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Green Growth

Green growth is now a central theme of the international climate change negotiations. The Rio+20 Conference in June will concentrate on green growth as one of its main priorities. The Europe 2020 strategy has identified green growth as a fundamental pillar of EU economic policy. This Forum takes stock of the academic discussion and examines the theoretical and empirical underpinning of the concepts of green growth and employment through environmental policy.

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Religion and Reality in the Search for Green Growth

The newfound popularity of "green growth" should not surprise. Repeated failures in international climate negotiations have led to the search for new motivations for emissions reduction. In parallel, the major emitters continue to endure economic stagnation and political instability in the aftermath of the 2008 financial crisis. The notion of "green growth" suggests a way out of both problems. Were "green growth" to become a reality, it would bypass the myriad problems of climate change mitigation – who should pay, how much, and when. If "green growth" were possible, then the shift to a low-emissions economy could pay for itself by catalysing a wave of investment, innovation and job creation. Rich countries could re-found economic competitiveness in an array of new "green" industries, while emerging markets could support their ongoing development on a foundation of new low-emissions technology.

But "green growth" today remains more religion than reality. The short-term jobs and investment generated by the move to renewable energy will come at substantial cost, last only as long as the retrofit period itself, and will partially displace jobs in legacy energy sectors. Longer-term prospects are equally unpromising. Radical success in renewable energy adoption will mean an energy system as reliable, ubiquitous and flexible as today's fossil fuel-based system. Beyond lower emissions, however, "green" electrons will provide consumers few obvious advantages over the "brown" electrons they use today. Absent new energy capabilities or improved energy services, the possibilities for economic growth based solely in the energy sector appear very limited.

This article considers how green growth might move from religion to reality. We make three straightforward arguments: *first*, that green growth will require a systems transformation; *second*, that a growth-inducing systems transformation must look beyond the energy sector; and *third*, that both green growth and energy systems transformation will require a range of policy interventions that go well beyond conventional prescriptions for emissions pricing and R&D subsidies. Appealing to the broad-based growth catalysed by earlier transformations in energy, transport, and information technology, we argue that the real green growth challenge lies in discovering the transformative potential of a low-emissions energy system for economic production and social innovation writ large.

Renewable Energy, Jobs and Growth

The green growth debate has emphasised job creation and export-led growth in energy sector jobs and technologies alone, rather than the intrinsic growth-generating dynamics of low-emissions technology itself. We summarise those arguments here to drive home the following point: that this narrow focus risks damaging both the long-term prospects for green growth and the broader enthusiasm for climate policy. Justifying climate policy

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by pointing to short-term gains to energy sector employment or export-led growth may undermine the long-run justification for climate change mitigation if those benefits do not materialise. It also risks international conflict over trade and industrial policy that damages both cooperation on emissions reduction and the broader framework of international trade cooperation.[1] Durable green growth will, instead, require a broader vision of the role of new forms of energy in sustaining and expanding economic possibility.

Mistaking Short-term Jobs for Long-term Growth

In the aftermath of the 2007-2009 financial crisis, the "green jobs" variant of the green growth argument gained currency across the industrial world. United States President Barack Obama, the European Union, and a range of American states and European countries have all sought to tie green energy investment to job creation.[2] This led to a significant quantity of economic stimulus funds – billions of dollars, equivalent to anywhere from 10% to 80% of national stimulus budgets – directed at energy efficiency, renewable energy, and energy-related research and development.[3] Support for these activities was buttressed by fears that insufficient domestic energy investment would lead to permanent disadvantages in a new green technology frontier, particularly vis-à-vis new economic powerhouses like China.[4]

This emphasis on jobs should raise immediate concerns on two fronts. First, a focus on job creation in the green energy sector alone cannot form the basis of sustained economic growth in advanced industrial societies. If those jobs result from Keynesian demand stimulus, as in 2008-2010, their viability will necessarily fade as the economy returns to full employment. The long-term opportunities for employment growth are similarly limited. Advanced industrial societies have fully built-out energy systems and relatively modest growth in energy demand. "Green jobs" will thus often replace "brown jobs" in operation of the energy system; and the new "green jobs" created for the period of system retrofitting will necessarily be short-lived, lasting only as long as the retrofit itself. Finally, those "green" jobs will have limited impact on the overall employment picture, as they emphasise the energy sector alone rather than the economy as a whole.[5]

1 For a broader treatment of individual green growth arguments and economics, see M. Huberty, H. Gao, J. Mandell: Shaping the Green Growth Economy: a review of the public debate and prospects for success, Report prepared for the Mandag Morgen Green Growth Leaders Forum, http://greengrowthleaders.org/wp-content/uploads/2011/04/Shaping-the-Green-Growth-Economy_report.pdf. Last accessed 9 May 2011.

