Chapter 11
Reducing the resource flows by a factor of 4, 5 or 10

11.1 Concern for mounting global resource flows - Factor Four

When in the beginning of the 1990s it was clear that the global resource flow had become far larger than planet Earth could sustain discussion on how to reduce it became serious. At the Wuppertal Institute in Germany its Director Ernst Ulrich von Weizsäcker together with American colleagues Amory and Hunter Lovins published the ground-breaking book Factor Four – Doubling Wealth, Halving Resource Use. The proposal in the book was that by being four times as efficient in resource use we, that is the world population, could half its resource use without losing any welfare. The authors write in the introduction:

"Factor Four, in a nutshell, means that resource productivity can - and should - grow fourfold. The amount of wealth extracted from one unit of natural resources can quadruple. That message is novel, simple and exciting.

It is novel because heralds nothing less than a new direction for technological progress. In the past progress was the increase of labour productivity.

We feel that resource productivity is equally important and should actually be pursued with highest priority.

Our message is simple by offering a primitive quantitative formula. Our book depicts technologies representing a quadrupling or more of resource productivity. Progress must, as we know since the Earth Summit of Rio de Janeiro, meet the criterion of sustainability. Factor Four progress does.

The message is also exciting. It says that some of that efficiency revolution is available now at negative cost, i.e. profitably. Much more can be made profitable. Countries engaging themselves in the efficiency revolution become stronger, not weaker in their international competitiveness.

That is not only true for the old industrialized countries. It is even more valid for China, India, Mexico or Egypt which have a supply of inexpensive labour but are short of energy. Why should they learn from the US and Europe how to waste energy and materials? Their development to prosperity will go smoother, swifter and safer if they make the efficiency revolution the centrepiece of their technological progress.

The efficiency revolution is bound to become a world trend. Who wants to be the early leader and rip the benefits of the pioneer?"

Later on they go in some detail and write:

"Most of the energy, water, and transportation services we consume are wasted too, often before we get them: we pay for them, yet they provide no useful service. The heat that leaks through the attics of poorly insulated homes; the energy from a nuclear or coal-fired power station, only 3% of which is converted into light in an incandescent lamp (70% of the original fuel energy is wasted before it gets to the lamp, which in turn converts only 10% of the electricity into light); the 80–85% of the gasoline used in a car wasted in the engine and drivetrain before it gets to the wheels; the water that evaporates or dribbles away before it gets to the roots of a crop; the senseless movement of goods over huge distances for a result equally well achieved more locally - these are all costs without benefits.

This waste is unnecessarily expensive. The average American, for example, pays nearly $2,000 a year for energy, either directly purchased for the household or embodied in businesses' goods and services. Add in wasted metal, soil, water, wood, fibre, and the cost of moving all these materials around, and the average American is wasting thousands of dollars every year. That waste, times a quarter-billion people, yields at least a trillion dollars per year that is needlessly spent. Worldwide, it may even approach $10 trillion, every year. Such waste impoverishes families (especially those with lower incomes), reduces competitiveness, imperils our resource base, poisons water, air, soil, and people, and suppresses employment and economic vitality.

Yet the wasting disease is curable. The cure comes from the laboratories, workbenches, and production lines of skilled scientists and technologists, from the policies and designs of city planners and architects, from the ingenuity of engineers, chemists, and farmers, and from the intelligence of every person. It is based on sound science, good economics, and common sense. The cure is using resources efficiently: doing more with less. It is not a question of going backward or "returning" to prior means. It is the beginning of a new industrial revolution in which we shall achieve dramatic, increases in the resource productivity.

Ways to do this have significantly expanded in the past few years, opening up wholly unexpected opportunities for business and society. This book is an introduction, description, and call to action on behalf of those opportunities in advanced resource efficiency. It shows practical, often profitable ways to use resources at least four times as efficiently as we do now. Or to put it another way, it

means we can accomplish everything we do today as well as now, or better, with only one-fourth the energy and materials we presently use. This would make it possible, for example, to double the global standard of living while cutting resource use in half.

