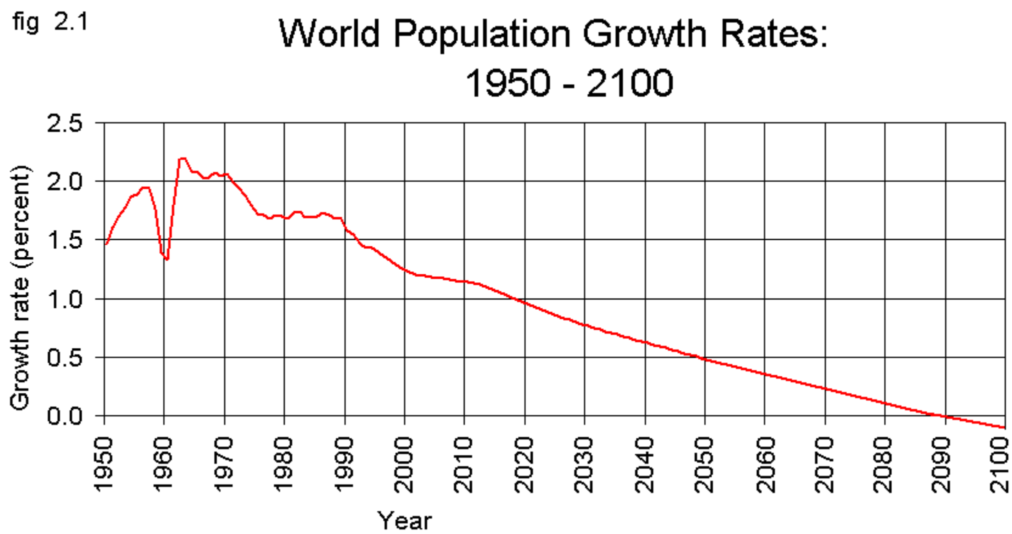
Inevitable Growth in the 21st Century

Beyond having to manage and stabilize global warming in the 21st century mankind will need to address additional, but related, worldwide challenges each of which is as daunting as mankind has ever faced.

It can be said that with nearly seven billion people on the Earth this is an un-sustainable population. As Figure 2.1 shows the growth rate in the world's population peaked in the mid 1960s and has fallen from just over 2% to 1.3% growth per year in 2007. This worldwide decline in birth rate is anticipated to continue throughout the 21st century as rates fall in both developed and under developed countries.

fig 2.1



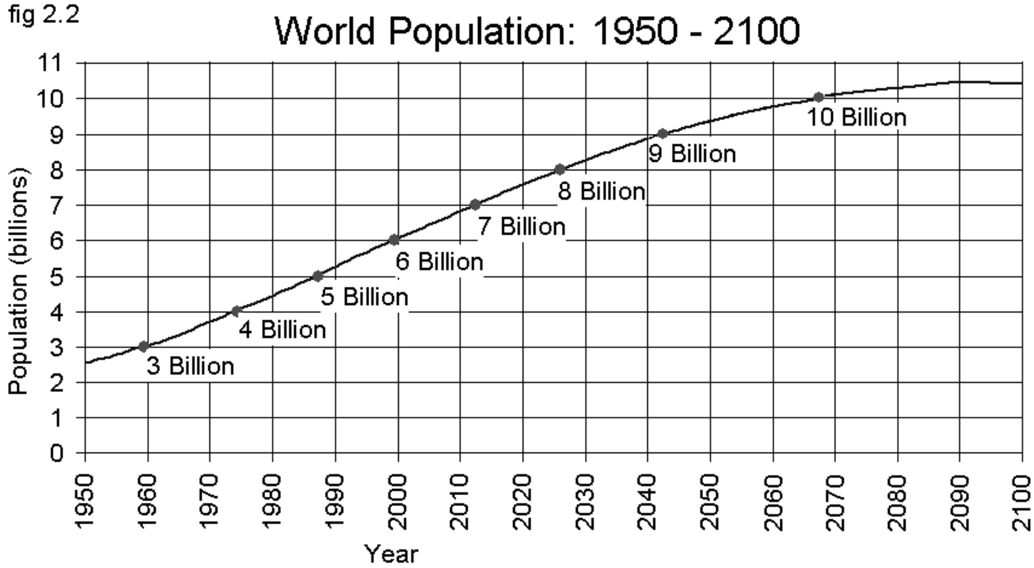
Source: U.S. Census Bureau, International Data Base, 2008 First Update to 2050 then extended at the same rate of decline

Although the rate of growth is declining it will probably remain positive until almost the end of the 21st century. But with 6.9 billion people on the Earth this means that the world's population will increase by a further 70 to 80 million people a year throughout the next 2 decades and lower levels thereafter.

