

Reducing Resource Consumption

A Proposal for Global Resource and Environmental Policy

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1 INTRODUCTION

Recently, the world has witnessed how market failures and foresight incompetence impaired the stability of the global financial system and with it the entire economy. Insufficient accounting methods and incomplete early warning systems, missing competence in systems analysis and unwillingness to implement precautionary policies, short-term profit maximization and wrong prices of products were among the key causing factors. As one consequence, even the CEOs of leading financial institutions have called for a framework of rules capable of avoiding a similar disaster in the future. As another, thousands of billions of Euros were committed by governments to limit the potential damage inflicted upon civil society by just one industry.

While the ecological crisis does not as yet seem as acutely threatening as the financial disaster, it does have some of the same roots. Here, too, market failures and foresight incompetence, short-term profit maximization and wrong prices of products are among the key causing factors. The current market process itself is thus prominently responsible for the continuing and long-term destruction of the life-sustaining eco-system services. While the health of the financial system can eventually be restored, this is not possible for lost ecosystem services, putting ultimately into question the very survival of humankind on earth.

Given the similarities between the drivers for the financial disaster and the ecological crisis, there is a window of opportunity for a systemic structural change that is crucial to avoid the ecological collapse. The paper at hand addresses this chance and proposes pragmatic adjustments to the present economic framework. But time is running out. There is no hope for replacing lost eco-system services by technology. „*Business as usual*“ can lead to a very critical situation within decades.

The most fundamental technical requirement for moving towards a sustainable human economy is to dematerialize¹ the production of material welfare and the provision of energy. In Germany, SME's could eliminate some 20% of their resource costs already today without jeopardizing end-use satisfaction. On the average, more than 90% of the resources lifted from nature are turned into waste before goods reach the market. And yet, a vast range of technical options exists to achieve radical dematerialization. But systematic

¹ Dematerialization in this context is taken to mean the radical reduction in the use of all materials by humans, where materials comprise, metals, non-metallic minerals, fossil fuels, water (marine, fresh, renewable and non-renewable), the atmosphere, and renewable resources such as ecosystems, forests and fish. With respect to the latter especially, a very important additional consideration is the limitation and regulation of land-use by humans.

eco-innovation² remains largely unimplemented because of a lack of economic incentives to do so.

In addition to concerns about diminishing eco-system stability through resource consumption, an emerging resource scarcity is increasingly driving technological change. Globalizing the current patterns of Western consumption and resource use is *not* possible because of insufficient availability of natural material resources, useable water and land on planet earth.

Among the potential added benefits of radically dematerializing the economy are these: Arresting climate change; reducing the loss of forests, species and soil; reducing dependence on resource-rich countries; avoiding conflicts resulting from regional scarcity of water, land, and other resources; and lessening the probability of ecological surprises in the future.

The human economy must be constrained to function within the limits of the environment and its resources and in such a way that it works with the grain of, rather than against, natural laws and processes. This argues for a strong conception of sustainability, whereby the economy respects and adapts to ecological imperatives, rather than seeking to substitute manufactured for natural capital where the former fails to deliver the full range of functions and services of the latter.

It has been argued that by 2050 the total global mobilization of natural resources for human use should no longer exceed 5-6 tons per person-year, while the emission of climate-changing greenhouse gases should be limited to 2 tons of CO₂-equivalent per person-year. These goals imply an enormous increase in the resource productivity of industrial economies: in Germany, for example, a Factor 10, in Japan 8, and in the USA a Factor of 18. Only by dematerializing their economies on this scale will the industrial countries free up the necessary resources and ecological space to allow an economic growth in developing countries that does not exceed the natural limits of the global environment.

The paper at hand gives a proposal for a globally coordinated environmental policy that might help to solve the problems. In section two the theoretical basis is developed, which follows the central ideas of Ecological Economics to focus on extractions rather than on emissions. In section 3 the global policy suggestion is presented that favours a dual strategy for the reduction of CO₂ emissions and resource extractions using economic instruments to get the prices right. Section 4 discusses some examples of already given

² Eco-innovation was defined in the INNOVA EUROPE Report of the European Commission as: “The creation of novel and competitively priced goods, processes, systems, services and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimum use of natural resources (material, including energy carriers and surface area) per unit output, and a minimal release of toxic substances.”

resource efficient technologies and products that would be chosen if only the prices would be right. Some conclusions in section 5 close the paper.

