Journal of Environmental Sciences Vol.13, No.3, pp.257—264, 2001

ISSN 1001—0742
CN11—2629/X

Article ID: 1001-0742(2001)03-0257-08 **CLC number:** X171 **Document code:** A

Engineering for problem solving in future: Eco-social market economy and eco-social tech

Anton Moser

(Institute of Biotechnology, Group Eco-Tech, A-8010 Graz, Petersgasse 12, Austria. E-mail: moser@biote.tu-graz.ac.at)

Abstract: The paper differentiates approaches in technology (end-of-pipe, cleaner production, industrial ecology, zero emission and eco-social-tech) and compares them in respect to the problem solving capacity on the ecological as well as social dimension by showing the eco-impact reduction and job creation. Eco-social-tech represents the approach with highest problem solution as it is based on "eco-social market economy", which will the replace free market economy. The deep background of these innovations is "ecosophy", the wisdom of nature, which serves as guideline for eco-restructuring the world.

Key words: eco-social-market economy; eco-social-tech; ecosophy

Introduction

Technology is playing a powerful role at present, even people think that problems can be solved mainly with technology. Indeed, admirable progress was made, however, at the same time, also the problems show an exponential growth. Fig.1 illustrates the shape of growth of nearly all things. But we cannot continue the business as usual. Even it will not be sufficient just to stabilize the growth as indicated in Fig.1, as the carrying capacity of our planet seems to be overloaded. Thus, human manking must adapt the growth to this limit in nature, k_{ecol}, as demonstrated in Fig.1: this is the meaning of sustainability, wellknown since 1989 from the Brundtland report. How should be proceed under such conditions? What is the role technology really has to fulfill? What problems to we have to solve until when and how big is their magnitude?

1 Problems based on backcasting from the year 2030

In this situation we cannot any longer continue the path of doing that, what is possible just now: we have to ask a quite different question: what do we need to be solved and when we have to start, as we need a certain time for development of about 25 – 30 years. This is called "backcasting" (Jansen, 1992), which will be outlined here.

1.1 Problems in respect to ecologic dimension

The quantification of the problems, which are to be solved in the next decades, can be demonstrated with the aid of a macroscopic pattern as given with Eq. (1):

$$L_{ecol} = P \times W \times f_{ecol}, \qquad (1)$$

where L is the load of environment due to increasing population P, W is the welfare of people, which is achieved by technologies having a nature-consuming factor f_{ecol}, the eco-impact reaction factor of technologies in order to compensate P and W in Eq.(1).

Fig.2 summarizes this situation acc. to Eq.(1) by demonstrating the increase in P, which cannot be handled at all and the increase in W, which is wanted esp. for poor people on earth until 2030.

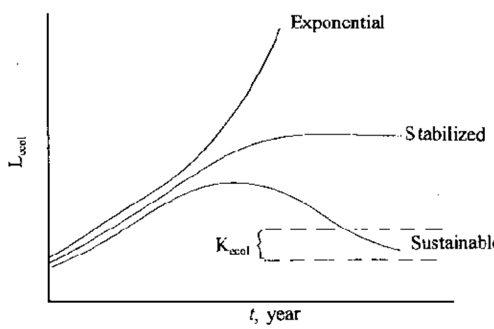

Fig.1 Illustration of the growth pattern in human society: the existing exponential growth overloading ecosphere (L_{ecol}) may come down to a stabilized zero-growth, which however, will not be sufficient for "sustainable growth" adapted to natures carrying capacities k_{ecol}

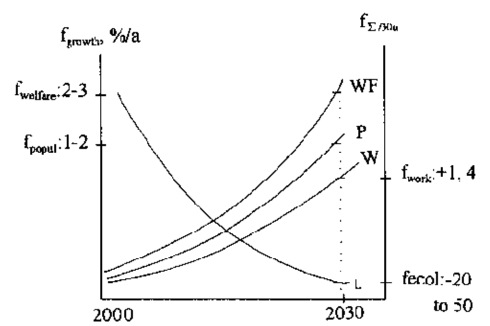

Fig.2 Quantification of the problems to be executed by backcasting in the year 2030: increase in population P and welfare W, given in values of increase in % per year, has to be compensated by a technology with a reduced eco-impact factor in f_{ecol} accompanied by newly created jobs (f_{work}), which must be realized in 2030