Factors that impact on world population are fertility rates and the increasing average lifespan of people in developed countries. The increase is tempered to some extent by killer diseases, such as aids and malaria, increased use of birth control and death through malnutrition in less developed nations.

Taking all factors into account the US Census Bureau and the United Nations Population Division project that the world's population will exceed nine billion by 2050. The consensus view of those who predict world population growth expect it to peak before the end of the 21st century at just over ten billion as shown in Figure 2.2.

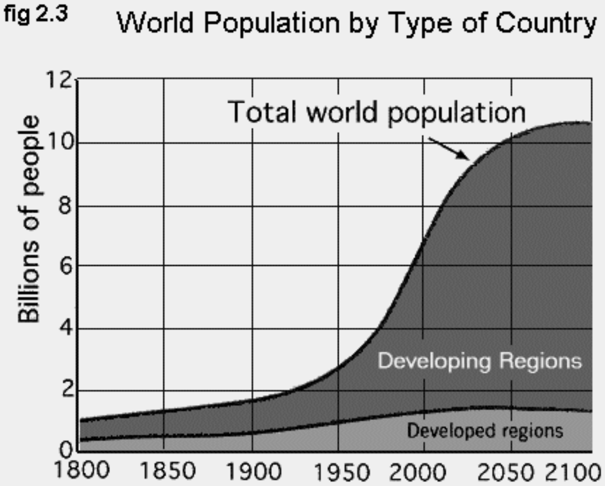
fig 2.2



Source: U.S. Census Bureau, International Data Base, 2008 First Update to 2050 then extended

This expansion in population is taking place primarily in developing regions since birth rates in many developed countries have already peaked. The population of all developed regions is moving towards a peak around 2030 and is then forecast to decline. It is the populations of the developing regions and particularly the countries with very low income that are driving population expansion.

fig 2.3



Some developing countries, however, have higher population growth than others, for example China with 1.3 million people has a current annual growth rate of 0.6% whilst India with 1.15 million has an annual growth rate of 1.4%. India may eventually become the country with the largest population.

Currently, countries with 45% of the world population have an annual growth rate of less than 1% although countries with less than 10% of the world population have a negative growth rate. Many more countries are expected to move towards negative growth rates over the next 50 years. In many of these countries life expectancy rates will be increasing which will put pressure on their government's ability to provide old age pension income. It is likely that people will choose to work longer in their life, and possibly part time, in these countries.

It is possible that the population of the world may peak at less than 10 million due the impact of the inevitable pressures that a further large increase in population will bring. Food production, which is already giving supply problems in 2008, and may reduce due to the impact of climate change, may not be able to meet the increased needs of 50% more people. In addition, in some countries there could be a shortage of water, both for human use and irrigation.

The increase in population on its own does not directly impact on the temperature of the Earth which is caused by a combination of solar activity and the level of greenhouse gases in the atmosphere. The levels, and rate of increase, of greenhouse gases are both increasing due Anthropogenic economic activity. Both will further increase as the population of the world rises and people in both developed and emerging nations become wealthier and expect a higher standard of living. More people will accentuate the level of economic activity across the world although the economic activity of countries with high birth rates is low.

Unless there are changes in technology, the increasing level of economic activity will continue to increase greenhouse gas concentrations in the atmosphere and probably accelerate the rate of global warming.

Different areas of economic activity will, however, vary in their rate of change.

Prospective changes in economic activity

Due to the increase in world population and to the increase in economic activity in all counties, but particularly the developing countries, there will be increasing and unremitting demand for energy thoughout the 21st century.