2 THE THEORETICAL BASIS

The twin fields of neoclassical environmental and resource economics are the predominant way in which economists currently seek to understand the interaction between the economy and the natural environment, and prescribe for the optimal use of the latter by the former. The enormous, global-scale environmental destruction and degradation being experienced in many countries, in the oceans and in the atmosphere, with climate change as the principal result of the last of these, bears witness to the gross inadequacy of the neoclassical conceptualisation of these issues.

Environmental economics focuses largely on the emissions of residuals from the economic process into the natural environment, and their mitigation. Through microeconomic partial analysis different emission problems are analysed, monetary valuations of environmental damages are carried out and policy recommendations are made as to how emissions can be reduced such that the marginal costs of emissions become equal to the marginal benefits from the activities that produce them. The emissions are thereby identified as technological external diseconomies and treated as “freakish anomalies in the process of production and consumption” (Ayres and Knees, 1969, p.287). The policy recommendation is the internalisation of the externalities either by regulation or, preferably, by market-oriented instruments like subsidies, taxes and pollution rights (Baumol and Oates 1998, pp.177).

For policy purposes, the approach tends to interpret the different emission problems as separate and independent. It formulates distinct programmes for CO₂, dust, NO_x, sulphur etc., and other emissions into air, water and soil. Many of these programmes have been successful in their own terms (for example, emissions of SO₂ have fallen by a factor of 10 in many European countries since around 1980). However, the approach fails to recognise the systemic issue that emissions are an inherent and to some extent inevitable part of the economic process, that they appear at many locations with different impacts, and that the emissions are not independent from each other (Ayres and Knees, 1969, p.287). One result is that the dependence between emissions means that instruments such as pollution rights which focus on emissions separately may not necessarily be the most efficient instruments to reduce emissions. Much more important, focusing on emissions distracts attention from the issue of extraction, whereby materials enter the economy in the first place. In fact, all emissions are the ultimate result of extraction. Extraction, however, falls into the domain of resource economics.

The predominant concern of resource economics is optimal depletion, and the price and other conditions which can bring it about. The environmental consequences of extraction, which can be very great, tend to be treated as ‘externalities’, like emissions (see, for example, Kuuluvainen & Tahvonen 1995, p.113). However, in many resource-producing

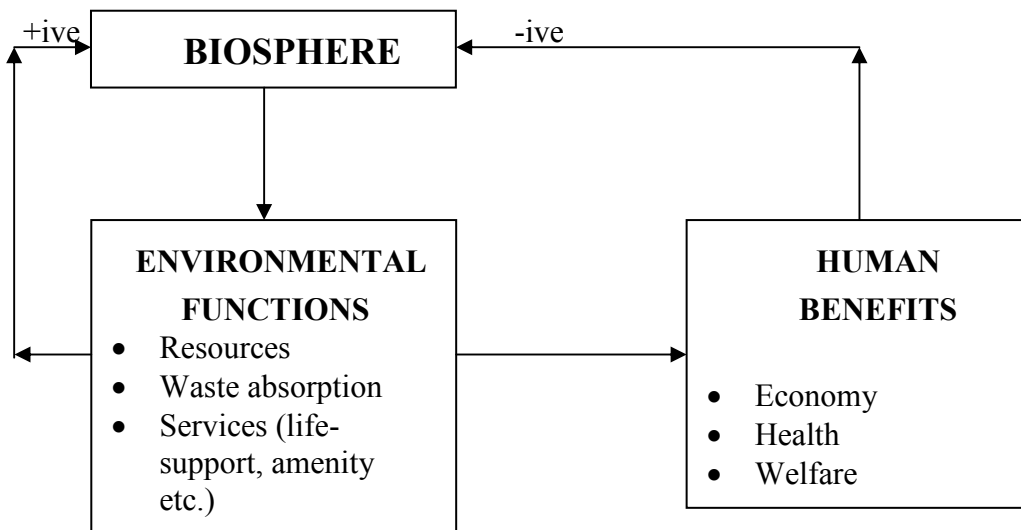
countries there is little consideration given to such externalities beyond what the extracting companies themselves decide to implement, so that the prices of many extracted resources little reflect the environmental costs of extraction that have been incurred.