Further improvements on an even more ambitious scale are also rapidly becoming feasible and cost-effective.

Doing more with less is not the same as doing less, doing worse, or doing without. Efficiency does not mean curtailment, discomfort, or privation. When several Presidents of the United States proclaimed that "energy conservation means being hotter in the summer and colder in the winter," they were not talking about energy efficiency, which should make us more comfortable by improving the building so that it provides better comfort while using less energy and less money. To avoid that common confusion, this book avoids the ambiguous term "resource conservation" and instead uses "resource efficiency" or "resource productivity."

11.2 Revolutionizing energy productivity

The Factor Four book has a long series of example how to improve resource productivity. Here is from Chapter 1 on energy.

"In earlier days people called it energy savings. This term had a moralistic connotation. Father would admonish his children to switch off lights when leaving a room and never to let motors or appliances run when not needed.

When environmental protection entered the scene, the obvious reaction was on the part of the establishment: You (young and demanding folks) can get as much environmental protection as you want if you are prepared radically to reduce your demands. Energy savings was thus very convenient a as notion for the establishment.

Later, a new term came up: the rational use of energy. By using this term you boost your reputation by signalling that you are an expert in energy matters. How could we therefore dare to reject this term. But we are not happy with it either. It sounds so bureaucratic, complicated and defensive. It doesn't convey any pleasures and is not straightforward in talking about technological progress.

Technological progress is where we come in. Our book is about redirecting technological progress. This is why our favourite term is energy productivity.

We actually find it a bit scandalous that the term productivity has been narrowed down by economists to mean only labour productivity. In the past, labour productivity was a nice thing meaning prosperity. Today, the inevitable connotation with labour productivity is the threat of unemployment.

Energy productivity, on the other hand, is something everybody can greet with joy. Virtually nobody is losing by it.

We are talking about a factor of four in increasing energy productivity.

How could that programme be expressed in terms of energy savings or the rational use of energy? How could we when using the older terms convey the sense of joyous attack on our prevalent technological dinosaurs? How could we create excitement with women and men in the engineering professions, in factories, think tanks, parliaments, governments, lobbies, in the US as well as in Japan, China, India, Europe, Brazil or Egypt?

By using factor four as a standard, we appear to exclude much of the manufacturing world. Smelting aluminium from bauxite cannot for reasons lying in the laws of thermodynamics be made four times more energy efficient. The same holds for chlorine, cement, glass and some other basic materials. But we need not give up for that. Aluminium and glass are superbly recyclable which saves a lot of energy. Some can be substituted with no damage to the manufacturing sector. On a life cycle basis a factor of four in energy productivity should be available for most end user services involving metals or glass.

However, in this book we are concentrating on examples with a straightforward potential of quadrupling energy efficiency or more."

The examples which follow include the more efficient car, either by being lighter, or cleverer such as hybrid cars, or being better used. It includes also houses which are better insulated or even the German passive houses. There is a total of twenty examples of how to achieve 4x energy productivity. Some of them are trivial. Thus if two people instead of one is travelling in a car we have achieved a factor of two without losing any welfare. If two families were sharing a tool or other equipment, instead of having one each, we have again achieved a factor of two.

11.3 The Factor 10 and Factor X Institute

Next step was taken by another of the directors of the Wuppertal institute, Prof. Dr. Friedrich Schmidt-Bleek. In his analysis he pointed out that resource use was not at all equally shared between the different countries in the world, and some had to decrease its material flows more than others. He said in his Factor Ten book published in 1993:

1) "The global resource use before the time when large-scale environmental impacts were observed was about ½ of that in the early 90ies;
2) Some 20% of the world population consumed about 80% of the natural material;
3) Equity demands equal access to natural resources by all people.

Presently the yearly global per capita material mobilization amounts to over 15 tons (without considering water and ploughed soil), suggesting that 6-8 yearly tons per capita may well be close to a sustainable consumption limit, including the use of energy carriers. Given the large-scale adjustments necessary, such a target may not be reachable before the middle of the 21st century."

