Sustainability and eco-design

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Abstract

This lecture discusses the implications of PDD in terms of environmental sustainability and gives an overview of the corresponding mitigation measures referred under the umbrella of eco-design—a term defined as the maximisation of the ratio between the product functionality and the associated environmental impacts. In a first section, it recalls the general notion of sustainability and links it to the design-related concepts of environmental impacts, product life cycle and functional unit. The second section introduces the rationale of eco-design and provides an overview of some eco-design strategies. The last section introduces some of the available tools for eco-design implementation in practice.

1 How is PDD linked with sustainability?

According to the most widely accepted definition, *sustainable development* or *sustainability** "is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1]. The "ability of future generation to meet their own needs" is generally understood as depending from the preservation of three types of capital: the environmental[1], social[2], and economical capitals[3].

Further efforts to break down this programmatic definition into concrete terms is inevitably bound to political implications and is therefore subject to diverging interpretations. One main topic of disagreement is whether capitals are substitutable, that is, for example, whether a certain amount of social capital can be sacrificed for a bit of environmental capital. In the one hand, proponents of the so-called *weak sustainability* consider the three capitals as interchangeable and of equal importance and seeks for a preservation or growth of their total balance. This school of thought tends to consider the environment from an utilitarian point of view. That is, the environment is 1) the supplier of all

[1] in other words: the 'nature', the 'natural resources', including living biological stock, usable mineral resources, breathable air and drinkable water, beautiful landscapes, etc.

[2] in other words: human well-being, happiness, and its constituents being eventually, health, education, equality of chances, freedom, etc.

[3] in other words: money and other forms of marketable assets.

the resources we need to satisfy human needs and 2) the repository of all we don't need anymore. Following this idea, the 'function' of natural cycles is to absorb wastes and to turn them into restored resources. Caring about the environment is a matter of ensuring the further fulfillment of human basic needs (e.g. breathe, eat, drink, reproduce) and well-being (to which may contribute things like mediated communication, mechanised transportation, cultural creation, entertainment, comfort, representation). On the other hand, proponents of the so-called *strong sustainability* consider there should be no substitution. This school of thought tends to consider the environment from an idealistic perspective and to speak for nature rights. It assumes that preservation of the social capital is the objective of human activity; those of the economical capital is a mean to achieve it; those of the environmental capital is understood as a condition. Weak sustainability is generally represented as a Venn diagram and strong sustainability as concentric circles [Slide 1].

Without taking position in this debate, we can state that each product is related to sustainability in three ways:

- it creates social value through its functionality (it is *useful* to someone)
- it participates to creation of economical value added (it can be sold for money)
- it contributes to transformation of natural resources (it has *environmental impacts**)

Consequently to the fuzziness of the definition of sustainability, it is not possible to say *whether* a product is sustainable or not in absolute terms. There is no such a thing as a threshold objectively marking the limit between a sustainable and an unsustainable product. The best thing we can do is to state sustainability in relative, comparative terms. That is, which of two comparable product alternatives fulfilling the same *functional unit** is the most or the least sustainable.

1.1 Environmental impacts

Let's approach the concept of environmental impact with a simple analogy: suppose you want—whatever the reason—to dig a hole in your well-grassed garden [Slide 2]. By doing this, you reduce the available surface to dig another hole in your garden. This activity consumes a specific resource which is the "garden area" and which becomes more scarce than it was before. Digging a hole also inevitably creates a heap somewhere else, hence leading to a disturbance of the local ecosystem (for the bugs, plants, and microorganisms living there, or even for people judging the sight of a heap as displeasing). In case you disposed the heap in your own garden, you even reduced the resource "garden area" of an additional amount (the surface of the heap base).

In this analogy the "garden area" stands for *depletion of resources** and the heap stands for *pollution**—the two interconnected ways of expression of the concept of environmental impact. These concepts are interconnected in the sense that pollution (in this case: the heap) leads to the depletion of a given resource or set of resources (in this case: the available garden area, the wealth of the grass and the quality of life of a few bugs).

1.2 About pollution

Pollution is defined as the introduction of physical (e.g. radiation, chemical substances) or biological (e.g. manure, seeds) agents into an ecosystem to an amount it cannot be absorbed, hence leading to its adverse disruption. Pollution can be either natural (like the disastrous eruption of Mount St. Helens in 1980 and reducing hundreds of square miles to wasteland) or anthropogenic (like the "smog" affecting the health of citizen in urban environments). It can either be accidental (like the Fukushima nuclear disaster) or chronic (like the smog, once again). Its causes can either be isolated (like in the case of the Hinkley groundwater contamination) or dispersed (like the omnipresence of long-lasting waste in oceans). The types of pollutions PDD can address are the anthropogenic, chronic and dispersed ones. Among the most often considered environmental impacts of this type are [Slide 3]:

