The European trade union movement and sustainable development ahead of the Earth Summit –
a European strategy for quality employment and the protection of the environment

ETUC Conference

Seville, 16-18 June 2002

Technological, Political and Social Changes Demanded by Sustainable Development: Towards a New Kind of Technological Progress

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1. Basic challenges and concepts

Humankind is approaching a critical turning point in its history. Most important is the wellbeing of a growing population in developing countries, and sustainability is one of its preconditions. Sustainability implies many aspects: beyond the physical aspects of resources and global ecological health, it is in particular a phenomenon of social cohesion, economic driving forces and of the differentiation of cultures. Here an integrated perspective should be necessary to analyse challenges, risks and opportunities for societies to overcome present limitations. Some of the challenges and unsolved questions are:

Conflicts between quantitative economic growth and sustainability

Sustainability is not possible without economic growth. Economic growth within the past and present patterns, however, has increased environmental pressures. Therefore, without a radical structural change of the patterns of growth (qualitative growth, e.g. dematerialisation; service orientation; closed loop economies; up cycling; zero emissions), mankind seems to be captured in a deadlock: If societies succeed in accelerating traditional quantitative economic growth, the further deterioration of nature seems to be inevitable. On the other hand, without growth in goods and services, as well as profits and personal incomes, it will not be possible to raise living standards, to overcome poverty and to reduce unemployment.

Short-term personal versus long-term societal sustainability

In most regions of the world there is a pronounced conflict between short-term personal needs for jobs, income, wellbeing and physical existence and long-term sustainability. In Europe millions of jobs are missing and in following traditional economic and labour policies sufficient growth in employment can not be expected. Moreover, an accelerated economic development is necessary in most developing countries to overcome hunger and poverty. This situation generates a high priority for jobs and economic development. This is the perspective of short-term personal sustainability which is in conflict with the longer-term sustainability as expressed in Agenda 21. This conflict can only be resolved by long lasting social learning processes and by the willingness to support economic development compatible with longer-term environmental necessities (qualitative growth). Questions of international and intergenerational equity and justice are involved.

Regional differentiation

Diversity is a necessity for ecological, social, economic and cultural sustainability as well as for regional wellbeing of people and for regional sustainability. The huge variations in culture and ecological conditions are a source of regional differentiation. With differentiation regional economic imbalances as well as national and ethnical movements occur. This aspect deserves careful political analysis on how to deal with regional imbalances which ones to preserve and which ones to fight.

Globalisation

Globalisation is often perceived as an economic factor but it is not only a matter of trade. Globalisation also concerns people, knowledge, travel, culture and learning. Globalisation occurs through rapidly increasing interconnectivity of the globe. Globalisation is the precondition of exchange and interconnections of all kinds, as it allows travel and tourism, removes barriers from trade, from the exchange of information, and as it supports learning about and from each other. Globalisation means both risks and opportunities to any region. But one key question has still to be solved: What globalisation will be sustainable and how can we keep globalisation and world markets within the new limits of growth (see below)?

Information Society

Another major challenge is posed by the driving forces of the information society. It offers vast new possibilities to become sustainable; essentially, no sustainability and no dematerialisation seems to be possible without the means of an information society. However it increases the destruction rate of jobs in established industries, making the more established industries obsolete, and it accelerates the exchange of capital, goods and services as well as the growth of new infrastructures and therefore poses new threats to sustainability. Without conscious and deliberate actions to advance favourable forms of the information society, this might well worsen the environmental situation and become another burden to building sustainability.

Population growth and ageing societies

World-wide, population growth and rising per capita incomes are still the most important driving forces of increased consumption of natural resources. On the other hand and in the longer run, the inversion of the population pyramid is becoming a world-wide phenomenon in industrialised countries: in most OECD countries the number of older people increases and the number of younger ones decreases. This new mega-trend has paramount ecological, financial and socio-economic implications for sustainable development. For example, it puts stress on public finance, social security and health systems. Moreover, it changes mobility needs and systems, lifestyles as well as the tastes and preferences of customers; for example, long-term business as usual energy scenarios for Germany show a decrease in energy consumption mainly caused by reduced population.

Given the range of these new challenges and risks, the old strategy of modernisation falls short in shaping a desirable future for humankind. The first reports and forecasts on the state of the environment in the 1970s brought the finiteness of raw materials and above all of fossil fuels into the focus of public interest (Meadows 1972). Though the physical exhaustion of fossil fuels has not turned out to be the most pressing problem, things have even worsened: It

is the distribution and relative scarcity of resources which accelerates regional conflicts (e.g. on oil, gas and water) and it is the limited capacity of ecological systems (e.g. the atmosphere) to absorb pollutants and wastes which is threatening to dictate limits to the economy (Naturschranken): Not only the earth, the sky is the limit.
Since the end of the 1980s, and at the latest since the Earth Summit in Rio de Janeiro in 1992, this realisation has crystallised into a new conception of development. Sustainable development is the catchphrase used to term a form of development in which the needs of present generations are to be satisfied without compromising the ability of future generations to meet theirs. With this new guiding concept goes the realisation that environmental policy problems cannot be examined in isolation from economic and social (as well as cultural) developments.

