Introduction: Factor 5 – The Global Imperative

By Ernst von Weizsäcker

At the Crossroads

The human race is poised at a time before great change. At no time in history have we been faced with a greater challenge. We have been so successful in developing our knowledge and skills that we have created untold wealth and material prosperity - prosperity that could only be dreamed of 100 years ago. The electrical and digital revolutions accelerated this progress to the point now that the human race covers much of the habitable land on the planet and harnesses resources from all its four corners. The world's innovators at the time could barely glimpse the world they were contributing to build, let alone the impacts that this new world might have on the environment. In the 21st Century, we stand at a cross road, where the size of the impacts from our global community is now rivalling the size of our home's ability to cope.

Responding to growing concerns of this in earlier days, environmental policy was enacted and was focused on saving the environment for our grandchildren to enjoy parks, animals and coral reefs, and to secure healthy air and water. However, today it is about rescuing the environment and preserving it as the basis of life as we know it. As our communities have grown and developed so too has the pressure on the environment; pressure for ongoing supply of resources such as oil, food, water, metals, and pressure to assimilate growing amounts of waste, pollution, and greenhouse gases. The 21st Century will mark the time when the impact of its human inhabitants will have the potential to destroy its ability to support us. If the world we live on was three, or three hundred, times larger we would not be writing this book. The truth that the world is now rapidly coming to grips with, is that we are damaging our planet to the point that it may not be able to maintain the conditions we have come to take for granted.

The 21st Century will see monumental change. Either the human race will use its knowledge and skills and change the way it interacts with the environment, or the environment will change the way it interacts with its inhabitants. In the first case we would use the sophisticated understanding in areas such as physics, chemistry, engineering, biology, commerce, business and governance that we have accumulated in the last 1,000 years to bring to bear on the challenge of dramatically reducing our pressure on the environment. The second case however is the opposite scenario. It will involve the decline of the planet's ecosystems until they reach thresholds where recovery is not possible. Following this we have no idea what happens next. If the average temperature of our planet's surface increases by 4-6 degrees Celsius we will see staggering changes to our environment, rapidly rising sea level, withering crops, diminishing water reserves, drought, cyclones, floods. Allowing this to happen will be the failure of our species, and those that survive will have a deadly legacy. In this book we support the many recent calls from leading governments to achieve 80 per cent

reductions in environmental pressures and provide a reasonable and realistic approach to reach this target by 2050, leading to and requiring already profound innovations across industries, across communities, and across cultures.

The results of the 2006 *Stern Review* of the economics of climate change[1] provides a glimpse of what is coming upon us regarding global warming. Business-as-Usual (BAU) - that is, a continuation of growth trends from the past without any serious decoupling of growth from carbon dioxide emissions - will lead to doubling annual emissions compared with the amounts from 2000. If we are able to stabilise CO_2 concentrations at 450 parts per million (ppm), we would have to reduce annual emissions by 50 per cent at least, which is a factor of 5 less than the BAU scenario. Even this extremely ambitious trajectory will not prevent some additional global warming in the range from 1 to 3.8°C. Coming to grips with this situation may require more capacity than our communities possess. Responding to the challenges now faced may require more understanding than our professions possess. And admitting that change is needed, and needed fast, may require more humility and courage than our typical national leaders possess; legally speaking, they are accountable to their respective national constituencies, not to the Earth.

The purpose of this book is not to repeat the litany of problems that face us. This has been thoroughly and rigorously presented in a number of recent works by UNEP, OECD, the IPCC,[2] and individual authors such as Lester Brown,[3] Al Gore,[4] and David Suzuki.[5] Nor is the purpose of this book to depict economic growth as the inevitable reason for destruction, as has been the motto of Edward J. Mishan,[6] and much of the *Limits to Growth*[7] debate of the 1970's. Nor is it our purpose to decry capitalism as the ultimate evil, as has become fashionable in our days after the deep dive the world economy took since the second half of 2008. But we surely join critics of capitalism to a certain extent – as some features of deregulated financial markets have been disastrous and demand careful re-regulation. What's more, in the context of the ecological state of the world, there is a need for regulation to prevent capital from investing in destructive industries and instead encouraging investment in value creating activities conserving natural treasures. The purpose of this book is to inspire hope. It is not good enough simply to present a highly theoretical picture of how technology could save the world. Instead we want to present practical pictures of whole systems of technologies, infrastructures, legal rules, education, and cultural habits interacting to produce economic progress while conserving a healthy environment. Virtually all the strategies outlined in this book can be applied now by nations, companies and households to achieve Factor Five. This 'whole system approach' will also help overcome the *rebound effect* of

[1] Stern, N. (2007) *The Stern Review: the Economics of Climate Change*, Cambridge University Press, Cambridge.
[2] UNEP = United Nations Environment Programme, OECD = Organization for Economic Cooperation and Development; IPCC = Intergovernmental Panel on Climate Change.
[3] Brown, L. (2008) *Plan B 3.0: Mobilizing to Save Civilization*, W.W. Norton & Company, New York.
[4] Gore, A. (2006) *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It*, Rodale Press, Emmaus, PA, USA.
[5] Suzuki, D. and Gordon, A. (1991) *It's a Matter o f Survival*, Harvard University Press, US; Suzuki, D., McConnell, A. and Mason, A. (2007) *The Sacred Balance*, Douglas McIntyre, Vancouver.
[6] Mishan, E.J. (1967) *The Costs of Economic Growth*, Staples Press, London.
[7] Meadows, D., Meadows, D., Randers, J. and Behrens, W. (1972) *The Limits to Growth: A Report to the Club of Rome*, Universe Books, New York.

additional consumption gobbling up all technological efficiency gains that were meant to save resources and conserve the environment.

To fill this message with real world substance, we present numerous examples of resource productivity improvements from the most relevant sectors, showing that the said Factor Five, or 80 per cent, reduction of environmental impacts per unit of economic output, is available. This multifaceted universe of opportunities represents the core body of our book.

While we strongly advocate for significant improvements in resource productivity, we add, however, that there will also need to be consideration of aspects related to *sufficiency* (discussed in Chapter 11). We shall need some rules of constraint or insights into other forms of satisfaction than the maximisation of monetary throughput, or GDP. Relating to capitalism and regulation, we repeat and support my understanding from some twenty years ago that '*communism collapsed because it was not allowing prices to tell the economic truth, and that capitalism may also collapse if it does not allow prices to tell the ecological truth*'. Markets are superb at steering an efficient allocation of resources and stimulating innovation, but they don't provide public order and law, moral standards, basic education, and infrastructures, and markets are miserably inefficient, often even counterproductive, when it comes to protecting the commons and steering innovation into a long term sustainable direction. Human societies, and the environment, will need a healthy balance between public and private goods, or between the state and the markets, as suggested in Chapter 10. The mindset dominating much of the world during the past couple of decades of weakening and ridiculing the state, was gravely mistaken. We do need strong states and engaged citizens working together to create good legal and moral frames for the markets. Moreover, citizens, nation states, and the international communities of states and of citizens are expected permanently to act on those markets, as consumers, innovators, workers, and guardians against destruction and for technological and civilisational progress in harmony with the conditions of nature.

