British Energy

Environmental Product Declaration of Electricity from Torness Nuclear Power Station

Summary of Results

A study for
British Energy
undertaken by

AEA TECHNOLOGY
ENVIRONMENT

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Summary of Results

AEA Technology has been commissioned by British Energy to develop an Environmental Product Declaration (EPD) for electricity from its nuclear power plant at Torness. This document provides a summary of the key findings from the study. The nuclear power plant comprises two Advanced Gas Cooled Reactors (AGRs) with a combined net power output of 1250MW electricity.

EPD concept

EPDs have been developed as a vehicle for industry in the communication of environmental impacts of products to professional procurers. Based upon the principles of Life Cycle Analysis, EPDs describe the environmental impacts of a product from 'cradle-to-grave'. This EPD has been developed in accordance with requirements for undertaking EPDs in the electricity sector (PSR2004:2)[1], which describes the scope and goal of the underlying LCA for the EPD according to ISO14020 and 14040. The environmental parameters captured in the EPD for Torness are described in Table 1.

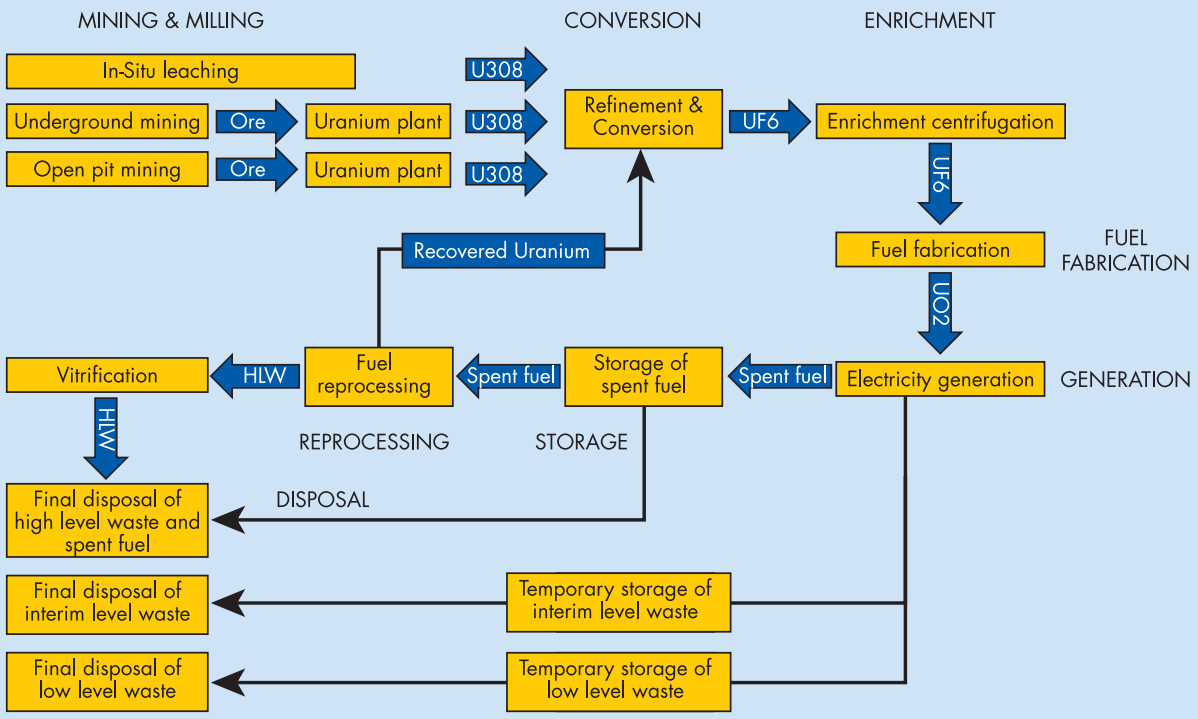
Table 1. Overview of the environmental parameters captured by the Torness EPD

Input parameters	Output parameters	Risk related issues
Extracted resources	***Impact***	***Impact***
• Non-renewable resources • Renewable resources • Water Use	• Air Emission • Water Emissions	• Radiology • Biodiversity • Safety and Security
Recycled resources	***Additional inventory data***	
• Recycled resources	• Hazardous waste • Nuclear waste • Other waste • Area of land use • Outputs subject to recycling	

In the case of Torness, the declared product is 1 kWh of electricity generated and thereafter distributed to the customer. All impacts are therefore expressed per kWh of electricity generation, based upon the impacts in the reference year 2002.