This will be mainly be caused for electricity to provide power for industry and commerce but increased living standards bring much higher use of appliances in domestic use. Demand will increase further if, as expected, batteries or hydrogen fuel cells, both of which are charged by electricity, power the next generation of emission free vehicles. There is, however, the opportunity to make the use of electricity much more efficient in all forms of use which will act as a counter balance. Worldwide demand for electricity has increased by 3% per annum for the past 30 years and it is reasonable to expect that this rate of increase will continue for the immediate decades ahead, and possibly for the whole of the 21st century.

fig 2.4 The growth of worldwide electricity generating capacity at 3% per annum

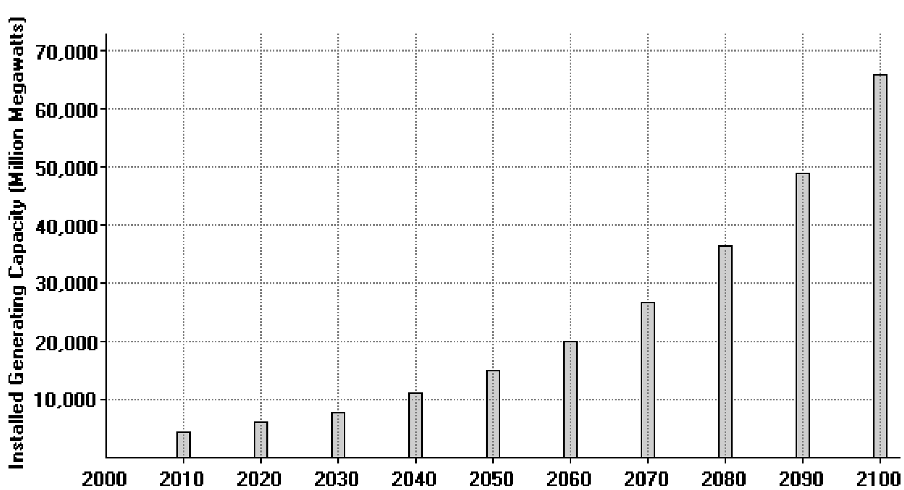


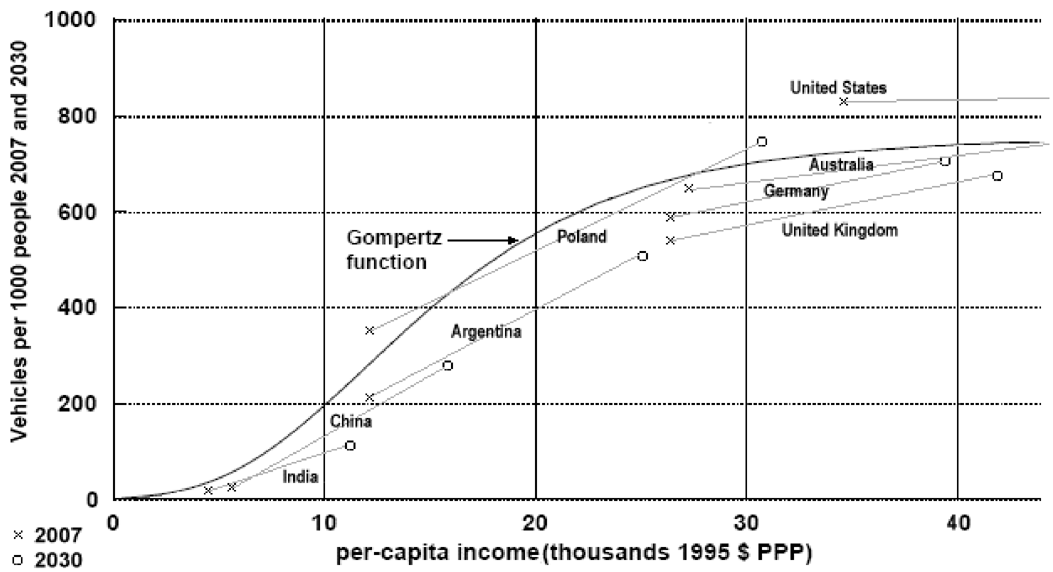
Figure 2.4 shows that the level of generation is likely to be at least 3 times the level of 2007 generation by 2050 and 15 times by 2100.

As people become wealthier they seek to have the personal use of a car to provide the freedom of personal mobility. This will become ever more prevalent throughout the 21st century as the personal wealth of people, and population, increases.

The number of vehicles in the world was about 900,000 in 2007 and is forecast to grow rapidly through to 2030, as people in China, India and other developing countries are able to afford cars.

