# Methane and climate change

Methane ($CH_4$) is a colourless, odourless, tasteless gas, which is naturally present in the atmosphere and is the main component of the fossil fuel, natural gas. The importance of methane ($CH_4$) is second only to carbon dioxide ($CO_2$) in terms of overall contribution to human-induced climate change. Whilst methane exists in a far lower atmospheric concentration than carbon dioxide, it is a particularly powerful greenhouse gas, deemed responsible for around 20% of post-industrial global warming.[1] The relative potency and short atmospheric lifetime of the gas make efforts to reduce methane emissions an attractive climate change policy option. A unit reduction of one tonne of methane is deemed equivalent to a reduction of 23 tonnes of carbon dioxide.[1] Because of the relative potencies, mitigating methane emissions is often more cost effective than mitigating carbon dioxide emissions and is therefore an ideal method of achieving international and government set targets at minimum cost to the economy. It can also buy time for the development of carbon dioxide mitigation technologies not sufficiently advanced at present to be cost-effective.

So far, methane has played a pivotal role in efforts to meet the UK's greenhouse gas emission reduction target under the Kyoto Protocol, accounting for 30% of the overall greenhouse gas reduction between 1990 and 2002. However, much of this decrease in methane emissions has been serendipitous, being a result of a decline in the UK coal industry and improved landfill cap technologies, rather than a result of targeted policy. In order to help mitigate climate change and be assured of meeting the Kyoto target and subsequent obligations, it is imperative that further methane emission reductions are both achieved and maintained in the long term. Identifying the most efficient way of reaching these goals, coupled with effective policies, must now be a priority. The question for policy makers is this – what is the easiest way of reducing our influence on the climate of our planet with minimal impact to individuals and minimum impact to the economy?

This report examines the major sources of methane in the UK, technologies for emissions abatement, current policies and future policy measures that could bring about lasting emissions reductions, with a particular focus on the potential for methane trading.

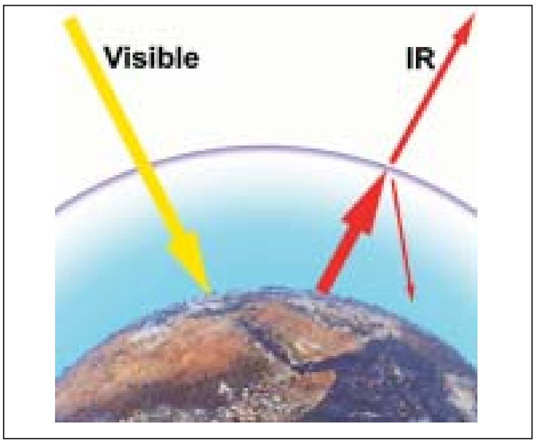



Figure 1 : Infra-red radiation is trapped within the earth's atmosphere by trace greenhouse gases

## 1.1 Climate change and the role of greenhouse gases

There is now widespread scientific consensus relating to the profound influence of human activity on the global climatic system, particularly through increased emissions of greenhouse gases in the post-industrial era. The effect on the global climate is already apparent and is likely to become more pronounced over the forthcoming decades.

