A Philosophical Approach towards Industrial Ecology

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Introduction

Since the late 60s of our century growing awareness and public interest on environmental issues led to actions by governments and industries and created a range of industrial and economic instruments of nature protection. Yet, the current patterns of industrial production and consumption still increase local pollution, resource depletion, climate change and an extensive loss of habitat and biodiversity.
Evident damages of milieux, physical sufferings, popular discontent with traditional industrial and societal processes and the growing knowledge that human performances may cause global destruction have thus created today's obligation to change attitudes and operations. The inherent task of this obligation - finding an appropriate balance between the development of industrial cultures and the conditions of natural surroundings - inspires a lot of theses that aim to improve industrial systems in technological civilisations.
One of the major concepts within these overall efforts marks the notion of "Sustainable Development" introduced during the Brundtland-discussion[1]. Within this frame "Industrial Ecology" defines a concept that aims to perform critical technologies within an innovated social environment.
In the following I am going to present some philosophical reflections on the underlying theoretical, methodological and strategical thoughts of Industrial Ecology and its consequences in praxi.

1. Present Denotations of Industrial Ecology

What significates a term like "Industrial Ecology"? Prima vista a philosopher sees here a classical type of a "contradictio in adiecto" (the linguist may see an oxymoron): the characterised subject excludes the characterisation. However, a careful analysis of the contents will show that this term implicates somewhat more of an "coincidentia oppo-

[1] 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." Our Common Future, Oxford 1987, p. 46

sitorum" (agreement of contrasts) because different factors of industry and society play together in the same concert. The term "Industrial Ecology" marks a position that intends to design industrial processes in a way that the society benefits with as less damage of the environment as possible. The formal recognition identifies "Industrial Ecology" as follows:

1. Semantically is Industrial Ecology a **precision**[2] of the notion or appellation "Sustainable Development" say, one possibility in the frame of Sustainable Development to perform critical technologies within an innovated social environment

2. **Per defintionem**: "Industrial Ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. It is deliberate and rational in contrast to unplanned, precipitous approaches such as famine and disease… Industrial ecology relies on a systems-oriented approach to integration of human economic activity and material management into fundamental biological, chemical and physical global system. "[3]

3. **Attributively** Industrial Ecology is mainly:
- holistic: a systemic, comparative and integrative perspective of all components of industry and its relations to the environment
- concrete: concentration on material flows used by human activities instead of abstract money terms or energy flows
- transformative: development from unsustainable industrial systems to viable industrial systems. Development of deliberated life- styles instead of annoying
- long-termed: a decisive value is the long-term viability of earth and its local ecosystems; without that technological success is meaningless

4. As a discipline or **field of study** Industrial Ecology investigates the flows of materials and energy in industrial and consumer activities, the effects of these flows on the environment and the influences of economic, political, regulatory and social factors on the flow, use and transformation of resources[4]

5. Industrial Ecology" as a **concept** follows the ideal of "environmental balanced industrial complexes" and perceives an industrial system not apart from its surrounding systems but in interaction with them. Industrial Ecologists anticipate eg that industrial development and low environmental impact are compatible

6. As a **strategy** it includes the following operational points:
- to minimise the use of resources by closing materials cycles
- to minimise harmful impact to the environment by Design for the Environment
- to optimise competitiveness within the market

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[2] Precision means: A notion is more precise than another if there is at least one interpretation of S that is no interpretation of E, but no interpretation of E that is not interpretation of S. In our case "Industrial Ecology" (E) allows all interpretations of "Sustainable Development" (S) but this is not necessary at the opposite.

[3] Graedel,T.E./Allenby B.R., Industrial Ecology 1994

[4] See White,R.M.,Greening of industrial Ecosystems 1994

- to advance product innovation according to future needs in society

2. The Milieu

Let me indicate here two domains that represent the maxims of Sustainable Development as well as those of the Industrial Ecology-concept.
The first "**Ecological Modernisation**" outlines:

> *"…a strategy that attempts to work out operations for environmental friendly production through technical innovations."*[5]

