



ECONOMIC IMPLICATIONS OF A GAS SUPPLY INTERRUPTION TO UK INDUSTRY

A report to DTI

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EXECUTIVE SUMMARY

National Grid in its 'Winter Outlook Report 2005/06' identified the requirement for a significant volume of demand side response from industrial¹ gas load if the winter of 2005/06 is colder than average. For a 1 in 10 cold winter, the demand side response identified in the Winter Outlook is 0.9 bcm. The bulk of this reduction in gas demand would be expected from the energy intensive industry in the UK, which would either reduce production or, in certain sectors, would have the capability to switch to run on alternative standby fuel stored on site.

DTI commissioned ILEX to study the economic impact of an interruption, by National Grid, to the gas supply in the winter of 2005/06. The purpose of this study is to understand the impact on energy intensive industry² and the sectors of the economy that are directly upstream and downstream of it.

This study focuses on the impact of a gas interruption lasting 1 day, 3 weeks, or 6 weeks. We have assumed that most or all of the gas supply to these sectors is curtailed in each of these time periods. This degree of interruption would probably only occur under emergency conditions – mandatory interruption by the National Emergency Co-ordinator. It would also require firm load shedding, since the majority of energy intensive users are on firm rather than interruptible contracts. We separately consider the reduced impact if the level of interruption is limited to self-curtailment by industry.

ILEX carried out interviews with the major companies and/or the trade organisations in each of the sectors that contain energy intensive industry (excluding the power generation sector). The interviews took place in the weeks commencing 21st and 28th November 2005 and were a combination of face-to-face interviews and telephone interviews, each one lasting up to 1 hour. Separately, ILEX has undertaken economic analysis based on data published by the Office of National Statistics.

¹ The Winter Outlook report identified a demand side reduction in the power sector, and, separately, in the non-power industrial sector. This report is solely concerned with the latter.

² The energy intensive sectors that we have considered are – as agreed between ILEX and DTI – those analysed in Global Insight's report "Demand side response from UK industry", Global Insight, 20 May 2005. The reasons for choosing these sectors are twofold: a) to be consistent with the parallel study undertaken by Global Insight in December 2005 and b) these sectors are likely to have to meet the bulk of a reduction in gas supply to industry.

Findings

A gas supply interruption to the industrial sector this winter could cause widespread commercial damage. This damage would consist of lost production at a minimum. It could also entail physical damage to certain plant if it is forced to cease production, interruptions to downstream customers and upstream suppliers and, in the longer term, loss of market share, plant closures and job losses³.

1-day emergency (involuntary) interruption

A 1-day emergency interruption would be an unplanned event, with industry given little or no notice. Its effects would differ substantially depending on whether the interruption is complete or whether a minimal supply (10-20%) of gas is retained to keep plant warm and for processes that have no alternative fuel.

Complete gas interruption would cause production to stop in most of the energy intensive sectors. A few sectors, such as paper and refining, might be able to switch entirely to back-up fuel for a day. Most sectors, however, even those with back-up fuel capability, require at least some gas to maintain operations. The highly integrated nature of many sectors (such as chemicals and vehicle manufacture) reinforces industry's reliance on gas.

If a certain amount of gas supply is retained during a 1-day interruption, then production will continue in most sectors, but at reduced output levels. The amount of gas that needs to be retained varies widely between companies: we found that on average across the energy-intensive sector, the retention of 10-20% of normal supplies would suffice to keep some production going, but certain sectors, including ammonia and aluminium, would require a much higher proportion. The sectors that have back-up fuel capability to substitute for a portion of their gas use (refining, paper, steel, glass, some heavy food and some chemicals) generally have enough for one day.

Generally, there are low stocks of finished product in most sectors, so even a 1-day production stoppage would affect downstream customers.

3-6 week emergency (involuntary) interruption

In a 3-6 week emergency interruption, all sectors would be forced to stop or severely curtail production, and their downstream customers would be interrupted. The road haulage industry in Britain could not cope with a significant rise in demand for back-up fuel; and none of the industries that we surveyed hold back-up stocks for this duration. At most, our research suggests that 10-15% of gas demand in the energy intensive sector could be substituted by back-up fuel.

³ In the longer term still, some of the lost market share might be won back; alternatively, there would be a transfer of employment to other sectors of the economy. A proper analysis of these effects would require a much longer study than this one.

The immediate effect on the economy of a 6-week interruption would be a loss of between 0.18% and 0.81% of annual GDP in 2006. Assuming the volume of gas saved is 0.9 bcm, the economic cost per therm ranges between £5.47/therm and £23.88/therm. These figures are solely based on the value of lost production during the 6-week period.

The lower end of the range assumes that all the GI sectors, except the refining and water sectors, cease production, but that sectors directly upstream and downstream are unaffected, i.e. they can immediately find alternative suppliers/customers for all of their purchases/sales. The upper end of the range assumes that certain sectors upstream and downstream cease production for 6 weeks. In deriving this range, we have tried to limit attention to sectors directly upstream or downstream, although in practice this is not clear-cut in the sectoral classifications of the British economy. Other sectors, not included in our study, might also incur some immediate reduction in production.

For a 3-week interruption, we estimate that the immediate impact would be approximately half as much, i.e. 0.09% to 0.40% of GDP in 2006, depending on the extent of production lost in sectors upstream and downstream.

Self-interruption

Global Insight have analysed the likely response if gas reduction is limited to self-curtailement by industry. For the purposes of this report, 'self-curtailement' is defined as reduction in production by industry in response to the price of gas. Their estimate is a reduction of 5.0 mcm/day (out of a total demand of 36.8 mcm/day), for a period of 60 days. This is equivalent, on a total gas volume basis, to a reduction in industrial production of around 20% for a 6-week period – rather than the reduction of 100% that we are assuming. However, it assumes also that industry save 4 mcm/day using backup fuel for a 60 day period – at the upper end of what is likely to be achievable.

ILEX estimates that the immediate economic consequence of this self-curtailement would be a loss of GDP in 2006 of between 0.04% and 0.16%; and an economic cost per therm between £1.91/therm and £8.34/therm.

It is also clear from Global Insight's analysis, and our own, that such a response would fall well short of the 0.9 bcm that the Winter Outlook has identified as potentially required from industry. To achieve this saving would require (the equivalent of) at least 3 weeks of complete production stoppage, even under optimistic assumptions for back-up fuel availability over a 60-day period. The bulk of our analysis has been concerned with the economic consequences of the 1 in 10 winter defined in the Winter Outlook, which cannot be limited to self-curtailement.

Longer term effects

In the longer term, there would be further economic effects including a loss of market share in most of the energy intensive sectors. Customers facing supply interruption would try to continue production by sourcing alternative suppliers outside the UK. It would be difficult for the UK to win back the market share, given the competitive globalised market in which the energy intensive sectors operate, and our research suggests that many customers will diversify their supply of materials and import more than they had previously.

Most of the companies interviewed are international companies with parent companies operating similar sites in other countries within the EU and further afield. Several companies expressed concern that the parent company would shift production to sites outside the UK.

Several sectors, including aluminium, steel, glass and chemicals, would be exposed to site damage if production stops. In the case of aluminium and glass, it is very likely this would entail permanent plant closure. If the weather is below freezing, site damage would be more widespread, due to frost damage to boiler houses and other site infrastructure.

Energy intensive industry employs around 400,000 people, and the immediate downstream sectors employ a further one million. Many of these jobs would be at risk from a 3-6 week interruption, although we have not quantified the exact number.

There would also be knock-on effects in the economy beyond the immediate customers and suppliers of energy intensive industry. These effects are beyond the remit of this study.

Recommendations

We recommend that consideration be given to making some industrial sectors “priority gas consumers” to be protected from the emergency load shedding requirements. We also recommend that consideration be given to allowing some industrial customers to take sufficient gas – typically 10 to 20% of normal consumption, but dependent on the company and sector - in order to maintain some production. A proper investigation into these recommendations would require a longer period of research and analysis than has been allowed for this study. Careful thought would need to be given to the basis of prioritisation to ensure that it does not lead to unwanted and unintended social and economic distortions.

The impact of a gas supply interruption on the CNI could potentially be severe; hence we recommend that further work be done to ensure that gas supply is maintained at all times to those companies/sectors where CNI effects are relevant.

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We suggest that an investigation of alternatives to demand side interruption from energy intensive sectors be undertaken.

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1. INTRODUCTION

- 1.1 National Grid in its ‘Winter Outlook Report 2005/06’⁴ identified the requirement for a significant volume of demand side response from industrial⁵ gas load if the winter of 2005/06 is colder than average⁶. The bulk of this reduction in gas demand would be expected from the energy intensive industry in the UK, which would either reduce production or, it was widely believed, would have the capability to switch to run on alternative standby fuel stored on site.
- 1.2 DTI commissioned ILEX to study the economic impact of an interruption to the gas supply to the energy intensive industry sectors occurring in the winter of 2005/06. We have considered emergency interruptions lasting 1 day, 3 weeks and 6 weeks. We have also considered reductions in gas consumption associated with self-curtailment by industry in response to the gas price.
- 1.3 The purpose of the study is to understand the impact on the sectors directly impacted by the interruption and the sectors of the economy that are upstream and downstream of the energy intensive industry sectors.

ILEX approach

- 1.4 ILEX carried out interviews with the major players and/or the trade organisations in each of the sectors that contain energy intensive industry (excluding the power generation sector). The interviews took place in the week commencing 21st and 28th November 2005 and were a combination of face-to-face interviews and telephone interviews, each one lasting up to 1 hour.
- 1.5 The questions asked at interview were:
- What would be the impact on production of 1 day without gas? As the study progressed it became clear that it was important to distinguish between two levels of interruption:
 - complete interruption of the gas supply; and
 - substantial interruption, with a minimal gas supply retained for processes that are critical and have no alternative to gas.
 - What would be the impact on production of 3 weeks and 6 weeks without gas?
 - What would be the impact on your suppliers and customers?

⁴ Winter Outlook Report 2005/06, National Grid, October 2005. Available from www.ofgem.gov.uk

⁵ We exclude power generation in this report.