Even more importantly neoclassical production functions pay little attention to the unique qualities of particular natural resources which tend to give them their utility. Rather they tend to assume that factors of production, including natural resources, are highly substitutable for each other, an assumption which, in Solow's words, implies that "The world can, in effect, get along without natural resources" (Solow 1974, pp.11).

The emphasis in environmental policy on the reduction of particular emissions, rather than on resource flows starting at the point of extraction, tends to displace environmental problems rather than resolve them. Most particularly, the mitigation of emissions does not necessarily reduce extractions, and their associated environmental degradation. For example, the mitigation of CO₂ emissions through the technique of carbon capture and storage (CCS), whereby in the case of coal power stations the CO₂ emissions are captured after combustion and stored underground, incurs a significant energy penalty which would increase the extraction and transport of coal and produce new emissions, which would have to be stored. Similarly, CO₂ mitigation through increased construction of nuclear power stations would induce a substantial increase in material extractions, as well as radiation and other emissions. The policy focus on reducing CO₂ emissions has also already induced growing demand for biofuels, with a whole range of consequent economic, social and environmental problems.

An alternative approach as the basis for global environmental policy is required. Fortunately, such an approach going under the name of 'ecological economics' has now been developed in some detail over many years, by writers such as Huetting (1980, 1992) and Daly (1991, 1992, 1996), and summarised in Ekins (2001). The essentials of this approach may be briefly outlined as follows.

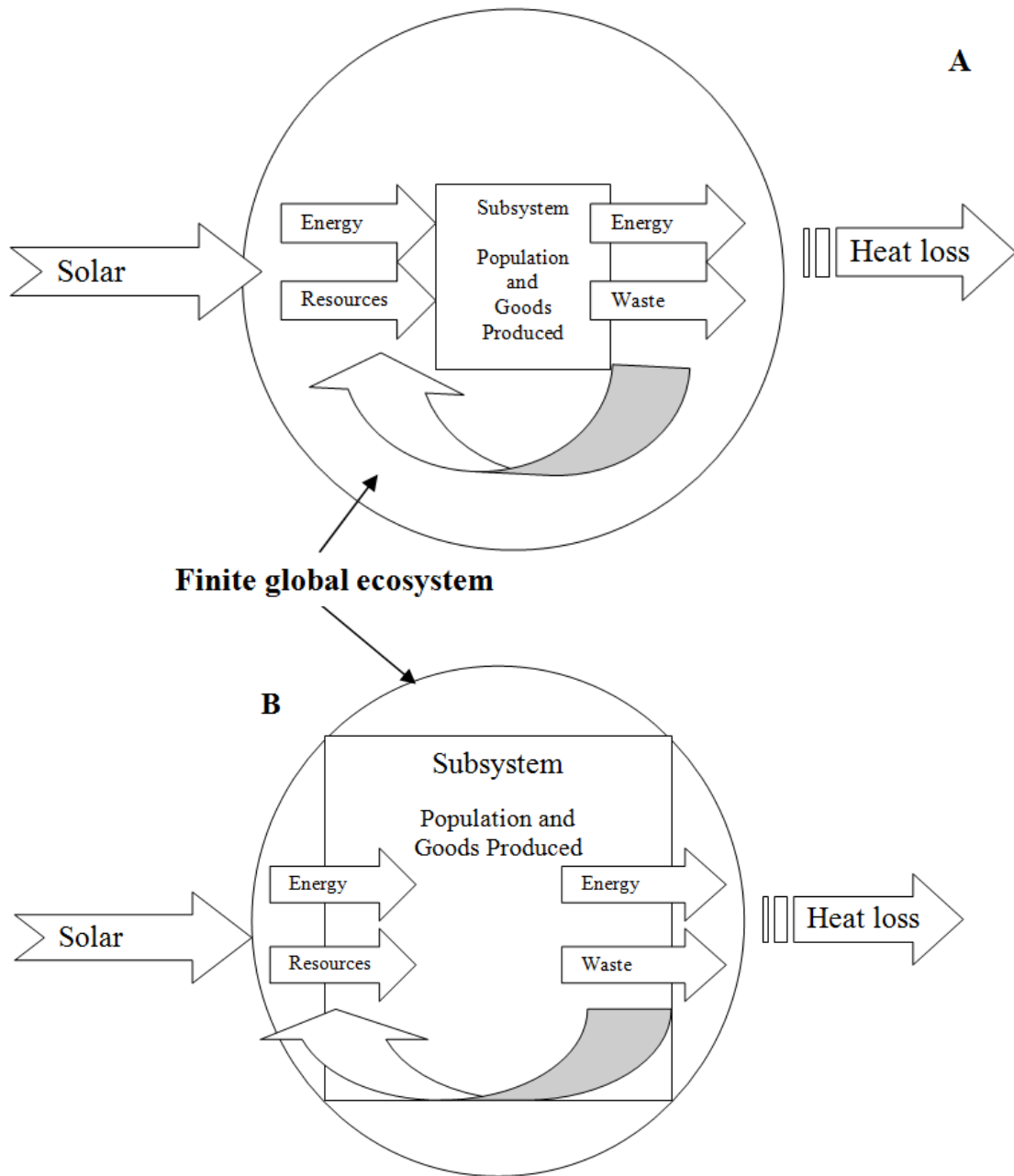
The natural environment, or biosphere, performs environmental functions of three broad kinds, as shown in Figure 1: the provision of resources, the absorption and neutralisation of wastes, and the generation of services ranging from life-support services (such as the maintenance of a stable climate) to amenity and recreation services (see Pearce & Turner, 1990 pp.35ff. for more detail on this categorisation). These three sets of functions collectively both maintain the biosphere itself (the positive feedback) on the left of the diagram, and contribute to the human economy, human health and human welfare. However, the economy's use of the environment can impact negatively on the biosphere, which can in turn impair its ability to perform its environmental functions. While the human population and its economic activity were small in relation to the biosphere, their negative environmental impact did not greatly affect the biosphere as a whole, although there are many examples of such impacts having devastating effects on particular localities (see for example Diamond 2005). Now, however, the scale of materials and energy utilised by the economy is having a globally destabilising impact on the biosphere, the clearest sign of which is climate change.

