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CAN GREEN GROWTH REALLY WORK AND WHAT ARE THE TRUE (SOCIO-) ECONOMICS OF CLIMATE CHANGE?

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Contents

List of figures

List of tables

CAN GREEN GROWTH REALLY WORK AND WHAT ARE THE TRUE (SOCIO-) ECONOMICS OF CLIMATE CHANGE?

Ulrich Hoffmann*

Abstract

Many economists and policymakers advocate a fundamental shift towards "green growth" as the new, qualitatively-different growth paradigm, largely based on enhanced material/resource/energy efficiency, structural changes towards a service-dominated economy and a switch in the energy mix favouring renewable forms of energy. "Green growth" may work well in creating new growth impulses with reduced environmental load and facilitating related technological and structural change. But can it also mitigate climate change at the required scale (i.e. significant, absolute and permanent decline of greenhouse gas (GHG) emissions at global level) and pace (i.e. in no more than two to three decades)? This paper argues that growth, technological, population-expansion and governance constraints as well as some key systemic issues cast a very long shadow on the "green growth" hopes. One should not deceive oneself into believing that such an evolutionary (and often reductionist) approach will be sufficient to cope with the complexities of climate change. It may rather give much false hope and excuses to do nothing really fundamental that should bring about a U-turn of global GHG emissions. The proponents of a resource efficiency revolution, re-structuring of economies and a drastic change in the energy mix need to scrutinize the historical evidence, in particular the arithmetic of economic and population growth. Furthermore, they need to realize that the required transformation goes far beyond innovation and structural changes to include better distribution of income and wealth, limitation of market power of economic agents that promote biased approaches to GHG reduction, and a culture of sufficiency. Climate change calls into question the global equality of opportunity for prosperity (i.e. ecological justice and development space) and is thus a huge developmental challenge for all countries, but particularly for the global South and a question of life and death for some developing countries.

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I. INTRODUCTION

In the run-up to the Rio+20 Conference in June 2012 and the United Nations Climate Summit on 23 September 2014 virtually everyone (from multilateral agencies to politicians, to businessmen, and to NGOs) advocated a fundamental shift towards "green and inclusive growth"[1] as the new, qualitatively-different growth paradigm,[2] which would considerably improve the energy efficiency of the economy and lead to drastic changes in its energy and material mix (replacing exhaustible by renewable materials), with corresponding structural changes.[3] "Green growth" advocates argue that such paradigm change would unleash new wealth creation and employment opportunities; provided that there was sufficient investment and companies had better information and supportive incentives. In other words, the impression occurs that the "green growth" concept is flawless, just the enabling conditions for it are lacking.[4] "Green growth", which should be rather seen as a process of structural change, may indeed create some new growth impulses with reduced environmental load, in particular at the microeconomic level. But can it also mitigate climate change at the required scale and pace (i.e. a significant, absolute and permanent decline of green-house-gas (GHG) emissions in a historically very short period of time) at macroeconomic and global levels?

The reality check below casts a long shadow on the "green growth" hopes. Our analysis argues that the arithmetic of economic and population growth, energy/resource/materiel efficiency limits related to the rebound effect (the phenomenon that efficiency increases tend to boost, rather than reduce overall energy/resource/material consumption) and horizontal shifting of problems, governance and market constraints, as well as systemic limits call into question the hopes of de-coupling GHG from economic growth. Rather, one should not deceive oneself into believing that such an evolutionary (and often reductionist) approach will be sufficient to cope with the socio-economic complexities related to climate change (and some other global environmental problems, such as loss of biodiversity). "Green growth" may give much false hope and excuses to do nothing really fundamental that should bring about a U-turn of global GHG emissions. The approach is largely reduced to a technocratic and technology-fetishized one, because changing technologies is much easier than altering societies and their socio-economic drivers.

"Green growth" proponents need to scrutinize the historical macro- (not micro-) economic evidence, in particular the arithmetic of economic and population growth, the colossal reductions required in the GHG-emission intensity of economic growth as well as the significant influence of the rebound effect. Furthermore, they need to realize that the required transformation goes far beyond innovation and structural changes to include better distribution of income and wealth, limitation of market power of economic agents that promote biased approaches to GHG reduction, and a culture of sufficiency.[5] Against this very background, an attempt is made below to elaborate on the true economics of climate change. Global warming also calls into question the global equality of opportunity for prosperity (i.e. ecological justice

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1 This should be a combination of smart (based on knowledge and innovation), green (i.e. a more resource-efficient and less environmental damaging), and inclusive growth (fostering a high-employment, social-services and cultural-values centered economy).

2 As put by Nair, 2014, "the truly insidious thing about inclusive growth and its partner falsehoods [like "green growth" or "carbon neutrality"] is that they are words of submission being spoken by some of the most powerful people in the world. As with other forms of propaganda, feel good phrases and lazy analysis have replaced the need to look for solutions and the hard decisions necessary to achieve them."

3 Energy efficiency is to a large extent also a function of enhanced material and resource efficiency.

4 For more information, see: UNEP, 2011: 2–3 and The New Climate Economy Report (The Global Commission on the Economy and Climate, 2014), published on the eve of the United Nations Climate Summit on 23 September 2014.

5 Conversely, The New Climate Economy Report simplistically purports that "structural and technological changes unfolding in the global economy, combined with multiple opportunities to improve economic efficiency, now make it possible to achieve both better growth and better climate outcomes" (The Global Commission on the Economy and Climate, 2014: 15).

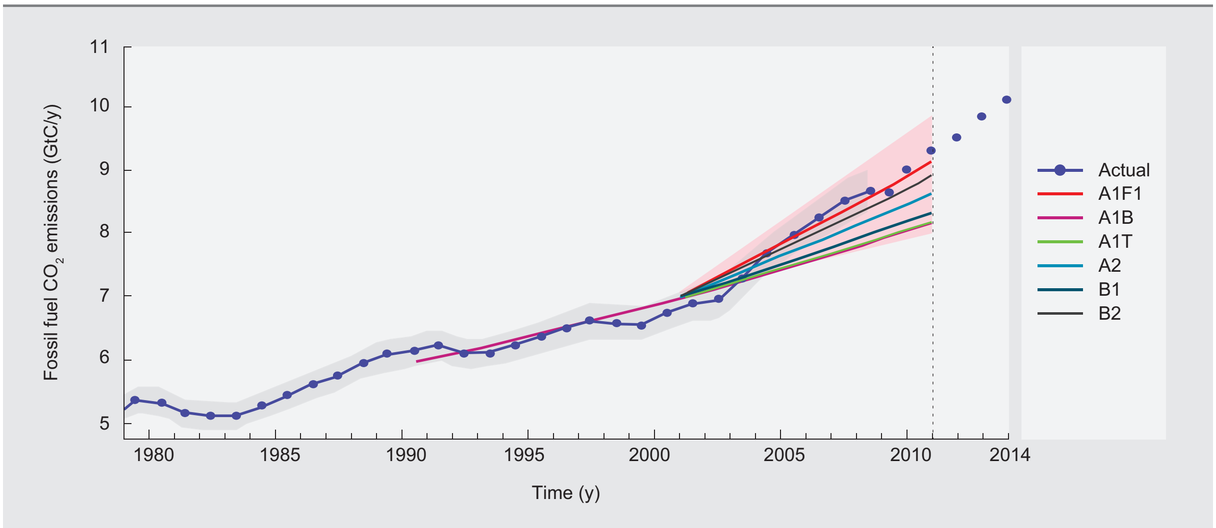
and development space) and is thus a huge developmental challenge for all countries, but particularly for the global South and a question of life and death for some developing countries.

II. LIMITS SET BY THE ARITHMETIC OF ECONOMIC AND POPULATION GROWTH

As can be seen from figure 1, in the last few years the fossil-fuel-related CO_2-emission trajectory has followed a trend that is worse than the worst case scenario (A1Fl – assuming a temperature increase of 4ºC by the end of this century) used in the 4th assessment report of Intergovernmental Panel on Climate Change (IPCC, 2007a).[6] If current GHG-emission trends continue unabated, according to the 5th assessment report of IPCC of 2014, we are likely on course to temperature increases of 4–6ºC and even more (figure 2),[7] which would undoubtedly have apocalyptic implications. The 4th assessment report of IPCC concluded that GHG reductions in the order of 85 per cent for developed countries and some 50 per cent for developing countries would be necessary by 2050 to keep global warming at a range of 2 to 2.4ºC (IPCC, 2007b: 15).

