# ECO-EFFICIENCY – STATE OF THE ART

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**Definitions and interpretations on eco-efficiency?**

The concept of eco-efficiency was first introduced and discussed by Schaltegger and Sturm in 1990 (Schaltegger 1996) and arrived as a result of the need for instruments that can translate sustainable development into working targets. Several definitions and interpretations on the concept of eco-efficiency have emerged. The World Business Council for Sustainable Development (WBSCD), a coalition of 120 companies from 33 countries and the most important actor in the work, defines eco-efficiency as:

> *"The delivery of competitively-priced goods and services that satisfy human needs and bring life cycle, to a level at least in line with the earth's estimated carrying capacity."* (OECD 1998)

Claude Fussler from Dow Europe includes the question of sustainable consumption when presenting the three securities of eco-efficiency (Fussler 1996):

- the reconcillation of environmental care and quality of life by developing *sustainable consumption* patterns;
- the building of greater environmental care into goods and services through *clean processes and distributions*;
- *creating value* through goods and services which provide quality of life.

An broader perspective on environmental issues is taken by Organisation for Economic Co-operation and Development (OECD). They feel that eco-efficiency as stated by WBSCD is a flexible and pragmatic approach, suitable for translating into action by governments, industry, other organisations and households. However the term "eco-efficiency" is insufficient on its own as a basis for policy making. A wider understanding would be needed of the links between economic activity and environmental damage, driving forces of change and the psychological and ethical motives of producer and consumer behaviour. They therefore express eco-efficiency as *the efficiency with which ecological resources are used too meet human needs* (OECD 1998).

More micro- and firm oriented is The President of WBSCD, Bjorn Stigson, when he sees eco-efficiency as a management philosophy designed to encourage businesses to be more competitive, more innovative, and more environmentally responsible (Stigson 1997). Stigson addresses the importance of producing more goods and services by using less resources. To do this, zero growth is not an option, further global economic development are needed, he claims. The consultants, Peck and Associates, (Peck &Associates 1996) look upon eco-efficiency as a business approach to sustainability that may be defined as a measure of the relative amount of pollution or resources required to produce a unit of product or service. To improve eco-efficiency, more of the desired outputs (real needs as high quality goods and services, income and meaningful employment for shareholders, customers and community) must be produced, while consuming less resources (such as energy) and generating less waste (such as pollution).

Eco-efficiency are measured as the *ratio* between the *value* of what has been produced (income, high quality goods and services, jobs, GDP etc) and the sum of the *environmental life cycle impacts* of the product or service:

Eco-efficiency = Value of products or service/ Sum of environmental life cycle impacts

In practice this product or service might be a small product or a large scale economic activity.
So again, if the eco-efficiency of a product or service should be improved the value of the product must be increased and the environmental life cycle impacts (production, use, recycling/disposal) must be decreased.

It is also worthwhile to make a point out of the interesting distinction between ecological efficiency and economic-ecological efficiency (eco-efficiency) (Schaltegger 1996):

Ecological Efficiency = Desired output of product or function / Environmental impact added

Two kinds of ecological efficiency measures can be distinguished:

- ecological product efficiency
- ecological function efficiency

The formula that includes the function takes a broader view by focusing on the function that are fulfilling a demand. A car might be ecologically product efficient, but will never reach the same ecological function efficiency as a bicycle if the function is, for example, to transport one person two kilo meters. (If the distance is 100 km one might claim that bicycle are unable to deliver the same function because the distance takes much longer time by using the bike than the car). As mentioned earlier:

Economic Ecological Efficiency = Value added / Environmental impact added
(Eco-efficiency)

Depending on their values the stakeholder groups assign different weighting to economic and ecological performance and to different environmental impacts. Schaltegger (1996) gives an example on how to calculate eco-efficiency of investments (see table 1). Both Investment A and B is valued to estimate the eco-efficiency when investing in equipment to reduce emissions from goods serving the same function. As it can be seen, Investment A is cheaper but gives less environmental improvements (value added) than Investment B and are therefore more eco-efficient than B.

| | Investment A | Investment B |
|---|---|---|
| Payments in the life span | -200 | -270 |
| Reduced environmental cost | -100 | -162 |
| Eco-Efficiency | 100/200 = 0.5 | 162/270 = 0.6 |
| Ranking | 2 | 1(best) |

Table 1: Eco-efficiency for two different investments.