Figure 1: The Relationship between Environmental Functions and Human Benefits

Source: Ekins 2003, p.154

Bizarre as it may seem to ecological economists, representations of the economy from which the ecological dimension is completely absent are by no means unusual. As Daly (1991, p.33) has observed, all too often the economy is conceived as an abstract flow of exchange value between households and firms, and, through taxes and transfers, between these and governments. Social and ethical issues may be considered in such a framework, through such questions as: who should get what? Or, through what institutions should production and consumption be mediated? But issues of resources and environmental quality often do not arise. This omission is rectified in the now celebrated diagram of Daly's shown as Figure 2, which emphasises the ecological scale of the economy compared to the planetary ecosystem, or biosphere, of which it is a subsystem. The top half (A) of Figure 2 shows natural resource inputs to, and physical waste outputs from, an economy which is relatively small compared to the global ecosystem of which it is a subsystem. Such an economy would be likely to experience at most local environmental constraints. The bottom half (B) shows the physical requirements of, and consequent wastes from, a much bigger economy which is much more likely to be causing global environmental disruption. Daly (1991, p.34) asks: "How big should the subsystem be relative to the total ecosystem? Certainly this, the question of optimal scale, is the big question for environmental macroeconomics".

Figure 2: The Finite Global Ecosystem Relative to the Growing Economic Subsystem



Source: Daly 1992, p.5

It is important to be clear that the metrics relating to Daly's question about the size of the economic sub-system are physical rather than financial. The relevant units are tonnes (of matter) or petajoules (of energy) rather than dollars or euros. Much confusion has been generated in the past in discussions about whether or not there are limits to economic growth by the failure to distinguish clearly between these metrics and specify which is being considered at any particular time. Thus, in a finite biosphere, there clearly are limits to the amount of matter that can be mobilised by an economy and, because all such mobilisation requires energy, and human economies are subject to the laws of thermodynamics, to the amount of material mobilisation and energy use that can be accommodated by the biosphere before its essential functions are affected and begin to deteriorate. With respect to greenhouse gas emissions, such limits have clearly already been surpassed. But this is very different to the financial scale of the economy, which is what economists are normally interested in. Whether economic growth in financial terms has a deleterious effect on the environment depends on the extent to which it is accompanied by growth in energy use and material throughput. Historically, growth in material and energy use have tended to be correlated with economic growth in financial terms, but there is no imperative why this should be so, and it is theoretically possible for this link to be broken by public policy (see Ekins 2000 for further discussion of this issue). Indeed, aspirations for large-scale reductions in greenhouse gas emissions while economic growth continues reflect the widespread belief in this theoretical possibility, although it has yet to be realised in a sustained manner anywhere in practice.

Such considerations from ecological economics lead to a clear policy proposition. In summary, and as shown in Figure 2, there is a recognition that the economy is embedded in nature and receives resources extracted from nature and ejects materials in the form of emissions into nature. There is a material flow from extractions to emissions, powered by the use of energy, and the total amount of emissions in physical units differs from the extractions only in the amount of material inputs that become embodied in the physical capital stock during the period. In terms of physical material flows there is no 'final use' of products, but use by the economy's production and consumption activities of services from the material flow, which changes the physical structure of the material flow. Furthermore, the need for energy to power the flow of materials through the different stages of production and consumption itself induces material extractions. Both activities – emissions and extractions – have negative, and now serious, impacts on the biosphere. To reduce these impacts to levels which do not disrupt the biosphere's key environmental functions, such as climate stability, will require a very substantial reduction in the flow of materials mobilised through economic activity.

These insights suggest that environmental policy should be targeted on *material extractions* and not on emissions. Emissions will fall as policies reduce extractions, but there is no guarantee that reducing emissions will reduce extractions, and the impacts associated with them, and may increase them, as in the examples above. Policies to reduce extractions will seek to increase resource productivity through all stages of production, and to reduce resource use in consumption. To inform and provide direction for such policies, an international process is needed to define time paths of targets for resource consumption

of the major resources, measured in tons per capita (similar to the greenhouse gas reduction commitments that are being sought under the UN Framework Convention on Climate Change), for all countries with significant resource use. The next section discusses the major elements of the policy approach that will be required.

3 SUGGESTION FOR A GLOBALLY COORDINATED DUAL ENVIRONMENTAL POLICY

One can avoid the emission of CO₂ by focusing environmental policy only on the use phase of raw materials, rather than their extraction. But, because a focus on the use phase may engender further emissions upstream, the risk still exists that climate targets may not be achieved. This suggests that a dual approach might be followed by simultaneously setting an emissions target for greenhouse gases and a target for the use of raw materials. Because it is a dual approach that is being suggested, it should be clear that there is no intention to challenge climate policy. A dual environmental policy, as discussed here, is not to be seen as alternative but additional to climate protection policy.

3.1 AIMS

The basis of a global system has to be the demand for a standardized use of resources per capita of the population. This has to be reached at some point in the future – around the year 2050 – in every country. Thereby, the use of resources includes internal extractions, import of resources as well as resources included in import goods minus resources included in export goods. Thereby, not only the weight of raw materials themselves counts, but also the total material removed during extraction. The damaging of nature correlates closely with the weight of materials. Transport, distribution and converting resources have severe consequences for the use of energy, particulate matter emissions, noise generation, detraction of bio-diversity and many more damaging effects on nature. Therefore, it makes sense to calculate the use of resources in tons, in a standardized way. Estimates by natural scientists consider a use of 6 tons per capita in the year 2050 with a population of 9 billion as acceptable, without the extraction of water and oxygen (used and unused material extractions) (Schmidt-Bleek 2007, 2009). Nowadays, nearly 20 tons per capita are used (Giljum et al. 2008; Meyer, Lutz, Wolter 2009).

In accounting for the emission of greenhouse gases, the values (evaluated in tons) of emitted gases have to be corrected with the climate equivalence. If global warming is to be limited to 2°C, then, with a global population of 9 billion people in the year 2050, CO₂ emissions should be limited to an average of 2 tons per capita (Stern 2008, 28). The current value is stable at 5 tons per capita (World Resources Institute 2007).

