# Cents and Sustainability

## Securing Our Common Future by Decoupling Economic Growth from Environmental Pressures

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# Achieving Economic Growth and Reducing Environmental Pressures

## What is 'Decoupling'?

> *It used to be taken for granted that economic growth entailed parallel growth in resource consumption, and to a certain extent, environmental degradation. However, the experience of the last decades indicates that economic growth and resource consumption and environmental degradation can be decoupled to a considerable extent. The path towards sustainable development entails accelerating this decoupling process.*
>
> Yukiko Fukasaku, OECD, 1999[1]

In 1987, *Our Common Future* was one of the first books to argue that it was possible to reconcile environmental sustainability and economic growth, although at the time and since many questioned this position.[2] This was despite the fact that, by the time *Our Common Future* was published, there were a number of significant examples of such decoupling. One of the first examples came as a result of the 1970s oil shocks, where, for seven years after 1979, the US economy grew by 27 per cent, with oil consumption falling by 17 per cent, and net oil imports from the Persian Gulf falling by 87 per cent. This led to the US oil intensity (barrels per dollar of real GDP) dropping by 35 per cent during 1977–1985.[3] Since then, there have been many further decoupling successes at both global and national levels, including efforts to reduce air and water pollution, largely phasing out the use of ozone-depleting chemicals, as well as lead and asbestos, and significantly reducing sulphur dioxide ($SO_2$) emissions. These success stories show that where there has been the political will, and the vested interests have been appropriately managed, effective and purposeful

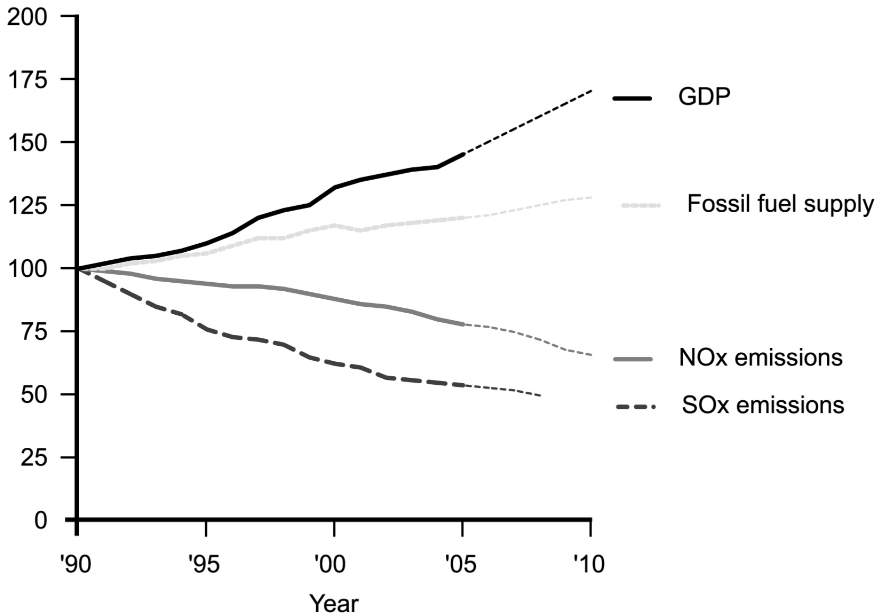


**Figure 2.1** *Performance of economic growth relative to fossil fuel supply, and $NO_x$ and $SO_x$ emissions 1990–2005 (with projections to 2010)*

*Source:* Based on data from the OECD Key Environmental Indicators Report (2008)[4]

policy responses and technical innovation have achieved significant reductions in pollution while maintaining strong economic growth.

A leading example of this has been global and regional efforts to decouple economic growth from $SO_2$ pollution through first the 1983 'Helsinki Protocol' and the United Nations Economic Commission for Europe (UNECE) Second Sulphur Protocol in 1994. The Second Sulphur Protocol committed nations to targets of reductions of 50 per cent by the year 2000, 70 per cent by 2005 and 80 per cent by 2010.[5] Initial perceptions were that it would be incredibly costly, but the arrival of cost-effective low-sulphur fuel and a range of supporting technologies altered the cost situation such that the use of sulphur could be reduced for significantly less cost than anticipated – US$90 per tonne rather than the anticipated US$1000–1500 per tonne.[6] When the costs of sulphur to health and the environment are taken into account, this phase-out has had negligible net impact on economic growth, as seen in Figure 2.1. In this case economic growth and the reduction of environmental pressures, namely the emissions of sulphur dioxide, have been quite compatible,[7] along with reductions in nitrogen oxides ($NO_x$) and fossil fuel consumption.

## What Level of Decoupling is Required?

The reality is that if economic growth is not absolutely decoupled from environmental pressure then at some point in the near future the systems that support life on this planet are going to collapse. David Suzuki often says to his audiences that we couldn't kill the planet if we tried but we can make it a place that we don't enjoy living on. So we have two choices, wait and see what the world looks like once we have further increased the global temperature and degraded the ecosystems beyond their ecological limits, or act with unprecedented urgency to decouple as fast as we can before irreversible thresholds are past for both the climate and the world's ecosystems. If the growing consensus about environmental trends is correct then this decision will either be made by the world's decision-makers in the near future, or it will be dictated by the state of the environment, forcing our and future generations to deal with the negative impacts and costs associated with climate change and ecosystem degradation.

If we as a global community do decide to act fast to secure our common future, we will need a number of organizing principles. As Kenneth Ruffing outlines in the foreword to this book, according to the OECD, the goal for the level of decoupling to work towards will be set by four main criteria:[8]

1. Regeneration: Renewable resources shall be used efficiently and their use shall not be permitted to exceed their long-term rates of natural regeneration. (*Meaning that we need to enhance production capacity of renewable resources, while controlling the growth in demand by improving demand management and increasing efficiency of use*.)
2. Substitutability: Non-renewable resources shall be used efficiently and their use limited to levels that can be offset by substitution by renewable resources or other forms of capital. It is interpreted by the authors that substitutability then means that non-renewable resources can be used (assuming the other three criteria are met), but must be used efficiently and when they run out, or are uneconomical, they need to be able to be fully replaced by substitution by renewable resources, hence the ability to source substitutes is the limiting factor on the use of non-renewable resources if the activity using the resource is to be sustained. (*For example if we are to use coal for power generation we can only use it if the other three criteria are met and to the level that it is possible to source alternatives – that also satisfy the other three criteria – to take over once the supply is diminished or uneconomical*.)
3. Assimilation: Releases of substances to the environment shall not exceed its assimilative capacity; concentrations shall be kept below established critical levels necessary for the protection of both human and environmental health. When assimilative capacity is effectively zero (e.g. for hazardous substances that are persistent and/or bio-accumulative), a zero release of such substances is required to avoid their accumulation in the environ-

ment. (*Thus the use of coal in the above example would need to satisfy, for instance, emissions requirements for toxins in waterways and greenhouse gas emissions in the atmosphere to be able to operate.*)

4 Avoiding irreversibility: Irreversible adverse effects of human activities on ecosystems and on biogeochemical and hydrological cycles shall be avoided; the natural processes capable of maintaining or restoring the integrity of ecosystems should be safeguarded from adverse impacts of human activities; and the differing levels of resilience and carrying capacity of ecosystems must be considered in order to conserve their populations of threatened, endangered and critical species.

It is for each nation to undertake specific studies to investigate appropriate levels and pace for decoupling efforts to contribute to achieving these system conditions (see Chapter 5). To provide further clarity on the magnitude of decoupling efforts required, the well-known IPAT formula is commonly used, such that: $I = A \times P \times T$, with I representing the total negative environmental impact, P representing population, A representing affluence, and T representing environmental impact per unit of product/service consumed. The formula shows that there are a range of levers for reducing impact, such as stabilizing population, reducing wasteful consumption patterns and reducing the environmental impact of various products/services. Given that these are the main options, it seems that due to the forecast ongoing increase of global population and affluence levels, the main opportunity for reducing impact is through a focus on 'T', namely to reduce the environmental impact per unit of product or service consumed. A range of studies now show that as much as 60–80 per cent reductions in environmental impact can be achieved across a range of sectors

Such a target may seem unachievable. However, historically, where governments and business have had the courage to try to achieve such targets, such as through the Sulphur Protocols outlined previously, industry has found significantly cheaper ways than forecast to reduce the costs of meeting such environmental regulation, as further explained in Chapter 5, and shown in Table 5.5. This book will show that there are many examples of where purposeful policy, combined with effective R&D, has lowered costs of complying with stringent and progressive environmental regulation to achieve remarkable levels of decoupling.

An effective way to achieve significant improvements in 'T' is to re-optimize the design process to harness opportunities to improve resource productivity and reduce environmental pressures early in the process. A range of leading examples of sustainable design now demonstrate that by taking what is known as a 'whole system design' approach, a range of cost-effective improvements can be made to achieve enhanced resource productivity outcomes while significantly reducing environmental pressures. Such a design process involves looking at the system in which the design is to become part, and then how the subsystems within the design will interact with the overall design. However, traditional design processes encourage what is referred to as an 'incremental' approach where designers focus on a subsystem of a design in relative isolation from the other subsystems and the interaction is not optimized. Over the last 20 years engineers and designers using whole system design techniques have found that across all sectors the potential exists to achieve between 60 and 90 per cent improvements in energy, water and materials productivity cost effectively. Such achievements are leading to a strong basis for informing the design process, as summarized in *Whole System Design: An Integrated Approach to Sustainable Engineering*.[8A] This body of work is important because it shows how, using existing technologies, we can cost effectively achieve environmental sustainability.