1 Product-Specific Requirements (PSR) for preparing an environmental product declaration (EPD) for electricity and district heat generation, PSR 2004:2, www.environdec.com

The nuclear fuel cycle



Nuclear fuel cycle

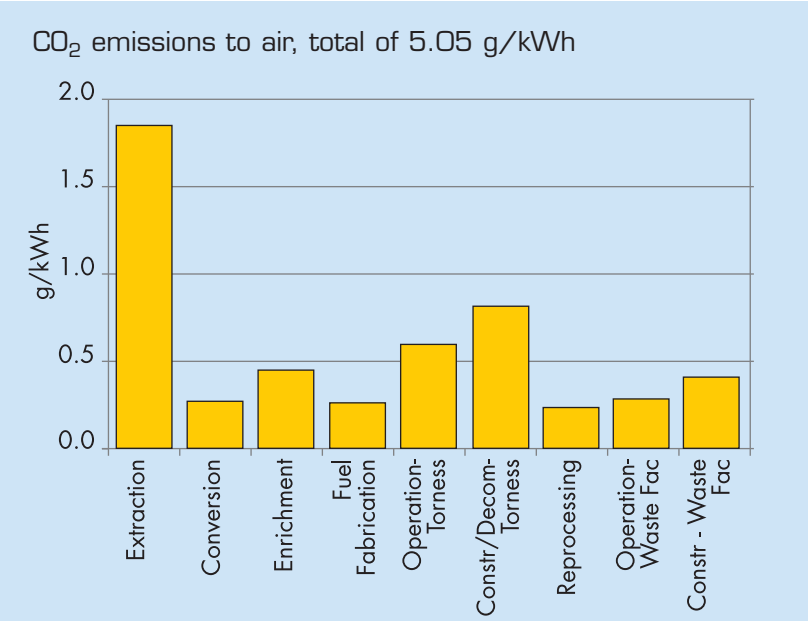
The fuel cycle describes the various stages and activities that are involved, on a life-cycle basis, in the production of electricity from uranium. The flow chart above illustrates the AGR fuel cycle relevant to Torness, step-by-step, from extraction to final disposal.

A representative facility has been identified and analysed for each of the stages in the Torness fuel cycle. The results are based upon three extraction sites and for all other stages a single site has been selected. The sites used to develop the Torness EPD are representative of the uranium balance, and impacts associated with a unit of electricity from Torness power station, although the coverage of suppliers is not comprehensive.

Environmental data has been collected for all stages in the fuel cycle. Assumptions regarding transportation of uranium are based on transportation routes during 2002. Due to limited data availability the refinement and conversion stage of the fuel cycle is based upon 1999 data. Elements of the fabrication and reprocessing stages are based upon 2003 data. For the final disposal stage the analysis has been based upon a reference case scenario[2]. Impacts have then been normalized to Torness's requirements during the financial year 2001/2002.

As far as possible site specific data has been used in the analysis, however, for certain impacts generic lifecycle data has been applied. For consistency, all generic data has been taken from the SimaPro LCA database[3].

2 The route for final disposal of radioactive waste within the UK is currently under consideration. Therefore, an assessment of the impacts of the final disposal of radioactive waste in the UK has been based upon a report prepared by Nirex, specifically for use within this EPD. Nirex Inputs to Environmental Product Declaration for Torness power station. 2005.
3 http://www.pre.nl/simapro/default.htm.