Figure 1

Recent trend in fossil-fuel-related CO_2 emissions, compared to the future emission scenarios used in the IPCC IV report of 2007



Source: Truhetz, 2014 and personal communication.

Note: The Emissions Scenarios used in the IPCC reports are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T) and a balance across all sources (A1B). B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy. B2 describes a world with intermediate population and economic growth, emphasizing local solutions to economic, social, and environmental sustainability. A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change.

As portrayed in figure 3, energy-related carbon emissions increased much stronger in the first decade of this century than in the 1980s and 1990s, mostly caused by higher carbon intensity of energy generation

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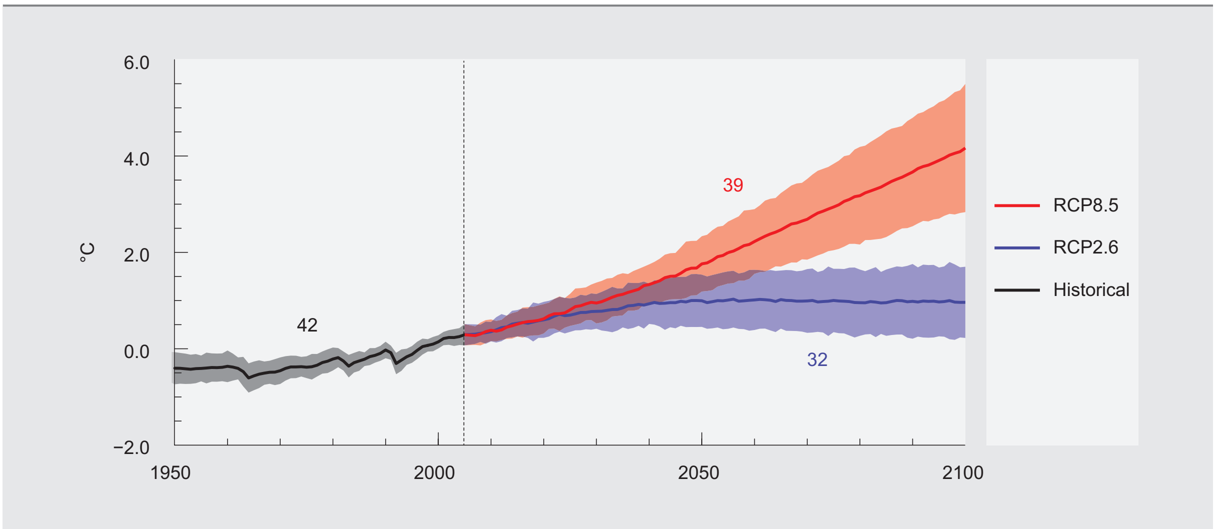
[6] For an overview of the six future GHG emission scenarios used in the IPCC IV report, see: IPCC, 2007a: 13.

[7] Because of the higher temperature increase over the continents and the polar reinforcement in the Northern hemisphere, the regional temperature increase could lead to averages between 6–10˚C (WBGU, 2014: 20).

Figure 2

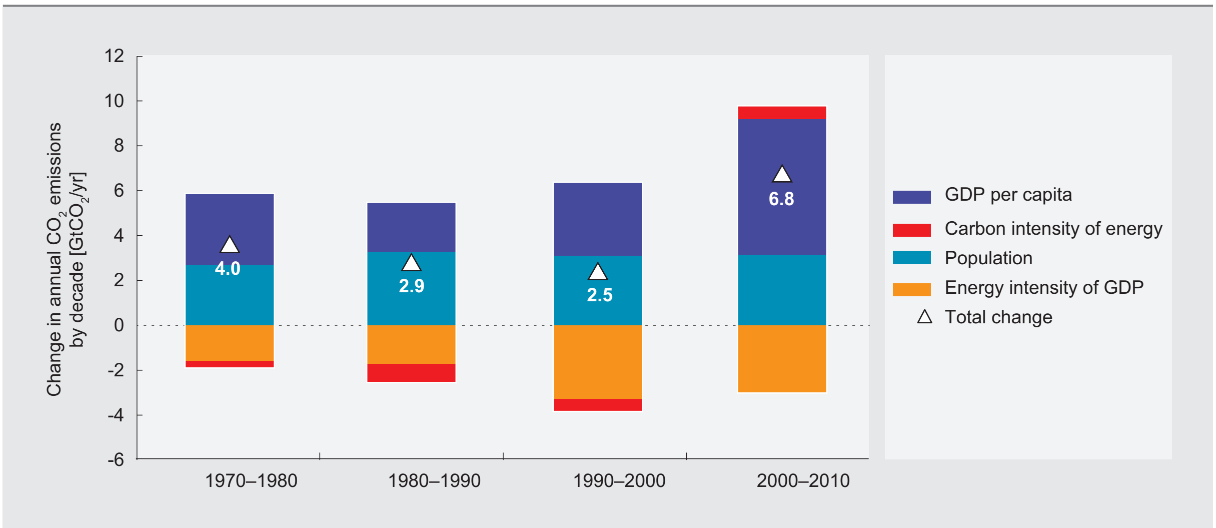
Change in global annual mean surface temperature relative to 1986–2005, based on the representative (GHG) concentration pathways (RCP) in the IPCC V report of 2014



Source: IPCC, 2014a: 21.
Note: RCP 8.5 is the business-as-usual scenario. RCP 2.6 is called "peak and decline" pathway, i.e. GHG emissions peak by 2013 and then fall continuously.

Figure 3

Decomposition of the change in total global CO_2 emissions from fossil fuel combustion



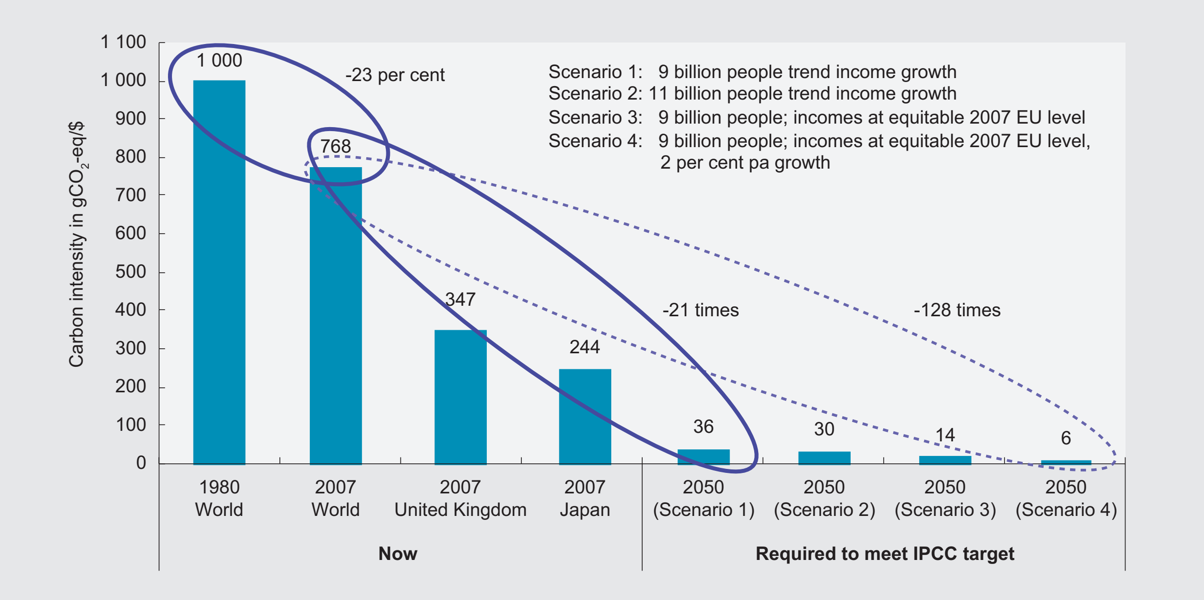
Source: IPCC, 2014b: 9.

