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TOWARDS AN END TO THE "ERA OF MATERIALS"?

Discussion of a Hypothesis

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1 Introduction

The postulate of reducing the rate at which the world converts material resources into emissions and waste has been part of the environmental discourse from the outset. Interestingly enough, even in the 1970s this prescriptive and somewhat pessimistic formula for preventing a global environmental crisis had received a more optimistic response: the hypothesis that advanced industrialised countries are progressing "beyond the Era of Materials".

Both of these "schools" have supported their arguments with long-term statistical trends, and both have great importance for the debate on global industrial change and environmental restructuring ("eco-restructuring"). A general trend towards reduced consumption of materials ("dematerialisation") would be accompanied by innovation and the rise of high-tech, information and service sectors, but it also would create losers in the mining and basic industry sectors, both of which not only play a strategic role in materials use but also display a high environmental intensity in their production processes. This change is essentially what eco-restructuring means.

In the following text I will attempt to show that the optimistic vision of an end to the era of materials remains an important one, even if it has thus far failed to be borne out by the facts. At present, there are more "N curves" than inverted "U curves" to be observed in per capita use of materials (shadowing the development of GDP). So where has the optimist’s hypothesis gone wrong? And how can the environmental postulate of dematerialisation (Herman et al. 1989, Schmidt-Bleek 1994) be realised in spite of this? Perhaps the hypothesis failed to take the powerful structural rigidity of the older industrial countries sufficiently into account. If this is the case, a "green" industrial policy would gain even greater importance than before. The key task is to transform the de facto industrial policy in favour of basic industries into a strategy which makes structural change possible and acceptable.

2 The Development of the Hypothesis

The hypothesis of a general decrease in materials use by advanced economies was explicitly proposed by Larson, Ross and Williams in the mid-1980s (Larson/Ross/Williams 1986). It was based on an analysis of long-term (1890-1983) trends in US consumption of cement, steel, ammonia, paper, chlorine, aluminium, and ethylene. It had parallels with a Swedish study on the long-term development of the steel and cement sectors (Johansson et al. 1983). Trends in Germany, France and the UK also reflected this picture in the period between 1950

and 1983. The studies were repeated in the famous study "Energy for a Sustainable World" (Goldemberg et al. 1988). This too came to the conclusion that **"a broad-based trend away from basic materials use in economy"** is taking place, not only with respect to steel or cement, but even in "modern" materials such as aluminium, chlorine, or ethylene (Goldemberg et al. 1988: 96, see fig. 1).

Figure 1: *Per Capita Use of Selected Basic Materials in Germany, France and the UK*