The Factor Ten book is in English called The Fossil Makers. From the introduction I cite:

"The material flows tied up with producing the wealth we have come to enjoy, are, especially for the people of the rich countries, a global phenomenon. It is our conclusion that our present goods, services and infrastructures are too material and energy intensive. This is calculated "from the cradle to the grave," or, as Walter Stahel3 says, "from the cradle to the cradle," as all the materials and energy we use eventually return to the earth. We must create a dematerialized economy, supported by a completely new technology and informed by a concern for the welfare of future generations. In this book we shall also entertain the question of whether or not the demands our economy makes upon surface - or land use - are too high, and how one could possibly measure surface use in an ecologically meaningful way.

If our present economic activity, i.e. the methods by which we generate wealth, stands a chance of ruining what is perceived to be a more or less beneficent environment, any future eco-politics, or "earth-politics," as Ernst Ulrich von Weizsäcker would call it, must concern itself with the creation of an ecologically sustainable economy.

We must dematerialize our western economies by an average factor of ten or more, as well as de-energize them, if they are to be sustainable. This emphasis on the West derives from the fact that in the industrialized North we lay claim to roughly eighty percent of the global anthropogenic material flows to create our material wealth. A more equitable distribution of access to resources would therefore require considerable reductions in the West, if we entertain the hope of merely cutting in half the global environmental burden.

It appears that such a dematerialization would also lead to a drastic reduction in the volume of solid waste, especially if sensible closed-loop options were utilized. Furthermore, entirely new means for limiting the use of toxic substances would emerge. From a technological perspective this is no utopian goal, even if the quality of goods and services remain equivalent. We shall be offering some examples of the "eco-efficiency revolution" in the pages to come."

And later: "In this book we attempt to get at the root causes of environmental changes, rather than trying to trim some of the branches. We believe this root to be the material flows which we set in motion - even those which permit us to use energy. To make this plausible, to draw some preliminary conclusions and to discuss these conclusions is the concern of this book."

11.4 Why Factor Ten?

Professor Friedrich Schmidt-Bleek writes about how the concept of Factor Ten originated during a discussion with some Russian colleagues. The question was how to avoid ever-increasing costs for protecting the environment. Or if there was perhaps even a way to reward increasing protection efforts within the "real" economy through market forces while simultaneously decreasing the resource use:

"The "Gedankenblitz" (the illuminating thought) occurred to me at a silent location: If too much environmentally dangerous material escapes at the back-end of an economy, one should curb the input streams of natural resources at the front end of the wealth machine. Of course some questions had had to be answered before this simplistic idea could be taken seriously. The first one is: Could technology provide goods and services that offer undiminished end-use satisfaction with substantially less natural resources?

The answer is yes, in principle. It is a question of engineering intelligence how much and what kind of energy and mass one invests for generating a certain quantity of value or utility. Today, some 35 kg of non-renewable nature are used on the average to produce 1 kg of product, and many times this quantity is used in the form of water. Moreover, the stuff we call high tech consumes at least ten times more solid nature than the average technology today. A service oriented knowledge society, supported by (dematerialized) information technology, can go a long way to replace mass and energy by brain power. In fact, how else can growth be had on a planet with limited resources in the face of a growing population with increasing demands?

So far so good, I thought. But then the question arose, what is the required reduction in using nature as input into the worldwide economy in order to approach sustainability? I did a very simple computation based on available evidence and arrived at about a Factor 2 as the best possible estimate. Nobody has as yet contested this rough number to my knowledge.

But surely the poor of this world, some 80% of its population, were not ready to reduce the little they had access to. They dream of proper health care, shelter,

washing machines and cars – not the least because we beam these dreams into their huts incessantly by satellite. We call this stimulating consumption in order to keep the throughput economy running. So if the worldwide take of nature must be reduced by a Factor 2 and equity demands that 5 or 8 billion people must have a better life than now, the rich must reduce their current take at least by a Factor 10. In my opinion, anybody suggesting less than10 should clarify the underlying.

