

Simonis, Udo E.

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Designing Sustainability of Industrial Society

Udo E. Simonis

There is something fundamentally wrong in treating the Earth as if it were a business in liquidation (Herman E. Daly).

1 Introduction

Garret Hardin, in his essay on “The Tragedy of the Commons”, remarks (1968:1245) “In a reverse way, the tragedy of the commons reappears in problems of pollution. Here it is not a question of taking something out of the commons, but of putting something in – sewage, or chemical, radioactive, and heat waste into water; noxious and dangerous fumes into the air; and distracting and unpleasant advertising signs into the line of sight”. Hardin states that utility considerations are much the same as before: “The rational man finds that his share of the total costs of wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. Since this is true for everyone, we are locked into a system of ‘fouling our own nest’, so long as we behave only as independent, rational, free-enterprisers”. He concludes: “The air and waters surrounding us cannot readily be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means, by coercive laws or taxing devices. We have not progressed far with the solution of this problem”.

In this paper, I shall focus on three elements of such a solution. First, I will present the potential of ecological structural and technological change of the economy and will provide some empirical evidence on the relationship between structure and scale of the economy and their environmental impacts. Secondly, I shall point to some of the shortcoming of environmental policy and will ask for a shift toward waste reduction or pollution prevention technology. Thirdly, I shall put forward some ideas on how to integrate ecological dimensions into practical economic policy.

“Ecological structural and technological change of the economy”, “preventive environmental policy” and “ecological orientation of economic policy” thus seem to me to be major strategic elements for decreasing the pollution load, or the points of departure for escaping from the (reverse side of the) tragedy of the commons and reaching sustainability of industrial society.

2 Ecological Structural and Technological Change of the Economy

In both the East and the West, economists, planners and engineers are seeking to change the traditional patterns of resource use. “*Perestroika*” and “modernization” are two actual catchwords in this process, and new environmental priorities play a part in the envisaged structural and technological conversion of the economy (cf. Enyedi et al. 1987). Reconciling ecology and economy in a specific sense relies on the premise that a reduction in the input of energy and material resource will also lead to an *ex ante* reduction of emissions and wastes that have a negative impact on the natural environment (*ecological structural change*).

In order to clarify the relationship between economic structural and technological change and environmental impacts, one needs suitable information concerning the material side of production, for long-term sustainability cannot appropriately be described in such terms as income, investments and consumption. One possibility is to select and compare some relevant indicators describing the environmentally significant feature of the production process.

The availability of environmental indicators such as emission data relating to ‘representative’ pollutants – like sulphur dioxide (SO₂), carbon dioxide (CO₂) and nitrogen oxide (NO_x) – has rapidly grown in the last decades (e.g. the annual reports on the Environment by several industrial nations, by UNEP and the OECD). These indicators concern certain negative environmental effects of production. Less is known on the environmental significance of the input factors in industrial production, or on the question of which indicators provide environmentally significant information about the structure of the economy. Given the present state of statistics, only a few such indicators can be tested in a cross-national comparison of Eastern and Western countries.

2.1 De-linking Economic Growth from Environmentally Significant Inputs

Using a set of four indicators (input factors), Jännicke et al. (1989; the following data and arguments rely on this article) have studied 31 countries of both COMECON and OECD with regard to the relationship between structure and scale of the economy and environmental impacts. The four factors whose direct and indirect environmental significance is thought to be self-evident are: *energy, steel, cement, and freight transport*. Regarding their patterns of production and consumption these are environmentally “hard” factors, characteristic of a certain structure, technology, and/or scale of the economy.

The main hypothesis of the research therefore was a rather simple one and reads like this: positive environmental effects of structural and technological change of the economy are to be expected by actively de-linking economic growth from the

use of environmentally significant inputs (resources). Such active *de-linking* (or *ecological structural policy*) would

- result in a decrease of *resource depletion* and/or *environmental pollution*;
- mean *ex ante* instead of *ex post* environmental protection;
- promote *integrated, less polluting technologies* which touch upon several environmental effects (pollutants) at one and the same time.

Ecological structural and technological change as a shift of input factors can thus be conceived as a process of *successive de-linking*: The contribution of traditional (hard) input factors to the national product decreases, i.e. they change or lose their function in the development process.

2.2 Examples of Successful and Unsuccessful De-linking

Taking the Federal Republic of Germany as an example, Figure 1 illustrates a five-fold de-linking from the growth of the Gross Domestic Product (GDP): The de-linking of energy and cement consumption and weight of freight transport from GDP became apparent during the 1970s; regarding steel, the de-linking process began already in the 1960s. In this way, structural change of the economy generated *environmental gratis effects* of various kinds:

- the stagnating consumption of primary energy led to a reduction of harmful emissions (pollutants);
- the relative decline in the weight of freight transport indicates that the volume of materials employed was reduced rather than increased;
- the fall in the use of *cement* represents a direct gratis effect as far as the emissions from *cement* factories are concerned; this decrease coincided with the trend towards labor-intensive renovation of the housing stock, as compared to new construction;
- the decrease in *steel consumption* accounts for a considerable reduction in harmful emissions as far as processing is concerned; this drop was strongly marked and partly due to increased recycling activities.