If one accepts the preservation of the natural bases of life as a natural precondition to the sustainability of a society, then this defines a framework of possible economic and social options. Within this action space, human beings can exploit the natural environment with the precondition that the right of every human being to use resources and to pollute the environment must be recognised. Quoting Hans Opschoor, we term this action space the environmental space (German: Umweltraum). This environmental space is a function of the carrying capacity of ecosystems, the recuperative power of natural resources and the availability of raw materials. The concept thus recognises the existence of new limits to growth (Naturschranken).

The concept not only embraces the ecological dimension but also that of international and intergenerational equity. Just as future generations should have a right to a natural environment that is as intact as possible, proceeding from the above value decisions, equal opportunities should be given within a generation. The integration of this social aspect lays the foundation for a balancing of interests with the countries of the South.

Accepting the limits of environmental space and the existence of Naturschranken, we need a new approach in the economic and social as well as in the ecology debate. Until now, environmental policy has largely taken an end-of-pipe approach, focusing on the disposal or prevention of pollutants. Social and economic implications, e.g. the impact on employment and on long-term economics, often were not integrated into ecological systems analysis. Despite the successes of this approach, it has proven to be inadequate and too cost-intensive. And even if it could be completely successful, environmental problems such as urban sprawl, consumption of landscape and raw materials, loss of biological diversity, soil erosion, water scarcity and burgeoning mountains of waste would continue to prevail. In addition to the specific impacts ascribable to individual substances, environmental policy is therefore becoming aware that the very quantities alone of energy used and substances moved as well as increased land use create a problem in itself. Every product and every service is linked throughout its entire life cycle with energy and material throughputs. Large proportions of these are not economically utilised, and are returned unaltered to the natural environment, which must then absorb them. These masses can be characterised as forgotten megatons or ecological rucksacks (Schmidt-Bleek 1994). Their reduction provides a pre-eminent contribution to environmental protection and long-term economic sustainability (eco-efficiency), and moreover, reduces conventional pollution. Resource utilisation should be oriented to the following guiding principles:

- No more of a renewable resource should be utilised than can be regenerated in the same period.
- Only that amount of materials should be released into the environment that can be absorbed there.
- Energy and material throughputs must be cut down to a low-risk level.

Traditional environmental policy focuses on pollution control. Based on a systems perspective together with the insight into anthropogenic material flows, modern policy concepts follow a dualistic approach (Figure 1):

- On the output side the release of pollutants is regulated in order to reduce well-known problems. This strategy is directed to specific substance flows (e.g. lead, cadmium, carbon dioxide, etc.). Derived policies may be generally characterised as re-active.
- On the input side the resource requirements are going to be diminished in order to lower the impacts of the resource extraction as well as the effects of the subsequent flows. This strategy is directed to general resource flows (primary material, energy and water) and area requirements. Derived policies may be addressed as pro-active.

Both strategies are complementary rather than exclusive. Pollution control alone could not control increasing resource requirements and a shift of environmental problems due to the control of selected substances. A reduction of resource inputs alone may not be sufficient to keep the flows of specific pollutants under critical levels.

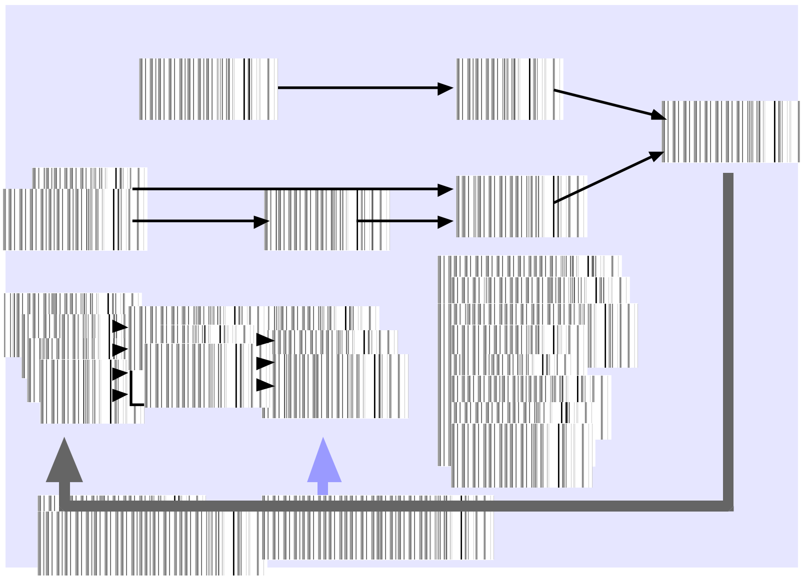

Fig. 1. Physical exchange of anthroposphere and environment (Wuppertal Institute 2000).

Pollution abatement and chemicals control are well established fields in terms of policy, methods, organisation and technology. However, the reduction of resource inputs is relatively new to the agenda. The increase in resource productivity shall guarantee that the economic performance and the welfare produced may be increased while the absolute burden to the environment as a consequence of resource extraction is being reduced.