⁶ National Grid figures for demand side requirement from industry were 0.9 bcm for a 1-in-10 cold winter

- Would there be any impacts on the Critical National Infrastructure?
- 1.6 We have not assessed, in this study, the likely extent of ‘voluntary’ reduction in gas consumption by industry in response to the gas price. This was the subject of a separate report commissioned by DTI and run in parallel with this study.
- 1.7 The interviews collected a mixture of site-specific information from individual firms, and general industry information from trade associations. Given the limited time for the study it was not possible to interview the upstream and downstream sectors to validate the impacts⁷ and this study relies on responses received from the energy intensive industry. Furthermore, ILEX and DTI agreed to limit the scope of the analysis to those sectors immediately upstream and downstream of energy intensive industry.
- 1.8 The analysis of economic impact was based on:
- interview responses;
 - subsequent material submitted by interviewees and their trade associations; and
 - data published by the Office of National Statistics.
- 1.9 We have assumed in our analysis that electricity supplies are unaffected.
- 1.10 Our report is structured as follows. Chapter 2 describes each of the affected industries in turn. Chapter 3 and Chapter 4 describe the impact of a 1-day interruption and a 3-6 week interruption, respectively. Chapter 5 summarises the Critical National Infrastructure impacts that we have identified. Chapter 6 considers the longer term impacts on industry. In Chapter 7, we quantify the broad economic effects in terms of Gross Value Added (GVA) in each sector directly affected, and also the sectors downstream and upstream. Chapter 8 presents our conclusions. Further data is contained in separate Annexes at the end of the report.

⁷ A small number of responses were received from manufacturing industry and these have been included in the study.

2. DESCRIPTION OF AFFECTED INDUSTRIES

Industrial sectors

- 2.1 This study looks at the energy intensive sectors of the UK economy. Global Insight studied these sectors in its report in early 2005⁸. The sectors are listed in Table 1 grouped by the type of process.

Table 1 – Energy intensive sectors

Sector	Type of process
Aluminium	Smelting
Steel	Smelting
Glass	Furnace
Refineries	Cracking
Ammonia manufacture	Feedstock for synthesis
Bricks	Baking
Lime and cement	Baking
Chlor-alkali	Electrolysis
Industrial gases	Electrolysis
Other chemicals	Chemical reaction
Plastics	Polymerisation
Paper	Milling
Heavy Food	Sterilising, baking, packaging
Manufacturing	Heating, baking

There is no gas usage in the Water sector. Source: interviews with industry

⁸ “Demand side response from UK industry”, Global Insight, 20 May 2005

Activities of each sector

Aluminium

- 2.2 Raw materials are a mixture of 35% alumina and 65 % scraps (recycling), coke/coal, cryolite, silicon metal and energy. The smelting process takes place at 900 degrees Celsius and the operation is continuous (24 hours a day 365 days a year). The smelters use electricity. Gas is used for preparing anodes, for reheating at secondary smelters, processing metal and for painting.
- 2.3 Aluminium is supplied to the following sectors:
- transport;
 - building and construction; and
 - packaging.
- 2.4 UK manufactures around 1% of world production of aluminium, and employs 30,000 people. There are primary smelters in the North East, North Wales, and Scotland, and secondary process operations in the Midlands and North Wales.

Steel

- 2.5 The main raw materials are steel scrap, ferro alloys, lime, carbon (coal), lime and oxygen. Electrodes are imported.
- 2.6 Gas is used to preheat the ladle in the electric arc furnace. The output is billets. At the rolling mills gas fired furnaces are used to reheat the metal and gas is used in the specialist part of the process (e.g. gas torches). Generally there is a capability to run much of the gas load on standby fuel, but the process is less efficient. A small proportion of the total potential gas load is required to continue the manufacturing process when running on standby fuel.
- 2.7 The steel sectors supply:
- reinforcing steel for construction;
 - wire rod used in fencing;
 - merchant bar used in the manufacture engineering steel, and iron panels.

Glass

- 2.8 Raw materials are cullet (broken glass that is recycled), limestone, sandstone, and soda ash. Raw materials are supplied from the UK. The process involves a furnace that must be run continuously, without interruption, for its working life of 10 years.
- 2.9 Glass manufacture supplies:

- the construction industry with products including windows, glazing, and fibre glass;
 - the container industry with bottles, jars etc. and
 - the automotive industry (10% of Pilkington's custom).
- 2.10 The process is a furnace that can in theory be run on standby fuel (capability will be plant specific), but HFO usage has now been maximised (see below). Gas is also used in a number of specialised processes on site (e.g. gas torches). There are a number of furnaces in the UK that can only be run on gas and that do not have a standby fuel capability.

Refineries and petrochemicals

- 2.11 The main input to the refining process is crude oil. As long as supplies of crude do not cease, refineries can keep operating. This will depend on international shipping constraints and domestic supply.
- 2.12 Fuels used in refineries include refinery gas, natural gas, electricity and fuel oil.

Ammonia Manufacture (Ammonium Nitrate)

- 2.13 Ammonia manufacture is a continuous process running at 900 degrees Celsius. Gas is a feedstock to the chemical process, as well as providing heat.
- 2.14 Products are:
- Solids – mainly fertilizer sold to farmers and wholesalers;
 - Liquids – nitric acid and ammonium nitrate used in other chemical processes; and
 - CO₂ – used in food and drinks and also some nuclear reactors

Bricks

- 2.15 Gas is used for the drying process and kiln firing.

Lime and cement

- 2.16 There is little gas use in the manufacture of cement. The fuel is coal and waste products for incineration.
- 2.17 Gas is used in the manufacture of lime and around 40% of UK lime manufacture is believed to be gas fired. Some but not all of the kilns have the ability to switch to an alternative fuel.
- 2.18 The raw material for lime manufacture is quarried along with other aggregates. It is fired in kilns to produce quick lime.

2.19 Lime is used in the following applications:

- Steel manufacture (50% of UK lime production), with some of the lime produced at the steel sites;
- Flue gas desulphurisation at coal power stations;
- Construction – used to stabilise clay for foundations;
- Effluent treatment - to neutralise acidity;
- Biosolids – used in water treatment;
- Lime mortar construction;
- Concrete block manufacture; and
- Small amount in chemical applications.

2.20 The material is hard to store as quick lime reacts on contact with moisture in the atmosphere.

Chlor-alkali and Industrial gases

2.21 The Chlor-alkali process takes salt as a brine solution that is mined on site. The electrolysis of brine produces chlorine and hydrogen. The process is integrated with secondary chemical processes and the output products from the sector include:

- Caustic (an alkali) used in silicate, alumina, phosphates and polycarbonates;
- Chlorine used as a raw material in PVC manufacture, pharmaceuticals, crop protection and water purification (98% of water supplies use chlorine in the purification process);
- Hypochlorite used in cleaners (domestos);
- Hydrochloric acid used in steel manufacture;
- Solvents and dry cleaning agents; and
- Nitrogen and hydrogen gases and derivative gases such as hydrogen peroxide used in the paper industry.

2.22 Natural gas is used in this sector to produce electricity in CHP and power generation plant. Most of the electricity is used for the electrolysis process and the remainder is used to drive rotating machinery on site. Steam is used for heating chemicals, and in cold weather to keep the liquids above melting point (caustic freezes between 6 and 12 degrees Celsius).

Chemicals

2.23 The chemicals sector takes chemical products (often the output of other energy intensive industry) to synthesise more complex and sometimes bespoke products manufactured in batches.

- 2.24 The processes involve a combination of heating, drying and cleaning (e.g. thermal oxidiser). The sites are typically large installations with the various stages of the manufacturing process linked by pipelines that need to be kept warm to prevent freezing.
- 2.25 The output is a vast range of chemical products used in other sectors of the energy intensive industry (e.g. hydrogen peroxide used in Paper sector), and in other secondary manufacture of products such as cosmetics. One plant interviewed estimated they supply over 20,000 products to 7,000 customers.

Plastics

- 2.26 The main raw materials are simple plastic monomers, de-ionised water, peroxide (a catalyst) and suspending oxides. Thermoplastics are produced as part of a continuous process, which starts with a polymerisation reaction that is exothermic. After polymerisation the process involves chilling, stripping, centrifuge to spin dry and an air drier.
- 2.27 The outputs are solid and may be granular or in powder form.
- 2.28 PVC products are used in:
- Building;
 - Packaging; and
 - Electrical cables and wires.
- 2.29 Gas is used in the process for steam raising or for CHP. Gas is also used for heating air for drying.

Paper

- 2.30 The raw materials in the paper sector are pulp and recovered paper and energy. 65% of the energy used is gas.
- 2.31 The process takes place at one of 76 mills in the UK (2004 data), most of which use gas. The mills include around 500 MW of gas-fired CHP. The process also consumes more electricity than the 500 MW it generates for its own use.
- 2.32 In 2004, the UK produced 6.2 million tonnes, imported 7.7 and exported 1.3 million tonnes.
- 2.33 The finished paper products include:
- Newsprint;
 - Printings and writings;
 - Corrugated case materials;
 - Packaging papers;

- Packaging boards;
- Tissue; and
- Speciality and other.

2.34 For the downstream sector as a whole, 40% of supply is manufactured in the UK, the remainder is imported from suppliers in the EU. Packaging and tissue products are bulky and are manufactured in the UK close to market demand.

Heavy Food

2.35 The sector can be split into processing (e.g. sugar manufacture), cooking (e.g. baking) and packaging. The raw materials are food stuffs, cans, bottles and other packaging materials.

2.36 The process uses gas for raising steam to cook and sterilise equipment, and direct firing of ovens for baking.

2.37 The output is packaged foods ready for supermarkets and smaller outlets.

Manufacturing Industry: vehicle and aircraft manufacture

2.38 Car manufacture and aircraft manufacture are complex processes involving a large number of parts supplied from a large number of suppliers located in Europe and further afield (e.g. engine blocks from Brazil).

2.39 In car manufacture many of the components are delivered just in time, by lorry for each shift. The process is an integrated production line and interruption to one part of the process will cause production to stop. Gas is used in boiler houses for water heating, and also in paint shops: boiler houses typically have limited back-up fuel capability but paint shops do not.

Energy usage by sector

2.40 The Aluminium, Steel and Glass sectors shown in Table 1 use gas for heating the raw materials in the smelting and/or furnaces, and for reheating the product in any secondary processes.

2.41 Refineries use gas for generating electricity and to provide heat for the cracking of hydrocarbons. Natural gas is a raw material for the Ammonia sector, and is also used for heating the materials to the temperature required for the chemical reaction.

2.42 The Brick sector uses gas for baking. Gas is used for firing heat to reduce calcium carbonate to calcium oxide in the manufacture of lime (the rest of the Cement sector does not use gas).