When I first published the Factor 10, people called me a fool. In particular engineers thought such acrobatics in numbers were far away from real life - until they discovered that I was not talking about 1000 % improvements in efficiency of existing technology, but rather meant the sharp reduction in use of nature for satisfying defined needs of people. The focus of my concept is on service or utility, not goods. As Aristotle remarked already more than two thousand years ago: "True wealth is the use of things, not their possession".

I said above that a future service oriented knowledge society should be capable of dematerializing the economy. But what about reality? Is Factor 10 a pipe dream or not?

There is now a wealth of published examples that demonstrates that Factor 10 and much more can be achieved without reducing end use satisfaction.

In 1993 we started at the Wuppertal Institute in Germany to get involved in practical approaches of dematerialization. Starting in 1997 my newly created Factor 10 Institute in the Provence continued practical work in Europe and Japan, and since 1998 the International Factor 10 Innovation Network has shown in more than 100 enterprises how systematic new design and sensible management approaches can profitably increase the resource productivity of goods and services. When designing products for improved resource productivity, the resource intensity of raw material plays an important role. For instance, we figured out that 1 kg of copper requires 500 kg of non-renewable nature before it is available for constructing something. The ratio for aluminium is 85, for paper 15, for steel around 10 and for most plastics considerably less than 10. Depending on its composition, a product can thus have a much larger - or smaller - "ecological rucksack" than its competitor and still weigh the same.

While painstakingly working through dozens and dozens of supply chains in order to evaluate the rucksack ratios for raw materials we discovered that it is the rucksack of finished products rather than the process of manufacturing that determines the overall resource intensity of the economy: Sustainability is won on the market or not at all."

11.5 Factor 5 and the Kondratiev cycles

In an update to the 1997 international best seller Factor Four Ernst von Weizsäcker again led a team to present a compelling case for sector wide advances that can deliver significant resource productivity improvements over the coming century. The purpose of this book is to inspire hope and to then inform meaningful action in the coming decades to respond to the greatest challenge our species has ever faced – that of living in harmony with our planet and its other inhabitants.

This 2009 book, called Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity, is a more detailed work on how to achieve the 80 % in reduction of resource use. The author team relies on technological development as analysed in the Natural Edge Project, of which they are all members. From the Introduction I cite:

"In the first case, the focus of this book, we would see our sophisticated understanding in areas such as physics, chemistry, engineering, biology, planning, commerce, business and governance accumulated over the last 1,000 years brought to bear on the challenge of dramatically reducing our pressure on the environment. The second case however is the opposite scenario, involving the decline of the planet's ecosystems until they reach thresholds where recovery is not possible, and following which we have no idea what happens. For instance, if we fail to respond to Sir Nicolas Stern's call to meet appropriate stabilization trajectories for greenhouse gas emissions, and we allow the average temperature of our planet's surface to increase by 4-6 degrees Celsius, we will see staggering changes to our environment, including 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.

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 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."

And later: "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. Although standard economic literature does not necessarily accept the idea of long-term cycles, they have been a useful way of describing, characterizing 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). His pivotal book was called The Major Economic Cycles and was published in 1925.

Kondratiev himself had no strong emphasis on technological change, but Joseph Schumpeter, the famous 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. 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 organization and management, based on 'technologies that underlie the existing economic cycle. Kondratiev cycles are thus associated with major technical changes'. 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 mechanization 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);
5. The information and communication cycle since the 1980s (he could have added biotechnology to the description).

Our point is that, according to historical evidence since Kondratiev's pivotal work, the magic of technological innovations tends to fade after some 20 to 30 years of its beginning. So it may not be too surprising that even the most exciting recent wave of innovations in information technology, biotechnologies and, somewhat more recently, nanotechnologies, is no longer strong enough to support worldwide economic growth.

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 Capitalism, also summarizing 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.

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, as shown in Figure 11.1, and noting that the time frame for such waves is quickening.