(notably related to the renaissance of coal in the fuel mix) and strong GDP per capita growth. These factors, in combination with population growth, have considerably outpaced the improving energy efficiency of the global economy (though even the pace of energy efficiency improvement in the first decade of this century slowed down compared to the one in the 1990s).

It is highly questionable whether the required drastic GHG-emission reductions are really achievable under the prevailing growth paradigm. By way of illustration, global carbon intensity of GDP fell from around 1kg/$ of economic activity to just 770g/$ (i.e. by 23 per cent) between 1980 and 2008 (a drop of about 0.7 per cent per annum). Even if the trends of global population (at 0.7 per cent per annum) and

Figure 4

Development of the carbon intensity of GDP, 1980 to 2050



Source: Jackson, 2009: 81; and additions by the author.

income growth (at 1.4 per cent per year) of the last few decades were just extrapolated to 2050, carbon intensity would have to be reduced to 36gCO_2/$ – a 21-fold improvement on the current global average – to limit global warming to 2ºC. Allowing developing countries to catch up with the present level of GDP per capita in the European Union would even require a much higher drop in global carbon intensity of almost 130 times by 2050 (see figure 4).

Although these estimates and projections, made by Tim Jackson, are already half a decade old, more recent analysis of global carbon intensity dynamics by PricewaterhouseCoopers (PwC) (2012, 2013 and 2014) as part of its annual Low Carbon Economy Index supports Jackson's projections. According to the PwC experts, carbon intensity of the global economy would have to be reduced by 6.2 per cent a year between now and 2050. As can be seen from table 1, even a doubling of the current rate of decarbonization would still lead to emissions consistent with 6ºC of warming by the end of the century.[8]

Not once since World War II has mankind achieved the rate of reduction of carbon intensity of GDP required for limiting global warming to 2ºC (PricewaterhouseCoopers, 2012: 1). Most recently (in 2013), global carbon intensity declined by 1.2 per cent (PricewaterhouseCoopers, 2014: 5). In retrospect, apart from Germany just for a short period of two years after reunification in the 1990s, the Russian Federation is the only large economy that has reduced emissions substantially since 1990, mostly caused by a breakdown of its heavy industry (an example of de-growth). The country's carbon emissions fell by almost 3 per cent annually in 1990–2005. The world (not only a handful of technologically very advanced countries) would have to repeat the Russian experience at a roughly three times more drastic extent (and even that would only result in limiting global warming to about 3ºC). The closest the world came to the required decarbonisation

[8] The estimates for carbon intensity dynamics by PwC are very conservative and at the lower end of the scale, because PwC analysis only considers energy-related carbon emissions. The majority of the emissions in agriculture (one of the biggest sources of global GHG emissions) are not included. The implications of additional GHG emissions caused by reaching trigger points of climate change, such as the thawing of perma-frost areas or the release of carbon from soil (the biggest carbon storage reservoir), caused by higher soil temperatures, were also not taken into PwC consideration. For more information, see PricewaterhouseCoopers, 2012: 12.

Table 1

Globally required decarbonization levels and likely temperature increase till 2050

Average annual rate of global decarbonization to 2050 (Per cent)	*Implied concentration levels, approximate (ppm CO_2e)*	*IPCC "best guess" of average global temperature increase above pre-industrial levels, rounded to nearest ºC*
1.6	1 200	6
3.0	750	4
4.5	550	3
6.2	450	2

Source: PricewaterhouseCoopers, 2012: 9, 2013: 3 and 2014: 3.

levels was during the recessions of the late-1970s/early-1980s (with an almost 5 per cent reduction in 1981) and the late 1990s (with a reduction of 4.2 per cent in 1999) (PricewaterhouseCoopers, 2012: 9). This seems to suggest that, historically, drastic rates of decarbonization have been linked to recessions and thus phases of stagnation or contraction of GDP. The highest decarbonisation rate ever achieved in a planned fashion was 4.5 per cent per annum, when France implemented its nuclear energy programme (World Bank, 2015: 5).

The rise of the global population by about 30 per cent, from 7.2 billion in 2014 to about 9.3 billion by 2050, will drive the scale effect of production and consumption (i.e. their absolute physical expansion). This growth, combined with a three-fold increase in per capita consumption (from about US$6,600 to US$19,700) (and even assuming that the rich world would not grow any more) would jack up the size of the world economy by four times, requiring 80 per cent more energy (OECD, 2012). While it is a fact that (with the exception of some oil-producing Arab countries) the countries with the highest population growth have contributed least to GHG emissions thus far, this is only because their populations continue to live in extreme poverty. In other words, population growth does not matter for resource consumption and GHG emissions as long as one accepts that people remain poor, with minimal levels of consumption. But it begins to matter a great deal if the international community has the ambition to reduce poverty amidst rapidly growing populations (if the 1.5 billion people currently without access to basic energy supply obtained that access and had the current average per capita CO_2 emissions, this would increase global carbon emissions by 20 per cent and double those of the developing world) (Pielke, 2010: 221).

It is often also overlooked that the drastic reductions in GHG intensity of GDP have to happen in a historically very short period of time, i.e. the next 20–30 years. According to McKinsey researchers, the "carbon revolution" needs to be three times faster than industrial labour productivity growth in the industrial revolution. "During the Industrial Revolution, the United States achieved an increase in labour productivity of ten times between 1830 and 1955. The key difference is the timeframe. The tenfold increase in labour productivity was achieved over 125 years; the carbon revolution" needs to happen in only 2–3 decades" (McKinsey Global Institute, 2008: 12–13).

A. The asymmetry between carbon intensity, scale and structural effects of economic growth

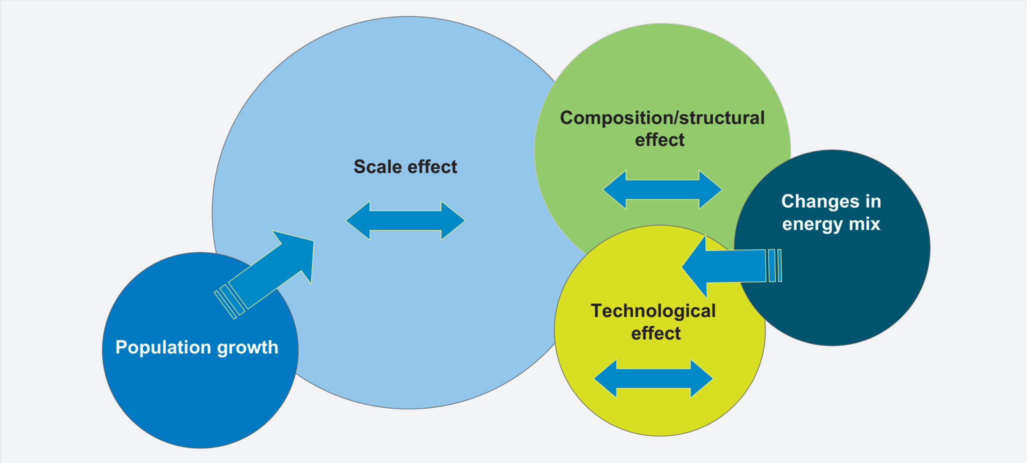
To really come to grips with ballooning GHG emissions, the global economy needs to decouple GHG emissions in absolute, not relative terms from GDP growth.[9] This absolute decoupling needs to be significant, fast, global and permanent.

The relatively modest progress achieved in reducing GHG intensity of GDP is related to the fact that technological progress in reducing GHG intensity and concomitant structural change have been outpaced by the scale effect of growth. To decouple GHG-emission from GDP growth (and thus a qualitatively

[9] Relative decoupling implies that the growth of GHG emissions is slower than GDP growth, which does not check GHG emission growth. The environmental impact of relative decoupling can even be negative, if the marginal ecological cost of scarce ecological resources outpaces the reduction in ecological input use per unit of GDP (for more information, see Paech, 2012).