Environmental gratis effects occur when the rate of usage of the input factors (resources) having a (strong) negative impact on the environment remains below the growth rate of the GDP. Comparing the rates of usage of the four selected input factors with the GDP growth rate, three distinct development patterns emerge (Jänicke et al. 1989):

- The factors having impacts on the environment decline absolutely; i.e. *absolute structural improvements* are induced, corresponding to absolute environmental gratis effects.

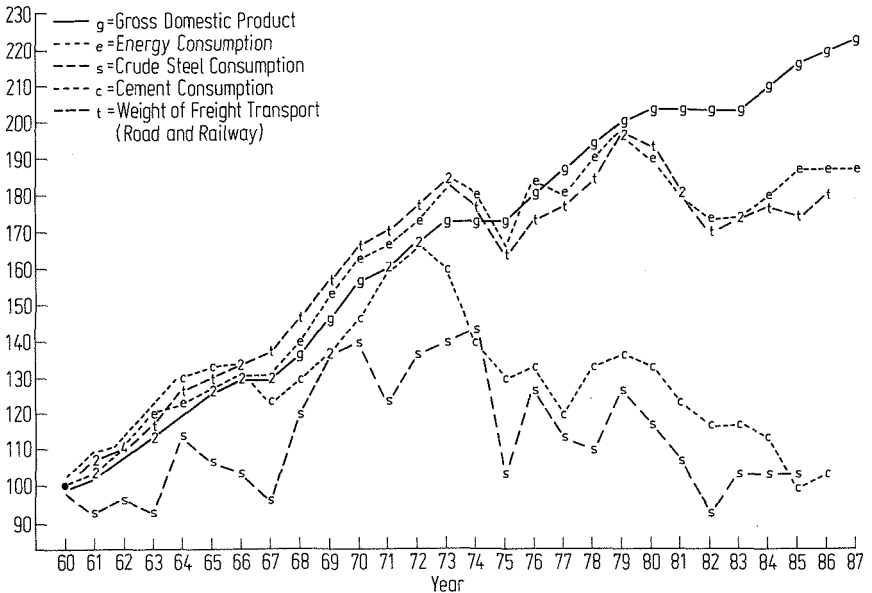


Figure 1: Structural economic change in the Federal Republic of Germany, 1960-1987 (1960=100)

Source: Jänicke et al. (1989)

- The factors having impacts on the environment remain constant, or increase, but with a lower growth rate than the GDP; i.e. *relative structural improvements*, corresponding to relative environmental gratis effects.
- The factors having impacts on the environment increase at a higher growth rate than the GDP; i.e. *structural deterioration*, corresponding to absolute negative environmental effects of economic growth.

In Table 1, 16 out of the 31 countries studied are grouped according to these three development patterns.

Of all the industrial countries investigated, *Sweden* went through the most rapid structural and technological change. The drastic reduction in cement production (-41%), the decreasing use of crude steel (-38%), and the decrease in the weight of freight transport (-21%) add up to notable environmental gratis effects (“absolute structural improvement”).

In *Japan*, the de-linking process was partly neutralized by the rapid growth in industrial production and thus only resulted in “relative structural improvement”.

In *Czechoslovakia*, by contrast, no de-linking of economic growth from the four input factors took place (see Figure 2). The development profile of this country,

Table 1: Environmental impacts deriving from structural change – Percentage changes, 1970-1987

Country	Consumption of Primary Energy	Crude Steel	Cement Production	Weight of Freight Transport	GDP*
<i>Group 1: Absolute Structural Improvement</i>					
Belgium	7.1	-24.5	-17.6	-2.2	42.7
Denmark	-2.7	-15.6	-33.2	20.1	40.8
France	30.3	-34.8	-23.4	-14.5	51.6
FRG	13.4	-26.3	-32.8	4.4	38.4
Sweden	26.4	-37.9	-41.2	-21.4	32.7
UK	-2.3	-43.5	-28.7	-18.2	32.4
<i>Group 2: Relative Structural Improvement</i>					
Austria	32.1	-33.9	-6.0	21.3	54.3
Finland	39.6	14.8	-11.2	12.2	65.7
Japan	37.3	-2.3	27.4	7.5	90.2
Norway	51.1	-21.6	-40.3	34.7	87.5
<i>Group 3: Structural Deterioration</i>					
Bulgaria	74.9	24.9	42.3	77.5	37.3
Czechoslovakia	31.5	22.5	37.3	62.9	33.9
Greece**	119.3	67.3	162.9	43.1	69.1
Portugal**	89.0	34.2	133.1	27.4	69.0
Soviet Union	76.3	33.4	35.9	70.2	47.7
Turkey	218.8	184.4	173.2	118.6	118.2

* Calculation of the Gross Domestic Product percentage changes on the basis of constant (1980) US\$. Bulgaria, Czechoslovakia and Soviet Union data refer to percentage changes, 1970-1983, of the Gross National Product.

