

*Eco-profiles of the  
European Plastics Industry*

**NATURAL GAS**

*A report by*

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*for*

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**Data last calculated**

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## IMPORTANT NOTE

Before using the data contained in this report, you are strongly recommended to look at the following documents:

### 1. Methodology

This provides information about the analysis technique used and gives advice on the meaning of the results.

### 2. Data sources

This gives information about the number of plants examined, the date when the data were collected and information about up-stream operations.

In addition, you can also download data sets for most of the upstream operations used in this report. All of these documents can be found at: [www.plasticseurope.org](http://www.plasticseurope.org).

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## CONTENTS

|  |          |
|--|----------|
| <b>INTRODUCTION .....</b>                          | <b>4</b> |
| <b>NATURAL GAS .....</b>                           | <b>5</b> |
| <b>NATURAL GAS SOURCES .....</b>                   | <b>6</b> |
| <b>NATURAL GAS EXTRACTION .....</b>                | <b>7</b> |
| <b>ECO-PROFILE OF NATURAL GAS PRODUCTION .....</b> | <b>8</b> |

## INTRODUCTION

Until the middle of the 20<sup>th</sup> century, the main source of hydrocarbons used in the chemical industry was coal. Since then the use of coal has all but disappeared and the primary source of hydrocarbons used today is petroleum (literally rock oil). The petroleum industry is primarily concerned with three main groups of hydrocarbon mixtures. These are:

1. Crude oil: a naturally occurring mineral oil comprising a mixture of hydrocarbons with associated impurities such as sulphur and some metals which normally exists as a liquid at normal surface temperatures and pressures.
2. Natural gas liquids (NGL): liquid or liquefied gaseous hydrocarbons recovered from natural gas in separation facilities. Typically NGL contains hydrocarbons from ethane ( $C_2H_6$ ) to pentanes ( $C_5H_{12}$ ).
3. Natural gas: a naturally occurring deposit, whether liquid or gaseous, consisting mainly of methane.

This report is concerned with the production and supply of natural gas to Western Europe because this is one of the main raw materials used in the production of all large tonnage polymers and most engineering polymers.

The world production of these raw materials in 2001 is shown in Table 1.

*Table 1*  
*World production of natural gas in 2001<sup>1</sup>*

| Region   | Natural gas<br>10 <sup>9</sup> cu m |        |
|--|-------------------------------------|--------|
| OECD North America <sup>1</sup>  | 783                                 | 30.2%  |
| OECD Europe <sup>2</sup>   | 306                                 | 11.8%  |
| OECD Pacific <sup>3</sup>  | 42                                  | 1.6%   |
| Latin America  | 101                                 | 3.9%   |
| Non-OECD Europe  | 16                                  | 0.6%   |
| Former USSR  | 725                                 | 28.0%  |
| Africa   | 134                                 | 5.2%   |
| Middle East  | 241                                 | 9.3%   |
| Asia (excluding China)   | 211                                 | 8.1%   |
| China  | 34                                  | 1.3%   |
| World production   | 2596                                | 100.0% |
| Notes:   |                                     |        |
| 1. OECD North America = Canada, Mexico and USA   |                                     |        |
| 2. OECD Europe = Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey and UK. |                                     |        |
| 3. OECD Pacific = Australia, Japan, South Korea and New Zealand.   |                                     |        |
| 4. Totals may not agree because of rounding  |                                     |        |

## NATURAL GAS

Natural gas occurs in many parts of the world in porous rocks. Sometimes, but not always, it occurs in the same location as crude oil deposits. The principal composition of all natural gases is methane but the detailed compositions of natural gases from different sources vary widely as shown in Table 2.