2 For the European Union, see The European Commission: An Energy Policy for Europe, Communication to the European Parliament and European Council, Document SEC (2007) 12, Brussels, Belgium 2007, The European Union. For the Danish emphasis on job creation from renewable energy, see The Danish Government: Danish Energy Strategy 2050, Denmark 2011, Danish Climate and Energy Ministry. For related arguments from prominent figures in the public debate, see V. Jones: The Green Collar Economy: how one solution can fix our two biggest problems, San Francisco 2008, HarperOne; and the European Green Party: A green new deal for Europe: manifesto for the European election campaign, 2009.

3 E. Barbier: Green stimulus, green recovery and global imbalances, in: World Economics, Vol. 11, 2010, No. 2, pp. 149–177.

4 See, for instance, European Union Commissioner for Energy Gerhard Oettinger, who justified increased EU support for low-carbon technologies on the fear that Europe would "start lagging behind China and the USA". Speech of Commissioner Oettinger at ENERI 2010, Brussels Presidency Conference on Infrastructure of Energy Research, 29 November 2010.

5 The scale of the energy sector points to the limits of job creation in that sector alone. For instance, Denmark obtains about 10% of its overall exports from its wind energy sector. But that sector employs only 24,000 people, or about 1% of the Danish workforce. In most Western economies, the total value of energy consumption runs at about 2-4% of GDP; not insignificant, but also not very large compared with the economy as a whole. As such, betting on massive job creation through renewable energy rings hollow.

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Second, the quality of those jobs is also open to question. Investments in green electricity may generate more jobs per unit of installed capacity than an investment in equivalent brown energy capacity.[6] But this implicitly suggests that the green energy industry achieves, at present, lower labour productivity than the fossil-fuel power sector. If the goal is pure Keynesian job creation to employ idle labour, then this justification may make sense. Moreover, this productivity differential mimics other periods of new technology adoption: learning how best to incorporate new technologies necessarily requires some up-front expenditure. But in those earlier periods, the intrinsic advantages of new technologies – lacking in renewable energy – helped offset the higher up-front labour intensity. Presently, "green tech" lacks such advantages. Thus as a long-term employment strategy, the deployment of a low-emissions energy system appears, on its own, to have limited capacity to sustain broad employment gains or high wages in advanced industrial economies.

Export-led Growth and the New Green Mercantilism

Export-led growth in new green technology provides a second growth channel commonly cited in popular green growth arguments. Countries now openly express concerns that the failure to create domestic markets in green energy will lead to lost global competitiveness in emerging industrial sectors. But as Huberty and Zachmann[7] have shown, comparative advantage in "green" technologies will likely concentrate in countries the industrial clusters of which already contain closely related forms of industrial and innovative expertise. Thus the connection between "green growth" and export competitiveness offers poor justification for low-emissions investments in many countries.

Furthermore, there is little reason to believe that green goods are *necessarily* insulated from the erosion of manufacturing competitiveness that has challenged developed economies in other sectors. The recent difficulties of firms like Solyndra, QCells, and FirstSolar testify to increasingly intense competition driven by rapid process innovation in East Asia.[8] Commodification and process innovation have kept down the cost of taking emissions out of the energy system, while simultaneously undermining attempts at coupling emissions reduction to domestic job creation. Furthermore, Dechezleprêtre et al.[9] provide evidence that policies using demand-pull investment in low-emissions energy goods will generate significant spillover effects that benefit foreign as well as domestic firms.

Using domestic low-emissions investment to drive comparative advantage abroad also poses political risks. China and the US area are already engaged in a series of fights in the World Trade Organisation over subsidies for renewable energy technologies and renewable energy deployment.[10] Given the lack of obvious channels for green growth beyond command of export markets, this conflict was perhaps inevitable. But it foreshadows a new "green mercantilism" which, like its 19th century predecessor, threatens to justify an array of restrictive economic policies at home and the aggressive political pursuit of zero-sum markets abroad. Given mercantilism's legacy of economic and political costs, reviving it to justify low-emissions energy policy appears unwise.