** Transport data only take railway transport data into account.

Source: Jänicke et al. (1989)

with sluggish structural and technological change, is also representative of the other economies of Eastern Europe.

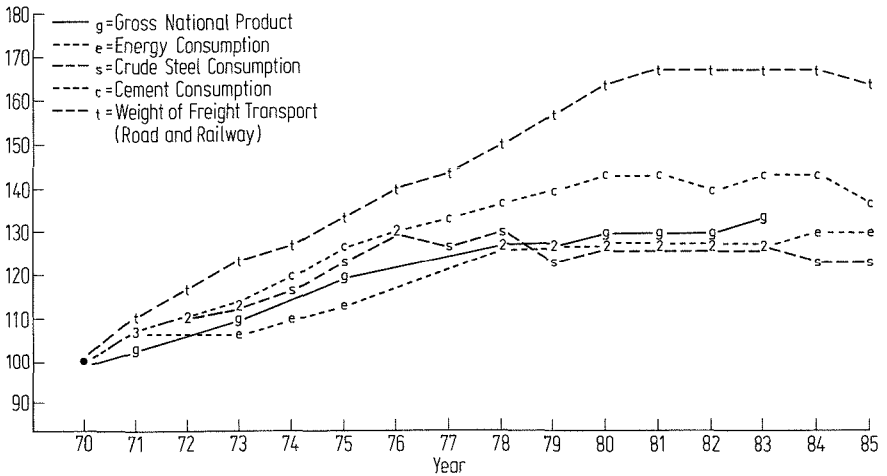


Figure 2: Structural economic change in the CSSR, 1970-1985 (1970=100)

Source: Jänicke et al. (1989)

2.3 Trends Towards Industrial Restructuring

Despite certain analytical limitations of such empirical research (e.g. the selection of only four input factors), several conclusions can be drawn from his international comparison as regards past trends of industrial restructuring (cf. Jänicke et al. 1989).

- Structural and technological change in the form of de-linking economic growth from environmentally significant inputs was evident in most but not all of the countries studies.
- Several countries enjoyed environmental gratis effects as a result of active structural change. In some cases, especially for Sweden, these effects were quite considerable.
- In other countries, the possibly beneficial environmental effects of structural change were levelled off by the rapid industrial growth pursued. This was especially true for Japan.
- The strong correlation between the level of production (GDP) and environmental impacts, still evident in the 1970s, had dissolved in the 1980s. The high-income countries featured fairly rapid structural change.
- In the medium-income countries, a distinct pattern emerged in that there were cases of rapid quantitative growth and cases of qualitative growth, i.e. economic growth with constant or decreasing resource input.

Summing up, it is not yet possible to speak of one dominant trend towards industrial restructuring. However, the environmental gratis effects of active structural and technological change are highly evident and thus provide one strategic element for designing sustainability of industrial society.

3 Preventive Environmental Policy

Theoretically speaking, environmental policy can be defined as “the sum of objectives and measures designed to regulate society’s interaction with the environment as a natural system; it comprises aspects of rehabilitation, conservation, and structural adjustment” (IIES 1982:6). Practice, however, does not conform to such a comprehensive definition. Only parts of the interaction between society and environment have become the subject of policy. So far, environmental policy has mostly been designed as react-and-cure strategies concerning air and water pollution, noise and waste, with emphasis on the rehabilitation aspect and on end-of-the-pipe technology.

For a variety of reasons, this conventional environmental policy was, and is still, meaningful and very much necessary. It has, however, a number of shortcomings, some of which are addressed in the following along with some suggestions for overcoming them through preventive environmental policy, i.e. anticipate-and-prevent strategies and integrated, low emission technology.

3.1 Environmental Expenditures – Environmental Damages

Since the beginning of the 1970s, when systematic records first began to keep track of the funds allocated for environmental protection, the sum of the respective public and private investments in the industrialized countries has reached large proportions. Industrial society thus appears to be ‘paying through the nose’ its back payments for the negative environmental impacts of production accumulated in the past.

In the Federal Republic of Germany, for instance, the sum of expenditures aimed at rehabilitating and conserving the natural environment has come to the handsome total of over 275 billion DM (or about 175 billion US\$). In a detailed study, Leipert/Simonis (1989) from the International Institute for Environment and Society (IIES) have first established the respective data which in the *Statistical Yearbook of 1989* were published as official data by the Federal Statistical Bureau. (The following data are from them.)

Table 2 shows the total and sectoral *environmental protection investments* for the manufacturing sector of the German economy for the years 1975 to 1987.

