Sustainable Development
A Framework for Industrial Ecology

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Introduction

The notion "sustainable development" was introduced through the Brundtland-report and describes one of the major concepts within the overall efforts to find adequate possibilities for nature protection.
The Brundlandt report defines "sustainable development as:

> *"…development that meets the needs of the present without compromising the ability of further generations to meet their own needs."*()

Consequently, the approach connotes "development" mainly with the principle to guarantee the comfort of human needs. It demands intra- and intergenerationally responsibility, say, claims to take care not only care of social domains but of ecological domains too.
Sustainable development as a model explicates, that economical, social and ecological development should be realised as connected and dependent on each other.
Social distress may cause as worse results concerning natural resources as unresponsible actions of an unlimited economic growth. The intention is therefore to co-ordinate the liveability of ecological systems with economical activities on one hand and to establish a balance between different national economies on the other. Besides it means a correction of contemporary perceptions of progress and expansion. Fate of humanity may depend upon whether we are able to found solutions that fulfil the interdependency of economical, social and ecological tasks.
However, along with the stimulation of "sustainable development" as a topic of a broad academic interest the notion has become a cliché in the last years for everything and nothing too.

> *" Sustainable development is a ´metafix` that will unite everybody from the profit-minded industrialist and risk-minimising farmer to the equity-seeking social worker, the pollution-concerned or wild-loving First*

Worlder, the growth-maximising policy maker, the goal-oriented bureaucrat, and therefore, the vote counting politician."()

Loosing sight of the forest for the tree by reacting on the mass of presentations and discussions on this notion, it seems important to elucidate first the frame we are working in. Therefore I will now shortly describe some essentials of sustainable development related to industrial ecology.

If we characterise "sustainable" as: "…making things last, making them permanent and durable" and "development" as "…balance between nature use and nature conservation" we get a sufficient working model:

Table 1

A Frame for Sustainable Development

> «Sustainable development is a guideline that attempts to harmonise societal claims for benefit and natural capacity in a way that fairness is granted for all humans - today as well as for further generations.»

Sustainable development concerns indeed a wider frame than just an improvement of current practices in industry and technology. In the following I am going to discuss two normative consequences ():

1. the guarantee of social values
2. the guarantee of durability

1. How to regard social values?

There is no doubt that humans have hopes towards their surroundings and one of this is the expectation to be satisfied. We do not only expect the world as purposeful but as willing to fulfil our wishes. Otherwise we would have no ambition to live as humans.

Self-preservation is the foremost aim of a living being - but for a cultural being (zoon politikon) ontology ("to live") is inherently tied with ethics () ("how to live"). *Homo sapiens* always wanted the world to be useful *and* beautiful not just as a food and shelter reservoir but as an aesthetic promise too. Mankind aims to create beauty themselves. Nevertheless, we do not live in Arcadia any longer where nature is present to satisfy our delights. According with Kant we even shouldn't be delighted because its our anthropological talent as well as a task to design the surrounding world.

> Human takes an active part of the creative processes in the environment and he is able to design adequate living spaces. ()

This is one underlying idea of the role that ecocapacity renders to industrial and technical and social development.
The natural surroundings offer a source of supplies of essential materials and possibilities to absorb pollution. Technological innovation can help to realise sustainability. Yet there is a real risk that technological innovation in itself will not be enough and it is very conceivable that other approaches will be needed based on options in terms of societal changes.
The first maxim of sustainable development mentioned above bears an ethical component that investigates forms of the "good life" and judges conditions on their optimal states of well-being. It is my impression, that questions after the good life and lifestyles of well-being cannot be answered merely by technological or instrumental rationality but have to be discussed in an intersubjective and practical/ethical context.
One reason for the communicative and interdisciplinary approach of sustainable development is generated here through its moral request.
2. It becomes evident that sustainability and flourishing of humans are connected with the sustainability of many other species and of the ecosphere. Again the realisation of human potentialities designing their surroundings goes beyond the protection of our lives and places much greater tasks towards the environment than just the upkeeping of the bodily integrity.
The maxim of guaranteed durability (), refers to this demands by regarding the preservation of natural capacity or the total natural capital stock at or above the current level.

> *"Natural capital stock… is equivalent to the stock of all environmental and natural resource assets from the oil in the ground to the quality of the soil and groundwater, from the stock of fish in the oceans to the capacity of the globe to recycle and absorb carbon and other waste materials."()*

Obviously perceives that kind of maintenance the natural capital stock not merely as a measurement as far as the quantity is concerned but intend to provide the durability of different functions () within the natural environment, whose deficiency would ruin human activity in general and economic activity in particular. These are functions like:

1.to supply: regenerative and non regenerative resources that nature provide as input for production purposes. The use and reduction of renewable resources may not overstep their rate of natural regenerabilty connected with the maxim to support the flourishing endurance of ecosystems.