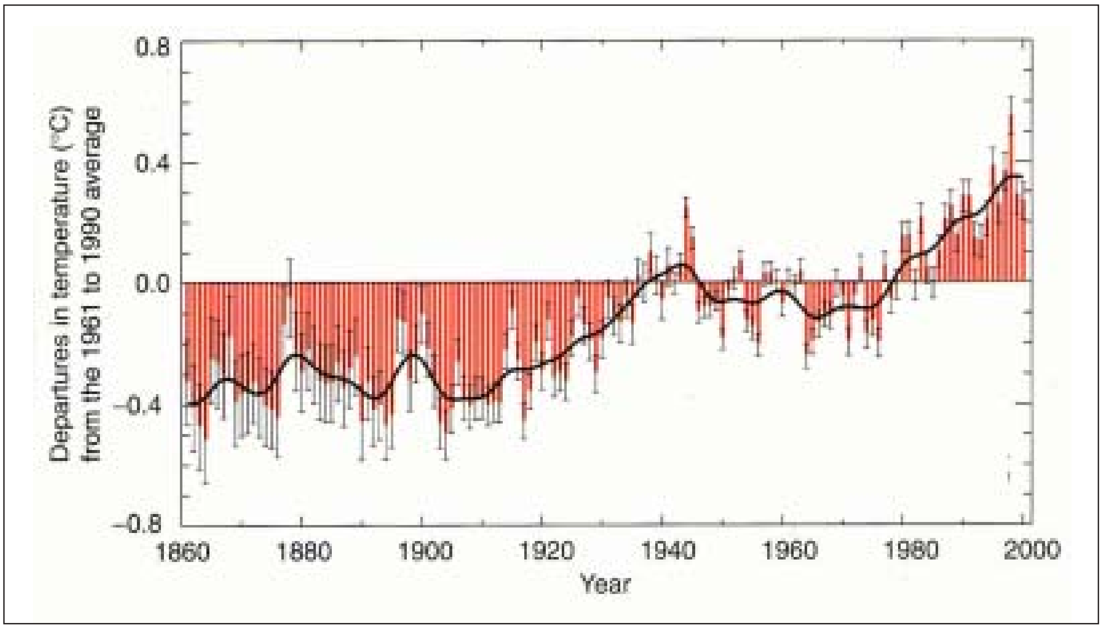
### What is the greenhouse effect?

The greenhouse effect is the term used to describe the warming mechanism provided by certain atmospheric gases. These are typically trace gases, known as greenhouse gases, which naturally make up about 1% of the atmosphere. Greenhouse gases are effective absorbers of infra-red radiation (heat), so the radiation emitted from the earth's surface cannot then escape into space (Figure 1). The net result is that the greenhouse gases trap energy inside the earth's atmosphere and maintain the earth's surface temperature at

Figure 2 Global average surface temperature since 1860

Note: Bars are annual average, solid line is decadal average

Source: IPCC, 2001[1]




approximately 30°C warmer than it would be were these trace gases not present. As such, the presence of greenhouse gases in the atmosphere is vital for our existence. Most notably, they maintain a moderate temperature where water can exist in liquid form – an important precondition for organic life.

### The changing global climate

Climate science is extremely complex and whilst our current understanding is incomplete, it is advancing as modelling and monitoring improve. The most accurate picture of our understanding of the planet's atmosphere has been achieved through a 'consensus' of current knowledge under the Intergovernmental Panel on Climate Change (IPCC). This is a body established by the World Meteorological Organisation and United Nations Environment Programme to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. It does not carry out its own research but collates information from peer-reviewed papers into a coherent whole. As such, the IPCC reports are seen as being as close to definitive as our current understanding allows. The IPPC's Second Assessment Report of 1995[2] was instrumental in the development of the Kyoto Protocol and the Third Assessment Report [1] was published in 2001.

It is now widely acknowledged that the delicate natural equilibrium is being thrown out of balance. The IPPC reports that during the last century, global average surface temperature has increased by over 0.6ºC[1]. This is likely to be the largest temperature increase of any century during the last 1000 years and the implications are becoming increasingly apparent. It is very likely that the warming during the 20th century has contributed significantly to the observed sea level rise of 10 to 20 cm, through thermal expansion of seawater and widespread loss of land ice. Since the 1950s, the extent of spring and summer ice cover in the Northern Hemisphere has decreased by 10-15% and, since the 1960s, land snow cover has reduced by around 10%. Global warming is also linked to marked changes in precipitation regimes. The intensity and frequency of droughts in some parts of Asia and Africa have increased, whilst elsewhere, areas have become wetter and heavy precipitation