As we have observed before, some greening of technologies and the economy is already under way. 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 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 characterized 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, characterized by petrochemicals, aviation and early electronics, was generated almost entirely in the US – but later also fertilized the Old World,

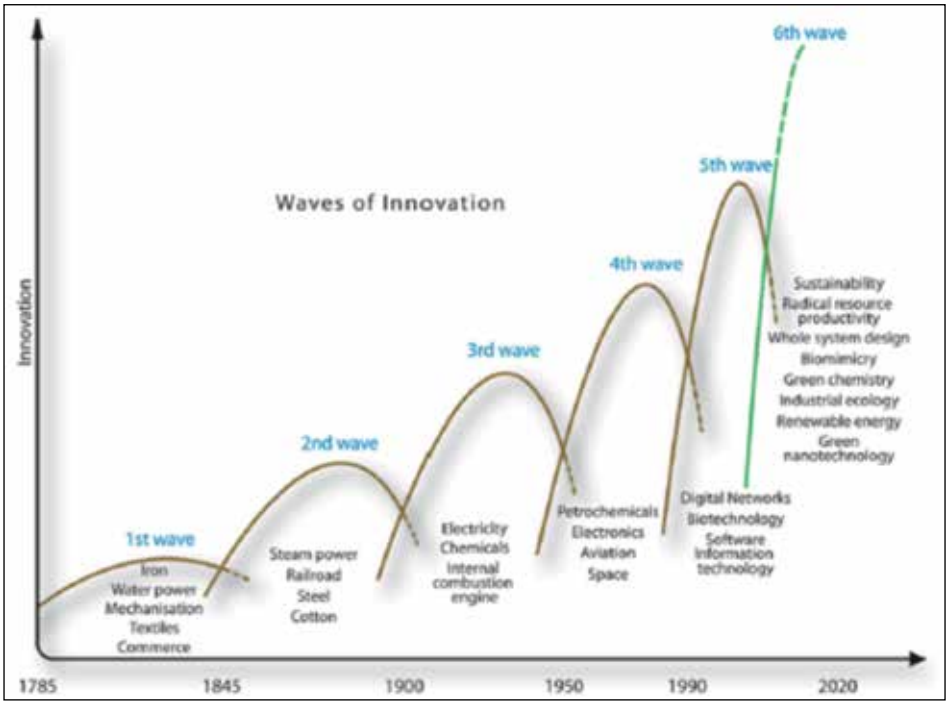

Figure 11.1 Waves of innovation (Source: Courtesy of The Natural Edge Project)

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 widespread as well, but nobody associated them with computer screens or data processing. The miniaturization of electronics to save weight for spaceships and aeroplanes 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 miniaturization 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, fertilizers 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, aircraft, the TV, uranium fission, penicillin, the laser, home computers, and centralized 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.

11.6 A Sixth wave of innovation

The Factor Five authors 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.

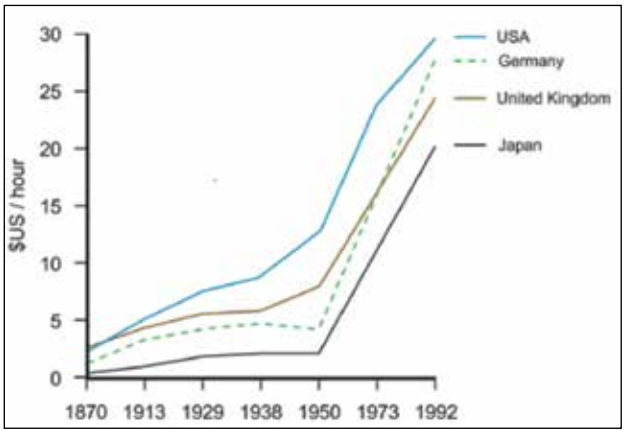

Figure 11.2 The development of labour productivity over 120 years (Source: Courtesy of Raimund Bleischwitz)

"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 in as much 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 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.

Greening the economy is perhaps a popular way of characterizing 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 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 twenty-fold over those last 200 years. Figure 11.2 shows a time window of some 120 years marking the impressive acceleration after World War II.

Today, labour is not in short supply. Otherwise the International Labour Organization (ILO) would not speak of a shortfall 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 emphasizing 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 industrialized 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:

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 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.

