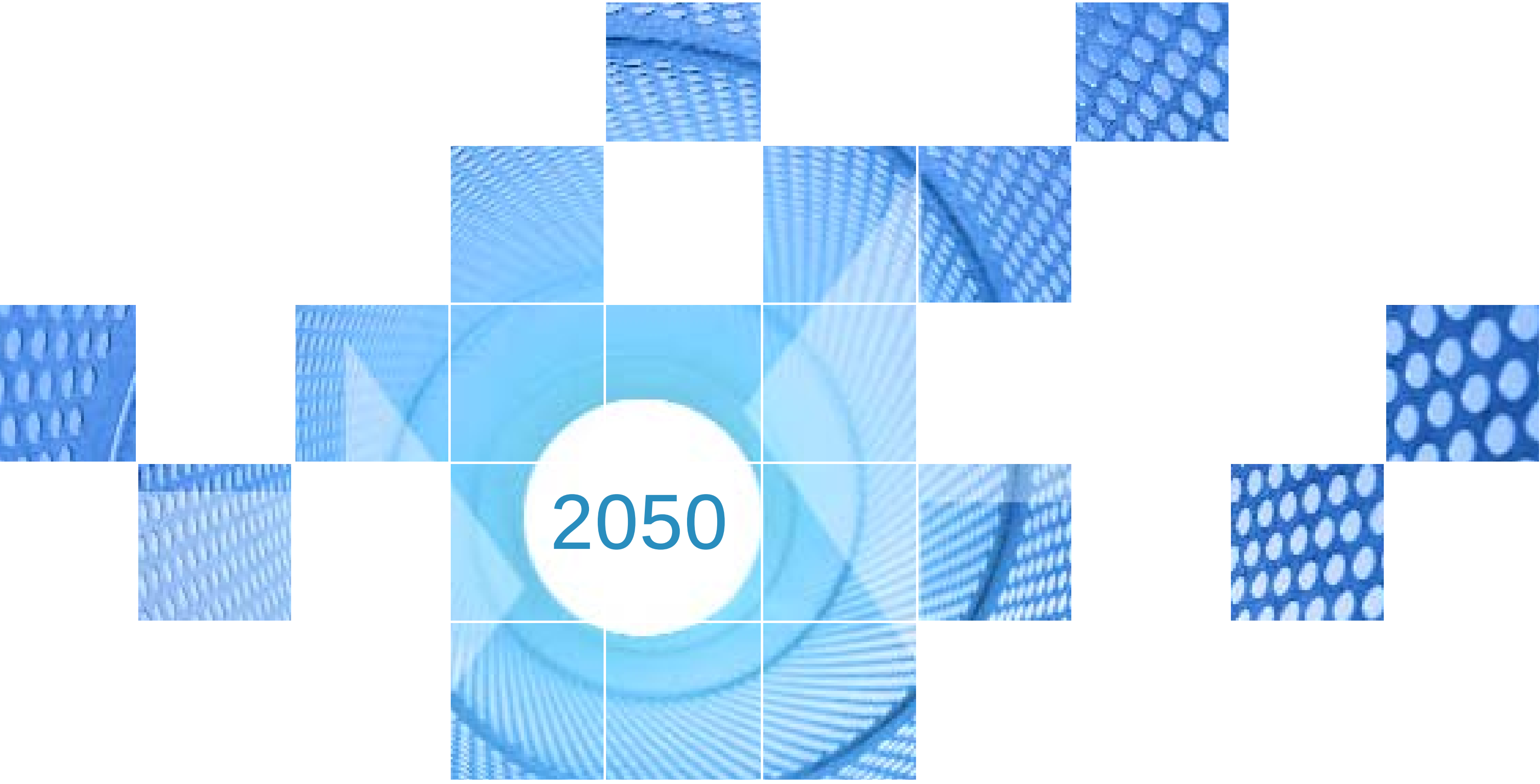
DEDICATED TO MAKING A DIFFERENCE

Facts and trends to 2050

Energy and climate change

World Business Council for
Sustainable Development



Introduction

This publication provides an overview of key facts and societal challenges related to economic development, future energy demand and the impact that demand could have on the climate system. It forms part of the work program of the WBCSD's Energy and Climate Council Project and provides a platform for future discussion. This will help further elaborate a business response to the challenges identified in this paper, which will require additional research and consultation.

We cannot know exactly how the world will develop over the next half century, but the scenarios used here fit with the United Nations (UN) development goals of poverty reduction and improved living standards in the developing world. Achieving these goals will require an increase in energy consumption.

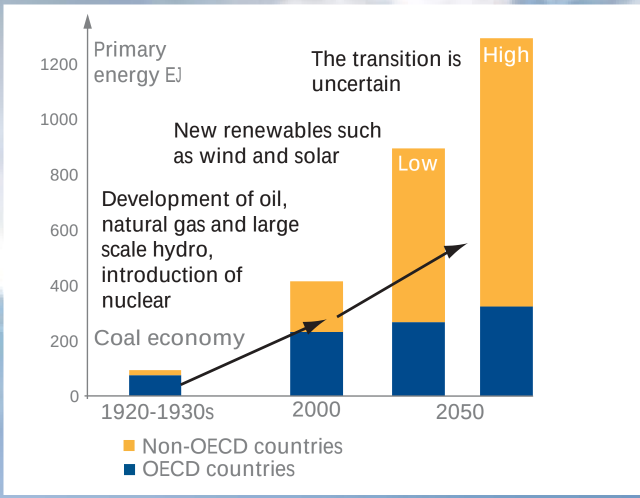
Although we recognize that a range of human activities have an impact on greenhouse gas emissions and that many of these practices will have to change, the focus of this publication is on the world's use of energy and its related impacts.

We have used existing data from the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA) and WBCSD studies. We present it here in a simplified and condensed form to stimulate forward thinking and discussion around the issues facing us as we begin to deal with climate change. Projections and examples based on particular global emission levels and eventual CO_2 concentrations in our atmosphere are only set out to illustrate the scale of the challenge.

The issue at a glance . . .

Growth, development and energy demand

Energy is the fuel for growth, an essential requirement for economic and social development. By 2050, energy demand could double or triple as population rises and developing countries expand their economies and overcome poverty. Transitions in our energy infrastructure will be needed, akin to those of the last 100 years. Today, as we face up to climate change as a major environmental threat, the way forward becomes less certain.

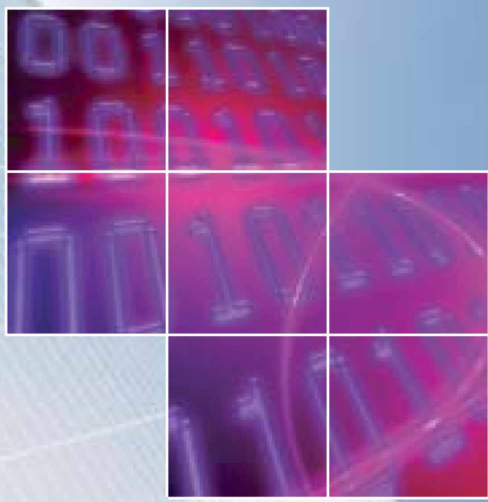


Energy use and climate impacts

Over the last century the amount of carbon dioxide in our atmosphere has risen, driven in large part by our usage of fossil fuels, but also by other factors that are related to rising population and increasing consumption, such as land use change. Coincident with this rise has been an increase in the global average temperature, up by nearly a degree Celsius. If these trends continue, global temperatures could rise by a further one to four degrees by the end of the 21st century, potentially leading to disruptive climate change in many places. By starting to manage our carbon dioxide emissions now, we may be able to limit the effects of climate change to levels that we can adapt to.

The dynamics of technological change

Many advocate an accelerated change in our energy infrastructure, away from fossil fuels, as the only solution to the threat of climate change. But it is not at all clear which technologies or policy frameworks might provide the impetus for change. Such transitions, which operate at a global level, take time to implement. Very large systems such as transport and energy infrastructures can take up to a century to develop fully.