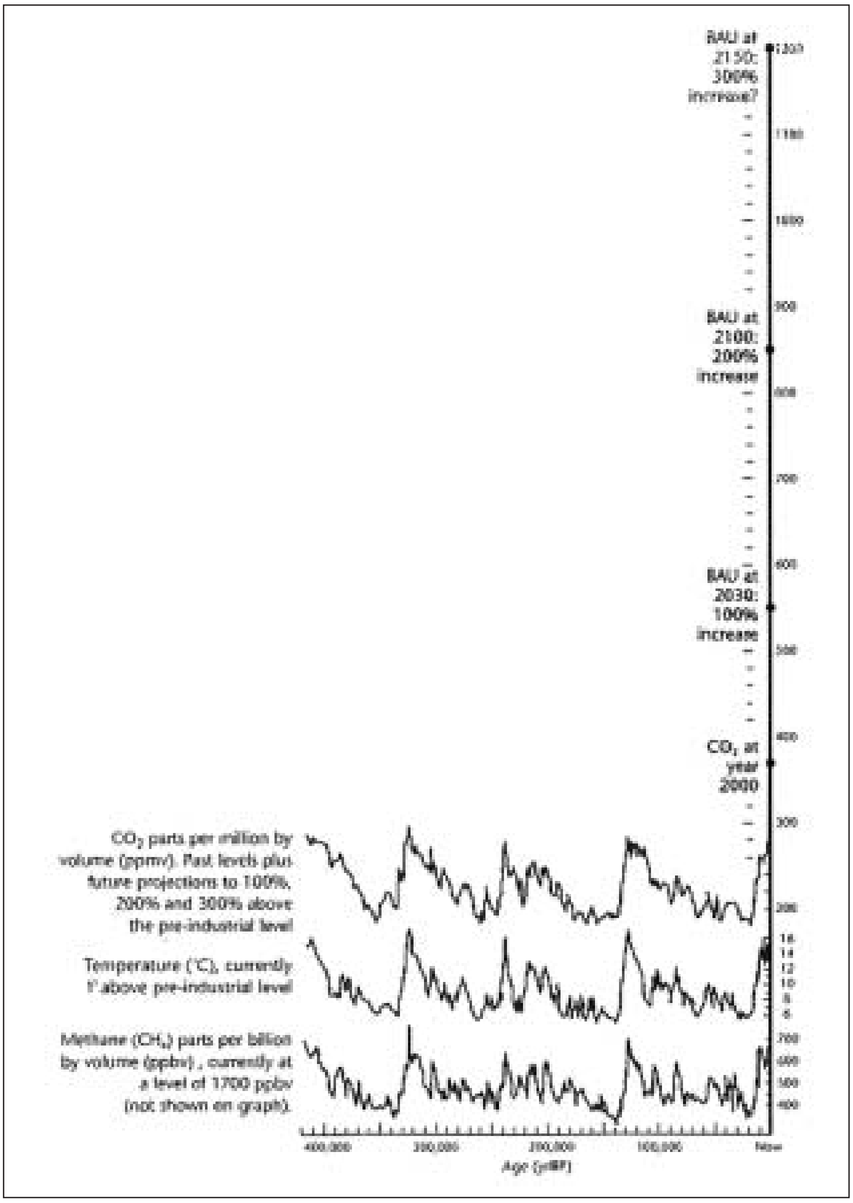



Figure 3 : Historical and projected atmospheric concentrations of carbon dioxide

Source: Global Commons Institute

events leading to flooding have become more commonplace.

The IPCC's Third Assessment Report[2] attributes 'most' of the observed warming over the last 50 years to human activity (anthropogenic emissions) and increased atmospheric concentrations of greenhouse gases (Figure 3), leading to an *enhanced greenhouse effect*.

Continued growth in greenhouse gas emissions is predicted to intensify climate change over the next century. In particular, global climate models predict that average surface temperature will increase by between 1.4 and 5.8°C between 1990 and 2100 based on a range of greenhouse gas emission scenarios. This is far in excess of the observed changes during the last century and consequently the knock-on effects for ice coverage, sea level rise and precipitation regimes are likely to be intensified.

## Global warming and climate change

Climate change is the variability in the earth's climate, which is increasing as a result of global warming. However, the relationship between global warming and the impacts of climate change is complex: we cannot say that, for example in terms of livelihood or economic impacts, a 4°C temperature rise will be twice as harmful as a 2°C temperature rise.