This includes the examination and improvement of present types of industry and technology. In case the results are not acceptable it aims the development of optional models of industrial processes appropriate to environmental problems.
"Ecological Modernisation" does not only focus on the invention and the application of entirely new products or methods. It indicates and definitely requires the enforcement of such alternatives, that can be done with technical and economical prospects but have not come into practice yet because of different reasons.
The objectives of this strategy concentrate on the *micro* and *meso* level - it seeks to order and optimise operations on specific sectors like for example product design, product use, cleaner production, sustainable energy use, waste minimisation and environmental management.
However, "Ecological Modernisation" marks not an isolated strategy but acts in a wider frame. It is influenced by questions like: "What is to do and can be done to maintain our present living standard[6] concerning the lowest environmental impact?"
Or: "How can we satisfy the needs of the present without depleting the fulfilment of the needs of future generations ?"
That points straight to social issues like how companies and consumers should act and clearly implicates normative dimensions instead of merely technological or economical responses. The challenge is here to satisfy individual needs and wishes of consumers *and* to couple them with broader social goals. To cite Ehrenfeld:

> *"One view of 'ìndustrial ecology' is that of a largely analytic framework that… identif(ies) and enumerate(s) the myriad flows of materials and technological artifacts within a web of producers and consumers. This aspect of industrial ecology has been called industrial metabolism. The idea… can be expanded to include the public and private institutions that are involved in the technological evolution process. Without the institutional aspects, industrial ecology is not likely to be effective as a practical guide towards sustainable development… Elements bearing on economic, legal, political, managerial and other social processes must also be included."*[7]

Of course, ecologically desirable changes will cause material resistances as well as social conflicts. The (perhaps needful) reduction of the increasing production and con-

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[5] Harborth,H.J., 1991, p. 88
[6] we can also distinguish here between "living standard" and "life quality"
[7] Ehrenfeld,J., MIT Program on Technology, Buisiness and Environment

sumption standards in industrial countries could become one of the most troublesome problems establishing "Ecological Modernisation."
To manage those difficulties I would like to introduce here an additional scope, the so-called "**Structural Ecologisation**" that provides a corresponding plan to "Ecological Modernisation."
"Structural Ecologisation" is:

> *"…the sum of any particular goal and every single step of social beings in relation to their environment. It includes aspects of sanitation, conservation and formation. Because human at last depend on their natural surroundings Structural Ecologisation concerns all human actions towards nature."* [8]

It acts upon a *macro level* within fields like economy, sciences, politics and education. It bases on the idea to modify the perceptions and the interpretations of environmental values in general (not just in public areas or experts' domains) and would manifest itself in daily life. It would not be designed to react to particular problems but to work broadly and enduringly problempreventing. Therefore it does not enterprise to cure single symptoms but - in case of success - it changes the underlying technical, social, economical and political structures.
This is essential because structural changes, even if they occur in a special sector, modify *de facto* the complete system. That is, according to Kuhn, one reason why our paradigms and resulting actions towards the environment shift. On the other hand, according to Popper, they shift because of material (objective) requirements and improvements depend upon impersonal circumstances.
In case of Industrial Ecology we are allowed to conclude that Kuhn´s paradigmatical view refers more to **structural ecologisation** and Popper´s more to **ecological modernisation**.
Even single claims like traffic reduction and waste decrement require *micro* and *meso* as well as *macro* levels of investigation.
When the two outlined strategies above are seen as categories the following synopsis shows more particular and more general inquiries.[9]

Ecological Modernisation	**Structural Ecologisation**
• design of environmental-friendly	• modifies the ideas of "prosperity" and

[8] see Prittwitz, ., 1988, in : Simonis,U.E. (Ed), p. 114
[9] A further example for the alliance of both marks the claim of Norway's prime-minister Torbjørn Jagland in the program of the labour party 1996, to develop models of mediating "Sustainable Development" to managers and workers at all levels within the companies, which should cause a better understanding and more involvement. This suggestion asks not only for a special case of explaination but for new types of environmental teaching .

car or vehicles (concerning weight, emission, construction of parts, like motors, batteries a.s.o.	"life-quality". Changes consumers behaviour: "rent instead of buy"; "common share instead of single possessions". Shifts producers aims from the sale of merely physical products towards functional criteria
• waste- recycling techniques, cleaner production, low waste production	• education to establish distinct views and customs towards consumption and conservation to avoid waste. Introduction of producers responsibility-concepts in firms. Formation of laws; agreement policies

Industrial Ecology reflects both schemes. Although it satisfies the first in case of strategies and norms to construct and perform operations - as a theoretical concept it considers not only to particular branches, companies or activities but the complete industrial *and* social process including the growth and change of different sectors.

