Energy Sufficiency

"You don't have to change – survival is not mandatory."

W. Edwards Deming

If we are serious about keeping the global temperature increase to no more than 2°C, we can only burn a quarter of our oil, gas and coal reserves. This is the startling conclusion of two studies, by Myles Allen of the University of Oxford and Malte Meinshausen of the Potsdam Institute for Climate Impact Research. These are probably the most comprehensive efforts yet to define climatic limits to fossil-fuel combustion.

Since the industrial revolution, humanity has burned about 500 billion tonnes of carbon fuels. Says Myles Allen: "We can afford to burn only 250 billion tonnes more – or perhaps 500 billion tonnes if we are willing to run the higher risk. . . . It took 250 years to burn the first 500 billion tonnes. On current trends we'll burn the next 500 billion in less than 40 years."[1]

The 'safe' goal of a temperature increase of 2°C at the most, means that global emissions must start falling after 2015. Given that at present we are increasing emissions by up to 3 percent each year this is no small feat. The two studies suggest that the G8 countries' target of cutting global emissions to 50 percent of their 1990 levels by 2050 may not be enough – the cutbacks will have to be closer to 70 percent!

These are dramatic challenges: even the most ambitious climate stabilization plans tabled so far are totally insufficient. In Chapter 2 we suggested that to deal with increasing GHG concentrations in the atmosphere it is crucial to find every possible way to enhance the carbon sequestration capacity of the biosphere. In Chapter 3 we described the policies which can dramatically accelerate the introduction of renewable energy technologies. But none of this will be enough to assure climate stability.

In this chapter we argue that we need to get to grips with the concept of *energy sufficiency* across the developed world if we wish to prevent runaway climate change. Whilst *energy efficiency* measures are necessary first steps, we need to go beyond that: there has to be an actual upper limit of global per capita fossil-fuel use.

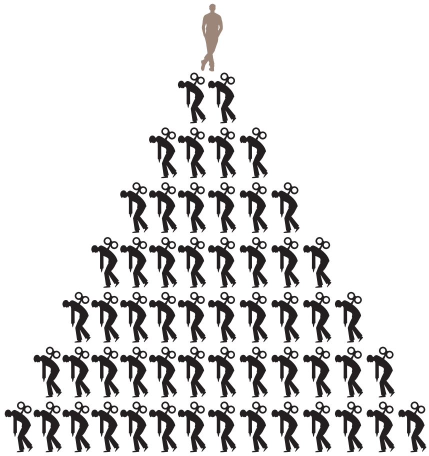
This chapter is trying to set the scene, but ultimately the world community has to agree the steps that are needed. There is no doubt that a clear understanding of energy sufficiency is crucial for the long-term ecological viability of the global economy. Assuring people's wellbeing across the world, whilst defining limits to the use of non-renewable energy, is one of the great challenges of the 21st century.

ENERGY SLAVES

How can the prolific use of energy use in the rich countries be illustrated vividly? It was US designer and futurist Buckminster Fuller who invented the concept of personal 'energy slaves' who make our comfortable lifestyles possible. This concept has been updated by World Future Council member Prof. Hans Peter Dürr, the former director of the Max Planck Institute in Munich. He divides our energy use into manpower equivalents – the muscle energy of a strong man (equivalent to a quarter horse-power) working six days a week, ten hours a day. By this reckoning, Americans have 110 energy slaves per person, Europeans have 60, Chinese have eight and Bangladeshis have one. If one looks at the global average, every person would only be entitled to 15 energy slaves. So energy supply is very unfairly distributed, whilst energy is also produced and used in a highly unsustainable way.

Dürr, like many other scientists, is convinced that increasing global energy consumption will soon threaten the integrity of the planet. He adds an additional perspective: "The question we must ask is not how many people the earth could sustain, but how many energy slaves it could sustain. My calculations indicate that the limit we have to observe so as not to destroy the world's bio-system is about 90 billion energy *slaves. Yet the world is presently home to about 130 billion energy slaves – 40 billion more than the Earth can sustain. Europeans are using four times and Americans nearly seven times the amount of energy per person that the earth could sustain. So you have really to get birth control of energy slaves."* [2]

Each European has about 60 energy slaves, each American about 110 energy slaves. That is the energy equivalent of a strong man working 10 hours a day six days a week represented by the energy output of the motors and engines, powered by fossil fuel energy, working on our behalf. In a sustainable world this figure would have to come down to a quarter or less.



Credit: Rick Lawrence.

Forecasting energy use

Energy is used for specific purposes – for cooking and heating, for cooling and powering buildings, for pumping water, for manufacture and food production, for transporting people and goods, and for providing us with information and entertainment.