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. Resource efficiency investments and demand management has been shown to help nations avoid infrastructure investment so that infrastructure funding can be targeted to where it is most needed. This is an important consideration since 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, A$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 20 years of previously rising electricity demand.

California through its strong climate change policies has achieved significant reductions in electricity consumption per capita compared to the rest of the US – an estimated net saving of US$1000 per family. Sweden, the UK and the Netherlands have all achieved flattening of previously rising electricity demand through policies that encourage energy efficiency.

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.

Thirdly, jobs are created locally by green initiatives. This results in more of a city's or town's energy, water and materials dollars being spent in a way that supports local jobs and the local economy. Also these new local 'green' jobs have a direct effect of attracting 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. 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 one million green jobs. US President Obama has promised to create five million green jobs.

In Australia, as mentioned above, the Australian Council of Trade Unions (ACTU) and Australian Conservation Foundation (ACF) says almost one million jobs could be created in the next 20 years if the Federal Government promotes green industries. Their 2008 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$15.5 billion and employing 112,000 people, could grow to a value of A$ 243 billion and 847,000 jobs by 2030.

11.7 Sectors with 5 times resource productivity increase

In Part one of the Factor Five book a more detailed description how to achieve five times improved resource productivity in different sectors is described. For each sector the different components of improvement are listed and how much percentage each of them contributes to the total of 80%. Below follows some of the proposals (source: Factor Five Sample PowerPoint Slides on Sector Studies: in http://www.naturaledgeproject.net/factor5.aspx)