- 2.43 Chlor-alkali, Industrial gases, Other chemicals and Plastics use gas for generating electricity, for heating and for direct firing of processes such as drying, thermal oxidation, methane reformers and high temperature processes. A typical modern plant would have a Combined Heat and Power (CHP) plant sized to meet the heat requirements at the site and to generate part of the electricity requirement.
- 2.44 Paper, Heavy Food and Manufacturing use gas for heating and for direct firing of processes such as baking. Many modern plants in these sectors have CHP plant.
- 2.45 Energy usage is significant in the sectors under study. The total daily gas demand from the energy intensive sector is 36.8 mcm/day (36.8 million cubic meters per day). Table 2 shows the breakdown of the daily gas demand between sectors, as determined by Global Insight.

Table 2 – Gas usage by sector

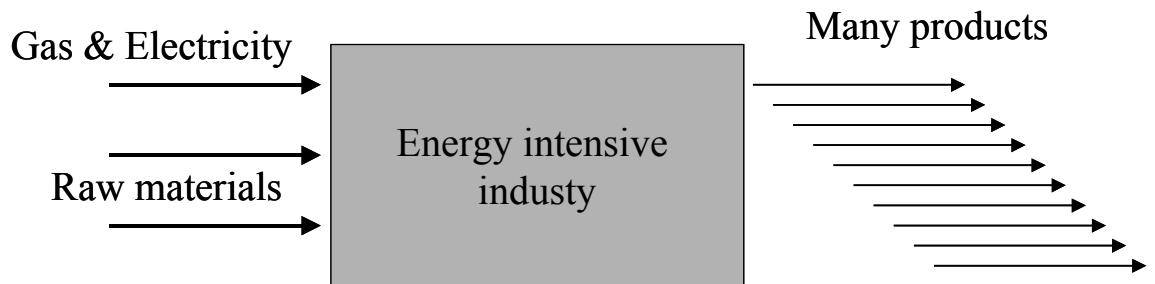
Sector	Gas demand (mcm/day)
Paper	4.4
Chemicals	7.6
Steel	4.8
Glass	1.3
Heavy Food	1.9
Ammonia	3.7
Other	13.1
TOTAL	36.8

Source: Global Insight

The economic chain: suppliers and customers

- 2.46 The energy intensive sectors are typically primary industry: they take raw materials that are mined (e.g. salt, sand) and recycled materials (e.g. glass cullet, aluminium scrap) and produce products that are used by secondary industry.
- 2.47 Typically the processes have a small number of suppliers, and supply a much larger number of customers.

Figure 1 – Representation of supply chain: few raw materials, many products



Source: ILEX

- 2.48 The economic impact of an interruption to production has a direct impact on suppliers of gas, electricity and raw materials. It also has a direct impact on a large number of customers, as the products supply a whole range of secondary industries.

3. ONE DAY INTERRUPTION

Key assumptions

- 3.1 A one-day interruption would be an unplanned event. The earliest that the industrial site would get notice of interruption is on the afternoon of the previous day; the notice could be within-day, in which case the site would have been interrupted with immediate effect.
- 3.2 We consider two scenarios for the gas interruption. Many sites require a proportion of the gas load for gas-critical processes, even when the main boiler plant is running on standby fuel. The scenarios we consider are:
- complete interruption of gas supply; and
 - substantial interruption, with minimal (essential) gas supply retained.
- 3.3 Under complete interruption of gas the site is isolated from the gas supply. However, it is still necessary to maintain pressure on the outlet pipe work for safety reasons.
- 3.4 Under minimal gas supply retained, the site is able to continue taking gas but at a greatly reduced level, and only for essential processes that have no alternative to gas. The site may continue production if it has the capability to meet the great majority of its energy needs from back-up fuel. It is envisaged that the minimal gas supply would be between 10 and 20% of the uninterrupted demand for the energy intensive sector as a whole (but with wide variation between individual companies). Sites that have no alternative fuel for the main process would retain a minimal supply to prevent freezing.
- 3.5 Under either of these scenarios, firm load shedding would be required, since the majority of energy intensive users are on firm rather than interruptible contracts.
- 3.6 In all of our analysis, we assume that electricity supplies are uninterrupted.

Interruption to the gas supply

Complete interruption

- 3.7 Under complete interruption, pursuant to an emergency and involuntary, no gas is used on the site. There are only a few sectors that can run the entire process from back-up fuel and within a sector the ability to cope varies.
- 3.8 Table 3 identifies the impact on the different sectors. Most sites are unable to continue production under a complete interruption. The exceptions are

Refineries⁹ and Paper mills, less than one third of Heavy Food manufacture, and, to a very limited extent, Chemicals, Glass and Steel manufacture..

- 3.9 Even in the sectors where some production continues, the gas supply for other on-site processes such as the catering facilities would be lost.

Minimal gas supply retained

- 3.10 Under minimal gas supply all the sites with back-up fuel capability for the majority of their energy needs would be able to continue production for one day.
- 3.11 Table 3 again identifies the impact on the different sectors. Sectors with sites that would be able to continue to operate include some Aluminium, most Steel, most Glass. Limited production would continue at sites in the Chlor-alkali, Chemicals, Plastics and Manufacturing and Heavy Foods sectors. There would be no production from sites in the above sectors that rely on gas as the main process. There would be no production from the Ammonia, Bricks and Lime sectors.

Site damage

- 3.12 When an interruption to the gas supply results in an interruption to the process it is possible that there will be damage to the site (e.g. freezing). When the gas supply is restored to the site it will be unable to restore production until it has repaired the damage. There may be damage to stock but this is unlikely to prevent the process from restarting. Site damage is likely to be much more severe under complete interruption than if a minimal gas supply is retained. However, it should be noted that many glass and steel furnaces, for example, are purely gas fired and would still incur damage if the bulk of their gas supply is interrupted.
- 3.13 Where the interruption occurs at short notice there may be insufficient time for an orderly run-down of production. It should not be assumed, however, that a notice period would always allow an orderly run-down and avoid site damage. Physical constraints at many sites (for example, a lack of space to dump molten material) mean that a stoppage in production would lead to site damage, however orderly the run-down.
- 3.14 Table 4 lists the site damage that could be expected if there were a one day gas interruption that resulted in the production process being interrupted. Aluminium, Steel and Glass would suffer damage from freezing of the molten materials in the process. Chlor-alkali, Chemicals and Plastics could suffer freezing of the

⁹ Our research indicates that a complete gas interruption would lead to some reduction in refinery output, although most production would continue. In the time available, we have not been able to quantify the reduction in refinery output. In our economic analysis (Chapter 7), we have not included any impact on refineries, or upstream oil and gas companies. This is likely to be over-optimistic and warrants further investigation.

materials within the pipes. Either of the above forms of damage would require capital expenditure and time for repairs and/or replacements.

- 3.15 Other processes may not incur physical damage but still incur delays in restoring the production process. Ammonia manufacture would take several days; Plastics could take several weeks.

Table 3 – Impact of one-day interruption to a site’s gas supply on production under two scenarios

Sector	Complete interruption of gas supply	Minimal gas supply retained
Aluminium	No production	Low level of production
Steel	Very limited production	Most production continues (except at sites that are purely gas fired)
Glass	Very limited production	Most production continues (excluding furnaces that are purely gas fired)
Refineries	Most production continues	Production continues
Ammonia manufacture	No production	No production
Bricks	No production	No production
Lime (Cement)	No production	No production
Chlor-alkali and industrial gases	No production	Limited production
Other chemicals	Few sites continue	Most sites continue
Plastics	No production	Limited production
Paper	Production continues	Production continues
Heavy Food	Less than one third continues	Less than one third continues
Manufacturing	No production	Limited production

Note the table considers the impact on the sites that use gas: production on sites that are fuelled by oil would not be impacted (e.g. lime kilns that burn oil). Source: interviews with industry.

Table 4 – Site damage if there is a one-day interruption to the gas supply

Sector	Site damage?
Aluminium	Freezing of the primary pots - 4 hours critical.
Steel	Freezing
Glass	Cracking of furnace – 1 hour critical
Refineries	
Ammonia manufacture	
Bricks	
Lime (Cement)	
Chlor-alkali	Freezing of product within pipelines
Industrial gases	
Other chemicals	Freezing of product within pipelines
Plastics	Freezing of product within pipelines
Paper	
Heavy Food	
Manufacturing	

Blanks mean that no significant damage to plant was identified. Source: interviews with industry.

- 3.16 Table 4 excludes the damage that could accrue from water freezing. All manufacturing processes that require water heating are susceptible to frost damage (burst pipes, etc.) if cessation to production coincides with cold weather. Such damage is potentially significant: one respondent reported damage of £500k from a single on-site frost protection failure.

Impact on customers

- 3.17 Interruption to the gas supply would result in reduced production, or no production from the energy intensive sectors. The customers supplied with finished product from the sectors may be supplied for a limited period from stocks of products held either on site or within the downstream supply chain.

- 3.18 All sectors hold at least some stock of the finished product. The amount varies by sector and by company within the sector. In some sectors, such as Chemicals and Lime, the product is covered by Control of Major Accident Hazards (COMAH) Regulations (1999) and only limited quantities are held in specially made containers.
- 3.19 Our interviews have shown that most of the sectors have moved to just-in-time manufacture, and have sought to reduce stock holdings in order to reduce capital requirement.
- 3.20 Following the interruption of the gas supply the ability to continue the supply of product will depend on the ability of a site to restore production. This will depend on the extent of any damage to the site.

Back-up fuel usage

- 3.21 Based on our interviews the sectors that are able to run on back-up fuel hold at least one day of stocks of back-up fuel. Assuming the one-day of interruption is an isolated day then there would be sufficient stocks.
- 3.22 If there were a number of one-day interruptions then stocks would have reduced and many sectors with back-up would require restocking for fuel to maintain production for a second or subsequent day.
- 3.23 We consider the impact of back-up fuel supply further in section 4.

4. THREE TO SIX WEEK INTERRUPTION

Key assumptions

- 4.1 The gas supply is interrupted for a continuous period of three to six weeks. The reduction in gas use might involve complete loss of gas supply, or the retention of a minimal supply, under emergency conditions; or alternatively be due to self-curtailed by industry in response to the gas price. The observations in this Chapter hold, whichever of these cases for gas supply pertains. As mentioned previously, self-curtailed would not on its own be sufficient to meet the requirements of a 1 in 10 winter.
- 4.2 Again, we assume electricity supplies are unaffected.