3.2 INSTRUMENTS AT AN INTERNATIONAL LEVEL

Timelines for the annual target attainment have to be defined for all countries that join the system. The timelines for the target values of the input amount of raw materials and greenhouse gas emissions should assess the actual, current values. It would be unrealistic to assume that the Kyoto target values of greenhouse gas emissions could be used as a starting point for industrial countries, because many countries like, for example, the USA, are far away from these values (Olmstead and Stavins 2006). The amount of raw material input has to be understood as the total of extractions in the home country plus imports plus indirect raw materials (included in import goods) minus the indirectly included raw materials of exports. Only linear developments can be provided for target ranges, based on current, actual input amounts of raw materials or greenhouse gas emissions. With these target ranges, rights for the use of raw materials and rights for greenhouse gas emissions are distributed which can be traded between the countries. In this way it is assured that the global aim will be reached in any case and that, at the same time, the different target attainment potentials will be used in several countries in the best way.

The group of countries which decides in favour of participation in the system will tax all import goods from non-participating countries to avoid distortions in international trade (Stern 2008, 25), provided that these countries have a use of raw materials per capita or CO₂ emissions per capita that is above the average of those countries in the system. Pressure will be produced, if a specific number of important industrial countries are already involved during the take-off phase of the system. In the case that a developing country or emerging nation reaches the average use of resources per capita or the average CO₂ emissions of the countries involved in the system, it is the case that their exports are subject to the compensation charge of those countries in the system. No pressure will be exerted to join the system, as long as the use of resources per capita or the emission of harmful materials lies below the average of countries within the system. Thus, a minimum of justice is given, which is based on the level of flows. Of course, with a view to the stocks of CO₂ in the atmosphere, industrial countries are well-positioned.

Of course, this leaves the question of measurement. Many countries do not currently measure their use of materials, nor do they have they the institutional capacity to do so. Yet it is essential that countries acquire this capacity (as for CO₂ emissions) if global materials management is to become a reality. Countries should be supported through the UN to acquire the ability to measure their resource use (this could be delivered as an extension to the UN support with national economic and environmental accounting). By the time a country reaches a certain level of income, it should also have in place an internationally approved materials measurement system that is open to independent international verification. Failure to deliver this would trigger the materials tax on its exports irrespective of its level of materials use.

Finally there is the issue of the still excessive environmental damage caused by much of the extraction of materials. Again this needs to be managed, and reduced, through a mechanism of global cooperation. One proposal (Ekins & Vanner, 2009, pp.300f.) is for the establishment of Sustainable Commodity Agreements, which would entail a charge on all

commodity exports to go into an international fund that would go back into the extraction sector to fund projects to reduce the environmental impacts of extraction.

3.3 INSTRUMENTS OF NATIONAL ENVIRONMENTAL POLICY

Each of the countries involved in the system will be interested in lowering the use of raw materials and greenhouse gas emissions, to reach the target settings. Otherwise, corresponding rights have to be bought on the international market. Freedom has to be given to every country in its choice of instruments. It is not easy to give recommendations taking into account different economic constitutions, cultural and trading conditions. Therefore, the differences identified in the perfect world of eco-economic literature cannot lead to a result whereby the decisions taken for every country regarding taxes, marketable rights of use, subsidies, information and communication tools and regulations, lead to the same results (Stern 2008, 23). The preference noticeable in the microeconomic literature for marketable environmental rights (cf. e.g. Baumol and Oates 1998, 177) does not have to mean that marketable emissions rights are superior to regulatory solutions within climate protection systems, in general. Particularly the intention of creating a global market for emissions rights with the greatest possible static efficiency, in which companies can act internationally as providers and consumers directly (cf. Flachsland et al 2008), can cause, in a dynamic perspective, serious problems: it is to be expected that waves of speculation on international capital markets will encroach on the market for environmental rights. Therefore, it would be reasonable to allow indirect linking of national markets only via CDM. It is also important to see the path dependency of political processes and their meaning for enforceability of measures. For Europe this would mean that the European Emissions Trading Scheme (EU ETS), while by no means perfect, would be preserved within the frame of climate protection, as its foundation was very complex.