Such approaches are being increasingly understood around the world and many nations and regional governments now are embracing and achieving strong decoupling targets to achieve as much as 90 per cent decoupling. Leading the way are countries such as Costa Rica, which has committed to become net climate neutral by 2021, Sweden, which has committed to be independent of oil imports by 2020, and Japan, which has committed to becoming a closed-loop society dramatically reducing waste, and regions such as Massachusetts, where since 1989, the private sector has worked with the government and university researchers to achieve a 90 per cent reduction in toxic chemical emissions by 2005 without harming businesses profits.[9] Hence, it is possible for nations working with the private sector, through a focus on improving efficiencies and resource productivity as well as changing processes and products, to both contribute to the imperative for decoupling globally, and to also unlock new ways to improve their own bottom line.

This may prove to be the most important 'convenient truth' of our generation as if efforts to achieve decoupling did not prove to be cost effective, and even in some cases provide opportunities to increase economic growth, then a decoupling agenda would have little chance of success. For these reasons the publication *The Natural Advantage of Nations*[10] proposed that we are seeing the beginning of a new wave of innovation that is being driven by businesses needing to reduce resource and energy costs, differentiate their products, and innovate for new rapidly growing markets in environmental solutions.

## How Can We Represent and Interpret Decoupling Trends?

Before exploring further examples of decoupling it is important to define further what is specifically meant by the term. According to the OECD, the term decoupling 'has often been used to refer to breaking the link between the growth in environmental pressure associated with creating economic goods and services'. Figure 2.2 provides a stylized impression by the authors of a decoupling graph developed to demonstrate the various relevant trends. It is assumed that at the start of the time period the relative growth rates of both

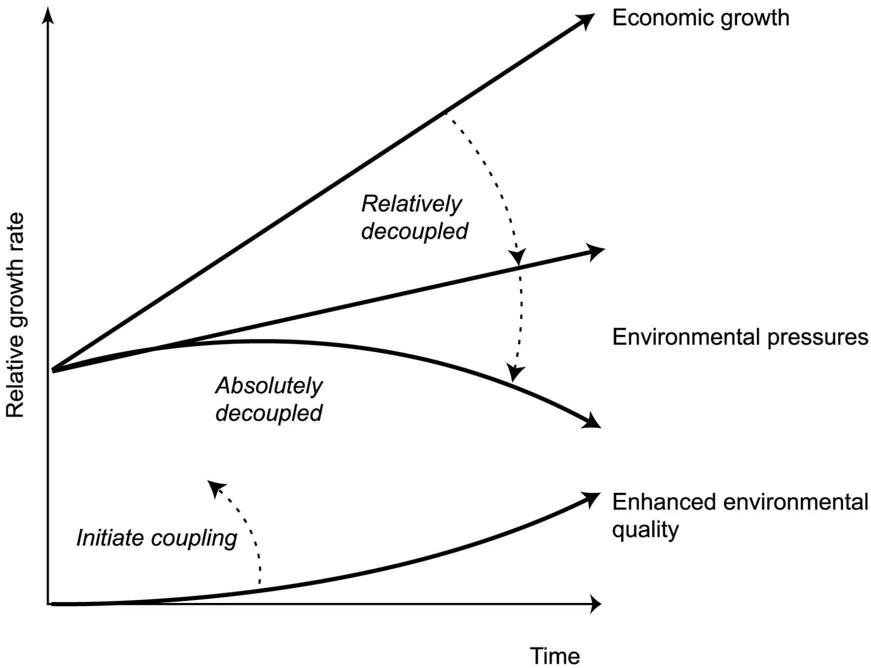


**Figure 2.2** *Conceptual and stylized representation of a decoupling graph*

*Source:* Developed by Karlson Hargroves, Peter Stasinopoulos, Cheryl Desha and Michael Smith

economic growth and environmental pressures are the same so that the trend can be established. As can be seen, the assumption is that economic growth continues to increase, although the resultant environmental pressures no longer grow at comparable rates. In the case where the growth rate of environmental pressures is less but is still rising, it is said to be 'relatively decoupled', and in the case where the growth rate of environmental pressures is decreasing, it is said to be 'absolutely decoupled'. The goal is to first relatively decouple the trends and then absolutely decouple them; however, it is unreasonable to expect that the environmental pressures will reduce to zero, realistically they will instead hit a lower bound signifying the minimum amount of pressure to deliver the economic growth. If this lower bound is still higher than the environment's carrying capacity then options to offset, remediate or substitute for the damage will need to be developed and represented in the figure as 'enhanced environmental quality'. It is intended that these enhanced outcomes are coupled with and enhanced by economic growth.

As economic growth and various environmental pressures are not measured in the same units, dollars verses tonnes of emissions for instance, they cannot be plotted directly on the same set of axes. However, as the purpose of a decoupling graph is to visually represent the behaviour of trends, the relative growth of each can be plotted and compared if they are given the same point of origin. In standard decoupling curves the first year of the data set is used as the origin on the x axis and runs as long as data are available. On the y axis both trends are set to 100 per cent, or an index of 100, to allow the different trends to be compared following the first year of record. Figure 2.1 uses the year 1990 as the beginning of the data set and presents the relative growth rate of GDP (typically 2–3 per cent per year) and the relative growth rates of three trends that had resulted in environmental pressure. Note that with reference to Figure 2.2 the curve for 'fossil fuel supply' is relatively decoupled from the curve for GDP, and both the remaining environmental pressure curves are absolutely decoupled from GDP.

In order to reduce the graph to a figure at the time of consideration the relative growth rate of the negative environmental pressure (NEP) can be calculated as a percentage of the relative growth rate of the economic growth (EG), such that the percentage is equal to $[1-(NEP/EG)] \times 100$ per cent. For example from Figure 2.1, the relative growth rate of $SO_x$ emissions in 2000 was approximately 52 per cent of the relative growth rate of the economic growth. However, this figure does not indicate whether the trend is relatively or absolutely decoupled. Therefore in order to calculate this using the data set, the relative growth of the NEP is either:

a Coupled, such that $EG_{(n-1)} = NEP_{(n-1)}$ and $EG_{(n)} - NEP_{(n)}$
b Relatively decoupled, such that $EG_{(n)} > NEP_{(n)}$ and $NEP_{(n)} > NEP_{(n-1)}$
c Absolutely decoupled, such that $EG_{(n)} > NEP_{(n)}$ and $NEP_{(n)} < NEP_{(n-1)}$

As mentioned above, it is unreasonable to assume that the negative environmental pressures will be reduced to zero, and there will always be a need for a range of initiatives to enhance the environmental quality and restore ecosystem resilience to offset the ongoing presence of environmental pressures. The level of such enhanced environmental quality (EEQ) can be calculated as,

d $\%EEQ \text{ of } EG = [(EEQ(n) - 100)/(EG(n) - 100)]$.

## What Potential Is There for Relative and Absolute Decoupling?

It is important to note that the concept of decoupling is a very recent one, as until the 1970s there was little evidence that economic growth and environmental pressures could be decoupled. In 1987, the Brundtland report, *Our Common Future*, reported statistics that showed that over the period 1972–1986 the relationship between energy use and economic growth in industrial countries had undergone a significant change from the broadly proportional relationship that had prevailed before.[11] In the US, energy intensity had decreased by 25 per cent from 1973 to 1986. Over the OECD nations, it decreased 20 per cent from 1973 to 1985. For the same period, in countries belonging to the IEA, GDP grew by nearly 32 per cent while energy use grew by only 5 per cent. The UK has achieved absolute decoupling of $CO_2$ emissions

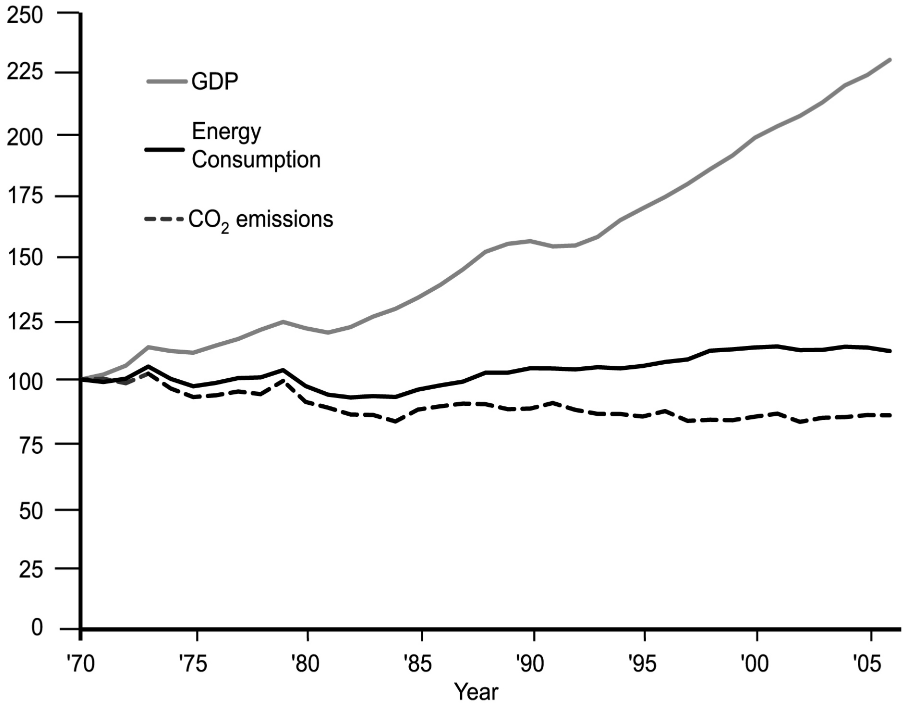


**Figure 2.3** *UK GDP, energy use and carbon dioxide emissions trends since 1970*

*Source:* Data from the UK Department for Environment, Food and Rural Affairs[12] and the WRI[13]

from GDP since 1970,[14] and while over the last 30 years the UK's GDP has doubled, its energy use has only increased marginally, as shown in Figure 2.3.