*Table 2*  
*Composition (wt%) of some natural gases.*

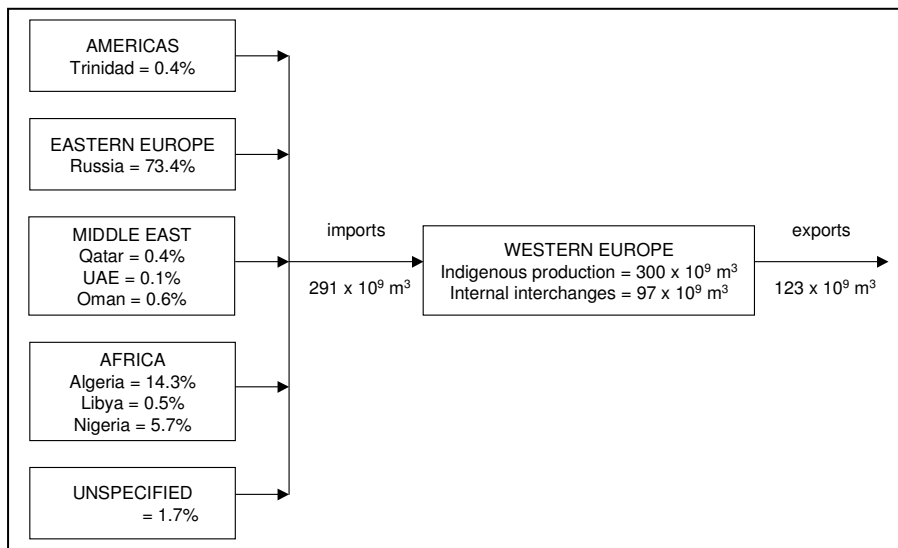
|                    | North Sea | Slochteren<br>Netherlands | Hassi R'Mel<br>Algeria | Lacq<br>France | Salt Lake<br>Utah, US |
|--------------------|-----------|---------------------------|------------------------|----------------|-----------------------|
| Methane            | 94.4      | 81.8                      | 83.5                   | 70.0           | 95.0                  |
| Ethane             | 3.1       | 2.8                       | 7.0                    | 3.0            | 0.8                   |
| Propane            | 0.5       | 0.4                       | 2.0                    | 1.4            | 0.2                   |
| Butane             | 0.2       | 0.1                       | 0.8                    | 0.6            | -                     |
| C5+                | 0.2       | 0.1                       | 0.4                    | -              | -                     |
| H <sub>2</sub> S   | <0.1      | <0.1                      | <0.1                   | 15.0           | -                     |
| CO <sub>2</sub>    | 0.5       | 0.8                       | 0.2                    | 4.0            | 3.6                   |
| N <sub>2</sub> /He | 1.1       | 14.0                      | 6.1                    | 6.0            | 0.4                   |

Natural gases are classified as wet or dry depending on the proportion of heavier hydrocarbons that can be condensed from them.

<sup>1</sup> International Energy Agency. *Natural Gas Information 2003*. ISBN 92-64-10219-1 published by OECD/IEA, Paris 2003.

## NATURAL GAS SOURCES

In 1999, Western Europe consumed some  $375 \times 10^9 \text{ m}^3$ . Of this some 48% was imported mainly from Russia and Algeria. The flows of natural gas into Western Europe are shown in Figure 1. Natural gas statistics are country based and, since Western Europe is a region rather than a single country, there is an interchange of gas between the different countries as shown.



*Figure 1*  
*Natural gas flow in Western Europe in 2001.*

Imports from Russia are by pipeline whereas the other imports are by sea as liquefied natural gas (LNG).<sup>2</sup> The transport used in importing natural gas can be calculated as shown in Table 3. Most of the indigenous production is moved by pipeline. Assuming an average delivery distance within Europe of 400 km the internal pipeline transport requirement is 0.4 tonne-km/kg. Thus by combining the data of Table 3 (multiplied by the factor 0.49 to account for the proportion of imports) with the above pipeline requirement, the total transport requirements for natural gas are 0.690 tonne-km/kg by tanker and 1.078 tonne-km/kg by pipeline.

<sup>2</sup> There is often some confusion about the use of LNG (liquefied natural gas) and NGL (natural gas liquids). NGL refers to the condensates recovered from natural gas processing and usually contains hydrocarbons with 2 or more carbon atoms. LNG usually refers to purified natural gas which is then liquefied.