Reshaping our energy future

By 2050, global carbon emissions would need to be at levels similar to 2000, but also trending downward, in contrast to a sharply rising demand for energy over the same period. No single solution will deliver this change, rather we need a mix of options which focus on using energy more efficiently and lowering its carbon intensity. Changes in supply and demand can help us shift to a truly sustainable energy path. While change takes time, starting the process now and laying foundations for the future are matters of urgency, and business has a key role to play.

energy demand

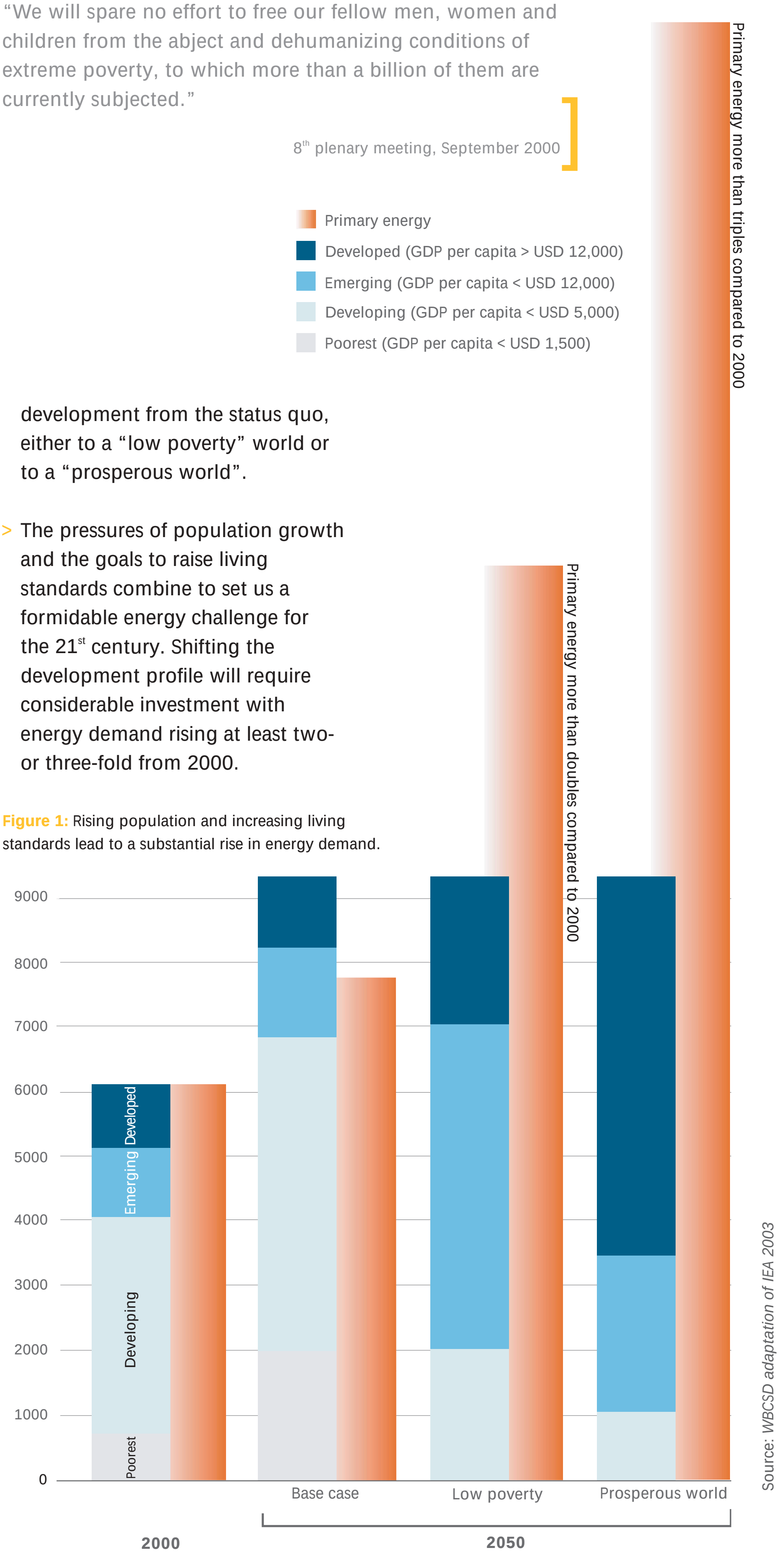
> **United Nations Millennium Declaration**
> "We will spare no effort to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty, to which more than a billion of them are currently subjected."
>
> 8th plenary meeting, September 2000

In 2000, only one in six of us on this planet had access to the energy required to provide us with the high living standards enjoyed in developed countries. Yet these one billion people consumed over 50% of the world's energy supply. By contrast, the one billion poorest people used only 4%. None of us finds poverty acceptable, so the world has set itself various goals to eradicate poverty and raise living standards. These goals require energy, the driver of modern living standards. Increased access to modern energy services such as electricity is a decisive factor in escaping the poverty trap; it vastly enhances opportunities for industrial development and improves health and education.

Figure 1 shows how energy demand increases as population grows, development needs are met and living standards rise. It contrasts the outcome of "business as usual" with two development scenarios.

- By 2050, world population could rise to around 9 billion (UN 2002). With no change in the global development profile, another two to three billion people would be living in poverty (base case).
- Two new development profiles are illustrated. Both reflect the UN goals to eliminate extreme poverty. Each shows increasing levels of development from the status quo, either to a "low poverty" world or to a "prosperous world".
- The pressures of population growth and the goals to raise living standards combine to set us a formidable energy challenge for the 21st century. Shifting the development profile will require considerable investment with energy demand rising at least two- or three-fold from 2000.

Figure 1: Rising population and increasing living standards lead to a substantial rise in energy demand.



Energy, the fuel for growth

Above USD3,000 per capita GDP (1995 PPP), energy demand explodes as industrialization and personal mobility take off.

From USD15,000, demand grows more slowly as the main burst of industrialization is complete and services begin to dominate.

Beyond USD25,000, economic growth can continue without significant energy increases, but the absolute level varies widely depending on national circumstances.

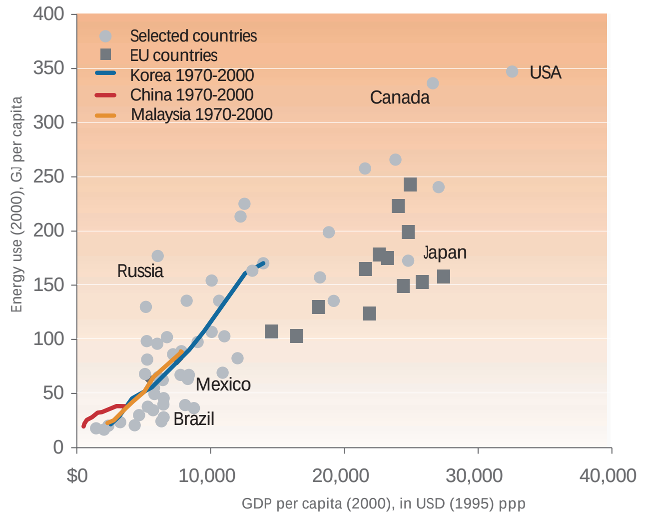


Figure 2: Income vs. energy use in 2000, with 1970-2000 trends for Korea, China and Malaysia.

Source: *WBCSD adaptation of IEA 2003*

Energy use, development and CO_2 emissions

CO_2 emissions vary widely at all levels of development. Differences in otherwise similar economies depend on factors such as geography, types of domestic energy available, public acceptance of energy sources and mobility options, including the development of mass transportation.

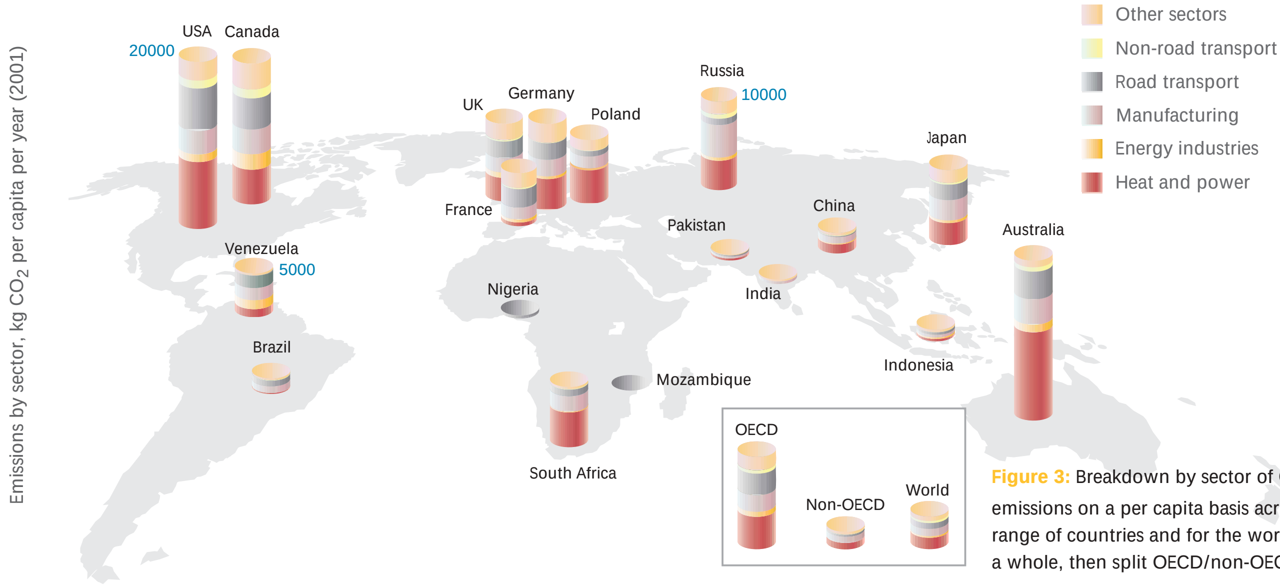


Figure 3: Breakdown by sector of CO_2 emissions on a per capita basis across a range of countries and for the world as a whole, then split OECD/non-OECD.