**Eco-efficiency for business only?**

Even though eco-efficiency is more or less designed for the business sector, work is also going on at the macro level. Interesting questions has been raised whether eco-efficiency only on firm levels is sufficient for reaching sustainable development and whether it is fruitful to try to measure eco-efficiency on, for instance, national level as well. An example which can illustrate these questions is the steadily improvements in the eco-efficiency of cars (particularly less use of energy in the user

phase). But still, the environmental impacts from the total amount of cars are increasing. So by only taking one car into account, the environmental conditions in total will not be improved if increased eco-efficiency in this product leads to increased volume or production and thereby the possibility of higher environmental impacts from the transport sector on macro level. To put it another way, cheaper and better cars may lead to less use of the often more environmentally friendly public transportation. To separate between micro- and macro level there has been some attempts to make a distinction between eco-efficiency and *eco-effectiveness* where eco-effectiveness a includes number, amount or volume of the unit (Brattebø 1998):

Eco-effectiveness = Eco-efficiency / Volume

For the example of cars above, the eco-efficiency of one car will increase, while the eco-effectiveness (for the society or in the transport system) will be reduced because more cars are being produced.

But is it meaningful to distinguish between these two expressions when the target is to evaluate whether a product, process or a service is more or less sustainable than the reference (there is always need for a reference when evaluating)? Or is it a matter of choosing the system (product or sector) and the system's boundaries? Very simplified one could say that a firm manager should measure and improve the eco-efficiency of a single unit of a transport product, while the government should deal with infrastructure, public transport etc. to improve the eco-efficieny of the transport system. Governments could therefore use many of the principles of the WBSCD approach to eco-efficiency and the same broad definition, but they would probably need different types of goals and indicators. A fabric that produces chairs might be interested in energy intensity of one unit, while the government will try to examine energy intensity per GDP or energy intensity per inhabitant. However the term eco-efficiency is mainly designed the business, and WBCSD has described eco-efficiency as creating «a needed bridge between the macro-level concept of sustainable development and the micro-level of corporate behaviour.» (Fussler 1996)

Whether or not it is possible to measure the eco-efficiency on macro level, the governments and municipalities will have an important role in addressing and implementing eco-efficiency initiatives (Peck&Associates 1996) by:

1. Regulation (e.q. on use of land)

2. Financial instruments and incentives (e.q CO2-tax, subsidising development and implementation of clean technology).

3. Procurement policies (public institutions can ask for and by eco-effiicient goods and services, e.q buying energy from renewable sources or recycled products)

4. Education programs (e.q. how to save money on less waste production**)**

5. Voluntary agreements (e.q extended producer responsibility)

Since the changes towards a more sustainable world seem to happen in a open global market, there is need for global agreement on internalising of environmental costs into business. This is to avoid that firms operating in countries without environmental regulations or -taxes will have competitive advantages.

**Why change to eco-efficiecient business?**

European Partners for the Environment (EPE), a multistakeholder organisation with 60 members from business, NGOs and government, suggest three possible environmental and social scenarios (Fussler 1996):

- *No limits* – Global environmental degradation has not materialised. Rapid technological innovation and economic growth based on new clean industries, service and information technologies have generated the wealth to pay for a safe and clean Europe

- *Orderly transition* – Environmental problems are serious. They are addressed with strong integrated economic and environmental policies. The EU role increases in setting targets, steering scientific programs and ecological tax reform. Business is proactive and works closely in partnership with stakeholders.

- *Values shift* – Scientific evidence and a series of environmental disaster lead to radical industrial and economic change. A bottom-up approach takes over where governments are ineffective. Social and ecological concerns are paramount and inspire a more caring, fair and vibrant community life.

Any of these scenarios put pressure on business (and governments) and the ones that are able to implement the concept of eco-efficiency should be better prepared for all of these scenarios. The first scenario puts competition among companies as the driver while only the most innovative and social responsible firms will survive in the last one. Governments will have a particularly strong role in the second scenario. Of course, becoming eco-efficient is not the answer to all challenges, but it might be a good indicator for how to run the future business and policy. The GDP will be redefined, but there will still be growth of a different kind. There will be customers with different values, more concerned on service, intelligence and quality. There will be a shift from (Fussler 1996):

- supply to demand
- product to service
- product proliferation to lean service
- quantity to quality
- articulated to unarticulated needs

But will there be any benefits for the business to change today, or will it be better to sit and wait for the competitors to spend money on development and implementation of technology, goods and services? Why not wait until the costs decrease? This is probably not a very good approach if the objective is to be competitive in the long run. Firstly, the world is very chaotic and we really do not know what the future will bring of services and goods. The future market is uncertain and the ones that are innovative and creative may be the "producers of the future". Secondly, innovation and implementation is a trial and fail process. It takes a long time to make the «perfect» products or services. Internalising of environmental costs like for instance CO2-taxes will probably be implemented very soon, so the ones that are not prepared will most likely have competitive disadvantages.