2. The basic strategy: Decoupling Wellbeing from GDP Growth

The challenge of sustainable development requires a comprehensive policy mix serving different ends regarding ecosystems and natural resourcesÆ scarcity, distribution of wealth and economic framework conditions. As a necessary but not sufficient condition for an essential leap forward to sustainable development, climatologists recommend a reduction in greenhouse gases (GHG) by some 50% by the middle of the 21st century. However, following a business-as-usual (BAU) strategy, the demand for energy and emissions of CO_2 are likely to double within the next few decades. Up to now, the Framework Convention on Climate Change (FCCC) and the Kyoto Protocol encourage only marginal GHG reductions in industrialised countries.

An even more depressing picture arises regarding the loss of biological diversity. Although the scientific debate about causes and effects is more complex than in other areas of environmental research, one reason for land conversion and habitat destruction is the gigantic flow of materials harvested and used by modern societies. On average, each inhabitant in the EU, the USA or Japan induces material flows between some 46 (Japan) to 85 (USA, Germany) tons per year. Protecting the remaining biodiversity will require reducing the current amount of material flows in OECD countries up to 80%. This issue is further strengthened by the overall concern about increasing waste. Only cautious steps in the direction of a 3R strategy (reduction, reuse and recycling) have been adopted in industrialised countries; at best, only a relative decoupling of GDP growth and of lead indicators of environmental impacts have been reached in OECD countries (e.g. concerning energy consumption and material flows); in most developing countries material and energy growth still outstrips GDP growth.

Therefore, looking from a global perspective, it has become obvious that any attempt of the developing world to emulate Western styles of mass production and mass consumption would end up in a serious ecological crisis, mainly with regard to the greenhouse effect, the loss of biological diversity and clean water scarcity. There is strong scientific evidence that overuse of natural resources will increase poverty and lead to international security conflicts (e.g. on oil, gas and water). In fact, in the light of the 11th of September, environmental security has to be ranked among the top policy issues world-wide. Steps in the direction of more sustainable development are promising contributions to world-wide security politics. After all, per capita energy and material consumption have to be reduced in OECD countries in order to tackle environmental, security and equity questions. Positively speaking, *resource productivity* has to be increased drastically (WeizsScker/Lovins recommended a Factor Four Doubling Wealth, Halving Resource Use 1999; Schmidt-Bleek even speaks of a Factor Ten, 1994). As a world strategy this seems to be an extremely ambitious challenge to technology and civilisation. But it could happen in the long run, if civil society, business and politicians seriously engage in greening productivity. But it has to be made clear what the factor x idea means (e.g. energy and/or resource flows), whether it is only a normative guideline or a quantitative strategy, and what should be the scope (micro/macro), the intended time horizon and the policy mix to get it implemented. Last but not least, the questions of technical eco-efficiency (resource productivity) must be integrated into the frame conditions of sufficiency, e.g. questions of more equal distribution of income and wealth as well as of social innovation and lifestyles.

On the programme level, the factor x goal has attracted wide attention. It was adopted by the special session of the United Nations (UNGASS 1997) and the World Business Council for Sustainable Development (WBCSD 1998). The environmental ministers of OECD (1996) expected progress towards this end. Several countries included the aim in political programmes (e.g. Austria, Netherlands, Finland, Sweden). In Germany the draft for an environmental policy programme (BMU 1998) refers to a factor of 2.5 increase in productivity of non-renewable raw materials (1993 to 2020). An increase in eco-efficiency has also being regarded as essential by the environmental ministers of the European Union (1999). Three feasibility studies showing in quantitative terms how the factor x idea could serve as a guideline for concrete national and international strategies have been summarised below:

Case study I: A sustainable world-wide energy system

Concerning the energy sector, a technically and economically feasible sustainable world energy strategy has been demonstrated by the Factor Four Scenario of the Wuppertal Institute. Essential assumptions and results are summarised and compared with the ecologically driven C1 scenario of the World Energy Council (WEC) in Fig. 1.

Fig. 2: Comparison of the "Factor Four" Scenario and WEC-C1 Scenario ("ecologically driven")

	1995/97	2020		2050	
		C1	Factor-4	C1	Factor-4
Population (bn)	5,56	7,92	7,58	10,06	9,50
GDP (mer), 1,000 bn US $ (1990(	23,3	40,4		75	
Primary Energy (Gtoe/a)	9,5	11,4	9,9	14,3	10,3
Renewables (Gtoe/a)	1,8		2,6	5,7	6,3
$C0_2$ Emissions (Gt/a)	5,9		5,6	5,3	3,0
Nuclear Energy (GW)	368			279	0
Energyintensity(PE/GDP%p.a.;Gtoe/bn US $ (1990(; historical average=1%p.a.)		-1,44%	-2,00%	-1,30%	-1,90%

Source: Lovins, A./ Hennicke, P., Frankfurt/New York 1999; World Energy Council (WEC)

The Wuppertal Scenario is a technology oriented bottom-up approach with a special focus on the demand side and on the end-use energy efficiency. Up to now, a world-wide scenario describing the final energy consumption on the basis of the concept energy services (e.g. pleasant room temperature, clean dishes, mobility) does not exist. But this approach is necessary in order to assess the technological and socio-economic implications of a Factor Four Strategy. The Wuppertal Scenario explicitly takes such highly efficient end-use technologies like hypercars (Amory Lovins), passive houses (Wolfgang Feist), energy efficient production processes, efficient lighting and electrical motor drives as well as a large number of efficient appliances into account and discusses the impacts of such strategy elements on the structural changes of the energy supply and industrial sectors.

