FORATOM
for nuclear energy in europe

Nuclear Energy and Greenhouse Gas Emissions Avoidance in the EU

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1. Introduction

Climate change, resulting from increases in greenhouse gas emissions (GHG), is considered one of the biggest environmental dangers facing the world today. Reducing atmospheric GHG concentrations have become an international priority as evidenced by the signing of the Kyoto Protocol.

Electricity is a clean energy carrier, but to a large extent coal, oil and gas are burned to produce it. In the future, the emphasis in the power generation sector will have to be on cleaner production methods, such as wind, solar, biomass, hydro and nuclear. This change in emphasis will be needed to meet future electricity demand in a way that is low on GHG emissions and compatible with sustainable development objectives.

Nuclear power is the single most significant means of limiting the increase in GHG concentrations in the power generation sector, while enabling access to abundant electricity at a stable and low cost.

2. Life Cycle GHG Emissions

Nuclear power, unlike fossil fuel, does not generate GHG directly. For nuclear power and renewable fuels, there are no GHG emissions at the point of generation, but there are releases during the mining and processing of the fuel, construction of the plant, disposal of spent fuel and by-products, and waste management and decommissioning (see Section 3). The emissions from these stages depend, among other factors, on the national mix of electric power production. For example, the GHG emissions from a nuclear fuel cycle are due to the fossil fuel-based energy and electricity needed to mine and process fuel and for the construction and materials of fuel cycle facilities.

The total GHG emissions from electricity production chains vary widely due to the plant characteristics (i.e. type, capacity factor, efficiency, and lifetime) and geographical sitting of the power plant. Recently published studies (see Appendix I) by International Atomic Energy Agency (IAEA), the World Energy Council (WEC) and the OECD's International Energy Agency (IEA) estimate that on a life cycle basis the emissions intensity of nuclear power is between 2 and 59 tonnes (expressed as tonnes of CO_2-equivalent) per GWh of electricity produced (t CO_2eq/GWh).

For example, according to a study by the International Atomic Energy Agency (IAEA) in 2000 [1], nuclear energy GHG emissions from the full energy chain (see Appendix I) amount to only about 9-21 tonnes of GHG (expressed as tonnes of CO_2-equivalent) per GWh of electricity produced (t CO_2eq/GWh), compared to some 385 to 1343 t CO_2eq/GWh for fossil fuel chains and 9-279 t CO_2eq/GWh for renewable energy chains.

3. Factors Influencing GHG Emission Rates from Nuclear Power (light-water reactor) [1]:

* Energy use for fuel extraction, conversion, enrichment and construction / decommissioning (plus materials);
* Fuel enrichment by gas diffusion, which is an energy intensive process that can increase GHG releases by an order of magnitude when compared to enrichment by centrifuge;
* Emissions from the enrichment step, which are highly country-specific since they depend on the local fuel mix; and
* Fuel reprocessing (uranium oxide or mixed oxide), which can account for 10% to 15% of the total nuclear GHG burden.

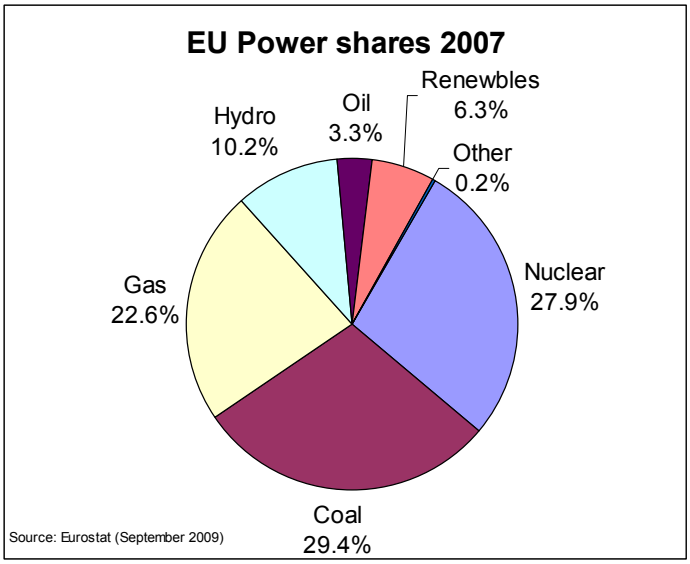
4. Updated Calculation for Annual Avoidance

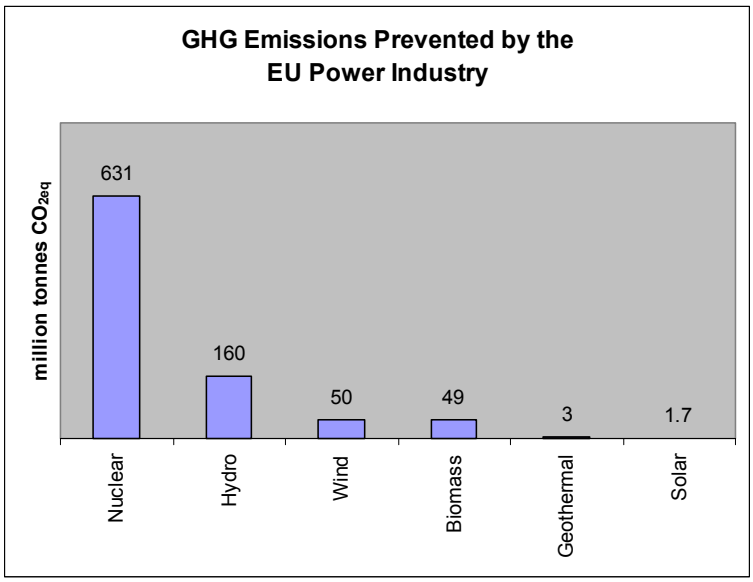
A calculation has been carried out by FORATOM using the range of total GHG emissions from fossil fuel electricity production chains calculated by the IAEA [1], the IEA [2] and WEC [3] and the latest available electricity generation figures from Eurostat [4].