Source: *WBCSD adaptation of IEA 2003*

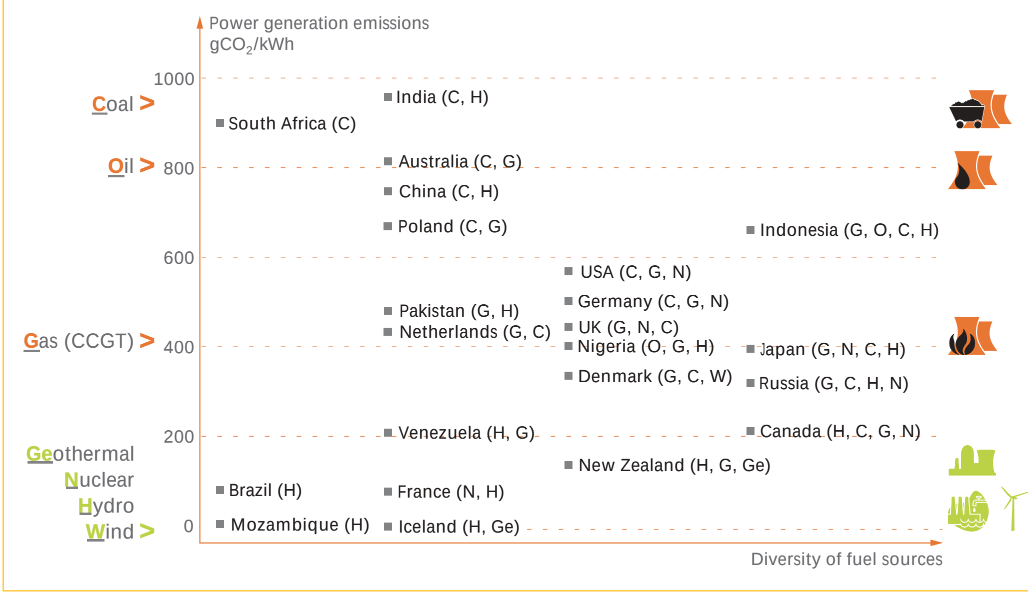
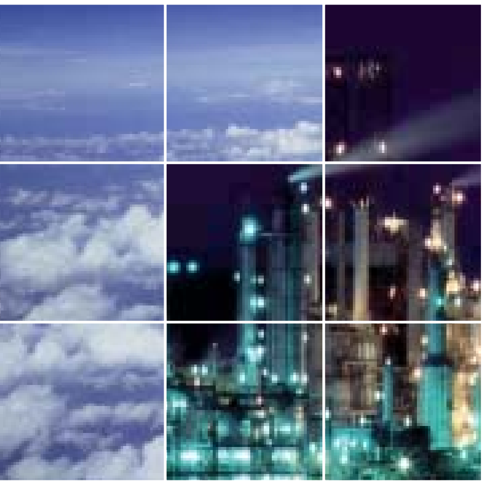


Figure 4: CO_2 intensity of various types of power generation and the current intensity in a range of countries (year 2000 data, electricity and heat generation including auto producers). Fuel sources for each country are ranked in order of importance, with those contributing less than 10% not identified.

Source: *WBCSD adaptation of IEA 2003 and CIA 2004*



Over the last century the amount of carbon dioxide in our atmosphere has risen, driven in large part by our usage of fossil fuels, but also by other factors that are related to rising population and increasing consumption, such as land use change. Although there is still debate as to the magnitude, there is solid evidence that our world is warming. The bulk of the scientific community, led by the IPCC and the United States National Academy of Sciences, has now linked these two phenomena in a likely cause-effect relationship.

The IPCC has created a number of development storylines (see Glossary for a more detailed description of this) for the 21st century to illustrate the magnitude of the changes we may be inducing in the climate. For illustrative purposes, only two of these have been used in this publication. They are aligned with anticipated global population growth and the changes we might expect as today's developing countries strive to end poverty and other nations achieve significant rises in living standards for their people (as illustrated in Section 1).

The higher energy use storyline (IPCC A1B) describes a future world of very rapid economic growth and the rapid introduction of new and more efficient technologies. In this world, regional average income per capita converges such that the current distinctions between "poor" and "rich" countries eventually dissolve.

The lower energy use storyline (IPCC B2) represents an intermediate level of economic growth with an emphasis on local solutions. In this world, there is less rapid but more diverse technological change with an emphasis on environmental protection. The primary energy use and fuel mix for the two storylines, based on the Asian Pacific Integrated Model (AIM, also see Glossary) scenarios for each, are shown.

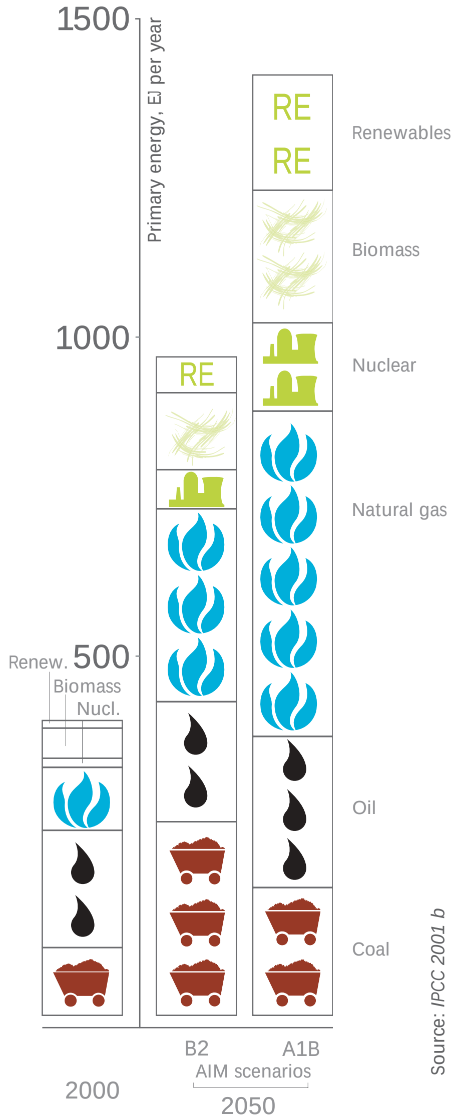
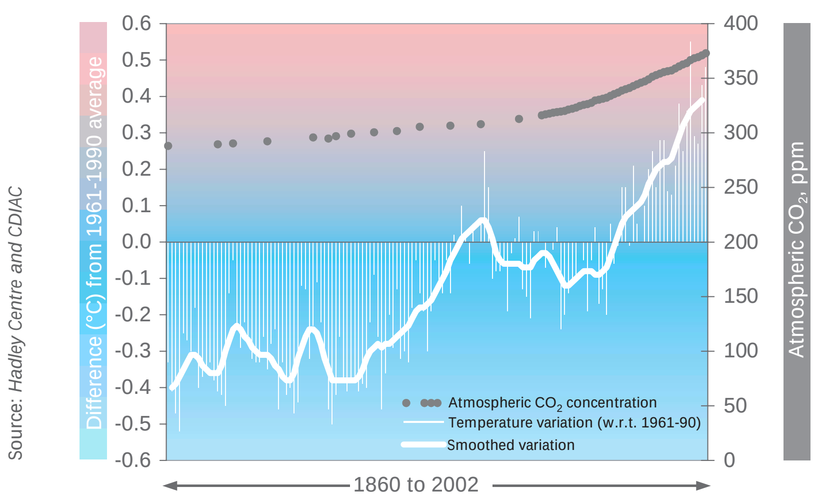


Figure 5: The IPCC scenarios show various options for energy use and fuel mix in 2050, dependent on growth and development assumptions and technological change in the coming years.