Starting from the needs of households, industry, transportation and other sectors for energy services, with the chosen model structure more adapted technologies can be identified fulfilling the energy service demand. This leads to a final energy demand met by an energy conversion sector which is disaggregated in as much detail as in the WEC scenarios. The scenario is based on all world-wide databases (base year 1999) which are available; however especially many data on technologies and costs of demand-side options are still missing; therefore in many aspects, the scenario had to be based on rough estimates and multinational regression analysis.

Some basic results of the complex scenario analysis are summarised in Fig. 2. Following the general basic assumptions from the WEC/IIASA scenarios (e.g. concerning regional differentiation and development of GDP or population growth), the more end-use oriented scenario analysis of Factor Four

- shows that climate protection and risk minimisation (e.g. nuclear phase-out) is possible

- identifies the three "green pillars" of sustainable energy systems, namely priority for the rational use of energy (RUE), fostering the market introduction of combined heat/cold power production in industry and district heating (CH/CP) and increasing the share of renewables (REG)
- outlines possibilities and demands for technology transfer between industrialised and developing countries ("leap frogging")
- identifies the co-operation between renewable energies with a fluctuating supply characteristic and other renewable or fossil energies which can be stored and used in a more flexible manner

The main difference compared to WEC C1 is that in the Factor Four Scenario the historical rate of efficiency increase (about 1% p.a.) is doubled. Instead of 1.4% p.a. (WEC C1) it increases to about 2% (p.a.) during the period of 1990-2050. This increase and a 60% share of renewables in 2050 are sufficient to a risk minimisation strategy up to 2050, e.g. energy productivity increases only by a factor of three. The scenario shows that this increase is technically feasible. It seems plausible that accelerating efficiency increase and decentralised technical options will keep the total costs in the range of the least-cost strategy of the C1 scenario. One important policy to make this happen should be to change the incentive structure: Reducing the bill of the customer by increasing energy efficiency should be made profitable to the suppliers of energy as well. New framework conditions are needed to establish a fair level playing field where final energy can compete with energy efficiency technologies. Not only profits from MEGAWatts (selling kilowatt-hours) but establishing new markets for NEGAWatts (by Demand Side Management [DSM] or Integrated Resource Planning [IRP], e.g. selling energy services and efficiency equipment at least societal cost) are needed.

By comparing the Factor Four Scenario not only with the C1 WEC scenario but with other long-run sustainable world energy scenarios (Schrattenholzer 2001; for Germany see: Energy Enquete Commission 2002), a key policy message can be derived: An absolute delinking of GDP growth and primary energy consumption seems to be world-wide and for industrialised countries by increasing energy productivity. Giving highest priority to end-use energy efficiency and fostering the market introduction of renewables and combined heat/cold and power production (tri-generation) seems to be the key strategy to sustainable energy systems especially in the North, but with some adaptation e.g. to the specific problem of rural electrification also for the cities and the commercial sectors in the South as well.

But what about the economic sustainability of ecologically sustainable energy systems? Some short remarks on this very complex question will be given based on three case studies for Germany:

Case study II: Sustainable energy systems can be financed

Looking at recent macro economic analysis for sustainable energy systems in Germany (Energy Enquete Commission 2002), good arguments supporting strong and early climate protection actions and phasing out of nuclear power at the same time could be derived. Fig. 3 shows the structure of primary energy consumption compared to a reference case (Business as usual/BAU) for two optional sustainable scenarios for Germany (IER vs. WI) which have been simulated with different models and different assumptions concerning the scenario philosophies.

Fig. 3: Primary energy consumption (EJ) of a sustainable energy system in Germany (80% C0$_2$ reduction in 2050); different models: WI/Wuppertal Institute; IER/ Stuttgart

Source: Energy Enquete Commission, Final report, Berlin 2002 (forthcoming)

Compared with the BAU/reference strategy, the extra costs of the sustainable energy strategy summarised above for the case of Germany have been calculated to be between 10 to 150 Euro/per capita/a. Nuclear energy has been phased out and an ambitious C02 reduction goal of 80% up to 2050 has been simulated. This calculation does not include the huge reduced external costs within a sustainable energy strategy. Therefore one important message even for countries like Germany with a high share of nuclear power production of 30% can be derived from this kind of modelling: Risk minimisation phasing out nuclear and reaching ambitious C02 reduction targets can be technically realised and financed up to 2050; but: energy managers, politicians and the public at large it is time to make up our minds! Within a BAU strategy (reference case), these results are definitely impossible. A complete new policy mix is needed, but it is economically feasible. If theses scenarios are right, there will not only be no trade-off between higher costs now and avoiding damages tomorrow. The contrary would be true: Climate protection policy and risk minimisation creates a double benefit to societies: First, to the living generation because the extra costs compared to business-as-usual are a cheap assurance in relation to the reduced risks; and secondly, for all following generations because the risks and damages of future global change will be minimised.