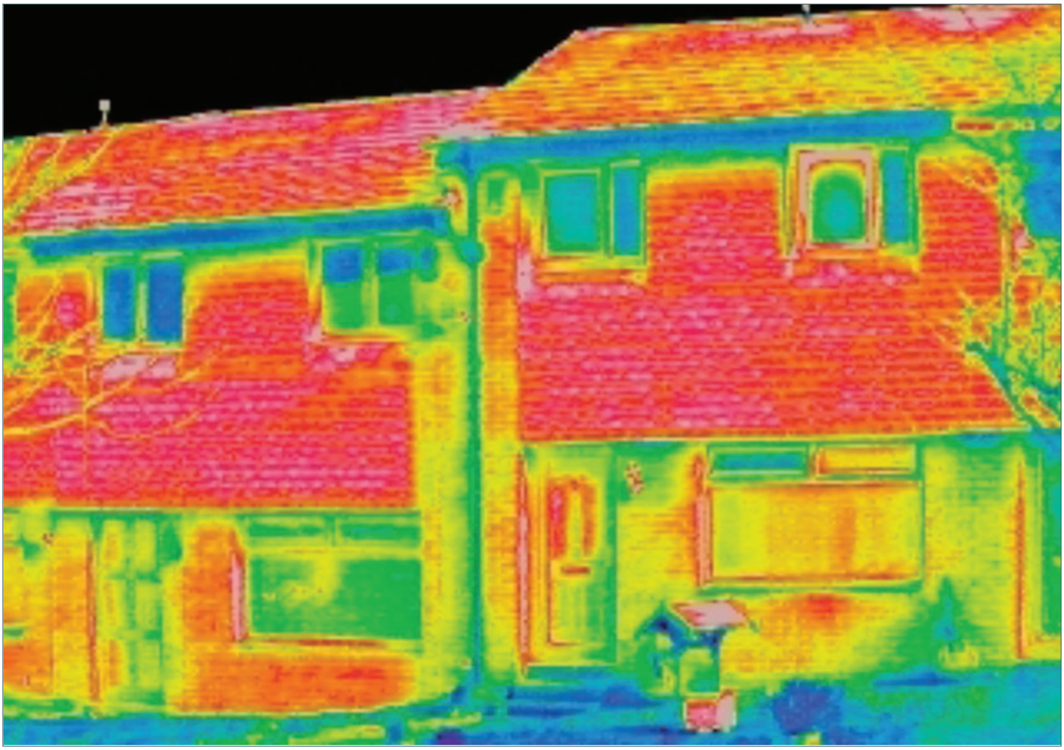
Despite growing concerns about climate change and long-term energy security, the use of fossil-fuel energy is continuing to rise steadily, most recently driven by the economic boom in countries such as China, India and the UAE. Worldwide, energy use per unit of gross domestic product (GDP) is in decline, but it is widely believed that overall global energy demand will continue to grow steadily over the coming decades. According to a UN Foundation report, "demand for global energy services to support economic growth has grown by 50 percent since 1980 and is expected to grow another 50 percent by 2030". The International Energy Agency (IEA), in its 2008 report, estimates an increase in demand of some 45 percent by 2030[3] compared to 2005 if there are no major policy shifts.[4]

Efforts at energy forecasting by bodies like the IEA seem increasingly confused: it predicts ever-greater global energy use

1. whilst worrying about potential energy shortages unless there is massive continued investment in fossil-fuel extraction,
2. whilst also painting an apocalyptic picture of the future state of the world if fossil-fuel burning is not drastically curtailed.

The World Bank has similar perspectives. Researcher Heike Mainhardt-Gibbs, consultant to the Washington-based Bank Information Center, has found that during its 2008 fiscal year the World Bank and the International Finance Corporation increased funding for fossil-fuel development by 102 percent. This compared with just 11 percent for new renewable energy. The Bank has put twice as much into fossil-fuel financing compared with both renewable energy and energy efficiency projects, and five times as much as into new renewable sources taken alone. From 2005 to 2008, the Bank spent 19 percent more on coal than on new renewable energy. Says Mainhardt-Gibbs: "The World Bank has the responsibility to assess each project's full contribution to climate change as its impacts . . . negatively affect developing countries and the poor of the world disproportionately – the very countries (its) programs are trying to benefit."[5]

These concerns are compounded by MIT's Center for Global Change Science in a



Credit: Jonathan Pope, CP Energy Ltd. Infrared photography is a very effective tool for discovering the energy leakage of our houses. Retrofitting with high-efficiency insulation materials and energy management systems has huge implications for their energy performance.

comprehensive computer simulation of global economic activity and climate processes which it has developed over the last 20 years. 400 runs of the computer model, with each run using slightly different input parameters, indicate "a median probability of surface warming of 5.2 degrees Celsius by 2100, with a 90% probability range of 3.5 to 7.4 degrees" if current trends are not drastically altered. Ronald Prinn, co-director of the MIT Centre concludes: "The least-cost option to lower the risk is to start now and steadily transform the global energy system over the coming decades to low or zero greenhouse gas-emitting technologies."[6]

Where do we go from here? Large-scale investments in biosequestration and renewable energy, as suggested in Chapters 2 and 3, are crucial for a climate-proof world. This chapter argues that, in addition, large-scale energy savings are both necessary and possible. For instance, according to a 2007 study by the German Aerospace Centre, a 47 percent reduction in worldwide final energy demand can be achieved by 2050. This scenario is based, firstly, on current best practice, and secondly, on the assumption that continuous innovation will take place in the field of energy efficiency in the years to come.[7]

In the light of the findings by Allen and Meinshausen, cited above, even more ambitious energy savings now have to be envisaged.

The efficiency option

Renewable energy itself is a major contributor to energy efficiency since it can increase local supply for local demand by reducing the need for long distance energy supply. But, in addition, measures to enhance energy efficiency in buildings, industrial processes, transportation and food supply must play a major role in addressing the problems of climate change, energy dependency, fossil-fuel depletion and high energy prices.

Maximum energy efficiency is crucial in a world demanding ever-greater energy supplies. Energy efficiency is also termed energy productivity: it is usually defined as the provision of energy services per unit of energy input. Efficient technologies and processes will deliver the same amount of services with a lower input of energy resources. An increase in energy productivity is – besides behavioural changes – one way to achieve energy savings.

Like labour or capital productivity, energy productivity measures the output of goods and services generated with a given set of inputs. Energy productivity improvements result either from reducing the energy inputs needed to produce a given level of services, or from increasing the quantity of economic output. By being clear about the relative importance of each, measuring energy productivity is useful for enhancing efficient energy use.[8]

The productivity of energy use will always tend to grow over time as technologies are first developed and then improved upon. In Chapter 1 we described how the energy productivity of steam engines increased 14-fold over a period of 100 years. Continuous improvements in designs, processes and supporting policies are needed to achieve this kind of outcome.

Reducing energy demand by a rapid increase in energy efficiency (and renewables) is widely regarded as crucial for assuring global energy security and minimizing climate change. Throughout the developed world a wide spectrum of initiatives is underway – to improve the efficiency of power generation, to phase in energy-efficient light bulbs, to improve energy management systems, and to increase the energy performance of vehicles, household machinery, and most importantly, buildings.