Changes in our atmosphere are already underway!



Over the last century we have seen a rise in the atmospheric concentration of carbon dioxide from 280 ppm to some 370 ppm. Coincident with this rise has been an increase in global average temperature, up by nearly 1°C. Projections show that if this trend continues, global temperatures could rise by a further one to four degrees by the end of the 21st century (see Figure 7).

Figure 6: Variation in atmospheric CO_2 and global temperature since 1860.

Is there an acceptable limit for CO_2 emissions?

The yardstick typically used to approach this question is the eventual concentration of CO_2 in the atmosphere, or stabilization level. Up to the time of the industrial revolution this remained at 280 ppm. The IPCC scenarios lead to CO_2 concentrations continually rising during the 21st century with no stabilization below the range 700 to 1000 ppm.

Such levels of CO_2 are, according to the IPCC, likely to lead to very damaging impacts. A temperature rise of some 2-4°C could bring more extreme climate events, threaten sensitive eco-systems such as coral reefs and lead to rises in sea level. In the 4-6°C range we may also see structural alterations to our weather patterns, possibly led by changes in important ocean currents such as the Gulf Stream.

A level of stabilization of less than 500 ppm will be very difficult to achieve, as it requires a sharp downward turn in emissions before 2020. Stabilization at a somewhat higher level would be more achievable as it allows a timeframe in which significant change in our energy infrastructure could take place.

Inertia is an inherent characteristic of the climate system, with CO_2 concentration, temperature and sea level continuing to rise for hundreds of years after emissions have been reduced. Thus some impacts of man-made climate change may be slow to appear.

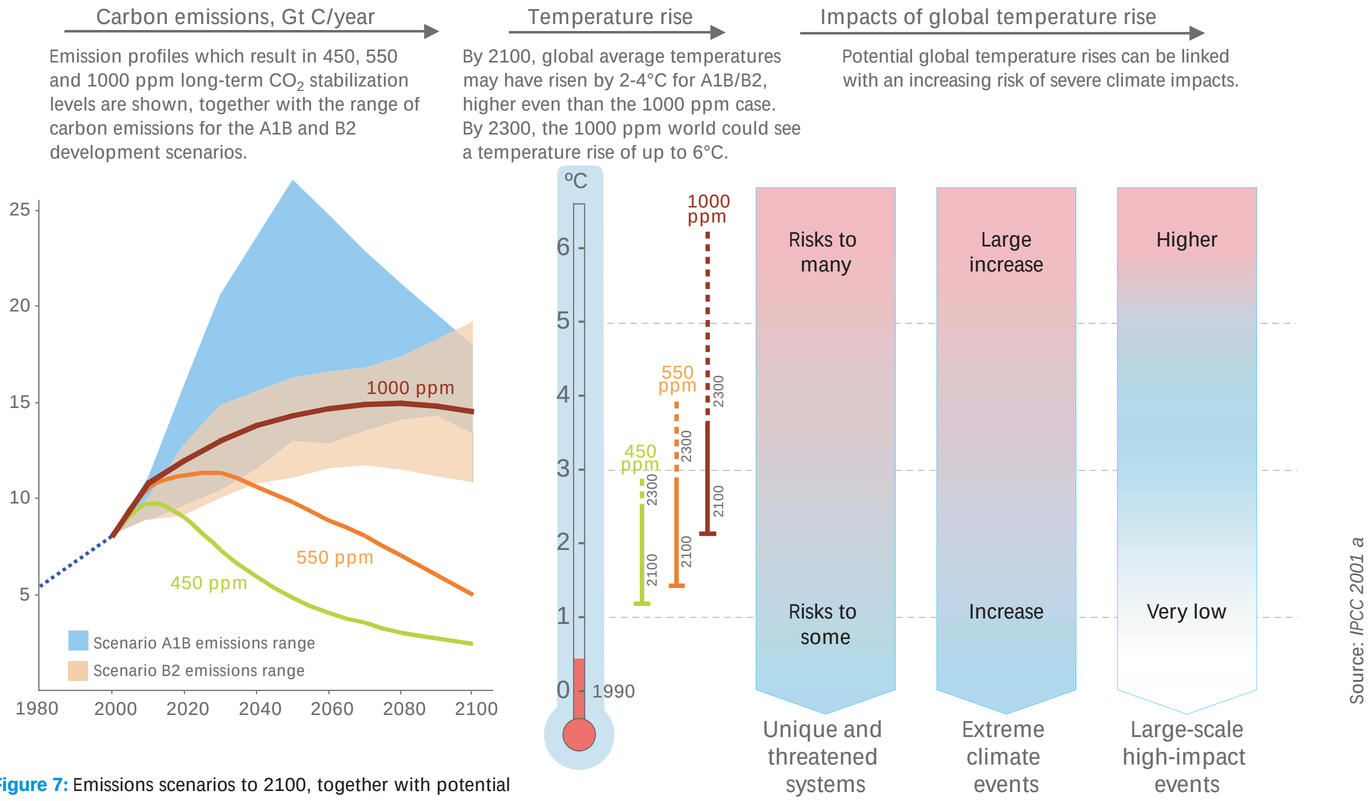


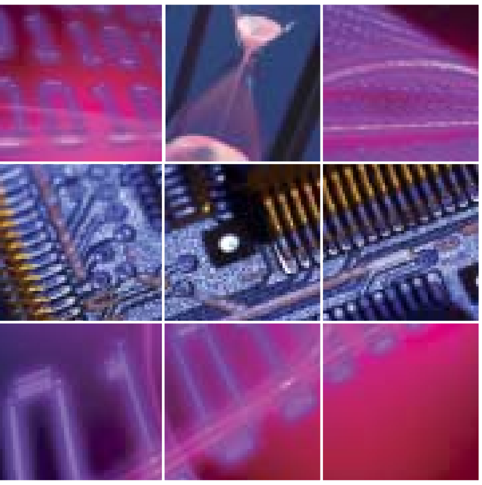
Figure 7: Emissions scenarios to 2100, together with potential global temperature rise and associated climate impacts.

Adapting to climate change

The impact on our climate could be substantial even at an achievable stabilization level, so adaptation to climate change will have to play a part of any future strategy. Impacts will vary from region to region; much of the detail is uncertain. We may have to deal with impacts on health from the spread of tropical diseases, regional shortages of water due to changing monsoon patterns and disruption to agriculture from possible shifts in growing seasons. The combined economic and social impacts of these changes could be large. Measures might include:

- Flood defences in low-lying areas, ranging from Florida to Bangladesh
- Refugee planning for island states such as the Maldives
- Improved water management (e.g. aqueducts) as rainfall patterns change

The dynamics of technological change



Many advocate that a rapid change in our energy infrastructure is the only solution to the threat of climate change. Realistically, however, major transitions at the global level will take time to implement. The speed with which new technologies diffuse depends on many factors:

> Size and lifetime matter. Very large systems such as transport and energy infrastructures can take up to a century to develop fully. Generally, the rate of technological change is closely related to the lifetime of the relevant capital stock and equipment, as illustrated in Figure 9.

> Cost is also a factor that can impede change. Emerging and future technologies, including new renewables, will see widespread take-up only when they can compete with existing technologies. However, an entirely new value proposition (e.g. MP3 player vs. much cheaper cassette tape) can herald a period of rapid change which then leads to cost reduction.

> Regional boundaries may limit change. New technologies in developed countries may arrive, mature and even decline before their widespread adoption in developing regions. The VW Beetle continued as a mainstream vehicle in many countries long after it disappeared from the roads in Europe and the USA.

How fast can change happen?

The Internet revolution that we are experiencing today is the result of the development and convergence of various technologies. The builders of ENIAC didn't plan for a computer in every home and the first network pioneers were focused on linking universities and military sites, not doing grocery shopping on-line. Even a few years after the launch of the PC, many saw its uptake in the home as limited.

Although very different in nature, there are many parallels to this in the energy and transport revolution. The oil industry boomed due to vehicle development and fuel availability was accelerated by the resulting consumer demand for cars. Both have added enormous value to our society; yet at the outset a car or computer in every home was seen as either unnecessary or prohibitive from a cost perspective. Both transformations are measured in decades, in contrast to our perception that change can happen overnight.

Figure 8: Technology convergence supported the 40-year development of the Internet.

