indicators are meant to reveal eco-efficiency at macroeconomic level, or at a sectorial level, while subject-wise indicators need to be able to show eco-efficiency aspects such as resource intensity of products, use of renewable energy for the production of products, usage of land for construction purposes, etc. Most of the indicators proposed by the UNESCAP could provide useful information primarily for policy-makers since most of them have the gross domestic product (GDP) in the denominator and therefore show information for tendencies in the economy. Some of them, particularly the ones which have the monetary output as numerator are presented in Table 1 below.

For individual companies, however, of particular interest is coming up with practical and easy to calculate and follow up indicators. Companies wish to be in a position to measure how efficiently vis-à-vis the environment they use the various resources for the production of goods and services. This is a complicated task, however, as already discussed above, due to the numerous specificities of the production processes within each company and each economic sector.

Muller and Strum analyze in detail the problems related to the composition of indicators applicable at micro level and propose methods of how this could be done (Muller and Strum 2001).

3.4. Muller and Strum approach to eco-efficiency indicators

Muller and Strum realized that unless a simple, understandable and yet capturing the necessary characteristics methodology is identified towards the composition of eco-efficiency indicators, companies would not start using them widely. In their research paper from 2001 dedicated to the standardized eco-efficiency indicators, Muller and Strum highlighted the importance of establishing a clear link between the environmental impacts from the activity of a company and its financial performance. They argued that there must be a way to show that is an inseparable connection between the care companies do for the environment and the value added which they create. The two authors shared the opinion that only in this way can executives be interested in tracking eco-efficiency through specially dedicated indicators.

Muller and Strum suggest three ways of compiling eco-efficiency indicators (Muller and Strum 2001):

1. Through comparison in quantitative terms of two environmental indicators, for example the amount of garbage generated and the raw materials used in one type of production process;
2. Through comparison between a certain environmental indicator in quantitative terms and some financial indicator, for example tons of CO₂ emissions resulting from the production of a kind of product and the sales volume of the same product in monetary terms;
3. Through comparison between some environmental indicator in its monetary terms and a certain financial indicator of the company, for example the expenses generated for buying energy from a certain type of source and the total volume of expenses made for the energy needs of the company.

Table 1. UNESCAP eco-efficiency indicators with monetary output as numerator

	Resource-use intensity	Environmental impact intensity
Economy-wide indicators		
	Water intensity (m ³ /GDP)	Emission to water intensities (t/GDP)
	Energy intensity (J/GDP)	Emission to air intensities (t/GDP)
	Land use intensity (km ² /GDP)	GHG emission intensities (t/GDP)
	Material intensity (DMI/GDP)	
Secotral indicators		
Agriculture	Water intensity (m ³ /GDP)	CO ₂ intensity (t/GDP)
	Energy intensity (J/GDP)	CH ₄ intensity (t/GDP)
	Land use intensity (km ² /GDP)	
Industry	Water intensity (m ³ /GDP)	CO ₂ intensity (t/GDP)
	Energy intensity (J/GDP)	Solid waste intensity (t/GDP)
	Land use intensity (km ² /GDP)	
Manufacturing	Energy intensity (J/GDP)	CO ₂ intensity (t/GDP)
	Water intensity (m ³ /GDP)	BOD intensity (t/GDP)
	Material intensity (DMI/GDP)	Solid waste intensity (t/GDP)
Public and services sector; Private ownership but open or accessible to public	Energy intensity (J/GDP)	CO ₂ intensity (t/GDP)
	Water intensity (m ³ /GDP)	Wastewater intensity (m ³ /GDP)
	Land use intensity (km ² /GDP)	Municipal solid waste intensity (t/GDP)
Transport sector (use of vehicules only, no manufacturing of vehicules)	Fuel intensity (J/GDP)	CO ₂ intensity (t/GDP)

Source: UNESCAP 2009

The most important quality which, according to Muller and Strum, an eco-efficiency indicator needs to possess, is the ability to show how the environmental performance of a company is reflected in the size of the value added it produces. As regards their approach towards the calculation of the value added, those authors step on Alfred Rappaport's approach. Alfred Rappaport is one of the authors of the concept of shareholder value. Shareholder value concept tries to capture in quantitative terms the outcomes of the management strategy of a company and thus to provide shareholders the opportunity to judge to what extent it has been successful (Rappaport 1997). According to Rappaport the main goal of managers is to maximize shareholder value which means maximizing the advantages of holding shares in the company. Since shareholder value is among the most important indicators for investors seeking to place funds in shares, it is logical to conclude that stock prices must reflect

exactly the understanding of market participants as regards the value which a certain business strategy creates.