New modelling by the World Business Council for Sustainable Development (WBCSD) shows how energy use in buildings can be cut by 60 percent by 2050 by a variety of measures – better building materials, new approaches to building design, better energy management. The central message of the WBCSD's four-year, $15 million Efficiency in Buildings research project, the most rigorous study ever conducted on the subject, is that immediate action is required to transform the way the building sector prioritizes energy.[9]

In the area of electricity supply and demand in particular, interesting new perspectives have emerged in recent years. In a speech in 1989 Amory Lovins, the founder of the Rocky Mountain Institute (RMI), coined the term 'negawatt power'. By this he proposed that significant investments in energy efficiency measures could reduce the need to produce additional megawatts in the United States.[10] He explained how this could be achieved:

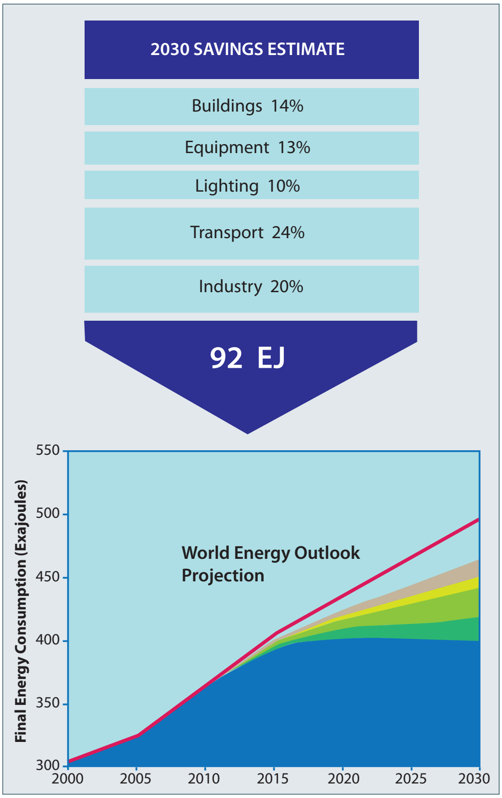
> *"An electricity supplier that has a requirement for additional supply capacity can invite suppliers to quote for the supply of that electricity and can equally invite its customers to quote to reduce their demand. The electricity supplier can then compare these quotations to establish the most economic alternative. This comparison can refer to peak load management – how much per additional kW to get the power company through the peak load due to air conditioning on an unusually hot day – or may refer to longer-term investments – comparing the cost of building a new power station with the cost of, for instance, providing customers with low-energy light bulbs."*[11]

Such approaches to energy efficiency are now widely regarded as the most cost-effective, 'low-hanging fruit' of climate-change mitigation. It is the "largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services".

For many years RMI has played a key role as an influential global leader in energy efficiency research and advocacy, particularly in the commercial sector. Lovins points out: "There are abundant opportunities to save 70% to 90% of the energy and cost for lighting, fan, and pump systems; 50% for electric motors; and 60% in areas such as heating, cooling, office equipment and appliances. In the US, 70% to 90% of the energy and cost for lighting, fan, and pump systems . . . up to 75% of the electricity currently used could be saved with efficiency measures that cost less than the electricity itself."[12]

The trick is to decouple a utility's profits from how much energy it sells. This means that it is no longer rewarded for selling more or, indeed, penalized for selling less. Consumers are encouraged to use more efficient appliances, by allowing suppliers to keep a small proportion of the savings as extra profits so that the incentives of energy producers and consumers are entirely aligned. This can have a dramatic effect on utility behaviour.[13]

There is no doubt that avoided electricity generating capacity is a hugely important step in an energy-hungry world. Enlightened self-interest has encouraged some US and European utility companies to help customers make more efficient use of energy, whilst reducing the need for making costly investments in additional electricity generating capacity. Providing efficient energy services rather than simply supplying megawatts of electricity according to 'unchallenged' demand has become part of the business vocabulary of utility companies.



Source: IEA 2008; In support of the G8 Action Plan, Energy Efficiency Policy Recommendations. http://www.iea.org/G8/2008/G8_EE_recommendations.pdf

FACTOR FOUR TO FACTOR FIVE

When first published in 1997, 'Factor Four: Doubling Wealth, Halving Resource Use' by efficiency pioneers Ernst Ulrich von Weizsäcker, Amory Lovins and L. Hunter Lovins, transformed the way economists, policy-makers, engineers, entrepreneurs and business leaders thought about innovation and wealth creation. Through examples from a wide range of sectors, the authors demonstrated how technical innovation could cut resource use in half while doubling wealth. Weizsäcker's new book, 'Factor Five', to be published in 2009, will examine the past 15 years of innovation in industry, technical innovation and policy. It aims to show how and where factor four gains *have been made and how we can achieve greater factor five or 80 percent improvements in resource and energy productivity; and how to roll them out on a global scale to retool our economic system, massively boost wealth for billions of people around the world and help solve the climate change crisis.*

The self-interest of energy producers and consumers certainly has to be further encouraged by public policy. Both energy efficiency improvements and emissions reductions can be achieved when effective policies are implemented to decouple energy consumption from profits made by utility companies. The idea that the latter can only make money by selling ever-larger amounts of energy must be discredited. Instead, companies must be allowed to benefit from offering demand-management services instead.

California Dreamin'

The negawatt approach has been particularly influential in California. Over the past 36 years, following the 1973 oil crisis, California has pursued an increasingly effective energy efficiency policy regime. A variety of regulatory programmes have been used to improve energy efficiency in domestic energy use, in building standards, and by utility providers and electrical appliance manufacturers. As a result, California has de-coupled from national trends of electricity demand, reducing its per capita energy requirements to 40 percent below the US average. This has brought considerable economic benefits. California has grown more prosperous even as its citizens have cut the amount of energy they use and the greenhouse gases they produce.