In the 21st century the challenge of decoupling economic growth from greenhouse gas emissions is inspiring a whole new wave of innovation in more energy-efficient products that provide further opportunities to achieve greater levels of decoupling. For instance, Japanese engineers have designed a vacuum-sealed refrigerator that uses only one-eighth as much electricity as those marketed a decade ago. Gas electric hybrid automobiles, getting nearly 50 miles per gallon, are twice as efficient as the average car on the road. Furthermore, the Climate Group's 2005 report *Carbon Down, Profits Up*[15] showed that 43 companies have increased their bottom line by a total of US$15 billion while developing ways to reduce their greenhouse gas emissions by as much as 60 per cent. Multinationals like IBM and Dupont have succeeded through such measures on reducing greenhouse gas emissions by over 60 per cent since 1990 while saving over US$2 billion each. Such savings can help keep businesses profitable and prevent job losses during tough times. The cost savings from energy and fuel efficiency can also help business pay for the costs of investing in shifting energy production from fossil fuels to low-carbon renewable technologies.

> *As many companies have already learned, acting on this issue [climate change] is simply good business. Reducing our use of energy reduces costs ... The debate is shifting from whether climate change is really happening to how to solve it. And when so many of the solutions make sense for us as a business, it is clear that we should take action not only as a matter of public responsibility, but because we stand to benefit.*
>
> Rupert Murdoch, Founder of News Corporation, 2007[16]

Across most sectors of the economy, examples exist of companies that have cost effectively achieved significant reductions in environmental pressures and resource consumption, and even up to 80 per cent. In the 2009 publication *Factor Five*,[17] an update of the internationally renowned book *Factor Four*, such efforts leading to an 80 per cent improvement in resource productivity were compiled by taking a whole systems approach, as seen in Table 2.1. *Factor Five* gives detailed sector studies which provide a step-by-step approach to achieving large energy and water productivity improvements of 80 per cent or better for the buildings, industry, agriculture, food and hospitality, and transport sectors – the sectors responsible for most of the world's energy demand.

Using such innovations, a number of countries and states, such as the Netherlands, Denmark, Sweden and the UK, have achieved encouraging levels of decoupling of economic growth from greenhouse gas emissions. For instance, for the past 25 years Denmark has experienced an economic growth of 75 per cent without increasing its $CO_2$ emissions (see Figure 2.4).

States like California, which have strong energy efficiency and demand management regulations and policies, have managed to decouple GDP from

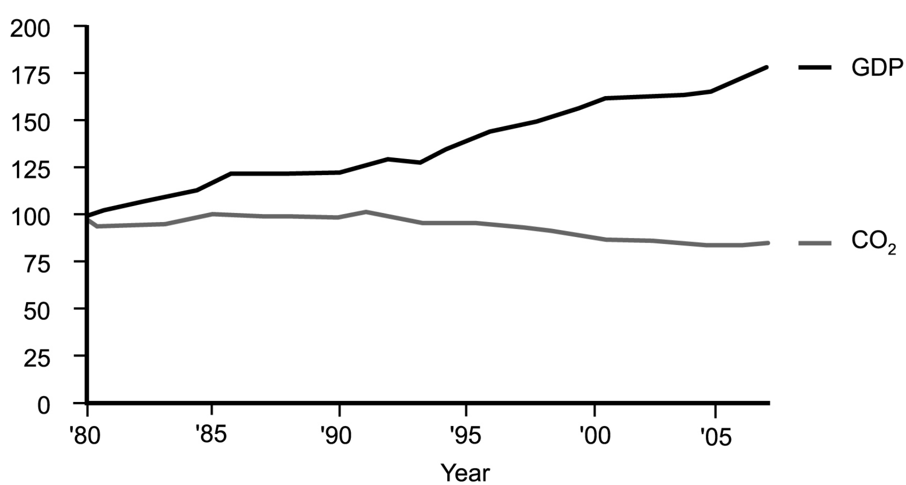


**Figure 2.4** *Decoupling economic growth from greenhouse gas emissions in Denmark, 1980–2005*

*Source:* Based on data from the WRI (2008)[18]

**Table 2.1** *Sample of best practice case studies demonstrating large decoupling potential*

| *Sector* | *Best practice case studies* |
|---|---|
| Residential buildings | Passive house designs have achieved significant reductions in heating requirements in Germany with an 80% improvement over contemporary German standards, and a 90% improvement over the average German building stock.[19] There are now examples of Passivhaus design in many OECD countries. |
| Energy in developing countries | Grameen Bank's subsidiary Grameen Shakti uses the bank's original micro-credit financing model to enable the people of Bangladesh to purchase energy-efficient lighting and cooking systems that are powered by solar energy. Since 1997 the company has serviced over 135,000 homes, and in 2008 its service rate was 5000 additional homes per month; 3 million trees have also been planted by customers.[20] |
| Commercial buildings | There are now many examples of outstanding green buildings, such as the Saunders Hotel Group, a third-generation family business that owns and operates three properties in Boston, MA. It is the first such group to retrofit its hotels to become climate neutral, through a combination of energy efficiency initiatives and purchasing renewable energy. The company is certified by the Climate Neutral Network as the first hotel group in the world to offer climate neutral rooms.[21] |
| Steel industry | Leading US steel company, Nucor Steel, is around 70% more energy efficient than many steel companies around the world,[22] using state-of-the-art electric arc furnace systems, adopting leading practices such as net shape casting, and implementing options such as energy monitoring systems for energy recovery and distribution between processes.[23] |
| Cement industry | Ordinary Portland cement manufacture is responsible for 6–8% of global greenhouse emissions and this is rising with demand. The good news is that an Australian company Zeobond Pty Ltd, based in Melbourne, is now making geo-polymer cement which reduces energy usage and greenhouse gas emissions by over 80%.[24] Geo-polymers can be used for most major purposes for which Portland cement is currently used.[25] |
| Paper and pulp industry | Catalyst Paper International has improved its energy efficiency by 20% across all operations since 1990, saving the company close to US$26 million between 1994 and 2004. At the same time, it has reduced its greenhouse gas emissions by 69% through greater use of biomass and sourcing electricity from hydro power.[26] The pulp and paper sector has the potential in both existing and new mills to become renewable electricity power generators through the use of black liquor gasification combined cycle technologies.[27] |
| Data centres | Google has achieved 80% energy efficiency improvements in its data centres through efficient data centre design, efficient power supplies and efficient voltage regulator modules on motherboards.[28] Unnecessary components, such as graphics chips, are omitted. Fan energy is minimized by running fans only as fast as required. Finally, Google seeks to use components that operate efficiently across its whole operating range, a strategy that the company estimates could reduce data centre energy consumption by half.[29] |

**Table 2.1** *continued*

| *Sector* | *Best practice case studies* |
|---|---|
| Supermarkets | Supermarket chains Tesco (UK) and Whole Foods (US) are showing that there are numerous ways to significantly reduce electricity usage through, for instance, reducing cooling and heating loads and utilizing more efficient lighting.[30] They are also experimenting with solar energy and wind micro-turbines.[31] Whole Foods Market are set to power an entire store using solar panels and combined cycle co-generation using fuel cells and heat recovery.[32] |
| Restaurants | Four profitable restaurants – Bordeaux Quay (Bristol, UK),[33] Foodorama (Berlin, Germany),[34] The Acorn House (London, UK)[35] and The Water House (UK) – demonstrate that restaurants can significantly reduce their energy consumption through building design, energy-efficient lighting and cooking equipment, purchasing their electricity from accredited renewable sources, buying organic fresh local food in season, composting and recycling all waste, and investing in carbon offsets. |
| Transport – vehicle efficiency | Integrating technical advances in light-weighting, hybrid electric engines, batteries, regenerative braking and aerodynamics is enabling numerous automotive and transport vehicle companies to redesign cars, motorbikes, trucks, trains, ships and aeroplanes to be significantly (50–80%) more fuel efficient than standard internal combustion vehicles. Plug-in vehicle technologies are opening up the potential for all transportation vehicles to be run on batteries charged by renewable energy.[36] |
| Transport efficiency from modal shifts (passenger) | Shifting transport modes can also lead to significant energy efficiency gains. One bus with 25 passengers reduces energy and greenhouse gas emissions per capita by approximately 86% per kilometre compared to 25 single occupant vehicles.[37] Trains are even more efficient. Typically, rail systems in European cities are 7 times more energy efficient than car travel in US cities.[38] |
| Transport efficiency from modal shifts (freight) | Shifting freight transport from trucks to rail can also lead to large efficiency gains of between 75 and 85%.[39] Several countries are moving to improve the efficiency of their transport sectors by making large investments in rail freight infrastructure, including improving the modal interfaces. For instance, China has invested US$292 billion to improve and extend its rail network from 78,000km in 2007, to over 120,000km by 2020, much of which will be dedicated to freight. |

*Source:* von Weizsäcker et al (2009)[40]

the typical rising electricity demand profile. Figure 2.5 shows that California, through its strong policies, has managed to achieve a significant reduction in electricity demand compared to the rest of the US.