Shortage of back-up fuel

- 4.3 An interruption to the gas supply for three weeks or six weeks, will result in a step increase in the demand for backup fuels (gas oil and heavy fuel oil). Demand for the fuels could be as much as 2-3 times current levels. For example, gas oil demand could rise from around 0.5mt per month to 1.5mt per month, if industrial customers seek to replace all the gas they use with back-up oil.
- 4.4 Supply of fuel oil from refineries may be increased slightly (some refineries currently over-produce by around 10%), but this increase would be offset by the need to use gas oil (an output product from the refinery) to fuel the refinery itself – and our research suggests that not all of the CHP plant in the refineries sector can switch away from gas. There is not likely to be any increase in the net supply from the refineries to the industrial sector; it is more likely that there would be a decrease, but we have not been able, in the time available, to quantify this decrease.
- 4.5 The increase in demand for gas oil and fuel oil over a three or six week period could in theory be met from the strategic reserves, including those held outside Britain. However, if strategic reserves were used, the limitation would be in the capacity of the road tanker fleet to transport the fuel from the refineries and ports to the sites. There appears to be little surplus capacity.
- 4.6 Unable to restock with the back-up fuel, the industrial sites that could run on back-up fuel would run out of stocks. Most sectors hold a few days supply of back-up fuel; companies in a few sectors (e.g. some paper mills, some steel companies) hold two to three weeks stock of back-up fuel.

Impact on customers

- 4.7 Given the shortage of back-up fuel, none of the sectors, with the exception of the refineries sector, would be able to maintain supply of finished product to customers over a period of three to six weeks. There would be an interruption (or at least a substantial percentage reduction, in the case that a minimal gas supply is retained) to the supply of product to the industry downstream of the sectors studied.
- 4.8 Customers would initially be supplied from stocks, but in all sectors interviewed the loss of supply of finished product from stocks occurs within a week (in many sectors a day or two).
- 4.9 Therefore, customers would be forced to locate alternative sources of product. Alternative sources of product require surplus production capacity or stocks offshore, and for the product to be interchangeable. In many sectors production capacity is already committed and/or the product cannot be readily substituted (e.g. mould for glass containers, approvals required for chemical products).

Summary

- 4.10 An interruption of the gas supply for a period of three to six weeks would cause loss of supply of finished product in all sectors studied, except for refineries. In section 7 we attempt to quantify the high level economic impact on the UK economy.

5. CRITICAL NATIONAL INFRASTRUCTURE IMPACTS

- 5.1 When asked about the impact of a loss of production on the Critical National Infrastructure, respondents identified a number of potential impacts (Details are not included in this published report but have been passed to DTI.)
- 5.2 The potential impact requires closer examination as it would need to take account of the stock holdings, the ability of the process to be restored following an interruption, and the ability to source the product from other suppliers outside the UK.

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6. LONGER TERM EFFECTS

- 6.1 In this section we look at the longer term effects of an interruption to the gas supply. We have established in section 3 that a one-day interruption to the gas supply will cause production to stop at many sites within each sector. In section 4 we have identified that interruptions for a period of 3 to 6 weeks will cause production and supply of product to stop, or be severely reduced, in all sectors except refining (and the water sector, which does not use natural gas).

Physical impact on production plant

- 6.2 Sectors that would suffer physical damage to plant – if they are not able to retain at least some of their gas supplies – are listed in Table 4. For these sites there will be a requirement to rebuild the plant before production can restart. At some of these sites it is likely that the capital will not be spent and the sites will close permanently. From our interviews the permanent closure of some sites is seen as inevitable in the Aluminium and Glass sectors. It is also likely at sites in the Brick and Lime sectors where permanent damage to kilns would require the kilns to be rebuilt before production could restart.
- 6.3 In other sectors where the damage is freezing of the plant there may be significant time and money spent to repair damage on the site. In the Chlor-alkali sector the site would have to wait till warmer temperatures in spring to begin thawing and repairing plant. At some sites in the Plastics sector it could take weeks to bring back production and to achieve a quality of product that is saleable.
- 6.4 In manufacturing industry damage to boiler plant would have to be repaired before production could restart.

Financial impact on industry

- 6.5 In all sectors the lack of stocks (back-up fuel and finished products) would force shutdowns and interruptions to the supply of finished product to customers, for any gas interruption longer than a week.
- 6.6 All sectors would lose earnings due to production shutdown, and this would be a permanent loss from the bottom line. The lost production could not be made up at sites that are designed to operate at near maximum capacity 24 hours a day.
- 6.7 Customers facing supply interruption would try to continue production by sourcing alternative suppliers outside the UK. The result would be at least a temporary loss of market share to overseas suppliers. It would be difficult, though not necessarily impossible, for UK to win back the market share, given the highly competitive and globalised nature of the markets in which the energy intensive

industries operate. It is likely that many customers will prefer to diversify their supply of materials and import more than they had previously.

Impact on investment in UK

- 6.8 All sectors identified the recent significant increase in fuel prices as impacting on the profitability compared with sites operating in other countries. One interviewee identified that the high fuel prices had led to his company closing a glass production facility in Kent (the closure had been announced the week before the study).
- 6.9 Interruptions to the gas supply could impair future investment in the UK. The UK could be seen, at least in the short term, as a high-risk business environment with high fuel prices and low security of supply.
- 6.10 Most of the companies interviewed are international companies with parent companies operating similar sites in other countries within the EU and further afield. Several companies expressed concern that the parent company would shift production to sites outside the UK.

7. HIGH LEVEL ECONOMIC IMPACT

- 7.1 We have been asked to provide a high level quantification of the impacts that might result from gas interruption. In developing our approach, we have borne in mind:
- the relatively short timescales to collect and verify the data;
 - that information needs to be calculated in a similar way for all sectors in order for it to be comparable across different industries; and
 - the extent to which the installations affected by gas interruption ‘match’ the sector definitions used to compile the statistics.
- 7.2 The purpose of this section is:
- to describe the information available;
 - to provide high level statistics that build up a picture of the sectors:
 - directly affected by interruption;
 - directly upstream of those sectors that will be affected; and
 - directly downstream of those sectors that will be affected;
 - to provide a high level quantification of potential losses to the economy of an interruption to these sectors.
- 7.3 The text below is structured along these lines.

Information available

- 7.4 We have reviewed the sources of information listed below. We have concentrated on using published information that is readily available for all sectors, supplemented with information provided at interviews with industry representatives where available.
- Digest of UK Energy Statistics (DUKES) 2005;
 - Office of National Statistics (ONS) publications, including the Annual Business Inquiry (ABI)¹⁰; and
 - information provided at sector interviews.

Matching statistics to the installations affected by gas interruption

- 7.5 Whereas the Global Insight study¹¹ used 123 level codes to identify sectors much of the published information classifies industries using the standardised industry

¹⁰ <http://www.statistics.gov.uk/abi/>

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classification (SIC) codes. We have chosen the most appropriate SIC code for the installations we understand are affected, as shown in Table 5 below. When deciding which data to use for each indicator, we have gone to the most detailed level possible. In some cases, due to incomplete data, it has been necessary to stay at a more aggregate level than the closest match. In these instances, the data will overstate the impact (for instance, if we use GVA for the 27.40 class when Aluminium production actually only constitutes the 27.42 class).

Table 5 – Matching sectors for project to SIC codes

Global Insight sector	123 level	SIC sub section	SIC 2 digit class	2 digit class description
Aluminium	55	DJ	27.42	Aluminium production
Ammonia/Fertilisers	39	DG	24.15	Manufacture of fertilisers and nitrogen compounds
Bricks	51	DI	26.40	Manufacture of bricks, tiles and construction products, in baked clay
Cement	52	DI	26.51	Manufacture of cement
Chlor-alkali	37	DG	24.13	Manufacture of other inorganic basic chemicals (includes manufacture of alkalis, lyes and other inorganic bases except ammonia)
Gases	36	DG	24.11	Manufacture of industrial gases
Glass	49	DI	26.11	Manufacture of flat glass
Glass	49	DI	26.12	Shaping and processing of flat glass
Glass	49	DI	26.13	Manufacture of hollow glass
Glass	49	DI	26.14	Manufacture of glass fibres
Glass	49	DI	26.15	Manufacture and processing of other glass including technical glassware
Heavy food	12	DA	15.61	Manufacture of grain mill products
Heavy food	15	DA	15.83	Manufacture of sugar
Newsprint	34	DE	22.21	Printing of newspapers
Paper	32	DE	21.12	Manufacture of paper and paperboard
Paperboard	32	DE	21.12	Manufacture of paper and paperboard
Petrochemicals	35	DF	23.20	Mineral oil refining (includes manufacture of products for the petrochemical industry and for the manufacture of road coverings)
Plastics	40	DG	24.16	Manufacture of plastics in primary forms
Refining	35	DF	23.20	Mineral oil refining (includes

¹¹ “Demand side response from UK industry”, Global Insight, 20 May 2005

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Global Insight sector	123 level	SIC sub section	SIC 2 digit class	2 digit class description
Steel	54	DJ	27.10	Manufacture of basic iron and steel and of ferro-alloys

Source: Global Insight, ONS and ILEX

Definition of indicators

7.6 We have used the following indicators to provide an idea of the magnitude of any impact:

- gross value added (GVA) at basic prices: the value of goods and services less the value of the products used to make them¹². GVA is measured before the costs of wages and capital investment are taken into account;
- number of enterprises: the number of enterprises reported in the annual business inquiry (ABI) by the ONS for 2003 or by industry representatives during interviews (which reflects the situation in 2005); and
- number of employees: again, taken from the ABI where more detailed data was not available from the interviews.

Input-output analysis

7.7 We have also used the Leontief Inverse¹³ for 2000 published by the ONS to determine the sectors upstream of those that we expect to be directly affected by gas interruption. The table shows how a marginal (1 unit) increase in demand for a product will impact on demand for the products in each SIC codes. It includes the direct and indirect impacts but not induced effects¹⁴. We have been able to use this table to show two things:

- the upstream sectors that would be affected by a marginal reduction in the output of a product in one SIC code (due to a gas interruption); and
- the relative magnitude of the upstream impact of a marginal reduction in output from different sectors.

¹² ONS definition: $GVA + \text{taxes on products} - \text{subsidies on products} = GDP$

¹³ Refer to the link below for a full description of how the Leontief Inverse is used for UK input output analysis
http://www.statistics.gov.uk/about/methodology_by_theme/inputoutput/

¹⁴ A definition of these is provided at
http://www.statistics.gov.uk/downloads/theme_economy/1995_UK_Analytical_Input-Output_Tables_detail.zip

- 7.8 Note that this table is produced on the basis of the 123 industry classification (rather than SIC codes). We have therefore mapped the SIC codes identified above onto the 123 classification. Again, in some instances, the 123 classification is much broader than the SIC code.