Through the EU ETS an extensive global system of marketable emissions rights exists in Europe. Essentially, it contains organisations in primary industry which burn fossil fuel sources. That means that in Europe the emissions from upwards of 10,000 industrial combustion processes have to be measured. Even with this considerable complexity it is only possible to cover approximately 50% of CO₂ emissions. The acquisition of emissions of other industries and, foremost, those of private households with these instruments would cause a multiplication of complexity. The adoption of 'Personal Carbon Trading' for private households has now been studied intensively (e.g. Fleming 2007), but the UK British Government decided on the basis of its own assessment (DEFRA 2008) that such a scheme would be too complex, too difficult to understand and too expensive. No other European country has come so close to the idea of an extensive system of marketable emissions rights. Therefore, it is likely that Europe will remain with a hybrid system for climate protection in which taxes and regulation have their place, alongside emissions trading. It is very unlikely that other countries are about to create conditions that are necessary for the complete surveillance of CO₂ emissions across the whole country on the level of both companies and households. There will be only a few energy-intensive industries with large companies that will be a part of an emissions trading system. A hybrid policy system for climate protection need not be excessively costly. The results of calculations with the global eco-economic model GINFORS (Lutz and Meyer 2009) for

several hybrid scenarios shows that a development path of CO₂ emissions that is compatible with the climate aim of 2050 can be reached by 2030 with comparatively low costs (certainly when compared with the costs of unabated climate change).

Turning to non-CO₂ emitting resources, the reduction of their use is possible by marketable rights of use and/or by taxation. Marketable rights of use have to be valid for all companies of the respective country which use raw materials as a production factor. In contrast, in case of taxation, only the few companies that extract raw materials, as well as importers of raw materials need to be included. Thereby, only importers who belong to a country that does not join the system have to be taxed. Therefore, the amount of input required during the raising of a resource tax is far less than with a system of marketable rights of use.

The raw material tax can be conceived of as a volume tax which is charged per unit of weight of raw materials. The general approach, on which the valuation of the raw material target in tons was based, acts on the assumption that extraction, further processing and transport of raw materials causes external effects which are dependent on weight. With the raw material tax the generation of those goods will become more expensive at all production levels which have a directly and indirectly high level of raw materials. Thus, there will be an incentive on every production level of intensive consumers of raw materials to lower their input of these materials. Through consumption, goods which are raw-material intensive will be substituted by other goods in consequence of their increasing prices.

One could abstain from an additional taxation on fossil fuels within a policy for increasing resource productivity, in a country with established and successful equipment for the avoidance of CO₂ emissions. In contrast, in a country without a climate protection policy, resource tax could include fossil fuels.

The levying of a resource tax would avoid the formerly described negative effects of some CO₂ strategies which are marked with the fact that they substitute fossil fuels with other natural resources and thereby produce other environmental problems.

Companies in the countries affiliated to the international system have no competition contortions to fear if the import of goods from other countries would be affected by a compensation charge. At first, one acts on the assumption that the threat of a compensation charge will only be applied to a few countries, which are important for trade. The level of the compensation charge will be chosen to equalise, as far as possible, the resource tax levied on comparable domestic and imported goods. The import company can appeal.

The income from energy taxes, resource taxes and auction proceeds of emissions rights (if auction is undertaken) is to be returned to the economy (Binswanger 1980). Companies are protected by compensation charges. Households have to pay the increased prices for goods which affect lower income groups more than upper income groups. Constanza

(1991,340) suggests a lowering of the income tax rate at the lower end of the income chart or even the adoption of a negative income tax, to realize distributive justice. An alternative would be to redistribute some part of the revenues as an 'Eco-bonus' on an equal per capita basis.

Part of the revenues should be for increasing awareness of resource-efficient technologies and products, so that price signals can lead to required profound behaviour modifications. This can include information campaigns as well as special events which inform people about the developments in several technical fields. As orientation help for the customer, quality labels and seals of environmental quality can be of help for their daily consumption decisions. The revenues may also be used to support research into resource efficiency.

Clearly these policies to reduce the use of resources in general, need to be supplemented by a continuation of intensification of policies which are addressed at specific hazardous materials, in order to protect human health and the environment.