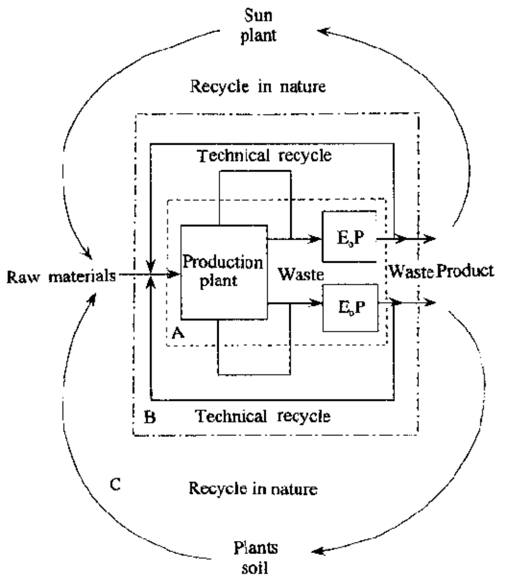

Fig.3 Schemes of the main three technology paradigms: end-of-pipe with an added purification plant (A), all sorts of cleaner production (B) using recycling by technical means and eco-social tech (C) which closes the cycles with the aid of ecospheric capacities based on soil/plants/sun

1.2 Problems in respect to social dimension

Fig.2 includes also the amount of jobs needed in the year 2030 as indicator for the social dimension of sustainability (Moser, 2000b). At the same time the increase in P and W must be compensated with the aid of eco-impact reduction factor of techs, which exhibit a factor of 20 – 50 i.e. the reduction must go down from 100% to 5% or even 2%. In any case we have to start just now in order to achieve the problem solving capability in the year 2030. What type of tech should we use? Are existing approaches powerful enough?

2 Existing approaches: end-of pipe tech, cleaner production, zero emission, industrial ecology and others

A high diversity in technology paradigms exist: end-of-pipe high-tech (EoP), cleaner production (CP) and the new eco-social tech (ET). Various names appear in literature, which come quite near to cleaner production with varying strategies in similar directions e.g. waste minimization (WM), design for the environment (DE), pollution prevention (P2), eco-efficiency (EE), integrated pollution prevention and control (IPPC), upsizing (U), industrial clusters (IC) to be summarized as "good business" although the main part of them will not be enough to lead to deep sustainability (2).

Industrial ecology is a new attempt, taking industrial process metabolism as analogy to metabolism from living cells as method. Zero Emission Initiative is a quite new effort, which is basically an utopy, which however, can be seen as quite similar to eco-tech (1).

Fig.3 compiles the basic types of techs which are: end-of-pipe (A), where a purification stage is added at the end of the production unit in case that money can be earned by that; cleaner production(B), where materials are recycled by technical means on several places, without, however, changing the process; eco-social tech, the new paradigm to be presented here, where biocompatible wastes are recycled using nature with its capacities.

3 Evaluation of exiting approaches

3.1 Problem solving capacity in ecologic dimension

What is the capacity of all these techs in respect to environment? Fig.4 illustrates a comparison of end-of-pipe high-tech and all types of cleaner production efforts mentioned before. It can easily be seen that EoP realizes a reduction factor of 2 – 3, while CPs are quite higher with a factor of 5 – 10.

Evaluating this result allows the conclusion, that these attempts are absolutely necessary but not sufficient on the long run, as they are not able to realize eco-impact reduction factors needed in the order of magnitude of 20 – 50.

3.2 Problem solving capacity in social dimension

Fig.5 is mirroring the situation of the existing techs, if they can provide people with new jobs. As can be clearly seen, this is not the case, neither EoP nor CPs create nearly no new jobs. Why is this so?