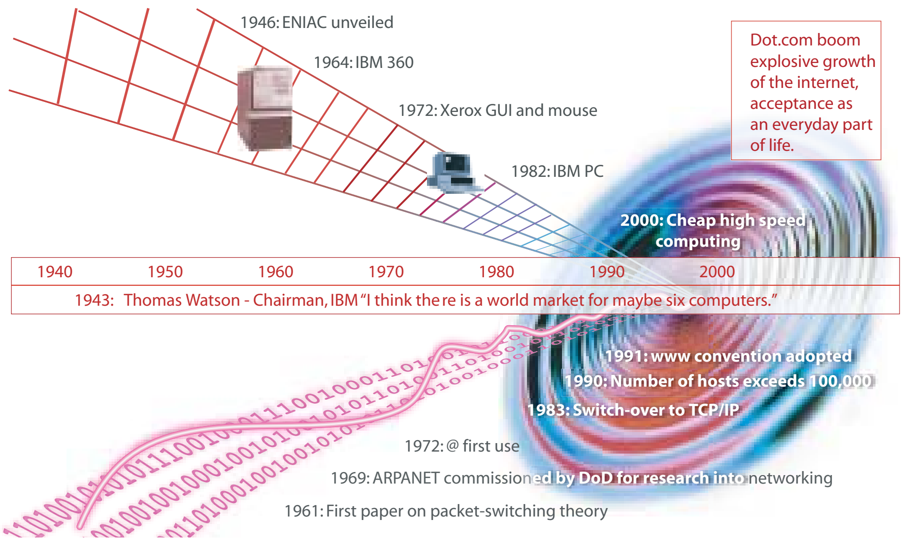
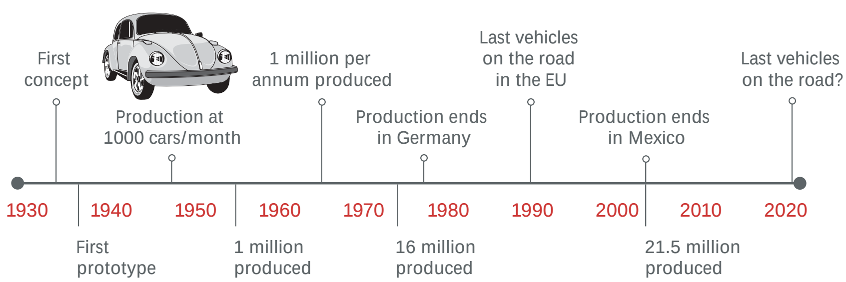


Figure 9: Typical infrastructure lifetimes, which are a factor in the rate at which new technologies enter the economy.

Infrastructure	Expected lifetime, years
Hydro station	75 ++
Building	45 +++
Coal station	45 +

Infrastructure	Expected lifetime, years
Nuclear station	30-60
Gas turbine	25 +
Motor vehicle	12-20

Figure 10: The original VW Beetle will have been with us for nearly 100 years when the last vehicles leave the road.



How difficult is it?

Change on a global scale is a massive undertaking. Even with challenging (and possibly unrealistic) growth assumptions and early deployment of the best new technologies, which arguably are not ready for large-scale use, it still proves difficult to hold emissions at current levels, let alone begin to see them decline.

The two case studies below illustrate this process.

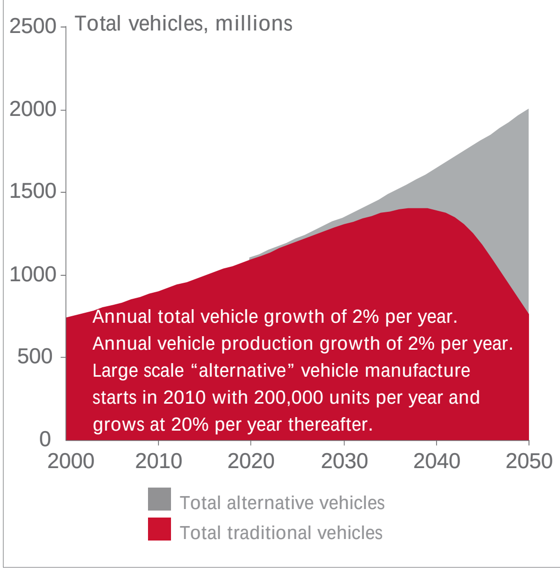
Case 1: The rapid introduction of zero carbon road transport technology

Limiting CO_2 emissions from transport to sustainable levels is an important goal in addressing climate change. As Mobility 2030 (WBCSD 2004) points out, "even under optimum circumstances, achieving this goal will take longer (probably quite a bit longer) than two or three decades".

Take the case of light duty vehicles (LDVs), which today represent around half of the transport sector's CO_2 emissions. In 2000 there were 750 million such vehicles in use with this number growing by 2% per year. To achieve significant CO_2 reductions from transport, these vehicles would have to be replaced with new advanced technology vehicles. However, the typical life of a car is some 12-20 years and also, the need to refit fuelling stations with lower carbon fuels could limit the take-up of new vehicles.

The illustration on the right shows that even if large-scale deployment of vehicles that emit no CO_2 at all could start relatively early and progress at a rapid rate, it would not be until 2040 that the total number of traditional vehicles in use begins to decline. This means that GHG emissions from all LDVs would not begin to decline until that time, unless emissions for traditional vehicles decline significantly (for a detailed assessment on the carbon impact of specific vehicle technologies, see WBCSD 2004).

Figure 11: An illustration of the rapid development and deployment of zero carbon vehicles.



Case 2: The immediate deployment of carbon neutral technologies in the power sector

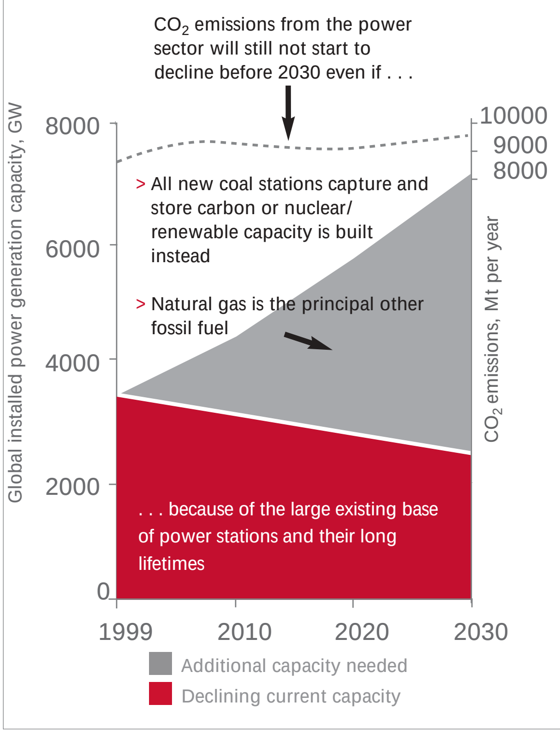
The IEA reference scenario *(World Energy Outlook 2002)* projects that to meet global demand for electricity the world's generating capacity will need to double from the year 1999 to 2030 (from 3500 to around 7000 GW).

The scenario further assumes that we will build 1400 GW of coal capacity and 2000 GW of natural gas capacity (both to replace retired facilities and to meet new requirements). This would see CO_2 emissions from the power sector nearly double over this time period.

But what if all new coal fired power plants utilized carbon capture and storage or nuclear/renewable capacity was built instead? Would that be sufficient for power sector emissions to start declining? At best, we could stabilize emissions from the power sector with these technologies. The 45+ year lifespan of existing and planned facilities gives us a considerable legacy through to 2030 and beyond.

Implementing such a plan would also be difficult for many developing countries that see abundant local coal and cheap mature generating technology as an ideal response to growing energy demand.

Figure 12: Impact of carbon-neutral technologies on power sector CO_2 emissions.