Figure 5

Conceptual underpinnings of a decoupling of GHG emissions from GDP growth



Source: Author's animation.

different economic growth) implies that the technology effect and the composition/structural effect of growth, supported by changes in the energy mix lead to higher GHG-emission reductions than GHG-emission growth fuelled by the scale effect of economic growth (see figure 5). However, there are only very few examples, where such decoupling has actually happened, one being the case of refrigerators in some developed countries,[10] another example concerns modern lighting systems.[11] Much more typical, however, has been the case of fuel efficiency of the privately-owned car population in the European Union in the last 20 years, which can be found in many other areas and sectors (figure 6).[12] Savings through more fuel efficient cars were outweighed by the strong increase in the car population and the total mileage travelled.[13] Whereas fuel consumption per privately-owned car decreased by about 15 per cent in the period 1990–2007, car population and total mileage travelled increased by over 40 per cent.

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[10] Since the 1970s, refrigerators and freezers in the United States, for instance, have increased in size by a third, while consuming two-thirds less energy at one-third the price. For more information, see: www.c2es.org/technology/factsheet/ResidentialBuildingEnd-Use. It should, however, not go without comment that some analysts call into question this progress. They refer to the rebound effect (analyzed at greater length below) pointing to the rather impressive expansion of general refrigeration dependence in modern agri-food chains, partly also caused by changes in consumption patterns in favour of perishable, highly cold-chain dependent foods (Garnett, 2011: 28–29).

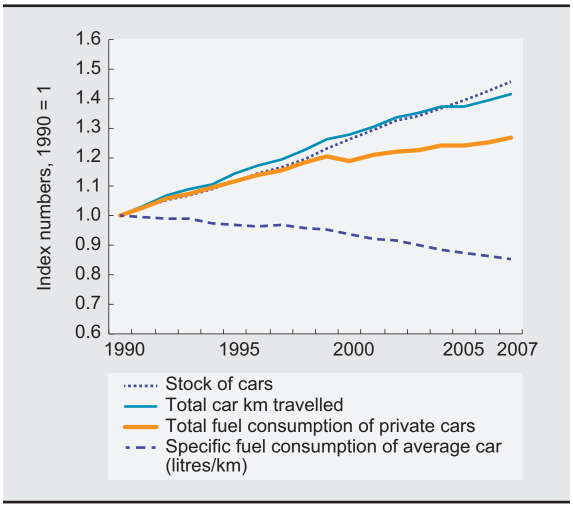
[11] A significant reduction in energy and material intensity of modern lighting systems is linked to three recent developments: (i) the development of new energy efficient lighting equipment; (ii) the utilization of improved lighting design practice; and (iii) the improvement in lighting control systems. Energy and material efficiency gains are estimated to be in the order of a factor of 4–8, caused by drastically lower energy consumption and much longer life time (http://energy.gov/energysaver/ articles/led-lighting).

[12] For an overview of the picture in other sectors, such as the building sector, cargo transport and air traffic, see Exner et al., 2008: 49–54.

[13] Improvements of fuel efficiency have also been handicapped by increased purchases of so- called sport utility vehicles (SUVs), which are 10 to 50 per cent heavier than normal passenger vehicles and thus tend to have a higher fuel consumption (estimated at 25 per cent or more). In Germany, the most sophisticated and technology-driven car market world-wide, SUV registration has recently accounted for almost 20 per cent of total passenger car sales, compared to 2–3 per cent at the turn of the century (in the United States, the market share of SUVs is almost 50 per cent) (Dudenhöffer, 2013). The average weight of passenger cars has also increased in the last few decades. The weight of Volkswagen's popular Golf model, for instance, has virtually doubled since its launch in 1974. The same is true for the Mini Cooper, now produced by BMW, which increased its weight from 670kg in 1997 to 1,210kg in 2014 (ADAC, 2014: 25).

Figure 6

Growth in private car travel versus fuel efficiency in the EU-27, 1990–2007



Source: European Environment Agency, 2010: 38.

Consequently, total fuel consumption of privately-owned cars rose by more than a quarter.

Interestingly, structural changes have also been far less effective in countering the scale-effect-induced GHG-emission dynamics than hoped for. Generally, for restructuring to be effective, GHG-intensive sectors and activities would have to shrink faster than the expansion of GHG-efficient ones, which actually has not happened. "Ecological" restructuring of the economy is a structural change at gigantic dimension and, as pointed out above, required at break-neck speed, which implies a huge loss in fixed-capital stock. However, unless motivated by a severe economic crisis or rather abrupt changes in demand, entrepreneurs tend to gradually replace the fixed-capital stock as a function of amortization cycles (that can be influenced by finance and fiscal policy measures of governments).[14]

Finance capital also plays a key role in ecological restructuring. On the one hand, finance capital provides, in addition to reinvested profits, the loan or share capital for required changes in the fixed-capital stock, which on its own, puts pressure on productive capital to generate profit for paying interest or revenues on shares and thus expands the scale of production. On the other hand, finance capital tends to have a rather short-term interest in the profitability of its invested capital. At the same time, it is risk averse as regards investing in technology for paradigm shifts or revolutionary changes. Hence a preference for supporting investment projects, based on evolutionary or incremental changes as regards energy (and related material and resource) efficiency and changes in the energy mix, which generally fall short of the required quantum-leap changes in a historically short period of time. In essence, scale effects, new technology and structural change all require active use of external finance capital, which on its own requires profit and underlying economic growth to pay interest and revenues on shares.

Also, the structural shift into a service-dominated economy has generated far less GHG-emission reductions than hoped for. This is caused by the fact that quite a number of service sectors, such as transport, health, IT services[15] or tourism, are rather fixed-capital and thus energy, material and resource intensive when it comes to setting up their infrastructure or operating base (conversely, operationally, most service sectors are labour-intensive).[16] What is more, emissions of the private consumption of a person are relative to his/her income and not the occupation. So, while shifting jobs into the service sector might reduce emissions in production somewhat, the people working there will drive their car to work, eat food and go on vacation in the same way as a factory worker. Stockbrokers earning a million dollar or more probably

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[14] In a very comprehensive analysis of micro-data for some 50,000 German companies, Petrick (2013) concluded that structural change and a cleaner fuel mix, rather than technological changes, have driven declining carbon intensity in the German manufacturing industry in recent decades. The structural change has however also included outsourcing of energy-intensive activities abroad.

[15] According to Schmidt-Bleek (2014: 137 and 169), "the ecological rucksack of IT equipment is generally ten times as high as for other products … This means that the material intensity of information and communication technology is on average 10 times bigger than that of the Mercedes-Benz S-class vehicle".

[16] But even in this regard, there are exceptions. In German on-line commerce, for instance, recent analysis suggests that there are more parcels returned from customers to on-line traders after purchase than the mailing of parcels among private individuals in the country, causing additional transport and fuel consumption (*Die Zeit*, 3 April 2014).

use little resources at work, but they will use a lot more resources and energy for private consumption than workers in manufacturing.[17]

B. Increasing the use of renewable energy – easier said than done

Much hope is put on the contribution of changes in the energy mix to reducing GHG emissions. However, evidence suggests that a complete or significant replacement of fossil fuel by renewable energy (RE) is very challenging on a number of fronts:

- There is the need for compacting RE.
- One needs a significantly modified, renewed or new transmission infrastructure.
- There is a reduced energy return on energy input (EROI).
- Certain RE-sources have to face up to material scarcities.
- There is not yet a really sustainable alternative for conventional transport fuel.