Whether we want it or not, we are in the midst of highly political issues when getting serious about protecting and restoring the basis of life on Earth.

Balancing Economic Aspirations with Ecological Imperatives

Balancing private with public goods means to a large extent balancing economic aspirations with ecological imperatives, and during early human history, there has been no visible evidence of such balancing. The environment seemed endless, for all practical purposes, and was often seen as hostile. Human civilisation developed by taming wild parts of nature and harnessing the powers of nature to extract some of the natural treasures and resources. Economic survival and the increase of welfare seemed like the natural mission and mandate for humanity, with impacts on the environment remaining a negligible affair. Even during early industrialisation, until as late as the 1960s, environmental impacts of economic activities looked mostly like local and peripheral concerns - a steel mill, a chemical plant, a textile dye factory here and there. A small power plant to supply the energy needed for factories caused local air and water pollution and local health problems, but the environment as such, outside

the cities, was not seen as affected. It was not until the 1960s, when human population was approaching 4 billion people that 'the environment' became a major political issue.

Overcoming some initial resistance on the part of industry, democratic states such as Japan, the USA and Canada, and the West European states initiated and adopted pollution control legislation, with muscles to enforce the law - and it worked. The cleaning of industry made rapid progress. Banning a few particularly unhealthy substances, filtering exhaust gases and purifying waste waters, and finally redesigning some processes were the means of decoupling industrial outputs from polluting nuisances. After a mere 25 years, the foam hills on rivers had disappeared and the industrial agglomerations, such as the Ruhr in Germany, Osaka in Japan, or Pittsburgh in the USA got cleaner than they had been for a hundred years. This success story surprised many sceptics who had seen the cause of the problem as economic growth as such. The lesson from pollution control seemed even to reverse such earlier fears: it was the rich, and further growing, democratically organised countries, or regions inside countries, which were the most effective in cleaning their environment, leaving the dirt to the poor and to the non-democratic societies. A very attractive new paradigm emerged - the Kuznets curve of pollution, shown in Figure 1, whereby countries having the economic maturity and financial means to deal with pollution control would engage in this agenda and move towards a wonderful harmony of 'rich and clean'.

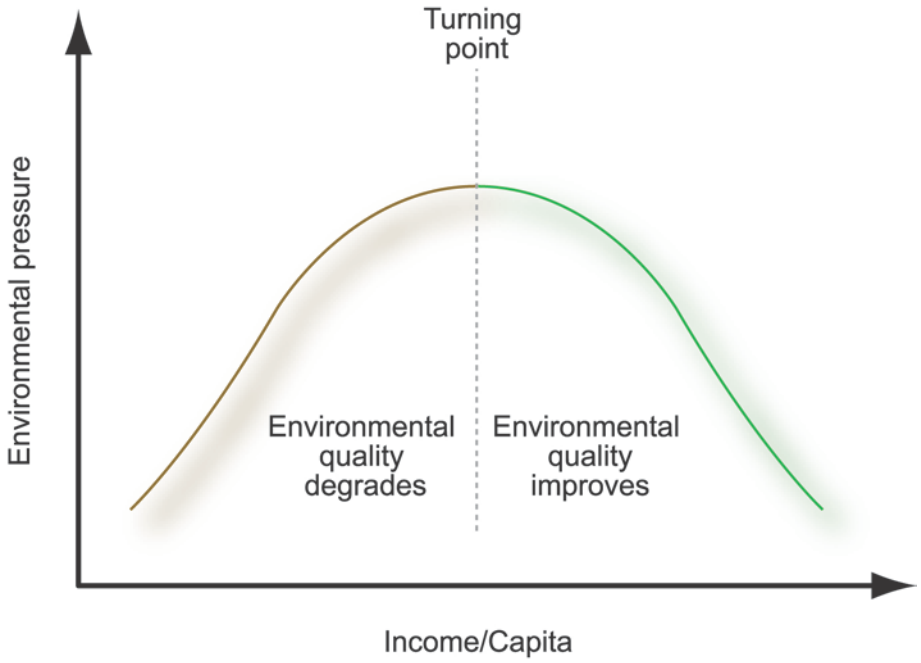

Figure 1 *Stylised Kuznets Environmental Curve*

(*Note: The historic development is typically from left to right, meaning that countries start poor and clean, then they industrialise to be come rich and polluted, until they are so rich that the can afford strict pollution control so that they end up rich and clean.*)

Source: Based on Grossman, G. and Krueger, A. (1991)[8]

[8] Grossman, G. and Krueger, A. (1991) *Environmental impacts of a North American free trade agreement*, National Bureau of Economic Research Working Paper 3914, NBER, Cambridge, MA.

During the 1980s, this convenient paradigm began to dominate the debate about the mutual relation between economic aspirations and ecological imperatives. It became perfectly respectable even for environmentalists to say: 'let the economy grow and take care of environmental concerns later'. Understandably, this attitude became the standard frame of mind of the leaders and representatives of developing countries in all international environmental negotiations. And the rich countries of the North had little to put against this view, as well as having no intention to contradict anyway.

Alas, the Kuznets curve paradigm does not work for the global environmental problems of our days. Pollution control is actually a very restricted part of environmental reality. Impacts such as climate change, resource shortages, and biodiversity losses follow a completely different logic from pollution control. In reality, it is the 'rich and clean' countries that are the biggest cause of such impacts. Carbon footprints so far relentlessly grow with increasing prosperity. The situation gets much worse for the rich if historical carbon emissions are also counted. The per capita cumulated carbon dioxide load from the US is about 1,000 metric tons, in China it is about 60 metric tons, in India 25, in Germany nearly 800.[9] Figures get still somewhat worse for the rich countries if world-wide supply chains are considered as well. Many countries have out-sourced the energy and carbon intensive segments of the supply chain to countries like China, which thereby got ever larger carbon footprints in the service of others.