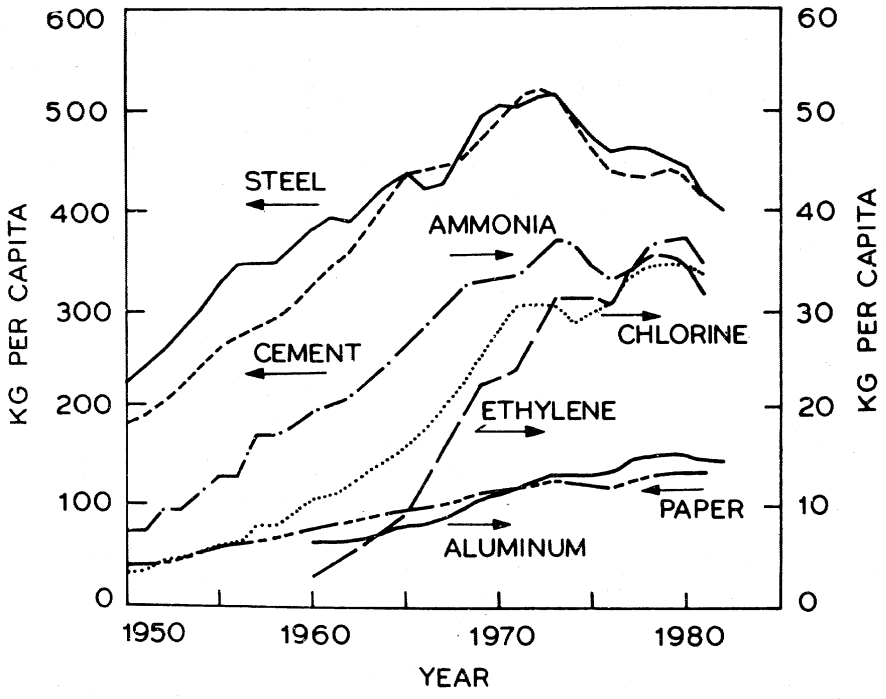


Fig. 1 shows the per capita use of some basic materials in European countries. The data are for aggregated apparent consumption in Germany, France, and the U.K., averaged over running 3-year periodes and plotted against the mid-year. The ammonia curve is for an aggregate of data for Germany and France only.

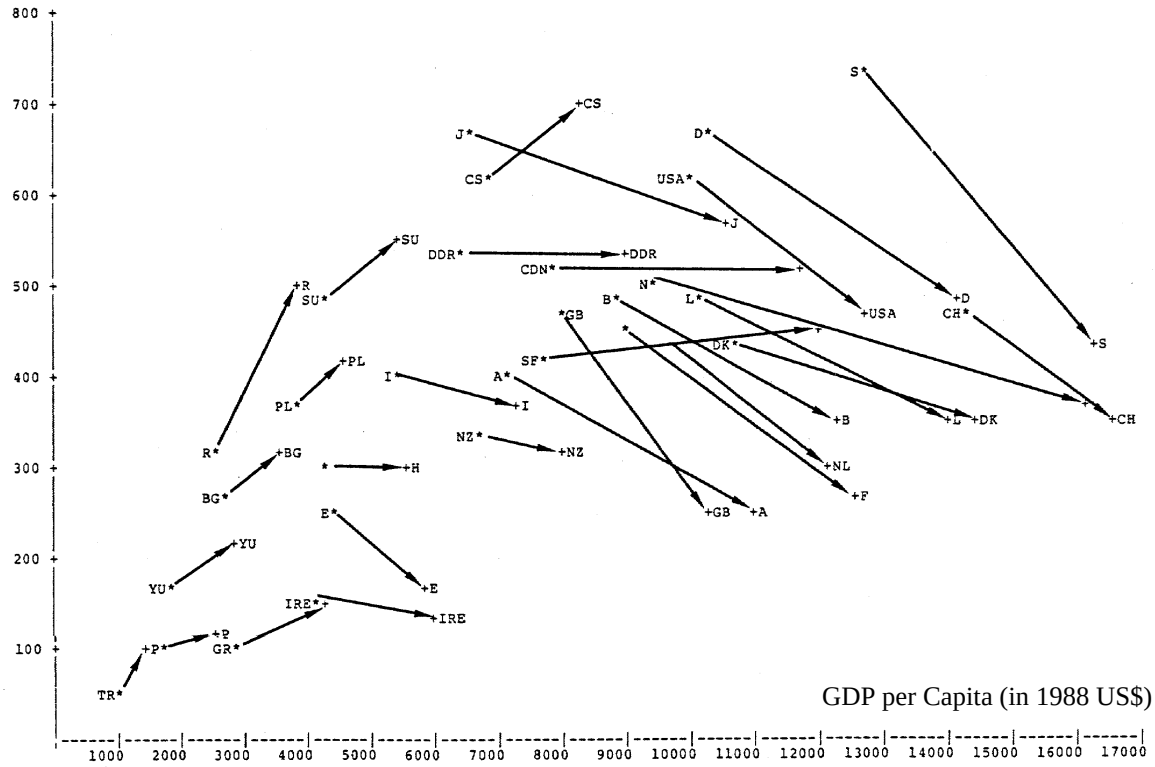
Source: Ross/Larson/Williams 1985, in: Goldemberg et al. 1988: 98.