Simplifying assumptions

- 7.9 In order to allow quantification of the impacts in the time available, we have made the following simplifying assumptions:
- a sector's output is spread evenly across the year (so a day's output constitutes 1/365 of total annual output). This assumption is least appropriate for those industries that are seasonal in nature:
 - it will overstate the impact where output tends to be lower than average in winter;
 - it will understate the impact where output is usually higher than average in winter; and
 - the GVA generated by a sector is spread evenly across all its output. This is least appropriate where we have used aggregate sector classes and that aggregate sector includes a range of diverse products the GVA of which varies significantly.

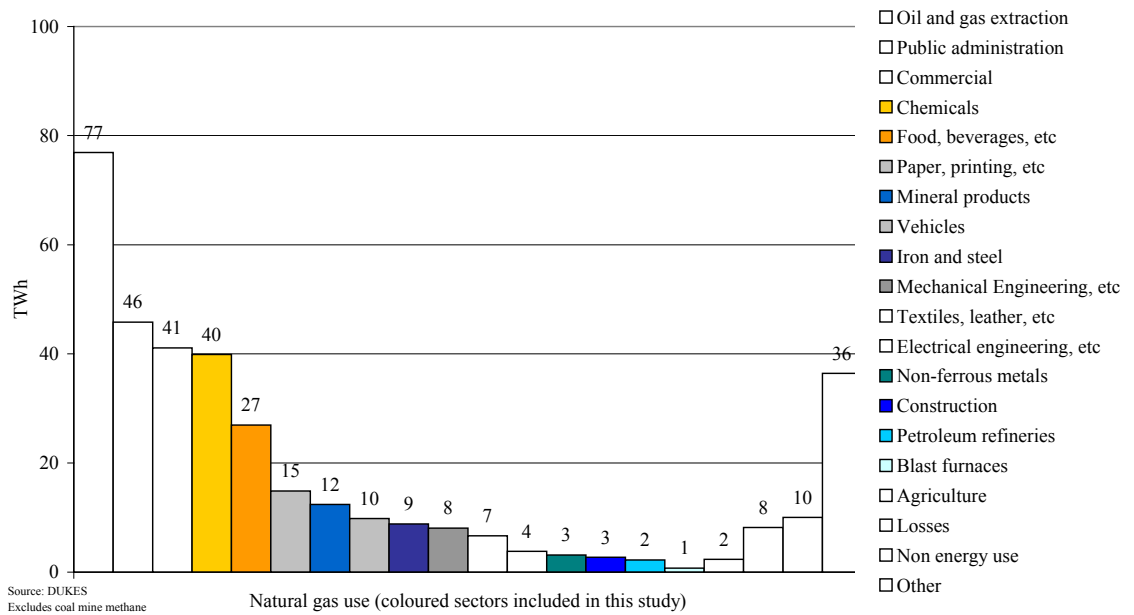
Sectors directly affected by gas interruption

- 7.10 We first look at the sectors from a UK wide perspective. The energy intensive sectors that we have considered are – as agreed between ILEX and DTI – those analysed in Global Insight's report "Demand side response from UK industry", Global Insight, 20 May 2005. The reasons for choosing these sectors are twofold: a) to be consistent with the parallel study undertaken by Global Insight in December 2005 and b) energy intensive sectors are likely to meet the bulk of a reduction in gas supply to industry.

Maximum potential reduction in gas use by sector

- 7.11 We show how much gas each of these sectors uses in Figure 2 below; the coloured bars represent those sectors covered in the report (the colours themselves are not significant). The height of each bar represents the amount that these sectors could reduce their gas demand if they stopped using gas altogether (either by stopping production or switching to an alternative fuel).
- 7.12 It shows that this study captures the main industrial users of natural gas, although it is worth bearing in mind that, in some cases (food and paper in particular), we have focussed on only a subset of the industries covered under each of these high-level sectors.

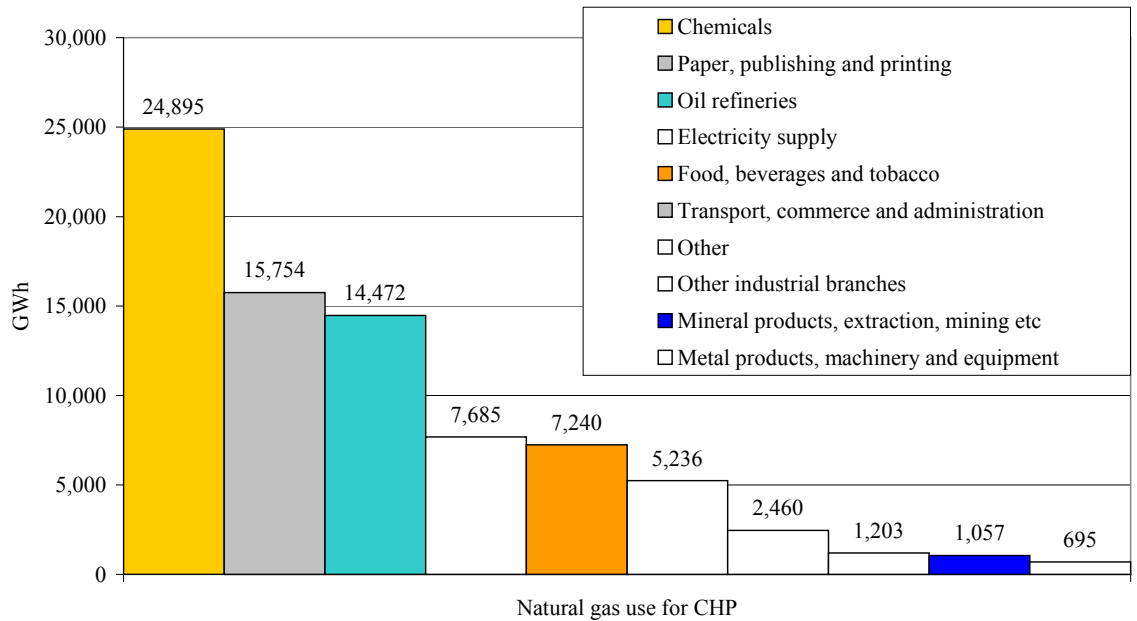
Figure 2 – Gas use by sector



Source: DUKES and ILEX Note: excludes domestic natural gas use and use for electricity generation.

7.13 We have also compared how much of this gas use is for the generation of electricity and heat in combined heat and power (CHP) plant. Figure 3 shows that the largest users of natural gas for CHP are chemicals; paper, publishing and printing; and oil refineries. Some of these sites would be able to switch to back-up fuels and continue to operate the CHP even if the gas supply was cut. Others would need to switch to importing power from the transmission grid and generating heat through stand-alone boilers in the event of a gas interruption. The extent to which this is possible depends on the site and the industry.

Figure 3 – Gas use for CHP by sector

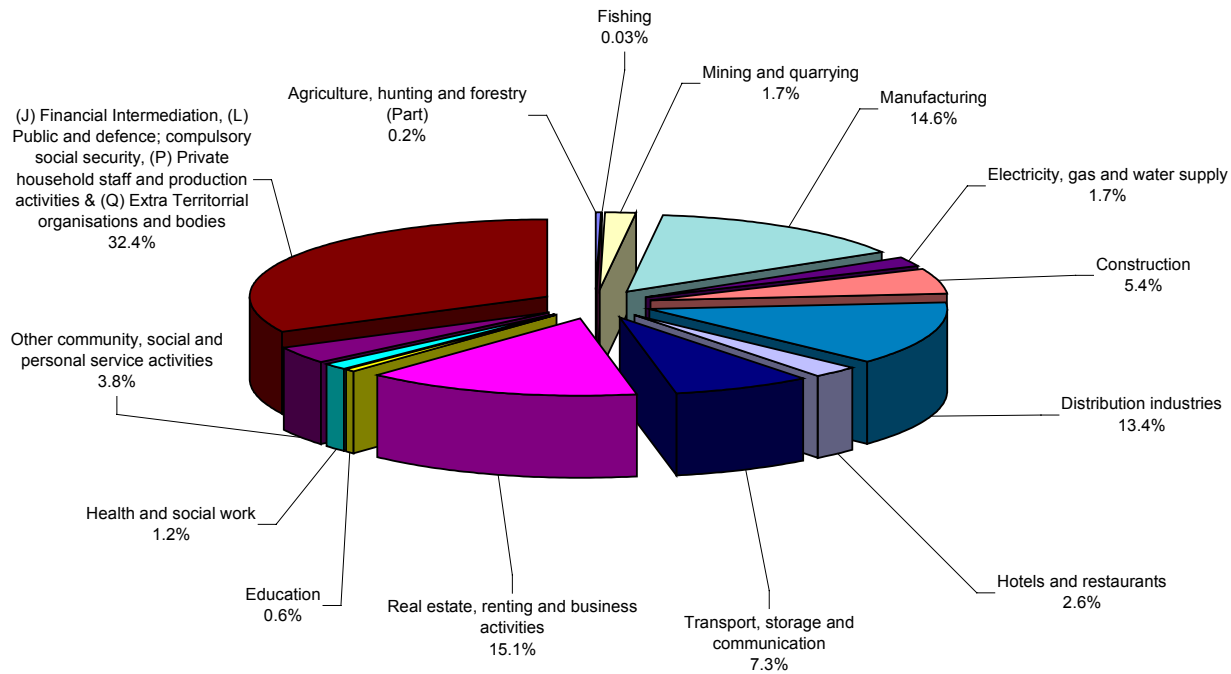


Source: DUKES and ILEX

Financial impact (gross value added)

7.14 Figure 4 shows a breakdown of the economy wide GVA by SIC sector.

Figure 4 – Breakdown of 2003 GVA by SIC sector



Source: ONS and ILEX. Note: ONS data for J, L, P and Q was calculated using ABI data and online material (<http://www.statistics.gov.uk/CCI/nugget.asp?ID=946&Pos=&ColRank=2&Rank=448>).

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7.15 We have compared the contribution to GVA of each of the sectors directly affected by a gas interruption in Table 6 below. We have excluded Refineries and petrochemicals, and Water, from the Table: the former on the basis that a gas interruption would not reduce production (although, as stated previously, this may be an optimistic assumption – we have been informed that some CHP plant at refineries cannot switch away from natural gas, but have been unable in the time available to quantify the magnitude of this effect); and the latter on the basis that the Water sector does not use natural gas. The table shows the sector with the largest GVA is heavy food, and the smallest is newsprint.