Statisticians who forecast the growth in car ownership have identified that there is a relationship between the number of vehicles per 1,000 people and average per-capita income. As per-capita income increases the growth rate accelerates before slowing down to stabilize at approximately 800 vehicles per 1,000 people in countries with high per-capita income. Whilst the topography of a country and the effectiveness of public transport will impact on the average level of car ownership, statisticians use a curve, described as the Gompertz function, as an indicative tool. Figure 2.5 shows the anticipated growth in vehicles per 1000 people over the period 2007 to 2030 when related to per-capita income for selected countries.

fig 2.5 Growth in vehicles per 1000 people related to per capita income



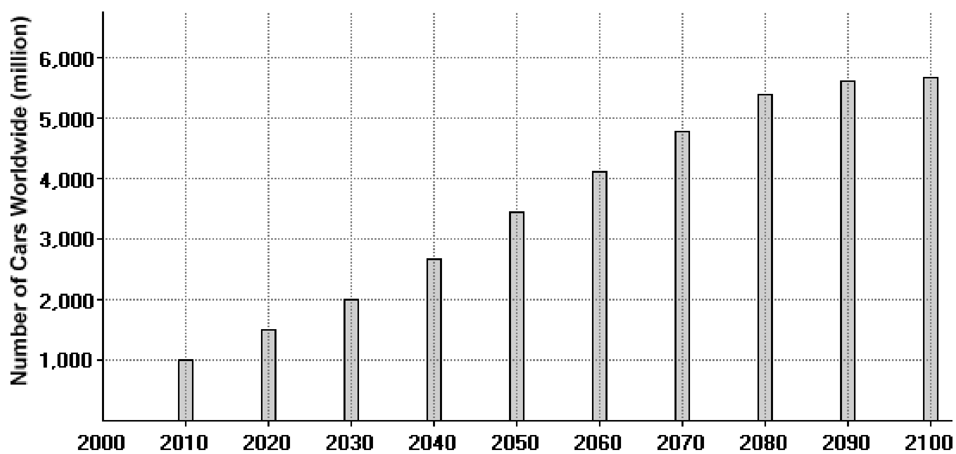
Data Source: Vehicle ownership and growth 1960 - 2030 - Dargay, Gately and Somner January 2007

The source of the data for this graph estimates that there will be over 2 billion vehicles on the roads across the world by 2030. If the price of vehicle fuel continues to increase as oil production cannot meet demand this will encourage vehicle manufacturers to design smaller cars, more of which may be powered by batteries or hydrogen fuel cells. Whilst the anticipated number of cars will not change, the mix of types of vehicles on the road in 2030 may be significantly different to the mix in 2007.

The per-capita income of all countries will continue to increase throughout the 21st century. Some countries will experience higher per-capita income growth than others. Currently, the most highly developed countries with per capita income of over $35,000 have between 650 and 850 cars per 1,000 people. It is possible that by 2100 over 80% of the population of the world will be living in countries where the per-capita income exceeds $20,000. On this basis it is likely that the number of cars worldwide will be less that 6 billion in 2100.

In the early part of the 21st century China and India, which have 40% of world population, will expand their economies and per capita income rapidly. In consequence the rate of increase in the number of cars is likely to reduce as the century unfolds. An estimate of the growth of cars worldwide during the 21st century is shown in Figure 2.6

fig 2.6 The growth of cars worldwide



The transport of people over longer distances will increase as more people can afford to travel to visit relatives in other countries or to holiday and as industry and commerce become even more global. This will increase the number of aircraft and the density of rail networks as people are encourage to increase their use of public transport to reduce carbon emissions and the number of ships will increase as global trade continues to increase. The growth rate of these forms of transportation will probably be proportionate to rates of economic growth.

In addition to electricity generating plants there are also other types of industrial plants, such as cement, steel, glass and chemical plants that emit large volumes of greenhouse gases. The level of their activity is likely to also increase in proportion to rates of economic growth.

In addition the developing nations, for example China and India, are changing their diet from fish, crops and small animals to include more meat from cows. This form of meat is a very inefficient, and expensive, form of food in that crops have grown to feed the animals and a high level of energy is used to slaughter, process and distribute the meat for consumption. It has been calculated that producing one kilogram of beef is equal to the carbon dioxide produced in driving 250 kilometres in an average European car or lighting a 100-watt light bulb continuously for 20 days.