Some climate impacts are directly related to the extent of the *temperature rise*; ice cover will reduce and sea levels will rise as temperature increases. For other climate impacts it is the *rate of temperature rise* that is the critical factor; ecosystems are capable of adapting to temperature rises, but only over suitably long timescales. The different greenhouse gases have different potencies and lifetimes and so affect the *extent* and *rate* of global warming in different ways. Methane is a peculiar case, being potent in


*Flooding and flood management currently cost the UK around £2.2 billion per year* the short term yet short-lived, therefore predominantly affecting the *short-term rate of global warming*.

## 1.2 Why methane?

Anthropogenic emissions of greenhouse gases have caused substantial changes to our climate and will continue to do so over the course of the next century and beyond, if emissions are not stabilised, or preferably reduced.

The IPCC has identified a 'basket' of six greenhouse gases that contribute to anthropogenic climate change. These are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), the chlorofluorocarbons (CFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$).

The Kyoto Protocol (Section 1.3) is a multi-gas abatement strategy, allowing reductions to be made in any of the six major greenhouse gases. Such multi-gas strategies have been shown to be cheaper than a single gas strategy.[3,4] They are also politically less sensitive as they allow countries to choose their own pathway to an overall greenhouse gas (GHG) emission reduction, rather than having limits per gas imposed on them by an external body. This allows flexibility between different countries with different portfolios of GHG emissions. For example, countries with good renewable energy resources may wish to promote these resources and thereby reduce carbon dioxide emissions. Other countries may find it more effective to reduce methane emissions by altering waste management or agricultural practices.

### Potency

Such multi-gas abatement strategies require a measure of the relative potency of the different gases. The Global Warming Potential (GWP) is the most commonly used parameter for this. Several different definitions of the GWP exist – by far the most common is the 100 year GWP, which is used in all international and government policies including the Kyoto Protocol (Table 1).

Table 1: Global Warming Potentials of the 'basket' of six gases

| *Gas* | *Global Warming Potential (100-year)* | *Lifetime (years)* |
|---|---|---|
| $CO_2$ | 1 | 5-200 |
| $CH_4$ | 23 | 12 |
| $N_2O$ | 296 | 114 |
| HFCs | 12-12,000 | 0.3 - 260 |
| PFCs | 5,700-11,900 | 2,600-50,000 |
| $SF_6$ | 22,200 | 3,200 |

Source: IPCC 2001[1]

It can be seen that on a 100-year timescale, one tonne of methane is 23 times more potent than one tonne of carbon dioxide. This makes methane an attractive option for greenhouse gas emission reductions because smaller reductions are necessary to achieve the same environmental goal. Methane is currently emitted in enough volume to make any reductions significant in terms of the overall GHG picture. Methane can be readily captured from localised sources such as landfill and coal mines. Furthermore, methane is a flammable gas with a high energy content which, once captured, can be used as a fuel with the added economic benefits of heat or electricity generation.

### True potential

The Third Assessment Report provided revised GWP figures for a number of gases, notably increasing the relative potency of methane from 21, quoted in the Second Assessment Report, to 23. However, parties to the UNFCCC have agreed that the revised figures will not apply until the second commitment period (2013-2017). Therefore progress towards the original Kyoto targets set for 2008-2012 will continue to be calculated using GWP figures provided within the Second Assessment Report (*i.e.* a GWP of 21). Similarly, inventory submissions will continue to be based on old GWP figures throughout this period, according to the current reporting guidelines.[5]

For the remainder of this report, a GWP of 23 is used when referring to the current level of scientific understanding. However, a GWP of 21 is implied in all discussions relating to current policy concerned with emissions as reported under the UN Framework Convention on Climate Change guidelines (Section 1.3).

### Lifetime

It is also worth noting that methane has a comparatively short lifetime in the atmosphere of just 12 years, compared with up to 200 years for carbon dioxide. This means that reductions in emissions are rapidly turned into atmospheric concentration reductions. Gases with a longer lifetime reach higher atmospheric concentrations and experience a longer lag between emissions reductions and decreased atmospheric concentrations. Reducing emissions of short-lifetime potent gases such as methane is therefore a valuable means of rapidly slowing global temperature rise. This gives reduction of methane emissions a high economic value (perhaps even greater than reflected in the GWP of 23) as they are effective at slowing the rate of global warming. They are also likely to be even more important at some point in the future should the effects of climate change become critical and fast-acting measures need to be adopted.[6,7]

## 1.3 International policy context

The international community originally drew attention to the link between climate change and human activities at First World Climate Conference in 1979. Extensive scientific research, international debate and a series of intergovernmental conferences followed, culminating in 1992 with the production of the UN Framework Convention on Climate Change (UNFCCC).