Table 6 – Gross Value Added (GVA) and proportion of UK GVA by sector

Global Insight sectors	Best SIC code match	Code used to provide data	GVA (£ million)	% of UK GVA
Aluminium	27.42	27.42	428	0.04%
Ammonia/Fertilisers	24.15	24.15	173	0.02%
Bricks	26.40	26.40	399	0.04%
Cement	26.51	26.51	442	0.05%
Chlor-alkali	24.13	24.13	535	0.05%
Gases	24.11	24.11	450	0.05%
Glass	26.10	26.10	1344	0.14%
Heavy food (grain)*	15.61	15.60	982	0.10%
Heavy food (sugar)*	15.83	15.80	8228	0.84%
Newsprint	22.21	22.21	122	0.01%
Paper and paper board*	21.12	21.10	879	0.09%
Plastics	24.16	24.16	1159	0.12%
Steel	27.10	27.1	602	0.06%

Source: ONS, stakeholder meetings and ILEX Note: The table shows the SIC code we would ideally use to classify these installations and the SIC code for which data was available. Where the SIC code on the right is less detailed than the SIC code on the left, the data covers more installations and operations that we would optimally have captured (e.g. we have used 21.10 which includes the manufacture of pulp as well as the manufacture of paper and paperboard).

7.16 These tables can be used to show the following (based on the simplifying assumptions described in paragraph 7.9 above). For instance, if the gas interruption were to result in one day's output being lost from the manufacture of Chlor-alkali, the GVA impact of this loss would be £1.47m ($535 \times (1/365)$). We summarise these results for each of a one day, three week and six week interruption in Table 7 below.

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Table 7 – Impact of different lengths of production interruption on GVA by sector

Global Insight sectors	SIC code for data	Impact of 1 day interruption (£ million)	Impact of 3 week interruption (£ million)	Impact of 6 week interruption (£ million)	Impact on economy GVA of 6 week interruption
Aluminium	27.42	1	25	49	0.005%
Ammonia/Fertilisers	24.15	0	10	20	0.002%
Bricks	26.40	1	23	46	0.005%
Cement	26.51	1	25	51	0.005%
Chlor-alkali	24.13	1	31	62	0.006%
Gases	24.11	1	26	52	0.005%
Glass	26.10	4	77	155	0.016%
Heavy food (Grain)	15.60	3	56	113	0.012%
Heavy food (Sugar)	15.80	23	473	947	0.096%
Newsprint	22.21	0	7	14	0.001%
Paper and paper board	21.10	2	51	101	0.010%
Plastics	24.16	3	67	133	0.014%
Steel	27.10	2	35	69	0.007%
Total		58	1219	2438	0.18%

Source: ONS and ILEX. Note: 0 represents an impact below £0.5million

- 7.17 We are assuming here that production ceases for a period of 1 day, 3 weeks or 6 weeks. By contrast, we understand that Global Insight, in the work they are undertaking concurrently, have identified a “voluntary” response (self-curtailment by industry) of around 14% production reduction (saving 5 mcm/day out of a total of 36.8 mcm/day) for a duration of 60 days. On a simple pro rata basis, this would equate to a reduction of 20% over a 6-week period (to achieve the same gas reduction).
- 7.18 Hence, the economic impact of a “voluntary” response (self-curtailment by industry) might only be around 20% of what we are projecting for full curtailment over a 6-week period. However, the Global Insight analysis shows further that, even with an ambitious increase in back-up gas oil consumption (15-20%, maintained for a 60-day period), the total gas saving is around 0.5 bcm, or approximately half that identified in the Winter Outlook for a 1 in 10 winter. The

voluntary response identified by Global Insight, taken in isolation, would not provide the necessary reduction in gas use as identified in the Winter Outlook.

Employment implications

- 7.19 We have also looked to see how many enterprises and employees work in the sectors that would be directly affected by a gas interruption (again excluding the refineries sector). Table 8 below shows that the heavy food sector has the largest number of enterprises and employees while the smallest number of enterprises are engaged in the manufacture of industrial gases and the newsprint sector employs the smallest number of individuals.

Table 8 – Number of employees and enterprises by sector

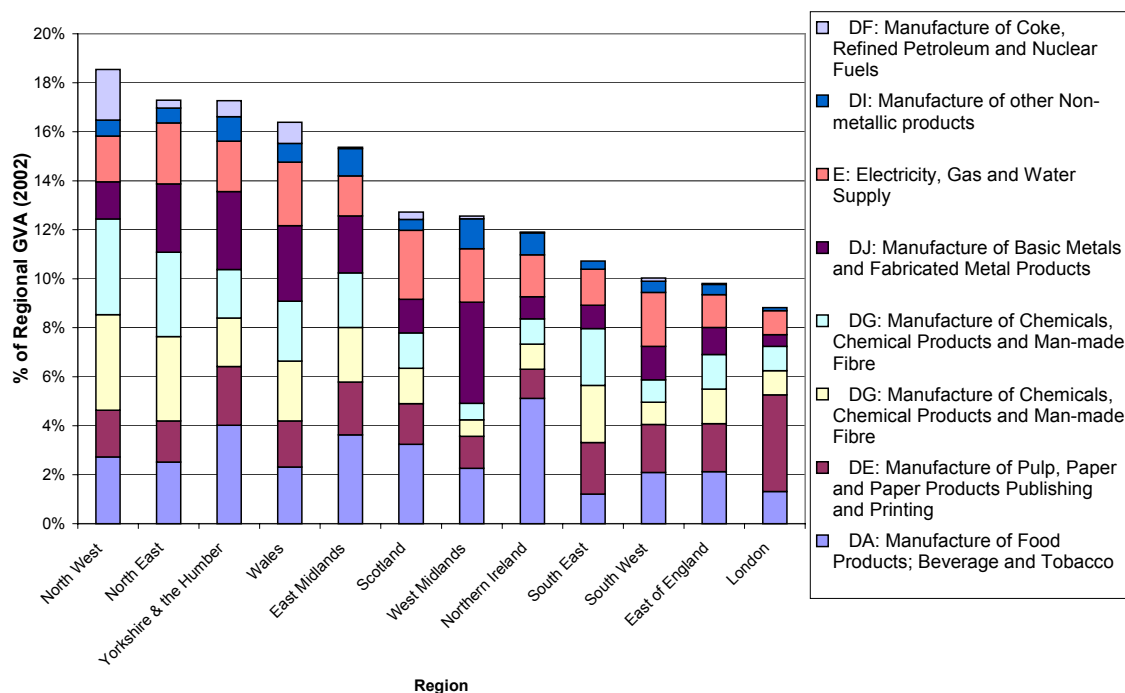
Global Insight sectors	Best SIC code match 2 digit class	Code used to provide data	Enterprises	Employees (Thousand)
Aluminium	27.42	27.42	227	11
Ammonia/Fertilisers	24.15	24.15	81	3
Bricks	26.40	26.40	271	9
Cement	26.51	26.51	27	4
Chlor-alkali	24.13	24.13	187	8
Gases	24.11	24.11	22	7
Glass	26.10	26.10	1443	33
Heavy food	15.61	15.60	129	14
Heavy food	15.83	15.80	3335	194
Newsprint	22.21	22.21	85	2
Paper and paper board	21.12	21.10	406	17
Plastics	24.16	24.16	623	19
Steel	27.10	27.1	399	28
Total			7235	349

Source: ONS and ILEX

Regional effects

- 7.20 In Figure 5 below, we show the regional distribution of the Global Insight sectors. Where data was unavailable for the exact SIC code we have aggregated up into the appropriate sector.

Figure 5 – Percentage of total 2002 GVA in each region by sector



Source: ONS and ILEX Note: South East has a negative GVA for section DF which we have excluded here.

7.21 The North West region, with 18%, has the largest percentage of its regional GVA accounted for by the Global Insight sectors whereas London has approximately half that. Because of the aggregated nature of the data, this graph is not a representation of the potential losses to each region by interruption to the Global insight sectors. It represents a comparison of the size (by % of GVA in each region) of the sectors that contain the Global Insight industries¹⁵.

Sectors upstream of gas interruption

7.22 We have identified which sectors are upstream of those directly affected by gas interruption using the Leontief multiplier. This shows how a marginal increase in demand would impact on the demand for other sectors. It can therefore also be used to indicate how a marginal decrease in demand might affect those sectors (e.g. as a result of a one day gas interruption).

7.23 The table below shows (in the left hand column) which sectors would be affected by a change in demand from the sectors directly affected by gas interruption (listed across the top row).

¹⁵ i.e. The North West is likely to experience a larger percentage GVA drop than London would, in the event of a cross Global Insight gas interruption.

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Table 9 – Upstream sectors affected by small changes in core sector demand

Upstream sectors	Sectors directly affected by gas interruption													
	Aluminium	Ammonia/ Fertilisers	Bricks	Cement	Chlor-alkali	Glass	Heavy food	Heavy food	Newsprint	Paper and paper board	Refining and petrochemicals	Plastics	Steel	Water
Banking & finance	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Wholesale distribution	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Other land transport	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Electricity production & distribution	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ancillary Transport services	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Oil & gas extraction	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Construction	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Estate agent activities	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Miscellaneous manufacturing nec & recycling	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gas distribution	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Agriculture	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Wood & wood products	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Coal extraction	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Coke ovens, refined petroleum & nuclear fuel	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Inorganic chemicals	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Accountancy services	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Paper & paperboard products	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Animal feed	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Membership organisations nec (pt)	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Industrial gases & dyes	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Insurance & pension funds (pt)	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: ONS and ILEX Notes: excludes impact on impact on demand within the directly affected sector. For each sector we have chosen the top five sectors that would be affected.

7.24 Table 9 shows that the Banking and Finance, Wholesale distribution, Other land transport and Electricity production and distribution sectors would be impacted as a result of changes in demand from nearly all of the core sectors.

7.25 We have not attempted to calculate the extent of the losses to these sectors in this report due to the significant difficulties with quantification from:

- the diverse customer base of these industries making it difficult to put a figure on the GVA losses we could expect from an interruption in gas supply specific to the Global Insight sectors;
- problems with looking at the direct chain of supply from the upstream sectors to the Global Insight sectors; and
- indirect effects to the banking sector as its performance will be strongly linked to the economy's performance as a whole.

7.26 We have also used the multipliers to rank the magnitude of the knock-on impacts upstream. The table below shows in descending order of impact the total multiplier for each of the directly affected sectors. The bigger the multiplier, the greater the knock-on impact a change in demand would have on upstream sectors. The right hand column excludes the impact of a change in demand on the demand in the sector itself.