Table 3

*Calculation of delivery transport for natural gas imports.*

| Source country | Sea/km               | Pipeline/km | Fraction from source | Sea tonne-km/kg | Pipeline tonne-km/kg |
|----------------|----------------------|-------------|----------------------|-----------------|----------------------|
| Trinidad       | 9500                 |             | 0.004                | 0.038           |                      |
| Russia         |                      | 3000        | 0.733                |                 | 2.199                |
| Qatar          | 12600                |             | 0.004                | 0.050           |                      |
| UAE            | 12600                |             | 0.001                | 0.013           |                      |
| Oman           | 12000                |             | 0.006                | 0.072           |                      |
| Algeria        | 3500                 |             | 0.143                | 0.501           |                      |
| Libya          | 5200                 |             | 0.005                | 0.026           |                      |
| Nigeria        | 8300                 |             | 0.057                | 0.473           |                      |
| Unspecified    | 5000                 |             | 0.047                | 0.235           |                      |
| Summary:       | 100 000 tonne tanker |             |                      | 1.408           | tonne-km/kg          |
|                | Pipeline             |             |                      | 2.199           | tonne-km/kg          |

## NATURAL GAS EXTRACTION

Fuel data for extracting and processing natural gas have been derived from the IEA statistics and these are summarised in Table 4.

Table 4

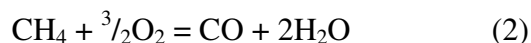
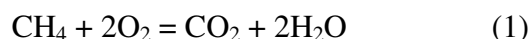
*Average fuel inputs in MJ to produce 1 kg of natural gas.*

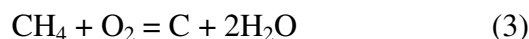
| Fuel           | Input   |
|----------------|---------|
| Kerosine       | 0.00015 |
| LPG            | 0.00350 |
| Gasoline       | 0.00004 |
| Diesel         | 0.03457 |
| Heavy fuel oil | 0.12069 |
| Petroleum coke | 0.00860 |
| Natural gas    | 1.42909 |
| Electricity    | 0.10221 |
| TOTAL          | 1.69885 |

The IEA statistics provide no information on the emission data and these have been obtained from five industrial extraction sites. Apart from the emissions associated with burning the fuels listed in Table 4, the emissions arise from two main sources; direct hydrocarbon loss to the atmosphere and flaring.

Estimating the accidental losses of hydrocarbons to the atmosphere is extremely difficult. Estimates vary widely but ranges that have been quoted verbally range from 0.1 to 5.0 g/kg oil. In this work an emission of 1000 mg/kg oil has been assumed since most of the estimates are at the lower end of the range.

Estimates for gas sent to the flare average 1.5 g/kg oil. The problem is that the reactions occurring in the flare are uncertain. The three main reactions are:





The results of the combustion, based on estimated fractions participating in the above reactions are summarised in Table 5.

*Table 5*  
*Estimated flare emissions*

| Reaction   | wt% | Mass/mg | Emission product          |
|------------|-----|---------|---------------------------|
| Reaction 1 | 60  | 900     | CO <sub>2</sub> = 2475 mg |
| Reaction 2 | 15  | 225     | CO = 394 mg               |
| Reaction 3 | 15  | 225     | C = 169 mg                |
| Unburned   | 10  | 150     | CH <sub>4</sub> = 150 mg  |
| TOTALS     | 100 | 1500    |                           |

Reported distribution losses are 889575 TJ for the supply of 98744735 TJ.<sup>3</sup> This corresponds to losses of 9009 mg/kg gas. The total emissions arising from the production and distribution of natural gas are summarised in Table 6.