- eutrophication: excessive growth of algae or plants in a body of water resulting from the excessive intake of nutrients such as nitrates or phosphates
- acid rains: unusual acidity of rainfalls due to emissions of sulfur dioxide and nitrogen oxyde in the air
- ozone hole: depletion of the stratospheric ozone layer at Earth's poles due to the emission of ozone depleting substances such as CFCs, leading to a reduced share of UV radiation dispersed by the ozone layer
- smog: noxious smoky fog hitting dense urban areas, composed of airborne particles and chemical compounds generated by combustion and leading to respiratory issues
- global warming: rise in the average temperature of the Earth's surface resulting from an increased atmospheric greenhouse effect due to the massive airborne release of greenhouse gases such as carbon dioxide and or methane
- light pollution: high concentration of misdirected light at night in densely populated areas which may cause diffuse and chronic adverse effects on human health and disrupts wild life (e.g. bird migration)
- land use: anthropogenic transformation of the natural terrestrial environment into functional spaces, leading to various adverse effects such as reduction of biodiversity, soil erosion, and water quality reduction.

These examples show that there isn't *one* pollution but rather a variety of ways ecosystems can be affected by anthropogenic activities. Different effects may even influence each other and be produced by the same agents, like the ozone depletion and global warming having complex interrelations and both being influenced by CFC emissions.

1.3 About resource depletion

Resource depletion refers to a decrease in the available stock of a given resource due to transformation activities. Depletion can either take the form of destruction of the resource or its dispersion to an extent which hinders further use. An example of dispersion is the use of precious metals in semiconductors: extracting the ores, refining the metals, embedding them in products and using these products does not obliterate the chemical elements, it just leads to their geographic dispersion which ultimately makes them unavailable for further industrial use. An example of resource destruction is the combustion of oil-based fuels: the resource disappears as it is transformed into something else (CO_2, among others). Resources ongoing destructive processes may further either be renewable or non-renewable. Destructed renewable resources can be restored, either through natural cycles (like clean freshwater) or through human intervention (e.g. food). In this case, depletion happens when the destruction of resources is quicker than the ability of the restoring mechanism to replenish the stock. The destruction of non-renewable resources can neither be restored by natural cycles nor by human intervention. Once a species is extinguished, once nuclear or fossil fuel is burnt, there is no comeback.

Resource depletion is or is about to become a critical for a large variety of economic branches [Slide 4]. The remaining reserves of certain precious metals like gallium and arsenic (used in semiconductors), indium and silver (used in photovoltaic panels), as well as gold and silver (used in electronic circuits) may be depleted in 5 to 50 years if consumption and disposal continues at present rate [2]. Those of uranium (used for nuclear energy production) as well as cadmium and nickel (used in batteries) may be depleted within 50 to 100 years (*ibid.*). The depletion of other resources like oil, coal or wild fish is a well-known issue often covered in the media.

1.4 About irreversibility

Let's go back to the garden analogy: suppose now you don't need the hole anymore and want to put everything back in place. You can restore the previous situation by putting the heap back in the hole. The result will however only *approximate* the original situation: you will still have a discontinuity in the grass where the hole was and eventually a damaged grass where the heap was. Restoring the soil and grass in *exactly* the same condition would require way more time and energy than what was necessary to dig the hole (e.g. you will eventually need to grow new grass). The domain of water management delivers another illustration of this principle [Slide 5]: mixing freshwater with any kind of liquid pollutant is easy and barely requires energy. But reversing the process, that is, separating the liquids, is difficult and may requires a lot of energy.

This principle is a simple consequence of the second law of thermodynamics: the total entropy of an isolated system can never decrease over time. In other words: the energy required to mess up something is lower than those required to tidy it up, so to say. This principle also says: if you want to increase the organisation of matter, you need external energy input. In other words: creating order is inevitably bond to creating more disorder somewhere else. A corollary conclusion of this is that the more organized you want the matter to get, the more disorder you have to create somewhere else. An illustration of this is provided by the semiconductor industry: in order to produce a 2g microchip, which embeds a fairly high organisation of matter requiring high material purity, more than 1.7kg of matter are required [6]. That is, only 1.1% of all matter involved in the production process ends up in the final product, 98.9% turns out to be waste. Creating a platinum ring requires refining approx. 100kg of ores [3], building a car 70t [5], sending an SMS 600g [4].

1.5 The role of products in sustainability

Obviously, single products do not generate EI by themselves. It is the combination of small environmental impacts generated by a large amount of diverse products (like all cars or all energy using home appliance) which generates pollution.

[Slide 6]

added contributions of small impacts create polution and depletion

refinement of material-¿ lot of entropy

every activity irreversibly increases entropy less is better: minimize physical transformation per unit of use.

2 ecodesign rationale

- ratonal approach - 4 levels of Brezet - radical change vs. end-of-pipe

3 tools for implementation

ecodesign pilot - communication - engineering tools

4 Take-aways

- product lifecycle
- Folie 19 AIIT

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