### The UN Framework Convention on Climate Change

The UNFCCC entered into force in 1994. Currently 181 governments and the European Union are party to the Convention. Its 'ultimate objective' is to stabilise atmospheric concentrations of greenhouse gases at safe levels, although it does not assess what these levels are. The signatories are required to submit regular national communications, including information on strategies for mitigating and adapting to climate change along with detailed greenhouse gas emission inventories.

The atmospheric concentration of any greenhouse gas is determined by the balance between emissions from sources of the gas and removals by sinks. At present, emission rates exceed rates of removal and consequently atmospheric concentrations of greenhouse gases continue to rise. The IPCC report that in order to stabilise carbon dioxide emissions at 450, 650 or 1000 ppm, global anthropogenic emissions would need to drop below 1990 levels within a few decades, about a century, or about two centuries, respectively, and continue to decrease steadily thereafter.

Even if emissions are stabilised now, global average surface temperature is expected to continue to rise for centuries to come. However, by stabilising emissions as quickly as possible, the temperature increase could be reduced from several degrees per century to tenths of a degree. The lower the level at which emissions are stabilised, the smaller the increase in temperature expected. Furthermore, by acting on the more short-lived methane, the global temperature increase can be minimised more rapidly.

### The Kyoto Protocol

The ultimate goal of the UNFCCC is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". In 1997, the adoption of the Kyoto Protocol went one step further towards this

*Renewable energy currently accounts for around 3% of UK electricity generation*

goal, strengthening the commitments under the UNFCCC by providing legally binding emission reduction targets for developed countries (the so-called Annex I countries). Targets for individual countries were established through negotiation, although in total are equivalent to a 5.2% reduction from 1990 levels by the first commitment period of 2010 (defined as the average emissions for the period 2008-2012, to cope with anomalous years).

It is widely acknowledged that these 5.2% targets set by the Kyoto Protocol are not stringent enough to avert potentially catastrophic climate change, but they are a major step in the right direction. Crucially, it is envisaged that the Kyoto Protocol will entail further five-year commitment periods, with progressively stricter emission reduction targets. The second commitment period is scheduled for 2013-2017, with negotiations of targets beginning in 2005.

The Kyoto Protocol will finally become legally binding on 16 February 2005, following ratification of the treaty by Russia in November 2004.

### How will the Kyoto Protocol work?

To alleviate the adverse economic effects of comprehensive limits on greenhouse gas emissions, three flexibility mechanisms, also referred to as the Kyoto mechanisms, were included in the Kyoto Protocol: International Emissions Trading (IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM). The purpose of these mechanisms is to allow industrialised countries to meet their targets through trading emission allowances with each other and gaining credits for emission-curbing projects abroad.

The central strategy to curb greenhouse gas emissions is that of emissions trading through the IET. Emissions trading involves the trading of permits to emit greenhouse as if they were conventional commodities such as gold or oil. It allows emissions reductions to be achieved at minimal cost to the economy, by allowing over-emission from those who cannot meet targets cheaply to be offset by under-emission from those who can mitigate at low cost. Emissions trading, and the role that methane might play within such a scheme, is discussed in greater detail in Chapter 3. While implementation of the three flexibility mechanisms at international level will become possible only once the Kyoto Protocol comes into force, emissions trading of greenhouse gases has already begun at a domestic level in the UK and in other countries such as Denmark. The EU has already put in place an EU-wide trading scheme, due to start in 2005.

Joint Implementation and the Clean Development Mechanism are designed to provide flexibility for countries to meet part of their Kyoto targets by taking advantage of opportunities to reduce greenhouse gas emissions in other countries at lower cost than at home. These two mechanisms are project-based and allow the generation of credits when projects achieve emission reductions that are additional to that which would have occurred in the absence of the project. Joint Implementation refers to projects in countries that also have emission targets, whereas the Clean Development Mechanism refers to projects in developing countries with no targets. The rationale is that, for the global environment, where the emission reduction occurs is of secondary importance provided that real emission reductions are achieved. In order to promote participation by corporate investors, this should be allowed to occur where costs are lowest.