3. What distinguishes Industrial Ecology from former views ?

Industrial Ecology bears fundamental paradigm shifts. If we say good-bye to the platonic interpretation of "paradigm" as an absolute idea gliding above lower strategies and goals and emphasise the **functional**[10] character of "paradigm" instead of the **ontological**[11] we discover that the core of paradigm shifts is indeed not only to be found in exterior changes of the environment like limited capacity and sinks but also in the way we express and carry out our wishes and demands.

The contemporary paradigm-shift[12] Industrial Ecology is in touch with documents eg that:

in humanities:

- human society and natural ecosystems have co-evolved
  former: homo sapiens is apart from nature
- moral/ethical transformation is necessary e.g. macroethics designed for global problems
  former: particular ethics for particular problems, like utilitarism, hedonism and deontics
- there is no dilemma between determination through nature and self-autonomy

[10] Functional use perceive "paradigm" as "patterns of discovery" or "ideals of natural orders. Industrial Ecology supports this perceptive view by assuming e.g. natural processes as metaphors (paradigms) for industrial processes.

[11] Platon used "paradigm" refering to his idealism (reality is a deception and the thruth belongs only to the ideals). For that reason paradigms are root-representations of the things that are experienced through the senses. They are "eternal, ideal and immaterial" remains while forming the foundations of the visible and instable world.

[12] If we anticipate the sum of disasters like Seveso, Bhopal and Chernobyl as cause for a *break-down* of old paradigms these successively chances show the development of sub-paradigms who are still found or evolve.

former: antinomy of sensual desires on one hand and rational and moral claims on the other

- a balance between man and the rest of nature is possible
  former: man as dominator of nature

in economies:

- a bioeconomical approach
  former: sustainability is not a concern. Future is created trough a price system based on free choice. Waste and pollution are economic externalities
- sustainability (strong) means independently maintaining stocks of human and natural capital
  former: environmental problems are failures in the economic system
- co-operation versus competition
  former: homo homini lupus est[13]
- economy based on functionality (service) not goods, or on quality, not quantity of life
  former: possessive individualism

in technologies:

- technological realism; precautionary principle to handle uncertainty (we should expect the worst effects)
  former: technological optimism

in ecology and ethics:

- strongly interdependent and systems oriented (entropy-theory, autopoesis-concept)
- nature has intrinsic value revealed through economic activity
  former: nature is a mean for human needs

4. Core Contents and Philosophical Attachments

In case of Industrial Ecology several experiences of insufficiencies of conventional industrial processes contribute to a change of former practices. These insufficiencies are tied together with other occurrences in the industrial culture that claim for shifts themselves: the growing of health problems connected with environmental impacts, the feelings of dissatisfaction with the design of natural and social surroundings, the questions whether the existing maxims and rules for environmental protection are adequate for the present situation.
The consequences from these changes appear explicit in the following theses and principles of Industrial Ecology:
Customary ideas about industrial systems appear to alienate them from their milieu and serve to create a theoretical dualism. This turn is applied if we anticipate the separation between industry on one hand and nature on the other. Therefore pollution prevention and cleaner production in traditional models concentrate mainly on a relatively isolated

[13] Aphorism from Th. Hobbes saying “dog-eat-dog”

"*Ding an sich*"[14] (the single industrial process) without considering integration of a broader perspective.
Industrial Ecology attempts to change this view. Reading critics from Georgescu-Roegen on the former view, it is obvious that industrial processes are no longer recognised as closed systems.