2.to bear: assimilation of the outputs from industrial processes in form of waste, emissions, toxic substances, radiation danger ans.
3.to survive: uphold of dynamically substance-flow balance within the global natural "oikos"() e.g. water- and carbon flows, climate stability
4.to recreate: grant landscapes and bioregions for well-being, health, relaxation and aesthetic experiences

Nevertheless there exists no unified boundary for the growth of population or resource use but different limits for the sustainability of particular ecosystems on earth. Many constraints only identify themselves today as increasing costs and decreasing earnings instead, as a loss of resource bases. But it is possible to summarise the human dilemma between production, consumption and resource reduction in ecological terms:

> "Homo sapiens has moved from an early succesional ´empty world´, where the emphasis and rewards were on a rapid growth and expansion, …and open waste cycles, to a maturing ´full world´, where the emphasis and rewards are on qualitative improvement of the linkages between components (development) cooperative alliances and recycled ´closed-loop´ waste flows." ()

In tracing the changing patterns of the erstwhile view, I see a main objective that takes place as a *strategic realisation* of ecologising economies. It signifies one of the core elements of sustainable development and industrial ecology elaborated as a philosophy *and* operational principles of the first.

2. Ecological Approaches within Sustainable Development

Ecological and economical researches had different objectives throughout their recent histories. Ecology as a term was defined by Haeckel 1866 as theory on the adaptations of organisms on towards their surroundings. Yet as an observational study it evolved from the natural philosophy of the Greeks, who described the interrelationships between organisms and between organisms and their nonliving environment. Later foundations for modern ecology were laid in the early work of plant and animal physiologists.
From the beginning of the 19th century the interest in population dynamics developed and led to studies on the dynamics of communities and populations and to investigations of energy-budgets of specific eco-systems concerning which details of energy-flow occur in an particular ecosystem. Quantified field studies of energy-flows followed studies on food-chains and the cycling of nutrients and that stimulated systems ecology exploring the structure and function of ecosystems.
Modern ecology focusses on the idea of an ecosystem, as a functional unit consisting interacting organisms and all aspects of the environment in a specific area.

To accomplish nutrial cycling and energy flow, ecosystems must possess a number of structured interrelationships between resources, on the one hand, and producers, consumers, and decomposers on the other. Ecosystems function by maintaining a flow of energy and a cycling of materials through a series of organic processes. Thereby they tend to keep up stability while evolving from a less complex to a more complex condition (succession).

The "logics" of biological evolution creates the modi operandi for sustainable, functional, and self- stabilising dynamical systems. The application of such models on anthropogentic-regulated systems eg economical, industrial or technological systems may contribute to an ecotrophic shift, say, to ecological modernisation and structural ecologisation ().

I believe it would be also interesting to pursue industrial ecology as a case of humans interaction with the environment in humans ecology ().

Ecological systems and economical systems of industrial societies have several common attributes (however those describe in some cases just formal analogies):

- they exist via both nonliving (abiotic) and living (biotic) components
- they have an certain environment in which they act and react
- they have a particular form of organisation
- they need energy, resources, produce waste and are controlled and navigated

Recognition of the importance to bring domains of economy and ecology together and to reintegrate situatively natural science and humanities have created what is now called "ecological economics".

Per definitionem:

> *"Ecological economics adresses the relationships between ecosystems and economic systems in the broadest sense, in order to develop a deep understanding of the entire system of humans and nature as abasis for effective policies for sustainability. It takesa holistic ´systems´approach that goes beyond the normal boundaries of the academiv disciplines. This does not implie that disciplinart approaches are rejected, or that the purpose is to create a new discipline. Ecological economics is interdisciplinary in the sense that scholars from various disciplines collaborate side by side using theit own tools and techniques, and transdisciplinary in the sense that new theory, tools and techniques are developed out of the dialogue to to effectively deal with sustainability. It focuses more on the problems facing Homo sapiens and the ecossystems on which we depend in longer term."()*

To express it simply: the idea of ecological economics reflects the fact that most of the industrial activities today still collide with their surrounding environmental systems. Yet, defusing the problem may only be achieved if nature can not be seen any longer just as physical "quantité négligeable". The immanent insight is that the ecosphere has, contradictionary to prices of economic markets, that are mainly short-term oriented on several forms of current measurements, its meaning developed through millennia of years of evolution. In this state sustainable development prescribes the integration of natural and cultural flows. Related to industrial operations this means foremost to minimise the use of resources by closing materials cycles and to minimise harmful impact to the environment by the reintegration of the industrial material flow as effective as possible in the natural solarpower supported flow.