Beyond Energy: Green Growth and Systems Transformation

Thus most arguments for green growth derive their claims about job creation or investment gains from a narrow focus on one aspect or another of the energy sector. These arguments do not hold up well to scrutiny. Rather, in their focus on the short-term employment or investment prospects for installing renewable energy technology or retrofitting buildings, they self-consciously limit their scope of impact and pose an array of economic and political risks.

Instead, we argue that any discussion of green growth must start from the premise that effective climate change mitigation will require the *transformation*, rather than marginal modification, of legacy energy systems. Reduc-

6 D.M. Kammen, D. Engel: Green Jobs and the Clean Energy Economy, Thought Leadership Papers Series No. 4, Copenhagen 2009, Copenhagen Climate Council, at http://www.copenhagenclimatecouncil.com/dumpfile.php?file=ZmlsZWJveC8xODk=&filename=VExTMDQgX0dyZWVuSm9icy5wZGY=.

7 M. Huberty, G. Zachmann: Green exports and the global product space: Prospects for EU industrial policy, Working paper No. 556, Brussels 2011, Bruegel.

8 See, for instance, S. Nicola: Merkel's green jobs ambition stalls with cuts for solar, Bloomberg Businessweek, 30 April 2012, online at http://www.businessweek.com/news/2012-04-29/merkel-s-green-jobs-ambition-stalls-with-cuts-for-solar, accessed 1 May 2012, on the shakeout of the German solar industry and its consequences for "green" job creation.

9 A. Dechezleprêtre, M. Glachant: Does foreign environmental policy influence domestic innovation? Evidence from the wind industry, Working paper, 2011, CERNA, Mines ParisTech, Paris, France.

10 See here K. Bradsher: To conquer wind power, China writes the rules, in: The New York Times, 15 December 2010, A1; M. Scott: GE, Vestas fall behind in China's 'Tough' wind market, in: The New York Times, 14 May 2010; and T. Woody: China snaps up California Solar Market, The New York Times Green Blog, 14 January 2010, at http://green.blogs.nytimes.com/2010/01/14/china-snaps-up-california-solar-market/#more-38129.

tions of 50-80% in fossil fuel emissions will require going beyond mere replacement of fossil fuel power plants. Rather, it will also require substantial changes to the power transmission and distribution infrastructure, improvements in end-user energy efficiency, and the use of information-enabled intelligence to better manage supply and demand. All these technical changes will require, in turn, corresponding changes to the markets and regulatory structures that frame energy production, distribution and use. Each of these changes provides an opportunity to capitalise on the transformation as a catalyst for broader economic growth. Identifying these opportunities, however, will require more careful consideration of the link between systems transformation and economic opportunity.

Systems Transformation and Economic Growth: Lessons from the ICT Revolution

The industrial age has undergone a series of systems transformations, each with profound consequences for job creation, investment and the organisation of production. For energy in particular, successive shifts from wood to coal, coal to oil, and from thermal to electrical energy fundamentally altered what was possible in the economy. The growth we associate with each of these shifts depended almost entirely on these changes to the broader trajectory for the organisation of production, distribution, and the use of goods and services in the economy, rather than the investment required for the transformation itself.[11]

We do not presume to know whether a low-emissions energy systems transformation holds the same growth possibilities. However, we argue that any viable approach to green growth will require a strategy capable of discovering whether they exist. How best to structure the technological, economic and political experimentation necessary to do so is thus the real question at the heart of the green growth problem.

To better understand how this might occur, we focus on the information technology revolution as a powerful example of how the evolution – or perhaps revolution – in a particular technology domain can have transformative effects in the economy and lead to widespread growth. The history of the ICT revolution provides three important lessons for the transformation of the energy system: first, the network proved to be a crucial enabling technology; second, the growth opportunities generated by the transformation came predominately from the possibilities it created in the broader economy, rather than the IT sector itself; and third, regulatory intervention and public support played a co-equal role with private ingenuity in initiating and driving the transformation.