Table 3 shows the *total expenditures for environmental protection* for both industry and government for the years 1975 to 1987.

Figures like these, however, are ambivalent. On the one hand, they give cause for proud political statements about the successes of environmental protection, according to the motto “the more, the better”. On the other hand, they are – presumably – not sufficient to secure industrial society’s sustainability. At the same time, they may symbolize a serious inherent deficiency of industrial society: Environmental protection expenditures are spent when damage to the natural environment has occurred and can no longer be denied. They are, in fact, repairs to the process of economic growth, signs of a “post-fact” policy that reacts at a rather late stage to damages (and must react to them) but does not, or cannot, prevent them. Therefore, it is necessary to always confront the ‘success stories’ of environmental protection *expenditures* with figures on the environmental *damages* themselves.

Again taking the Federal Republic of Germany as an example, an estimation by Lutz Wicke (1986:123) from the Federal Environmental Protection Office says that the *annual damage* to the natural environment in monetary terms may be over 103 billion DM, or in the order of 6% of GNP, and not 3%, as the OECD had estimated for the industrial countries some years ago.

Table 4 is based on differing estimation methods, combining data on actual damage costs and findings from willingness-to-pay studies. Though the results therefore must be taken with some care, the table leads to the conclusion that, despite high annual environmental protection expenditures, enormously high environmental damages still occur annually. Of course, this conclusion may not only be true for Germany but for all other industrial countries as well.

There are more shortcomings to conventional environmental policy (Simonis 1985). To name the more obvious ones: environmental policy often identifies the given problem too late, so that the ecosystems affected cannot survive. As it is pursued as a *media-specific* policy, i.e. separately regulating air or water quality, noise or waste, it also lacks coordination among its specific goals, measures and institutions. This then may result in shifting a problem from one environmental medium to another – e.g. from air to water or soil, or from one place to another, as is the case with long-range, trans-boundary pollution. In addition, environmental policy often becomes entangled in a debate on principles. If measures must instantly be taken, the argument is twisted by the *polluter-pays principle* – which is advocated in general – to the taxpayer-pays principle, thus shifting the burden of environmental protection costs from the individual polluter to the community, the government or society at large.

Thus, innovations in policy planning and implementation are needed. Preventive environmental policy, it seems, can counter the shortcomings of conventional environmental policy. But in order to switch towards preventive policy, several conceptual as well as practical constraints have to be overcome (in the following, I rely on the arguments put forward by G. Scimemi 1988).

Table 2: Environmental protection investments, manufacturing sector, Federal Republic of Germany, 1975-1987, in million DM

Year	Total Investments		Waste Disposal		Water Pollution Control		Noise Abatement		Air Pollution Control	
	Current Prices	1980 Prices	Current Prices	1980 Prices	Current Prices	1980 Prices	Current Prices	1980 Prices	Current Prices	1980 Prices
1975	2,480	3,090	170	210		1,110	200	240	1,210	1,530
1976	2,390	2,830	200	230			220	260	1,150	1,380
1977	2,250	2,560	200	230			210	230	1,100	1,250
1978	2,150	2,370	170	180			200	220	1,100	1,220
1979	2,080	2,190	260	160			200	210		1,020
1980	2,650	2,650	210	210			240	240	1,290	1,290
1981	2,940	2,810	250	240			210	200	1,530	1,460
1982	3,560	3,250	390	360		1,030	230	210	1,810	1,650
1983	3,690	3,270	290	260		1,100	230	200	2,070	1,820
1984	3,500	3,100	270	240		1,040	230	190	1,960	1,750
1985	5,620	4,940	330	280		1,060	260	220	3,970	3,530
1986	7,300	6,400	420	350		1,150	250	200	5,480	4,900
1987	7,890	6,900
<i>Annual Change in %</i>										
1975-1979	-4.3	-8.2	-1.5	-6.6	-4.1	-7.9	0	-3.3	-5.6	-9.6
1979-1984							2.8	-2.0		
1975-1984	3.9					-2.1	1.6	-2.6		

Source: IIES research project. Data for 1986 and 1987 from Statistical Yearbook (1989:587)

Table 3: Total costs of environmental protection investments for industry and government, Federal Republic of Germany, 1975-1987, in million DM

Year	Industry		Government		Industry and Government	
	Current Expenditures	Depreciations	Total Costs	Current Expenditures	Depreciations	Total Costs
<i>At Current Prices</i>						
1975	3,200	1,520	4,720	3,000	1,920	4,920
1980	5,160	2,250	7,410	4,690	3,390	8,080
1985	7,930	3,160	11,090	6,430	4,340	10,770
1987	9,050	3,780	12,830	7,580	4,790	12,370
<i>At 1980 Prices</i>						
1975	4,050	1,870	5,920	3,790	2,570	6,360
1980	5,160	2,250	7,410	4,690	3,390	8,080
1985	6,230	2,640	8,870	5,340	4,030	9,370
1987	7,260	3,080	10,340	6,330	4,270	10,600