3. The Bioeconomical Perspective: Some Comments

What has been outlined so far shows that economic decisions and activities in industrial societies have to consider that they depend on natural-material environments. This means in particular: as long as companies neglect ecological data, economy and ecology remain antagonistic. Even if this contradiction is not solvable in many cases, nature can provide models for sustainable ways of living and therefore Rousseau's imperative "back to the nature" might become quite beneficial concerning ecological flows.

The base of these hypotheses is the premise that ecological systems and their *functional courses* have already proved their sufficiency in case of sustainability. For that reason they are appropriate models and reference systems for sustainable industrial actions.

Before I am going to characterise the development from ecological adjusted industrial plans to operational activities through the concept of industrial ecology, let us consider some dissimilarities between ecological and industrial or economical processes in order to see how we can react on these problems.

The environmental burden of economical systems results of certain quantitative and qualitative differences from such of ecosystems.

1.They are not optimised in case of material exchanges within the system
2.They are not energy saving in a way that solar power is sufficient to support them
3.The internal energy and material flow deliver large amounts of energy unused to the external environment
4.Recycling procedures are more or less neglected
5.Processes of growth are not limited to the internal system
6.Processes of growth are highly dependent on consumption of materials and energy and give no direct feedback to the system
7. Ecological and economical afflictions are not overtaken by the perpetrators but by the society or particular groups or become problems for further generations

In summary we can distinguish between a cyclic ecology and an non-cyclic economy that are a priori antagonistic.

Cyclic Ecology Non-cyclic Economy

circularity rotation of materials autoregulation low entropy steady state increase and decrease reversibility systems optimisation multiplicity heterogeneous decontrol structures community principle linearity flow of materials heteroregulation high entropy exponential growth increase and burden irreversibility parts optimisation simplicity isolation central structures individual principle

Regarding the "translation" of ecological principles in economical systems we certainly need several translation tools, like careful observation and adequate procedures, improved laws and decisionmaking in companies. At least it is important to realise that aphoristic

recognitions of natural systems like "everything is connected with everything" should not be confused in a naturalistic way with real facts. This may cause in the best case extensive and finally unproductive collections of data gathering and in the worst it will lead to persuasive ideologism and dogmatic moral demands.
However the model is obvious: the global ecosystem and its functional principles. The economic systems are inherent parts of the material closed system earth and integrated in dynamic processes of nature. Economic rationality therefore should aim to keep up the ability of evolution of the biosphere and the vitality and creativity of our environments. Sustainable development confirms these objectives definitely and industrial ecology attempts to actualise them.

4. Industrial Ecology as a Consequence of the Ecological Implications of Sustainable Development

The current discussions concerning the compatibility of industrial actions and claims of ecology have to face growing critiques of former models and their restricted capacities to solve environmental problems. The basic problem formulates Daly () in the following metaphor: the view of the traditional economical theory regarding economic activities within closed material- and money flows and isolated from their surroundings is analogous to see an animal as a living being that owns a blood circulation but no intestines. Sustainable economies and industries should accept on the other hand the open, smooth and fluent character of industrial and economical systems. As an organism exists through the upkeeping of its metabolism economical operations transform resources withdrawn from nature and cause emissions with the only but important difference that economical processes implicate an irreversible character in production and consumption concerning material as well as in energy and cause degradation of nature in form of increasing entropy.
However industrial ecology is an approach to meet this difficulties and as a procedural () precision of sustainable development it intends to improve industrial processes in a way that the society benefits with as less damage of the environment as possible. As a concept it gives responses to environmental problems in the field of industry and technology and aims to enable management of human activity on a sustainable basis by minimising energy and materials usage, ensuring acceptable quality of life for people, minimising ecological impacts of human activity to levels natural systems can sustain, and maintaining economic viability of systems for industry, trade and commerce.
The insight that industrial systems should observe nature and learn from the structure and dynamics of natural ecosystems needs the application of systems science to industrial systems. The dynamic, systems-based origin lays also descriptions of the system boundaries and asks for the optimisation of the particular system. We perceive industrial ecology here as a fundament for designing and operating industrial systems as living systems interdependent with natural systems.
To show the most important contents:
• Industry operates within the limits of global, regional, and local carrying capacity, maintaining a cautious margin for error

• Industry should reflect ecological and biological principles in the design and operation of its activities, from the shop floor to the executive suite
• Materials have to be cycled through the economy to an optimal degree, approaching a closed-loop system
• Use of renewable materials in balance with their production and non-renewable materials are important
• Efficiency and productivity are to bring in dynamic balance with resiliency, ensuring continued natural capacity
• Societies may attempt the transition to this state while maintaining the economical viability of systems for extraction, production, distribution, transportation, and services. The transition supports development of more viable communities, with improved quality of life around the planet is desirable.