3.4 AN ALTERNATIVE REGIME

For the just discussed regime it is essential that a taxation of imported goods has to take place to avoid negative competition effects in international trade from those countries which do not belong to the club and have higher emissions per head and higher resource consumption per head than the average of the club. Problems of measurement and administrative costs may occur which could prevent the success of the regime.

Establishing a world wide tax rate on extracted and imported resources, an alternative commitment would work without target lines for every country and intergovernmental emissions and resource consumption rights by intergovernmental certificate trading. The tax rate on fossil fuels has to be in line with the emission targets, and together with the tax rates on the other resources have to be in line with the resource consumption target. The advantage would be that no additional institutions would be necessary (Stern 2007, pp 532-533). If all industrialized countries and all developing countries follow this agreement, a time path for the tax rates is to be established that guarantees the meeting of the target for 2050. It might be doubtful that from the beginning all industrialized and developing countries are part of the system, and of course the developing countries would need direct public transfers from the industrialised countries to get an incentive for joining the commitment.

4 CONCLUSIONS

Human societies face profound environmental and resource challenges, which demand a systematic and comprehensive policy response. Chief among the challenges is climate change. The requisite global response to this challenge is beginning to emerge (though still far too slowly), but it is important to recognise the other challenges of environment and resources – biotic and abiotic – and to produce appropriate policy responses.

It has gradually become recognised that there are limits to the human appropriation of natural resources, and their accumulation in natural systems as wastes, if the earth is to remain habitable for large human populations. With regard to greenhouse gas emissions, the limit has been set to be about 2 tonnes of CO₂-equivalent emissions per person per year by 2050, falling to one tonne per person per year by 2100. This paper has argued that current material resource use of about 20 tonnes per person per year will need to fall to about 6 tonnes per person in 2050 – more than a halving of resource use in absolute terms. This is a formidable challenge, to achieve which policy has barely begun to be formulated.

In climate policy, a focus only on greenhouse gas emissions reduction runs the risk (through such technologies as CCS) of increasing the unsustainable use of raw materials. Climate policy therefore needs to be complemented with a broader policy focus on resource use.

Greenhouse gas (especially carbon) emissions arise from many small, as well as some large, emitters. It might have been best to seek to tackle it through carbon taxation, but carbon taxes now seem unlikely to supplant the carbon emissions trading schemes that have been or are being established. However, they can be used to reinforce trading schemes. Regulations also have their place for more targeted interventions (for example, the energy efficiency of buildings, vehicles and appliances). Climate policy therefore seems likely to continue, and be developed, as a hybrid policy approach.

The policy approach advocated in this paper is for an international system of marketable permits for use of natural resources, with the number set to decline by 2050 to the per capita limit mentioned above. The permits would be traded only between countries. Countries would be invited to join this system as soon as their resource use exceeded the average person global allowance on the declining trajectory to 2050. The group of countries which decides in favour of participation in the system will tax all import goods from non-participating countries to avoid distortions in international trade, provided that these countries have a use of raw materials per capita or CO₂ emissions per capita that is above the average of those countries in the system. The tax would also be applied to those countries that had failed to develop an adequate system for the measurement of resource use in their territory. On the national level countries are free to choose instruments, but the paper recommends a tax on the extracted materials.

Such a scheme would doubtless need much elaboration to cope with the complexities of the real world, and this paper is hoping to start the debate that will lead to such elaboration. It will also be necessary, in parallel with the broad scheme of resource taxation and the trading of resource use permits suggested here, to maintain the local regulation of specific substances according to their hazardous properties. And it has further been suggested here that a special new international Sustainable Commodities Agreement should be entered into specifically to address and reduce the environmental impacts of resource extraction.

An alternative approach would be to establish world wide tax rates on the extraction and import of resources. This would avoid problems in international trade and the construction of complex institutions. But it would only work, if all industrialized and developing countries would be part of the system which implies that direct public transfers from industrialised to developing countries would be paid.

In this way the resource and environmental policy framework would both regulate and reduce the macro-material impacts which are currently so threatening the future of humanity, while continuing to control the local environmental hazards of pollution.

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