*Table 6*  
*Total air emissions in mg for the extraction and distribution of 1 kg of natural gas, excluding emissions from fuel burning*

| Emission        | From losses | From flare | From distribution | Total |
|-----------------|-------------|------------|-------------------|-------|
| CH <sub>4</sub> | 1000        | 150        | 9009              | 10159 |
| CO <sub>2</sub> |             | 2475       |                   | 2475  |
| CO              |             | 394        |                   | 394   |
| C               |             | 169        |                   | 169   |

## ECO-PROFILE OF NATURAL GAS PRODUCTION

Table 7 shows the gross or cumulative energy to produce 1 kg of natural gas feedstock and Table 8 gives this same data expressed in terms of primary fuels. Table 9 shows the energy data expressed as masses of fuels. Table 10 shows the raw materials requirements and Table 11 shows the demand for water. Table 12 shows the gross air emissions and Table 13 shows the corresponding carbon dioxide equivalents of these air emissions. Table 14 shows the emissions to water. Table 15 gives the solid waste generated and Table 16 shows the solid waste in EU format.

<sup>3</sup> International Energy Agency (IEA). *Energy statistics of non-OECD countries 2000-2001*. ISBN 92-64-10215-9. OECD/IEA, Paris. 2003.



*Table 7*

*Gross energy required to produce 1 kg of natural gas. (Totals may not agree because of rounding)*

| Fuel type   | Fuel prod'n<br>& delivery<br>energy<br>(MJ) | Energy content<br>of delivered<br>fuel<br>(MJ) | Energy use<br>in<br>transport<br>(MJ) | Feedstock<br>energy<br>(MJ) | Total<br>energy<br>(MJ) |
|-------------|---|--|---------------------------------------|-----------------------------|-------------------------|
| Electricity | 1.79  | -  | 0.81                                  | -                           | 2.60                    |
| Oil fuels   | 0.03  | 0.15   | 0.03                                  | -                           | 0.21                    |
| Other fuels | 0.07  | 1.38   | <0.01                                 | 54.00                       | 55.46                   |
| Totals      | 1.89  | 1.54   | 0.85                                  | 54.00                       | 58.27                   |

*Table 8*

*Gross primary fuels required to produce 1 kg of natural gas. (Totals may not agree because of rounding)*

| Fuel type            | Fuel prod'n<br>& delivery<br>energy<br>(MJ) | Energy content<br>of delivered<br>fuel<br>(MJ) | Fuel use<br>in<br>transport<br>(MJ) | Feedstock<br>energy<br>(MJ) | Total<br>energy<br>(MJ) |
|----------------------|---|--|-------------------------------------|-----------------------------|-------------------------|
| Coal                 | 0.64  | 0.01   | 0.29                                | -                           | 0.94                    |
| Oil                  | 0.06  | 0.15   | 0.07                                | -                           | 0.28                    |
| Gas                  | 0.67  | 1.38   | 0.27                                | 54.00                       | 56.32                   |
| Hydro                | 0.01  | -  | 0.01                                | -                           | 0.02                    |
| Nuclear              | 0.46  | -  | 0.20                                | -                           | 0.66                    |
| Lignite              | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Wood                 | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Sulphur              | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Biomass (solid)      | 0.01  | -  | <0.01                               | -                           | 0.01                    |
| Hydrogen             | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Recovered energy     | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Unspecified          | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Peat                 | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Geothermal           | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Solar                | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Wave/tidal           | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Biomass (liquid/gas) | 0.02  | -  | 0.01                                | -                           | 0.04                    |
| Industrial waste     | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Municipal Waste      | 0.01  | -  | <0.01                               | -                           | 0.01                    |
| Wind                 | <0.01                                       | -  | <0.01                               | -                           | <0.01                   |
| Totals               | 1.89  | 1.54   | 0.85                                | 54.00                       | 58.27                   |

*Table 9*

*Gross primary fuels used to produce 1 kg of natural gas expressed as mass.*

| Fuel type          | Input in mg |
|--------------------|-------------|
| Crude oil          | 6100        |
| Gas/condensate     | 1000000     |
| Coal               | 33000       |
| Metallurgical coal | 4           |
| Lignite            | <1          |
| Peat               | <1          |
| Wood               | <1          |