The growth in economic development and population throughout the 20th century has been substantial and this will continue throughout the 21st century. This growth has already increased greenhouse gas emissions to levels which are higher than those experienced for over one million years and which are directly impacting on the ecosystems and temperature of the Earth in a way that the Earth has never experienced.

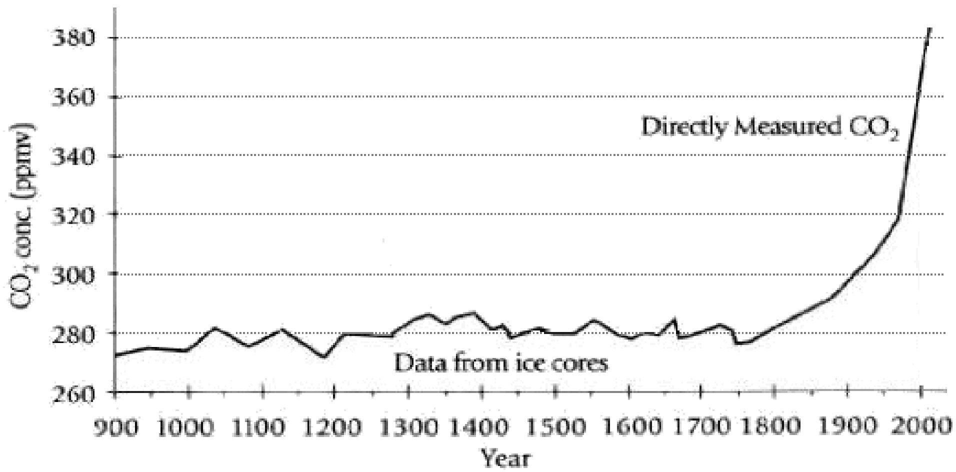
Changes in greenhouse gas levels up to 2007

Atmospheric concentrations of carbon dioxide and methane — greenhouse gases — rose sharply in 2007, according to the U.S. weather agency, the National Oceanic and Atmospheric Administration (NOAA). Their measurements show that global levels of carbon dioxide in the atmosphere, the primary driver of global climate change, climbed by 0.6 percent, or 19 billion tons in 2007. Methane levels increased by 27 million tons after nearly a decade when there was little or no increase.

NOAA estimate that atmospheric carbon dioxide levels currently stand at 385ppm, or about 38 percent higher than the average level of 280ppm which had existed for thousands of years prior to the Industrial Revolution. NOAA noted that the rise in carbon dioxide atmospheric concentration has been accelerating since the 1980s when annual increases were around 1.5 ppm per year. In 2007 the increase was 2.4ppm.

Figure 2.7 shows the concentration of carbon dioxide in the atmosphere for the past 1,000 years and illustrates the increasing rate of concentration since the start of the Industrial Revolution at the beginning of the nineteenth century.

fig 2.7 Concentration of carbon dioxide in the atmosphere



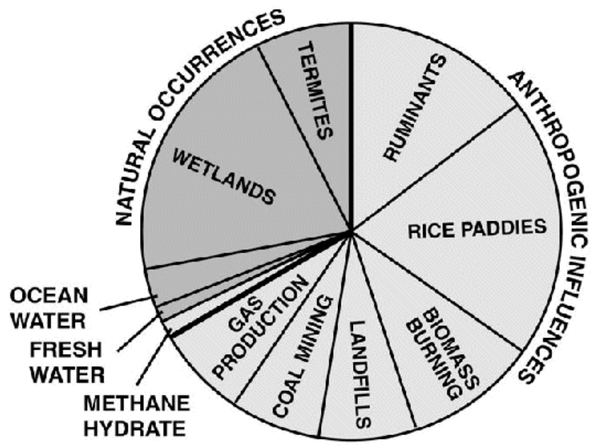
The burning of fossil fuels as coal, oil, and gas, is the primary source of increasing carbon dioxide emissions. The earth's oceans, vegetation, and soils soak up about half of these emissions, currently. Some emissions stays in the air for a century or longer with 20 percent of carbon dioxide emissions possibly remaining in the atmosphere for millennia, according to the latest scientific assessment by the International Panel on Climate Change. The increase in carbon dioxide levels in 2007 means that 2.4 molecules of this gas were added to every million molecules of air, boosting the global concentration to over 385 ppm.