The cost savings from energy and fuel efficiency can help individuals, business and government pay for the costs of investing in shifting energy production from fossil fuels to low-carbon renewable technologies. Denmark, for example, today gets 20 per cent of its electricity from wind and has plans to push this to 50 per cent. Some 60 million Europeans now get their residential electricity from wind farms. By the end of 2007, some 40 million Chinese

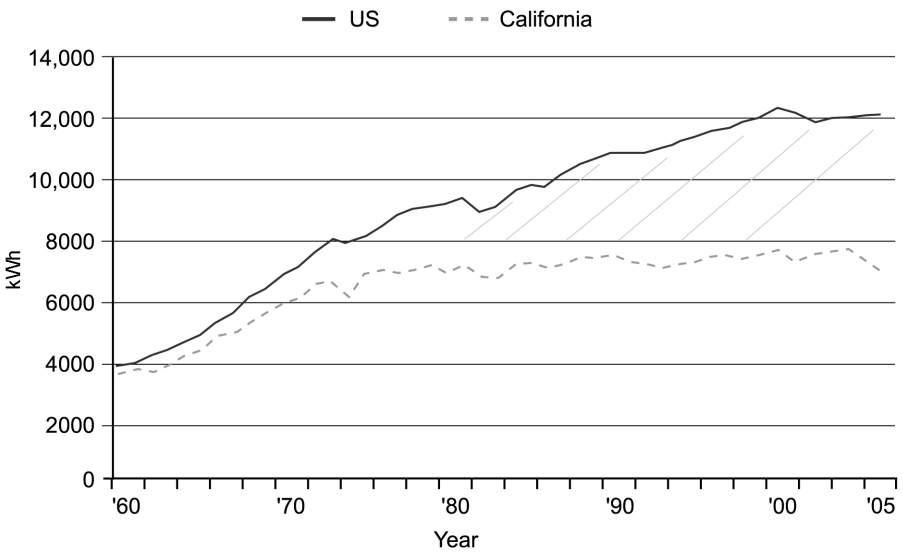


**Figure 2.5** *Total electricity usage in California, per capita, 1960–2001*

*Source:* Based on data from Shirley (2006)[41] and the California Energy Commission[42]

homes will be getting their hot water from rooftop solar water heaters. Iceland now heats close to 90 per cent of its homes with geothermal energy, and in so doing, has virtually eliminated the use of coal for home heating. Iceland, New Zealand, Norway and Costa Rica have committed to becoming net climate neutral – 100 per cent decoupling of economic growth from greenhouse gas emissions – over the next 30 years through energy efficiency, demand management, renewable energy, sustainable transport options and carbon offsets (see Chapter 6 and in particular Table 6.1 for further evidence of leading national programmes and policies). Respected economists such as Nicholas Stern and Paul Ekins, have argued that it is theoretically and practically possible to decouple economic growth from environmental pressures sufficiently to enable economic growth to continue to grow strongly.

> *Changes in energy technologies and in the structure of economies have created opportunities to decouple growth from greenhouse gas emissions ... Tackling climate change is the pro-growth strategy for the longer term, and it can be done in a way that does not cap the aspirations for growth of rich or poor countries.*
>
> Sir Nicholas Stern, Executive Summary of *The Stern Review*, 2006[43]

> *It is clear from past experience that the relationship between the economy's value and its physical scale is variable, and that it is*

> *possible to reduce the material intensity of GDP. This establishes the theoretical possibility of GDP growing indefinitely in a finite material world.*
>
> Paul Ekins, *Economic Growth and Environmental Sustainability*, 2000[44]

Since *Our Common Future* was published in 1987, a wealth of evidence has been developed to show that along with greenhouse gas emissions significant decoupling of other environmental pressures from economic growth can also be achieved. Given the size and scope of this publication, it is not feasible to cover each environmental pressure in detail, instead we have selected five main areas, aligned with the focus areas of the OECD, as this would allow the work in this book to complement and extend such leading efforts. The categories and their corresponding chapters are as follows:

1 greenhouse gas emissions – Chapters 6 and 7;
2 biodiversity loss and deterioration of natural systems – Chapter 8;
3 freshwater extraction – Chapter 9;
4 waste production – Chapter 10;
5 air pollution – Chapter 11 (with a detailed case study from Delhi in Chapter 12).

Greenhouse gas emissions is expanded to cover two chapters because we see it as the overarching issue that affects each of the other areas, as well as being the issue that is posing the largest-scale immediate threat. Then each of the remaining four areas are investigated for particular aspects that can be decoupled from economic growth such as those outlined as a priority or as urgent by the OECD in Table 2.2.

The first area of focus, decoupling economic growth from greenhouse gas emissions, shows that urgent decoupling is needed to avoid dangerous climate change; furthermore, that achieving such decoupling is both technically possible and economically affordable if we act in the coming decade, particularly as the costs of inaction are set to be significant. The remaining chapters then make the case that this is also true for actions to reduce environmental pressures on biodiversity, water resources, waste management, and air quality, such as:

- Biodiversity loss and deterioration of natural systems: South Korea has already shown how biodiversity and natural systems can be restored as a part of their economic development goals. Having lost the majority of its forests by the end of the Korean War, the South Korean government invested in a major national reforestation effort, utilizing village cooperatives involving hundreds of thousands of people to dig trenches and to create terraces for supporting trees on barren mountains. As Se-Kyung Chong, researcher at the Korea Forest Research Institute, writes, ‘the result

**Table 2.2** *Environmental protection priority areas*

| *Priority area* | *Well managed* | *Priority* | *Urgent* |
|---|---|---|---|
| Climate change | | • Declining greenhouse gas emissions per unit of GDP | • Global greenhouse gas emissions<br>• Increasing evidence of an already changing climate |
| Biodiversity and renewable natural resources | • Forested area in OECD countries | • Forest management<br>• Protected areas | • Ecosystem quality<br>• Species loss<br>• Invasive alien species<br>• Tropical forests<br>• Illegal logging<br>• Ecosystem fragmentation |
| Water | • Point-source water pollution in OECD countries (industry, municipalities) | • Surface water quality and wastewater treatment | • Water scarcity<br>• Groundwater quality<br>• Agricultural water use and pollution |
| Air quality | • OECD country $SO_2$ and $NO_x$ emissions | • Partculate matter (PM) and ground-level ozone<br>• Road transport emissions | • Urban air quality |
| Waste and hazardous chemicals | • Waste management in OECD countries<br>• OECD country emissions of CFCs | • Municipal waste generation<br>• Developing country emissions of CFCs | • Hazardous waste management and transportation<br>• Waste management in developing countries<br>• Chemicals in the environment and in products |

*Source:* OECD (2008)[45]

was a seemingly miraculous rebirth of forests from barren land. Today forests cover 65% of the country, an area of roughly 6 million hectares. While driving across South Korea in November 2000, it was gratifying for me to see the luxuriant stands of trees on mountains that a generation ago were bare. We can reforest the Earth!'[46] Further to reforestation efforts, South Korea is also taking steps to reduce timber demand, shifting to metal and plastic chopsticks (with China discarding an estimated 25 million trees worth of chopsticks a year), and having one of the highest paper recycling rates in the world of 77 per cent.

- Air pollution: Significant advances have been achieved over the last few decades both in the scientific understanding of air pollution and in the technological innovations to reduce it. Through these advances, air quality has been improved dramatically in many cities, especially in the OECD, at much less cost than first anticipated. The US Environmental Protection Agency (US EPA), for instance, conducted an extensive study which found that the total benefits of the Clean Air Act programmes 1970–1990 saved the US economy US$22 trillion.[47] In other words, if US air pollution trends in 1970 had continued to 1990, then the measurable economic, social, health and environmental costs to the US economy would have been an extra US$22 trillion. By comparison, the actual cost of achieving the pollution reductions observed over the 20-year period was US$523 billion, a small expense compared to the estimated costs of the impacts avoided.

- Freshwater extraction: There are also significant success stories from which we can learn in decoupling economic growth from freshwater extraction. In the US between 1980 and 1995 the amount of fresh water withdrawn per American fell by 21 per cent and water withdrawn per dollar of real GDP fell by 38 per cent.[48] This trend is being seen worldwide in OECD countries, although greater efforts are needed if freshwater supply is to meet demand in the long term. Most industry sectors, homes and commercial buildings can cost effectively reduce water usage by over 50 per cent through using water-efficient appliances, and utilizing and recycling rain and greywater onto gardens. Further, farmers in India, Israel, Jordan, Spain and the US have shown that drip irrigation systems that deliver water directly to crop roots can reduce water use by 30–70 per cent and raise crop yields by 20–90 per cent. Rice farmers in Malaysia saw a 45 per cent increase in their water productivity through a combination of better scheduling of their irrigations, shoring up canals, and sowing seeds directly into the field rather than transplanting seedlings.
- Waste production: Most OECD nations have achieved significant levels of decoupling of economic growth from waste production, although further improvement is both needed and will be cost effective. For instance, in OECD countries in the mid-1990s, approximately 64 per cent of municipal waste was sent to landfill, 18 per cent for incineration and 18 per cent for recycling.[49] In 2005, only 49 per cent of municipal waste was being disposed of in landfill, 30 per cent was being recycled and 21 per cent was being incinerated or otherwise treated.[50] While waste production has only been relatively decoupled from economic growth, the OECD has not advised slowing economic growth to achieve further decoupling. Rather, the OECD has advocated stronger waste reduction policies and better whole system approaches to sustainable design to achieve more significant decoupling in this area. According to the OECD, 'New integrated approaches – with stronger emphasis on material efficiency, redesign and reuse of products, waste prevention, recycling of end-of-life materials and products and environmentally sound management of residues – could be used to counterbalance the environmental impacts of waste throughout the entire life-cycle of materials.'[51]