Wind and solar, the two most promising RE sources, are variable and intermittent, and therefore cannot serve as "base-load" electricity, requiring substantial conventional electricity capacity as backup. They also require significant material input into the production of solar panels and wind turbines and a major upgrading of storage capacity, transmission lines and the creation of intelligent grids, all set to drive up material consumption (and related costs), in some cases completely exhausting supply of strategic materials (for more information, see Achzet et al., 2011).[18] Furthermore, two-thirds of fossil fuel is used as transport fuel, for which there is no real substitute within sight (biofuels cannot meet more than a small fraction of the world's transport fuel demand).[19]

Hänggi (2011) cautions that a change in the energy mix does often not lead to a straightforward replacement of fossil by renewable fuel. Rather, the new energy is likely to be used in parallel with the old one for quite some time (a phenomenon that applies to many social innovations), both for technical reasons, but also linked to the rebound effect (see below). For instance, the present global consumption of coal is higher than that before the oil age, so is the current consumption of fuel wood compared to what was used before the coal age. Also, to assure reliable electricity supply, gas-reliant power stations are likely to play an important role in backing up wind and solar power facilities (Röpke and Lippelt, 2011).

It should also not be overlooked that, unlike conventional fuel, renewable energy is usually only available in non-concentrated form; it has to be "compacted" to generate sufficient power. This "compaction" or,

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[17] For more information, see: Alcott, 2012.

[18] Just one illustration: to meet global electricity consumption by (solar) photovoltaic panels in 2030 would require a consumption of copper of 100–200 million tons; this compares to a recent global copper production level of about 15 million tons per annum. Similar scenarios apply to rare earths and some heavy metals. What is more, their production is highly environmentally and/or socially problematic (Exner et al., 2008: 68, 69, 72). For more information, also see Bleischwitz et al., 2012.

[19] Estimates of land requirements for biofuels vary widely, but mainly depend on the type of feedstock, geographical location, and level of input and yield increase. The massive scale of land requirements for meeting biofuel blending targets however poses a serious competitive challenge for land for food-crop production. To replace 10 per cent of global transport fuel demand by first generation biofuels in 2030 would require the equivalent of no less than 8 to 36 per cent of current global cropland, including permanent cultures (UNEP, 2009). This contrasts with recent estimates that only about 5 per cent of the arable land on the planet remains unused (Kluger, 2010: 34–39). Furthermore, a recent study of the Institute for European Environmental Policy on the effects of indirect land-use change associated with the increased use of conventional biofuels that EU Member States have planned for within their National Renewable Energy Action Plans till 2020 (i.e. 10 per cent of consumed transport fuel should come from renewable resources – recent discussions suggest a lowering of this share to 5 or 7 per cent) concludes that meeting this target would lead to between 80.5 and 167 per cent more GHG emissions than meeting the same need through fossil fuel use (Bowyer, 2010).

in technical terms, the reduction of entropy of a system,[20] can only be achieved by increasing the entropy in other parts. In practical terms of renewable energy, this means that one can only compact wind, solar, bio or hydro energy by increasing the use of conventional fuel or raw materials.[21]

As a result, the EROI[22] is low and sometimes even negative (in fact, even for conventional fuels the EROI has dramatically declined in recent decades).[23] According to Hall et al. (2009: 25–47), it is not important to have renewable energy alternatives per se, but that they have:

- a sufficient energy density;
- an appropriate transportability;
- a relatively low environmental impact per net unit delivered to society;
- a relatively high EROI; and
- RE obtainable on a scale that society demands.

Hall et al. (2009: 25-47) stress that "we must remember that usually what we want is energy services, not energy itself, which usually has little intrinsic economic utility". MacKay (2009: 103–104) adds that "for a sustainable energy plan to add up, we need both the forms and amounts of energy consumption and production to match up. Converting energy from one form to another ... usually involves substantial losses of useful energy ... Conversion losses [in the United Kingdom, for example] account for about 22 per cent of total national energy consumption".

In sum it should be noted that low EROI, losses in storage, transmission and conversion, and less efficiency at the point of use for renewable energy can mean that the need for energy supply can increase considerably compared to the current fossil fuel dominated energy mix – just to keep energy utility at the point of use the same.

C. The efficiency illusion – the rebound effect

Enhanced energy (and related material and resource) efficiency and ample availability of cheap renewable energy will encourage a "rebound effect", i.e. physical consumption is likely to increase as a result of efficiency increases, which leads to lower costs and prices and the shifting of thus saved consumer money or investment funds.[24]

The Rebound Effect was first described by the English economist William Stanley Jevons in his book "The Coal Question", published in 1865. Jevons observed that England's consumption of coal soared after James Watt introduced his coal-fired steam engine, which greatly improved the efficiency of Thomas Newcomen's earlier design. Watt's innovations made coal a more cost-effective power source, leading to the increased use of the steam engine in a wide range of industries. This in turn increased total coal consumption, even as the amount of coal required for any particular application fell. Jevons argued that improvements in fuel efficiency tend to increase, rather than decrease, fuel use: "It is a confusion of ideas to suppose that the economical use of fuel is equivalent to diminished consumption. The very contrary

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[20] In classical thermodynamics, the concept of entropy is defined by the second law of thermodynamics, which states that the entropy of an isolated system always increases or remains constant. Entropy is the unit of measurement for the unavailability of a given volume of energy.

[21] For more information, see Sarkar, 2009: 316–318 and Rundgren, 2012: chapter 6.

[22] There are different methods for calculating EROI and there is a large range of EROI values for individual energy sources depending on the method used.

[23] For more information, see Exner et al., 2008: 60–79.

[24] For a more in-depth analysis, see Hoffmann, 2011: 4–5.

is the truth … no one must suppose that coal thus saved is spared – it is only saved from one use to be employed in others" (Jevons, 1865).[25]

The Rebound Effect reflects the causality between efficiency increases and additional demand. The definition not only includes the energy/material/resource (EMR) efficiency, but also the additional demand impact of increased labour and capital productivity.

Besides the financial rebound effect (denoting that part or all of the EMR-efficiency-induced cost savings are used for re-investment or additional consumption) there is also a material rebound effect. In addition, there are psychological and cross-factor rebound effects. Material rebound effects are caused by higher EMR consumption resulting from the need to change fixed capital and infrastructure for increasing EMR efficiency. The psychological rebound effect provokes higher EMR consumption, because users of more efficient technologies are under the impression that they have economized on EMR use and that there is thus no harm in using the concerned device a bit more (e.g. the user of a more fuel efficient or electrical vehicle increases the mileage). The cross-factor rebound effect, in turn, is triggered by enhanced labour productivity, which replaces labour by mechanization and motorization, driving material and resource consumption, but in particular energy use. In other words, labour productivity increases are bought by reduced energy efficiency. Technological developments that besides EMR efficiency also increase the capital efficiency and labour productivity are likely to cause "backfire effects", i.e. ultimately increasing EMR demand (Santarius, 2012: 17).

There is yet another, more complicated aspect of Jevons' paradox.[26] Even if higher labour productivity can make workers redundant, it also increased the remaining workers' salaries. This creates new demands and new employment opportunities. Those that are made redundant, in turn, are mostly productive in some other trade. Even if we see a lot of unemployment globally, one must admit that the enormous gains in productivity have not resulted in widespread or mass unemployment. To some extent, workers have reduced their work hours, but certainly not at all in parity with the increase of labour productivity. Therefore, despite all efficiency improvements our society has neither significantly reduced the number of hours worked nor the resources used, not in total and not per capita. Rather, efficiency gains have fuelled increased consumption.

Rebound effects have been poorly analysed so far, with some estimates limited to the financial rebound effects. The latter alone are estimated to neutralize up to half of the total EMR efficiency gains (Santarius, 2012: 19). Empirical information on material and cross-factor rebound effects is not yet available. Against this background, it will be simplistic to assume that EMR efficiency gains can play the main role in reducing GHG intensity. The key dilemma is that efficiency and productivity gains tend to boost economic growth, thus ushering in more physical consumption. This is one of the key reasons, which calls into question the effectiveness of the "efficiency revolution" as a key element in the de-coupling strategy at macroeconomic and global levels.

Theoretically, some rebound effects could be neutralized by eco-taxes. However, such taxes (being increased in line with higher EMR efficiency) would have to be designed in a way that does not remove the incentive for efficiency innovation and would also have to be coordinated internationally. Setting absolute EMR consumption limits would be more promising, for instance in the context of caps for emission/pollution trading schemes. However, almost all of such trading schemes on carbon-emission reductions have not been very successful so far, the virtual collapse of the EU emission trading scheme

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[25] Quote taken from http://www.econlib.org/library/YPDBooks/Jevons/jvnCQ7.html.