The rate of increase in carbon dioxide concentrations accelerated over recent decades along with fossil fuel emissions. Since 2000, annual increases of two ppm or more have been common, compared with 1.5ppm per year in the 1980s and less than one ppm per year during the 1960s. There is evidence to show that part of this increase is caused by a decline in the ability of the earth's oceans, vegetation and soils to soak up anthropogenic carbon dioxide.

In contrast, the increase in methane levels, which is another important greenhouse gas, has been steadily increasing from 700 parts per billion prior to 1700 to approximately 1780 parts per billion in recent years. Since 2000 the methane concentration has remained constant. Methane levels began to increase earlier and increased for a longer period due to anthropogenic activity because the source of methane emissions is entirely different to carbon dioxide.

Figure 2.8 shows that approximately 35% of emissions come from wetlands and other natural sources with 65% coming from anthropogenic sources. A recent reduction in emissions from wetlands and improved waste management has caused the current pause in the increase of methane concentration in the atmosphere.

fig 2.8 Sources of methane



Source: U.S. Department of Energy National Energy Technology Laboratory

As a greenhouse gas methane is 25 times more potent than carbon dioxide, but there's far less of it in the atmosphere – just under 2ppm compared to 385ppm for carbon dioxide. When related climate affects are taken into account, methane's overall climate impact is less than that of carbon dioxide, but still significant. Its impact, however, lasts for a shorter period of time in that methane in the atmosphere dissipates over 10 years. The NOAA advises that rapidly growing industrialization in Asia, increasing wetland emissions in the Arctic and tropics, and increases in agriculture are the most likely causes of the increase in methane concentration. There is increasing concern, however, that the permafrost, or permanently frozen ground in the Arctic region may thaw and release large volumes of carbon into the atmosphere in the form of methane. This could possibly accentuate global warming.

Using technology to reduce greenhouse gas levels

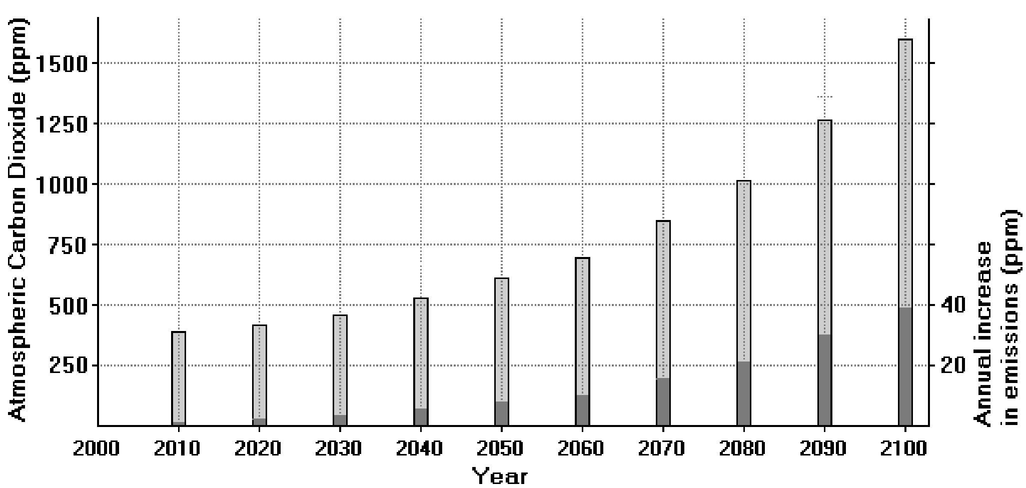
The nations of the world and their people have a choice. They can choose to ignore the potential impact that the increase in greenhouse gases will bring through global warming or they can introduce alternative technologies to replace the processes that produce greenhouse gas emissions.

If they choose to introduce alternative technologies, industrial and commercial organisations will need to invest in industrial plants and deploy products that reflect technologies that are not only free of carbon emissions but are are affordable. Developing an alternative, carbon free world where electricity generation, other industrial processes and agriculture, which are cheaper to use, could become a primary source of world economic activity throughout the 21st century.