In any case, the strong correlation between carbon footprints and GDP led many people in the USA as well as in the developing countries to believe that reducing carbon dioxide emissions was tantamount to reducing economic welfare and was therefore politically unacceptable. The most convenient way of dealing with that situation was, of course, denying that there was any scientific proof of global warming or of human causes for additional warming. Fortunately, that's the past, at least as regards the attitude of the US government. But the challenge remains to find a new and healthy balance between economic aspirations and ecological imperatives. Addressing global warming is the most prominent aspect in our days of ecological imperatives. But biodiversity protection is no smaller challenge. Biodiversity losses result mostly from land-use changes, and these usually occur in the service of more production, i.e. more economic growth. The most commonly used measure for land-use in the service of consumption is 'ecological footprints', which estimates the land required for specific goods or services, or for the standard of living of average citizens of different countries. US (or European) footprints include land areas abroad that are needed for goods and services consumed at home. Bananas from Ecuador, copper from Chile, palm oil from Malaysia, and the life cycle footprints caused by computer manufacturing in China, all count towards the European footprints to the extent that Europeans consume bananas, copper, palm oil, or computers. It is therefore not surprising that ecological footprints tend to be biggest for the rich, as can be read from Figure 2.

[9] World Resources Institute (undated) 'Earth Trends Portal: Cumulative CO_2 emissions 1900 – 2004', http://earthtrends.wri.org/searchable_db/index.php?theme=3&variable_ID=779&action=select_countries, accessed 30 May 2009.

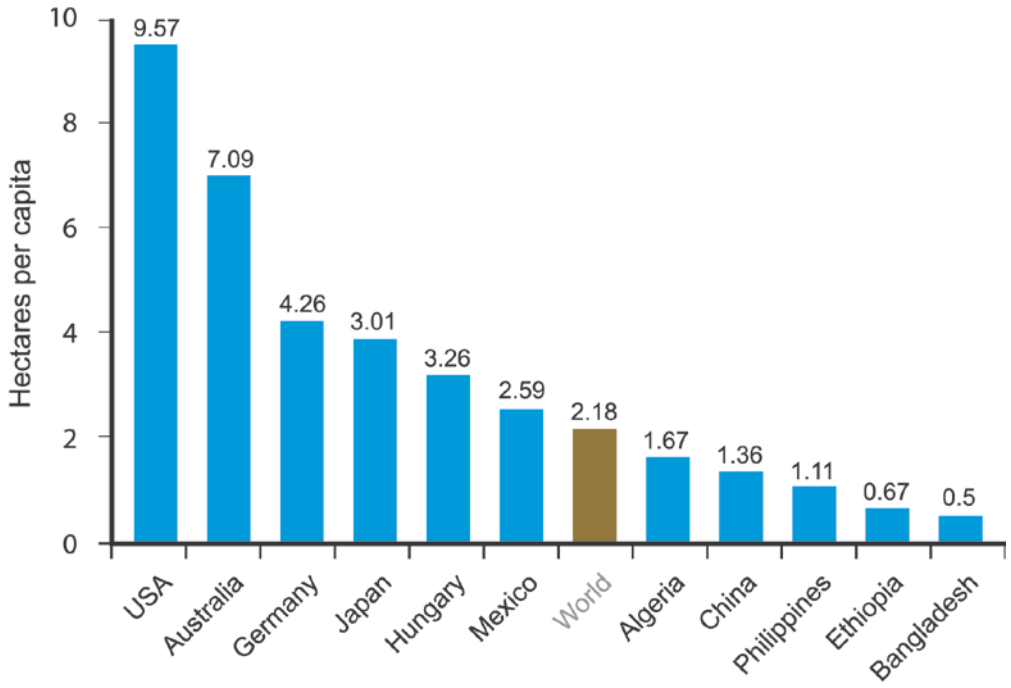

Figure 2 *Ecological footprints of different nations*

Source: Courtesy of Mathis Wackernagel, Global Footprint Network

On our invitation, Mathis Wackernagel and Kristin Kane explain further,

> *Humanity's Ecological Footprints have grown too large. According to research by the Global Footprint Network, since the late 1980s humanity's Footprint has exceeded the world's estimated bio-capacity. The Ecological Footprint is a measure of the biologically productive area (or biocapacity) a human population requires to produce the resources it consumes, and absorb its wastes, using prevailing technology. Populations with a Footprint larger than the regenerative capacity of their region run ecological deficits. If humanity uses more ecological services than what nature can replenish, humanity is in global overshoot.*
>
> *To know our demand on the biosphere, as well as how much of the biosphere's biocapacity is within our region, we need to measure our use of nature. We need resource accounts that keep track of how much nature we have, and how much we use. Ecological accounting operates like financial accounting: it tracks income (the ecological services nature provides) and expenditures (human use of these ecological services). As with financial assets, it is possible to spend more than is being regenerated. But this is possible only for a limited period of time. Continued ecological deficit spending leads to environmental bankruptcy, eroded economies, decreased quality of life and societal instability.*
>
> *We obtain our resources from forests, cropland, fisheries, and grazing land, and other ecosystems. Additionally, ecosystems absorb and assimilate the wastes we produce as a result of our resource consumption. The Ecological Footprint adds up these ecosystem services in terms of the biologically productive areas needed to provide the services. In other words, Ecological Footprint analysis builds on a mass flow balance,*

and each flow is translated into the ecologically productive areas necessary to support these flows. The largest and most dramatically growing component in the footprints is the 'Carbon Footprint'. This is the land needed to absorb the excess carbon dioxide from burning fossil fuel. Since it is such a large component of the overall Footprint, the Carbon Footprint is getting currently most attention. However, reducing the Carbon Footprint at the cost of increasing other Footprint components, as in the case of many first-generation biofuels, may lead to a net-loss, not a gain.

Global Footprint Network's latest estimates conclude that humanity's demand in 2005 exceeded the regenerative capacity of the planet by about 30 percent. This means, humanity is in ecological overshoot. Per person, the biosphere offers about 2 global hectares of biologically productive space. Global hectares are hectares with world average productivity, relating to the productive quarter of the world's surface – the rest is deserts, ice fields, and deep oceans. The average US Footprint is roughly ten global hectares per person, the average Indian Footprint is nearing one global hectare per person. In other words, it would take about five planet Earths if all humanity adopted American lifestyles, or about half the Earth's capacity if all lived like the average Indians.

A Global Green New Deal

The second half of 2008 marked the beginning of the biggest economic downturn in 70 years. The economic crisis, which is on everybody's mind, is likely to be felt for another couple of years, at least. Millions have lost their jobs already, and many more are in danger of losing it.