Household energy savings of $56 billion from 1972-2006 have enabled Californian households to redirect their expenditures toward other goods and services, creating about 1.5 million jobs with a total payroll of $45 billion. A report by Ceres, a US network of investors, environmental organizations and public interest groups, found that the economic benefits of energy efficiency innovation had a compounding effect. For instance, it estimates that the first 1.4 percent of annual efficiency gains produced no less than 181,000 new jobs in California.[14]

More recent policy measures have seen the introduction of the Global Warming Solutions Act which became law in California in 2006. This is America's first comprehensive global warming legislation with an enforceable cap on GHG emissions. As well as a long-term goal of reducing emissions by 80 percent below 1990 levels by 2050, it sets out requirements for delivering further energy efficiency improvements. Through this legislation it is estimated California will gain more than 400,000 new jobs, a large proportion relating to energy efficiency programmes.[15]

Now a new Long-term Energy Efficiency Strategic Plan is becoming a comprehensive roadmap for achieving even more energy savings in California. The Plan was developed by a stakeholder-driven process in 40 public meetings and workshops with some 500 organizations. It covers government, utility and private sector initiatives. The plan emphasizes a variety of practical 'negawatt' measures: for instance, utilities that help customers reduce energy demand can avoid the cost of investing in new power plants; manufacturers that conduct life-cycle assessments on their products can reduce energy and raw material costs.

It advances a detailed framework that incorporates energy efficiency measures for utilities and businesses as well as consumers. It includes four 'Big Bold Strategies' for significant energy-savings across California:

- **All eligible low-income homes will be energy-efficient by 2020**
- **All new residential construction will be zero net energy by 2020**
- **All new commercial construction will be zero net energy by 2030**
- **The building services industry will be regulated to ensure optimal equipment performance** [16]

"If California had not moved as forcefully to decrease energy consumption over the last three decades, we would be in a much more precarious economic position right now. Imagine where the country could be if it were as efficient as California", says F. Noel Perry, venture capitalist and founder of the Next 10 project, an online, interactive, educational tool. [17]

Such findings provide much ammunition to those who want President Obama to launch a green energy revolution, encouraging renewable power and energy efficiency as a way of generating large numbers of jobs during the current recession. The American Council for an Energy-Efficient Economy is set to encourage other US states to replicate California's energy efficiency measures, and to get Washington to implement relevant nationwide policies.

Barriers to efficiency

It would be nice if caps on fossil-fuel burning were universally applied in developed countries. The reality is that only a small share of the energy efficiency potential has so far been realized, because of various barriers. Identifying these barriers is a first step to overcoming them.

A major problem in the commercial building sector is split incentives: these exist where building owners are responsible for investment decisions, but tenants pay the energy bills. Owners have little interest in commissioning energy-efficient buildings. This reluctance can only be overcome by strong public policy directives regulating for high levels of energy efficiency in all commercial buildings.

Market barriers towards energy efficiency investment also exist due to too low energy prices or the adverse effects of fiscal incentives. For instance, the office space market in London is a clear example why energy efficiency has not gone mainstream: energy costs there are equivalent to just 1 to 2 percent of total business running costs – a very limited incentive to save energy.

In addition, ignorance about energy matters among owners, end-users and energy providers all along the value chain can result in barriers to greater energy efficiency. This has to be addressed by better provision of information about the benefits of energy efficiency.

In the United States, another barrier to efficient energy use is in evidence: capital investments in commercial buildings must be depreciated over 30 years or so, while energy purchases can be fully deducted from taxable income in the year in which they occur.

Likewise, householders often find it difficult to evaluate information on energy use, for instance verifying savings and calculating the payback period for buying more efficient appliances. Energy-efficient equipment is often more expensive than the less efficient alternative. Even though efficient appliances often have a longer lifetime, end-users still tend to purchase the less efficient products because of their lower cost, and this applies particularly to low-income households and small businesses.

But probably the most important barrier to greater efficiency in energy use is the 'rebound effect', which refers to the fact that people tend to use more energy and buy additional appliances as soon as they see that they have reduced their energy bills. There is more about this at the end of the chapter.

The case for Combined Heat and Power (CHP)

The concept of energy efficiency relates not only to energy use, but also to production. With large centralized power stations, typical for much of the electricity that is produced, only about one-third of the energy contained in the fuel source is actually used, while two-thirds get lost during transmission. Therefore, a switch to decentralized and localized production of energy in CHP systems has great potential to minimize losses while maximizing energy efficiency. So called cogeneration or tri-generation plants can achieve up to 90 percent efficiency by providing electricity as well as heating (and cooling in tri-generation) for industrial and building sectors. Since CHP accounts for only 7 percent of world power generation today, a lot of energy and financial savings are yet to be made.

The Danish experience

The country with the most extensive use of cogeneration in Europe is Denmark. In the following paragraphs we describe some of the steps taken to switch the country to ever-greater energy efficiency.

In 1979, after the two major oil crises in the 1970s, the Danish government passed the first legislation on efficient energy supply, aiming to connect more than half the country's 2.5 million homes to a district heating system (DH), using gas or biomass boilers and CHP systems.

With the coming of the 1986 Agreement on CHP, decentralized cogenerated heat and electricity became a major policy priority. In 1988, the installation of electric heaters in new buildings was banned and this ban was extended to electric boilers in buildings with water-based central heating systems. Fuel taxes were levied, with biomass and biogas exempted. The legislation was complemented by energy savings initiatives, such as improved building insulation.

In 1981 the Danish Renewable Energy Development Programme was introduced, which enabled households or enterprises to apply for subsidies for installing biofuel boilers, solar hot water panels, wind turbines and heat pumps. In 1990 the law on heat supply was amended to support the use of cogeneration and environmentally-friendly fuels.

The conversion of district heating boilers to CHP systems took place in three phases and was more or less completed in 1998. But a problem arose: electricity production increased so much that surpluses had to be sold to neighbouring countries below production costs. As of 2003, CHP plants were therefore exempted from the obligation to cogenerate heat and electricity at all times.[18]

Energy performance contracting

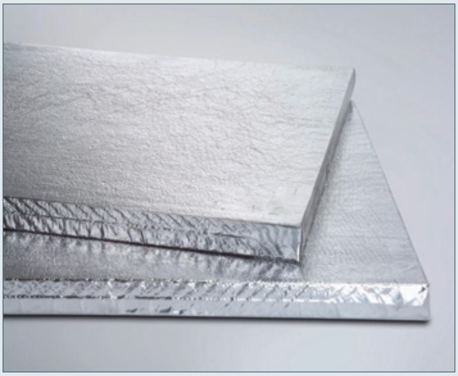
An energy performance contract is a partnership between a building owner or a long-term tenant and Energy Services Company (ESCO), whereby the ESCO provides the up-front capital for energy upgrade projects, which is then paid back over time with the energy savings those upgrades yield. This methodology is widely used to improve the energy performance of buildings because it is both simple and effective.