It is possible for nations to achieve decoupling simultaneously across a range of environmental pressures. A leading overall example of national decoupling comes from the Netherlands where significant progress has been made on decoupling economic growth from a range of environmental pressures, as shown in Figure 2.6. The Netherlands is also one of the first countries to undertake research to investigate the relative levels of decoupling of environmental pressure needed to meet the OECD's sustainability criteria. This has

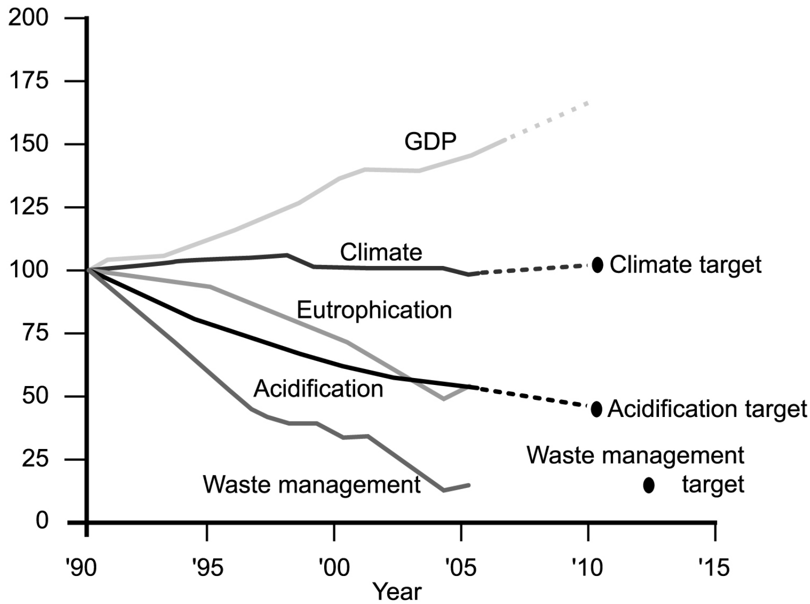


**Figure 2.6** *Achieving decoupling in the Netherlands, 1985–2010*

*Source:* Netherlands Environmental Assessment Agency (2007)[52]

been done through the Netherlands' government Sustainable Technology Development (STD) project, which is one of the first national government programmes to suggest that it is possible to decouple economic growth and environmental damage by as much as 75–95 per cent (a factor of 4–20) over a 50-year period in many critical sectors of the economy.

The STD project has been documented in detail in the 2000 publication *Sustainable Technology Development* by Paul Weaver et al.[53] One of the most remarkable works to enter the sustainability debate, *Sustainable Technology Development* provides a very powerful methodology for generating innovations that are driven by the need to achieve ecological sustainability. The book starts with a 'no-flinching' analysis of just how big a change would be needed to achieve ecological sustainability. This was assessed for a range of issues and the result in all cases is that the changes need to be very big (factor 20–50 improvements). This would not shock most people, but it is very rare for government-sponsored projects to face this level of reality.

Rather than giving up at the point where they discovered that nothing less than wholesale technology innovation and reinvention was required, the project went on to figure out how the necessary efficiency gains and redesigns could be accomplished. The project looked at case studies covering the issues of nutrition (food supply), water management, chemicals supply and alternative engine/fuel systems for cars. The methodology also dealt with how to create the commitment and momentum to ensure that innovation programmes were followed through to their results. The STD project was also a key influence, leading to the development of the Fourth Dutch National Environment Plan that looks specifically at system change to achieve ecological sustainability.

> *Certainly many use growth [of global material and energy flows, population, environmental damage] to forecast disaster. But there is an alternative vision: one of a sustainable future where [economic] growth is not seen as a threat but as a driving force behind innovation.*
>
> Paul Weaver et al, *Sustainable Technology Development*, 2000[54]

Table 2.3 provides a summary from *Sustainable Technology Development* of the Netherlands government's targets for factor 10–50 (depending on the issue) in 50 years from 1990 levels (that is, by 2040). For example, fossil carbon emissions were targeted at factor 25 (p42), oil was factor 40, copper factor 30 and acid deposition factor 50 (p43). Table 2.3 was originally adapted by Phillip Sutton for the 2005 publication *The Natural Advantage of Nations*,[55] to show the specific factor improvements needed (without adjustment for population growth and poverty reduction), ranging from 20 to 99 per cent improvements, including page numbers from the source document. However, the table has now been updated for this publication and includes direct comments from the Chairman of the STD programme (1993–1998) Professor Leo Jansen. Jansen has stated that since the STD project, the Netherlands' GDP grew by 220 per cent between 1990 and 2006, and by 2006, greenhouse gas emissions reduced by 3 per cent relative to the 1990 baseline,[56] although final consumption of petroleum products also grew by nearly 18 per cent from 1995 until 2006.[57]

> *Since the STD programme has been closed, the STD approach has been further developed, spread and applied … as a stepping stone for transition policies in the Netherlands. Furthermore, the STD approach is embedded and applied in (higher) education for sustainable development.*
>
> Leo Jansen, Chairman of the STD programme and Professor of Environmental Technology at the University of Delft[58]

While it is relatively simple to describe the STD programme with its rationale, underlying philosophy and methodology, or to expand upon case studies, evaluating the programme is somewhat more complex. Measurable results will only be evident in the long term and may be inextricably linked with outcomes from other influences. Hence the updates added to the table above focus on the short-term and indirect indicators of influence, with some more recent trends and achievements. The five-year programme was completed in 1997, and since then many of the case studies have been embedded in continuation activities in the Netherlands.

**Table 2.3** *Results of the Netherlands Sustainable Technology Development (STD) project (with recent progress and reflections from the Chairperson of the STD programme)*

| *Case study area* | *Programme target* | *Predicted potential and indicators of progress* |
|---|---|---|
| **Nutrition** | | |
| Sustainable multifunctional land use | | Factor 20 (95%) over several eco-capacity criteria (p100).<br>**Update:** *Greenhouse gas emissions in the agricultural sector decreased by 19% from 1994 to 2004, while the amount of nitrogen and phosphates used both decreased by 25%. Ammonia emissions decreased by 32%, and mineral losses from soils have more than halved in the preceding 20 years. Manure is being traded between intensive livestock and stockless arable farms to decrease fertilizer use and eutrophication of surface water.*[59] |
| High-technology closed-cycle horticulture | | Wastage of $CO_2$ can be cut by factor 8 (87%) and water by factor 18 (94%) (p116).<br>**Update:** *The energy per product used in glasshouse horticulture was 54% less (factor 2) in 2005 than it was in 1980. The industry is now investigating the prospect of being a net energy provider, treating glasshouses like solar collectors*.[60] |
| Novel protein foods | Average factor 20 improvement by 2035 (p145). | In general in many cases: factor 20–30 (95–97%) with half to one-fifth of the cost (p104).<br>Specific examples: Lupin cheese factor 9–21 (89–95%) improvement on dairy cheese production (p112); potato-derived pasta factor 8 (87%) improvement over wheat pasta (p112); by 2035 novel food protein could be produced more efficiently than pork today by factor 80 (99%) or factor 60 (98%) better than meat in 2035 (p143).<br>**Update:** *Several research projects are under way to explore the economic, environmental and social aspects of novel protein foods (NPF) and consumer choices.*[61, 62] *One such project found land use efficiencies of factor 3–4 when meat production was replaced with novel proteins production, while water efficiency increased by factor 30–40.*[63] *Another study, which found that consumer expenditure on NPF has been increasing in the Netherlands, predicted that in the next 30 years NPF will replace 40% of current meat consumption.*[64] |
| Protein Foods, Environment, Technology and Society (Profetas) (added by Professor Leo Jansen) | As a follow-up to NPF an inter-university programme was constituted to explore and deepen further developments.[65] | The Profetas results show that the environmental benefits of a transition from animal to plant protein may be factor 3–4 for land and energy requirements, but 30–40 or more for water requirements and acidification. The geographical distribution of potential environmental and economic benefits strongly depends on the actual protein crop selected. |

| *Case study area* | *Programme target* | *Predicted potential and indicators of progress* |
|---|---|---|
| **Water** | | |
| The water-handling system (does not deal with water use efficiency measures) | Factor 20 improvement (p158) by 2040 (p159). | Some of the most important actions need to be taken on the demand side by system users in households, businesses and industry (p152). Abiotic depletion can be reduced by factor 3 (67%) and aquatic eco-toxicity by factor 4 (75%), fossil energy use by around factor 1.25 (15–20%), solid waste production by factor 1.3 (25%).<br>**Update:** *Over a ten-year period to 2006, overall water efficiency improved by 23%.*[66] |
| The 'Waterpact Twente'[67] (added by Professor Leo Jansen) | An integral sustainable water system in the Twente region. | In a follow-up of STD all relevant stakeholders, municipalities, industries, water authorities, drinking water industry, farmers and the province of Overijssel joined in the Waterpact. In seven years the goals were achieved. The pact is seen as an example for other regions and cities. |
| Cleaning domestic textiles | Factor 10–20 (p176) by 2040 (p186). | Household by 2025: factor 2.5 (60%) for energy, factor 4 (75%) for water, factor 5 (80%) for detergent (p194).<br>Neighbourhood by 2025: factor 2 (50%) for energy, factor 10 (90%) for water, factor 10 (90%) for detergent (p195).<br>Centralized by 2025: no conclusions reported.<br>More efficient technologies expected to be cheaper: less than half the cost possible by 2005 (p197). |
| **Chemicals** | | |
| Chemical and industrial materials | By 2040 no fossil fuels used to source industrial organic chemicals/materials and factor 20 improvements in efficiency of eco-capacity use (p215). | Many promising technology changes identified but no quantitative results reported. |
| Sourcing organic chemical feed stocks | To supply sufficient biomass to source organic chemicals and materials (plastics, liquid fuels, etc.), and to find effective chemical pathways from biomass to needed organic chemical materials. | The quantity of biomass that can be produced is adequate for chemicals and materials, but there is a shortfall for liquid fuel (p221).<br>Feasible synthesis routes were available for practically all major commodity products. The quantity of phenolic compounds sourced from biomass may not be adequate (p245).<br>**Update:** *The National School in Process Technology is currently undertaking an extensive list of research projects into sourcing organic chemical feed stocks.*[68] *DSM, a Netherlands-based chemical manufacturing company, reported its strongest quarter in 2008, largely resulting from the 17% growth in sales of organically based chemicals.*[69] |