Table 10 – Ranking of sectors by Leontief multiplier

123 classification	Directly affected sector	Sum of multipliers	Sum of multipliers excluding impact within that sector
15	Sugar	2.30	1.30
12	Grain milling & starch	2.21	1.14
54	Iron & steel	2.04	0.87
39	Fertilisers	2.00	0.83
35	Coke ovens, refined petroleum & nuclear fuel	1.95	0.92
55	Non-ferrous metals	1.92	0.63
49	Glass & glass products	1.88	0.73
32	Pulp, paper & paperboard	1.79	0.70
36	Industrial gases & dyes	1.78	0.73
37	Inorganic chemicals	1.71	0.66
52	Cement, lime & plaster	1.71	0.66
40	Plastics & Synthetic resins etc	1.70	0.63
34	Printing & publishing	1.70	0.54
51	Structural clay products	1.65	0.65

Source: ONS and ILEX

- 7.27 The table above shows that the heavy food sectors would have the greatest impact on demand upstream followed by iron and steel and fertilisers. If we exclude the impacts within a given sector, the multiplier on heavy foods is still the largest and that for refineries is larger than that for iron and steel.
- 7.28 The multiplier is best used to measure marginal losses or gains and their demand affects across sectors (paragraph 7.22). The application of this multiplier to a complete loss in production (i.e. simply multiplying directly affected sector GVA) is not possible due to the non-marginal production losses we would expect from gas interruption.
- 7.29 We can, however, use the multiplier to identify those upstream sectors that are likely to be affected by our Global Insight sectors. As can be seen in Table 9 above, the Banking & Finance, Wholesale distribution, Other Transport and the Electricity production and distribution sectors are all upstream of the majority of the affected sectors although quantifying the effect on these sectors would be very problematic (see paragraph 7.24).
- 7.30 Table 11 shows the GVA of Agriculture. This upstream sector has been included specifically due to its direct linkage to the Heavy Foods sector and the likely unrecoverable nature of its sales losses. Other identified sectors have been

excluded here not because they are unlikely to be affected but due to difficulties in quantifying these effects (see above).

Table 11 – 2003 GVA of upstream sectors affected by a reduction in output in the core sectors

Upstream sectors	Code used to provide data to right	Number of enterprises	Approximate gross value added at basic prices (£ million)	Total employment - point in time (Thousands)	GVA as percentage of whole economy GVA
Agriculture	01	16219	1304	59	0.13%

Source: ONS and ILEX

- 7.31 We stress once again that we are assuming the refineries sector would not experience reduction to output, because we have not had time to quantify the impact associated with CHP schemes that cannot switch away from gas. If refineries were to be significantly affected, then Table 11 would look very different, because the upstream oil and gas sector would also be included: this sector contributes 1.48% of economy GVA.

Sectors downstream of gas interruption

- 7.32 We have also looked at the possible impacts downstream of the directly affected sectors. To do this we have taken information provided during interviews with stakeholders to form a view of the key customers of the sectors studied.
- 7.33 The table below shows the GVA of the downstream sectors we understand would be most affected by a reduction in output in the core sectors. Some of the sectors that are directly affected by gas interruption are also downstream of some other sectors. We have not included them here in order to avoid double counting the impact. Since we have not included Water in the directly affected category, we include it here: the Water sector is downstream of the Chemicals sector.

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Table 12 – 2003 GVA of downstream sectors affected by a reduction in output in the core sectors

Downstream sectors	Code used to provide data to right	Number of enterprises	Approximate gross value added at basic prices (£ million)	Total employment - point in time (Thousands)	GVA as percentage of whole economy GVA
Vehicles	34.10	657	4089	93	0.42%
Aviation	35.30	664	6446	99	0.66%
Construction	45.2	93718	33291	775	3.39%
Concrete	26.63	165	425	7	0.04%
Packaging	74.82	1449	635	27	0.06%
Packaging (Plastics)	25.22	532	1084	30	0.11%
Glass Containers	26.13	88	353	7	0.04%
Wires & cables	31.3	388	383	11	0.04%
Silicon chips	30.02	1628	1888	26	0.19%
Shoes	19.3	299	200	6	0.02%
Water	41.00	136	2838	28	0.29%
Total		99588	48794	1081	5.26%

Source: ONS and ILEX

Economic impact of various emergency interruption scenarios

- 7.34 We have developed a number of scenarios to try to quantify the possible effects of an emergency gas interruption on the UK economy. It is worth noting that such an interruption could have many far reaching effects, the quantification of which is outside the remit of this study.
- 7.35 We have identified costs to directly affected sectors and also to those sectors immediately upstream and downstream of the affected sector. There is also the potential for very large additional costs (due inter alia to plant damage, market loss, site closures, etc.) to some industries, above and beyond the direct loss in production from the gas interruption.

Direct effects

- 7.36 In the simple direct effects or best case scenario, set out in Table 13 below, we assume that the only effect on the economy of a gas interruption will be the production loss of those industries which have their gas interrupted. This assumes that all downstream industries can source inputs from alternative sources and all upstream industries can supply to alternative customers at no extra cost. Further costs will be introduced as we move on to subsequent scenarios.

Table 13 – Best case scenario for a 1 day, 3 week and 6 week interruption of gas to Global Insight sectors.

(£m)	Impact of 1 day interruption	Impact of 3 week interruption	Impact of 6 week interruption	Impact on economy GVA of 6 week interruption
Direct effects	43.13	905.76	1811.52	0.18%

Source: ONS and ILEX

Direct and Downstream effects

- 7.37 We now examine the knock-on effects to the immediately downstream sectors identified in Table 12 of an interruption to the directly affected sectors. We use a similar method to that outlined above (i.e. 1/365 of GVA lost per day of interruption), although in practice it is unlikely that any of these downstream sectors would experience a complete production loss in the short term. However, in the case of a three to six week interruption, where alternative supplies were unobtainable, we could expect large production losses across these downstream sectors.

Table 14 – Direct and downstream scenario: Best case + Downstream effects for a 1 day, 3 week and 6 interruption of gas to Global Insight sectors

£m	Impact of 1 day interruption	Impact of 3 week interruption	Impact of 6 week interruption	Impact on economy GVA of 6 week interruption
Direct effects	43.13	905.76	1811.52	0.18%
Downstream effects	141.46	2970.61	5941.22	0.61%
Total	184.59	3876.37	7752.74	0.79%

Source: ONS and ILEX

Upstream effects

- 7.38 The Leontief multipliers show how a marginal loss in demand for each directly affected sector will have differing levels of upstream effect depending on which sector is affected (paragraphs 7.22 to 7.27). The multiplier is best used to measure marginal losses or gains and their demand affects across sectors (paragraph 7.22). The application of this multiplier to a complete loss in production (i.e. simply multiplying directly affected sector GVA) is not possible due to the non-marginal production losses we would expect from gas interruption.
- 7.39 We can, however, use the multiplier to identify those upstream sectors that are likely to be affected by our Global Insight sectors. As can be seen in Table 9 above, the Banking & Finance, Wholesale distribution, Other Transport and the Electricity production and distribution sectors are all upstream of the majority of the affected sectors although quantifying the effect on these sectors would be very problematic (see paragraph 7.24).
- 7.40 In Table 15 we have added the quantifiable knock-on effects of an interruption on the immediate, identifiable upstream sectors from Table 11 on page 36. This total (of the direct, downstream and upstream effects) can be referred to as the ‘immediate effect’ (i.e. the effects on industries directly next to and largely reliant on the Global Insight industries).

Table 15 – Full ‘immediate effect’ scenario: Best case + Downstream + Upstream effects for a 1 day, 3 week and 6 interruption of gas to Global Insight sectors

£m	Impact of 1 day interruption	Impact of 3 week interruption	Impact of 6 week interruption	Impact on economy GVA of 6 week interruption
Direct effects	43.13	905.76	1811.52	0.18%
Downstream effects	141.46	2970.61	5941.22	0.61%
Upstream effects	3.57	75.02	150.05	0.02%
Total	188.16	3951.39	7902.79	0.81%

Source: ONS and ILEX

- 7.41 The results for economic impact show a range of 0.18% to 0.81% for the immediate impact on GDP in 2006, depending on whether the downstream and upstream sectors are taken into account as well as the directly affected sectors. Assuming that the volume of gas saved is 0.9 bcm, the economic cost, on a £/therm basis, ranges between £5.47/therm and £23.88/therm.

Additional effect

- 7.42 We take ‘additional’ effects or costs to be costs to the economy or industries above and beyond those associated with a simple loss in production.
- 7.43 Additional effects include:
- upstream and downstream effects that were unquantified, including effects further up and down the supply chain;
 - the costs and extra time needed to restart the process of production once gas supplies return (in some cases restarting the process would be impossible once stopped);
 - costs of replacing equipment or stock damaged by the loss of gas supply (in some cases this is much more significant than the loss of production itself);
 - loss of both short and long term market share of domestic producers to continental companies in industries where produce can be imported/exported; and
 - loss of investment in the UK due to a downgrading of perceived security of supply.

Full economic impact

- 7.44 Within the above scenarios are contained a range of estimates of the economic impacts of a gas interruption to our core sectors.
- 7.45 The Best case scenario, in that only core sectors are affected, is unrealistic in practice due to the interconnected nature of UK industry, and the existence of large ‘additional costs’ to specific industries of even a short-term, complete loss of gas supply. However, effects of an interruption on industries both immediately before and after the affected industries in the supply chain (Upstream and Downstream effects) are, on balance, likely to be mitigated somewhat by the possibility of sourcing from alternative suppliers and supplying to alternative customers.
- 7.46 We can expect an actual ‘immediate effect’ of somewhere between the Best case scenario shown in Table 13, and the Full ‘immediate effect’ scenario shown in Table 15. The additional costs of such an interruption have not been quantified here (and would prove difficult to estimate at all) although it is reasonable to assume that for a 3 to 6 week interruption they would be significant.

Economic impact of ‘self curtailment’ by industry

- 7.47 As discussed above in paragraph 7.18, the parallel study performed by Global insight has identified a potential ‘self curtailment’ by industry that would lead to a saving of approximately 0.5bcm, assuming also an increase in gas oil

consumption of around 15-20%, maintained over a 60-day period. It is worth noting that this is approximately half the amount needed as identified in the Winter Outlook 1/10 winter scenario.

- 7.48 The described 'self curtailment' described was approximately 14% of production for a 60 day period or, on a pro rata basis, 20% over a 6 week basis. We have applied this scaling (i.e. a 19.4% reduction in output rather than the 100% reduction in output seen in Table 15) in Table 16 below.

Table 16 – Immediate effects of Global Insight 'Self Curtailment' by industry

£m	Impact of 6 week 20% 'Self Curtailment'	Impact on economy GVA of 6 week 20% Self Curtailment
Direct effects	351.44	0.036%
Downstream effects	1152.60	0.117%
Upstream effects	29.11	0.003%
Total	1533.14	0.16%

- 7.49 The results are a range of 0.04% to 0.16% impact on GDP, depending on whether upstream and downstream effects are included. On a per therm basis, the economic cost ranges between £1.91/therm and £8.34/therm.