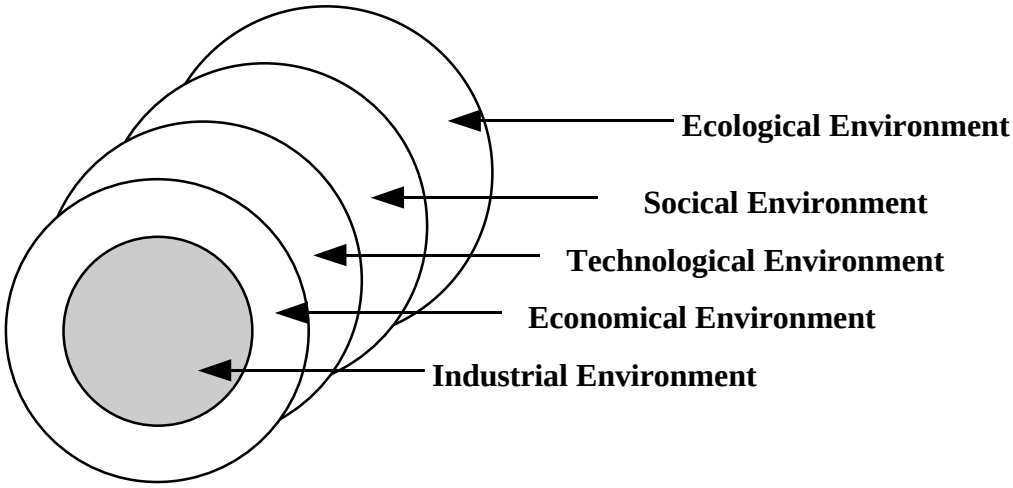
> *"… an isolated self-contained and ahistorical process - a circular flow between production and consumption with no outlets and inlets, …a no deposit and no return affair in relation to nature." (The entropy law and the economic process, 1971, p.2)*

and Daly:

> *"…the view of the traditional economical theory regarding economic activities within closed material- and moneyflows and isolated from their surroundings is analogous to see an animal as a living being that owns a blood circulation but no intestines. "*

Daly support his critics with the notion of an "empty world economy" and emphasises on contrary a "full world economy". Economic systems are therefore open sub-systems within the limited, non-growing and closed ecosystem earth, while their abilities of operating and developing depend on the permanent flow of material and energy.

Table 1



"Within systems adjusted industrial management we see industrial companies as productive socio-technical systems"

Reaching sustainable development in industry natural resources can not be seen any longer just as physical "quantité négligeable". The task is rather to bring economic interactions in relation to their ecological environment than to economise ecology by getting the prices right. This includes the principle that if industrial operations are alike natural systems they have to function in a course that do not overstrain the limits of their local ecosystem and biosphere.

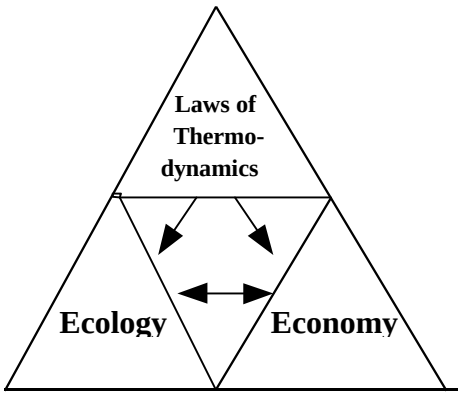
[14] "thing in itself" I.Kant, Kritik der reinen Vernunft

However, the approach to combine results from natural sciences like the laws of entropy with economical actions marks a path to find integrative problem solutions because:

> *"…there is no doubt that every economic and technical activity has its ultimate boundaries in the physical world described by natural sciences."*[15]

Every economic activity implicates in se the consumption of energy and/or materials. Undeniable too that each market-, production- and consumption process depends on natural regulations. Insofar ecological adjusted industrial management has to integrate acknowledgment from natural sciences to achieve sustainable development. On the other hand natural laws like thermodynamics provide models for economical and ecological performances while those do not influence the laws of thermodynamics.
The thermodynamic laws show a frame for closing loops by regarding natural sciences. Instead of a linear understanding of economical and industrial processes Industrial Ecology operates with this closed loop model.
Similar to the functions of ecological systems, industrial systems can be understood here as self-organising evolving entities. These keep up their functionality while taking low-entropy matter and energy from their environment and release high-entropy waste heat. This assumption implicates that industrial systems are characterisable as open equilibrium-far systems with dissipative structures.
So, the entropy onset offers the possibility to find a common conceptual fundament for ecology, economy and industrial processes considering the integration of complex relationships between extractions of resources, production and energy use.