*Table 10*  
*Gross raw materials required to produce 1 kg of natural gas.*

| Raw material                               | Input in mg |
|--|-------------|
| Air  | 1           |
| Barytes                                    | <1          |
| Bauxite                                    | <1          |
| Bentonite                                  | <1          |
| Biomass (including water)                  | 5600        |
| Calcium sulphate (CaSO <sub>4</sub> )      | <1          |
| Chalk (CaCO <sub>3</sub> )                 | <1          |
| Clay                                       | <1          |
| Cr   | <1          |
| Cu   | <1          |
| Dolomite                                   | <1          |
| Fe   | 10          |
| Feldspar                                   | <1          |
| Ferromanganese                             | <1          |
| Fluorspar                                  | <1          |
| Granite                                    | <1          |
| Gravel                                     | <1          |
| Hg   | <1          |
| Limestone (CaCO <sub>3</sub> )             | 2           |
| N <sub>2</sub>                             | 1           |
| Ni   | <1          |
| O <sub>2</sub>                             | <1          |
| Olivine                                    | <1          |
| Pb   | <1          |
| Phosphate as P <sub>2</sub> O <sub>5</sub> | <1          |
| Potassium chloride (KCl)                   | <1          |
| Rutile                                     | <1          |
| S (bonded)                                 | <1          |
| S (elemental)                              | <1          |
| Sand (SiO <sub>2</sub> )                   | <1          |
| Shale                                      | <1          |
| Sodium chloride (NaCl)                     | <1          |
| Talc                                       | <1          |
| Unspecified                                | <1          |
| Zn   | <1          |

*Table 11*  
*Gross water consumption required for the production of 1 kg of natural gas. (Totals may not agree because of rounding)*

| Source        | Use for processing (mg) | Use for cooling (mg) | Totals (mg) |
|---------------|-------------------------|----------------------|-------------|
| Public supply | 180                     | -                    | 180         |
| River canal   | <1                      | <1                   | <1          |
| Sea           | <1                      | 44                   | 45          |
| Well          | <1                      | <1                   | <1          |
| Unspecified   | 35000                   | 150                  | 35000       |
| Totals        | 35000                   | 200                  | 35000       |

Table 12

Gross air emissions associated with the production of 1 kg of natural gas.  
(Totals may not agree because of rounding)

| Emission                       | From<br>fuel prod'n<br>(mg) | From<br>fuel use<br>(mg) | From<br>transport<br>(mg) | From<br>process<br>(mg) | From<br>biomass<br>(mg) | From<br>fugitive<br>(mg) | Totals<br>(mg) |
|--------------------------------|-----------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------------|----------------|
| dust (PM10)                    | 97                          | 18                       | <1                        | 170                     | -                       | -                        | 280            |
| CO                             | 430                         | 37                       | 1                         | 390                     | -                       | -                        | 870            |
| CO2                            | 150000                      | 89000                    | 2200                      | 2500                    | <1                      | -                        | 240000         |
| SOX as SO2                     | 680                         | 200                      | 44                        | -                       | -                       | -                        | 920            |
| H2S                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| mercaptan                      | <1                          | <1                       | <1                        | -                       | -                       | -                        | <1             |
| NOX as NO2                     | 330                         | 220                      | 11                        | -                       | -                       | -                        | 560            |
| NH3                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Cl2                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| HCl                            | 18                          | <1                       | <1                        | -                       | -                       | -                        | 18             |
| F2                             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| HF                             | 1                           | <1                       | <1                        | -                       | -                       | -                        | 1              |
| hydrocarbons not specified     | 92                          | 18                       | 4                         | -                       | -                       | -                        | 110            |
| aldehyde (-CHO)                | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| organics                       | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Pb+compounds as Pb             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Hg+compounds as Hg             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| metals not specified elsewhere | <1                          | <1                       | <1                        | -                       | -                       | -                        | <1             |
| H2SO4                          | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| N2O                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| H2                             | 28                          | -                        | <1                        | -                       | -                       | -                        | 28             |
| dichloroethane (DCE) C2H4Cl2   | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| vinyl chloride monomer (VCM)   | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| CFC/HCFC/HFC not specified     | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| organo-chlorine not specified  | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| HCN                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| CH4                            | 950                         | 100                      | <1                        | 11000                   | -                       | -                        | 12000          |
| aromatic HC not specified      | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| polycyclic hydrocarbons (PAH)  | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| NMVOC                          | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| CS2                            | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| methylene chloride CH2Cl2      | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Cu+compounds as Cu             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Cd+compounds as Cd             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Zn+compounds as Zn             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Cr+compounds as Cr             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |
| Ni+compounds as Ni             | <1                          | -                        | <1                        | -                       | -                       | -                        | <1             |