Many countries reacted by launching massive packages of economic stimuli. Fortunately for the environment and for the long term durability of measures, most countries allowed for a considerable environmental emphasis within the packages. HSBC, the London based international bank, has done a survey of those 'green' components. On average, more than 10 per cent of the money appears to be committed to environmentally friendly activities. In South Korea, that share is above 80 per cent. Figure 3 shows the result of the survey. Doubts as to the legitimacy of the expenditure are allowed if HSBC's criteria for 'green' were strict enough, but it is clear that some countries, notably South Korea, China, France, Germany, and the USA tried to use the packages for moving the economy in the direction of a healthy environment.

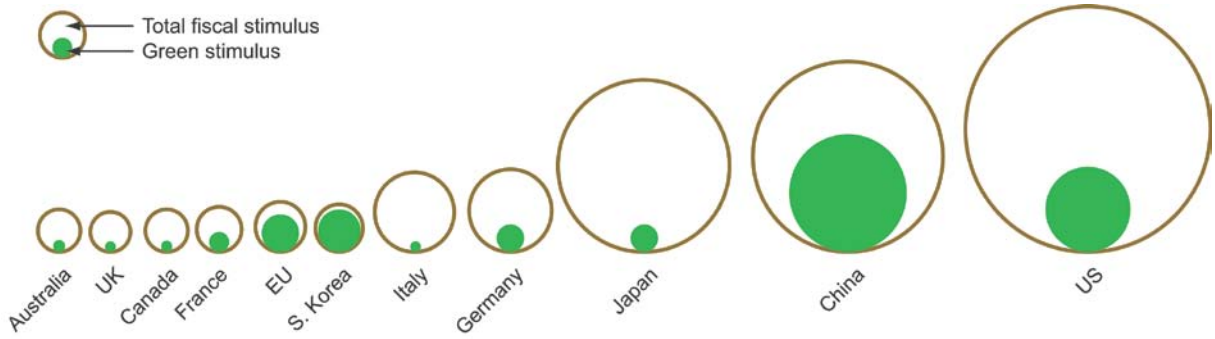

Figure 3 *Eco-friendly components of fiscal stimuli 2008/2009*

Source: Based on data from HSBC

HSBC has undertaken a thorough analysis of the stimulus packages of 17 nations in order to learn what types of public and private green investments produce the highest economic multipliers.[10] It found that most investments in a low-carbon economy led to strong economic multipliers, with the highest of those multipliers being building for energy efficiency, renewable energy technologies, low-carbon vehicles, rail transport, and finally 'smart' grid and 'smart' meters. It is worth noting that South Korea's stimulus package, and most other nations stimulus packages focus on sectors of the economy that are presented in Part 1 of this book – namely green buildings, ultra-efficient green cars/trains and bikes, green infrastructure, and recycling. Thus Part 1 is designed to assist nations like South Korea ensure they achieve the maximum resource productivity improvements from their investments. For example, South Korea's stimulus package includes the following:

- *Housing*: US$6 billion for a) the construction of 1 million green homes, b) energy efficiency upgrades for 1 million homes, c) energy conservation improvements in villages and schools, and d) the installation of LED lighting in public facilities. Chapter 2 provides a detailed overview of how to improve energy productivity in this sector and how to design green homes.
- *Cars*: US$1.8 billion towards the development of fuel-efficient vehicles, such as electric and hybrid cars, by automakers Hyundai and Kia. Resource efficiency opportunities for this sector are covered in the opening section of Chapter 5.
- *Trains and bikes*: US$7 billion for a) the expansion of electrified rail tracks, b) the construction of new high-speed rail links, and c) the construction of more than 4,000 km of bicycle paths. South Korea and other nations can learn from best practice case studies of what other nations are doing in this area in Chapter 5.
- *Water*: US$11.1 billion for river restoration and water resource management. Chapter 4 features an in depth analysis of how to achieve Factor 5 improvements in resource productivity in the agricultural sector which will help South Korea and other nations enable more water to be returned to rivers to restore environmental flows and river ecosystems. The remaining chapters in Part 1 all show how to achieve Factor 5 water

[10] Robins, N., Clover, R. and Singh, C. (2009) *A Climate for Recovery – The Colour of Stimulus Goes Green*, HSBC Global Research, London.

efficiency improvements and thus demonstrate also how cities can reduce their water usage as well. Improving water efficiency in irrigation, residential and commercial buildings, and industry also reduces the amount of energy needed to pump the water or heat it. Part 1 shows that there is a strong energy/water nexus across all major sectors of the economy.

- *Forestry*: US$1.7 billion for a) forestry management, including tree planting to increase carbon sink capacity, and b) the construction of new facilities that use wood as biomass energy. Chapter 3 overviews advances in the pulp and paper industry along with Chapter 4 which investigates the agricultural opportunities for energy generation.
- *Recycling*: US$670 million for resource recycling, including the construction of electricity plants that run on the methane emissions generated from incinerating rubbish. Recycling to achieve greater materials efficiency is a critical strategy to enable many energy intensive industries to also achieve Factor 5 energy productivity gains. The in-depth sector studies in Part 1 look at ways to increase recycling levels and use more recycled materials as feedstocks in those sectors to simultaneously achieve large energy and material resource productivities. Part 1 also shows that there is a strong energy/materials productivity nexus in most sectors.

The South Korean government believes that such investments will drive economic growth and help position South Korean companies at the forefront of the next wave of innovation – the green economy. South Korea is also aiming to become the home of the world's first 'smart national grid', which uses information and communication technology to maximise electricity transmission efficiency. However, on the whole, such stimulus packages by definition will be temporary measures, and their environmental components are likely to be considerably smaller than 1 per cent of the GDP. What can be done to create a more lasting environmental effect? One proposal tries to answer this question, namely to call all the new public debts 'climate debts' and to enter political commitments of repaying the debts by raising energy taxes or auctioning carbon emission permits. This proposal was first published by Jakob von Weizsäcker.[11] His expectation is that such commitment would serve as a long lasting signal of making climate endangering energy consumption economically less attractive.

We are arguing in this book that the world will have to move on to a green economy anyway, irrespective of the momentary financial crisis. We therefore fully support the idea articulated by UNEP's Executive Director, Achim Steiner, of a 'Global Green New Deal'. Obviously, the idea alliterates Franklin D. Roosevelt's New Deal of the early 1930's which helped pull the USA out of the deep depression that unfolded after Wall Street's collapse of October, 1929. The idea of a Green New Deal is to spend public money to create jobs for the public good of a sustainable environment. And the Global Green New Deal is meant to co-ordinate the most important economies of the world to give the Green New Deal sufficient impetus and volume. National commitments of the kind shown in Figure 3 are still much too timid, with the notable exception of South Korea. We assume that the world has too little confidence so far in the

[11] von Weizsäcker, J. (2009) 'Greening the Debt', Op-Ed Contributer, *International Herald Tribune*, 15 April, 2009.

opportunities lying in a new green technological revolution. We obviously hope that this book will help create strong additional confidence in this regard.