### Table 2.3 *continued*

| *Case study area* | *Programme target* | *Predicted potential and indicators of progress* |
|---|---|---|
| Biomass production on saline soils | To find halophytic plants that produces useful biomass as feedstock for the production of chemical products so that biomass production can be expanded by utilizing otherwise unavailable salinized land. | Several appropriate halophytic plants are available. **Update:** *A three-year project which commenced in 2006 is developing bio-saline agro-forestry systems for the Netherlands to both remediate saline wastelands and to produce biomass.*[70] |
| **Motor vehicle propulsion** | | |
| Hydrogen fuel/ fuel cell cars | To find alternative renewable energy 'carrier' fuel(s) – with high end-use conversion efficiency to offset any inefficiency of the initial production (p249) – that can provide the basis for a significant Dutch industry to replace fossil fuel oil in the refinery sector (p248). | Hydrogen fuel (or hydrogen-rich liquid carriers, such as cyclohexane and methanol) identified as possible alternatives (p248).<br>A hydrogen-fuelled fuel cell car could have an increased energy efficiency of factor 1.75 (43%) compared to conventional internal combustion engine cars (p263). Renewable energy use with carbon removal from the fuel and carbon sequestration could enable $CO_2$ to be removed from the atmosphere (p265).<br>**Update:** *The Netherlands has developed a fuel cell system and the first Dutch hydrogen vehicles are entering operational service.*[71] *Amsterdam ran a successful three-year trial of hydrogen buses and is currently developing the world's largest hydrogen public transport project in Rotterdam with 20 hydrogen buses and associated refuelling infrastructure*.[72] |
| **Update**<br>**Further developments (added by Professor Leo Jansen)** | | |
| Adaptive Integration of Research and Policy for Sustainable Development[73] | Evaluation of ten research and technology development programmes. | This evaluation confirmed and proved the applicability of the STD approach for sustainable development. The report contains annexes on pitfalls and recommendations for setting up and evaluating research and technology programmes for sustainable development. |
| Strategic sustainable development | Comparison of sustainable-development-oriented approaches.[74] | Among the investigated approaches the STD approach is 'backcasting', and focused on societal needs.[75] |
| Climate OptiOns for the Long term (COOL) | The STD approach was applied in a programme to reduce use of energy and $CO_2$ emissions by factor 4. | The programme was a participatory process based on the STD approach with dialogues on three levels: National, EU and Global.[76] |

| *Case study area* | *Programme target* | *Predicted potential and indicators of progress* |
|---|---|---|
| Transition policies | The STD programme was a stepping stone to the Dutch transition policies. | Transition theory has been developed as a follow-up to STD.[77] In Dutch policies, transitions are to be achieved in the fields of energy, mobility, agriculture and biodiversity. |
| Plant of the future, Austria | A governmental programme, 2002–2009, with 142 projects to date. | In a number of projects the STD and transition approach was applied. |
| **Education (added by Professor Leo Jansen)** | | |
| Delft University of Technology | STD-derived backcasting applied to education of engineers. | The university is investigating the competences of the engineer in ten years working in a developing world as the basis of a programme to embed sustainable development into courses at the university.[78] |

*Source:* Weaver et al (2000);[79] summarized by Philip Sutton in Hargroves and Smith (2005);[80] and updated by Professor Leo Jensen and The Natural Edge Project for this publication.

## How Does Decoupling Directly Contribute to GDP?

Historically, political parties tend to rise or fall based on the performance of the GDP. Tony Blair once stated that growth in GDP would be the 'judge and jury' of British Labour's success. Hence to the majority of the governments of the world, increasing GDP is an imperative, as it is directly linked to a range of important 'voter' issues, such as employment, interest rates, health care, education and infrastructure development, and is therefore a strong determinant of political success. This is ironic as many commentators in this area now point out that the measure was never intended by those who invented it to be such an influential indicator. John Maynard Keynes, John Hicks and Simon Kuznets who first developed the system of national accounting (to specifically assist nations manage their economies out of the great depression), warned against using the GDP as a measure of well-being and prosperity. As Simon Kuznets told the US Congress in 1934, 'The welfare of a nation can scarcely be inferred from a measurement of national income ... Goals for more growth should specify of what and for what.'[81] As US Senator Robert Kennedy famously stated in 1968:

> *The Gross National Product includes air pollution and advertising for cigarettes, and ambulances to clear our highways of carnage. It counts special locks for our doors, and jails for the people who break them. GNP includes the destruction of the redwoods and the death of Lake Superior. It grows with the production of napalm and missiles and nuclear warheads. And if GNP includes all this, there is much that it does not comprehend. It does not allow for the health of our families, the quality of their education, or the joy of their play. It is indifferent to the decency of our factories and the safety of our streets alike. It does*

> *not include the beauty of our poetry or the strength of our marriages, or the intelligence of our public debate or the integrity of our public officials ... GNP measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country. It measures everything, in short, except that which makes life worthwhile; and it can tell us everything about America – except whether we are proud to be Americans.*[82]

Even though not traditionally reflected in the calculations of GDP, some economists have long made the distinction between economic activity that is created from activities that impact on society and the environment, such as cleaning up oil spills and fighting wars, and economic activity which services the optimal social good and builds sustainable wealth. For instance, in 1848 French economist Frederic Bastiat outlined what he called the 'broken window fallacy', and explained that if someone throws a stone and breaks a shop window, the owner needs to repair it ... this puts people to work ... and hence it would easy to assume that if more windows were broken it would be a positive thing for the overall economy. However, Bastiat pointed out that what is seen is the broken window being repaired, the activity of the workers, and the money they in turn spend. What is not seen is that these workers and resources may have been better employed on something else if not for the broken window. Bastiat believed that when assessing the economic situation one must not only consider the foreseeable and immediate consequences, both good and bad, but one must also look to the longer term, across the whole of society. Bastiat stated that, 'In the economic sphere an act, a habit, an institution, a law produces not only one effect, but a series of effects. Of these effects, the first alone is immediate; it appears simultaneously with its cause; it is seen. The other effects emerge only subsequently; they are not seen; we are fortunate if we foresee them.'[83] What ultimately benefits society is not fixing more broken windows, or repairing damage from wars,[84] or dealing with the impacts of pollution, but instead directing material and human resources to develop goods and services, infrastructure, policies and practices that improve conditions and increase wealth and well-being.

There have been a number of calls for alternative indicators to the GDP, such as the 1972 work of William Nordhaus and James Tobin to propose a 'measure of economic welfare'.[85] This work was later further developed by Herman Daly and John Cobb in 1989 when they proposed substituting GDP with an 'index of sustainable economic welfare',[86] aligned with the much earlier work of John Hicks in 1939, when he suggested that 'the purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves'.[87] Further calls have been made to replace GDP with measures including the 'genuine progress indicator' (GPI), and a measure of 'net national income' (NNI), but GDP remains entrenched in systems of national accounts. A 2009 report by the

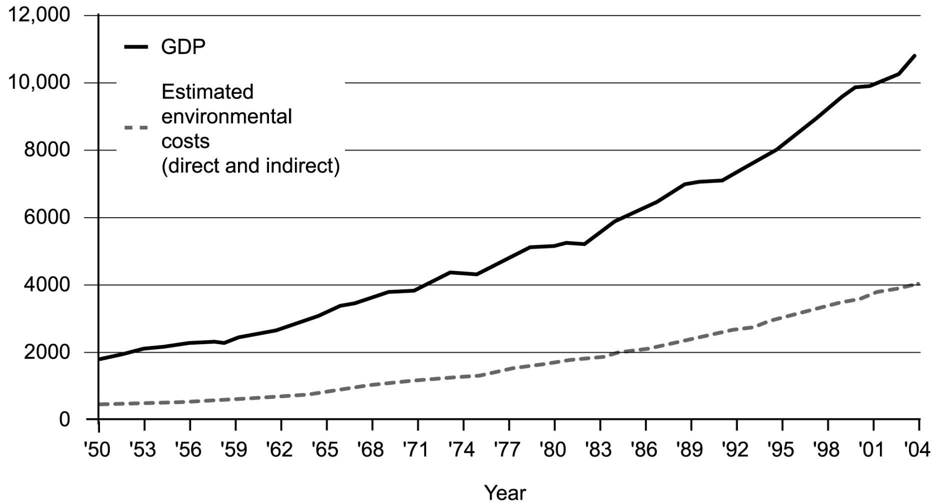


**Figure 2.7** *Gross domestic product compared with estimated environmental costs (billions) for the US, 1950–2004*

*Source:* Data reinterpreted by K. Hargroves from Talberth, J. et al (2006)[88]

'Commission on the Measurement of Economic Performance and Social Progress', initiated by French President Nicholas Sarkozy, and led by notable economists Joseph Stiglitz and Amartya Sen, argued for the adoption of measures of well-being to be used in conjunction with the GDP.[89] Further to the understanding that additional measures need to be compared to GDP, such as 'decoupling indicators' as explained in Chapter 5, it must also be understood that environmental pressures are leading to real and measurable costs that reduce a nation's GDP.