The explanation is, that techs always are the instrument of economy and as long that the free market economy is dominating, with only and purely monetary orientation and gross national product (GNP) measuring the flux of money as index, new jobs will only be created in countries with cheap working salaries under lower social and ecological conditions. Thus, jobs will travel around the world in a certain period of time without, however, really creating work. Evaluating this result allows the conclusion, that the type of economy is governing the whole thing and not technology itself. Thus, we should look for a new type of economy, which follows the path towards sustianability exhibiting four dimensions: ecologic, social, economic and temporal aspects.

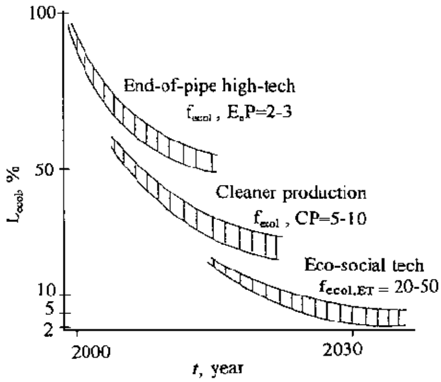

Fig.4 Evaluation of the ecologic problem solving capacity of different technology paradigms in a plot of reduction of eco-impact (L_{ecol}) as a function of time: from factors of 2 – 3 (EoP) over values of 5 – 10 (CPs) the highest solution realized in future is given with the aid of eco – social tech approach: 20 – 50 times less load

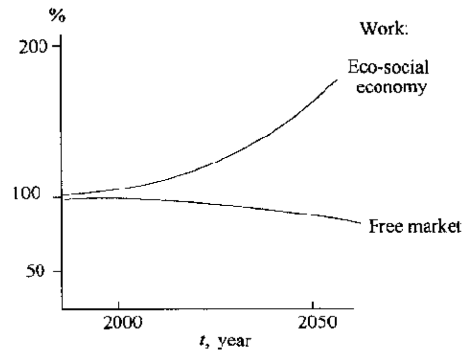

Fig.5 Evaluation of the social problem solving capacity of the two types of economies, the free market economy with EoP and CPs as instruments and the eco-social market economy with ET as engineering instrument. While the first decreases with 10% and more, the new paradigm shows an increase of jobs with 50% and more

4 New approach

4.1 "Eco-social market economy" as instrument of sustainability

Sustainability is manyfold defined and remains unclear. Acc. to ecosophy, i. e. natures wisdom nature (Moser, 2000a), it can be seen that normally sustainability is understood as shallow sustainability, while nature teaches us a deep understanding of sustainability.

Thus, it is: long term oriented as the criterion of benefit is and not short term; holistic, eco-centric and not purely anthropocentric as benefit is; fulfilling the eco-principles i.e. sufficiency, efficiency, non-invasiveness and embeddedness as outlined later on; and time as driving force towards final sustainability.

In contrast to the existing world a new type of society, economy and technology was developed and matured during the last decade, known as "eco-social" economy (4), "eco-society", "eco-tech" (1,3). Systemic characteristics of eco-social economy are compiled here: new boundaries with the "eco-social" values acc. to the ESP, which take into account economic, ecologic and social values as equal; the inner circle i.e. behavior in society and esp. in economy is not any more only competition but includes the diversity of interaction pattern in analogy to nature derived from S.O. as essential part of the "eco-principles" (Moser, 1995) representing "ecosophy" (Moser, 2000a) outlined later on.

The most essential consequence from that lays in the fact that a selforganising system integrates the boundary conditions by itself.