There is wide spread confidence that eventually the financial crisis will come to an end. Some key ingredients are there for a new economic upswing. Demand is almost unlimited, notably in the developing countries, but even in the rich and seemingly saturated countries, demand is still on the rise: for education, health, personal care, and entertainment. Labour, capital and technologies are also there to satisfy such new demand. Reassuring signs come also from politics. The G20 Summit in London in April, 2009 showed a new sense of partnership among the most economically significant countries of the world. Some first steps were made to re-regulate financial markets, which had gone wild. And the erroneous dreams of perfectly self-stabilising markets and of a weak state have come to an end.

What seems to be missing is a clear sense of direction. It was there in earlier centuries when prosperity growth with little regard to the environment was the guiding philosophy nearly everywhere. There were technological breakthroughs from time to time, spurring growth and creating a sense of excitement. Those breakthroughs included the steam engine, railways, electricity, cars, chemical technologies, radio and TV, and, most recently, IT, biotechnology and nanotechnology. Also the globalisation of industrial supply chains can be seen as a breakthrough, notably in terms of keeping consumer prices down. However, there are signs of fatigue with this kind of progress as it hits its natural limits. For the world economy to find its way back to healthy and robust development, a new and reliable sense of direction will be needed. Providing this new sense of direction is the basic motive both of the Global Green New Deal and of our book. We suggest that we are at the dawn of a new long term cycle, a new 'Kondratiev Cycle', or wave of innovation.

Kondratiev Cycles[12]

During a time of recession, commentators often speak about, and hope for, the 'next upswing'. Usually it is the short kind of business cycles people have in their minds. But there are also long term cycles, every 30–50 years, which can be attributed to major technological innovations, such as the ones mentioned above. Although standard economic literature does not necessarily accept the idea of long term cycles, they have been a useful way of describing, characterising and perhaps even explaining historical periods that are associated with technology driven major economic upswings. The best known early scholar to describe such long term cycles was the great Russian economist Nikolai D. Kontratiev (1892 – 1938).[13] His pivotal book was called *The Major Economic Cycles* and was published in 1925.[14] Kondratiev himself had no strong emphasis on technological change, but Joseph Schumpeter, the famous

[12] This subchapter and the next two summarise deeper discussions on technologies and long term cycles presented by Hargroves, K. and Smith, M. (2005) *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century*, Earthscan, London, The Natural Edge Project, Australia, Chp 1, Chp 6 and Chp 13.

[13] Jacob an Gelderen and Samuel de Wolff are the two Dutch economists who proposed long term cycles as early as 1913, but their work, written in Dutch, remained unknown to N. Kondratiev, J Schumpeter and others and was translated into English only recently.

[14] Kondratiev, N.D. (1925) *The Major Economic Cycles* (Russian), Translated and published in English as Kondratiev, N.D. (1984) *The Long Wave Cycle*, Richardson & Snyder, New York. See also Kondratiev, N.D., Wilson, S. and Makasheva, N. (1998) *The Works of Nikolai D. Kondratiev*, 4 Volume set, Pickering and Chatto, London.

Austrian and later American economist, saw business cycles and long term cycles as associated with major technological innovations. It was Schumpeter himself who suggested honouring Kondratiev (killed in 1938 by Stalin's 'Purge' firing squads), by calling the long cycles 'Kondratiev Cycles'. Paulo Rodriguez Pereira gives a crisp account of the long cycle discussion, with some emphasis on what it means for developing countries.[15] Referring to Joseph Schumpeter, Christopher Freeman and Carlota Perez, Pereira says that Kondratiev cycles are not an exclusive economic phenomenon but result from a reorientation of industrial organisation and management, based on, '*technologies that underlie the existing economic cycle. Kondratiev cycles are thus associated with major technical changes*'.[16] From this observation, he also derives the need for developing countries to strengthen their technological capacities.

In line with such a 'Schumpeter-Freeman-Perez' paradigm of waves, Pereira describes the five familiar historical cycles as:

1. The early mechanisation cycle, since the 1770s
2. The steam power and railway cycle, since the 1830s
3. The electrical and heavy engineering cycle since the 1880s
4. The Fordist and mass production cycle since the 1930s (although he could have given an earlier start for that one), and
5. The information and communication cycle since the 1980s (he could have added biotechnology to the description)[17]

Our point is that, according to historical evidence since Kondratiev's pivotal work, the magic of technological innovations tends to fade after some twenty to thirty years of its beginning. So it may not be too surprising that even the most exciting recent wave of innovations in information technology, bio-technologies and, somewhat more recently, nanotechnologies, is no longer strong enough to support world-wide economic growth.

[15] Pereira, P.R. (1994) 'Chapter 13: New technologies - Opportunities and Threats', in Sagasti, F., Salomon, J.J. and Sachs-Jeantet, C. (eds) *The Uncertain Quest: Science, Technology, and Development*, UNU Press, New York.
[16] Pereira, P.R. (1994) 'Chapter 13: New technologies - Opportunities and Threats', in Sagasti, F., Salomon, J.J. and Sachs-Jeantet, C. (eds) *The Uncertain Quest: Science, Technology, and Development*, UNU Press, New York, p2.
[17] Pereira, P.R. (1994) 'Chapter 13: New technologies - Opportunities and Threats', in Sagasti, F., Salomon, J.J. and Sachs-Jeantet, C. (eds) *The Uncertain Quest: Science, Technology, and Development*, UNU Press, New York, pp4-6.

The New Cycle will be Green

Fading excitement with certain technologies would not yet make for a massive – and sudden – economic downturn. The arrogance and failures of much of the financial sector was the obvious cause of the present crisis. But if we want the economy to gain strength again, an exciting new wave of technologies might be the biggest hope for the world. A couple of years before the present crisis, Paul Hawken, Amory Lovins and Hunter Lovins, in *Natural Capitalsm,* also summarising the theory of long term cycles, came up with the suggestion of a new industrial revolution unfolding, with energy and resource efficiency at its core.[18] Building on from this pivotal work, Charlie Hargroves and Michael Smith from The Natural Edge Project, and co-authors of this book, suggested in their 2005 book, *The Natural Advantage of Nations,* that the emerging wave of green technologies could be seen as the beginning of a new Kondratiev Cycle and offered the following optimistic picture for it:

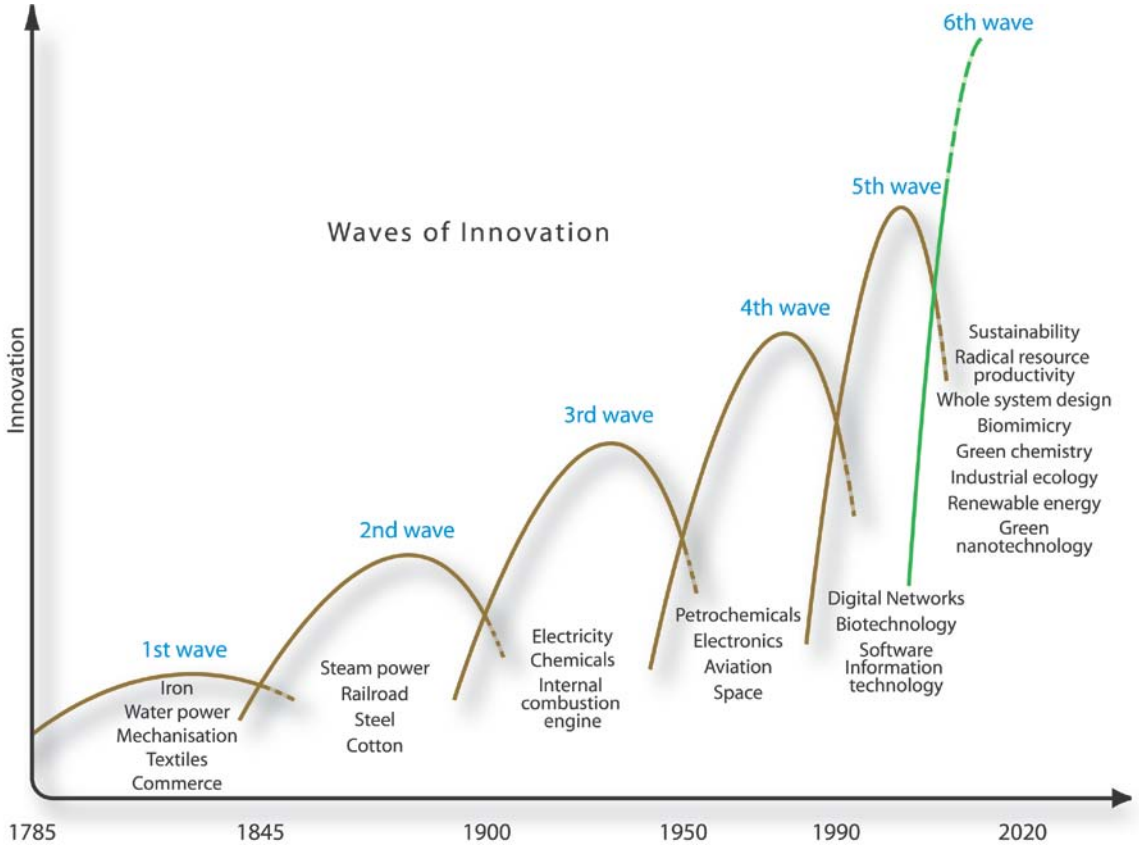

Figure 4 *Waves of Innovation*

Source: Courtesy of The Natural Edge Project[19]

As we have observed before, some greening of technologies and the economy is already underway. We do suggest that the process of greening, being the logical answer to the environmental constraints, will generate the new and reliable sense of direction that could pull us out of the recession. For this to happen, some additional momentum will be highly desirable. If the conviction spreads that the greening trend is inevitable and can take the shape

[18] Hawken, P., Lovins, A. and Lovins, L.H. (1999) *Natural Capitalism: Creating the Next Industrial Revolution*, Earthscan, London.
[19] Hargroves, K. and Smith, M.H. (2005) *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century*, Earthscan, London, The Natural Edge Project, Australia, pp39-42.

of a full-size Kondratiev Cycle, we are confident that the desired momentum will come. Investors then have clarity about where to put their bets.

Reflecting on the ingredients for a big new cycle, we seem to discover three that can be identified in each of the earlier Kondratiev cycles.

1. One ingredient, as we said, seems to be the loss of magnetism of the technologies that characterised the former cycle. Such was the case with the railroads around 1900. The discoveries and innovations of electricity, the internal combustion engine, and chemical technologies created a lot more excitement at the time than a further expansion of the railway network would have done. Thomas Edison, Gottlieb Daimler and Henry Ford, and European chemical innovators and entrepreneurs became the heroes of a new wave of growth and innovation. The next wave, characterised by petrochemicals, aviation, and early electronics, was generated almost entirely in the United States – but later also fertilised the Old World, including the Soviet Union. It was triggered, in part, by the fading excitement with classical electrical and chemical engineering.
2. Another ingredient for a new wave is strong demand for new products and services. It should be noted, however, that much of the demand may be sleeping in the early phase of the new wave. Perhaps the best example for that has been information technology. Mainframe computers did not look like they would be useful to everybody. Electric typewriters, copiers and printers were widely used but did not spell excitement. TVs became wide spread as well, but nobody associated them with computer screens or data processing. The miniaturisation of electronics to save weight for spaceships and air planes remained an ‘outlandish’ affair. However, when computers, typewriters, TV screens and miniature electronics merged into the desktop computer technology, a whole new universe of applications and demand was awakened. Endless waves of software development, breath-taking advances in further miniaturisation, and finally the development of the Internet and of search machines made IT a seemingly non-ending success story, constantly creating its own additional demand. Also, earlier technological waves met with moderate demand at the beginning, but more demand germinated and blossomed as supplies got ever more affordable. This was surely the case for textiles, railroads, strong machinery, automobiles, chemical plastics, fertilisers and machinery for the farm, pharmaceuticals and diagnostics, electric appliances, air travel, and industrial robots. And mass manufacture, explicitly mentioned by Rodriguez Pereira for the fourth Kondratiev cycle, clearly made goods more affordable and thereby stimulated demand that was unimaginable at the beginning of the cycle.
3. The third ingredient for a new big wave is perhaps the most visible: the invention and development of exciting new technologies - the steam engine, the internal combustion engine, chemical plastics, aircrafts, the TV, uranium fission, penicillin, the laser, home computers, and centralised data storage and search engines, were all celebrated as scientific inventions or technological breakthroughs. But hundreds of other inventions were also made without having big economic impacts.