The building owner or long-term tenant enters into an agreement with an ESCO, which does a building survey by which opportunities for energy savings are identified. It then recommends a package of improvements on the understanding that they will be paid for through energy savings. The ESCO guarantees that savings meet or exceed annual payments to cover all project costs – usually over a contract term of seven to ten years. If savings don't materialize, the ESCO – not the owner or tenant – agrees to pay the difference. To ensure that savings are realized, the ESCO also offers staff training and long-term maintenance services.[19]

Funding for energy performance contracting is usually supplied by banks, but sometimes backed up by government-backed Energy Saving Funds. Their purpose is to support end-users in their energy efficiency investment decisions. State programmes to finance energy efficiency measures exist in many countries. Funds can be supplied through:

- **treasury funds**
- **charges on energy prices**
- **emissions trading schemes**
- **taxes on inefficient products**
- **abolished subsidies for conventional energy sources**

Vacuum insulation panels



Source: RTF Manufacturing. This new insulation technology is highly efficient – a 3 cm layer has the same insulation capacity as a 30 cm layer of rockwool or fibreglass. It can be used on the inside of buildings without much loss of interior space.

Passive house design

The 160 million buildings in the European Union account for over 40 percent of its primary energy consumption. Energy use in buildings therefore represents a major contributor to fossil-fuel use and carbon dioxide emissions. The passive house concept has become increasingly influential in recent years, and more and more countries are passing legislation for ultra-low energy buildings to become standard in the coming years.

The term 'passive house' (Passivhaus in German) refers to a rigorous voluntary standard for ultra-low-energy buildings that require little energy for space heating or cooling. A similar standard, Minergy-P, is used in Switzerland. These standards can refer not only to residential properties but also to office buildings, schools and shops. The passive integrated design concepts are applied mostly to new buildings, but are increasingly used also for building refurbishment.

Beyond passive houses, 'energy-plus' houses are starting to be built as well – these are buildings that don't just supply their own energy needs from PV roofs and other renewable energy devices but are actually capable of supplying a surplus of electricity. An example of this is the Solarsiedlung in Freiburg, Germany, discussed in Chapter 8.

WARM ZONE KIRKLEES

In the UK the city of Kirklees is pioneering a comprehensive approach to urban energy efficiency. 'Kirklees Warm Zone' is Britain's biggest and most comprehensive programme to tackle domestic energy efficiency, fuel poverty and climate change, providing practical energy efficiency support to householders. The Warm Zone brand was established by the UK government in 2000 and has since helped over 500,000 homes across the country.

In Kirklees an estimated 45,000 householders are in fuel poverty, unable to adequately heat their homes. The Warm Zone can offer help to *every household to improve its energy efficiency whilst also offering other support services. The main aim is to provide warm, energy-efficient homes. Installation of all energy efficiency measures is made dependent on an initial technical survey of the home.*

Warm Zone offers:

- *Free cavity wall and loft insulation for all households*
- *Free low-energy light bulbs to all*
- *Free improvements to heating systems for needy households*
- *Competitive prices for replacement boilers for households that can afford to pay*
- *Reduced prices for renewable technologies*

Warm Zone works on a ward by ward, street by street approach so no home is missed. Funding is being provided by Kirklees Council, Scottish Power, National Grid, the Regional Housing Board, Scottish Power Energy People Trust and British Gas Energy Trust.

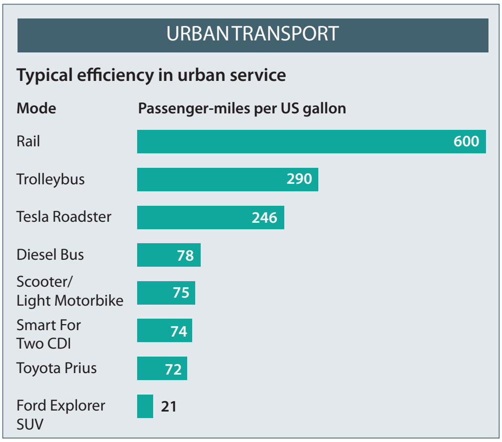
www.kirklees.gov.uk/community/environment/energyconservation/warmzone/warmzonefaq.shtml

Energy and transport

The evolution of transport technologies from the 18th century onwards has extended the distances which we travel and across which goods are transported further and further. In 2004, the transportation sector accounted for 26 percent of global energy use, 70 percent of which was caused by road transport (passenger cars and trucks). Roughly two-thirds of the global transport energy is used for passenger mobility, while one-third is used to ship freight. With many of the world's economies expected to grow in the decades ahead, the share of energy used for transportation could increase dramatically. Rapid moves towards more energy-efficient transportation systems are therefore critically important.

Efforts towards energy efficiency in the transport sector involve improvements not only in vehicle fuel economy but also in transportation infrastructure, as well as limitations to the unnecessary use of carbon-based forms of transport. To make the vehicle fleet more fuel-efficient, standards to reduce carbon emissions have to be established, financial incentives have to be provided for the purchase and use of low-emission vehicles, and regulations introduced for replacing inefficient vehicles. Government agencies should take the lead in all this by adapting appropriate public procurement policies.

The following diagram by Canadian transport researcher James Strickland gives a concise impression of the energy efficiency (or the lack of it) of various modes of transport.



Source: IEA 2008; In support of the G8 Action Plan, Energy Efficiency Policy Recommendations. http://www.iea.org/G8/2008/G8_EE_recommendations.pdf

The vehicle mileage in this graph assumes full utilization of vehicle seating capacity. Evidence from the work of many urban transport planners indicates the much greater efficiency of electric transportation. Of course, wherever possible the need for urban transportation should be minimized, by planning policies aiming to the reintegrate work, schools, shopping and residential land use in close proximity.[20]

Transport specialist Prof. Jeffrey Kenworthy ranks cities across the world according to their per capita transport energy use (see p170). There is a direct correlation between urban density and car use in the wealthy cities. Cities with the most sustainable transport produce about five times less CO_2 per person than cities with the least sustainable transport system. Kenworthy has been able to show clearly that cities must strategically raise their densities to develop more sustainable mobility patterns. High public transport usage is a key feature of cities with more sustainable transport. Integrated development around public transport stops, especially railway stations, is fundamental to achieving this. Improved conditions for pedestrians and cyclists are essential to sustainable urban transport development.

