



Electricity Generation and Greenhouse Gas Emissions

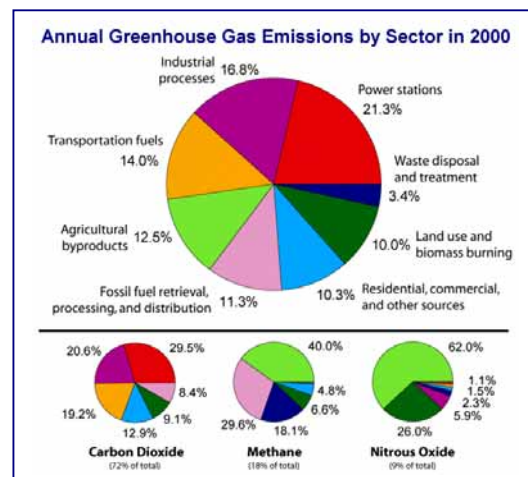
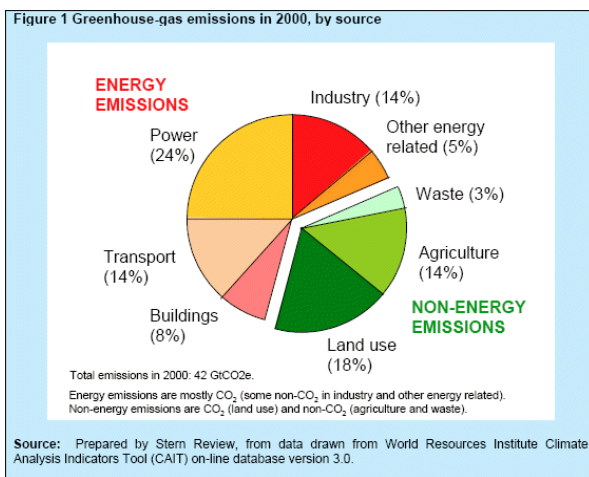
The vision of the Comino Foundation (Comino) is that people in Britain should live more fulfilled lives within a prosperous and responsible society. This vision will only be achieved by if global warming is contained and does not exceed a 2⁰ rise. This paper sets out the impact of electricity generation on global warming, some thoughts on mitigation and responds to the UK Government White Paper 'Meeting the Energy Challenge'⁴.

There is widespread agreement amongst the scientific community as to the scale and nature of climate change. International scientific reports¹⁻² detail the potential extent of global warming, the impact on the people of the world over the next 100 years and the cost of stabilisation. The considerable, and accelerating, increase of greenhouse gases since the start of the Industrial Revolution, as caused by human activity, is widely accepted as the major cause. Scientists agree that it should be possible, given progressive technology advances and political support, to reduce emissions, stabilise the level of CO₂ in the atmosphere and restrict global warming to a 2⁰ rise.

Electricity generation – a hidden opportunity

The Stern Review³, the recent 4th Assessment Report of the International Panel on Climate Change (IPCC) and other international reports set out the sources of greenhouse gases. These comprehensive reports, however, fail to emphasise that the technology exists for every nation to eliminate at least 90% of the most prolific source of greenhouse gas emissions by 2040.

A significant proportion of greenhouse gases originate from power stations but published diagrams disguise the fact that the proportion from electricity generation, as a whole, is much higher. 90% of emissions from Buildings and the majority of emissions from Industry originate from the use of electricity. About 40% of worldwide greenhouse gas emissions (CO₂) come from electricity that is generated using fossil fuels, e.g. coal.



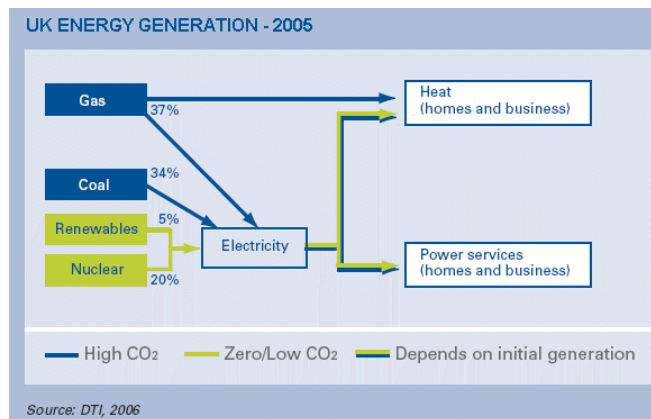
The reports also fail to observe that the sources of greenhouse gases fall into two broad groups. Emissions from the generation of electricity from fossil fuels originate from a finite number of known power stations, whilst emissions from all other sources originate from an almost infinite number of diverse sources, e.g. vehicles, industrial plants, waste sites, etc.