The inverted U curve for the intensity of materials use had been described before by Malenbaum (1978: 18). It shows materials use increasing parallel to a country's industrial development up to a certain point, after which it begins to fall. This curve was subsequently also named the "ecological Kuznets curve" – a term which is now also applied to other environmentally significant indicators of long-term economic development (Grossman/ Krueger 1994, WWF 1996).

In 1986, independently of the study by Larson et al., the Freie Universität Berlin conducted a similar study of steel, cement, primary energy, and the weight of transported goods in 32 industrialised countries (Jänicke/Mönch/Ranneberg 1986, Jänicke et al. 1987, Jänicke/Mönch 1988). The study was influenced inter alia by a general hypothesis about the long-term cycle of steel production (Prognos 1983). Comparing less developed industrialised countries with advanced OECD countries, we discovered that these factors were also described by inverse U curves (Jänicke et al. 1987, see fig. 2).

Theories of at least a relative decline in the importance of materials to highly developed countries date back to the 1960s and early 1970s.

Figure 2: *Crude Steel Consumption in Industrial Countries 1970 - 1985 (kg per cap.)*



Source: Jänicke/Mönch 1988: 397

Daniel Bell's theory of post-industrial society is worth mentioning in this context (Bell 1967, 1973; see also Kahn/Wiener 1967, 1971, Clark 1940). Although only partly concerned with materials and energy consumption, it describes tendencies towards a relative decrease in industrial production. In some senses it could be understood as the theory of a long-term tendency to at least partially substitute physical factors with services, knowledge and of a continuous increase in efficiency (including recycling). The theory consequently contains some grounds for environmental optimism (Bell 1973).

Incidentally, a similar theoretical debate took place early on in Eastern Europe. In the well-known Richta Report (1968), Czech reformers – citing Daniel Bell and other Western authors – described "a new ('postindustrial') type of growth..., based not on the growing quantity of the means of production and the labour force, but on the changing quality and the degree of using new production forces". Compared with "extensive growth" during the era of industrialisation, they emphasised the advent of an "intensive economic growth" based on high R&D input and combined with a growing service sector (Richta et al. 1968). Emphasis on innovation in this direction was well justified, in the light of extreme inefficiency of materials use, especially in the USSR – albeit without much success.

The environmental impact of this technological revolution was not mentioned in the Richta Report, but its conclusions were clearly moving in the direction of "qualitative growth", which was subsequently to play an important role in the environmental debate.

Other, more value-based theories concerned with the intensity of materials use could be found in the USA, Japan, and Eastern Europe. Most of their criticism was on environmental grounds, arguing against existing trends in industrial development and seeing nothing in the way of an automatic improvement.

In the USA, authors like Boulding, Ayres and Kneese had been postulating the need for closed materials cycles since the late 1960s – stressing the importance of the "fundamental law of conservation of matter". In 1974, a comprehensive empirical analysis of material flows relative to population and GDP in the US was published (Kneese/Ayres/D'Arge 1974, Fischer-Kowalski 1997). The global models of Forrester (1971) and Meadows et al. (1972) demonstrated the potentially disastrous consequences – not least for the environment – if the era of materials and industrial growth were to persist in the long-term.

Japan was the first country to develop a more technocratic economic doctrine based on these new ideas. As early as in 1971, the MITI published its vision of a "knowledge-intensive industrial structure": branches with high energy and material intensities would be substituted with knowledge-intensive forms of production (Foljanty-Jost 1995: 159). In 1978, Japan was also the first – and only – country to introduce a law providing precise targets for reduction in material- or energy-intensive branches such as fertilisers (-45 %), primary aluminium (-32%), shipbuilding (-35%), or electro-steel (-14%) (Weidner 1996: 485).