### Addressing climate change in the UK

The UK was amongst the first nations to ratify the Kyoto Protocol. Under burden sharing agreements within the EU, the UK has committed to an emissions reduction target of 12.5%, relative to a 1990 baseline, on the 'basket' of six greenhouse gases by 2008-2012. This target can be met through reductions in all or any of the basket of six gases, allowing flexibility in the choice of policy options, and is calculated in $CO_2$ equivalent terms.

The Energy White Paper, published in February 2003, has positioned the UK at the forefront of international efforts to tackle climate change, with an ambitious target of a 60% reduction in carbon dioxide emissions by 2050.[8] The UK Government is working to encourage the international community to adopt similar targets with the launch of its International Energy Strategy in October 2004.[9]

## 1.4 UK policy context

There are certain UK policies which have played a role in encouraging methane emissions reductions, either directly or indirectly.

### Renewables targets

Under the EU Renewables Directive, which came into force in October 2001, the UK has adopted a target of 10% of UK electricity consumption by 2010 to come from renewable sources. In previous years wastes have been included with renewables, but from 2004, the international definition of total renewables has been adopted which excludes non-biodegradable wastes.[10]

### Renewables Obligation

The Renewables Obligation, introduced in April 2002, is the key policy measure to help achieve the UK's renewable energy targets and will remain in place until 2027, with yearly targets set up until 2011. It requires all licensed electricity suppliers in England and Wales to supply a specific proportion of their electricity from renewables, evidenced via a system of Renewables Obligation Certificates (ROCs).

ROCs are issued to accredited generators and may be traded separately from the electricity to which they relate, allowing suppliers who have failed to reach the target to purchase certificates from those suppliers that have surpassed their Obligation requirements. Renewable technologies eligible for ROCs include wind, landfill gas and incineration of biomass, amongst others. Incineration and co-firing of mixed waste are excluded. ROCs are one of the key economic drivers in the UK for encouraging investment in methane mitigation.

### Climate Change Levy

The Climate Change Levy (CCL) was introduced in April 2001 as a tax on electricity supplied to non-domestic customers in the UK. Intensive users of energy are able to join Climate Change Levy Agreements, helping to mitigate the effects of this tax. Under these agreements, businesses that accept and subsequently meet energy reduction targets will receive an 80% levy discount until the year 2013. Electricity from qualifying renewable sources, such as solar and wind power, is exempt from the Levy and eligible for Levy Exemption Certificates (LECs). Electricity from some energy from waste schemes is not exempt.

## 1.5 Role of methane emissions reductions

The importance of methane in meeting the UK's Kyoto target cannot be understated. So far, methane emissions have fallen by 43% between 1990 and 2002 (Section 4.5), equivalent to 30% of the UK's total greenhouse gas emission reductions. The proportional contribution of methane to total emission reductions is expected to increase, with UK Government baseline projections aimed at halving methane emissions by 2020. [11]

Emphasis on methane emission reduction could pave the way for commercial opportunities and enhanced competitiveness, with increased efficiency and technological developments in methane mitigation, capture and utilization forming an integral component of a lower carbon economy. Methane emission reduction is also particularly apposite to improved safety, owing to the flammable and explosive nature of the gas. Furthermore, the high energy content of methane makes its combustion for energy recovery highly desirable. Utilisation of methane to generate electricity or heat, producing the less potent carbon dioxide, can offset emissions from more carbon-intensive coal or oil powered generators.

On a global basis, the benefits of methane emission reductions in terms of climate change abatement may be even more profound. The short lifetime and relative potency of methane in the atmosphere mean that the benefits of emission reductions are quickly apparent. Investment in methane abatement technologies would buy time for the development of cheaper carbon dioxide mitigation technologies, especially new renewable energy technologies. Large cuts in methane emissions could potentially avert or delay climate change in the short term, providing the much needed time for carbon dioxide mitigation policies to be implemented and their effects observed in the atmosphere.