Reduction in emissions from sources other than electricity plants will depend on the development of technology, e.g. energy sources for transport, and the action taken by governments to stimulate change. Progress to reduce emissions in these areas is likely to be slow and will be difficult to control. In contrast, the technology already exists to enable electricity to be generated on a zero, or low carbon, basis across the world. Concerted action by all nations to secure electricity generation from power plants with zero or low carbon emissions could reduce greenhouse gas emissions by 40% well before 2050 and ensure that the 60% overall reduction by this date, as seen as essential by the IPCC, is met. It would also address increased emissions from additional energy generation.

International organisations such as the IPCC, the United Nations (UN) and the European Union (EU) are moving towards working together to reduce greenhouse gas emissions. Progress would be substantial if all nations could agree to move towards zero, or low carbon, electricity generation in the immediate future with all electricity being generated in this way before, and after, 2040.

The UK as potential leader in carbon emissions reduction

The UK is in the position where it has the knowledge, technology, geological infrastructure, commercial interest and a fleet of aging power stations to lead the world with this important initiative. It has the potential to near eliminate carbon emissions from electricity generation in the UK by 2025. If this can be achieved it will stimulate similar action by other industrialised nations. The White Paper⁴ is positive in indicating that the UK Government is seeking to provide international leadership in some areas of energy policy.



In the UK approximately 20% of electricity is generated, currently, from nuclear power plants, compared with 16% across the world. Technology has enabled nuclear waste to be reduced by 90% and construction to be simplified with shorter build times⁷.

The White Paper⁴ indicates that the UK Government proposes that its aging nuclear power plants should be progressively replaced with new nuclear plants. The intention is to maintain, or increase, the current 20% of total UK electricity generated from nuclear plants. On an international basis there are extensive plans to increase the number of nuclear power stations although there are concerns about the international management of certain aspects of nuclear power generation.

A small, but increasing amount of electricity in the UK is generated from renewable sources, mainly hydro and wind. The UK, and particularly Scotland, is one of the windiest places in Europe. Given developments in technology, current commercial activity and current Government targets and support for renewable energy as set out in the White Paper⁴ it is possible that 20% of UK power generation will come from renewable sources by 2020⁷. Other parts of the world are developing electricity from other renewable sources, e.g. solar power. Electricity generation from renewable sources will increase worldwide, progressively.

The majority of electricity generated in the world and in the UK uses fossil fuels, i.e. coal and gas in the UK and oil. World reserves of coal are extensive but reserves of gas are now limited with political sensitivity on the security of gas supply due to their location. Maintaining or increasing the 35% of electricity that is generated from coal in the UK whilst reducing that generated from gas is the best option to maintain security of power supply. The White Paper⁴ supports this view. Coal is used extensively, and on an increasing scale, to generate electricity by industrialised nations, e.g. the US and China.

The low carbon fossil fuels option

Although there has been limited action to date to reduce emissions of CO₂ from fossil fuels used for electricity generation the technology has existed for over 20 years to capture and store CO₂ underground. This is demonstrated by the successful storage of CO₂ in depleted oil fields in the US to give enhanced oil recovery (EOR).

There has been extensive research⁵ into the potential for carbon capture and storage (CCS). CO₂ can be stored underground in a variety of ways, in particular in saline aquifers. Initial scientific estimates show that there is the potential to store current world emissions of CO₂ underground for at least three centuries.

In recent years this technology has been applied in the US to coal fuelled power generation with several 'clean coal' power plants with carbon capture and storage⁶ being built. More are planned. What is known as 'clean coal' power generation technology⁵ is developing. 'Clean coal' power plants are more expensive than conventional designs but costs will reduce. In the EU, however, there are no 'clean coal' plants but there are plans to have 12 demonstration plants with CCS in place by 2015. Given the extensive use of coal to generate electricity, both now and in the future, there is a clear case for ensuring that 'clean coal' technology is developed and fully tested as a matter of urgency, so that international deployment can follow as soon as it is commercially and technically possible. The White Paper⁴ states that the UK Government will ensure that a CCS demonstration plant is in place in the UK by 2014. It has been announced that this will be a coal fired power station with post combustion carbon capture. New pre combustion technology is, therefore, excluded. This decision has been taken to demonstrate that it is possible to apply CCS to existing coal fired stations.

In the East of the UK, and Scotland, at least 9 'clean coal' power plants are planned with over 10,000 MW generating power by 6 companies in the power industry. A few of these will be IGCC plants which will capture and store CO₂ in the North Sea's depleted gas/ oil fields. Others will use a super critical burn process, which reduces emissions by 22% with the ability to go fully carbon capture and storage at a later date.