So we suggest that much of the dynamics leading to a Kondratiev cycle comes from a combination of the three major ingredients: fading excitement with old technologies, rising demand for and affordable supplies of the new goods and services, and indeed some exciting new technologies. At any rate, we feel that all three ingredients are there for the launching of a very major new wave of innovation, the Green Kondratiev Cycle, or the 6th Wave of Innovation. In this case we suggest that the strongest pull factor is demand. A world population almost twice the size of the time of the last big cycle wants food, shelter, and huge amounts of additional goods and services, and all under conditions of decreasing or stagnating supplies of energy, water, land, and minerals. The greenhouse effect greatly exacerbates the problem by further reducing energy and farming options. Some fatigue can be observed also with the old technologies notably inasmuch as they are seen as destructive to the environment. Even IT and biotechnology are experiencing some signs of saturation. IBM, one of the most successful companies in the modern high tech world, sold their computer manufacturing to China. And Silicon Valley in California, the cradle of the IT revolution, is shifting its attention to green technologies. Biotechnology companies try to prove their usefulness by offering drought resistant crops or energy saving microbes for washing and cleaning. Nanotechnologies came into lots of controversies and legal questions[20] and are in need of proving their usefulness for resource saving technologies as well. What is more, and this is the core of our book, is the availability of a wide range of fascinating new technologies promising to be roughly five times more resource efficient than those still dominating industry, households, and the service sector. So we do not hesitate to call for and promote a new green Kondratiev cycle.

This vision is actually closely related to Thomas Friedman's line of thinking in his brilliant 2008 bestseller *Hot, Flat and Crowded*.[21] His book has the subtitle: *'Why we need a green revolution and how it can renew America'*. Quite so. The greening of production and consumption has become a powerful method of renewing a country's fabric. What holds for the United States, should be even more suggestive for countries like China or India, less richly endowed with natural resources but with much higher economic growth rates and much larger populations. These two giants stand symbolic for the 'crowded' world of soon to be seven billion people living on a small planet that is still losing forests, fertile land, fish stock, minerals, water stores, and fossil energy resources at an alarming rate.

From Labour Productivity to Resource Productivity

Greening the economy is perhaps a popular way of characterising the innovations we expect to happen in the course of the Green Kondratiev. But we suggest going one philosophical step further. We observe, as economic historians are likely to agree, that the first 200 years of modern age economic development had the 'increase of labour productivity' as the one unifying motto. Labour productivity rose at a pace of roughly 1 per cent per year during the

[20] Bennett-Woods, D. (2008) *Nanotechnology: Ethics and Society*, CRC Press, London and Boca Raton.
[21] Friedman, T.B. (2008) *Hot, Flat and Crowded: Why the World Needs A Green Revolution – And How We Can Renew our Global Future*, Allen Lane.

19th Century until the middle of the 20th Century. From then on, owing to the accelerated global spread of technologies, progress increased by about 2–3 per cent per year. Overall, labour productivity has increased twentyfold over those last 200 years. Figure 5 shows a time window of some 120 years marking the impressive acceleration after World War II.

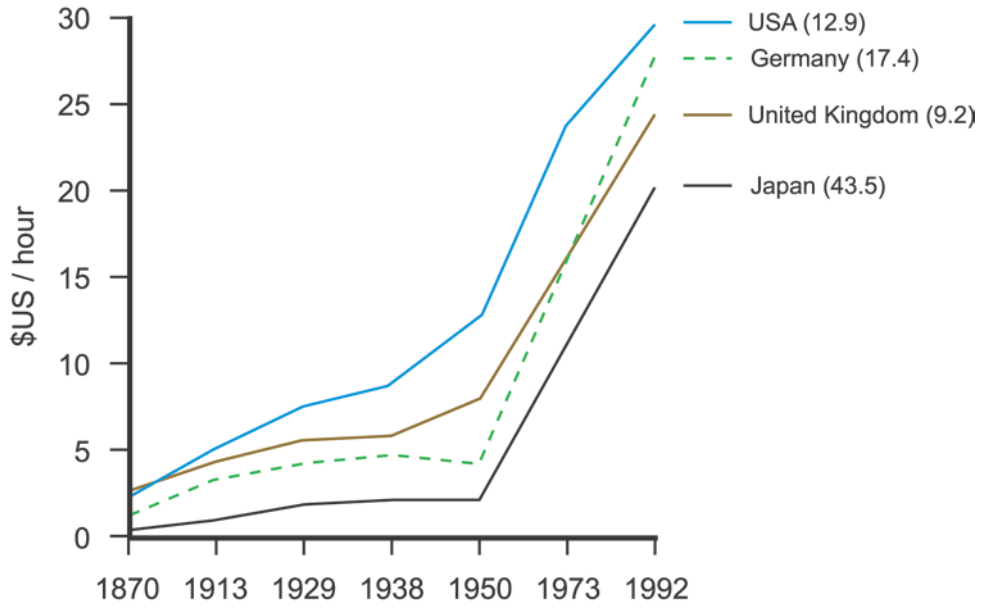

Figure 5 *The development of labour productivity over 120 years*

Source: Courtesy of Raimund Bleischwitz

Today, labour is not in short supply. Otherwise the ILO would not speak of a short fall of 800 million jobs to create a situation of near full employment. On the other hand, as we have indicated before, energy and other natural resources are in short supply, and the scarcity is getting worse every decade. This situation calls for a reversal of the emphasis on technological progress. Resource productivity should become the main feature of technological progress in our days. Countries making the scarce production factors more productive should enjoy major economic advantages over those ignoring the new scarcities. This is another way of emphasising the need for a new technological cycle and a new orientation for the world economy, for national economies, and for individual firms. To relate this to the long cycle considerations, the green Kondratiev should become the first cycle during which resource productivity grows faster than labour productivity. In developing countries, the increase of labour productivity will, of course, remain a high priority because they want to catch up with industrialised countries. But they should avoid doing so at the expense of resource productivity. Many studies show that such a focus will help to boost the economy and create jobs, while reducing environmental pressures. As The Natural Edge Project explain in their upcoming publication *Cents and Sustainability*, investments in resource productivity transform and stimulate the economy in three main ways.[22]

[22] Smith, M. and Hargroves, K (2010) *Cents and Sustainability: Decoupling Economic Growth from Environmental Pressures*, (In Press) The Natural Edge project, Earthscan, London, www.naturaledgeproject.net/centsandsustainability.aspx, accessed 10 June 2009.

1. First, investments in resource productivity, such as building energy efficiency, have a higher economic multiplier than general expenditure, as resource efficiency investments provide a tangible financial return on investment as well as usually providing additional productivity improvements. A recent 2007 study by McKinsey & Company[23] has found that, through investing in energy efficiency, global emissions could be reduced by 20-30 per cent by 2020 without harming business profitability or economic growth at all. Thus once the return on investment is achieved, usually within 1-2 years, business, government departments and households have lower annual costs and thus more money to spend elsewhere. If they then choose to invest this money in additional cost effective resource efficiency opportunities, still more funds are generated over time, which can be reinvested, further stimulating economic activity.