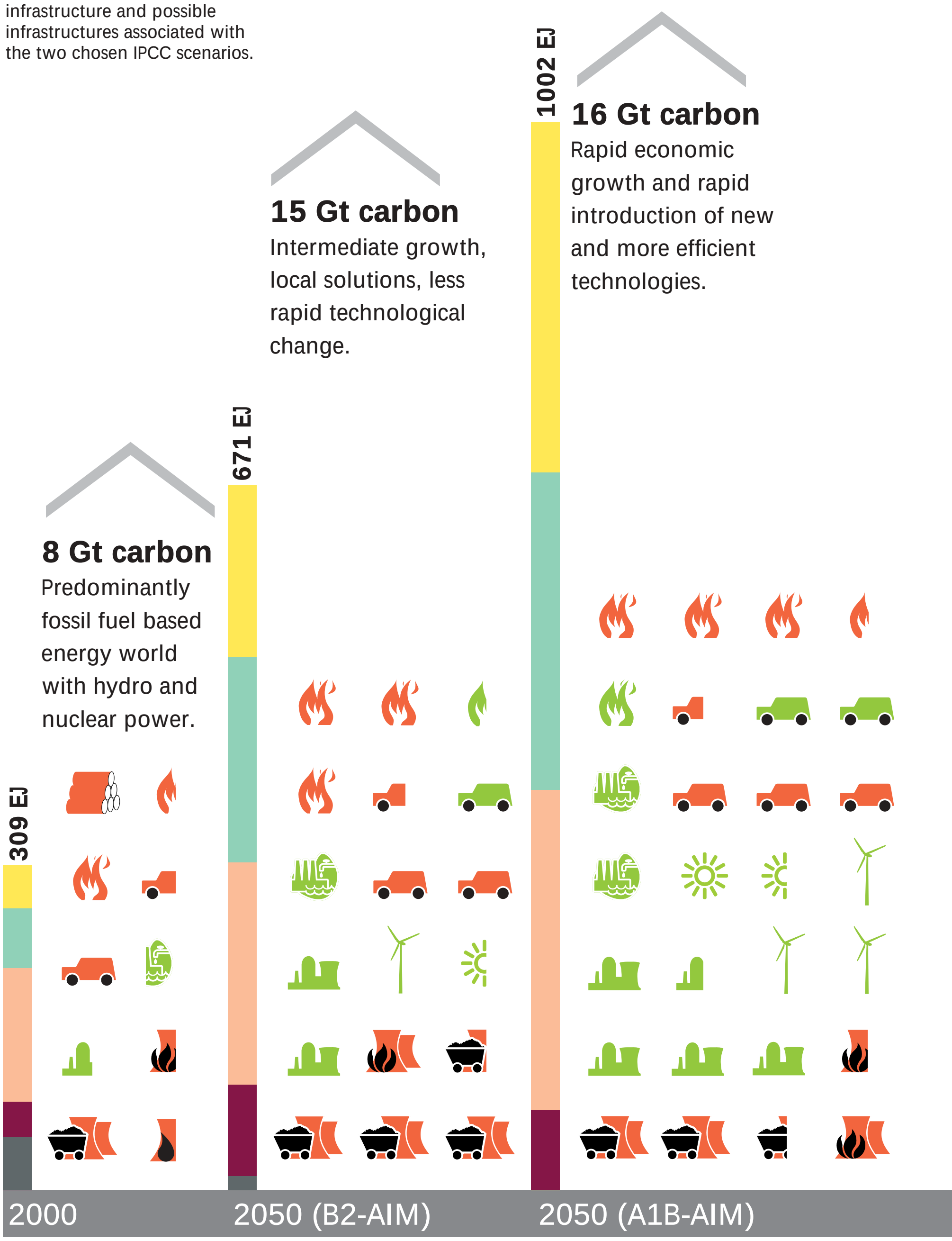


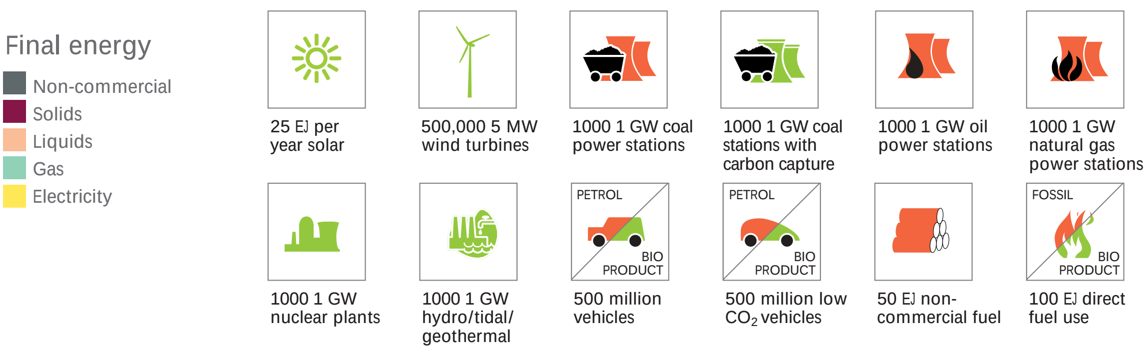
The challenge ahead

A reduction in growth is not an acceptable path to a lower carbon world. Rather, we need a decoupling of the current direct link between standards of living and energy consumption. The developing world has the right to aspire to the levels enjoyed in OECD countries, and improved efficiency, diversity and technological development in our energy systems will be the keys to achieving this without escalating emissions unsustainably.

We are already seeing examples of change, such as an increased use of gas, the introduction of advanced forms of renewable energy and high efficiency vehicles offered to the consumer. The two chosen IPCC scenarios (A1B-AIM and B2-AIM) build on these changes, with the evolution that we might see in the coming years illustrated in the side chart. This will not be enough, however, as both development paths lead to an eventual CO_2 stabilization of around 1000 ppm.

Figure 13: Our current energy infrastructure and possible infrastructures associated with the two chosen IPCC scenarios.





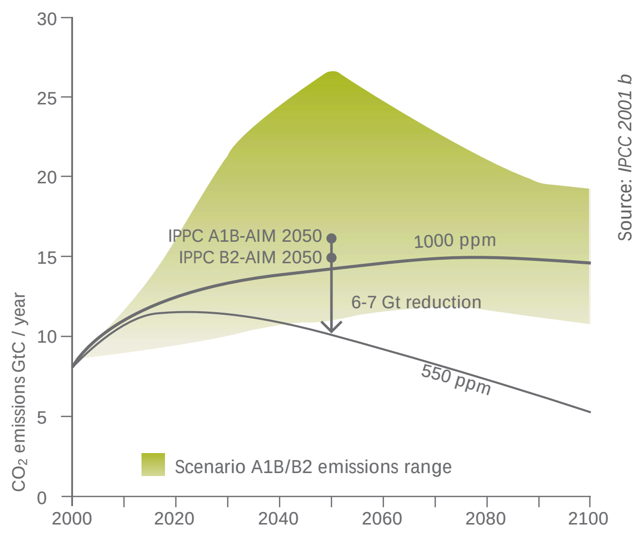
There are many paths to a lower carbon world. The foldout chart illustrates but one of these. However, all paths will require solutions from a range of emission reduction technologies as well as energy conservation and efficiency measures.

How can an acceptable atmospheric CO_2 stabilization be achieved?

A reduction of 6-7 Gt of carbon (22 Gt CO_2) emissions per year by 2050 compared to the A1B and B2 scenarios would place us on a 550 ppm trajectory rather than 1000 ppm CO_2, but a step-change (r)evolution in our energy infrastructure would be required, utilizing resources and technologies such as:

- A further shift to natural gas
- Nuclear energy
- Renewables
- Bio-products
- Carbon capture and storage
- Advanced vehicle technologies
- Other energy efficiency measures

Figure 14: The reduction in CO_2 emissions needed for a 550 ppm trajectory.

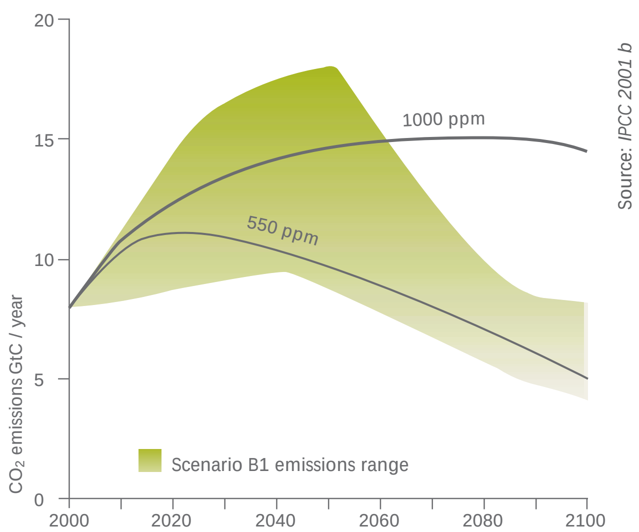


Energy conservation, energy efficiency and societal change

A lower carbon world will require a marked shift in the energy/development relationship, such that similar development levels are achieved but with an average 30% less energy use. Both energy conservation through behavioral changes and energy efficiency through technologies play a role.