Source: IIES research project. Data for 1987 from Statistical Yearbook (1989:587)

Table 4: Environmental damage in the Federal Republic of Germany ("measurable damage" in billion DM per year)

Environmental Sectors	Environmental Damage
<i>Air Pollution</i>	ca. 48.0
Health hazards	between 2.3 and 5.8
Material damages	more than 2.3
Degradation of vegetation	more than 1.0
Forest blight, etc.	between 5.5 and 8.8
<i>Water Pollution</i>	far more than 17.6
Damage to rivers and lakes	more than 14.3
Damage to North Sea and Baltic Sea	far more than 0.3
Contamination of ground water, etc.	more than 3.0
<i>Soil Contamination</i>	far more than 5.2
Costs of Chernobyl accident	far more than 2.4
Rehabilitation of 'yesterday's waste'	more than 1.7
Costs of preserving biotopes and species	more than 1.0
Other soil contamination, etc.	far more than 0.1
<i>Noise</i>	more than 32.7
Degradation of residential amenities	more than 29.3
Productivity losses	more than 3.0
'Noise rents', etc.	more than 0.4
Grand total of damage	more than 103.5

Source: Wicke (1986)

One constraint has to do with the particular history of an environmental impact. In cases of yesterday's wastes, when damage has already occurred, a curative strategy obviously is the only conceivable option. However, in all cases where damage must be expected for the future, the choice between a preventive and a curative strategy is basically open. The anticipatory principle strongly leads to encourage the first option. As practice often is a mixture between the existing and the new, most policies actually will also include a mixture of prevention and cure. Demanding preventive environmental policy will then mean seeking, and at last finding, a *better balance* between the anticipatory and the reactive component within policy action and, particularly, between end-of-the-pipe technology and integrated, low-emission technology.

3.2 Basic Conditions of Preventive Environmental Policy

One can conceive three factors as concomitant policy-relevant processes in time: the accumulation of environmental damage, the acquisition of technical knowledge, and the rise of public awareness. The time sequence of these processes, especially the relative timing of their *critical levels*, may be decisive for the whole issue of preventive environmental policy.

To illustrate the relationship between these three factors, Scimemi (1988:34) has redrawn a diagram suggested by Winsemius, using three separate functions: *Level of Environmental Damage*, *Level of Technical Knowledge*, *Level of Public Awareness*. The relative position and the shape of these functions depends, of course, on the specific circumstances (country, environmental sector, historical phase) under consideration; the common case may be the one illustrated in Figure 3.

Line $D_1 - D_2$ indicates the *accumulation of environmental damage* over time. The accumulation of damage starts at a given point in history (in the diagram somewhere between time 0 and time 10). At that point, neither the scientific community nor the general public is yet aware that anything of importance is happening. Line $T_1 - T_2$ indicates the process of acquisition of *technical knowledge*. This process may not start until some time after damage has begun to accumulate (in the diagram somewhere between time 10 and 20), and proceeds gradually. During that phase, the public may still be unaware of the hazard. Somewhere between time 20 and 30, *public awareness* starts to rise, as is indicated by line $P_1 - P_2$.

Within these concomitant processes, a certain stage becomes important (*critical level*). As illustrated, the technical understanding of the issue reaches a critical level, t , thus ensuring the first of two conditions required for effective policy action, i.e. *technical rationality*. Public awareness also reaches a critical level, p ; at that time, the second condition for effective decision-making, i.e. *political viability*, is fulfilled. It is at this stage that action will be taken to avoid the occurrence of further damage.

Recalling past developments in environmental policy, at the national or the international level, one may easily discern that these developments evolved very much in conformity with Scimemi's theoretical interpretation. Thus, the diagram may be considered to be a true representation of real events. (There may be cases, however, where public awareness, line $P_1 - P_2$, started earlier than technical knowledge, line $T_1 - T_2$.)

What then are the opportunities to influence these basic conditions of policy action to favor preventive environmental policy? Figure 3 helps to formulate three general and two more specific options (cf. Scimemi 1988:38-39).

General options:

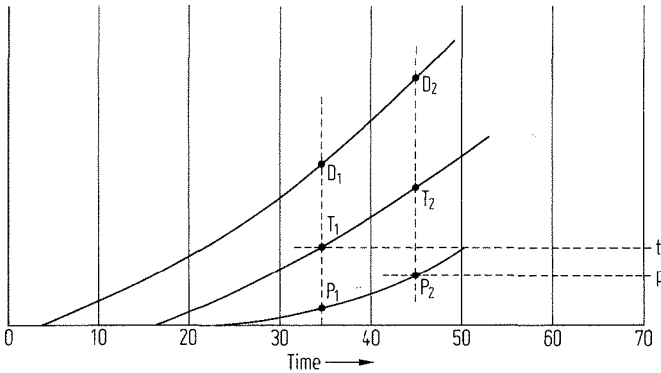


Figure 3: Factors of the environmental policy life cycle: Damage, Technical Knowledge, Public Awareness
 Source: Scimemi (1988:38-39)

- retarding damage accumulation (i.e. sliding the $D_1 - D_2$ curve towards the right);
- accelerating technical knowledge (i.e. sliding the $T_1 - T_2$ curve towards the left and/or raising its slope);
- increasing public awareness (i.e. sliding the $P_1 - P_2$ curve towards the left and/or raising its slope).