Alternatively mankind could choose to maintain what is termed 'business as usual' and ignore greenhouse gas emissions. If this is the case the continuing increase in population and economic activity throughout the 21st century will accelerate the annual increase in greenhouse gas concentration in the atmosphere, which is currently about 0.6% per annum or 2.4ppm.

40% of greenhouse gases originate from generating electricity which is forecast to increase at 3% per annum during the 21st century. Emissions from other sources of greenhouse gases will also increase, but at varying rates, for example emissions from cars could increase more rapidly whilst the level of de-forestation may decrease. Overall one option is to assume that under a business as usual scenario the annual increase in emission will be 3% per annum. If this is the case figure 2.9 shows what the potential increase in greenhouse gas emissions could be throughout the 21st century under a business as usual scenario.

fig 2.9 Projected atmospheric carbon dioxide level with no action to reduce emissions with the rate of emissions increasing at 3% per annum



Under a business as normal scenario the level of carbon dioxide in the atmosphere will be approximately 465ppm in 2030, 600ppm in 2050 and over 1500 in 2100. Scientists have estimated the concentration of carbon dioxide in the atmosphere over geological periods for millions of years. This historical estimate shows that the concentration of carbon dioxide has not been above 500ppm for 35 million years.

In the Cretaceous era 65 million years ago and for much of the previous 450 million years the global temperature of the Earth is estimated to have been 22^{0}C, or 8^{0}C higher than today. This being the highest estimated temperature that the Earth reached over 500 million years even though the concentration of carbon dioxide is estimated to have been 2,200ppm for part of this period. As is well known these very warm periods have been punctuated by ice ages of varying severity where it has been difficult for life on Earth to survive. The Earth's carbon cycle converted the lush vegetation of many of these years into the carbon deposits of coal, oil and gas that mankind is currently releasing.

Mankind is rapidly transferring back into the atmosphere of the carbon deposits that were put in place over millions of years ago. It has been calculated that the sunlight from about 500 years, as in these carbon deposits, is required to keep the world's current economy going for just one year. It has also been calculated that approximately 100 tonnes of ancient plant life is required to create four litres of petrol. Mankind's rapid conversion of these ancient carbon deposits into atmospheric carbon dioxide has the potential to alter the temperature of the earth, its climate, its topography, its vegetation and all living beings in ways that are beyond anything that is known to mankind, currently.

Throughout the history of the earth, changes in the earth's orbit around the sun and solar activity have altered the temperature of the earth with the associated carbon cycle subsequently changing the atmospheric concentration of carbon dioxide over decades, or more usually centuries. Mankind is currently creating a process to change the world's environment in a way that the Earth has never experienced.

Never before has the change in the concentration of carbon dioxide in the atmosphere preceded temperature change. Inevitably, scientists do not yet understand the extent of what may happen to the world's environment as this takes place and it may take several decades for them to understand and define these scientific principles.

In the first decade of the 21st century the nations of the world and its people have realised that the 'business as usual' scenario where the level of carbon dioxide in the atmosphere could reach 1,500ppm by the end of the 21st century is a risk not worth taking.

Co-ordinated worldwide action to understand the problem, estimate the impact on global temperature, climate, topography and sea levels are being thought through by the Intergovernmental Panel on Climate Change (IPCC) with action to reduce greenhouse gas emissions being put in place by the United Nations (UN), the European Union (EU), individual nations and other international, and national, organisations.

Protecting the environment for future generations

There are two options for reducing greenhouse gases to protect the environment for future generations. The first is to for industry and the people, who cause greenhouse gases, to change their behaviour and reduce emissions. The second is to replace the technology that is the basis of their production.

In the modern world mankind is very wasteful. Many industrial processes, transportation systems and people in their houses are very inefficient in their use of energy. In many developed economies there are now many initiatives to make the use of energy more efficient in all sectors. A minority of citizens in many countries are taking personal action to conserve energy but the scale of these initiatives in general, however, is often localised and is often not supported by government legislation except in the form of taxation, which may be focused on political issues, rather than on key emission reduction.

Initiatives to change behaviour to reduce emissions are valuable in the short term and will, in any event, create better, and more cost effective, practice for the future. Across the world they will not, however, reduce greenhouse gases to the extent that is necessary to stabilise and then progressively reduce global warming and high atmospheric concentrations of carbon dioxide. The only way for mankind to permanently reduce and eventually near eliminate greenhouse gases emissions is to progressively change the technology that is currently being used.