There will also be more obvious benefits of changing to eco-efficient ways of running business (Fussler 1996, Peck & Associates 1996):

- savings on raw materials and energy
- reducing inefficiencies and waste resulting in lower cost/unit of production
- quality improvements in existing products
- simplifying processes and procedures
- increased market shares for eco-efficient products and services
- pollution prevention is normally cheaper then end of pipe
- increased competitiveness through use of new and improved technology, products and services
- reduced risk from on- and off-site treatment, transport, storage and disposal of toxic wastes
- improved health and safety of employees
- improved public change
- less pressure from environmental restrictions

- motivating employees and boosting productivity through the establishment of a corporate culture of continuos improvement

3M is an example of a company that has had enormous economical benefits from their work with eco-efficiency. By using pollution prevention projects and other strategies they have saved more than 750 million $ (Kiernan 1998).
Matthew J. Kiernan, chairman and CEO of the environmental finance and investment advisory firm Innovest Capital Risk Advisors claims that there is evidence of a strong, positive, and growing correlation between industrial companies' eco-efficiency and their competitiveness (Invest horizon-web). As an example he is mentioning Royal Dutch Shell who lost over 30 % of its total market share in one month in 1996 because of their planned dumping of Brent spar at the bottom of the North Sea. He finds it unbelievable that most investors and analysts continue to conduct business as usual and claims that what they are sleeping trough is nothing less than the beginning of a profound and world wide industrial restructuring. However a few leading-edge financial analysts and investors have recently recognised the correlation between a company's eco-efficiency and their competitiveness and financial performance. What has been lacking, until recently, is a set of robust, credible analytical tools and databases capable of translating environmental risk and performance profiles into terms meaningful to financiers and investors (Kiernan 1998).
In 1996, Stephan Schmidheiny, the founder of the Business Council for Sustainable Development (now WBSCD), said: "I predict that within a decade it is going to be next to impossible for a business to be competitive without also being eco-efficient" (McDonough and Braungart 1998) .

**How to improve eco-efficiency**

To become eco-efficient, a firm or government should focus on well-known strategies and methods like design for environment, life cycle assessment, total quality management, pollution prevention, cleaner production, source reduction, reuse and recycling. However more is needed. WBSCD has defined four success factors for improving eco-efficiency (Fussler 1996):

1. An emphasis on customer service (service to provide instead of product to supply)
2. An emphasis on quality of life (products and service should meet real needs not perceived wants)
3. A life cycle view (monitoring and assessing impacts on each life cycle stage)
4. The eco-capacity imperative (do more with less within the earth's carrying capacity)

The President of WBSCD claims that going eco-efficient means a significant change for business as usual (Speech 1996). Many firms have already done quite a lot:

- building of environmental stewardship and excellence into corporate, philosophy or fabric
- setting targets for improved performance, and introducing systems to track, measure and enforce those targets
- taking responsibility for their products throughout their life cycles
- being innovative in developing new processes and products
- putting the priority on preventing pollution, rather than paying for clean up

To answer if a product or a service as it stays today is really necessary, or whether it should be changed to meet the sustainable market where governmental tools like environmental taxes and incentives probably will be much more used than today, the need test (Fussler 1996) is developed. The following questions should be examined in this test:

<u>The diagnosis</u>

1. What is the primary function of the product or service?
2. What other benefits does the product or service offer?

3. Is there likely to be a long-term need and/or demand for the product or service?
4. What is the value: impact ratio for the product or service today?
5. Would this product or service be sustainable in an equitable world of 8-10 billion people?
6. Are there more sustainable ways of providing the same function, or of meeting the same need?