According to Muller and Strum, as it has already been widely accepted that shareholder value is not the result of solely financial parameters such as sales, earnings, profits etc., but increasingly depends on other non-financial factors, a way must exist these non-financial factors to be somehow incorporated in the calculation of shareholder value.

Muller and Strum make the connection between those two types of aspects – environmental and financial in the following manner. As they point out, care for the environment implies making expenses which are additional to the business as usual ones. However, these expenses contribute to the increase of the amount of the free cash flows of the company and this happens in three ways:

1. Investments in environmental improvements lead to enhanced product qualities, products thus could be sold at higher prices or/and market could be expanded easier due to the higher qualities. This generates cash inflows;
2. When environmental risks are evaluated and managed, this leads to overall risk mitigation. When risks are mitigated, fewer costs are incurred for managing incidents, damage and other adverse effects. Thus environmental risk management contributes to cash preservation. It needs to be underlined here that “investment decision could prove to be inappropriate as a result of incorrect risk estimation” (Dimitrov, 2013), so it is of vital importance all risks to be understood and their evaluation to be incorporated in the evaluation of the products of the company;
3. Environmental impact management implies knowing and abiding by the environmental legislation and the various environmental requirements related to the products produced. This saves cash which otherwise would have been released for paying fines, taxes and various penalties imposed by the government on companies for not complying with the pertinent regulations.

4. CONCLUSION: IMPORTANCE OF ECO-EFFICIENCY AND APPLICABILITY OF INDICATORS

Industrial development for the last 50 years have shown that economic progress goes hand in hand with a number of adverse effects especially evident in the state of the environment. Extensive resource usage leads to gradual depletion of various materials necessary for the production of goods and services. Numerous research papers done to date reveal the fact that unless production methods change, prosperity is threatened within the next less than 100 years. What changes should be done, and how? The concept of eco-efficiency appeared in order to provide answers to this question. According to it, the future growth and the prosperity stemming from it can happen, if only mankind learns to produce more goods with fewer resources. This can take place when production processes and patterns change so as to be oriented towards nature preservation and smart production.

One of the key problems to working towards eco-efficiency, in line with yet the lack of sufficient understanding of the benefits it brings to companies, is the practical non-existence of simple, understandable, and uniformly used indicators which to facilitate measurement of progress and decision-making both at company and at governmental level. Since its wide popularization back in 1992 at the Earth Summit, the concept of eco-efficiency has been promoted in many companies and at country level by many governments in the world. Already there is hardly any doubt as to whether the economy needs to operate in an eco-efficient way. This is no longer a point to be considered or discussed.

The main questions which are still open are: how to do it, how to organize the work of each and every company in a way so as to be eco-efficient and how to measure to what extent eco-efficiency has been achieved, and how it impacts shareholder value?

Indeed, a lot of efforts have been made to date to find the answers to these questions. UNESCAP, the Canadian government through the round table that it organized back in 1997, individual scientists such as Muller and Strum and many others have made their significant contribution. Even if precise and

uniformly accepted indicators have not been composed to date, the research efforts have greatly facilitated the process, at least by revealing the complexity and multi-sidedness of the process and by proposing certain viable solutions.

Thus UNESCAP came up with very useful indicators that can be applied at country level to see where the economy is moving towards eco-efficiency or not. They have divided the indicators in two groups depending on their scope – sector-wise and economy-wide, and these indicators could be particularly useful for policy makers a governmental or municipal level.

During the Round Table on Eco-efficiency organized by the Canadian government, many case studies of eco-efficiency indicators application in different companies were reviewed and discussed, and as a result, concrete types of indicators were proposed. Those indicators, despite the fact that in some part are debatable, have the advantage to be simple to compose, easy to understand and comparatively easy to apply and follow-up.

Muller and Strum approach the problem of eco-efficiency indicators from the perspective of identifying and quantifying the connection between environmental and financial performance, thus outlining the most important aspect of those indicators for executives and for shareholders. The methodology they propose for composing the indicators is logical, easy to grasp and therefore can be used by companies in their efforts to compile indicators straightforward.

Finally, unless there is governmental decision of the need eco-efficiency indicators to be collected by companies, this exercise will remain within the domain of the micro level management which on its turn will keep on choosing the methodology for composing the indicators which best suits it. In order for cross-country comparisons to be possible, standards for indicators need to be introduced all over the world. This implies huge work and strong cooperation among governments and belongs to the future.

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