All these companies are concerned that the current European Union Emission Trading Scheme (ETS) is revised to make investment in 'clean coal' power plant attractive and viable. Some Government subsidy is being sought to help initiate the move to 'clean coal' power generation, which is offered, to a limited extent, in the White Paper⁴. The level of commercial activity to initiate investment in 'clean coal' power plants in the UK demonstrates that the power industry has recognised the potential to replace existing coal power plants with high carbon emissions.

The White Paper states that 2030 is the target date for conversion to carbon capture and storage on a commercial basis but given the age of existing plants and the degree of commercial interest a much earlier date, say 2020, could be feasible. This would reduce carbon emissions in the UK by approximately 20% and demonstrate world leadership in the use of carbon capture and storage for coal fired electricity generation.

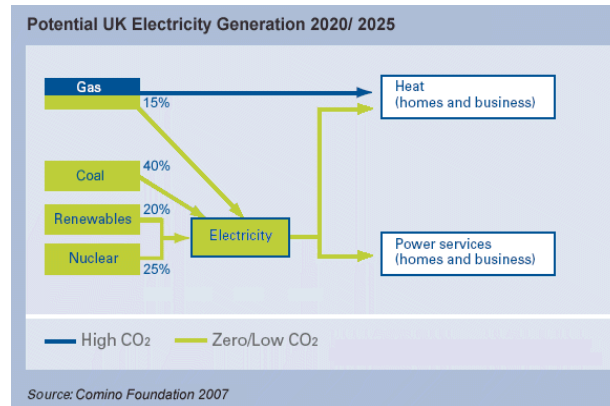
There are, however, two major issues to overcome to enable this to be achieved in the UK and, probably, in other parts of the world.

To provide the financial incentive for the private sector to build 'clean coal' power plants without Government subsidy it is essential that the structure of the ETS, and the resultant carbon price, must generate the additional income needed by power companies to justify investment in the current, higher capital cost of these plants. The White Paper⁴ recognises the importance of a robust ETS structure to stimulate investment in power plants with CCS and the UK Government is seeking to ensure, currently, that CCS technology is included in the 2008 – 2012 ETS period and is firmly established within the scheme, thereafter. It is a clear priority that this scheme should meet the needs of the power generating companies both in the UK and other European nations. In particular new IGCC plants must be given the same allocation of CO₂ allowances as existing coal plant not, as at present, the allowances for a gas fired power station. A scheme that is successful in attracting substantial investment in power plants using CCS in the EU will serve as a model for carbon trading schemes in other parts of the world.

The White Paper⁴ points out that the UK can use its depleted, but still active, off-shore gas and oil fields to demonstrate carbon capture and storage technology. However, the infrastructure, both physical and commercial, to transport and store the CO₂ in the North Sea has yet to be established. It is unlikely that revisions to the ETS in the near future will provide any support towards covering the cost of this infrastructure. The White Paper⁴ and recent announcements by Ministers are silent on who will pay for the necessary pipeline infrastructure to store the CO₂ in the North Sea which is clearly the best option.

The companies developing 'clean coal' power plants consider that the Government and the oil companies should provide some financial support because the CO₂ provided by 'clean coal' power plants can be used to increase oilfield output by 20%. This will prolong their life, increase income to the oil companies, increase tax revenue and delay de-commissioning costs.

The cost of a pipeline infrastructure to transport and store the CO₂ will vary dependent on the storage location. £1.5bn is an estimate for an initial, limited network to transport and store the CO₂ in the North Sea⁷. It is clearly important that all parties involved conclude current negotiations to address and solve this issue, in conjunction with robust revision of the ETS, as a matter of urgency to ensure that further CCS generating plants can be developed after 2012. The White Paper⁴ does not mention the possibility of any grant support from the EU for CCS infrastructure.



If these two issues can be solved in the near future, the technology and commercial infrastructure will be in place to provide the opportunity for UK electricity generation to be near emission free by 2020/ 2025.

The above illustration shows the contribution from nuclear, 'clean coal' and gas which is a possible outcome for the UK, as set out in the White Paper⁴. The exact outcome will depend on the commercial, fiscal and political considerations that emerge over time. This will be the same in other nations.