Index of sustainability——An overall index, the "eco-social product" (ESP) can be defined as:

$$SI_{ecol} = A_{Nature}/A_{total}, \tag{2}$$

$$SI_{econ} = \text{money earned}/A_{total}, \tag{3}$$

$$SI_{ecol} = \text{work created}/A_{total}. \tag{4}$$

The understanding of the ESP is clarified with the aid of the use of wisdom, which is superior to the science approach, as it is a complex system. The background of ESP is the eco-active area of soil as the "new currency", however, including the old currency money, which is responsible for the economic dimension (Eq.3), being related, however, to a natural good like area of soil (*pecunia* from pecus).

Thereby, area of soil, money and work serve as macroscopic orientors for the ecologic, economic and social dimension of sustainability. Ethics in a society decide, how much area is given to nature for its own evolution e.g. $SI_{eco.}$ = 15% – 20% of total ecoproductive area of soil. "Eco-social product" ESP will replace GNP of free market economy.

4.2 Eco-social tech as instrument of eco-social economy

Eco-tech is based on ESP, the index of sustainability and follows the path described by the "eco-principles": sufficiency, efficiency, embeddedness and non-invasiveness, derived acc. to ecosophy.

In order to illustrate the potential of eco-tech a series of case studies are shortly described here including the evaluation using the area based indices of sustainability Eq.(2 – 4), where A can be calculated (Moser, 1998; 1996; 1995; Riegler, 1996). The sustainable process index acc. to Eq.(2), SPI, is used (Krotschek, 1996). The resulting reduction factor f_{ecol}

of the ecological impact of technologies is presented thereby.

(1) Case 1

Drinkingwater-denitrification comparing chemical and biological processing (electro-dialysis vs. microbial denitrification (Table 1).

Table 1 Drinking water-denitrification comparing the areas consumed for the chemical and biological processes using SPI

E-dialysis	Area, $m^2/(m^3$ water·a)	Microbial process
168	$A_{Row\ materials}$	213
3175	$A_{Energy\ supply}$	729
6	$A_{Infrastructure}$	10
112	$A_{Product\ assimilation}$	875
3461	A_{total}	1827
4.1 - 5.4	Total costs, ATS/m^3	2.7 - 4.5
3.3	SPI (10^{-6})	1.6

Note: the area for the chemical process is twice is high. Thus $f_{ecol} = 2$

Table 2 Comparison of fertilizers, chemical (urea) versus biological (*rhizobium*) showing the economics and the areas used

Urea		*Rhizobium*
250	Application, kg/hm^2	0.01
4×10^8	Price, $	3×10^6
29.5×10^6	$Area_{total}$, $km^2/(kg \cdot a)$	400
7	A_R, %	0.01
100	A_E, %	36
0.3	A_I, %	0.5
0	A_P, %	56

Note: the SPI in case of the bioprocess is smaller: $f_{ecol} > 10^4$

(2) Case 2

Production and application of fertilizers: comparing chemical synthetics (urea) and biological fertilizers (*rhizobium*). Certain microbes live in symbiosis with plants (roots) are able to fix N_2 from air. This potential of biosphere cannot be generally used as a lack of knowledge is given, it is uncertain if such symbioses exists in case of e.g. cereals and other plants of human use. Nevertheless this case is chosen to illustrate the path towards sustainability (Table 2).

(3) Case 3

"Green biorefinery": this strategic concept for eco-tech in general demonstrates its potential to replace petro-chemical industry. As illustrated in Fig.6 the main idea behind is the use of renewable raw materials from agriculture and forestry in a bioplant with bioreactors integrated with down stream processes in order to purify the series of products like enzymes, organic and amino acids, ethanol, biogas from the juice of grass or potatos or other masses.

Fig.7 shows quantitative data on market and price of such "biologicals", which are gaining market year by year at a decreasing price. Thus, they are capable to replace "chemicals", which are conventionally produced using petrochemistry with its danger for the environment. Success stories shown in Fig.7 are surfactants (a), pigments (b), detergents (c), textile dyes (d), wall paints (e) and plastics (f). Extrapolation to the future is very promising.

(4) Case 4

Comparing fossil and renewable raw materials for industry (Table 3).