[26] For more information, see Rundgren, 2013.

in recent years is a case in point.[27] One should also not overlook the equality challenges of emission trading schemes and the fact that there is no link between the value of the service in a free market and the total cost for society. What is more, even the smartest-designed carbon offset trading scheme cannot overcome the constraints set by the above-mentioned limits of the maths of decarbonization – as stressed by Pielke (2010: 111), carbon "markets cannot make the impossible possible".

D. Linear thinking and horizontal shifting

There is also a tendency of too much linear thinking and approaches to enhancing EMR efficiency, often resulting in an outcome that only shifts the problem. Some of the technical advances for EMR efficiency gains, for instance, rely on material, which is either scarce or very energy intensive to produce or difficult to re-use, recycle or safely dispose of. According to Bleischwitz et al. (2012: 21), "the upswing for eco-industries in the North may have a dark side in the South: resource-rich countries being moved into rapid extraction paths exceeding the eco-systems and socio-economic institutions of those regions and fuelling civil wars with resource rents". To use a concrete example, according to Schmidt-Bleek (2014: 65), "the damages in nature caused by electrical vehicles are far bigger than the ecological savings obtained by lower emissions".[28]

A considerable part of GHG intensity drops in developed countries has been achieved not by "real physical savings", but by "outsourcing" very EMR-intensive production to developing countries (almost a quarter of GHG emissions related to goods consumed in developed countries has been outsourced). A team of scientists at Oxford University, for instance, estimated that under a correct account, allowing for imports and exports, Britain's carbon footprint is nearly twice as high as the official figure (i.e. 21 t CO_2eq/person/year instead of 11). The share of CO_2 net imports to total carbon emissions of individual developed countries has recently ranged from about 15 per cent for Greece to almost 60 per cent for Switzerland. (Aichele and Felbermayr, 2011: 13). Against this background, EMR and carbon efficiency gains in developed countries need to be scrutinized with care and are often far less impressive than appearing at first sight.

III. GOVERNANCE AND MARKET CONSTRAINTS

No doubt, the drastic and quick changes required for achieving the unprecedented absolute, permanent and global GHG emission reductions necessitate a clear strategic political vision, a sound strategy and consistent implementation. Yet, in practice we remain far away from that. The climate is changing much faster than the international efforts to address it and the political rhetoric does not match the scale and the seriousness of the problem.[29] The international climate regime, though without alternative, is not providing

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[27] On 24 September 2014, the day that followed the United Nations Climate Summit 2014, the European Parliament's environment committee voted in favour of giving away free carbon permit allowances – equivalent to 5 billion Euro – to a select group of heavy industries in the EU, in an effort to discourage them from moving production abroad to countries with lower environmental standards. Carbon prices in the European Emission Trading Scheme were at above 30 Euro/t in 2008, but were just a mere 7 Euro/t in December 2014 (http://www.bloomberg.com/news/articles/2014-11-26/eu-carbon-rises-to-highest-since-march-as-nations-tackle-glut). While the European Commission plans to reform the current system, analysts predict that carbon prices may not rise to much more than 10 Euro/t by 2020 (ICTSD, 2014: 13–14).

[28] All too often the mistake is made to calculate ecological gains of new products only based on their ecological footprint during the life-time of the concerned product, while ignoring the ecological rucksack caused by the material that is used in the production of the new good. As regards cars, life-time fuel consumption and related carbon emissions account for only 20 per cent of the total ecological impact of a car (Schmidt-Bleek, 2014: 81).

[29] As pointed out by Schmidt-Bleek, 2014: 38, we are in the paradoxical situation that never in history have we practiced so much environmental policy as today, yet the extent of environmental damage keeps rising.

a coherent and sufficiently effective approach yet.[30] According to Fatih Birol, the chief economist of IEA, "potentially, we are already with our feet in water, reaching the level of our knees. Yet we make decisions and keep promising that our toes will remain dry" (cited in Kriener, 2011).

Existing market structures are also complicating the "green" transformation of economies. For instance, from a systemic point of view, a considerable part of renewable energy can (and should) be deployed in a local, decentralized way, avoiding much of the required investment in new grids, avoiding transmission losses and matching supply with demand. Yet, the market domination of few energy companies leads to a preference being given to central, grid-based approaches that retain their market power (off shore wind parks, nuclear energy and project proposals for huge solar power generation facilities, for instance, in the Sahara are cases in point).

The externalization of environmental costs and massive subsidization of fossil-fuel dependent industries and industrialization approaches have become a fundamental part of the capitalist market economy. More generally, there is a systemic problem of free riding of "conventional producers" that take advantage of all kinds of "perverse" subsidies and misguided incentives. Conversely, sustainable producers, who want to distinguish themselves, have to provide (and pay for) the evidence/certification that they are indeed meeting specific sustainability criteria (usually partly reflected in public or private sustainability standards).

Internalization is a cost-shifting process. Effective policy design, environmental taxes, command-and-control instruments and various market mechanisms (including cap-and-trade markets) can lead to some internalization. However, as emphasized by Giorgos Kallis, it is naïve to think that internalization is just a matter of policy and can be done without significant political and social change. Powerful interests will not sit back quietly, accept environmental caps and taxes and adapt to economic restructuring. On the contrary, they will use their political muscle. Valuation is subjective and thus also subject to power manipulations. Many activities that form the core of the current economy would have never come to be if they had to pay for their externalities. Properly priced, civil aviation would have come to a halt, and there would probably not be many cars on the streets (Kallis, 2011: 878).[31]

It is often argued that policy instruments, such as eco-taxes, and market-based tools, such as cap-and-trade schemes, need to be fully and effectively applied so that GHG emissions are properly priced. The European Environment Agency summarized and evaluated the effectiveness of the existing policy instruments in the European Union on encouraging changes towards sustainable production and consumption (see table 2). The Agency came to the sobering conclusion that "overall, current policies are rather incremental than transformative" (European Environment Agency, 2010: 46). Carbon-offset markets, for instance, are bound to remain far behind GHG-reduction hopes, because the level of 'caps' is often influenced by pressure of key lobby groups or specific industries that insist on the allocation of free-of-charge emission permits. What is more, the rapid increase of renewable energy supply capacity and its bearing on notably electricity prices in several European countries has put additional downward pressure on permit prices

[30] It is beyond the scope of the analysis in this paper to elaborate on the key issues that delay and hamper progress in international climate-change negotiations, particularly in the United Nations Framework Convention on Climate Change (UNFCC). The main points of contention in the climate negotiations can be summarized in two positions, which are far apart: on the one hand, the demand of developing countries that the remaining atmospheric space for further economic and social development has to be shared on the basis of the use of a carbon budget for future emissions and the consideration of carbon debt for past emissions since the industrial revolution. This would imply a rather significant financial compensation of developing countries (for a more elaborate analysis, see Khor, 2010). On the other hand, there is the position that the decarbonization of the economy and the related changes in economic structure and energy mix as well as considerable improvements in material/energy/resource efficiency would altogether generate more opportunities and ultimately income and jobs than costs (for more information, see for instance Hennicke, 2014).

[31] One should also not overlook the conflicts and complexities in internalization of costs, especially for complicated systems, like agriculture. By way of illustration, one can reduce methane emissions by culling cows, but then biodiversity of many landscapes will be devastated.