Environmental performance

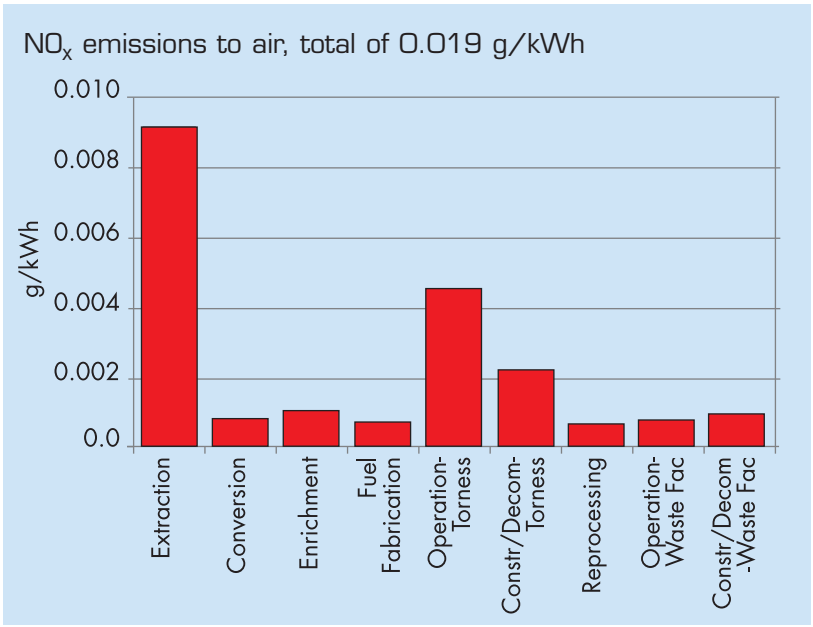
Environmental impacts have been calculated for each of the stages in the Torness life cycle. Resource use, emissions, and waste are distributed over 40 years, the assumed station life for the purposes of this study[4].

Emissions of greenhouse gases

Carbon dioxide is the dominant greenhouse gas. The extraction phase contributes 37% of greenhouse gases. Uranium is extracted at three locations where different concentrations of uranium ore are mined. The underground mine in Australia generates proportionately more greenhouse gases per kg uranium extracted than the two underground mines in Canada. The main reasons are the use of fossil fuel as the energy source for electricity generation and a lower content of uranium in the ore.

Emissions of atmospheric ozone depleting gases

Emissions of ozone depleting gases are very small from all facilities in the nuclear fuel cycle.



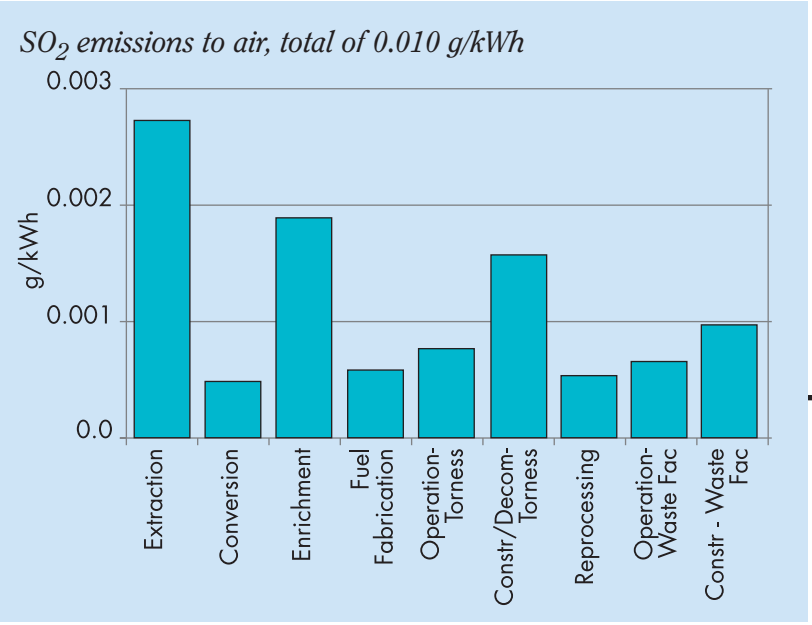
Emissions of acidifying gases

Emissions of identified and quantified acidifying gases are almost totally dominated by SO_2 and NO_x. The extraction phase is the most dominant source (38%) followed by the operation of Torness (18%). The main source of acidifying gases from the operation of Torness is from the combustion of fuel oil in the stand-by generators and the auxiliary boilers.

Emissions of toxic substances

The processes and stages involved in the fuel cycle release a wide range of potentially toxic substances into the environment. However, at each individual point source the amounts of toxic

4 The currently declared accounting life for Torness is 35 years.



substances are small. There are minute emissions of e.g. arsenic, poly-aromatic hydrocarbons, and heavy metals mainly emanating from mining of raw materials for construction of nuclear power plants and waste management facilities.

Waste and recycled material

Fuel-related radioactive waste originates from the operation of the power station at Torness, but also from some of the other fuel chain facilities. Intermediate and low level waste is produced during the operation of Torness, and during the decommissioning of the Torness site. A proportion of Torness's spent fuel is sent for reprocessing[5] with the remainder in long-term storage prior to final disposal. Reprocessing of the spent fuel produces low and intermediate level radioactive waste, as well as some high level radioactive waste.