Even in Russia, economists in the early 1970s linked the intensification of materials use to the natural environment (Fedorenko/Gofman 1973). The first complete audit of national material flows in the Soviet Union was conducted in 1974 – in parallel with Ayres and Kneese in the US – by Gofman, Lemeschew and Reimers, demonstrating (at least for the experts) the extreme wastefulness of materials use at all levels of production (Streibel 1990). Members of the East German Academy of Science stated in May 1973 that "the greatest proportion of environmental pollution is a direct consequence of an underdeveloped materials economy", and therefore that the goal of a "closed material cycle" should be set (Maier/Roos 1974: 32, 35).

Later on, in the debate on economic reform in Eastern Europe, the intensification of production – i.e. higher energy and materials productivity – was regarded as almost a substitute for environmental protection. The low modernisation capacity of the Eastern communist systems, however, did not permit taking the necessary strategic steps.

3 The Hypothesis is Highly Plausible

Thus the hypothesis of an end to the era of materials was developed in two steps. Firstly, Larson et al. and Goldemberg et al. demonstrated empirically the inverted U curve for materials use intensity relative to growth in GDP. On this basis, a theoretical assumption was then made that this development would also lead to an absolute fall in materials use. This

hypothesis was based on arguments and observations which – at least at the time – appeared more or less plausible.

It was not the hypothesis on intensity of materials use as such, but rather the second part of the argument which has proved problematic today, and which will be discussed in the following.

Larson, Ross and Williams and Goldemberg et al. mention the following driving forces as causing at least a "saturation in the use of basic materials" (Goldemberg et al. 1988: 98):

- substitution of traditional materials
- greater materials efficiency
- greater efficiency of industrial processes
- "more services and less material-intensive products" (Goldemberg et al. 1988: 98). Saturation of markets for products with high material intensity and the development of new markets for products and services with lower material intensity (Larson/Ross/Williams 1986).

Indeed, there are many plausible theoretical reasons for an inverted U curve in the intensity of materials use to accompany the economic development of a country. To summarise the most important of them:

- the increasing importance of the service and information sectors and an associated decrease in the economic relevance of industry, especially mining and the basic industries
- the rise of post-materialism, or at any rate shifts in consumer preferences towards non-materialistic, "green" products
- the falling demand for basic materials within processing industries, brought about by increased efficiency and "intra-sectoral ecological modernisation" (Jänicke/Mönch/Binder 1993)
- the decrease in the materials intensity of the basic industries themselves
- improvements in the quality of materials (e. g. steel), reducing their relative mass
- political regulation raising the costs of environmentally intensive materials, or directly influencing demand or the efficiency of materials use.

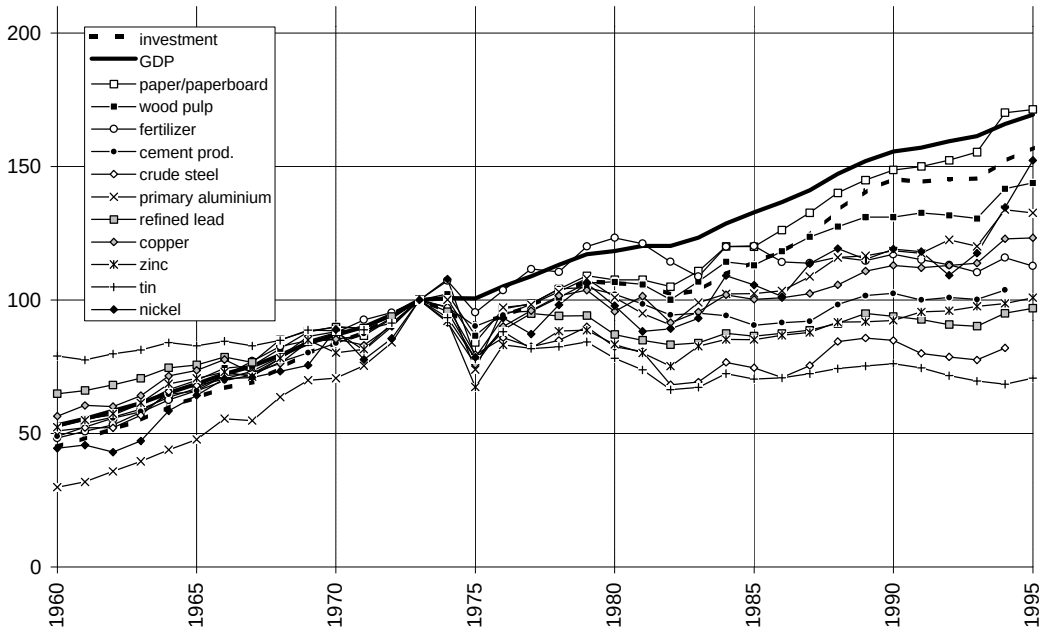
The trend towards lower intensity of materials use was enhanced by more temporary factors, such as the oil price rises in 1973 and 1979 and the subsequent fall in industrial growth (see below). Unfortunately, this constellation of driving forces was short-lived. Thus it might be useful to look at the statistical trends in materials use, including more recent developments. What do they tell us?