The UK Government has set a target for 15% of electricity to be generated from renewable sources by 2015 and 20% by 2020 with total financial support of £38bn. This is confirmed in the White Paper⁴ which also states that the UK Government is committed to meeting the EU target of saving 20% of the EU's energy consumption by 2020, and of reducing greenhouse gas emissions by 20% by this date. The UK Government has been asked to provide detailed proposals for discussion and agreement with the European Commission on the UK's targets for greenhouse gas reduction. Given the commitment to a low carbon electricity generating policy as set out in the White Paper⁴ it is clear that the UK could, and should, set more ambitious targets for greenhouse gas reductions by 2020, 2025 and 2030. This will provide strong leadership within the EU and worldwide. Such targets could be set out in the White Paper⁴ with stated support for a UK CO₂ transport and storage grid. This might cost £8bn. This financial support would reduce 95% of greenhouse gases, at a cheaper electricity price, from 40% of UK electricity generation. It should be noted that £38bn is being spent by the UK Government on renewable electricity generation which only addresses 20% of the UK's demand.

Since electricity generation is such an important aspect of greenhouse gas emissions it is clear that separate targets and outcomes should be stated in the UK and the EU. Outside the EU it would be helpful if international organisations associated with climate change publish the emissions from electricity generation for each nation.

The European Council has agreed that Europe should aim for all new fossil power generation built beyond 2020 be equipped with CCS. The White Paper could indicate that the UK will seek to ensure that all new fossil power plants will be equipped with CCS at a much earlier date. In practice current planning consent requires that such plants will be able to be converted to CCS.

If the UK Government of the day takes the lead in creating the commercial and fiscal arrangements to ensure zero, or low carbon, electricity generation in the near future there should be significant benefits:

1. The UK will be seen to lead the world in demonstrating how an industrial nation can near eliminate carbon emissions from electricity generation in the short term;
2. This lead by the UK should stimulate the EC, other international organisations and progressively other nations, to set, and achieve, targets to near eliminate emissions from electricity generation by 2040;
3. If the UK supports 'clean coal' and CCS in the near future, the UK will accumulate significant expertise in these technologies and in the associated commercial arrangements. Many nations in the world will rely on coal for electricity generation well into the future. The UK can provide appropriate technical support to these nations;
4. As the need for consumers to reduce the need for electricity becomes less important in the UK the focus will progressively switch to accelerating the reduction of greenhouse gas emissions from other sources, e.g. transport, industrial processes, waste and agriculture;
5. Targets for, and progress towards, near elimination of greenhouse gas emissions from electricity generation will be popular with voters of all ages. Such Government targets will demonstrate that the most important aspect of global warming is being addressed whilst consumer needs to use electricity are protected. It will be a popular political policy in other nations and is, therefore, a policy that can be promoted by international organisations;
6. Electricity generation with low greenhouse gas emissions will stimulate increased use of electricity for public and private transport. This will help address the reduction of carbon emissions from the difficult area of transport.
7. A by-product of power plants using 'clean coal' technology is hydrogen. Significant volumes of hydrogen could be produced from 'clean coal' power plants to initiate the development of an 'automotive hydrogen infrastructure' for vehicle transport in the UK.

Summary of Comino's response to the White Paper

The Comino Foundation see the UK Government's White Paper 'Meeting the Energy Challenge' as a positive step in the right direction in addressing the issue of global warming, subject to the following points:

- ◆ Electricity generation is by far the largest contributor to greenhouse gas emissions. The White Paper⁴ could be more explicit on this point and stress the opportunity to make substantial reductions in greenhouse gas emission by moving rapidly to zero - or low - carbon electricity generation.
- ◆ The structure of the EU ETS, the UK Phase II National Allocation Plan (2008 – 2012) and the subsequent UK Phase III National Allocation Plan are crucial in establishing the competitive commercial framework which will provide the incentive for power generating companies to build new power plants with CCS. Although recognising this issue, the White Paper⁴ could give stronger UK Government commitment to ensuring that a truly competitive ETS framework is established.
- ◆ Currently the EU ETS does not include CCS, specifically. The White Paper⁴ could give stronger commitment to ensuring CCS is included in Phase II, and subsequently, and that the correct CO₂ allowances are given to coal fired CCS power generators.
- ◆ A successful EU ETS has the potential to establish a model for other parts of the world. The White Paper⁴ could point out the potential international importance of the EU ETS being seen to create successful competitive commercial conditions and the importance of electricity generation within that scheme.
- ◆ The White Paper⁴ sets out the framework for a 'competition' to develop a CCS demonstration electricity generating plant power. However it is not clear how a pipeline infrastructure will be put in place to transport and store the CO₂. The White Paper⁴ should have been more explicit on this issue.
- ◆ The White Paper⁴ indicates that discussions are taking place regarding a legislative requirement that future fossil fuel power stations should be equipped with CCS. The White Paper⁴ could point out that it is intended that this will be part of the planning consent process in the near future.
- ◆ Replacement of the existing nuclear power plants with new nuclear power plants is important to reducing greenhouse gas emissions and in preserving a balanced and secure energy policy. This should be an element of the energy policy.
- ◆ The White Paper⁴ makes extensive reference to EU targets for reducing greenhouse gases and in stating that the UK is committed to achieving these EU targets. However, the White Paper⁴ could, and should, be more explicit, and ambitious, in setting UK targets for reductions in greenhouse gas emissions from fossil fuel power plants which will enable more ambitious, overall reductions to be achieved.