Specific options:

- dynamic environmental standard setting (i.e. lowering threshold t);
- active public participation (i.e. lowering threshold p).

All these various options make policy decisions possible at a stage when the level of environmental damage is still relatively low, or even non-existent (for a detailed discussion, see Scimemi 1988:39-45). Two of these options are illustrated in Figure 4.

3.3 Environmental Impact Assessment as Part of Preventive Policy

Accelerating technical knowledge and public awareness can, of course, be promoted through a variety of approaches and methods, but it depends a great deal on the specific environmental issue at hand. *Environmental Impact Assessments* (EIA) are increasingly being applied, not only for public but also for private investment projects. They entail efforts to learn more about possible environmental impacts, and are intended to allow appropriate action to be taken before damage has occurred. In that sense, environmental impact assessments can be said to be part and parcel of preventive environmental policy (Wathern 1988).

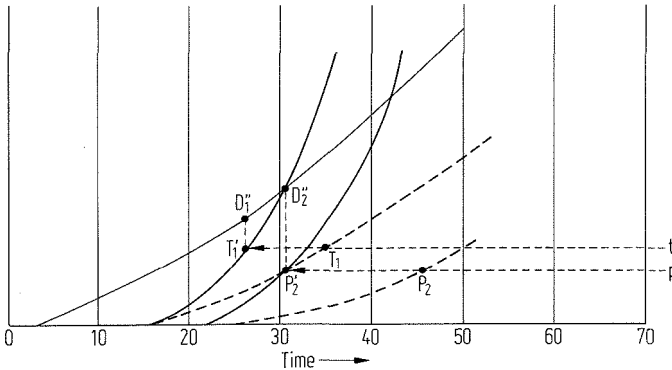


Figure 4: Accelerating the generation of Technical Knowledge and/or the development of Public Awareness

Source: Scimemi (1988)

In the last decade, some headway has been made to institutionalize and standardize EIA procedures, both nationally and to a minor extent also internationally. As the EIA procedure is particularly used for specific investment projects, it allows for the 'accelerating effort' to be targeted, and generally it also permits the burden of such efforts to be imposed upon the project initiator himself, thus conforming to a precondition of preventive environmental policy, i.e. the *polluter-pays principle*. Difficult questions, however, remain in implementing EIA as a preventive procedure in cases of global environmental change, like climatic warming or ozone depletion.

The required levels (thresholds) regarding technical knowledge and/or public participation in environmental decision-making differ widely from one environmental medium and one country to the other. The question of *how much knowledge/awareness is enough* normally falls upon the political decision-maker (the government, the environmental agency, the institution in charge of the problem), even if the scientific community (or parts of it) is ready to say "we know enough" and the public (or parts of it) is demanding "something must be done". Therefore, stalemates in decision-making on environmental issues are quite frequent (cf. Scimemi 1988:44).

What is "enough knowledge/awareness" for one country (government, agency, institution) may not be enough for the other. The normal outcome of such a situation is a compromise over the *emission standards* to be implemented. They will be weaker than technically/politically feasible because knowledge/awareness on cause-and-effect relationships and social priorities are said to be insufficient.

Eminent cases in point are the emission standards for SO_2 , CO_2 and NO_x in the air-pollution field, and the nitrate standard in the water-pollution field. Thus, the dilemma of setting strict emission standards is a serious one. Meanwhile, the

forests may continue to die back, the ozone layer may continue to be affected, and water may continue to become contaminated ... or, as Prince Charles said at the Second International North Sea Conference in 1988, "While we are still waiting for the doctor's diagnosis, the patient may die".

The conclusion therefore is that for designing sustainability of industrial society, environmental standard setting must be conceived as a continuous technological process. With growing knowledge/awareness on actual and probable environmental damages, the thresholds for action must be consecutively lowered, i.e. standard setting must be dynamized to make industrial restructuring possible on time.

This need to come to terms with the future is not unique to environmental policy, of course. Implementing the prevention principle is requested in all other domains of policy where collective interests are at stake and/or by which the commons are threatened. One such major domain we have to address when discussing the possibilities and impediments of the *sustainability of industrial society* is economic policy.