Case study III: Retrofitting the German Building sector

In most OECD countries, heating is one of the main factors responsible for carbon dioxide (CO_2). In Germany about one fifth of all emissions of CO_2 result from heating. In private households heating is responsible for around one half of all emissions. Renovation of existing buildings could clearly reduce the use of energy and thus the discharge of CO_2. In addition, new jobs would be created because renovation measures are labour-intensive.

In a recent study the Wuppertal Institute has investigated the possible effects on the environment and jobs of extensive renovation of residential buildings to optimise energy savings.

The assumption underlying the analysis is that by a strategic initiative of the Federal Government the number of residential buildings to be renovated in terms of energy-saving measures every year can be increased from around 150,000 today to approximately 330,000 a year. In order to achieve this, around DM 15 billion will have to be invested annually between 1999 and 2020. This sum corresponds to almost three per cent of the total construction volume of the year 1997. According to the complex input-output analysis, the investments to this extent

- will secure and create on a long-term basis approximately 430,000 jobs,
- will decrease energy costs through the reduction of the final energy by 1,111 PJ (50%) and avoid up to 97.5 million t (58%) of carbon dioxide compared with the reference year 1999
- will achieve considerable savings of resources (balance of expended and saved material flows), which will reach a scale of around 68 million tonnes annually by the year 2020.

This investment plan, which would have to be activated by a support programme among other measures, is facing additional revenues of the state from national insurance and from direct and indirect taxes. At the same time, expenditures for social benefits will decrease because of an improvement in the labour market situation (Wallbaum et al 2000).

Case study IV: Macroeconomics of sustainable development in Germany
Together with project partners, the Wuppertal Institute (DIW, WI, WZB 2000) has conducted a macroeconomic analysis of three scenarios which compare the triangle of sustainability (ecological, economic and social goals) within complex strategies and scenarios.

Our modelling exercise has been performed with the Panta Rhei model, the largest and most complex model of the German economy. In our study, three different scenarios have been developed. One was focused on cost cutting in order to improve competitiveness and create jobs through export surplus. It ended up with reduced investments, a lower innovation rate and subsequently with less growth than both its competitors.

The second one was a growth promotion scenario based on public investments, flexibilisation of labour conditions and differentiation between salaries. It resulted in significant growth levels and a high income increase and low unemployment while meeting the required CO_2 emission targets. However, it contributed to more social imbalance and failed to meet the targets for land use preservation and material flow (and thus solid waste) reduction.

The third scenario focused on eco-efficiency and extended social security. It reduced unemployment just as much as the growth scenario and led to a fairer income distribution and extended social security, while meeting the targets for energy consumption, material flows/waste and land use. However, the income growth was lower than in the growth scenario, although higher than in the cost-cutting one. The working hours were shortest as compared to both other scenarios, and the public debt was lowest.

Although not solving the long-term problems of absolute limits to resource productivity and the resulting limits to growth, and thus the challenge to the globalised model of free markets and its dynamics, our exercise seems to indicate that there can be sustainable transition strategies, diminishing the environmental impact as well as unemployment. They form a range of options between the growth and the eco-scenario, but any of them beats the cost-cutting approach in economic, social and environmental terms.

As far as they are economically viable, such strategies could be the starting point for the transformation of our economies, while buying time to adjust the institutional regulation mechanisms and readjust the systems of global governance to provide the appropriate frameworks and incentives for an economic development no longer depending on growth. From our point of view, such intermediate but realistic approaches are urgently needed, since otherwise abstract theories of sustainable development will be made obsolete by an unsustainable practice of unregulated global markets that cannot be sustained in the long run.

The eco-scenario and its assumptions

The Panta Rhei simulation runs are based on a broader scenario, comprising institutional and equity issues like distributional or gender equity as well as consumption patterns, attitudes of societal actors and so forth. The draft of this scenario underwent a consultation process with societal actors including government and opposition politicians, trade union representatives, environmental NGOs, feminist groups and the churches, and was discussed in a final hearing with scientists from economics, social and environmental sciences.

The quantifiable elements of the scenario were then transformed into model assumptions, and for aspects that could not be implemented directly due to the specifics of the model, side calculations were performed. This refers in particular to the negative income tax included in the scenario as a specific version of basic social security; the model itself calculates the functional, however not the personal income distribution. Obviously, a number of open research questions results from this fact (growth effects of transfers, etc.), while other questions could not be modelled due to the lack of empirical data (labour market effects of a basic income).

The model itself determined the growth rate, employment effects and the resulting levels of energy consumption and material flows, however without being able to fully incorporate specific assumptions, e.g. on technology improvements (aside from a more general technological progress all across the board, based on historic trends), or on sector specific assumptions, e.g. for the transport sector. These caveats must be taken into account when interpreting the modelling results.

When translating the quantifiable part of the scenario into Panta Rhei variables (see table 3), we used the model to quantify and balance the proposed new expenditures (doubling R&D,

basic income, a public investment initiative) with the new sources of revenues (Material Input Tax MIT and energy taxation) and the proposed modifications of existing ones (revising subsidies, differentiating the VAT to support personal and social services).