Table 2

Examples of existing policy instruments for encouraging sustainable production and consumption in EU member countries

Policy instrument	*EU level examples*	*National and local examples*
Economic instruments	Energy Taxation Directive, Vignettes for Heavy Good Vehicles, The *EU Emissions Trading Scheme*	Energy and fuel taxes, emission based car taxation, water fees, subsidies for installation of renewable energy systems and energy saving measures in buildings, traffic congestion charges, deposit refund schemes
Regulatory instruments and standards	The EU *Ecodesign Directive on energy-related products*, several waste-related directives aiming at enhancing recycling, and the EU *RoHS Directive*	Regulatory requirements for energy performance of buildings (e.g. the German *Federal Ordinance on Energy Saving*)
Voluntary agreements	The *EU Retail Forum, the European Food SCP Roundtable* and the Communication on *Green Public Procurement*; the *EU-Asia partnership on Sustainable Consumption and Production* (*SWITCH Programme*), the *European Destinations of Excellence* (*EDEN*) project to promote sustainable tourism	Public-private partnerships, for example the Austrian *Sustainability Seal*, the British *Red/Green Calculator*, the German *Sustainable Retail Initiative* or the French retailers' commitments with regard to sustainable development
Information based instruments	The European *Ecolabel Regulation* (including its revision), the *EU Organic food label* and the Energy Label including its extension to more products, the *Control Climate Change* campaign, and the *Buying Green* Handbook	Numerous guidelines and portals, for example, *topprodukte.at* (Austria); Campaigns include *Love Food*, *Hate Waste* (the United Kingdom), *Et ton mindre* (Denmark) or *Faisons vite, ça chauffe* Energy Campaign (France)

Source: European Environment Agency (2010: 46).

in the European Union Emission Trading Scheme.[32] In any case, the price of carbon would have to be so (very) high that drastic de-carbonization of production and consumption became a reality.[33] As mentioned above, this would undoubtedly wipe out quite a number of carbon-intensive sectors and would require very pro-active government engagement to smoothen the socio-economic consequences of such restructuring and make it socially acceptable. All this is theoretically possible, but unlikely to happen at global level in the remaining very short period of 2–3 decades for drastic decarbonization of the world economy.

[32] For more information see: www.mckinsey.de/sites/mck_files/files/mckinsey_energiewende -inde_et_september_2014.pdf.

[33] According to one estimate (Hänggi, 2011: 261), effective drastic changes in conventional-fuel-dominated production and consumption patterns for Switzerland can only be expected beyond a level of US$ 270 per tonne of CO_2.

IV. CHANGING CONSUMPTION PATTERNS

The colossal de-carbonization of the economy and human life required will only be achievable if current consumption patterns, methods and lifestyles are also subject to profound change. Yet, far-going and lasting changes will be very difficult to bring about. The globalization of unsustainable Western life styles and consumption trends, including the tendency towards higher animal protein content of food and the high mobility obtained through modern, but carbon-intensive transport systems, will be very hard nuts to crack on the consumption front. What is often underestimated by the advocates of "green growth" is the fact that changing consumption and concomitant lifestyles need to be understood as a social issue, factoring in equity, not just as an environmental issue. Consumption patterns are unlikely to significantly change unless income distribution changes as well.[34]

V. SYSTEMIC LIMITS – THE ECONOMIC GROWTH FETISHISM

If the technological, governance and market constraints were not already enough, some systemic issues are also calling into question the "green growth" hopes. Their essence is that there are doubts whether the capitalist economic system can operate without growth at all times, i.e. rather than just with the exception of short cyclical crises. It has long been debated whether "expand or perish" is an inexorable force and the constant accumulation of capital has inherent expansionist features, i.e. all economic agents are under competitive pressure to either undercut the costs of their competitors or conquer markets by creating new products. In this reasoning, increases in labour productivity and the permanent creation of new consumer needs generally lead to more, not less physical production and consumption (i.e. the principle of capitalist accumulation).[35]

Similar debates have come to the fore over the past few years under the heading "capitalism in crisis".[36] For example, as argued by Lockwood (2011), "growth is inherent in capitalism, which means you can't have capitalism without growth, and you can't have a capitalist steady state economy", as advocated by Herman Daly and others. Rather, under capitalism, as described by Green (2011), "growth is like a bicycle – if it stops, you fall off". By contrast, Robert Solow, the growth economist, is quoted as saying that "there is no reason at all why capitalism could not survive without slow or even no growth".[37] Still others hold that climate change cannot be effectively addressed under unregulated free-market capitalism because climate change is a product of that economic system. But they argue that changing the rules of capitalism, rather than shutting it down, would provide a workable solution (see, for example, Klein, 2014).

In any case, all these positions agree that "green growth" naively postulates that technological progress and structural change would be sufficient to uncouple economic from GHG and resources/material/energy consumption growth, without questioning the existing asymmetrical market structures, related supply-chain governance, social problems and economic driving forces. Without changes in income-distribution and culture related to consumption behaviour, the fundamental transformation required for dematerialized growth will remain illusory. Furthermore, it should not be overlooked that there are natural-science and technical limits to growth, which cannot be circumvented by green technology alone. According to Tienhaara, "an overemphasis on technology … tends to displace solutions to problems that are simple,

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34 No matter whether it concerns the purchase of goods with a certain longevity, organic food or the renting of well-insulated flats, consumers will only switch to them if they dispose of a proper income.

35 For a more elaborate analysis, see Hoffmann, 2011: 13–16.

36 For debates on this issue, see for example the Financial Times series on Capitalism in Crisis, started by David Pilling *Capitalism in crisis: Perilous path to prosperity*, 16 January 2012, available at www.ft.com/cms/s/0/1d92589a-3090-11e1-9436-00144feabdc0.html#axzz3aTlJsUsI, and the series with the same topic by The Guardian, available at: www.theguardian.com/commentisfree/series/capitalism-in-crisis.

37 See http://preservenet.blogspot.ch/2008/10/robert-solow-on-no-growth-economy.html.

yet effective, and reinforces the belief that changes in lifestyle (or in ways of doing business) are not necessary in order to reduce humanity's impact on the planet" (Tienhaara, 2009: 18).

VI. THE MAMMOTH CHALLENGE: HOW CAN WE EXTRICATE OURSELVES FROM THE ECONOMIC GROWTH PREDICAMENT?

What the above-developed analysis on the true (socio-) economics of climate change has brought to light is that a paradigm shift, rather than a green turn is required.

However, the ongoing and collective ballooning of GHG emissions has squandered the opportunities for "evolutionary change" afforded by the earlier 2ºC carbon budget. Furthermore, a spate of positive practical examples on GHG reduction opportunities and a large body of knowledge on the catastrophic consequences of likely temperature increases of 4–6ºC and more will not be sufficient to alter the current GHG-intensive, GDP-growth-fetishizing development paradigm. As emphasized by Chandran Nair, it is also pointless to hope that the world's countries will find a universal notion of responsibility and then act on it. The rich nations will not opt to halt or reverse growth while the poor catch up, and, conversely, the developing world will not forgo growth while the rich countries try to figure out if they can maintain their current lifestyles in a sustainable way (Nair, 2011: 143).

The growth paradigm ignores the fact that in a bio-physically finite system, beyond a certain point, marginal growth makes mankind poorer, not richer, because the incremental income generated is overtaken by the incremental damage, thus reducing global wealth (if properly calculated). As put by Randers, once in overshoot, the sustainable carrying capacity of the planet can only be re-established in one way: down. "Either through managed decline, or through collapse – leaving it to the market or to nature to reduce human activity" (Randers, 2013: 10). It thus seems likely that recurrent crises in nature and the economy, which are sufficiently large, will be required to bring about the required change. The question is not, whether the world economy – in particular the economy of rich Northern countries – has to shrink, but how this process will happen: in a chaotic or organized way and how it will end.[38] This is the very background, against which Tim Jackson pointed out that "the climate may just turn out to be the mother of all limits" (Jackson, 2009: 13).

Admittedly, this is scary prophetism, to which there are alternative transformative measures under what was above-termed "managed decline of the current overshoot". The questions to be posed, however, are: how likely will such measures be harnessed under prevailing power relationships; can they really have a sufficiently large impact to move from a growth to a post-growth paradigm; and do such transformations not imply very far-going system change?

Three elements seem to be imperative for the required transformation:

- Assurance of consistency so that the development of production and consumption methods and related technologies is in harmony with nature (in particular its reproductive capacity).
- Taming the growth paradigm by practicing sufficiency, the collective use, rather than individual ownership of products (through the so-called sharing economy),[39] a more local and social, rather than global focus of the economy, and the realignment of the financial sector with the real (material) economy.
- A better distribution of income both within and between countries (for an elaborate analysis, see Unmüssig et al. 2012). Essentially, ecological sustainability needs to go hand in hand with social

[38] For an elaborate analysis, see Adler and Schachtschneider, 2010: 67.