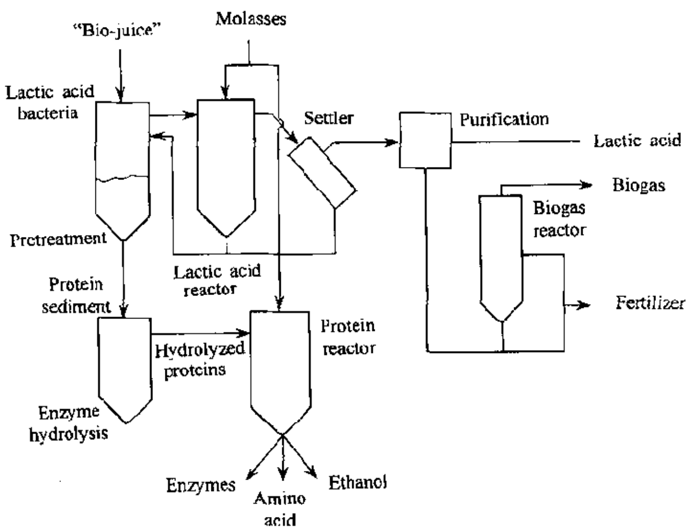

Fig.6 Scheme of "green biorefinery" based on renewable raw materials in order to produce "biologicals", which are available to replace chemicals, which are conventionally produced by petro-chemical industry (Narodoslawsky, 1999)

Table 3 Comparing raw materials (production of biopesticides, 10)

Fossil	Area	Renewable
380 – 500	A_{tot} (m^2) Areas, %	6 – 25
72 – 90	A_R	2 – 14
8 – 23	A_E	0.1 – 15
2 – 5	A_I	71 – 97
$3 - 5 \times 10^{-2}$	SPI	$5 - 40 \times 10^{4}$

Note: f_{ecol} = up to 100

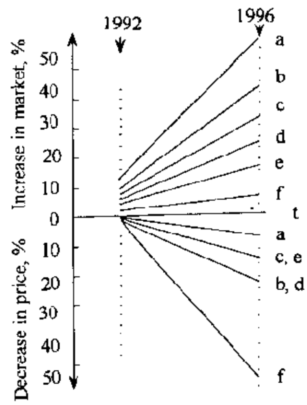

Fig.7 Market and price situation of "biologicals" during the last 5 years; the price is decreasing, while the market increases e.g. in case of surfactant (a), plasticizers (b) detergents (c), textile dyes (d), wall paints (e) and plastics (f)

5 Evaluation of eco-social tech and comparison

5.1 Problem solving capacity in ecologic dimension

Using the data from the case studies a comparison with existing techs can be executed. Fig.4 is supplemented with these data resulting that eco-tech is able to reach reduction factors in the order of magnitude needed to solve the eco-problems in future.

5.2 Problem solving capacity in social dimension

Similarly data on the capacity to create jobs are added into Fig.5 for eco-tech. As can be seen, work for people is created based on the fact that renewable materials are used, which are locally given and, thus, need more work to be done in a given region.

Comparison of techs: The divers technology paradigms (EoP, CPs and ET) can clearly be differentiated: while the modern trends in high-tech with nuclear energy plants and genetically engineered organisms (GEO), used in food and agriculture, are anti-evolutionary, the development from end-of-pipe over cleaner production will make a step in the right direction leading finally to eco-tech, which is based on a change in consciousness fully obeying the "eco-principles" (Moser, 1995).

The main fields of application of eco-tech lay in the ecosphere: supporting and sustaining the ecocycles i.e. soil, water, minerals and organic plant material cycles. The fundamental idea behind is to work with ecosphere and not against it, i.e. to use nature's wisdom, which was the starting point of old indigenous technologies.