Table 2



Interrelations between Economy, Ecology and Thermodynamics

The **holistic approach** and the **systemic**, **comparative** and **integrative** perspective of components of industry and their relations to the environment are the **most significant characteristics of Industrial Ecology.**

> *"Model the systemic design of industry on the systemic design of the natural system …industrial ecology involves designing industrial infrastructures as if they were series of interlocking man-made*

[15] Fritsch,B.,Schmidtheiny,S.,Seifritz,W.,Towards an Ecologically Sustainable Growth Society. Physical Foundations, Economic Transitions and Political Constraints, Berlin 1994, p.2

> *ecosystems interfacing with the natural global ecosystem. Industrial ecology takes the pattern of the natural environment as a model for solving environmental problems…"*

We will extract in the following one theoretical principle connected with theories of cognition that is the perception of the **industrial metabolism** and one practical principle connected with ethics in the widest meaning, that is the comprehension of **high functional complexity in industrial processes**.

The industrial metabolism: Human history cannot provide metaphors[16] for sustainable ways of living as our history is a succession of states generally built on the last one. Nature can however lead us to metaphors.[17]
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. As a result new researches perceive for instance single companies as "living systems" and industrial processes as analogies of "biophysiological metabolisms".
The thought of "industrial metabolism"[18] is a very important element in the theory of Industrial Ecology. It refers to the **connection between micro meso** and **macro** levels of industrial processes.
"Metabolism" origins from the greek word "μεταβολη - metabole - change, modification" and relates in biological and physiological context to assimilation and metabolic processes of living organisms. So, it covers a complete system and the interaction of all biological functions that serve the endurable conservation of the organism. The motions of single metabolic sequences occur via principles of **autopoetical**[19] organisation and via cybernetical[20] control.
Autopoesis means that a system or organism keeps up its existence by using energy and resources from the environment and produces waste. While in biology the single living organism appears as the object of investigation the single industrial organisation is here the analogon. A superordinated system of steering is market competition with its mechanisms of supply and demand.

High functional complexity in industrial processes:
"Industrial metabolism is a powerful metaphor for the illumination of the processes that mobilise and control the flow of materials and energy through industrial activities."[21]
The background of the industrial metabolism mediates a comprehensive perception how to manage industrial societies in general and industrial companies in particular to

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[16] A "metaphor" is the transfer of a concrete notion to an abstract meaning e.g. "head of the family"

[17] See f.e Ehrenfeld,J and Rorty,R., Contingency, Irony and Solidarity, Cambridge 1989

[18] See Ayres,R./ Simonis.U.E.(Ed.) Industrial Metabolism. Theory and Policy, 1994

[19] Self - organisation" ("autopoesis" from greek "αυτο - auto-self" and "ποιεσις -poiesis - to do, to create" is a procedure that the organism directs for the purpose of selfpreservation-reference and development. It implicates coevolutional growth with other forms of life and surroundings where the organism participates. The organisms organise their environment autopoetical means: although they are in an exchange with their environements they follow their own autonomous guidelines. For more information see: Maturana,H.R./ Varela F.J. Autopoesis. The Organization of the Living. San Francisco 1973

[20] "Kybernetic - greek "κυβερνησις- kybernesis- steering,navigation"

[21] Husar,R. in: Ayres,R/Simonis, U.E.(Ed.) 1994, S.21

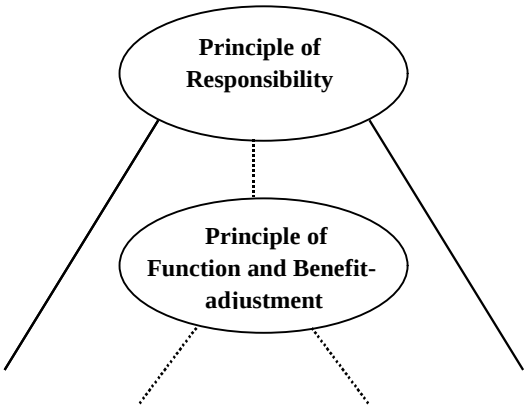
reach a sustainable development. For single industrial processes it would concern likewise the strive for the best circulation of material flows in the economic system. This implicates likewise ecological responsibility within the companies, that matters all production activities even the pre- and post-production processes - as it were from cradle to grave. Another more institutional concentrated point that involves ecological benefit as well is the establishment of metabolistic producer -consumer- waste-manager networks. The possibilities for the waste-managers are almost neglected in conventional industrial systems. Yet for industrial companies the chance to complete the chain is available by focusing company purposes and goals consequently towards an economic flow that includes functions of recycling and decomposition of different forms of waste. To achieve large energy and material efficiencies may grant here long-term viability of the ecosystems as well as it may generate competitiveness and economical benefits.