5. Industrial Management between Ecological and Economical Performances

The issues and problems discussed in this essay have emerged from professional practices in economy and industry as well as from social actions. The unifying theme however is that of a rational debate on the environmental crisis and the goal how to reduce menaces of our natural surroundings. In the final sections of this work I will try to indicate two types of responses: one on the micro and meso level regarding environmental management in industry and the other on the macro level referring to structural changes in industrial societies.
Assuming that the environmental issues have been revealed in and their evaluation has been clarified, we can describe four perspectives as a platform to elucidate possible solutions for ecological questions connected with industrial performances ().

- <u>material- and energy adjusted perspective</u>: Are the particular performances environmental responsible from a material- and energetically viewpoint ?
- <u>emission adjusted perspective</u>: how big are the dangers of jeopardising the environment with toxics, radioactivity etc. as results of production, including by-products ?
- ecosystems' perspective: are the functional courses of regional ecosystems like self-preservation and -development disturbed via particular industrial activities ?
- <u>environmental ethics perspective</u>: are living conditions and possibilities of other beings as well as of further generations injured ?
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Focusing on all these issues it is possible to design an "ecologically balanced scorecard" that delivers a multidimensional and perspicuous survey. A simultaneous minimisation of superfluous informations and the integrative method of different problem perspectives may also allow the integration of economical-ecological scales.

Table 2

Ecologically Balanced Scorecard

Of course, there remains an extensive requirement of further researches() on this scorecard in case of optimisation and capability in practice. To say it frankly:
The quality and usability of the "ecologically balanced scorecard" depends on the acknowledgements or non-acknowledgements of ecology and environmental sciences, their ability to mediate this insights and the willingness from other participants to overtake it into discourses and operations. Even if it is quite difficult to quantify criteria from ecological perceptions there may be probabilities to combine results with heuristics as

mentioned in the sustainable development onset. Thus the scheme marks an instrument for ecological and economical rational decisionmaking.

6. Societal Shifts - Potential Changes in Industrial Cultures

The analysis of implementing ecological methodology in industrial contexts shows possibilities and fields for this endeavour as well as deficiencies. The similar system structure of natural and industrial processes allows the outline of the latter up to a certain level as analogous to natural processes, yet with awareness of dissimilarities like mentioned above.

However the bigger problem is that though ecology may deliver a methodology for industry it can not pronounce values of nature. Since we should take care not to fail in some kind of "ecologism" it has to be clear that ecology is a *descriptive* science. Therefore it is investigating the *meanings* not the *purposes* of natural processes. The "naturalistic fallacy" (G.E.Moore) may help us here to realise that merely physical existence may not be confused with a postulated right to exist. Evolution has no value or purpose in itself but is valued by humans. It is up to humans decisions too what kind of life is precious. Whether we like this autonomy or not doesn't really matter - it signifies humans responsibility. Of course, it it not a license to treat other beings just as means but to develop humanity by respecting other forms of live.

If we agree on sustainability as a concern for the future it seems to be necessary to investigate common views and values on the environment created within and through the society to proof whether they are still sufficient for the contemporary questions and demands. Those that led into today's environmental crisis should be changed.

One of my central points is, with respect to industrial ecology, to couple instrumental discourses: what is possible to achieve and how - with practical and ethical discourses: what is worth to achieve and why. I have also sought to indicate that reaching sustainable development on all levels needs more efforts like industrial ecology and more societal support of such efforts.

What has been outlined so far may at last figure the following table as a summary of conceivable societal shifts.

Table 3

Potential Changes within Industrial Societies

I. Traditional Industrial Society (ca. 1800 - 1970)	II. Superindustrial Society (ca. 1970 - 2005)	III. Postindustrial Society (ca. 2005 - …)
patriarchal, hierarchic top-down structures	role-changes-breaks, hierarchical conflicts	flexible net-work structures, functional leadership, synergy, heterarchy
expansion euphoria, quantitative orientation, environment pollution, nature consumption	limits of growth, qualitative development, environment- laws and examinations	principles of sustainability, restauration of environments, design of eco-systems and surroundings
resource exploitation, waste-problems	recycling, cyclic industrial systems	artifical products, nature integrating processes (e.g. solar- energy)
material orientation	stagnation, status quo desire	postmaterial "telos"-adjustments