While most of these measures are intended to increase the resource productivity, some assumptions had to be made for the labour issue as well. The key element in this respect is a wage policy increasing the salaries in line with labour productivity increases (which are already diminished as compared to a standard model by the competition of labour and resource productivity for limited investment finance). This increase in salary was then assumed to be paid out half in cash, half in reduced working time, resulting in slightly increasing incomes and decreasing working time. Furthermore, a contribution to employment from increasing numbers of part-time jobs was expected, however a limited one since only some more privileged workers can afford to shorten their working time significantly without salary compensation. Consequently, part-time labour plays only a minor role in our scenario, which is also helpful due to the significant uncertainties resulting from the unknown effects which the basic income provision may have on it.

The simulation of our inputs with Panta Rhei was a premiere and thus a challenge in two ways. First, such integration of physical flows into economic models is quite new and secondly no quantitative simulation of a material input tax with a macro-econometric dynamic model had been undertaken before.

Fig. 4 : Selected inputs of the scenario into Panta Rhei

Parameter	**Comments**
Real wage	Orientation on labour productivity per hour
Working week & overall lifetime work are shortened	About 50% of the increase in productivity are transformed into reduction in working hours
Tax on profits	Increase in average tax on profits by 50% of the reduction between 1980 and 2000, increase is introduced gradually between 2000 and 2010
Transfers abroad	Foreign aid is increased to 0.7% of GDP until 2010, payments to the EU increase to 2% of GDP until 2010 and then remain constant.
Material Input Tax	Quantitative tax on material flows, gradually increased to 60 DM/ton in 2020.
CO_2-Tax	Tax on emissions, gradually increased to 250 DM/ton in 2020.
Subsidies	Restructuring and reduction between 2000 and 2020 following ecological criteria
Investment Plan	One third of the revenues gained by a cut in subsidies are used for investment in some economic sectors
Expansive financial policy	Discount rate lowered by 1%
Expenditures on research	Doubled between 2000 and 2020
Value Added Tax	Gradually raised to the EU average (20%), however, reduced VAT of 10% for certain products which are chosen using social, cultural and ecological criteria

The main results of the simulation for the aforementioned scenario are shown in table 3. Furthermore, structural change as measured by shifts between the 58 SNA sectors analysed is less than expected; in particular reformed subsidies do not effectively promote intersectoral structural change, but their effects focus on intrasectoral improvements of eco-efficiency.

As for the economic variables, we can say at a first glance that the results are satisfactory. The economy remains quite stable despite some important, new instruments, which affect many parameters in the model. The economy is still growing, but at a lower rate than before. Other economic figures like the balance of payments, the balance of trade, the inflation rate and investments are within a normal range. The state budget is even positive in 2020, which gives enough room for the introduction of the negative income tax not yet included in the model as presented here.

Concerning the second dimension of sustainability, the social cohesion of the society, the most important indicator is the rate of unemployment. It is decreasing from 12% in 2000 to about 3% in 2020 with 1.2 million unemployed left. This result is indeed satisfying and helps to reduce other social problems like poverty, social exclusion, psychological problems and others. The working time per capita per year is decreasing, the average weekly working time in 2020 is about 27 hours per week. The available income is increasing by close to 30%. Effects of flexible pension age schemes and the revaluation of non-paid forms of labour are not captured, however.

Thirdly, the environmental indicators show a promising trend. Both the CO_2 emissions and the material inputs are decreasing, although the economy is still growing, indicating an absolute delinking. The material inputs are reduced by 27.8% within 20 years, while the long-term target was minus 90% within 50 years. Given the lacking possibility to introduce assumptions on specific resource productivity increases caused by the changed taxation environment into the model by changing the material input coefficients used, the result is considered acceptable. Concerning the CO_2 emissions the picture is a similar one. The emissions are reduced by 13.9% within 20 years as compared to 1994, which comes close to a 20% reduction as compared to 1990. While this is already achieved with a (slowly) growing economy, it does not reflect a number of specific scenario assumptions regarding transport efficiency policies and the full range of fuel switches (e.g. from lignite to gas). Other models taking such assumptions into account expect reduction in CO_2 emissions twice as high as our scenario. This result is encouraging as regards the possibility to reduce greenhouse gas emissions to a justifiable minimum as suggested by the IPCC, provided the political will is given.

Fig. 5 : Selected results of the eco-scenario

Indicators	1994	2000	2005	2010	2015	2020
GDP (1991 prices) in billion DM	2960.1	3409.9	3759	4089.8	4448.4	4809
Unemployed in thousands	3670	4087.3	3732.8	3390.3	2344.2	1262.1
Unemployment rate (%)	10.5	12	10.6	9.2	6.3	3.3
Employed in thousands	34981	33374	35145	37169	39141	41157
Labour productivity (per cap.)	84620	10217	10695	11003	11365	11684
Overall working hours in billion hours	48671	43703	43616	44011	44529	45290
aver. annual working hours	1550.4	1459.1	1382.9	1319.4	1267.8	1226.3
Gross wage rate	30.2	42.5	51.3	61.2	73.6	89.2
Disposable income in billion DM	1880.6	2124.4	2252.6	2365.8	2514	2693.7
Disp. income / Gainful workers	53760	63652	64091	63648	64227	65449
Balance of trade in billion DM	15.5	44.3	48.6	40.4	68.1	101.6
Balance of payments in billion DM	-33.2	-47.6	-52.2	-69.0	-52.4	-32.3
All investment in billion DM	691.3	788.3	842.3	898.6	960.3	1041.1
Public spending in billion DM	585.3	661.6	741.5	828.4	915.4	990.6
Budget deficit (deficit = +) in billion DM	73.1	21.1	15.1	18.0	8.4	-11.8
Consumption in billion DM	1698.1	1928.7	2066.5	2180.7	2317.2	2484.2
CO_2 emissions in million tons	904.5	932.6	837.6	799.4	793.6	803.1
All Material Input in million tons	8035.1	8667	7542.3	6817.3	6458.8	6257.8