A reinterpretation by the authors of the results of a leading study undertaken by the US public policy think tank, Redefining Progress, demonstrates such costs, with the results shown in Figure 2.7.

As part of a process to calculate an alternative measure to the GDP, the genuine progress indicator (GPI), the group Redefining Progress researched and quantified a number of environmental costs during the period 1970–2004 in the US. These costs included: household pollution abatement; water pollution; air pollution; loss of wetlands; loss of farmland; loss of primary forests; resource depletion; carbon dioxide emissions damage; and ozone depletion.[90] When such costs are aggregated and plotted against GDP it can easily be seen that as GDP increases so do the estimated environmental costs, and increasingly so, with the costs rising from 22 per cent of GDP in 1950 to 37 per cent in 2004. This simplified example is complicated by a number of factors related to measurement and assumptions regarding the distribution of costs, but it provides a clear picture of the trends associated with economic growth and costs related to environmental pressures. Hence, in order to monitor the overall economic progress of a society, the GDP must be held against the level of environmental damage it creates, and in particular the direct and indirect costs associated with this damage. This will then provide an indication of both the economic progress and the level of reliance on damaging the environment that is required to deliver it, potentially providing a strong indicator of a nation's risk of maintaining future economic growth.

Hence a focus on decoupling provides nations with a strategy to reduce the costs related to environmental pressures while undertaking activities that allow an increase in GDP. As GDP is an aggregation of the economic activity of a nation, both 'good' and 'bad' economic activity will contribute to its growth. Hence activities that promote the 'good' and discourage the 'bad' can still lead to overall growth. Furthermore, the 'good' actions that reduce environmental pressures can lead to a range of additional benefits that support economic growth. In particular, investments to reduce the consumption of resources – such as to improve the efficiency and/or productivity of energy, water and other resources – are now being recognized as having a compounding effect on GDP. This is due to the fact that such investments lead to reduced input costs, reduced running and maintenance costs, and reduced waste-related costs, and hence can be recovered over a reasonable timeframe to then deliver ongoing cost savings that can then be invested to achieve even greater improvements, and so on. Furthermore, as such investments can lead to reduced levels of consumption of resources, such as water and electricity, this can lead to delays in or even the avoidance of costly investments in increasing the capacity of energy and water supply infrastructure, as well as plant and infrastructure in extractive industries. Typically such investments are at a local level and can spur job growth and economic development, attracting companies and operations keen to be part of such initiatives.

However, in order to understand how efforts to reduce environmental pressures can enhance economic growth it is important to understand the two main approaches used to calculate GDP.

The most common approach is called the 'expenditure' method, where:

GDP = Consumption + Investment + Government spending
+ Gross (Exports − Imports)

Represented as GDP = C + I + G + (X−M)

The following explains the formula above with reference to how the efforts to reduce environmental pressures can contribute positively to GDP:

- Consumption (C) represents the private consumption in the economy. This includes most personal expenditures of households such as food, rent, medical expenses and so on, but does not include new housing. Thus if a household purchases energy-efficient light bulbs and appliances, organic food, new bicycles, accredited green electricity from renewable energy sources, this all adds positively to GDP.

- Investment (I) is defined as business investments in capital,[91] such as spending on new houses, including those with sustainable aspects. Such investments include a range of activities such as: onsite energy recovery and generation; onsite water recovery, capture and treatment; green retrofitting of buildings; and improvements to operating plant and equipment – all counting positively to a nation's GDP.
- Government spending (G) is the sum of government expenditures on final goods and services. It includes salaries of public servants, military expenditure and any investment expenditure by a government, along with:
  - spending to support and encourage the development of decentralized, low-carbon, renewable energy supply infrastructure (including upgrades to national electricity grids to accommodate such new supply – referred to as a 'smart grid');
  - spending to undertake green retrofitting of the publicly owned built environment infrastructure (such as defence and military bases, schools, housing commission homes, hospitals, university campuses and general government buildings, and public and street lighting), along with increasing environmental performance requirements for new buildings;
  - spending on sustainable transport infrastructure and vehicles (such as in expanding coverage of rail and light-rail infrastructure, increasing the use of low-carbon alternatives for buses and rail services, the construction of bicycle paths and preferential lanes for high-occupancy vehicles);
  - spending on the restoration and enhancement of natural systems and biodiversity, along with improvements to agricultural techniques and practices;
  - spending on national broadband infrastructure that can enable video conferencing to dramatically reduce dependency on air transportation;
  - spending on structural adjustment packages and retraining of workers and business managers to reduce their burden of environmental pressure, to completely transition those unsustainable industries that need to be made redundant, or to create entirely new industries such as recycling of materials and products;
  - spending on overseas development aid to assist developing countries to cost effectively reduce environmental pressures.
- Gross exports (X) is the amount of goods and services produced for overseas consumption, and gross imports (M) are subtracted from the gross exports since imported goods will be included in the accounts for government spending, investment or consumption, and must be deducted to avoid counting foreign supply as domestic. A range of decoupling-related activities can help improve this balance of trade results, including:
  - A transition to sustainable transport systems reduces the amount of oil

and gas imports needed. Oil imports over the coming decades will add significantly to import bills for most nations unless they find alternative sustainable transport approaches.

– Efforts to reduce waste and encourage greater recycling will also reduce the amount of new appliances, cars and equipment plus raw materials, metals, chemicals and plastics, and fertilizers, needing to be imported. This can also lead to a surplus of materials being created, thus enabling more exports. For instance, Australia recycles more paper and cardboard products and PET bottles than it can reuse, creating export opportunities.
– Nations which shift their subsidies and incentives to reward businesses that are innovating lower consumption and/or pollution technologies will help the economy to position itself to capture the growing markets for these products.

Hence sustainable consumption, green investments, reducing unnecessary imports and increasing environmentally friendly exports all positively adds to a nation's GDP.

The second most used method for measuring GDP is to measure the total income payable in national income accounts. In this situation, one will sometimes hear of gross domestic income (GDI), rather than gross domestic product. This should provide the same figure as the expenditure method described above. (By definition, GDI = GDP; however, in practice measurement errors will make the two figures slightly off when reported by national statistical agencies.)

Calculating GDP using the 'income' approach involves:

GDP = Compensation of employees + Gross operating surplus + Gross mixed income + Taxes less subsidies on production and imports

Represented as GDP = COE + GOS +GMI + Taxes − Subsidies, where:

- Compensation of employees (COE) measures the total remuneration to employees for work done. It includes wages and salaries, as well as employer contributions to social security and other such programmes. During an economy-wide transition to lower environmental pressures, which would be a period of several decades at least, the economy would have a strong structural tendency to higher levels of employment. The structural tendency to favour higher employment is caused by three things:
  – the recycling of revenues from eco-taxes to reduce payroll taxes or other costs of employing labour;
  – the greater labour intensity of new ways of doing things where the technology and the manufacturing and operational techniques are not yet highly refined;
  – the pump-priming effect of investments brought forward to replace scrapped capital.

- Gross operating surplus (GOS) is the surplus due to owners of incorporated businesses, also called profits, although only a subset of total costs is subtracted from gross output to calculate GOS. There is now significant empirical evidence that, wisely applied, pursuing practices that reduce environmental pressures can help improve a business's bottom line both through eco-efficiency savings in the short term but also by positioning itself for new emerging markets longer term.
- Gross mixed income (GMI) is the same measure as GOS, but for unincorporated businesses. This often includes most small businesses.

Hence once it is clear how GDP is calculated, and the range of decoupling actions that can contribute to its growth, an important consideration in understanding the economic implications of particular investments is the concept of an economic multiplier, which is effectively the direct increase in GDP for each dollar of spending. This measure can then be used to compare how much economic activity can be generated by different combinations of purchasing and investment. A higher economic multiplier will lead to greater economic vitality because business activity is encouraged, creating jobs and encouraging investment. Investments made locally in reducing energy and water demand, and in generating electricity through small-scale renewable options (e.g. solar, wind, hydroelectric and co-generation) can create significant economic multipliers. For instance, as mentioned above, investments to increase energy, water and resource productivity have a high economic multiplier as they not only reduce pollution-related costs but they also reduce the levels of inputs needed, thus reducing energy and water bills and input resource costs, along with delaying and even permanently preventing the need to spend money on expanding resource intensive infrastructure, which is particularly valuable as such investments have low economic multipliers.

Several local and state governments have now analysed the actual and projected economic development effects of energy efficiency or alternative energy projects, including:

- In Osage, Ohio, they found that a US$1.00 purchase of ordinary consumer goods in a local store generates US$1.90 of economic activity in the local economy. In comparison, petroleum products generate a multiplier of about US$1.51; utility services US$1.66; and energy efficiency US$2.23.[92] The reduced demand has delayed investment in energy infrastructure, reducing electricity rates by 19 per cent over an eight-year period, and natural gas rates by 5 per cent over a five-year period.[93] In addition, the programme reduced unemployment to half that of the national average as the lower electricity rates attracted more factories and companies to town, while reducing the emissions and costs of the utility itself.[94]
- The Massachusetts Division of Energy Resources reports that the state has realized a 257 per cent job growth in energy efficiency firms, such as

energy service companies, between 1988 and 1992, indicating vigorous business growth.