It has been known for decades that building more freeways pushes cities towards higher automobile dependence. Cities need to minimize, stop or even reverse their supply of freeways. Reserved routes are essential to ensure the speed-competitiveness of public transport. The most sustainable cities offer a high level of provision of rail systems and dedicated bus facilities. Reserved rights-of-way are critical for transit. The evidence shows that public transport, walking and cycling can compete successfully with cars when given priority.

In eco-cities a nexus between transport and urban form is the core framework around which many other factors must operate. Creating sustainable urban form and transport depends upon:

1. Compact, mixed use development;
2. Human-oriented city centres and sub-centres with high density levels;
3. Priority given to high-quality public transport and non-motorized mobility;
4. Protected natural areas and spaces for food production in and around cities.[21]

RIVERSIMPLE URBAN HYDROGEN CAR

Credit: Hugo Spowers.

Its creator, Hugo Spowers, said this at the car's launch in London in June 2009: "This is a car for the future. Travel powered by fossil fuels is a major contributor to climate change. We want to demonstrate that clean and efficient hydrogen fuel cell vehicles are within our grasp. Our car emits only 30g/km of CO_2, well to wheel, in the urban cycle, even with hydrogen from natural gas. This is a quarter of the emissions of the lowest emitting car on the market today.

But our concept is also about the ownership, or non-ownership, of the cars; they will only ever be leased, not sold. This business model rewards longevity and low running costs. We will persuade people to keep their cars as long as possible rather than change them as frequently as possible.

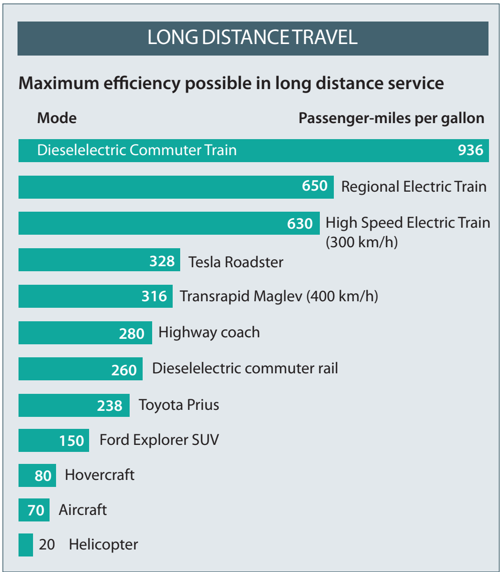
We are also creating a manufacturing model that generates high-quality jobs in human-scale plants. There will be a large number of small plants to build our cars from advanced composite materials. This allows much greater resilience in fluctuating economic circumstances and much greater flexibility to produce what *different regions and niches need.*

We have further created an open intellectual property model, based on that used in open source software but not yet implemented in manufacturing. This will encourage the adoption of efficient vehicle technology as widely and quickly as possible.

Finally, we have developed a partnership corporate structure that balances the interests of all stakeholders. We can never achieve a sustainable system whilst the interests of one stakeholder group, such as shareholders, trumps the interests of society or the environment. Our partnership is bound by its constitution to pursue our purpose above the interests of any one group.

Our purpose is to systematically work towards the elimination of the environmental impact of personal transport. There are many fine initiatives that focus on the particular, but everything is connected and we need to look at the whole system in order to develop truly sustainable solutions."

www.riversimple.com



The obvious conclusion from the graph on this page is that passenger transportation rail vehicles are more efficient than road vehicles, except trolleybuses and the electric Tesla Roadster, and far more efficient than aircraft. Magnetic levitation (Maglev) trains, often proposed as a primary option for future long-distant transport, are about half as efficient as high-speed trains.

Road vehicles are, in general, more efficient than aircraft, but tend to cover much shorter distances. However, on some routes aircraft can be more efficient, as they can travel in a straight line whilst surface transport must often travel on winding roads. Generally road vehicles are less efficient than rail, though trolleybuses come quite close in similar service.

Goods transportation is a different matter, as bulk cargo is much more compact than 'people cargo'. Ships transporting goods are more energy-efficient than rail which, in turn, is more efficient than trucks.[22]

A more general point that needs to be raised here is that our insatiable appetite for mobility threatens to render all efforts to improve the efficiency of our transport systems wholly inadequate. Only a concerted effort to limit our desire for and dependence on mobility can ultimately deliver sustainable outcomes.

Image and patented 'solarsails' courtesy of Solar Sailor www.solarsailor.com.au. New approaches to reducing energy use and emissions in shipping include the use of kites, sails (some integrating PV), and blowing bubbles under the hull.

The rebound effect

Under the right circumstances, moves towards greater energy efficiency can become a useful tool for dealing with energy shortages or, indeed, climate change. But since reductions in CO_2 emissions by a factor of four or five over the coming decades are necessary in the developed world if catastrophic climate change is to be avoided, positive and very deliberate limitations on energy use may be required.

But the snag is that whilst encouraging efficiency helps consumers save energy, it does not necessarily stop them from buying an ever-greater variety of gadgets that require additional energy. Whilst energy-efficient light bulbs and fridges may reduce the consumption in this segment of energy use, additional computers or ever-larger plasma TV screens may add to overall energy consumption. While the consumer gets more service for the same amount of energy, they also increase overall consumption. So, all in all, greater energy efficiency per se does not necessarily result in reduced energy use.

Today's typical refrigerators, which account for 20 percent of a household's utility costs, use about one-fourth the energy of 1972 models. But, on the other hand, they are also likely to be twice or three times the size of 1970s models. Similarly, the thermal efficiency of car engines improved substantially in recent decades as design improvements were made. But this does not necessarily translate into better fuel economy of cars overall, as people in developed countries have tended to buy bigger and heavier cars with ever more powerful engines.