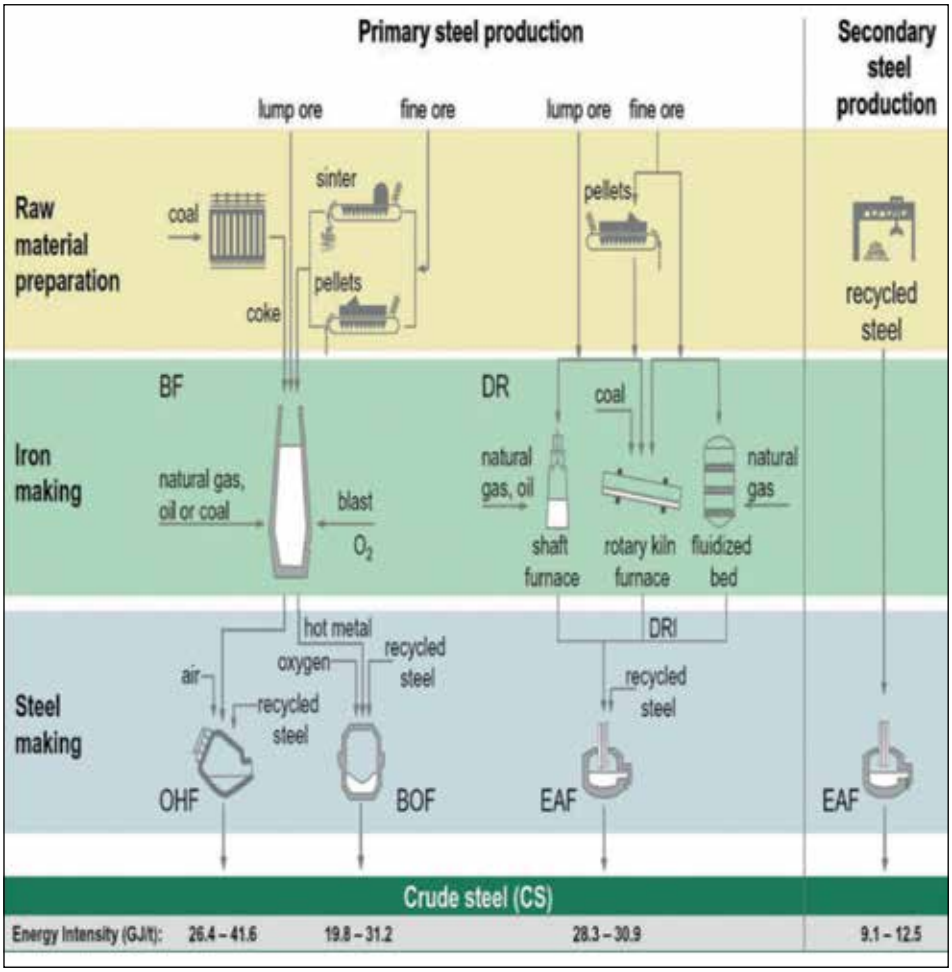

Figure 11.3 Resource efficient steel production (Source: http://www.naturaledgeproject.net/factor5.aspx)

1. Residential Buildings
   Improvements in heating and cooling of the house; More efficient hot water system; Indoor lighting; energy efficient refrigeration and appliances.
2. Commercial Buildings
   Building orientation and envelope; Better Air conditioning; efficient office equipment; retrofitting of existing buildings
3. Heavy Industry (Steel Production)
   EAF production method, Net Shape Casting, Energy recovery, Fuel switching, Preventative maintenance.

Figure 11.4 The Hypercar Revolution. Source: http://www.naturaledgeproject.net/factor5.aspx

4. Heavy Industry (Cement Production)
   Use of Alumina silicate, Improved Materials efficiency, Fuel Switching, Kiln design
5. Agriculture
   Material efficiency, Renewable energy, Fuel Switching, Appropriate selection of crop species, Energy efficiency
6. Transport (Cars & Light Vehicles)
   Light weighting rolling resistance, Aerodynamics, Engine and driveline efficiency, Vehicle-Grid integration, Alternatives to internal combustion engine, ICE; behaviour change; Transit oriented cities
7. Transport (Heavy Freight Vehicles)
   Light weighting rolling resistance; Aerodynamics, Engine and driveline efficiency, Operational improvements, Logistical improvements, Alternative modes of freight transportation

1. Transport (Rail) Light weighting

Figure 11.5. Standard truck and an energy efficient truck, the Eaton/Peterbilt Diesel-Assist Hybrid. Source: http://www.naturaledgeproject.net/factor5.aspx

Engine efficiency, Regenerative breaking, Reduced drag/friction, Improved logistics, Load factor management, Idling energy saving, Energy efficient lighting, Speed optimisation

One may add to this list of possibilities several more. Thus for the housing sector, low energy housing of passive housing reduces energy use in housing very dramatically. In addition wooden houses decreases resource use in the building itself.

Steel industry should use as much as possible recycled scrap metal. It reduces energy need by a factor of about 6. As to the cement industry it should decrease as much as possible since cement production contributes considerably to CO2 emissions.

Agriculture should make efforts of recycling nutrients and use manure and other organic material for biogas production.

It is interesting to see that in the transport sectors the Factor Five authors include elements of organisation and behaviour as important for resource use improvements. Probably this is valid for all sectors although more detailed analysis is needed to specify exactly what should be done.

Chapter 11 sources:

Factor Four - Doubling Wealth, Halving Resource Use; The new report to the Club of Rome by Ernst Ulrich von Weizsäcker; Amory B. Lovins and L.Hunter Lovins

http://www.ima.kth.se/im/3c1395/Pdf/FactorFour.pdf

Factor 10 Institute http://www.factor10-institute.org/

The history of Factor 10 by Friedrich Bio Schmidt-Bleek

http://www.factor10-institute.org/files/MIPS_History.pdf

The Fossil Makers (Wieviel Umwelt braucht der Mensch?) by Friedrich Bio Schmidt-Bleek

http://www.factor10-institute.org/files/the_fossil_makers/FossilMakers_Intro.pdf

The World Resources Forum http://www.wrforum.org/

Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity by Ernst Ulrich von Weizsäcker, Charlie Hargroves, Michael H. Smith Cheryl Desha and Peter Stasinopoulos

http://www.naturaledgeproject.net/factor5.aspx
Factor Five Sample PowerPoint Slides on Sector Studies
http://www.naturaledgeproject.net/factor5.aspx)
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