The ICT revolution was a systems transformation in two senses. First, it required a transformation of both the technologies for computation and communication, and the broader regulatory and market context that determined how firms and consumers adopted those technologies. Second, it generated massive spillover benefits by transforming the possibilities for economic activity in the broader economy. The major changes we associate with ICT – in logistics, inventory management, retailing, firm structures and other domains, while unimaginable without ICT, were themselves not purely ICT innovations. Instead, by altering the possibilities for economic production across a wide range of sectors, the ICT revolution ensured that most of its growth potential would come from outside the ICT sector itself.

Achieving this kind of transformative growth required both private investments in new technologies and business models, and public support for open, competitive, standards-based markets in which those investments could thrive. Government support for both R&D and procurement – largely in the American defence and space sectors – initiated the modern IT industry and drove much of its early demand. Government policing of the network and technology monopolies controlled by AT&T, IBM and Microsoft restricted incumbent firms' ability to hinder competition and innovation. In parallel, private sector innovation generated a new set of business models – the small start-up and the venture capitalist – and firms, including future giants like Intel and AMD, founded on an array of new technologies. Together, this activity seeded both radical innovation and intense competitive pressure. Finally, the public sector's role in generating a redundant, open communications protocol produced a network – the internet – that became an innovation platform unto itself, driving waves of new innovation that competed on product and service quality rather than network access.

Real doubts exist as to whether a low-emissions energy systems transformation holds the same promise for economic growth as ICT. Spectacular success in adding

11 For coal, see J. Nef: The Rise of the British Coal Industry, London 1932, George Routledge and Sons, and R.P. Sieferle: The subterranean forest: energy systems and the Industrial Revolution, Cambridge 2001, The White Horse Press. For electrification, see T.P. Hughes: The Electrification of America: the system builders, in: Technology and Culture, Vol. 20, No. 1, 1979, pp. 124-161; T.P. Hughes: Networks of Power: electrification in Western society, 1880-1930, Baltimore 1983, The Johns Hopkins University Press; and C. Perez: Structural change and the assimilation of new technologies in the economic and social system, in: Futures, Vol. 15, No. 5, 1983, pp. 357-375. For energy transitions in broad historical perspective, see V. Smil: Energy in world history, 1994, Westview Press; V. Smil: Energy Transitions: History, Requirements, Prospects, New York 2011, Praeger.

renewable energy to the energy system will mean that energy users will notice no difference between today's coal-generated electrons and tomorrow's wind-generated electrons. All the investment in storage, the smart grid and new energy sources will go towards ensuring that today's patterns of energy use remain viable. In contrast to the first era of electrification, this transformation presently offers few obvious new possibilities for energy use. Meanwhile, achieving these ends will require substantial public and private investment over decades, in an era marked – for the rich countries in particular – by austerity and retrenchment.

Searching for the Opportunities in Systems Transformation

However, the economic significance of radical systems changes often comes in disguise. The advantages of a new technological system are rarely evident at the outset. While the potential of ICT appears obvious in retrospect, at the outset even industry insiders wildly underestimated the potential for their own products. IBM, the apocryphal story goes, projected that it would sell only a handful of its new mainframes. Translating the idea of the microprocessor to even an engineering audience required Intel's marketing director to have a PhD in electrical engineering.[12] Most cell phones today contain vastly more memory than Bill Gates thought even a personal computer would ever need.

The marketplace may yet discover similarly real advantages to "green" tech not obvious at present. But the very different nature of this transformation, and the very large investments it will require, mean that the participants – private and public sector alike – must proactively identify the conditions that would support the process of experimentation that discovery will require. That process will prove a necessary precursor to policy that can go beyond merely driving the development and adoption of "green" energy to enable the broader adaptation in the economy as a whole.

Instruments and Policy Goals

Climate change mitigation confronts policymakers with a wide range of choices in service of both "green growth" and a low-carbon energy systems transformation. The most vibrant policy debates today concern the role that four different policy instruments should play:

- carbon pricing to incentivise technological development, low-emissions energy adoption, and behavioural change;
- technology policy to support research and development;
- regulatory policy to change market rules to favour new forms of energy production, distribution and use[13];
- direct state action for public infrastructure investment and industrial policy.

Conventional policy wisdom for carbon emissions mitigation calls for a credible, sustainable and high carbon price, perhaps supplemented by subsidies to basic research and development for new energy technologies.[14] Such policy, its advocates argue, will allow the economy to discover the most efficient way of reducing emissions. In contrast, other options – such as industrial policy, subsidy of renewable energy sources or mandates for energy efficiency – are seen as inefficient meddling in the market that will ultimately cost more than a policy reliant on price alone.