Table 13

Carbon dioxide equivalents corresponding to the gross air emissions for the production of 1 kg of natural gas. (Totals may not agree because of rounding)

| Type           | From<br>fuel prod'n<br>(mg) | From<br>fuel use<br>(mg) | From<br>transport<br>(mg) | From<br>process<br>(mg) | From<br>biomass<br>(mg) | From<br>fugitive<br>(mg) | Totals<br>(mg) |
|----------------|-----------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------------|----------------|
| 20 year equiv  | 210000                      | 96000                    | 2300                      | 690000                  | <1                      | -                        | 1000000        |
| 100 year equiv | 170000                      | 92000                    | 2300                      | 260000                  | <1                      | -                        | 520000         |
| 500 year equiv | 160000                      | 90000                    | 2300                      | 81000                   | <1                      | -                        | 330000         |

Table 14

Gross emissions to water arising from the production of 1 kg of natural gas.  
(Totals may not agree because of rounding).

| Emission   | From<br>fuel prod'n<br>(mg) | From<br>fuel use<br>(mg) | From<br>transport<br>(mg) | From<br>process<br>(mg) | Totals<br>(mg) |
|--|-----------------------------|--------------------------|---------------------------|-------------------------|----------------|
| COD  | <1                          | -                        | <1                        | -                       | <1             |
| BOD  | <1                          | -                        | <1                        | -                       | <1             |
| Pb+compounds as Pb                                 | <1                          | -                        | <1                        | -                       | <1             |
| Fe+compounds as Fe                                 | <1                          | -                        | <1                        | -                       | <1             |
| Na+compounds as Na                                 | <1                          | -                        | <1                        | -                       | <1             |
| acid as H+   | <1                          | -                        | <1                        | -                       | <1             |
| NO <sub>3</sub> <sup>-</sup>                       | <1                          | -                        | <1                        | -                       | <1             |
| Hg+compounds as Hg                                 | <1                          | -                        | <1                        | -                       | <1             |
| metals not specified elsewhere                     | <1                          | -                        | <1                        | -                       | <1             |
| ammonium compounds as NH <sub>4</sub> <sup>+</sup> | <1                          | -                        | <1                        | -                       | <1             |
| Cl <sup>-</sup>                                    | <1                          | -                        | <1                        | -                       | <1             |
| CN <sup>-</sup>                                    | <1                          | -                        | <1                        | -                       | <1             |
| F <sup>-</sup>                                     | <1                          | -                        | <1                        | -                       | <1             |
| S+sulphides as S                                   | <1                          | -                        | <1                        | -                       | <1             |
| dissolved organics (non-                           | <1                          | -                        | <1                        | -                       | <1             |
| suspended solids                                   | 8                           | -                        | <1                        | -                       | 8              |
| detergent/oil                                      | <1                          | -                        | <1                        | -                       | <1             |
| hydrocarbons not specified                         | <1                          | -                        | <1                        | -                       | <1             |
| organo-chlorine not specified                      | <1                          | -                        | <1                        | -                       | <1             |
| dissolved chlorine                                 | <1                          | -                        | <1                        | -                       | <1             |
| phenols  | <1                          | -                        | <1                        | -                       | <1             |
| dissolved solids not specified                     | <1                          | -                        | <1                        | -                       | <1             |
| P+compounds as P                                   | <1                          | -                        | <1                        | -                       | <1             |
| other nitrogen as N                                | <1                          | -                        | <1                        | -                       | <1             |
| other organics not specified                       | <1                          | -                        | <1                        | -                       | <1             |
| SO <sub>4</sub> <sup>--</sup>                      | <1                          | -                        | <1                        | -                       | <1             |
| dichloroethane (DCE)                               | <1                          | -                        | <1                        | -                       | <1             |
| vinyl chloride monomer (VCM)                       | <1                          | -                        | <1                        | -                       | <1             |
| K+compounds as K                                   | <1                          | -                        | <1                        | -                       | <1             |
| Ca+compounds as Ca                                 | <1                          | -                        | <1                        | -                       | <1             |
| Mg+compounds as Mg                                 | <1                          | -                        | <1                        | -                       | <1             |
| Cr+compounds as Cr                                 | <1                          | -                        | <1                        | -                       | <1             |
| ClO <sub>3</sub> <sup>--</sup>                     | <1                          | -                        | <1                        | -                       | <1             |
| BrO <sub>3</sub> <sup>--</sup>                     | <1                          | -                        | <1                        | -                       | <1             |
| TOC  | <1                          | -                        | <1                        | -                       | <1             |
| AOX  | <1                          | -                        | <1                        | -                       | <1             |
| Al+compounds as Al                                 | <1                          | -                        | <1                        | -                       | <1             |
| Zn+compounds as Zn                                 | <1                          | -                        | <1                        | -                       | <1             |
| Cu+compounds as Cu                                 | <1                          | -                        | <1                        | -                       | <1             |
| Ni+compounds as Ni                                 | <1                          | -                        | <1                        | -                       | <1             |