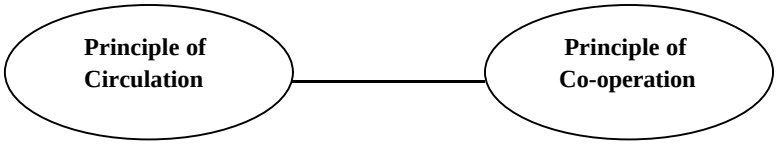
5. How to proceed ? Consequences of Industrial Ecology

In summary the frame for Sustainable Development and Industrial Ecology are determined through the global ecosystem and its functional principles. Therefore economical and industrial systems are an inherent part of a material closed, limited system - earth. Further they are integrated in sustainable concepted and circular organised cycles of natural processes.
Criteria of sustainable development in industry, technology and society should aim to maintain abilities of biological evolution -vitality and -creativity and to provide satisfactory living conditions for the species of mankind.
As shown above “industrial metabolism” and “high functional complexity” are core elements of Industrial Ecology.
Four subordinated principles can be connected with both to certify their realisation in industrial processes:

1. the principle of circulation
2. the principle of function- and benefitadjustment
3. the principle of co-operation
4. the principle of responsibility

Table 3





Consequences of Industrial Ecology Principles in Economy

The principle of circulation is evident through "industrial metabolism" and does not need further explanations for now. The ecological formulated goal is here a starting point for actual management decisions.

The principle of function- and benefitadjustment can be regarded as equivalent to the documentation of functions within natural environments at the beginning of this paper. It claims the change from product orientation towards function- and benefit-factors, say: instead of selling a product as a possession the producer should intend to sell the use of the product. In case of Industrial Ecology the principle tends mainly towards durability that aims to develop a notion of "usage" that goes beyond short-sighted depletion without denying competition. To give an example: a car producer has to think about the need of mobility instead of merely selling vehicles. As a result the short-tern maximisation of production and consumption should transform into long-term usage. In practice this may concern for example the sale of usage permits instead of possession permits.

The co-operation principle emphasises the necessity to meet ecological questions and problems with agreement policies. The triangle of producer-consumer-waste-manager in case of material recycling may exhibit one reference model here.

The principle of responsibility relates to the duty to warrant the sustainability of the natural main supports of life. Therefore it concerns company-philosophies, their normative background and the surrounding of their actions.

Industrial Ecology is *eo ipso*[22] a self-reliant philosophy for industrial companies as it provides operations (like time-management) for firms that correspond with societal goals and hence it delivers necessary identification patterns to anchor these types of economy in our culture. Yet, there is still the task for the single companies to develop the concept as a guideline within their own frame.

Conclusion

Some of our world views changed rapidly during the last decades and we have to take new guidelines into account when we decide about our future goals and strategies. As

[22] through itself and its contents

far as we can see industrial processes have an important influence on ecological environments. Industries take also part to shape social surroundings.
For that reason humans should not escape from the dialogue with industry and technology. It is important today to elaborate lifestyles as well as industrial and technological operations that face the environmental crisis.
Industrial Ecology seems to be a rational approach to combine those factors. Yet it is difficult to carry new concepts through without co-operation of environmental policies, societal support and company agreements.
In praxi the concept requires adequate responses from those participants. How then to reach broader fields like economy, sciences, politics and education ?
One of the main objectives in Industrial Ecology at the level of academia is implicated through its holistic and comparative approach: the interdisciplinary collaboration of scientists from different disciplines.
That means first: more comprehensive information and discussion of research topics than it is given in the single disciplinary fields. Second: to establish an exoteric consensus of scientific rationality and third: to popularise academic research results in forms of common language in the hope that society benefits.
Regarding human as prepetrator of the environmental crisis and as *animale rationabile* - able in this case to find ways out of this crisis - Industrial Ecology seems to be the right beginning. If we return here to the philosophical point of view how to evaluate industrial civilisations the concept does not only provide new fields of studies but also ask for the inspection of values and perceptions guiding our decisions and solutions how to live in the future.

Bibilography

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