We can debate whether a price-based approach would suffice if the only goal were emissions reduction. But the conventional policy wisdom falls short if we hope to exploit the possibilities of energy systems transformation for economic growth. Three shortcomings stand out:

- the preconditions for a successful carbon pricing policy – a universal, sustainable, high carbon price – appear politically difficult domestically and impossible internationally;
- it is by no means clear that an efficient carbon price set at the marginal cost of emissions can overcome the network externalities present in the energy system;
- the carbon price offers little support for the coordination and market reform developments critical to future energy innovations.

The political shortcomings pose particularly acute challenges. Since any price on carbon is entirely a political

12 W. Davidow: Marketing High Technology: an insider's vie, New York 1986, The Free Press.

13 These three elements of the energy system are configured differently in each country by regulation and ownership structure, creating distinct national dynamics of demand and supply. Hence there will not be one universal trajectory to a low carbon future and cannot be a single best regulatory strategy.

14 W. Nordhaus: Designing a Friendly Space for Technological Change to Slow Global Warming, in: Energy Economics, Vol. 33, No. 4, 2010, pp. 665-673.

construct, a product of a mix of taxes and subsidies, the durability of the carbon price depends on the ability of a political system to sustain it. Sustainability will depend entirely on the relative ability and desire of carbon price supporters and opponents to influence policy. Even if environmental interests can build a coalition to pass carbon pricing, political science research makes clear that the concentrated economic interests that lose from carbon prices will likely still succeed in eroding the carbon price over time.[15] These problems worsen with higher and more punitive carbon prices. Thus "high" prices undermine both "universal" and "sustainable" prices, putting the viability and effectiveness of a price-driven energy systems transformation in doubt.

Points of Leverage in a Green Energy Systems Transformation

Looking beyond emissions pricing, however, policymakers face difficult choices about where and how to apply other policy tools in diverse regional and national contexts. With limited resources, policymakers have little choice but to seek points in the energy system where limited interventions can change the trajectory of development, by altering the choices of actors throughout the system. Past transformations, like that of ICT, pointed to the role of networks as levers for catalysing broad changes to the trajectory of an industry. Do similar levers exist for energy, which if pulled would induce broad private investment to capture the diverse advantages of the new system?

We define a lever to be a change or set of changes to part of the system that, if carried out, will induce or enable complementary changes in the rest of the energy system. For the case of the energy system, the power grid provides an excellent example of such a lever. The grid is central to choices about how to produce, distribute and use energy; and changes in the grid alter options in all three dimensions of the energy system. Consequently the grid provides significant leverage for policies intent on accomplishing energy systems transformation. Transforming today's power grids from passive means of energy transport to an active platform for innovation will require an array of technological and regulatory changes. Digital intelligence in the grid can enable both greater energy efficiency and new and different forms of renewable energy integration. But capitalising on the possibilities of such change will require complementary changes in grid access, control and standardisation. Together, these changes may provide the leverage for both the technological advances required for the adoption of new energy sources, and the investment and employment required for green growth.

The Search Process in Multiple Countries: National Idiosyncrasy and Experimentation

Economies as diverse as Denmark, South Korea, California and Colorado have pursued economic growth strategies that link action on climate change mitigation to new economic opportunities. Amidst the diversity of policy seen in these and other green growth strategies, two dimensions appear particularly critical. *First*, a country's choices on energy policy in particular derive from a set of idiosyncratic national goals – whether for energy security and independence, reliability, affordability, emissions reduction or other goals. *Second*, those goals are viewed through the lens of a country's domestic resources, natural or otherwise. For example, as Zysman and Kelsey[16] make clear, the sharp contrast between China and Denmark reflects sharply different priorities.

"Denmark's core problems and objectives have to do with: (1) ensuring predictable availability of energy at an acceptable long-term cost, ideally by achieving energy independence; (2) driving economic growth; and (3) lowering emissions. Choosing to make green industry a core of Denmark's economy – and choosing to structure its economy and infrastructure to take full advantage of this industry – creates a unified solution to all of Denmark's problems.