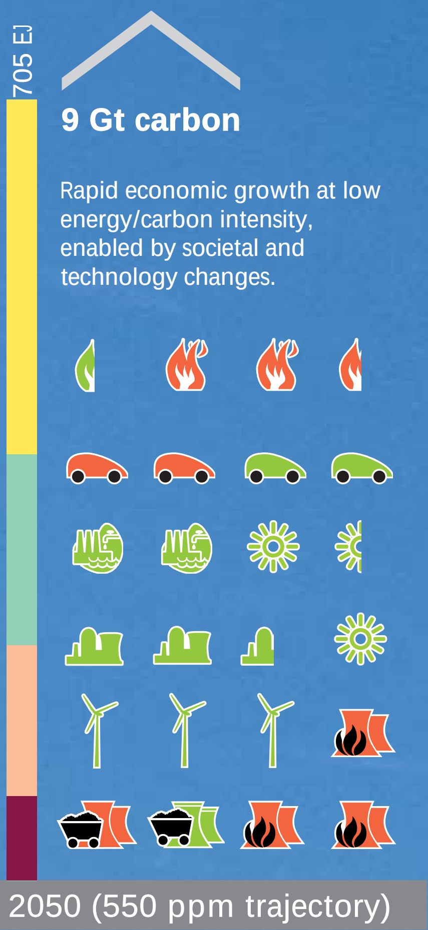
Such a trend is a feature of the IPCC B1 storyline, which sees a future with a globally coherent approach to sustainable development. It describes a fast-changing and convergent world toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The scenario leads to relatively low GHG emissions, even without explicit interventions to manage climate change.

Figure 15: IPCC scenario B1 shows the impact of a globally coherent approach to sustainable development.



Emission reduction

Figure 16: There are many paths to a lower carbon world. One of these is illustrated here. However, all paths will require solutions from a range of technologies as well as energy conservation measures.



A further shift to natural gas

Natural gas is more efficient from a carbon perspective than conventional coal (assuming no CO_2 capture) or oil (see Figure 4). 1400 1 GW CCGT rather than coal fired plants, means 1 Gt less carbon emissions per year:

- A consistent growth of 2.6% per year over 50 years is needed for the 9 Gt world. This is greater than the 2.4% which is forecast by IEA in the *World Energy Outlook* (2000-2030).
- Natural gas is still a fossil fuel with economic supply limits, which means its role is transitory, rather than long-term.

Mass transportation

CO_2 emissions per person vary over a 3:1 range for developed countries with similar lifestyles due to infrastructure differences and public attitude to mass transit.

Nuclear energy

700 1 GW nuclear plants rather than equivalent conventional coal facilities would reduce emissions by 1 Gt carbon per year.

However:

- The 4+% growth rate needed exceeds the <2.5% growth rate in nuclear in the 1990s.
- Nuclear has to overcome public acceptance obstacles.

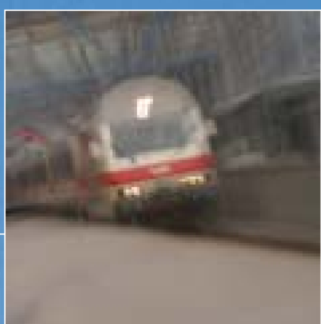
Road transport

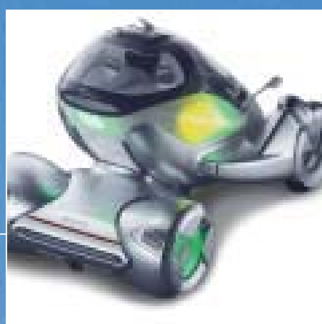
Road transport emissions contributed 1.5 Gt of carbon emissions in 2000. This could rise to over 3 Gt by 2050 as the number of vehicles exceeds 2 billion. Yet:

- If all these vehicles increased efficiency levels (e.g. using hybrid or advanced diesel technologies), emissions could be lower by 1 Gt carbon in 2050.
- If 800+ million vehicles utilized a new hydrogen transport infrastructure (including fuel cell technology) with zero emission fuel production, emissions would also be lower by 1 Gt carbon.

The 9 Gt world presented here is based on the use of high efficiency ICE vehicles, partly run on biofuel (see “Bio-products”).

Energy conservation and efficiency





Renewables

An emission reduction of 1 Gt carbon per year could be achieved by replacing 700 1 GW conventional coal plants with facilities based on renewable energy.

Wind power – Over 300,000 5 MW wind turbines would be required (for 1 Gt) and would cover an area the size of Portugal, although much of the land would still be usable. Many are now sited offshore.

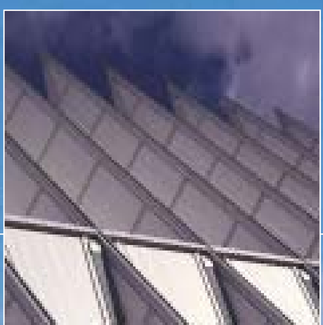
Solar power – Becoming an important source of electricity for the more than 2 billion people worldwide who have no access to the electrical power grid.

Geothermal – Current capacity and potential growth prospects are similar to wind and it has a very low land use ‘footprint’.

Hydroelectricity – Hydropower offers a renewable energy source on a realistic scale in many developing countries where its potential is not fully utilized.

Buildings

The US DOE Zero Energy Home program has shown that a 90% reduction in net home energy use can be achieved in new buildings.

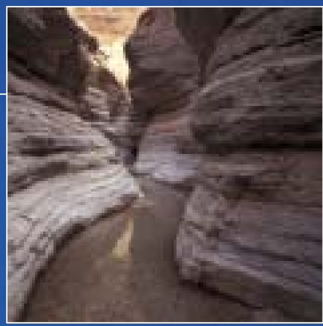


Bio-products

Biofuel- and biomass-based products can reduce emissions from power generation, manufacturing and transport. In 2000, the non-sustainable use of biomass added 1 Gt carbon emissions to the atmosphere, for the production of only 50 EJ of non-commercial final energy (typically for cooking in developing countries). By 2050, sustainable biofuel and biomass production could contribute 100 EJ of final energy with little or no net CO_2 emissions.

Low energy appliances

Today, over 0.5 Gt of carbon emissions come directly and indirectly from lighting. Two billion people in developing countries use direct fuel burning as their only source of lighting, consuming more energy per capita than many in developed countries for the same purpose. A shift to advanced lighting technology, such as white LEDs (Light Emitting Diodes), could see global reductions in related carbon emissions of up to 50%.



Carbon capture and storage

Carbon capture and storage may provide an effective route to further utilize the world’s abundant coal resources. 700 1 GW coal fired power stations utilizing capture and storage would result in 1 Gt less of carbon emissions.

A number of challenges exist:

- Low-cost CO_2 separation technology
- Societal acceptance of the technology
- Identifying and developing sufficient sites
- Establishing monitoring protocols

Doing things differently

The information society offers real opportunity for energy conservation. Better stock management through on-demand services and mobile communication results in less waste, reduced transport and ultimately lower greenhouse gas emissions.

Advances in wireless technology may allow developing countries to rapidly adopt such approaches, avoiding unnecessary infrastructure investment, which in turn could help their growth progress along a lower Energy per GDP trend line.

Glossary and references

Glossary

ARPANET: The Advanced Research Projects Agency Network was formed by the US government in the early 60s and led to the development of ARPANET, the world's first network enabling communication between computer users.

AIM: Scenarios from the Asian Pacific Integrated Model (AIM) from the National Institute of Environmental Studies in Japan – see "IPCC Scenarios" below.

Carbon dioxide (CO_2): The principal gaseous product from the combustion of hydrocarbons such as natural gas, oil and coal. CO_2 exists naturally in the atmosphere and it is a greenhouse gas, but its concentration has been rising over the last century.

Carbon capture and storage: A long-term alternative to emitting carbon dioxide to the atmosphere is capturing and storing it. Geological carbon storage involves the injection of CO_2 into subsurface geological formations. If the CO_2 source is not of sufficient purity, separation must take place first.

CCGT and CHP: Combined Cycle Gas Turbine is a highly efficient type of plant that can convert more than 50% of the chemical energy in the gas to electrical energy. The overall efficiency can be further improved in a combined heat and power plant (CHP).

Concentration: The amount of CO_2 in the atmosphere at any given time, typically measured in parts per million (ppm). In this publication CO_2 concentration means CO_2 only and does not include other greenhouse gases.

DOE: United States government Department of Energy.

Emission: The release of a material (CO_2 in this context) into the atmosphere, typically measured in tonnes per year.