*Table 15*

*Gross solid waste associated with the production of 1 kg of natural gas. (Totals may not agree because of rounding)*

| Emission  | From<br>fuel prod'n<br>(mg) | From<br>fuel use<br>(mg) | From<br>transport<br>(mg) | From<br>process<br>(mg) | Totals<br>(mg) |
|---|-----------------------------|--------------------------|---------------------------|-------------------------|----------------|
| Plastic containers  | <1                          | -                        | <1                        | -                       | <1             |
| Paper   | <1                          | -                        | <1                        | -                       | <1             |
| Plastics  | <1                          | -                        | <1                        | -                       | <1             |
| Metals  | <1                          | -                        | <1                        | -                       | <1             |
| Putrescibles  | <1                          | -                        | <1                        | -                       | <1             |
| Unspecified refuse  | 74                          | -                        | <1                        | -                       | 74             |
| Mineral waste   | 7                           | -                        | 1                         | -                       | 8              |
| Slags & ash   | 2300                        | 25                       | <1                        | -                       | 2300           |
| Mixed industrial  | 74                          | -                        | <1                        | <1                      | 74             |
| Regulated chemicals   | 90                          | -                        | <1                        | -                       | 90             |
| Unregulated chemicals   | 69                          | -                        | <1                        | -                       | 69             |
| Construction waste  | <1                          | -                        | <1                        | -                       | <1             |
| Waste to incinerator  | <1                          | -                        | <1                        | -                       | <1             |
| Inert chemical  | <1                          | -                        | <1                        | -                       | <1             |
| Wood waste  | <1                          | -                        | <1                        | -                       | <1             |
| Wooden pallets  | <1                          | -                        | <1                        | -                       | <1             |
| Waste to recycling  | <1                          | -                        | <1                        | -                       | <1             |
| Waste returned to mine  | 6400                        | -                        | <1                        | -                       | 6400           |
| Tailings  | <1                          | -                        | <1                        | -                       | <1             |
| Municipal solid waste   | -1200                       | -                        | -                         | -                       | -1200          |
| Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation. |                             |                          |                           |                         |                |