4 Disappointing Statistics

Larson/Ross/Williams and Goldemberg et al. did indeed demonstrate a slight reduction in the use of selected materials between 1973 and 1985 (Goldemberg et al. 1988: 98). In our comparative study, mentioned above, we found similar trends for some materials in 1986. But we were loath to generalise upon such limited results: "An empirical argument against such theories could be that structural change in the 1970s was mainly due to the increase of prices of raw materials (not only energy prices). As the prices of raw materials have tended to decline since the beginning of the 1980s, the process of structural change could be expected to come to an end. Moreover, the appearance of new 'hard' raw materials could have a similar effect." (Jänicke et al. 1987). In a later, more comprehensive study, we found statistical confirmation of this cautious position (Jänicke/Mönch/Binder 1993). At present the statistical trends can be summarised as follows:

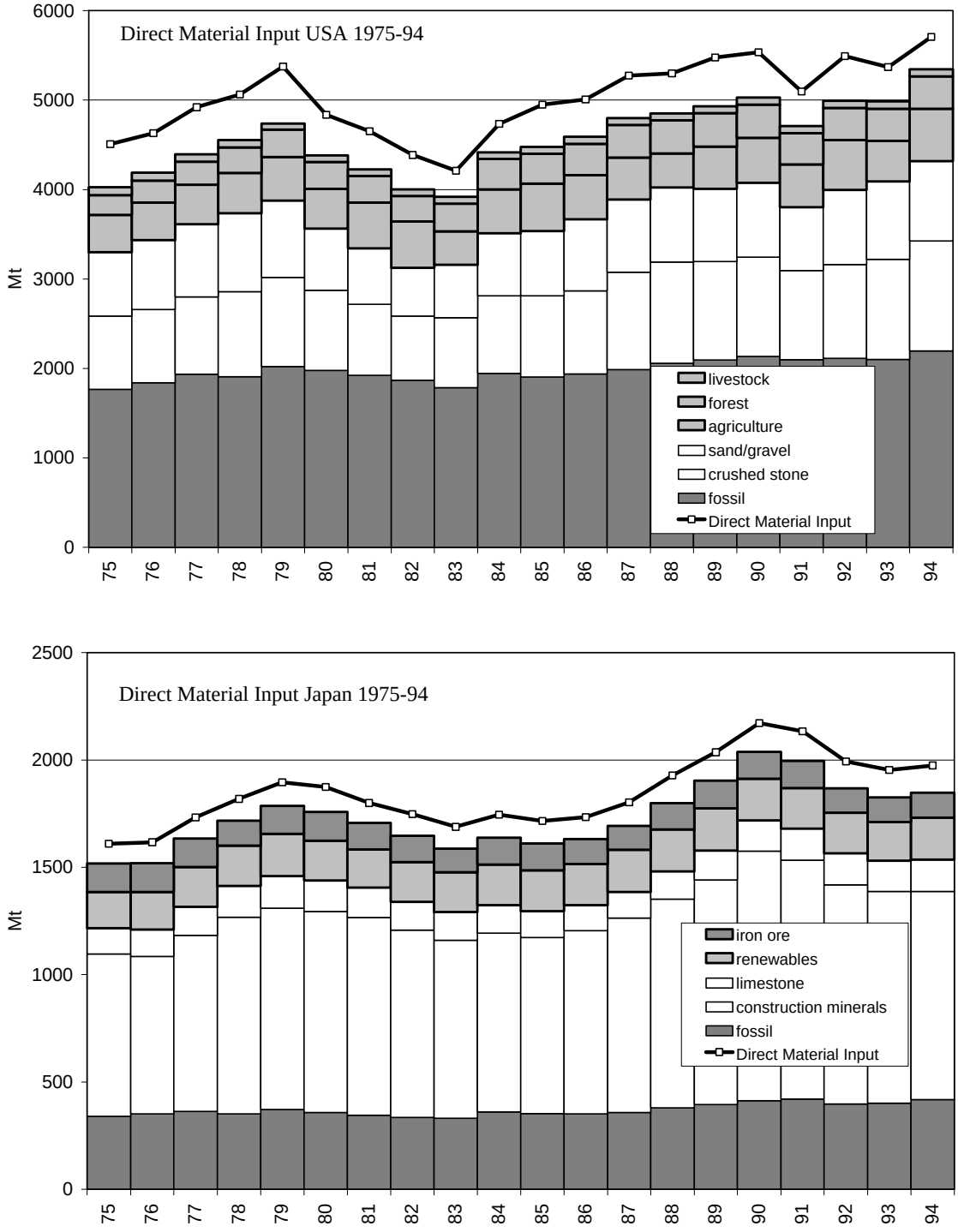
1. **The hypothesis of a long-term reduction in materials use intensity by highly developed countries remains statistically plausible**. A general de-coupling of GDP and the use of certain materials has been observed since 1973. Figure 3 demonstrates that this is the case for crude steel, cement, primary aluminium and fertilisers in OECD countries, although not for paper/paperboard. Furthermore, in five countries – USA, Japan, Germany, the Netherlands, and Austria – total materials consumption is similarly de-coupled from GDP (Adriaanse et al. 1997, Hüttler/Payer/Schandl 1997). Figure 4 shows this trend for USA and Japan. In addition, the OECD mentiones a general "declining primary resource intensity of OECD output" between 1985 and 1995 (OECD 1997: 34).