ENIAC: Electronic Numerical Integrator and Computer, commissioned in 1943 by the US Department of Defense (Dod) for their Ballistics Research Laboratory.

Final energy: The energy we actually use in our cars, homes, offices and factories.

GDP: Gross domestic product, a measure of the size of the economy.

Gigatonnes (Gt): Carbon emissions to the atmosphere are very large, so we measure them in gigatonnes, or billions of tonnes. One Gt CO_2 in the atmosphere is equivalent to 0.3 Gt carbon.

Greenhouse gas (GHG): Gases in the earth's atmosphere that absorb and re-emit infrared radiation thus allowing the atmosphere to retain heat. These gases occur through both natural and human-influenced processes. The major GHG is water vapor. Other primary GHGs include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), CFCs and SF_6.

ICE: Internal combustion engine.

IEA: International Energy Agency, an intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation. A principal publication produced by IEA is the *World energy outlook (WEO)*.

IPCC: The Intergovernmental Panel on Climate Change (IPCC) has been established by the United Nations to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.

IPCC scenarios: The IPCC developed four narrative storylines to describe potential pathways and encompass different demographic, social, economic, technological, and environmental developments. Importantly, the storylines do not include specific climate initiatives such as the implementation of the Kyoto Protocol.

Each scenario then represents a specific quantitative interpretation of one of the storylines. For each storyline several different scenarios were developed using different modelling approaches. All the scenarios based on the same storyline constitute a scenario "family".

In this publication we have used the A1B (balanced energy supply mix) and B2 storylines, and for our illustration of specific energy infrastructures, the scenarios from the Asian Pacific Integrated Model (AIM) from the National Institute of Environmental Studies in Japan. The A1B-AIM is a marker scenario for the A1 storyline, with emissions in the middle of the range of all 40 IPCC scenarios. We have also referenced the B1 storyline and family of scenarios given their strong emphasis on energy efficiency and consequent low future emissions.

Joule, GigaJoules (GJ) and ExaJoules (EJ): A joule is a measure of energy use, but being a small amount, must be expressed in very large numbers when discussing global energy. A GigaJoule is one billion joules (1 followed by 9 zeroes), an ExaJoule is 1 followed by 18 zeroes. One ExaJoule is 278 billion kWh, or 278 thousand GWh, or the equivalent of 32 1 GW power plants running for one year.

OECD: Organization for Economic Development and Cooperation.

Parts per million (ppm): Parts (molecules) of a substance contained in a million parts of another substance. In this document "ppm" is used as a volumetric measure to express the amount of carbon dioxide in the atmosphere at any time.

PPP: Purchasing Power Parity, the rate of currency conversion that equalizes the purchasing power of different currencies. PPPs compare costs in different currencies of a fixed basket of traded and non-traded goods and services and yield a widely based measure of standard of living.

Primary energy: The total energy available from our resources, such as coal, oil and natural gas, assuming 100% efficient use of those resources.

Stabilization: The long-term balanced concentration of CO_2 in the atmosphere. CO_2 constantly migrates from the atmosphere to the oceans, to plant and animal life and then back to the atmosphere where a balanced concentration has been maintained for thousands of years. Following a change in the balance due to additional emissions, a new balance, or stabilization, may take centuries to establish itself.

Watt, KiloWatts (KW), MegaWatts (MW), GigaWatts (GW) and Watt-Hour (Wh): A watt is a measure of the rate of energy use, and is equivalent to a joule per second. A MegaWatt is one million watts, a GigaWatt is one billion watts. Power generation is typically expressed in watt-hours (Wh), which is the supply or use of one watt for a period of one hour. Households express energy use in kilowatt-hours (kWh). An appliance that requires 1000 watts to operate and is left on for one hour will have consumed one kilowatt-hour of electricity. See also the definition of Joule.

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About the WBCSD

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) is a coalition of 170 international companies united by a shared commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. Our members are drawn from more than 35 countries and 20 major industrial sectors. We also benefit from a global network of 50 national and regional business councils and partner organizations involving some 1,000 business leaders.

Our mission

To provide business leadership as a catalyst for change toward sustainable development, and to promote the role of eco-efficiency, innovation and corporate social responsibility.

Our aims

Our objectives and strategic directions, based on this dedication, include:

> **Business leadership:** to be the leading business advocate on issues connected with sustainable development

> **Policy development:** to participate in policy development in order to create a framework that allows business to contribute effectively to sustainable development

> **Best practice:** to demonstrate business progress in environmental and resource management and corporate social responsibility and to share leading-edge practices among our members

> **Global outreach:** to contribute to a sustainable future for developing nations and nations in transition

Energy and Climate Council Project

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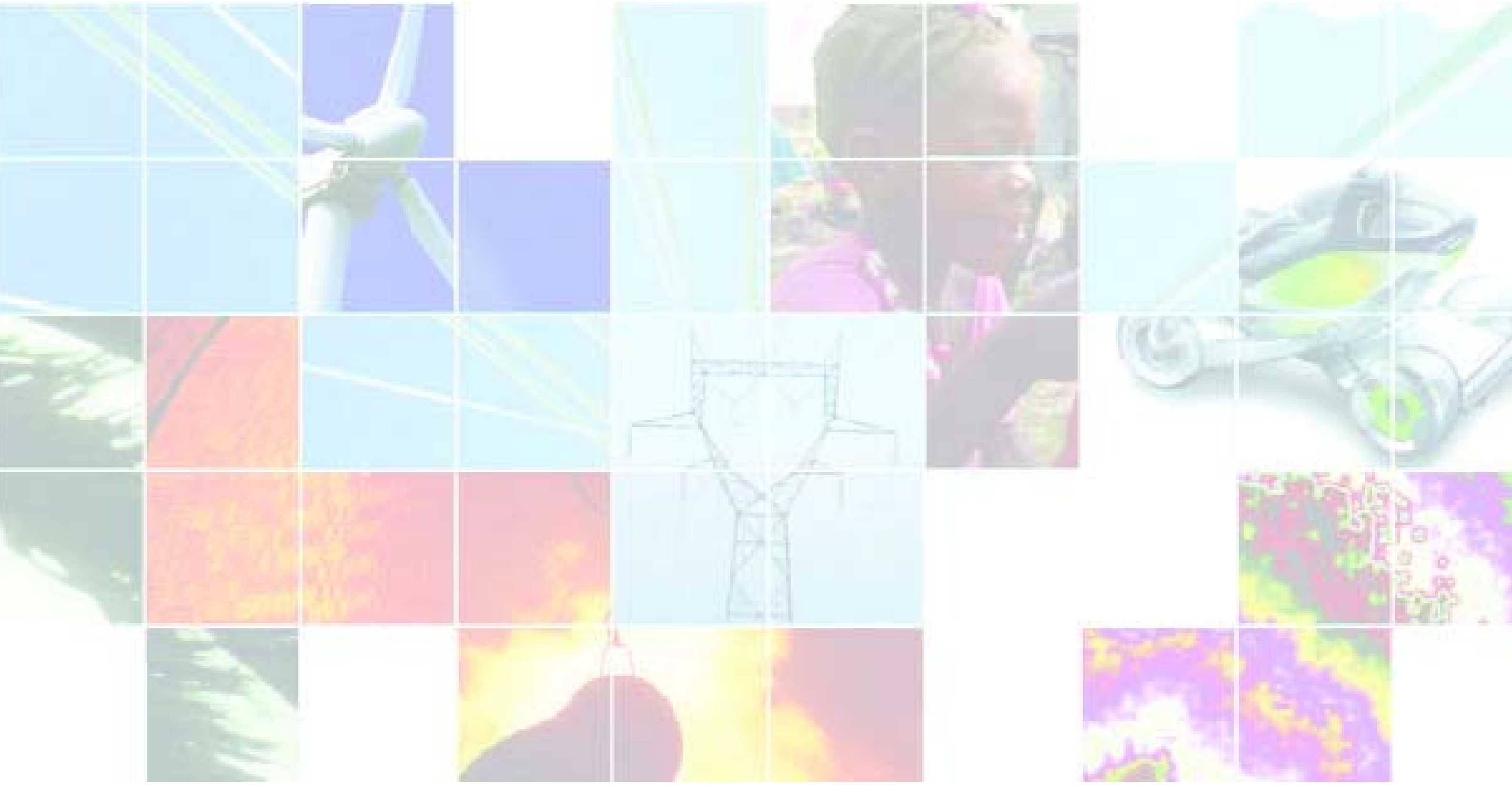

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