3. The Eco-Efficiency Revolution Has Started

It is widely believed that productivity growth is somewhat like the engine that drives overall wellbeing. The more productivity, the better for society thatÆs a well-known message for policy makers and business people. But which kind of productivity should grow and what direction of economic growth is sustainable? Although productivity sounds like a comprehensive and multi-dimensional concept, it is usually restricted to labour productivity. Since the beginning of the industrial revolution in the nineteenth century, western industrialised countries have witnessed a productivity growth by a factor ten (UK) or even forty (Japan) (Maddison 1995). Nobody will deny that labour productivity increase has its economic merits in times of labour shortages. Unfortunately, these bright times are over. In harsh times with some 18 million people unemployed in the European Union, rationalising labour may be profitable from the perspective of short-run shareholder maximisation. But it is not a wise strategy for the economy as a whole and in the long run disastrous for the legitimacy of global capitalism. From the perspective of responsible entrepreneurs and sustainable democracies, technical progress should be as nature conserving and labour augmenting as possible and not labour saving. With this vision in mind, new types of social innovations and of technological progress are desired.

In WIÆs view, the traditional emphasis on labour productivity ought now to be widened or even transformed towards increasing eco-efficiency. The concept of multi-factor productivity ought to include the productivity of natural resources and material flows (Bleischwitz 2001). By still looking after the increase in labour productivity while speeding up resource productivity, countries which have high levels of unemployment and which are faced with environmental problems could become richer. Economies can revitalise by disseminating best practices, by stimulating innovation, by setting up new ways of efficient management and organisation, and by investing in human and social capital. Keeping within the natural limits of growth (crash barriers) and decreasing economic and environmental risks will lead to new markets and business opportunities. Regulation, if properly designed and incentive-oriented, can offer powerful dynamics to the evolution of new technologies and eco-efficient products and services. A concept like Factor Four, i.e. increasing economic prosperity while reducing the use of natural resources, combines different governance arenas as a decision rule that makes people smart and reduces uncertainties for business makers. Taken together, technological-economic change and sustainable development may coincide to a greater degree than is usually expected.

The ongoing debate on sustainability and on greening resource productivity has led to designing and spreading many good-practice examples. These examples include highly efficient production processes, appliances, lighting, motor drives, ultra light cars using less than 2 litres per hundred kilometres (e.g. LovinsÆ Hypercar), or passive house buildings (Factor Ten reduced energy consumption). This eco-efficiency revolution means a quantum leap for productivity increase and a new direction of technical progress. The new direction could increase the market share for products which meet criteria of low or zero emissions, low waste, zero toxic dispersion, etc. Additionally, elements of reuse, recyclability and durability are to be integrated leading to better materials and new product design. For business, eco-efficiency assists companies in their quest for continuous improvement in minimising their use of resources, lowering costs and being more competitive. It encourages creative strategies of preventative management by integrating environmental considerations throughout the whole life cycle of products and promotes an active shift to multi-use products and services and other use concepts (use instead of own). In doing so, it involves many stakeholders and creates tangible economic benefits. Companies actively enhancing eco-efficiency are able to improve their product design, procurement, manufacturing processes, product maintenance and their customer relationships. A longer durability will reduce the number of products sold while increasing their individual value and supporting activities of repairing and remanufacturing. New and additional types of eco-efficient services will occur: among producers, broker agencies and specialised companies will deal with reusing materials, product elements and with operating heating and cooling systems generated by nearby sources. Financial services for high-quality goods will offer opportunities for those reluctant to invest in high-priced goods (with lower running costs). They also pre-select supply options and enforce producers to increase the lifetime of their goods. A third type of new service is related to information and communication. Companies and consumers have strong preferences for better information about eco-efficient innovations, helping them to lower their costs. Any leasing and sharing of goods used only for a certain time (e.g. cars) will be assisted by communication systems offered by SMEs or larger companies. No wonder that the concept of sustainable enterprises gains in one form or another more and more acceptance.

After all, compared to costly end-of-pipe technologies, this new direction of resource-saving technical progress is economically beneficial and is integrated into the entire value chain. It stimulates the co-operation within industry as well as between industry, services and the public sector. Such a development will nevertheless *not* lead to a non-industrial service economy, but rather to a service-driven industrial society with less material and energy intensive production and consumption (dematerialisation). If one likes to put it emphatically: the coming age of resource productivity with low information prices and quality production could supersede the contemporary age of labour productivity with low energy prices and mass production of goods.