2. Secondly, investments in improving resource efficiency and recycling have a higher economic welfare outcome than general expenditure on many goods and services because they reduce demand for energy, water and virgin resources and thus delay (and even in some cases prevent) the need to spend billions on new energy and water supply infrastructure and new extractive industries. Delaying this spending frees up capital to be invested in other much needed infrastructure. Resource efficiency investments and demand management has been shown to help nations avoid needless infrastructure investment so that infrastructure funding can be targeted to where it is most needed. This is an important consideration since all experts readily acknowledge that there are already insufficient funds to spend on all the potential and desirable infrastructure projects. Take the electricity sector in Australia. Experts say if current demand for electricity continues to rise with the current trend, AUD$30 billion will need to be spent on new electricity supply infrastructure. By contrast, in California, energy efficiency, greener building codes and demand management have led to a flattening over the last twenty years of previously-rising electricity demand.[24] California through its strong climate change policies has achieved significant reductions in electricity consumption per capita compared to the rest of the USA - an estimated net saving of US$1,000 per family. Sweden, the UK and the Netherlands have all achieved flattening of previously rising electricity demand through policies which encourage energy efficiency.[25] Thus, tens of billions of dollars can be saved by avoiding unnecessary infrastructure investments, and thus freeing up capital to instead be invested in additional eco-efficiency initiatives, recycling plants and local distributed renewable supply options for energy and water.

3. Thirdly, jobs are created locally by these green initiatives. This results in more of a city's or town's energy, water and materials dollars being spent in a way that support local jobs and the local economy. Also these new local 'green' jobs have a direct effect of attracting

[23] McKinsey & Company (2007) Curbing Global Energy Demand Growth: The Energy Productivity Opportunity, McKinsey & Company.
[24] Shirley, W. (2006) *Decoupling Utility Profits from Sales*, Prepared for Arizona Decoupling Stakeholder Meeting, Regulatory Assistance Project (RAP).
[25] Smith, M. and Hargroves, K. (2009) 'Achieving both economic growth and reduced environmental pressures in the current financial climate', *CSIRO ECOS*, Issue 148. This article includes excerpts from the forthcoming publication on how to decouple economic growth from environmental pressures to underpin a new era of 'green' growth - Smith, M. and Hargroves, K (2010) *Cents and Sustainability: Decoupling Economic Growth from Environmental Pressures*, (In Press) The Natural Edge project, Earthscan, London, www.naturaledgeproject.net/centsandsustainability.aspx, accessed 10 June 2009.

more people to the city or town who then contribute to that local economy. California's energy-efficiency policies created nearly 1.5 million jobs from 1977 to 2007.[26] Germany claims to have 1.2 million green jobs already, and another 500,000 on the drawing board. The UK has announced a target of 1 million green jobs.[27] USA President Obama has promised to create 5 million green jobs. In Australia, as mentioned above, the ACTU and Australian Conservation Foundation says almost 1 million jobs could be created in the next 20 years if the Federal Government promotes green industries.[28] Their 2009 report showed that, with the right policy settings, six market sectors in the Australian economy (renewable energy, energy efficiency, sustainable water systems, green buildings, biomaterials, and recycling and waste) currently valued at US$15.5 billion and employing 112,000 people could grow to a value of AUD$243 billion and 847,000 jobs by 2030.[29]

Kick it Off, Quickly but Smoothly

The next question is how the new Kondratiev can be kicked off. Do we have to wait for the whole world to be persuaded towards the new paradigm? Can single countries or companies go it alone or do they need a broadly accepted business environment for resource productivity and the rest? We suggest that pioneers can go ahead prudently with little if any risk on their economic performance. Philips has decided to concentrate on LED (light emitting diodes) for example, and Toyota went ahead, together with Honda to introduce the hybrid car and was very successful domestically and abroad. Véolia Environnement pioneered 'city mining', the extraction of valuable metals from old waste dumps. Japan during the period from 1974 to 1980 went ahead with the phasing out of energy intensive manufacturing such as aluminium smelting from bauxite, and celebrated fabulous successes in other branches such as electronics and optics. Germany became the leader in renewable energies through a law of generous feed-in tariffs.

However, in the absence of certain framework conditions such as rising petrol prices, high electricity prices in Japan, high scrap metal prices from 2003-2007, and global warming concerns, it is less clear if such pioneers could have been successful. This is slightly different from the pioneers of the IT revolution who did not really need favourable framing conditions to make their technological advances a commercial success. This indicates that for the Green Kondratiev cycle to really take off, some political decisions on framing conditions would be most welcome. As a matter of fact, we devote the entire second part of this book to the politics, economics, and psychology of framing conditions for a massive launch of the exciting new efficiency and renewable energy technologies that are available right now. We describe them in the following Part 1 of this book. The transition into the Green Kondratiev cycle may actually be less dramatic than one might fear. The systems approach taken in this

[26] Roland-Holst, D. (2008) *Energy Efficiency, Innovation, and Job Creation in California*, Research Papers on Energy, Resources, and Economic Sustainability, UC Berkeley.
[27] ACTU/ACF (2008) *Green Gold Rush: How Ambitious Environmental Policy can Make Australia a Leader in the Global Race for Green Jobs*, ACTU/ACF.
[28] ACTU/ACF (2008) *Green Gold Rush: How Ambitious Environmental Policy can Make Australia a Leader in the Global Race for Green Jobs*, ACTU/ACF.
[29] ACTU/ACF (2008) Green Gold Rush: How Ambitious Environmental Policy can Make Australia a Leader in the Global Race for Green Jobs, ACTU/ACF.

book essentially means redesigning the systems of industry, transport, buildings, or agriculture, which were found to be destructive to the climate and the environment. The process of redesigning, as radical as it may be in terms of a new philosophy, can be a gradual and smooth one, encouraged by prudently designed and predictably changing framing conditions. We don't need to lose much physical or financial capital that is invested in our industrialised world. We only have to avoid investing fresh money into outdated and destructive operations and technologies.

For the smooth transition, we certainly need an educated workforce, educated consumers, and a new generation of researchers, engineers, marketing people, investors, and politicians. Achieving a Factor 5 transition is as much a technical challenge as it is a social one. Renewing education systems and curricula, fostering sustainable behaviour, developing policy and mechanisms to allow commerce and economic development, will all be crucial components. This book will focus on the range of options available for achieving significant design improvements, in Part 1, and will then provide commentary as to how governments can best support their economy and offer structure and direction to underpin a prosperous transition, in Part 2. Before starting the in depth sector studies in Part 1, Chapter 1 of this book addresses a significant barrier to the uptake of Factor 5 resource productivity opportunities, namely the historic failure of designers, engineers, architects and technicians to take a whole system approach to the identification and implementation of resource productivity opportunities.