[39] This would also encourage longevity of products, their re-use, repair and recycling.

justice and in this regard the question arises as to what (parts of the economy and social system) shall grow for that objective and what parts should rather shrink.[40]

To get there, a number of analysts favour an alternative regulation of capitalism (capitalism 3.0), which overcomes its neo-liberal phase. An accumulation regime with a strong social-ecological thrust should lead to a boost of eco-technological solutions, reduce rates of profit, overcome the alienation of finance capital from the real economy and pay greater attention to a regional focus of supply chains (Adler and Schachtschneider, 2010: 159). For this objective, the following directions (or rather aspirations) for development are proposed (Loske, 2011: 20–54):

- Giving up the extreme fixation on GDP as central indicator of welfare by differently valuing productive and reproductive performance, including at family level, voluntary activities and in the informal sector.[41]
- Checking the all-too-embracing trends of commercialization of human activities and nature services.
- Development of new work and living models that reduce the growth of labour productivity and cut the working time.
- Reorientation of companies on quality- and less on price-focused competition. Companies should find ways of extracting value from longer-lived goods, from services built around the performance of their goods rather than their sale, and from reselling and recycling their materials and components (Nair, 2011: 135).
- Development of a taxing regime that discourages striving towards higher physical production and profit and that improves income distribution (this should include redirecting taxes from labour to material/energy/resource use, introducing pollution taxes and taxing financial speculation).
- Stimulation of social and ecological innovation.
- Providing incentives to develop and maintain public goods and services.
- Regionalization of supply chains. Re-adaptation of economic activities to local and regional resources.
- Increasing the room for public and common property, including sharing property/economy elements.
- Reform of the monetary system so that money is only created and put into circulation by central banks, which would avoid the detachment of the monetary system from the real economy.
- Reform of the rules governing international trade and foreign direct investment so that regionalization of economic activity is not jeopardized and a race to the bottom for ecological and social standards avoided.

The key question related to the proposed directions in the bullets above is: how can they really be translated into practice? Their implementation would challenge many well-established and vested power interests and positions, which are unlikely to give up their influence without resistance. Some issues are bordering on systemic changes, for which sufficient societal or political support needs to be created. Furthermore, some new "post-growth" elements, such as the sharing economy, might run the risk of being undermined by vested interests of large companies.[42] In sum, under prevailing circumstances and the current political

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[40] In a recent report, even the World Bank emphasizes that "it is … critical to use the savings or new proceeds generated by climate policies to compensate poor people, promote poverty reduction, and boost safety nets" (World Bank, 2015: 16).

[41] Some alternative indicators already exist, such as the Genuine Progress Indicator, the Happy Planet Index or the Index of Sustainable Economic Welfare. The latter, calculated for Germany for the period 1990 to 2009, for instance, showed an increase of 6 per cent, whereas conventional GDP increased by 11 per cent. While classical GDP contracted in the financial crisis of 2008–2009, the Index of Sustainable Economic Welfare increased. For more information, see Hoffmann, 2011: 11 and Pinzler, 2013.

[42] There are already the contours of serious conflicts in the "sharing economy". Large internet platforms for taxi or hotel/guest room services, for instance, are increasingly dominating the business and encourage expansion of the use of such services, leading to increased, rather than reduced material and energy consumption. Furthermore, there is the risk that these internet platforms create precarious working or contractual conditions and challenge basic requirements of public safety (for more information, see Loske, 2014).

system, some of the flagged directions are only likely to be conceivable as a result of severe or frequently reoccurring crisis and catastrophic situations[43] and related public pressure for change.

On a somewhat less pessimistic note, as emphasized by Randers (2012), some recent projections on population and consumption growth might suggest a less dynamic development of the world economy and a resulting less dramatic global warming trend. Randers, for instance, projects that world population might peak at roughly 8 billion people in 2040 and be in decline by 2050.[44] Furthermore, the workforce in developed countries will decrease and rich countries will hardly grow on a per capita basis over the next 40 years. As a result, the world economy might not be 4 times as big in 2050 as it is today, but only 2 times. Moreover, although global GDP will double, global society may be forced to spend so much labour and capital on repair and adaptation that global consumption would level off before the middle of the century.[45] As a consequence, Randers projects CO_2 emissions that might limit temperature increase to 3–4 degrees by the end of the century.[46]

Some scientists pin a lot of hope on new technologies for directly removing CO_2 from the air. Most of these technologies are producing methane, methanol, plastic and foam material. Yet all these technologies are very energy-intensive and would require a considerable part of the globally generated renewable energy. What is more, the produced fuel through these technologies would be eventually consumed and re-generate a considerable part of the carbon emissions removed from the atmosphere before. Estimates suggest that about 2 billion tons of CO_2 could thus be removed from the atmosphere annually, i.e. equivalent to some 6 per cent of annual global CO_2 emissions. In other words, these new technologies will remain far from playing a pivotal role in mitigating climate change (for a review, see Schramm, 2014: 37–38).

To wind up, a strategy of quantitative sufficiency is in blatant contradiction with the rules of prevailing capitalism that are based on cut-throat competition. Only if capitalism succeeds in (i) creating value while reducing the quantitative throughput (i.e. making profit from dematerialized activities and regeneration of resources) below planetary boundaries (and the reproductive capacity of our environment), and (ii) improving the socio-economic conditions for the majority of mankind will it have a chance of survival in the future.[47]

From a more practical point of view, in the light of the above analysis and existing time constraints for mitigation, it seems logical that the pendulum of international attention should swing more towards

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[43] The word “catastrophe” is of Greek origin (katastrophé). It means “a drastic turnaround”. In other words, a catastrophic situation might also offer opportunities for change. Examples of such “crisis” or “catastrophic” situations are severe floods, extremely strong tropical storms or severe draughts leading to drastic policy measures or changes in approach.

[44] This contrasts, however, with the rapid expansion of the so-called “middle class”, in particular in large rapid industrializing developing countries, such as Brazil, China, India and the ASEAN countries. The number of people with a per capita income between US$6,000 and US$30,000 in China and India alone is projected to double from roughly 800 million in 2010 to some 1.6 billion in 2020. These people have a high catch-up demand in terms of material, energy and emission-intensive household appliances, vehicles and leisure activities. Such rapid expansion of the “middle class” is without a historic precedent. For more information, see: www.statetrust.com/page/en/BRICs-Middle-Class-Growth/0/247 and www.csmonitor.com/World/2011/0517/Surging-BRIC-middle-classes-are-eclipsing-global-poverty.

[45] This will however also imply that most developing countries may have little prospect for economic and developmental catch-up with the North and that poverty levels largely remain unchanged.

[46] The downside of lower economic growth under the Randers scenario is that there will only be some 5 billion middle class people in the world by 2050, the rest of the population would be poor. It basically means that there would be more poverty than there would otherwise have been.

[47] The approach of Bhutan on making public happiness the principal objective of the economy and development process of the country (including the complete conversion of energy generation to renewable sources, a matching of energy supply and demand at regional level, the full conversion of agriculture to organic production, the taming of the expansion of the financial sector, as well as the ban on advertising for boosting private consumption) is an interesting example. In this way, the country currently seems to be the only one that has a determined strategy to break the logic and neck of growth fetishism.

effective adaptation and enhancing resilience to climate change in the next few decades. Many of the adaptation measures can be combined with mitigation. One should however not lose sight of the fact that a not unimportant part of the much-required adaption measures, such as the protection of coastal zones, river banks or adaptation in the building sector, are boosting economic activity and thus also GHG emissions. Yet, successful adaptation and enhanced resilience can effectively prevent and/or reduce damage, but it can most importantly protect and save human life. One needs to remember that the seriousness and scale of the forthcoming climate change challenge is new to mankind, but not to our planet and its wildlife, when those species and animals survived climate extremes that proved best adapted and most resilient.[48]

[48] For more information, see: The Prince of Wales et al., 2010.

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