The relative simplicity of the benefits of demand management was being questioned as long ago as 1865 when the British economist W. Stanley Jevons published his book *The Coal Question*. The 'Jevons Paradox' states that conservation of fuel paradoxically leads to increased consumption of fuel: if large numbers of people start conserving fuel, this will lower the price of that fuel which, in turn, will encourage increased consumption. Thus, argues Jevons, increased energy efficiency results in raising demand for energy in the economy as a whole.

In the real economy a rebound effect is often observed: for instance, if householders switch from using 18W compact fluorescent bulbs instead of 75W incandescent bulbs, the energy saving should be 76 percent. But in reality this is seldom so. Because the lighting now costs less per hour to run, users are often less motivated to switch lights off. Thus, they 'take back' some of the energy savings by leaving more lights on for longer, particularly when past levels of energy services – lighting, heating or cooling – were regarded as inadequate.[23]

This observation reinforces the Jevons Paradox. Nevertheless, critics argue that this view is likely to break down when significant energy shortages and price rises occur, because these encourage conservation measures, whether people like it or not.

Efficiency or sufficiency: when enough is enough

Because vehicles last for years, and buildings and power plants last for decades, it is crucially important to initiate major changes through the introduction of significant national and international policies.

In Europe, America and Japan, significant efficiency gains have resulted from new technical developments, often driven by new regulations, policy standards and tax incentives. But is this enough to bring CO_2 emissions down to levels required for global climate security? The Austrian philosopher and social critic Ivan Illich (1926–2002) had some interesting things to say about energy matters. In an essay entitled

Energy and Equity, published in 1975, he questioned the wisdom of increases in energy use as a prerequisite of social betterment. He insisted that ever-greater energy use was also a step towards ever-greater alienation and social separation: "The energy policies adopted during the current decade will determine the range and character of social relationships a society will be able to enjoy by the year 2000. A low-energy policy allows for a wide choice of lifestyles and cultures. If, on the other hand, a society opts for high energy consumption, its social relations must be dictated by technocracy and will be equally degrading whether labelled capitalist or socialist. . . . While people have begun to accept ecological limits on maximum per capita energy use as a condition for physical survival, they do not yet think about the use of minimum feasible power as the foundation of any of various social orders that would be both modern and desirable. Yet only a ceiling on energy use can lead to social relations that are characterized by high levels of equity."[24]

This view is a fierce challenge to the widely held view that the rest of the world must play catch-up with the countries that have gone furthest in their use of energy. Illich's views, of course, are now highly topical because of the huge climate challenges facing humanity: we must all meet at a certain level of energy use that is compatible with climate stability as well as the limits to the use of fossil fuels, which are much better understood now to be a finite resource. It is interesting that Illich should argue for limited energy use from the point of view of social wellbeing and equality. This is certainly food for thought.

Illich again: "What is generally overlooked is that equity and energy can grow concurrently only to a point. Below a threshold of per capita wattage, motors improve the conditions for social progress. Above this threshold, energy grows at the expense of equity. Further energy affluence then means decreased distribution of control over that energy."

PACE: A New Policy for Energy Efficiency from Berkeley, California

Randy Hayes, World Future Council

Fundamental to achieving a renewable world is to maximize energy efficiency in the already built world. Property Assessment for Clean Energy (or PACE) is a method of financing the work of insulation, lighting, window replacement, appliance upgrade, etc.

Imagine that property owners can borrow from a special city fund to improve the energy efficiency of their property. They can even use the money to install renewable energy systems. Building owners pay the low-interest loan back over 20 years. Often, the annual savings on the energy bill will be greater than the annual payment!

Here is how it works: you apply for a loan from this special fund that your city can set up. An annual tax is added to your property tax bill. If your home or office building is sold, the changes to the building stay with the building. So the new owners pay the remaining tax obligation. Even the city's costs to administer the programme are covered in the programme.

The city of Berkeley, California came up with this model, which they call the 'Berkeley First'. The pilot programme is focused on financing solar power, but will expand to energy efficiency. For more information: ***www.ci.berkeley.ca.us/ Content Display.aspx?id=26580****.*

Where does the city get the money? They issue bonds. The way they issue the bonds is similar to how cities typically finance sewer upgrades and neighbourhood beautification projects. It is a well-known and trusted financing system therefore it should be easily replicated. Hundreds of cities across the US and in a few *other countries are looking into replicating this approach. Contact your city now and ask them to look into it. This is low-cost capital for building retrofits – an important part of the path to a renewable world.*

The 2000-Watt Society

The idea that it is necessary to define a level of global energy use beyond which we should not go has a rapidly growing following. There is much evidence that it is necessary to define overall limits on energy use – both in terms of 'what is sufficient for us' and in terms of what is good for the planet. A really worthwhile proposal was made in 1998 by the Swiss Federal Institute of Technology in Zürich – the 2000-Watt Society. In this scenario each person in the developed world would cut their overall rate of energy use to no more than 2,000 watts – 17,520 kilowatt-hours per year for all energy use, by the year 2050 – by a range of energy efficiency measures. (The Swiss Solar Energy Society is pushing for a much more rapid move to 2,000 watts, namely by 2030.) The concept can be scaled up from personal or household energy use to the collective energy use of the whole society. Together with this energy limit, a 1 ton of CO_2 emissions limit per person per year was also stipulated.

Limiting the total energy use per person will be a critical goal in any future energy scenario. 2,000 watts corresponds to the average consumption of Swiss citizens in 1960 and is approximately the current world average rate of total energy use. It compares to current averages of around 6,000 watts in Western Europe, 12,000 watts in the United States, 1,500 watts in China, 1,000 watts in India, and only 300 watts in Bangladesh. The last time Switzerland was a 2,000-watt society was in the 1960s, but it currently uses a per capita average of around 5,000 watts.

In response to concerns about climate change and energy security, the scenario further envisages that the use of carbon-based fuels would be cut to no more than 500 watts per person, or a quarter of the 2,000 watt allocation, within 50 years.