Figure 3: *OECD Materials Use 1960-95 (1973=100):*



Sources: OECD, IEA, FAO, Metallgesellschaft UN, ECE/UN; figure by Manfred Binder.

Figure 4: *Direct Material Input, USA and Japan 1975-94:*



Source: Adriaanse et al. 1997. The DMI was recalculated by Manfred Binder

2. **However, no general reduction of materials use can be found in the OECD countries**. This is not only true for most of the materials discussed here. In general, material flows are even growing in absolute terms, at least in the five countries mentioned above (Adriaanse et al. 1997, Berkhout 1997). Total materials use in Japan and the USA had noticeably stabilised between 1975 and the mid-1980s. Thereafter, however, they have experienced a renewed rise (Figure 4).

3. **Instead of inverted U, or ecological Kuznets curves, we often found an up-down-up trend, an "N curve"** (Jänicke 1979: 111). There is no stable or general trend in materials use. In the mid-1980s – after the oil crises – a rising tendency in OECD countries could be observed, even for cement, although not for steel or fertilizer. The increased materials use in the USA and Japan has already been mentioned. In our own studies, some of the "declining basic industries" covered have experienced a revival since about 1985.

4. **Up to now, there is also no significant observable trend towards delocation of basic industries into developing countries,** in the sense of production being substituted with material imports (Jänicke/Binder/Mönch 1997). The OECD countries are still seen the main net exporters of e.g. iron and steel. The share of primary products in total exports by the "Big Five" developing countries fell by one half, to 29 per cent in the period 1985-1995 (OECD 1997: 34-35).