Is such technology currently available, or will it become available in the near future? Fortunately the breadth and inventiveness of mankind throughout the 20th century brings an array of technologies, and associated scientific knowledge, that can be employed and improved to achieve this goal. Cost effective technologies are available, or nearly available, for most of the major sources of greenhouse gases.

40% of greenhouse gas emissions originate from the use of fossil fuels for electricity generation. This form of generation can either be replaced by electricity from renewable sources such as solar, wind, wave or tidal power, or by nuclear power. Alternatively the technology used by coal-fired power stations can be modified to capture and store underground the carbon dioxide that is emitted. Replacing emissions from electricity generation is the most important technology change.

Electricity grids have become the norm in developed countries to distribute electricity from large power stations due to convenience and low cost. In some less developed countries that do not have comprehensive grid systems small-scale electricity generation (microgeneration) has been developed using solar power or water for domestic dwellings. At the start of the 21st century the technology of microgeneration from solar panels is advancing, rapidly, with significant cost reduction. In the 21st century this cost reduction and the increasing cost of electricity generated and provided through grids will drive households to switch to microgeneration which will become the norm rather than the exception. This will be mirrored in buildings used for commercial purposes.

Some industries, such as those producing cement, metal, glass and chemicals all produce emissions in addition to using electricity. The technology in each industrial process must be progressively refined to reduce emissions through research and development.

Virtually all vehicle transport is powered, currently, by the internal combustion engine which uses petrol or diesel as refined from oil, which is becoming more difficult and more expensive to extract and is increasing in price. The world's vehicle manufacturers are already researching and producing new power systems and new vehicles will soon be manufactured with power from more efficient batteries, hydrogen cells or even compressed air. Since the energy for these power sources comes from electricity this will accentuate the need to move quickly to methods of electricity generation that do not cause greenhouse gas emissions. In the short-term fuels with lower emissions and more fuel efficient vehicles will help curb emissions.

Some rail networks are powered by fossil fuels and can be converted to emission free electric power. Aircraft and shipping, however, are also powered by fossil fuels with alternative power sources not being easy to identify. Currently power design efficiency and alternative fuels with lower emissions are reducing greenhouse gas emissions. These trends are likely to continue for the next few decades until emission free power sources can be developed.

17% of greenhouse gas emissions, mainly methane, come from livestock and agriculture, e.g. rice paddies. Alternative animal feedstock and modified ways of farming rice are already demonstrating the potential for significant reduction in emissions from this sector.

The forests of the world store huge amounts of carbon and annual de-forestation contributes over 15% of greenhouse gases. The solution to deforestation is not technical; it requires individual nations to stop cutting down forests and using land for agriculture, and planting new woodlands. Scientists have discovered that new forests are more efficient is soaking up carbon dioxide from the atmosphere than mature rain forests.

Co-ordinated and effective political action, possibly supported by compensation incentives, is the only way forward to stop the destruction of forests in developing countries.

The extent that mankind will be able to meet the great challenge of the 21st century will depend on how quickly there can be effective international agreement to reduce emissions and introduce alterative technologies. In many cases market forces supported by carbon trading schemes and government incentives will drive their introduction.

At the start of the 21st century there are still some sources of greenhouse gases that appear to be difficult to eliminate, for example aircraft propulsion, animal emissions and rice farming. The second half of the 20th century has seen the introduction of new technology expand at an exponential rate in some sectors. In some cases new industries, which were never foreseen, have emerged, for example the Internet and mobile telephone communication. Scientists in many universities and across industry are seeking to invent new, and cost effective ways, of helping to reduce emissions. It is very likely that new technologies that are not yet foreseen will emerge to ensure that the challenge is met.

Increasingly, in the 21st century, mankind will see how essential it is to protect the environment for future generations by changing the technologies that have the potential to cause an explosion in greenhouse gas emissions as rapidly as possible. A second Industrial Revolution has just begun to reverse the impact of the first Industrial Revolution.

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The intention of this article is to advance knowledge and understanding of some issues associated with climate change. The views expressed are those of the author and do not, necessarily, represent the views of the Comino Foundation.