Table 16

Gross solid waste in EU format associated with the production of 1 kg of natural gas. Entries marked with an asterisk (\*) are considered hazardous as defined by EU Directive 91/689/EEC

| Emission   | Totals<br>(mg) |
|--|----------------|
| 010101 metallic min'l excav'n waste  | 8              |
| 010102 non-metal min'l excav'n waste   | 6400           |
| 010306 non 010304/010305 tailings  | <1             |
| 010308 non-010307 powdery wastes   | <1             |
| 010399 unspecified met. min'l wastes   | <1             |
| 010408 non-010407 gravel/crushed rock  | <1             |
| 010411 non-010407 potash/rock salt   | <1             |
| 010499 unsp'd non-met. waste   | <1             |
| 010505*oil-bearing drilling mud/waste  | 88             |
| 010508 non-010504/010505 chloride mud  | 69             |
| 010599 unspecified drilling mud/waste  | 74             |
| 020107 wastes from forestry  | <1             |
| 050107*oil industry acid tars  | <1             |
| 050199 unspecified oil industry waste  | 3              |
| 050699 coal pyrolysis unsp'd waste   | 5              |
| 060101*H <sub>2</sub> SO <sub>4</sub> /H <sub>2</sub> SO <sub>3</sub> MFSU waste | <1             |
| 060102*HCl MFSU waste  | <1             |
| 060204*NaOH/KOH MFSU waste   | <1             |
| 060313*h. metal salt/sol'n MFSU waste  | <1             |
| 060314 other salt/sol'n MFSU waste   | <1             |
| 060399 unsp'd salt/sol'n MFSU waste  | <1             |
| 060404*Hg MFSU waste   | <1             |
| 060405*other h. metal MFSU waste   | <1             |
| 060499 unsp'd metallic MFSU waste  | <1             |
| 060602*dangerous sulphide MFSU waste   | <1             |
| 060603 non-060602 sulphide MFSU waste  | <1             |
| 060701*halogen electrol. asbestos waste  | <1             |
| 060703*BaSO <sub>4</sub> sludge with Hg  | <1             |
| 060704*halogen pr. acids and sol'ns  | <1             |
| 060799 unsp'd halogen pr. waste  | <1             |
| 070107*hal'd still bottoms/residues  | <1             |
| 070108*other still bottoms/residues  | <1             |
| 070111*org. chem. dan. eff. sludge   | <1             |
| 070199 unsp'd organic chem. waste  | <1             |
| 070207*polymer ind. hal'd still waste  | <1             |
| 070208*polymer ind. other still waste  | <1             |
| 070213 polymer ind. waste plastic  | <1             |
| 070214*polymer ind. dan. additives   | <1             |
| 070299 unsp'd polymer ind. waste   | <1             |

continued over .....

*Table 16 - continued*

*Gross solid waste in EU format associated with the production of 1 kg of natural gas. Entries marked with an asterisk (\*) are considered hazardous as defined by EU Directive 91/689/EEC*

|   |       |
|---|-------|
| 080199 unspecified paint/varnish waste  | <1    |
| 100101 non-100104 ash, slag & dust  | 2300  |
| 100102 coal fly ash   | <1    |
| 100105 FGD Ca-based reac. solid waste   | <1    |
| 100114*dangerous co-incin'n ash/slag  | <1    |
| 100115 non-100115 co-incin'n ash/slag   | <1    |
| 100116*dangerous co-incin'n fly ash   | <1    |
| 100199 unsp'd thermal process waste   | <1    |
| 100202 unprocessed iron/steel slag  | 3     |
| 100210 iron/steel mill scales   | <1    |
| 100399 unspecified aluminium waste  | <1    |
| 100501 primary/secondary zinc slags   | <1    |
| 100504 zinc pr. other dust  | <1    |
| 100511 non-100511 Zn pr. skimmings  | <1    |
| 101304 lime calcin'n/hydration waste  | <1    |
| 150103 wooden packaging   | <1    |
| 170107 non-170106 con'e/brick/tile mix  | <1    |
| 190199 unspecified incin'n/pyro waste   | <1    |
| 190905 sat./spent ion exchange resins   | <1    |
| 200101 paper and cardboard  | <1    |
| 200108 biodeg. kitchen/canteen waste  | <1    |
| 200138 non-200137 wood  | <1    |
| 200139 plastics   | <1    |
| 200140 metals   | <1    |
| 200199 other separately coll. frac'ns   | <1    |
| 200301 mixed municipal waste  | <1    |
| 200399 unspecified municipal wastes   | -1100 |
| Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation. |       |