As has been demonstrated, the employment effects of coupling technical progress with green resource productivity will most likely be positive. One reason is simple and straightforward. New environmentally benign goods and services emerge and will improve competitiveness and employment. Besides these qualitative growth effects, the increasing attempts to enhance eco-efficiency would lower the pressure to rationalise solely labour. A push towards sustainability and resource productivity will stimulate learning processes and investments towards new technology paths. These new paths will partly consist of high-tech products. Recycling activities, for instance, can still enhance their labour productivity. But a significant additional share will be labour intensive resulting from repairing, remanufacturing and various other service activities. These activities normally require technical as well as communicative skills. Relatively low skills are required for processes like returning, dismantling, sorting, cleaning and repairing as well as for some communication activities in the eco-efficient service sector. These low-skill activities will contribute to a labour augmenting technical progress. In some cases (e.g. organic farming), human labour might even directly substitute current energy and material intensive processes.

While the direction of technological progress gradually changes, the employment threshold will stagnate or even come down. This would mark a break in ongoing trends. Lowering the employment threshold would add substantial benefits to the employment situation, if the overall expectation for productivity is strong enough to stimulate further investments. What economies might aim at is resource productivity having a higher growth rate than the overall (qualitative) growth rate of GDP which, in turn, should be higher than the average increase in labour productivity.

4. Politics Must Set the Rules – Innovative Regulatory Policies

The new direction of technical progress can not be driven by autonomous technological progress, unregulated markets and maximising short-run profit margins of companies as mainstream economics might believe. Instead, national governments and world-wide governance under the guidance of the UN must take the lead. A policy mix, combining (re)regulation with innovative market instruments, and global with specific sector and target group instrument bundles are needed. "Laissez-faire" and unregulated markets will never bring us to functioning competition, responsible entrepreneurship and sustainable development. Additionally, resource productivity has a strong tie to consumers' demand and societal values. Consumers are relevant for the demand of quality goods, energy-efficient appliances and their individual use. They might also practise new patterns of sharing goods, thus reducing the overall number of products produced. In this context, the factors of technology push and consumers' pull fit together almost smoothly. Increasing services means also a better co-operation among producers and with consumers and their individual needs. Moreover, the principle of durability extends the product life cycle and will certainly help to overcome the short-sightedness of many contemporary economic processes. Against this background, eco-efficiency is not in opposition to any sufficiency and a sustainable civilisation, but rather a supporting and co-evolutionary activity. Experience and tradition might come back as individual and societal values. Increasing resource productivity might hence facilitate new models of wealth based upon co-operation, learning, solidarity, calmness and prosperity in time (rather than in products).

Therefore, the eco-efficiency revolution will not succeed on a broad scale unless the framework conditions for doing green business are changed. Reducing resource flows and energy must be made profitable obtaining more services and wellbeing from less resource consumption. Politics should change the incentive structure to an economy of prevention, and new models of wealth should be encouraged by pilot projects, education and social marketing campaigns. On the other hand we should not wait and see for political actions, because to an astonishing extent eco-efficiency is profitable now. Eco-pioneers and those companies undergoing eco-auditing procedures have discovered that they gain through innovations and through transparency from the link between materials and energy on the one hand and financial and knowledge flows on the other. All this has led to promising experiences that a portfolio of green stocks can perform even better on the international stock markets than the MSCI index.

It is nevertheless to be feared that the scope for resource productivity will be narrowly limited if the present market conditions prevail. These are characterised to a large degree by the cognitive and institutional bias towards old-fashioned manufacturing processes and cheap nature. As a result, one sees an incredible amount of subsidies going into natural resource consumption and labour rationalising activities. As Andre De Moor, then with the Dutch Institute for Fiscal Studies, has estimated, some 700 billion dollars are spent world-wide annually in agriculture, energy consumption, water and motor transport. This does not yet account for all the tax advantages, free infrastructure and land given to the investor. Nor does it account for certain public policy programmes intended as drivers for an economic upswing, but which essentially transform nature into cement while having doubtable economic success. De-subsidising resource use will thus become an important policy world-wide.

A related policy tool is the ecological tax reform. In the current world of mass unemployment (in many countries) and of scarce natural resources, it does not make sense to draw the biggest part of fiscal revenues from labour while resource use goes essentially free of charge. Almost all EU membership states have adopted some kind of eco-taxes since the late nineties. Ideally, the aim might be a moderate but steady increase in resource prices. Such an increase would lead to further innovations and cumulative effects. If designed together with other tax reductions and incentives to create markets for efficiency and renewables, the overall effects on international competitiveness would not be insupportable. There is both increasing theoretical and empirical evidence from economics (Oates 2000) that fiscal and regulatory competition resulting from unilateral action contribute to increasing institutional efficiency and will not have dramatic effects. Nakata and Lamont (2001) arrived at similar conclusions for the impact of carbon or energy taxes on Japan. And this might hold true for GHG emissions trading schemes as well. But a caveat should be added: Internal (within multinational companies like BP or Shell) and national GHG emissions trading schemes should not be institutionalised, but instead closely integrated into existing climate protection policies and measures.

To conclude: Looking forward to the new millennium, a new paradigm for green technological progress and models of wealth is needed if one wants to successfully tackle challenges of qualitative growth, environmental concerns, unemployment, ageing societies and the unequal distribution of wealth and living standards. In spite of many remaining uncertainties, the general idea of increasing eco-efficiency seems to be a robust and necessary first step towards sustainability.

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