Category	Normalised value	Typical annual value[7]
• High level radioactive waste	9.34×10^{-11} m^3/kWh	0.8 m^3
• Spent fuel	2.15×10^{-9} m^3/kWh	18 m^3
• Intermediate level radioactive waste	1.55×10^{-8} m^3/kWh	130 m^3
• Low level radioactive waste	4.88×10^{-8} m^3/kWh	400 m^3

Table 2. Life cycle radioactive waste and spent fuel

The amount of radioactive waste and spent fuel arising from the operation and decommissioning of Torness is summarised in the table above. The quantities are expressed in terms of volume[6]. This includes direct waste from the other facilities in the fuel chain, but excludes any indirect waste that results from the electricity used in the fuel chain.

5 Current estimates suggest that this will represent 45% of total spent fuel arising from Torness.
6 The analysis has used the latest estimates of the total volume of radioactive waste arising during the lifetime (operation and decommissioning) of the Torness facility. For consistency with the other environmental parameters the values have been normalized (by dividing the total volume of waste arising by the total electricity generation during the assumed lifetime of Torness) and presented in terms of m^3/kWh.
7 Based on reference year generation of 8.3TWh.

Indirect fuel related waste, associated with the electricity used in the fuel chain, amounts to some 3.65×10^{-14} m^3/kWh, equivalent to 3×10^{-4} m^3 /year.

The dominant non-hazardous waste produced as part of the Torness fuel cycle is the rock and mineral waste emanating mainly from the mining and milling activities. Non-recyclable waste material from the construction and decommissioning of Torness are also considered important.

Uncertainties

EPD system requirements impose restrictions on the selection of data. Environmental impacts must be distorted by less than 1% because of selections concerning the specified categories (such as e.g. greenhouse gases). Construction and decommissioning of certain facilities in the nuclear fuel cycle, in relation to extraction, refining and fuel fabrication have been excluded. An assessment carried out by Vattenfall on similar facilities demonstrated the omissions to account for less than 1% of environmental impacts in any category. The Torness study excluded construction and decommissioning of a further facility, associated with reprocessing.

EPD guidance states that generic data can be used when specific data is lacking and as a general rule, the sum of the contribution from processes described by generic data instead of specific data must not exceed 10% of the contribution to the separate impact categories. For certain sites it has not been possible to collect specific reliable life cycle data for impacts associated with electricity use. Instead, generic life cycle data has been applied to the local electricity supply mix at each site. Unfortunately it has not been possible to demonstrate that this comprises less than 10% of the impacts.

In some instances it has not been possible to determine the location of certain suppliers. Where transport impacts have been calculated a worst-case estimate has been used to avoid under allocation.

For certain product impacts e.g. certain chemicals, it has not been possible to collect reliable life cycle data. This may lead to an underestimate in the total impacts, however, this is not thought to be significant for any of the sites.

These omissions and approximations are not considered to significantly affect the conclusions drawn from this study. Whilst the EPD has not been certified, a series of data validation and verification procedures have been carried out to ensure the quality of the data presented.

Key conclusions

- The mining and milling stage has the largest single contribution to the emission of greenhouse gases and acidifying pollutants. The variation in emissions between sites relates to the fossil fuels use at each site and the uranium content of the ore.

- The construction, operation and decommissioning of the power plant combined also make a strong contribution to the overall environmental impacts.

- The impacts of the conversion and fuel fabrication stages of the fuel cycle are generally small in comparison to the other stages.

- The reprocessing of spent fuel from Torness produces high level radioactive waste. The final route of disposal for high level radioactive waste in the UK is currently under consideration.

- The total emissions of CO_2 from electricity generated at Torness power station, calculated on a lifecycle basis, are estimated to be just over 5 g/kWh. This compares to emissions of CO_2 from a typical UK coal plant of around 900 g/kWh, based upon the operational stage alone. Typical CCGT CO_2 emissions are around 400 g/kWh.

- The emissions of acidifying pollutants from the fuel cycle relate closely to the use of fossil fuels. The total lifecycle emissions of NO_x and SO_2 from the Torness fuel cycle amount to 0.02 g/kWh, and 0.01 g/kWh, respectively.

- Radioactive substances are handled during the course of the normal operation of facilities in the nuclear fuel cycle. These substances emit ionizing radiation that may result in doses to the people working at the facility, and to people outside the facility. At all sites in the fuel cycle during the reference year, the occupational dose was within the respective national regulatory limits.

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