The following values have been used to estimate CO_{2eq} emissions from the use of fossil fuels for electricity generation. The figures used are at the middle-to-lower end of the range (see Appendix I).

Coal:	960 (g/kWh or tonnes/GWh)
Oil:	720 (g/kWh or tonnes/GWh)
Gas:	480 (g/kWh or tonnes/GWh)

We can assume, in a hypothetical scenario, in which the EU's 146 nuclear reactors are removed from the current (2007) energy mix and the individual contributions from all other sources are increased by the same factor (1.45), with the exception of hydropower, to make up for the loss of production and to reach a total generation figure of 3,361,694 GWh. It is assumed that it is unlikely that there could be a significant increase in hydropower capacity in the EU. Two further assumptions are made: zero emissions from other non-fossil sources, such as renewables and nuclear; and no weighting in favour of gas and wind to take into account of a possible increase greater than the factor given above.





Source: Emissions avoided in 2007 calculated using fossil fuel-emission rates from the IEA, IAEA and WEC and plant generation data from Eurostat.

The outcome is a rise in total CO_{2eq} emissions from 1,405 million tonnes to 2,037 million tonnes, the difference being just over 631 million tonnes CO_{2eq}. GHG emissions from electricity generation would rise by 44.92% if there was no nuclear contribution.

To put the figure of 631 million tonnes into perspective, it can be pointed out that the annual amount of CO_{2eq} avoided by nuclear is equivalent to nearly all the CO_{2eq} emissions from all sectors in the United Kingdom in 2007 (636.6 million tonnes).

The overall Kyoto GHG emission reduction target of the EU is approximately 446 million tonnes CO_{2eq}.

5. Conclusion

Nuclear energy makes a significant contribution to the lowering of carbon emissions from the energy sector in the EU and worldwide. The current use of nuclear energy (accounting for about 15% of the world's electricity generation) avoids the emission of about 2.1 billion tonnes of CO_{2eq} every year. In the EU as whole, the avoidance levels amount to 631 million tonnes of CO_{2eq} per year, taking into account the current (2007) energy mix. By comparison, the EU has a GHG emission reduction target of 446 million tonnes of CO_{2eq} below 1990 level by 2008-2012. Switching to less carbon intensive or low carbon fuels such as gas, nuclear and renewables will play a major role in reducing emissions.

Appendix I: Range of Total GHG Emissions (t CO_2eq/GWh) from Electricity Production Chains

Energy/Technology	IEA 2000 [2]	IAEA 2000 [3]	WEC 2004 [4]
Lignite	790-1182	837-1464	1062-1372
Coal		756-1310	757-1085
Oil	n/a	547-903	657-866
Natural Gas	389-511	385-690	398-499
Solar PV	13-731	30-280	13-104
Hydroelectric	2-48	4-237	4-120
Biomass	15-101	31-61	15-49
Wind	7-124	9-48	7-15
Nuclear	2-59	9-21	3-20

Appendix II: World Figures

Based on the same hypothetical scenario in Section 4, in which the world's 437 nuclear reactors are removed from the current (2006) energy mix [5], the outcome is a rise in total CO_{2eq} emissions from 10,118 million tonnes to 12,276 million tonnes, the difference being just over 2.1 billion tonnes CO_{2eq}. GHG emissions from electricity generation would rise by 21.32% if there was no nuclear contribution.

To put the figure of 2.1 billion tonnes into perspective, the UNFCCC estimates that the Kyoto Protocol's Clean Development Mechanism (CDM) will generate 1.2 billion tonnes of emission reductions by the end of 2012. The overall Kyoto GHG emission reduction target of Parties bound by the Kyoto Protocol is approximately 549 million tonnes CO_{2eq}.

References

[1] Spadaro, J.V., Langlois, L. and Hamilton, B., *Greenhouse Gas Emissions of Electricity Chains: Assessing the Difference*, IAEA Bulletin, 42/2/2000, Vienna, Austria, 2000.

[2] Frans H. Koch, *Hydropower-Internalised Costs and Externalised Benefits*, International Energy Agency (IEA)-Implementing Agreement for Hydropower Technologies and Programmes, Ottawa, Canada, 2000.

[3] *Comparison of Energy Systems Using Life Cycle Assessment*, A Special Report of the World Energy Council, London, United Kingdom, 2004.

[4] The Statistical Office of the European Communities (Eurostat) (2009). (http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/)

[5] OECD International Energy Agency (IEA) Energy Statistics. Electricity/Heat Data for World (2009). (http://www.iea.org/Textbase/stats/index.asp).