In order to clarify the different types of technologies in comparison with the new eco-tech several statements are summarized here. Definitions are changing with time. However, the original understanding of end-of-pipe (EoP), cleaner production, eco tech are quite different: eco-(social) tech realizes all 4 eco-principles, while cleaner production's (CP) focus is on efficiency with low embeddedness; eco-tech includes all three dimensions of sustainability (employment), while cleaner production and others are missing the social dimension; clean production from NGOs has the same meaning as eco-tech/ET; "sustech" has a shallow meaning, only "win-win" situations; eco-(social)-tech obeys the deep ecology principles; while biotech follows the path of just applying biosystems in existing industry, eco-(social) tech deals with transferring eco-principles into technosphere, deeply changing it; biotechnology includes in its definition a preamble at least in Europe mentioning, that "it is obeying the biological principles and is oriented towards benefit". Thus, basically the widening of biotech in direction of socio-economic dimension represents a chance for the future; "industrial ecology" (IE) has recently appeared as new topic, it comes quite near to the meaning of eco-tech, as it contributes well towards sustainability as in analogy to nature. However, it remains an approach of cleaner tech and is a method only; zero emission research initiative (ZERI) is a relatively new topic focussing on the total closing of material cycles, which is basically an utopy, but which is identical with eco-tech when using nature to close the cycles with carrying capacities k_{prod} and k_{assim}; basically sustainable development requires a transition in steps: (1) to repair and recycle (EoP); (2) to refine (IPPC, CP, EE); (3) to redesign (ZERI, IE, ET, U); (4) to rethink (ET).

Finally the use of ESP is illustrated in case of the same topic as in Table 4 where the holistic evaluation of applying renewable raw materials in from of firewood is compared to fossil mass i.e. crude oil import for a medium community with 10000 capita. This experience was made in the region of Styria in Austria.

Table 4 Evaluation of fossil versus renewable raw material supply for heating with the aid of ESP with the ecologic, economic and social index expressed as natural area saved, money earned (a: remaining in region; b: going to central state; c: money for import) and jobs created

	A_{ecol}, m^2	ATS, %			Nr of jobs
		a	b	c	
Firewood	2 – 14	52	48	0	135
Fossil oil	72 – 90	19	30	51	9

Table 5 Quantification of the problem solving capacity in the three paradigms of technologies known: the "end-of-pipe" high-tech approach, the "cleaner production" and the "eco-tech"

Technology	Reduction in eco-impact f_{ecol}	Increase in job creation f_{social}
End-of-pipe high-tech type	2 – 3	0.9(1)
Cleaner production type	5 – 10	0.9(1)
Eco-tech type	> 20(50)	> 1.3(2)

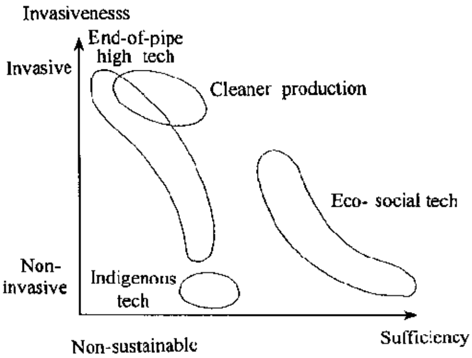

Fig.8 Differentiation of the divers technology paradigms EoP, DPs and ET including the ancient indigenous techs in a plot of invasiveness resp. non-invasiveness vs. sufficiency resp. sustainability

Thus this type of eco-tech will be able to solve the problems we encounter in society, economy and environment today better compared to the existing technology systems.

The problem solving capacity can be quantified in respect to solve problems in the environment (f_{ecol}) and in respect to the capacity to create jobs (f_{social}). This is summarized in Table 5.

The central instrument of eco-social economy is a technology, which is in full agreement with the eco-principles: "eco-tech" (5). The basis of this new technology paradigm is in natural capacities to produce renewable raw materials (k_{prod}) and to degrade biocompartible products by assimilation (k_{assim}), thereby assuring that evolutionary capacity in nature remains sustainable (k_{evol}).