4 Ecological Orientation of Economic Policy

"Ecology in essence means the necessary and feasible harmony between man and nature, society and environment" (C.F. von Weizsäcker). Economy in general means disharmony with nature or even war against the environment. Use is made of nature both directly and indirectly when raw materials are processed into products, and the environment is polluted by the emissions and wastes generated by industrial production. These are, then, the two processes in which nature remains the loser; she exchanges natural raw materials for produced waste materials. Besides labor and capital, nature is the truly quiescent and exploited third production factor. How can nature's position in the 'economy game' be strengthened (cf. Simonis 1988)?

4.1 Conflicts between Economy and Ecology

The use of raw materials and the generation of emissions and wastes are of course old, not new issues. Scientific and technological developments, however, have made it possible to increasingly exploit depletable resources and have lead to an ever increasing accumulation of harmful emissions and non-biodegradable wastes. Nature is no longer able to absorb all these substances, many of which are not only toxic for flora and fauna but for human beings as well.

Efforts to hide harmful emissions and toxic wastes – in landfill sites, in transfer stations or permanent depositions, to spread them through high smokestacks and incinerators, or to dump them into the water bodies and abroad – have at best

been temporarily successful because many emissions and wastes are “mobile poisons” or reappear in different form. These activities lead to a *linearization of ecological cycles* (Johan Galtung) – i.e. the natural diversity is reduced, the robustness of ecosystems declines, ecological symbioses and equilibria break down. As a consequence, environmental degradation increases and the absorption capacity of the natural environment decreases.

Accordingly, the conflict between ecology and economy can be attributed to two actually or possibly (?) incompatible basic principles: the ecological principle of *stability*, as a precondition for the sustainability of ecological systems, and the economic principle of *growth*, as the inherent logic of economic systems – more precisely, the principles of business profitability, national economic growth, and world market expansion.

Given the actual and the pending ecological crisis, the question on whether these economic principles can be changed, reshaped and finally brought into harmony with ecological principles, on which level, in what way, and at what time, is, of course, a controversial question in both theory and practice; and it represents a specific challenge to the natural, the technical and the social sciences.

The answer to that question not only depends upon the respective individual and the societal constellation of interests. The answer particularly depends upon the ability of and the willingness to plead for social innovations, i.e. on (i) whether and how the potential of an ecological self-regulation of the economy is used, and on (ii) whether and how the option of an ecological economic policy is implemented.

4.2 Ecological Self-Regulation of the Economy

Generally speaking, only a small fraction of the present environmental problems would exist if the economic contexts would have remained so comprehensible that producers and consumers would personally be able and liable to recognize and perceive the consequences of their own decisions towards depleting resources and polluting the environment. Or, if business profitability, national economic growth, and world market expansion could not be increased by externalizing parts of the ensuing costs. This is the old but still relevant – because unresolved – problem of the *external effects of production*. Scientific and technological developments have been, and still are, coupled with negative external effects – i.e. the shifting of costs to society, future generations, and nature. With respect to the environmental problem, all these cost components are relevant. Take, as an example, acid rain and the ensuing damage to our forests:

- First, this example shows the shifting of a part of the costs of industrial production, i.e. insufficiently-reduced air pollutants, onto nature, which is resistant only up to a certain level: the forests are dying.

- Second, this example shows the shifting of costs onto the succeeding generations, i.e. a future with less and/or regionally even no forests.
- Third, this example shows the shifting of costs onto third parties (i.e. partial expropriation of the forest owners) and onto society, in the sense that economic and technical decisions of individual polluters (especially emissions from power plants, cars, transboundary pollution) impair the well-being and physical health of the population.

Thus, the economic system evidently makes incorrect calculations with respect to the 'ecosystem forest'. Both business accounting and national accounting do not provide adequate signals which may prevent pollution levels that are not tolerable for the ecological systems. Conventional accounting shows favorable balances for the production of energy, for the automobile producers, and for the exporters of pollutants (just to stay with the three sources of pollution mentioned above), although the 'ecosystem forest' is definitely being damaged by the emissions from these economic actors. Losses here – profits there; compensation does not take place nor is liability provided for.

One of the pending tasks both for theory and practice can thus easily be prescribed: "Internalize the external effects of production; shift the costs back to the economic units that cause the environmental problem; include the ecological perspective into all technological decision-making!"

To re-organize the economy towards a materially *integrated cycle* would, first of all, mean reducing systematically the use of depletable resources and the generation of polluting emissions and wastes – but this is in contradiction to the prevailing "throughput economy". In practice, recycling and clean technology are still at an incipient stage and the step from simply disposing or handling wastes towards systematically avoiding wastes ("low waste economy") has not been made.

Certainly, this is in part because many waste products cannot be recycled or only at high cost. But it is also true because the right price signals have not been set ("Prices should tell the ecological truth") (von Weizsäcker 1990:141). So far, no adequate incentives exist for preventing waste generation and conserving depletable resources. This state of affairs has also to do with the above mentioned shortcomings of the economic accounting procedures which do not adequately measure the diminishing stocks. Therefore, two contradictory trends prevail: increasing monetary income – *decreasing natural stock*.