The Prognosis

7. On the basis of 1-6 above, what threats and opportunities will there be for the product or service during the sustainability transition? What are the smart innovation opportunities

On the practical level WBSCD has proposed the following business strategy to improve eco-efficiency (OECD 1998):

a) Developing indicators and goals.
b) Working towards the goals through a process of innovation in technology, modes of organisation in technology, modes of organisation and ways of thinking;
c) Monitoring the indicators and modifying the strategy if necessary

Even though eco-efficiency has become a popular term in society and especially within business, there are many challenges connected to innovation of technology, practices and ways of thinking, and to identify indicators for both environmental impacts (input) and value of products and service produced (output).
The consultants Peck & Associates (1996) has set up public and private sector tools for eco-efficiency objectives and evaluating process:

*1.Audits, to:*
- help of developing a baseline for understanding use of energy, water and material use and emissions
- be able to compare environmental management with the best in class
- identify areas for improvement
- estimate the cost of taking action
- prioritise action areas
- develop realistic targets for eco-efficiency improvements

*2. Goals, to*
- quantify and clearly state an eco-efficiency objective
- send a strong public signal
- provide the employees in the organisation with a strong commitment
- establish a standard for comparison

*3. Indicators, to*
- allow to assess and explain the progress
- have an opportunity to adjust the eco-efficiency process if it is not going in the right direction

**Criteria and indicators**

Since eco-efficiency is about different goals such as reaching better quality of life, new values, and environmental improvements from a life-cycle perspective, it is obvious that it is difficult to quantify these factors and to define criteria and indicators for reaching these goals. Allenby (1998) argues that there should not be one set of eco-indicators, but many depending on the audiences and users. For manufacturing, energy or resource consumption per unit produced may be relevant. For public policy purposes, metrics linked to longer term goals may be more relevant. One should also keep in mind that the modern economy is 70-85 % services and that the eco-efficiency metrics tends to focus on

manufacturing or manufactured products. Allenby asks the question whether it is suitable to establish a harmonised set of eco-efficiency indicators when there is lack in scientific and technological knowledge, and when there is different norms and values in different countries. We should also be aware of the possibility that a firm might claim that they are eco-efficient because of one clean product, even if the rest of their business is unsustainable. Allenby thinks that eco-indicators should be developed, but they should only be a part of the fully consideration of environmental affairs in a company or sector.

Even if there is reluctance against «the set of criteria and indicators» and the fact that it is resource demanding to develop a measure of eco-efficiency (OECD 1998), industry finds it relevant. WBSCD identifies seven eco-efficiency criteria for firms:

a) minimise the *material intensity* of goods and services
b) minimise the *energy intensity* of goods and services
c) minimise *toxic dispersion*
d) enhance *material recyclability*
e) maximise the use of *renewable resources*
f) extend *product durability*
g) increase the *service intensity* of goods and services

Useful indicators should be (Peck & Associates 1996):

- comprehensive,
- calculable,
- understandable to policy makers and the public,
- sensitive to changes over time, and
- reliable

Canada's National Round Table on the Environment and the Economy brings together industry and government representatives to develop a common understanding of environmental issues (OECD 1998). They are examining indicators of eco-efficiency, and have so far concluded that:

- Indicators for reduction of material intensity and energy intensity are measurable, but should be measured separately. These measures are particularly relevant because they relate directly to cost.
- Indicators for reduction of toxic dispersion are highly desirable and relatively feasible, but further work is required to be able to compare toxicity of different substances
- Indicators of material recyclability, use of renewable resources and product durability could easily be developed, but further consideration is needed on the best choice of indicators.
- Indicators for service intensity and product life time cost will be more difficult to design and implement

Attempts from among others The Swiss pharmaceutical company Roche, which has developed an indicator called «eco-efficiency rate» (EER) (OECD 1998), have been done to express in a single dimension, but since weighting between value added and environmental issues, and between different environmental impacts is difficult and controversial, such a system will most likely not be standardised.

**Eco-Compass**

An interesting method for evaluating eco-efficiency and improving eco-innovation has been developed by Dow Europe (Fussler 1996). It is called an eco-compass and represents six different components of eco-efficiency. An existing product or service, a base case, is set to have a score of 2 on each of the six scales, while an ideal product will score 5 in each category, covering the entire surface area of the hexagon. If the quality of one of the components, for instance service extension, decrease the score for that dimension will be 1 or 0.

Since eco-efficiency includes economical issues as well, an economical evaluation must also been done in order to see if the changes from the eco-compass method is economical valuable.
Fussler claims that LCA is an important tool for gathering and analysing data, but that the final assessment is so complex that it is difficult to base decisions on this methods only. The eco-compass is developed to overcome these disadvantages. It is used to identify and evaluate improvements in a creative way. All six dimensions are considered ensure that every aspect of ecological and resources security is taken into account. The trade-offs between them are highlighted too. Eco-compass data are always expressed per specific unit and measure a delivery of a service to a customer.

The objective when using the eco-compass is to develop scenarios for implementation by using the five innovative moves (Fussler 1996):

1. *Accept the eco-efficiency challenge and assemble key data.* You need environmental, product and marketing information to identify needs and ground ideas. You must also define your expectation of value and the criteria you will use to assess it.