The Comino Foundation urges the Government of the day to emphasise the crucial importance of moving to zero - or low - carbon electricity generation as quickly as possible with extensive use of 'clean coal' technology. The Government of the day should also ensure that the short term policies, as set out in the White Paper⁴ regarding CCS, are achieved and that the target dates for significantly reducing greenhouse gas emissions from electricity generation are brought forward.

The views in this paper are derived from numerous published scientific views and reports. In particular from the following:

- ¹ Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the **Intergovernmental Panel on Climate Change (IPCC)** in 1988. It is open to all members of the United Nations and WMO.

The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature.

A main activity of the IPCC is to provide in regular intervals an assessment of the state of knowledge on climate change. The IPCC also prepares Special Reports and Technical Papers on topics where independent scientific information and advice is deemed necessary and it supports the UN Framework Convention on Climate Change (UNFCCC) through its work on methodologies for National Greenhouse Gas Inventories.

Reports on climate change are available from <http://www.ipcc.ch/>

- ² **The Royal Society**, the national academy of science of the UK and the Commonwealth, is at the cutting edge of scientific progress. It supports many top young scientists, engineers and technologists. It influences science policy, it debates scientific issues with the public and much more. It is an independent, charitable body which derives its authoritative status from its 1400 Fellows and Foreign Members.

A strategic priority is to influence policy making with the best scientific advice through its International Science Policy Centre where one theme is climate change, environment and energy.

Policy, reviews and reports on climate change are available from <http://www.royalsoc.ac.uk>

- ³ The Chancellor of the Exchequer asked Sir Nick Stern to lead a major review on the economics of climate change to understand more comprehensively the nature of the economic challenges and how they can be met, in the UK and globally. **The Stern Review on the Economics of Climate Change** was published 30th October 2006

The Review is available from:

http://www.hm-treasury.gov.uk/independent_reviews/independent_reviews_index.cfm

- ⁴ **The UK Government White Paper 'Meeting the Energy Challenge'** as published 24th May 2007 is available from: <http://www.dti.gov.uk/energy/whitepaper/page39534.html>

- ⁵ The **International Energy Agency** (IEA) acts as energy policy advisor to 26 Member countries in their effort to ensure reliable, affordable and clean energy for their citizens.

The IEA Clean Coal Centre (IEA CCC) provides unbiased information on the sustainable use of coal worldwide. Funded by member countries and industrial sponsors IEA CCC produces in-depth topical reports and online databases of coal information. IEA CCC also provides direct advice, facilitation of R & D and networks

Information on Clean Coal power generation technology is available from <http://www.iea-coal.org.uk>

- ⁶ **The Carbon Capture & Storage Association** (CCSA) exists to represent the interests of its members in the business of capture and geological storage of carbon dioxide (known as Carbon Capture and Storage, or CCS). This being one way of abating atmospheric emissions of carbon dioxide and, potentially, a means of enhancing the production of fossil hydrocarbons. From its base in London the Carbon Capture & Storage Association brings together specialist companies in manufacturing & processing, power generation, engineering & contracting, oil, gas & minerals as well as a wide range of support services to the energy sector such as law, banking, consultancy and project management. The Association is a model for sectoral cooperation in business development and government welcomes its existence.

Information on carbon capture and storage is available from <http://www.ccsassociation.org.uk>

- ⁷ **The Parliamentary and Scientific Committee** is a primary focus for scientific and technological issues and provides a long-term liaison between UK Parliamentarians and scientific bodies, science-based industry and the academic world. The main aim is to focus on those issues where science and politics meet, so that Members of both Houses of Parliament in the UK can be informed of the relevance of scientific and technological developments to matters of public interest and to the development of policy.

Information on the presentations given to the meeting on 15th March 2007 which considered innovative scientific and engineering solutions for the management of climate change is available at http://www.vmine.net/scienceinparliament/nsew_ppt.asp

Anthony Darbyshire MA (Oxon), FRSA,
Environment Fellow,
The Comino Foundation,
+44 (0) 1777 711141
anthony.darbyshire@cominofoundation.org.uk

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.