Promising proposals for *ecological accounting* on the factory level and on the national level have been made. With ecological accounting the volume of energy, materials, wastes, land use, etc. are being computed and, by simulating the given shortage, accounting units are determined which then enter *the* business accounts. Thus a measure can be developed which may guide private investment decision-making and at the same time provides a public information instrument for

promoting qualitative economic processes. At the national level, *satellite systems* are being developed which complement the traditional national accounts.

In industrial society, another ecological principle that is no longer adhered to is the *sustainability or resource* use. Traditionally, for instance, forest owners have followed the rule: "Do not cut down more wood than you regrow". This rule is substantially undermined: in industrial countries, externally produced acid rain collides with internal resource conservation; and in developing countries, accumulated external debt lead to an overexploitation of the given national resources. Sustaining the yield of the forest capital stock thus is being replaced by indirect expropriation and by resource depletion.

Another basic principle to be re-established in industrial society is that of *liability*. With respect to environmental problems, the legal system, and also economic behavior, is marked in most countries by strict proof of causality. Only when the injured (damaged party) can prove who caused the damage (polluting party), is the polluter held liable for compensation. Instead, in some countries (for some cases) statistical probability is sufficient for obligating industry to compensate for damages (*collective liability*). In Japan, once this principle was established by the courts and through legislation, it quickly helped to improve environmental quality through ecological self-regulation of business activities.

In general, the liability principle would strengthen the anticipate-and-prevent strategy in environmental policy and shift the technical solutions for environmental problems from *ex-post* to *ex-ante* approaches, i.e. from *controlling or end-of-the-pipe technology* towards *low-emission or integrated technology*. To implement this principle in practice, small steps or big leaps could be taken: from continuous reporting on wastes or automatic monitoring of harmful emissions, to collective funds or strict individual environmental liability.

4.3 Ecological Economic Policy

Confronted with serious environmental damage, conventional economic policy is increasingly being challenged. Its guiding principles, goals, instruments, and institutions are questioned, and a new concept is emerging: *ecological economic policy*.

Conventional economic policy is based on the *guiding principle* of maximizing flows: volume of production, income, profits, turnover. (Kenneth Boulding, nearly twenty years ago, called this the "throughput economy".) Instead, the "ecological economy" would have to be based on a different guiding principle, i.e. "increasing efficiency and maintaining substance". Aspects such as environmental compatibility and resource conservation would become important, and structural adjustment of products and technologies according to ecological considerations would become the task (cf. WCED 1987).

Regarding goals, it seems necessary to redefine the growth targets and to include “environmental stability” into *the* catalogue of economic policy goals. The conventional policy goal indicators were *developed* at a time when environmental pollution was already a problem but not yet a public issue; and since then they have not really been readjusted. Economic growth is still being measured in terms of goods and income categories only (GNP – Gross National Product), while their effects on the stock and the quality of the resources (natural capital) are not adequately being considered. In the conventional concept of economic growth, all monetary transactions are summed up independently of their specific function; also, increasingly more expenditures are included which are solely being spent for the (necessary) compensation for damage originally caused by the given technology (*compensatory or defensive expenditures*).

Qualified goal indicators for economic policy could be defined in various ways: Computations of compensatory expenditures, i.e. assessment of an environmentally adjusted net product (ENP – Eco National Product); combined growth and distribution indices (RWG – Redistribution With Growth); integrated system of economic and environmental indicators, or attached “Satellite Systems”, etc.

Regarding *instruments*, conventional economic policy relies mainly on two instruments, i.e. variations of interest rates and of tax rates. From an ecological point of view, new taxes and charges are required which, to some extent, should replace traditional taxes. In a situation of structural unemployment and environmental pollution, the introduction of resource *tares* (as e.g. an energy tax) and *emission charges* (as e.g. charges on SO₂, NO_x, and CO₂ emissions), and a decrease of wage taxes, are all called for. Such a structural tax reform would change the existing incentives in the economy towards accelerating resource efficiency *and* increasing employment opportunities at one and the same time.

Economic policy manifests itself in and works through particular *institutions*. An ecological orientation of economic policy therefore suggests creating new economic institutions and abolishing or redefining old ones (cf. Ausubel et al. 1990). (The debate on the negative environmental effects of decisions by the World Bank and the IMF is just a case in point.) The actual and the pending environmental crisis requires structural reforms by which economic and technological institutions would have to incorporate the ecological perspective and environmental institutions to improve their conceptual and practical competence, and by which environmental impact assessments (EIA) would have to be integrated into all major economic and technological decision-making (cf. Wathern 1988:5-25).

5 Conclusions

According to the above deliberations, designing sustainability of industrial society is obviously a demanding concept, both theoretically and practically. It requires

a far-reaching conversion of economy and technology and a reorientation of environmental policy. The natural, the technical and the social sciences have to improve *the* methodological foundations and the institutional arrangements for a successful practical implementation of such a concept.

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