- The Wisconsin Energy Bureau found that the use of renewable energy generates about three times more jobs, earnings and sales output in Wisconsin than the same level of imported fossil fuel use and investment. Given a 75 per cent increase in the state's renewable energy use, now representing 6 per cent, the Bureau found that the state would realize more than 62,000 new jobs, US$1.2 billion in new wages and US$4.6 billion in new sales for Wisconsin businesses.

Hence investments to reduce environmental pressures – such as eco-efficiency improvements; building new industries such as recycling and processing; and building low-carbon energy infrastructure – can have a positive effect on local economies. Often these initiatives can lead to lower costs of living in the form of lower utility bills, taxes and rates, or lower costs of local goods and services.

## Understanding and Reducing the Risk of Negative Rebound Effects from Decoupling Activities

Eco-efficiency investments, in particular, can yield such cost savings to business and households, that, without appropriate mechanisms and government policies, can result in direct or indirect negative rebound effects which can undermine the intended environmental benefits. Direct negative rebound effects include where the demand and consumption of a good increases due to a price reduction caused by the more efficient production methods and lower operational costs. Thus when a more eco-efficient technology, process or product is introduced into the market, it does not automatically imply that, due to the greater eco-efficiency, there will be a significant reduction in environmental pressures. As the product is cheaper to produce, it will be cheaper to purchase, leading to the potential for more people being able to afford to use the product leading to greater demand for such products. The direct negative rebound effect was first noticed in 1865 in the book *The Coal Question*[95] by William Jevons which showed that improving the efficiency with which coal was used to produce steel by over two-thirds in Scotland, was followed by a tenfold increase in total consumption, between the years 1830 and 1863. This was of course due to the fact that the lower coal consumption required to make steel meant that steel could be produced more cheaply. With steel available at cheaper prices, the demand for steel rose significantly. This occurrence is now referred to as a 'rebound effect', or as the 'Jevons paradox', after the author of *The Coal Question*, William Jevons. So, without effective government policies or market mechanisms in place, simply making production methods more efficient will not necessarily lead to an overall reduction in environmental pressures as consumption levels may grow due to the lower price in the market. However, improving the operational end-use efficiency of products, appliances and transport vehicles does lead to significant reductions

**Table 2.4** *Summary of estimates of rebound effects in the US residential sector*

| *Device* | *Potential size of rebound* | *Number of studies* |
|---|---|---|
| Space heating | 10–30% | 26 |
| Space cooling | 0–50% | 9 |
| Water heating | <10–40% | 5 |
| Residential lighting | 5–12% | 4 |
| Appliances | 0% | 2 |
| Automotive transport | 10–30% | 22 |

*Source:* Greening et al (2000)[96]

in environmental pressures per item and effectively managed can lead to significant reductions overall. For instance, there is no evidence that owners of hybrid vehicles have driven twice as much just because their cars were more fuel efficient as some predicted, with similar results found in green buildings. Furthermore investing in end-use energy and water efficiency can have further positive rebound effects such as delaying the need to build new unsustainable energy (coal- and gas-fired power stations) and water supply infrastructure (more dams, desalination plants run from carbon-intensive electricity) if governments institute effective policies.

However, even here the positive effect can be reduced by negative rebound effects:

- Once homes are effectively insulated and people get used to the extra comfort of having a warm or air-conditioned house, this can lead to them running their heating or air-conditioning systems more often.
- Installing much more energy-efficient lighting can lead to people not being so conscientious in turning them off when they are not needed. Since people know that the light bulbs they have installed are ultra-efficient, and thus cost so little to run, they can neglect the need to turn them off regularly.
- Ultra-efficient transportation vehicles can use so much less petrol per 100 kilometres, this can make it easier for people to financially afford regularly to drive long distances. These sorts of factors have been shown to lead to negative rebound effects as shown in Table 2.4.

Furthermore, indirect negative rebound effects can also occur where the money saved on the particular good or service, due to a reduction in price, is spent on other goods and services that have a negative environmental impact. Such examples include people increasingly taking advantage of cheap airflights and travelling more by air, which uses far more resources than train or bus travel.

And even though there is growing social concern and understanding around the issues related to environmental pressures, particularly in relation to greenhouse gas emissions, surveys have identified a disconnect between the level of environmental concern and the consumption patterns of households.[97] This can be due to a range of factors, including the impact of social pressure to conform to a particular pattern of work and consumption outweighing the individual desire to reduce environmental impact. Also, when people have little spare personal time to research up-coming purchases, it is often easier simply to purchase something that is 'conveniently available' even though it may not be environmentally the best available product in that market. This is often the case as there is a lack of information available to the public to inform them of the sustainability performance of products in the marketplace. The reality is that much of the current global economy, and the goods and services it produces, are intrinsically unsustainable, and will be for some time to come, and hence anything that saves people and businesses money and enables them to purchase more, will often lead to purchasing new products and services that are on the whole unsustainable. Furthermore, as this phenomenon involves the nexus between technical performance and social behaviour, it is a very complex issue to manage, as it can negate many well-intentioned technical and policy innovations designed to reduce environmental pressures and advance societal progress, particularly as the effect can actually see increases in GDP.[98]

To further complicate the issue, it has been found that the rebound effect can result in a range of economy-wide effects (also referred to as 'the inter-sectoral rebound effect' to signify the macroeconomic scale[99]), namely:

- Producers may use cost savings from improvements in efficiency to increase output which results in increasing consumption of capital, labour and materials.
- Efficiency improvements will also increase the labour, capital and materials productivity, which may stimulate further economic growth and subsequently increase resource use.
- Efficiency improvements in the use of a particular resource will decrease the price of goods that contain that resource relative to other goods, thus causing a substitution towards those goods.[100]

These impacts can be significant, as according to long run analyses of the US economy from an industrial ecology perspective by Robert Ayers and colleagues, 'physical rebound' (efficiency improvements in energy and materials) was the main motor of GDP growth (and thus use of energy and materials) over the last 100 years.[101] Another study of clean development mechanisms in India found that implementing aggressive end-use efficiencies caused a rebound of 25 per cent, largely negating the greenhouse rationale for the clean development approach.[102] Hence efforts to reduce overall environmental pressures and levels of resource consumption cannot rely solely on technological or process improvements to productivity, and must be complemented with a range of underpinning mechanisms, government policies, education and initiatives

Whilst clearly negative rebound effects can be significant, it is important to note that they need not be because it is also likely that the businesses and households will use their financial savings from eco-efficiency improvements to further invest in actions that reduce environmental pressures. According to Adjunct Professor Alan Pears, much can be done to encourage these positive amplification effects.[103] Pears argues that it is just as likely that positive environmental change from investments in eco-efficiency initiatives, like energy efficiency, will lead to people in their homes and workplaces undertaking more ecologically sustainable initiatives, not less (leading to a positive amplification effect rather than a negative rebound effect), including:[104]

- the purchase of accredited 'green' power, or third-party-certified carbon offsets;
- reducing the amount of water needing to be heated in the home through installing water-efficient shower heads and tap fixtures, and then investing in options to reduce energy consumption in hot water systems, such as upgrades to solar PV, solar thermal or heat pump systems;
- options to reduce internal heating and cooling loads, such as increased insulation, painting roofs white, double glazing or applying films to windows, installing appropriate window furnishings and pelmets, and planting appropriate vegetation to shade homes;
- reducing the ecological footprint of travel, such as substituting with low-emission transportation options like public transport, bicycles or walking;
- purchasing locally grown goods, preferably organic (meaning that chemical pesticides and fertilizers are not used, considering that it takes more energy to create a tonne of fertilizer than a tonne of steel).

Similarly, business can be encouraged to utilize financial cost savings from eco-efficiency investments to invest in further eco-efficiency opportunities with longer payback periods. For instance, this can be done through governments increasing mandatory energy efficiency standards of new appliances and industrial equipment with longer payback periods to divert money towards reinvestment in energy efficiency and away from other economic activity, reducing the negative rebound effect. Governments can also require companies above a certain size to invest in eco-efficiency opportunities with a designated payback period, (say, initially one- to two-year payback periods, then ramped up over time to three- to four- and then four- to eight-year payback periods), to ensure that savings from short-term eco-efficiency gains are invested in further eco-efficiency opportunities. To ensure that this does not just delay and make the negative rebound even larger, a portfolio policy approach is needed. Government policies and incentives are needed to require companies to go further than simply eco-efficiency and also invest in, for instance, onsite co-generation, renewable energy and other sustainability initiatives such as onsite rainwater harvesting. Government policies, incentives, rebates, education and information can powerfully influence how people and businesses choose to reinvest their financial savings from eco-efficiency initiatives and thus significantly reduce the negative rebound effect and instead encourage positive amplification effects. Governments can do much to help businesses and households move on from just simplistic focus on 'efficiency alone' to encourage them to invest in other initiatives that reduce environmental pressures. Governments can do this by using a range of policies, such as:

- mandatory renewable energy targets supported by feed-in tariffs to encourage the direct substitution for renewable energy from fossil fuel-based energy;
- product stewardship, recycling and waste reduction policies and targets;
- limitations to carbon based energy use and excessive use of natural resources (by physical caps, rationing or higher prices) – using financial instruments to ensure that the price of energy, water and other materials remains relatively constant while the efficiency of their use increases can reduce direct and indirect rebound effects;
- capturing a percentage of the financial benefit from efficiency gains to invest in greening activities, such as national infrastructure improvements and natural resource/habitat restoration, through the use of carbon/ecological taxation.

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