6 Conclusions

6.1 The eco-principles

The wisdom of nature as expression of the intelligence of evolutionary forces represents the universal law, which can be extracted from nature using a sort of systemic analysis (Riegler, 1996; Moser, 1995; 2000a). Thereby selforganisation (S.O.) becomes the key term as it plays the central role in the evolutionary restructuring resulting in highest diversity of the processes of life. The macroscopic pattern of nature includes a high diversity with endless interactivities based on selforganisation resulting in the wellknown beauty in nature (Moser, 1995).

From this macropattern of ecosphere a series of working principles can be derived, which are very useful for the refunctioning of anthroposphere, the "eco-principles" as basis for eco-social society: (1) Sufficiency i.e. we understand that nature as the basis of life is limited in its carrying capacity (renewal rate for raw materials and assimilation rate for products resp. "wastes" i.e. the k-values); (2) Efficiency resp. Effectiveness i.e. to focus all efforts incl. engineering on optimum output from given input; (3) Embeddedness i.e. to accept that anthroposphere is part of ecosphere, thus, all activities are to be integrated in the existing local ecological but also socio-cultural-economic structure; (4) Non-invasivenes i.e. to be aware of the "whole", thus, to avoid any deep harm to evolution of local ecological but also social structure.

The usefulness of the eco-principles is demonstrated in Fig.8 with the chance to differentiate the different technology paradigms mentioned before. While EoP became quite antievolutionary, CPs can only stabilize the situation, however, remaining on the same level of high invasiveness and low sufficiency as they are part of the free economy system. Eco-social tech (ET) will reach the needed high sufficiency and low invasiveness as indicated in Fig.6.

6.2 Ecosophy

Ecosophy (Moser, 2000a) is a new term describing the wisdom of nature as we can learn from ecosphere how the whole is functioning. The core message from ecosophy in respect to technology is outlined in detail in Fig.9, where the changing approaches of mankind during history is compared. Most essential is the fact, that modern sciences missing ethical boundaries; while in early days of men handicraft were done based on some experience and with ethical values behind.

Fig.9 plots knowledge against the not-knowing as it is always a fight of cognition against ignorance. Modern industry ignoring ethical values increasingly uses a working hypothesis 2, that we can study everything and elucidate the unknown. However, this assumption is

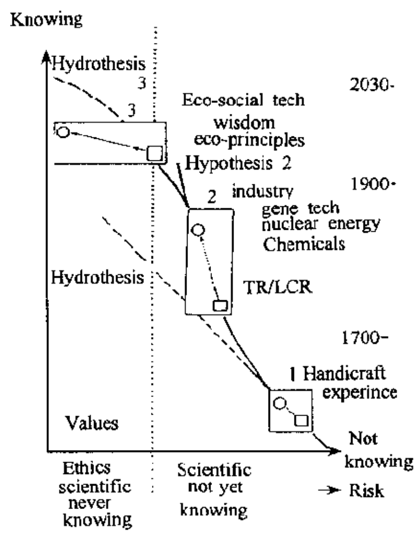

Fig.9 Schematic plot of the change in knowledge by decrease in the not-knowing with human efforts: while the ancient handicraft approach follows hypothesis 1 based on ethical value system behind and some experiences, the modern industry uses modern sciences as driving force (Hypothesis 2), where ethics were marginalized. This resulted in an increase of knowledge without, however, decreasing the not-knowing as the approach is totally materialistic. Hypothesis 3 acc. to ecosophy is integrating ethics in sciences thus combines knowledge with values and, thus, represents wisdom

wrong: there are many risks appearing with new techs e. g. with chemicals, nuclear energy and genetically engineered organisms. Risk was then thought to be studied with the aid of the concept of technology assessment TA resp. LCA, life cycle analyses. However, also this was a mistake as it remains an instrument of materialistic view unable to take into account social and ecologic values. Thereby a limit of reduction of the not-knowing is to be accepted indicated with the dotted line for the area of ethics. The third working hypothesis 3, that of eco-tech, is to execute ecosophy which means that obeying the eco-principles is identical with a path, where ethical values are integrated a priori esp. due to non-invasiveness as guideline.