The proposal is backed by major bodies such as the Swiss Federal Office of Energy and the Association of Swiss Architects and Engineers. It is envisaged that achieving a 2,000-watt society will require, among other measures,

- **a refocusing of research into new priority areas**
- **a major investment in the country's capital assets**
- **refurbishment of the nation's building stock to low-energy standards**
- **major improvements in the efficiency of road transport and aviation**
- **revisioning of energy-intensive materials use, and**
- **widespread introduction of renewable energy, district heating and microgeneration.**[25]

LIFESTYLE WITH 2,000 WATTS

Hans Zulliger

2,000 watts is today's continuous power requirement of an average world citizen. A central European inhabitant demands 3-4 times this amount and is responsible for about 8 times more CO_2 output than would be required to stop global warming. To put it in technical terms, we are challenged to use no more than 17,500 kWh equivalent per person per year and to discharge no more than 1 ton of CO_2. (1 litre of oil or gasoline contains about 10 kWh of energy and 2.5 kg of CO_2.) The energy balance presented here is the energy used by a *private person, not including the consumption of the workplace.*

What lifestyle would be possible if this were the consumption limit for a European of good social standing?

The first priority is to eliminate fossil fuels for heating the living space and hot water. Passive solar heat with thermal solar collectors can supply more than half of the energy required in a well-insulated house. The rest can be produced with a heat pump (the electricity must come from a renewable source like wind, hydro or waste biomass) or by burning biomass cleanly.

Credit: Hans Zulliger.

Our house (2 persons) requires 5,000 kWh for hot water and heating a year. Lighting, cooking, appliances (we have no dryer), computers etc. use about 3,500 kW. This is primarily a matter of well-chosen investments and a conscious lifestyle. We have made the necessary upgrades and enjoy a very comfortable room temperature, typical for houses with low energy consumption.

A more serious challenge is the energy consumption and CO_2 output of transport. If all the energy allocation were to be used for transport only, each of us could consume 1,750 litres of gasoline for a small car or kerosene in an airplane. This would let us travel a distance of about 25,000 km a year. But 1 ton of CO_2 lets us drive or fly only 6,000 km, a goal we have not yet achieved, since we have been flying too far. We have opted to use mostly trains for our travels. In addition, we drive our hybrid car about 5,000 km a year, using 250 litres of gasoline. We could fly 8,000 km a year if we ignored the CO_2 limit. This is certainly a severe restriction, since air travel is cheap and there are many fascinating places in the world.

Overall, our lifestyle is very comfortable and satisfying and we find great joy through personal contacts with family and friends. We gladly forgo our desire to fly to exotic places, knowing that we are making a significant contribution to reducing the world's resource consumption.

Energy descent

The idea of a 2,000-Watt Society links closely with the concept of 'energy descent' that has been developed in Britain in recent years. This discussion has been raised primarily out of concern about the continued availability of fossil fuels and about global competition with developing countries that are demanding a fairer share of energy resources.

But even for developing and emerging countries, there are limits to increasing their use of fossil-fuel energy. An ever-growing number of energy analysts are coming around to the view that we are close to reaching peak oil, and that gas and even coal may also be approaching peak production rates in the coming decades.[26] With less and less fossil fuels available to us at an ever higher price, we need to move towards living within the annual energy supply available from the sun. Whilst there is no doubt that the harvest of renewable energy will grow as technologies develop, this means developing lifestyles that are better integrated with natural processes and cycles than we are presently used to.

In the global context, energy descent is used as a term for a transitional phase during which humanity goes from the growing use of fossil fuels, which has occurred ever since the industrial revolution, to a diminishing use of fossil fuels. In the end we must ask ourselves 'What do we really need to be happy, healthy and vibrantly alive?' There is much evidence to suggest that we could live very well on 80 to 90 percent less energy than we presently use. It is a matter of adjusting our lifestyles, values and priorities, and this may take some reorientation.

Whilst all energy efficiency improvements are helpful, we should start exploring what energy sufficiency could mean in practice. In the richer countries we will have to start climbing down the pyramid of energy slaves, which will require significant changes in our habits. But it will be apparent that gains in quality of life will emerge from this energy descent, that life will become less hectic, that there can be more personal contacts, more walking, less driving, better air quality and less noise. All of these changes, discussed in more detail in Chapter 8, are bound to be beneficial to both our mental and physical health.

We need to utilize a new kind of 'linking thinking', connecting concern about climate change and energy security with sustainable energy solutions. A fundamental change in the ways in which societies produce and consume energy is indispensable for global sustainable development.

This means that we must deal with the mismatch between what we know and what we are actually doing much of the time.

The effectiveness of energy capture is a central organizing principle in living organisms as well as in social systems. The performance quality of any energy system is determined by a complex combination of factors – physical, technical, economic, social and environmental. A much more sophisticated use of energy is called for at this time.

In order to guarantee every inhabitant of this planet a safe, reliable, efficient, accessible and affordable energy supply, future energy policies need to:

- **decouple energy consumption from utility company profits**
- **remove subsidies for fossil fuels and nuclear energy**
- **use energy performance contracting for retrofitting existing buildings**
- **define procurement specifications for transportation, office equipment and buildings**
- **shorten transmission distances between production and consumption**
- **reward competition between market participants to assure efficient solutions**
- **define necessary limits on per capita energy consumption**

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Keeping warm

Keeping warm in winter, or keeping cool in summer under a tropical sun, need not require vast amounts of fossil fuel. When fuel resources seemed limitless, and when climate change was not an issue, living in an 'age of fire' seemed to make sense. But now we need the right incentives to insulate rather than to light a fire.

Being energy-efficient makes environmental sense. But it must also make economic sense. Governments have not shied away from subsidizing fossil-fuel burning with vast amounts of money. The challenge now is to assure that it becomes cost-effective for everybody to save energy rather than to use it.

Long-term thinking has been alien to governments driven by the desire to be reelected in a few years time. But it is up to all of us to assure that governments are inventive in the interests of both present and future voters. We the voters need to change the parameters under which governments make laws on behalf of all of us.