5. In general, **the engines of demand for materials "are deep-seated and persistent"** (Berkhout 1997: 288).

6. **Most of the material is consumed and emitted rapidly**; the amount of recycled materials is of a rather small order of magnitude, usually ranging from 2 to 5% – but 9% in Japan (Berkhout 1997: 291, Foljanty-Jost 1995: 124). Even the most highly developed industrial countries are therefore a long way from achieving "sustainable development" in terms of a closed materials cycle.

There is, however, an open question as to the effects of recent policy developments. It may be assumed with some plausibility that a more rapid increase in the efficiency of materials use will be brought about by recent waste management and recycling strategies, eco-auditing etc. The debate on factor 10 (Schmidt-Bleek 1994) or factor 4 (v. Weizsäcker/Lovins/Lovins 1995) may have at least some additional effects. Countries like the Netherlands, Germany (Adriaanse et al. 1997), or Sweden (where factor 10 was proposed by the government "Eco-Cycle Commission" in 1997) may be effectively influenced by the new policy paradigm.

5 Inverted U curves vs. ecological N curves

In the following section I discuss the weaknesses of the "end of the era of materials" hypothesis. To clarify matters, we should address the issue of which questions a theory or hypothesis of the decline of materials use in highly developed countries should answer. At least four groups of driving forces should be analysed:

1. long-term technological and socio-economic factors which cause a reduction in materials use intensity
2. exceptional economic factors which cause a reduced demand for materials

3. normal competition within branches for new markets
4. political factors which promote or obstruct structural change

The hypothesis of an end to the "era of materials" is based solely on analysis of the first group: increased process and material efficiency, substitution of materials, shifts towards information and services in consumer preferences, the knowledge and service intensity of production itself, etc. All of these are facts, except that the new knowledge-based service economy has generated new forms of materials use and has been accompanied by a rapid "industrialisation" of private households (Gershuny/Miles 1983).

The second group refers to the rapid rise in oil (and energy) prices post-1973, but also to the subsequent slowing down of growth and investment (lower demand for machinery, buildings and the corresponding materials), which led to over-capacity, especially in the basic industries. This trend reversed itself in the mid-1980s, which at least partly explains the aforementioned N curves.

The third group of driving forces may provide an additional plausible explanation for the N curves. It would be unrealistic to assume that a sector will react passively to a fall in demand, caused in this case by modernisation in purchasing branches and other factors associated with the aforementioned first group. It can be safely assumed that it will fight to overcome the crisis, find new solutions and conquer new markets. Why should it fail?

The fourth group comprises political factors: government or regional political actors where the basic industry sector is concentrated play an important role as to whether or not structural change is accepted. This factor cannot be ignored. Political actors may help the branch to survive and find new markets. Possible options include direct public-sector demand, public investment (in the cases of cement or steel) or subsidies. On the other hand, policy can make the decline of a basic industry more acceptable through subsidies for alternative investment, retraining, social measures etc. Policy has sometimes even been able to force the phasing out of an environmentally harmful product.

The ecological N curve is commonly found in environmental research (Jänicke 1979, Jänicke 1985). Whenever the causal factor of a problem increases and the counter measures address only the symptoms, there is no permanent solution to the problem. The same holds for a sector’s environmental problems: during growth they exhibit a tendency to recur in time, unless additional measures are taken (which may result overall in a long-term stabilisation of problem indicators). This is a crucial point in environmentally sustainable development.

End-of-pipe measures in a growing industry (and also the transport sector) have typically been associated with ecological N curves – or with additional measures which stabilised the de-coupling of growth in output and pollution. The OECD has recently predicted that environmental indicators connected with motor traffic will follow an N curve (OECD 1997a: 104).