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8. CONCLUSIONS

- 8.1 A gas supply interruption to the industrial sector this winter could cause widespread commercial damage. This damage would consist of lost production at a minimum. It could also entail physical damage to certain plant if it is forced to cease production, interruptions to downstream customers and upstream suppliers and, in the longer term, loss of market share, plant closures and job losses¹⁶.

1-day emergency (involuntary) interruption

- 8.2 A 1-day emergency interruption would be an unplanned event, with industry given little or no notice. Its effects would differ substantially depending on whether the interruption is complete or whether a minimal supply (10-20%) of gas is retained to keep plant warm and for processes that have no alternative fuel.
- 8.3 Complete gas interruption would cause production to stop in most of the energy intensive sectors. A few sectors, such as paper and refining, might be able to switch entirely to back-up fuel for a day. Most sectors, however, even those with back-up fuel capability, require at least some gas to maintain operations. The highly integrated nature of many sectors (such as chemicals and vehicle manufacture) reinforces industry's reliance on gas.
- 8.4 If a certain amount of gas supply is retained during a 1-day interruption, then production will continue in most sectors, but at reduced output levels. The amount of gas that needs to be retained varies widely between companies: we found that on average across the energy-intensive sector, the retention of 10-20% of normal supplies would suffice to keep some production going, but certain sectors, including ammonia and aluminium, would require a much higher proportion. The sectors that have back-up fuel capability to substitute for a portion of their gas use (refining, paper, steel, glass, some heavy food and some chemicals) generally have enough for one day.
- 8.5 Generally, there are low stocks of finished product in most sectors, so even a 1-day production stoppage would affect downstream customers.

3-6 week emergency (involuntary) interruption

- 8.6 In a 3-6 week emergency interruption, all sectors would be forced to stop or severely curtail production, and their downstream customers would be interrupted. The road haulage industry in Britain could not cope with a significant rise in demand for back-up fuel; and none of the industries that we surveyed hold back-

¹⁶ In the longer term still, some of the lost market share might be won back; alternatively, there would be a transfer of employment to other sectors of the economy. A proper analysis of these effects would require a much longer study than this one.

up stocks for this duration. At most, our research suggests that 10-15% of gas demand in the energy intensive sector could be substituted by back-up fuel.

- 8.7 The immediate effect on the economy of a 6-week interruption would be a loss of between 0.18% and 0.81% of annual GDP in 2006 (a range of £5.47/therm to £23.88/therm for each therm of gas saved). These figures are solely based on the value of lost production during the 6-week period. The lower end of the range assumes that sectors directly upstream and downstream are unaffected, i.e. they can immediately find alternative suppliers/customers for all of their purchases/sales. The upper end of the range assumes that certain sectors upstream and downstream cease production for 6 weeks. In deriving this range, we have tried to limit attention to sectors directly upstream or downstream, although in practice this is not clear-cut in the sectoral classifications of the British economy. Other sectors, not included in our study, might also incur some immediate reduction in production.
- 8.8 For a 3-week interruption, we estimate that the immediate impact would be approximately half as much, i.e. 0.09% to 0.40% of GDP in 2006, depending on the extent of production lost in sectors upstream and downstream.

Self-interruption

- 8.9 Global Insight have analysed the likely response if gas reduction is limited to self-curtailement by industry. For the purposes of this report, 'self-curtailement' is defined as reduction in production by industry in response to the price of gas. Their estimate is a reduction of 5.0 mcm/day (out of a total demand of 36.8 mcm/day), for a period of 60 days. This is equivalent, on a total gas volume basis, to a reduction in industrial production of around 20% for a 6-week period – rather than the reduction of 100% that we are assuming.
- 8.10 ILEX estimates that the immediate economic consequence of this self-curtailement would be a loss of GDP in 2006 of between 0.04% and 0.16%.
- 8.11 It is also clear from Global Insight's analysis, and our own, that such a response would fall well short of the 0.9 bcm that the Winter Outlook has identified as potentially required from industry. To achieve this saving would require (the equivalent of) at least 3 weeks of complete production stoppage, even under optimistic assumptions for back-up fuel availability (a 15-20% increase in gas oil consumption, maintained over a 60-day period). The bulk of our analysis has been concerned with the economic consequences of the 1 in 10 winter defined in the Winter Outlook, which cannot be limited to self-curtailement.

Longer term effects

- 8.12 In the longer term, there would be further economic effects including a loss of market share in most of the energy intensive sectors. Customers facing supply interruption would try to continue production by sourcing alternative suppliers outside the UK. It would be difficult for the UK to win back the market share,

and our research suggests that many customers will diversify their supply of materials and import more than they had previously.

- 8.13 Most of the companies interviewed are international companies with parent companies operating similar sites in other countries within the EU and further afield. Several companies expressed concern that the parent company would shift production to sites outside the UK.
- 8.14 Several sectors, including aluminium, steel, glass and chemicals, would be exposed to site damage if production stops. In the case of aluminium and glass, it is very likely this would entail permanent plant closure. If the weather is below freezing, site damage would be more widespread, due to frost damage to boiler houses and other site infrastructure.
- 8.15 Energy intensive industry employs around 400,000 people, and the immediate downstream sectors employ a further one million. Many of these jobs would be at risk from a 3-6 week interruption, although we have not quantified the exact number.
- 8.16 There would also be knock-on effects in the economy beyond the immediate customers and suppliers of energy intensive industry. These effects are beyond the remit of this study.

Recommendations

- 8.17 We recommend that consideration be given to making some industrial sectors “priority gas consumers” to be protected from the emergency load shedding requirements. We also recommend that consideration be given to allowing some industrial customers to take sufficient gas – typically 10 to 20% of normal consumption - in order to maintain some production. A proper investigation into these recommendations would require a longer period of research and analysis than has been allowed for this study. Careful thought would need to be given to the basis of prioritisation to ensure that it does not lead to unwanted and unintended social and economic distortions.
- 8.18 The impact of a gas supply interruption on the CNI could potentially be severe; hence we recommend that further work be done to ensure that gas supply is maintained at all times to the companies/sectors where CNI effects are relevant.
- 8.19 We suggest that an investigation of alternatives to demand side interruption from energy intensive sectors be undertaken.

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ANNEX A – GLOBAL INSIGHT SECTORS MAPPED ONTO SIC CODES

Table 17– Global Insight sectors mapped onto SIC codes

Global Insight sector	Sub section	2 digit class	Division description	1 digit class description	2 digit class description
Aluminium	DJ	27.42	Manufacture of Basic Metals	Manufacture of basic precious and non-ferrous metals	Aluminium production
Ammonia/Fertilisers	DG	24.15	Manufacture of Chemicals and Chemical Products	Manufacture of basic chemicals	Manufacture of fertilisers and nitrogen compounds
Bricks	DI	26.4	Manufacture of Other Non-metallic Mineral Products	Manufacture of bricks, tiles and construction products, in baked clay	Manufacture of bricks, tiles and construction products, in baked clay
Cement	DI	26.51	Manufacture of Other Non-metallic Mineral Products	Manufacture of cement, lime and plaster	Manufacture of cement
Chlor-alkali	DG	24.13	Manufacture of Chemicals and Chemical Products	Manufacture of basic chemicals	Manufacture of other inorganic basic chemicals (includes manufacture of alkalis, lyes and other inorganic bases except ammonia)
Gases	DG	24.11	Manufacture of Chemicals and Chemical Products	Manufacture of basic chemicals	Manufacture of industrial gases
Glass	DI	26.11	Manufacture of Other Non-metallic Mineral Products	Manufacture of glass and glass products	Manufacture of flat glass
Glass	DI	26.12	Manufacture of Other Non-metallic Mineral Products	Manufacture of glass and glass products	Shaping and processing of flat glass

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Global Insight sector	Sub section	2 digit class	Division description	1 digit class description	2 digit class description
Glass	DI	26.13	Manufacture of Other Non-metallic Mineral Products	Manufacture of glass and glass products	Manufacture of hollow glass
Glass	DI	26.14	Manufacture of Other Non-metallic Mineral Products	Manufacture of glass and glass products	Manufacture of glass fibres
Glass	DI	26.15	Manufacture of Other Non-metallic Mineral Products	Manufacture of glass and glass products	Manufacture and processing of other glass including technical glassware
Heavy food	DA	15.61	Manufacture of Food Products and Beverages	Manufacture of other food products	Manufacture of grain mill products
Heavy food	DA	15.83	Manufacture of Food Products and Beverages	Manufacture of other food products	Manufacture of sugar
Newsprint	DE	22.21	Publishing, Printing and Reproduction of Recorded Media	Printing and service activities related to printing	Printing of newspapers
Paper	DE	21.12	Manufacture of Pulp, Paper and Paper Products	Manufacture of pulp, paper and paperboard	Manufacture of paper and paperboard
Paperboard	DE	21.12	Manufacture of Pulp, Paper and Paper Products	Manufacture of pulp, paper and paperboard	Manufacture of paper and paperboard
Petrochemicals	DF	23.2	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel	Manufacture of refined petroleum products	Mineral oil refining (includes manufacture of products for the petrochemical industry and for the manufacture of road coverings)
Plastics	DG	24.16	Manufacture of Chemicals and Chemical Products	Manufacture of basic chemicals	Manufacture of plastics in primary forms
Refining	DF	23.2	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel	Manufacture of refined petroleum products	Mineral oil refining (includes manufacture of products for the petrochemical industry and for the manufacture of road coverings)

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Global Insight sector	Sub section	2 digit class	Division description	1 digit class description	2 digit class description
Steel	DJ	27.1	Manufacture of Basic Metals	Manufacture of basic iron and steel and of ferro-alloys	Manufacture of basic iron and steel and of ferro-alloys
Water	E	41	Collection, Purification and Distribution of Water	Collection, Purification and Distribution of Water	Collection, Purification and Distribution of Water

Source: Global Insight (GI), ILEX and ONS

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Director David Cox	Date: 6 January 2006
Project Manager Andrew Nind	Date: 6 January 2006
Author David Cox Andrew Nind Ben Farrington	Date: 6 January 2006
Quality Control Beverly King	Date: 6 January 2006

ILEX Energy Consulting
King Charles House
Park End Street
Oxford, OX1 1JD
UK

Tel: +44 (0)1865 722660
Fax: +44 (0)1865 722988
E-mail: energy.consult@ilexenergy.com
www.ilexenergy.com
www.electrowatt-ekono.com