6.3 New consciousness

The before demonstrated path towards deep sustainability, which is realizing a highest problem solving capacity in respect to ecologic as well as social aspects, however, will only be achieved when enhancing the build-up of new awareness for the entirety of the one world, which is our world. Fig.10 graphically shows the whole picture, what aspects are contributing to the needed transition in world view: Nature with its wisdom as source can teach us through our six senses, so that a new consciousness will become effective only due to the fact that we overlook the whole by our internal eyes. Finally the vision of eco-social society and economy will change the world as indicated: not money is the central part but life.

All areas of human societies are effected by ecosophy (Riegler, 1996; Moser, 2000a), technology is one of them, but it may be an essential one, as any action is mirroring the ethical value system and thus changing the world.

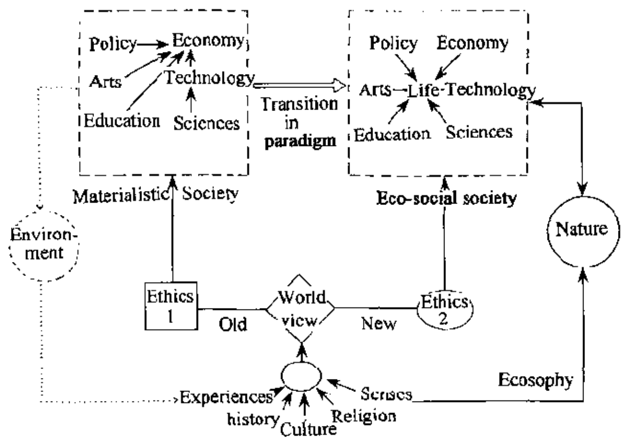

Fig.10 Scheme of the needed transition in our world based on a change in world view: from the materialistic view, where all parts focus on economy and money, the transition path will start from nature's wisdom, which we can learn through our senses influencing our thinking and doing in order to become responsible for the whole

6.4 Engineering

The meaning and definition of engineering must change: from the past as "activity to demonstrate, that human beings can make everything in terms of manipulation" to the understanding in future as "activity to harmonize between the technical, economic, ecologic and social dimension". The next "industrial revolution" will result in measuring prosperity as savings of resources, productivity as job creation and progress as reduction of toxic emissions and, on a deeper level, will respect nature as the basis of like on earth.

References:

Jansen L, 1992. Towards a sustainable future, the route with technology [M]. In: The Environment: Towards a sustainable future. Dortrecht/NL: Kluwer Acad. Publ. Chap. 19.

Krotschek C, Narodoslawsky M, 1996. Ecol Engng[J], 6:241.

Moser A, 1998. The green book of eco-tech [R]. 4th internat conf ecol engng in Graz/A, Sustain/Graz, A(publ.).

Moser A, 1996. Eco-tech in industrial practice[J]. Ecol Engng, 7: 117—138.

Moser A, 1995. Priccipia ecological[J]. Science & Engng Ethics, 1: 241—260.

Moser A, 2000a. Macroscopic pattern analysis[J]. Acta Biotechnologica, 20 (in press).

Moser A, 2000b. Integration between sciences, ethics, arts and nature[J]. Science & Engng, 6 (in press).

Moser A, 1998. Ecological process engng[M], In: Ecorestructuring (Ayres R ed,). United Nations Univ Press Tokyo. 3:77—108.

Moser A, 1999. Eco-tech the new technology paradigm[C]. In: The green biorefinery (Navodoslawsky M ed.). Proc Internat Conf in

Feldbach/Graz, A, Sustain/Graz, A (publ.). 23—42.
Riegler J, Moser A, 1996. Öko-soziale Marktwirtschaft [M]. Stocker Verlag Graz/A. (publ.)
Schnitzer H, 1999. 2nd Scientific meeting on zero emission[C], Frohnleiten/Graz/A, Zeria, Graz (publ.).

(Received for review May 11, 2000. Accepted June 30, 2000)