2. *Identify eco-efficiency opportunity for each compass dimension.* The central question is always how environmental impacts can be reduced so that customer value is increased?

3. *Organise the ideas* emerging from stage two

4. *Harvest the value options* that emerge at stage three to identify potential eco-efficiency «winners»

5. *Prepare* and commit to implementation of the most promising proposals.

Dow Europe's eco-compass has been used for several businesses, among them the well known Ranx Xerox case. Ranx Xerox is remanufacturing, reusing or recycling the 80.000 copiers it takes back each year (Fussler 1996). This is a typical win-win situation:

- Customers deliver their old machine and get a remanufacture machine for a cheaper price than a new one, but with the same quality
- Xerox saves money because reuse is cheaper than producing a new machine
- The impacts on the environment decrease because of less use of raw materials and energy and the decreased emissions.

The eco-compass for Xerox remanufactured copiers compared (Fussler 1996) to an ordinary machine shows that:

- Service extension has increased from score 2 to score 3 (more durable machines)
- Revolarisation from score 2 to 4 (2/3 of the machines are recovered)
- Energy from 2 to 3 (less use of processing virgin materials)
- Mass (mass intensity reduced by 19 % through less use of virgin materials)
- Health and environmental potential risk remain unchanged (score 2)
- Resource conservation not changed

**Final remarks**

There has been some critique against the concept of eco-efficiency. McDonough & Braungart (1998) call eco-efficiency the current industrial buzzword, which will neither save the environment nor foster ingenuity and productivity. They claim that "doing more with less" is nothing more than what Henry Ford did when he started with recycling, minimised the use of packaging etc. McDonough & Braungart think that eco-efficiency is well meant but it does not reach deep enough because it works within the same system as caused the problem. The result will be the opposite of increased environmental performance because the industry will by increased recycling, less use of material and

energy, releasing fewer dangerous materials into nature and other defensive strategies, not be given the challenges for the necessary changes. Today's product are seldom designed for recycling and by doing that the costs will often be to high and quality of the recycled product poor. The authors are looking for the Next Industrial Revolution where the industry will be reshaped and where focus is on design, which they claim are not the case in eco-efficiency. The alternative is eco-effectiveness and the challenge is to not mix the technical and natural metabolism, and to increase the use of material (like for instance organic material in packaging) that can enter and be transformed in the biological metabolism.

The case with eco-efficiency it is that is defined (and worked with) very differently, from "implementing of production and consumption within the level of the earth's carrying capacity" to "produce more with less". But when considering WBSCDs definition and reading the latest report from OECD (1998), it is obvious that eco-efficiency is more than recycling and that it should be operated at macro-level as well as the firm level. Design of new technology, infrastructure and society as a whole is in fact stressed very much as a mean to achieve sustainable development. But every firm and municipality can not do everything, so eco-efficiency in practice will therefore vary from the incremental changes to changes dealing with social structures. But there is a question on how much a firm must do before they can call them self eco-efficient. Is it eco-efficiency as long as the economic value increases while the environmental impact decreases compared to the reference situation? Can a nuclear bomb ever be eco-efficient? And what about the problem with cleaner but more and more goods and services which lead to increased use of material and energy and emissions in total? A change from supply of products to demand of service or function will lead to increased eco-efficiency. But the world’s company cannot live of leasing alone. And what are “the real needs” as opposed to “as opposed to “perceived wants”

Eco-efficiency is about increasing value added while decreasing environmental impacts. There is of course difficulties with the evaluation and weighting of different environmental impacts but this seems small compared to the difficulties in setting and comparing of the values added. Values added might be increased income, increased GDP or more satisfied employees depending on level and what is wanted to be improved. So if a change in an organisation leads to more money but less happy employees and increased environmental performance, the eco-efficiency becomes better if the target is to make more money, but worse if the target is to satisfy the employees. And how can then different product and services be comparable (for the conscious consumer) in terms of eco-efficiency? For eco-efficiency on a national level it is discussed whether GDP is a suitable measure for value added as long as it does not include social welfare. And if increased quality of life should be the target for addition of value, how should this be measured?

Much of the critique against eco-efficiency might be relevant, and eco-efficiency is probably not the only way to sustainable development. But it is extremely important that the industry, which has been the primary target for the notion of eco-efficiency, takes responsibility. That can only happen if the industry face the reality and turn the problems into competitive challenges. If eco-efficiency are not facing the right problems the history will probably tell us that it was at least an important step towards sustainable production and consumption.

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