Within fast-growing industries, even ecological modernisation may be followed by a renewed upturn of environmental indicators. We have shown this for the case of Japan, where impressive industrial modernisation between 1973 and 1985 was in the end balanced out by rapid industrial growth (Jänicke/Mönch/Binder 1993). Even this extremely advanced country has achieved only a weak level of eco-restructuring in basic industries.

There are therefore often N curves where there should have been ecological Kuznets curves, if the hypothesis of an end to the "era of materials" is to be borne out by the statistics. In the field of materials use, however, such N curves do not have the same argumentative force as those associated with end-of-pipe treatment or economic growth. They result from the last three groups of driving forces listed above, which means that they are open to very different influences.

One point is nonetheless particularly important in the context of environmental policy. There is a contradiction between ecological modernisation and the response of basic industries to being affected by this as suppliers. Efficient use of materials, energy savings or phasing out the use of a toxic substance creates loser branches, who may react by competing for new markets, as is the rule in market economies. Electricity-efficiency measures, for example, are often responded to by the power industry (and its allies) through strategies to find new markets and, quite possibly, new ways to waste energy (such as the stand-by mode for electrical appliances). Action taken against the use of chlorine has been successfully counteracted by the target industry’s efforts to increase consumption of PVC, etc.

More generally speaking, if structural change is not accepted (or effectively enforced), and if the "struggle for revival" remains a driving factor, the environmental improvements from modernisation within branches will be limited, if not balanced out by the supplying industry’s search for new markets. An ecological N curve may then be the result (many of them typically tending towards stagnation).

6 The Importance of Political Factors

If this is the case, the stable forces pushing towards an end to the "era of materials" may be seen as *necessary* conditions for the corresponding eco-restructuring. But the *sufficient* condition will be a strategy which makes structural change acceptable to the loser branches (especially mining and basic industries). This provides a special argument in favour of "green" industrial policy, as opposed to a policy of structural conservatism.

The political factor – positive or negative – in structural change which, together with more temporary influences, has been ignored by those hypothesising the end of the "era of materials", may therefore prove crucial. The modern state currently exhibits a strong tendency to increase demand for materials through its policy on sectors such as construction, transport or agriculture, or through its general industrial policy. Only recently has a new strategy of

policy integration emerged, and tried to influence those "other" policy areas as well. This has sometimes gone hand in hand with a target group policy, using the innovatory potential in industrial branches to achieve more environmentally sustainable development. As mentioned above, policy measures such as life-cycle analysis, material flow analysis, eco-auditing, a waste policy based more on prevention, or a shift towards environmental taxation may also influence materials use in the long-term. But it is too early to measure their effects.

It may even be too early to formulate a detailed strategy for material flow management and eco-restructuring on the basis of dematerialisation. The knowledge base is still insufficient, and the goals of such a green industrial policy still require concrete design and development. For example, we must differentiate between the quantity of a sub-group of materials and its environmental importance. A distinction between *cleaning* and *reducing* materials flows would be a first step. As a second step, it would be important to formulate different strategies for different groups of materials: metals could (and should) be recycled as far as possible, but fossil fuels, which cannot be dealt with in this way, appear to be candidates for radically reduced consumption. The role of construction materials – the other major group of consumed materials – may be better discussed in association with sustainable land use, because even perfect recycling would solve only a small proportion of the environmental problems caused by the spread of built-up areas. The group of biotic materials on the one hand, and salts on the other hand, again imply very different forms of resource management and structural policy.

Many questions, therefore, still need to be answered. The question remains open as to whether the hypothesis of an absolute decrease in materials use by highly developed countries could – in the long run – be borne out in reality. From the point of view of sustainable development, we know only that there is an urgent need to move in this direction. It seems that the realisation of the empirical vision of an end to the era of materials depends upon the successful implementation of the prescriptive goal of dematerialisation. Malenbaum, Larson, or Goldemberg have shown empirically that there are powerful driving forces which can be used for a corresponding strategy for the sustainable use of materials.

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