China, by contrast, needs to do the following: (1) achieve massive, near-future increases in energy availability; (2) continue growing economically at a rapid rate; and (3) very much secondarily, deal with a growing particulate emissions problem. Moreover, it is well-endowed with coal, a cheap-but-dirty energy source. Given the current state of technology, these objectives mandate both green technology and brown growth. Denmark's solution would not solve China's problems."

Amidst the diversity of strategies, instruments and goals, however, we find commonality in the political requirements for creating a stable foundation for green growth. That foundation requires a deal between industry and those who would advocate significant transformation of the energy system. Sometimes those advocates will be

15 E. Patashnik: Reforms at risk: what happens after major policy changes are enacted, Princeton 2008, Princeton University Press.

16 J. Zysman, N. Kelsey (eds.): The Green Growth Economies Project, Part Two: Country Cases and Analysis, prepared for the Mandag Morgen Green Growth Leaders Forum, 2011.

environmental or energy consumer groups, as in California or Colorado. In others, as in the case of Korea, the advocates will include or be led by government strategists concerned with security – either energy security in a narrow sense, or national security more broadly – or with finding the basis of a new trajectory of economic growth. No matter where the initial impetus comes from, however, the energy system transformation cannot be sustained by environmental consciousness alone. Rather, it requires a broader deal that brings economic interests inside the coalition in favour of a low-carbon energy systems transformation. And the process of building and sustaining that coalition will necessarily require a multifaceted policy approach.

Conclusions

Today, green growth remains largely "religion". Governments pursuing it have done so either as a justification for environmental policy, or on the basis of faith in a new approach to industrial development. But the opportunities that appeared in past instances of large-scale technological transformations have yet to materialise in this one, and appeals to short-term job creation or export-led growth face limits of their own making. Thus the potential for "green growth" lies in the discovery, rather than exploitation, of whatever opportunities low-emissions technology may hold for broader patterns of economic activity.

There are three significant implications of our argument:

- first, with limited resources, policymakers should seek points in the energy system where limited interventions can change the trajectory of development, by altering the choices of actors throughout the system;
- second, enduring economic and political success in a green energy-led systems transformation can only come from the possibilities it would create for the broader economy;
- third, achieving this transformation will require a complex set of offsetting deals, and an array of policy instruments, capable of compensating those discomfited or disadvantaged while allowing market incentives to induce the enormous private investments required.

At such an early juncture we cannot presume to know whether a green growth "reality" will emerge. We can, however, identify the shortcomings of today's faith-based arguments for green growth, and anticipate what a durable green growth strategy would require of firms, consumers and governments. Moving green growth from religion to reality will, we argue, require a technological and economic transformation akin to those of the emergence of steam, rail or information technology. That transformation will not come through a focus on one technology or another, nor through reliance on short-term job creation, nor from abstract appeals to economic efficiency. Rather, it will require attention to the restructuring of the energy system as a whole, the opportunities present in the transformation for widespread economic activity, and the role that policy must play in structuring and facilitating that systems transformation.

Arno Behrens and Bert Colijn

The Socio-Economic Transition towards Sustainability and its Impacts on Jobs in Europe

At the 1992 UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, 178 governments adopted the Agenda 21, an agenda aimed at promoting sustainable and environmentally sound development on the global level. In 1992, there was widespread consensus that economic development and environmental protection need to go hand in hand and that local, national and global strategies are required to provide economic growth while halting and reversing the effects of environmental degradation. However, 20 years after UNCED in Rio and despite broad recognition of, and commitment to, the principles of sustainable development, "action has not moved beyond the margins and certainly has not led to the core changes needed to support a transition to sustainable development".[1] Although such a transition might generally be regarded as desirable, there is still a lack of highly organised societal driving forces and the transition towards a more sustainable society "is more a matter of reason than of passions, and certainly does not yet appear to be the logical and inevitable next stage".[2] While there has been some progress in terms of poverty alle-

1 J. Drexhage, D. Murphy: Sustainable Development: From Brundtland to Rio 2012, Background paper commissioned by the Panel secretariat, Highlevel Panel on Global Sustainability, New York 2010, United Nations, p. 1.

2 M. Fischer-Kowalski, H. Haberl (eds.): Socioecological Transitions and Global Change, Advances in Ecological Economics, Cheltenham, Northampton 2007, Edward Elgar, p. 7.