Profiling Energy Consumption and CO_2 Emissions in Industry 2004 Update

Sensitivity to Energy Price Changes

SUSTAINABLE ENERGY IRELAND
Energy Policy Statistical Support Unit

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Report prepared by
Martin Howley, Dr. Brian Ó Gallachóir and Amanda Barriscale

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Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy agency. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at:

- assisting deployment of superior energy technologies in each sector as required;
- raising awareness and providing information, advice and publicity on best practice;
- stimulating research, development and demonstration;
- stimulating preparation of necessary standards and codes;
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Energy Policy Statistical Support Unit

Sustainable Energy Ireland has a lead role in developing and maintaining comprehensive national and sectoral statistics for energy production, transformation and end use. This data is a vital input to meeting international reporting obligations, for advising policy makers, meeting international reporting obligations and informing investment decisions. Based in Cork, the Energy Policy Statistical Support Unit is SEI's specialist statistics team. Its core functions are to:

- collect, process and publish energy statistics to support policy analysis and development in line with national needs and international obligations;
- conduct statistical and economic analyses of energy services sectors and sustainable energy options;
- contribute to the development and promulgation of appropriate sustainability indicators.

Highlights

Context

- The average annual growth rate of primary energy consumption in industry during the period 1990 – 2003 was 1.3%, compared with 6.3% for transport, 5.5% for the commercial and public services sector and 1.8% for the residential sector. Industry now accounts for 20% of Ireland's primary energy consumption, (3.0 Mtoe in 2003) compared with 27% in 1990 (2.6 Mtoe).
- Industry was responsible for 8.7 Mt CO_2 emissions in 2003, of which 4.7 Mt CO_2 were associated with electricity consumption and 4.0 Mt CO_2 associated with direct fuel consumption. This represents 19% of energy-related CO_2 emissions, a lower share than either the residential (25%), transport (25%) or services (20%) sectors.
- Energy-related CO_2 emissions increased from 8.1 Mt in 1990 to 10.6 Mt in 2001 and have been decreasing since then, reaching 8.7 Mt in 2003. The recent decrease is due mainly to improved efficiency of electricity generation and reduced final energy consumption in industry.
- Between 1990 and 2003, industrial output measured by gross value added (GVA at constant 1995 prices) of industry grew by some 226% whereas industrial final energy consumption grew by only 28%. More than half of this improvement in energy productivity is attributed to structural changes within industry.
- Electricity prices to industry in Ireland in 2002 increased by 22% compared with a 0.2% increase in average EU prices. This was due largely to oil and gas price increases (58% of Ireland's electricity was generated from oil and gas compared with only 24% in the EU) and investment in electricity network refurbishment and upgrading.

Sensitivity Analysis

- 96% of industrial output (GVA) in 2001 was produced by enterprises where the energy bill represented 4% or less of total direct costs. These enterprises (4387 or 92% of all industrial enterprises) account for 96% of industrial employment and also for 61% of industry energy-related CO_2 emissions.
- About 211 enterprises (4% of all industrial enterprises) have energy costs in excess of 5% of their direct costs and this group is responsible for 34% of energy-related CO_2 emissions.
- Within this group there are 54 enterprises whose energy bill/direct cost ratio range from 10-50%. These 54 do not include all of the 15 largest energy consumers, indicating that high energy consumption in absolute terms does not in itself connote high sensitivity to energy price changes.
- 10 enterprises have an energy bill accounting for more than 20% of their direct costs. These account for 15% of industrial expenditure on energy and 18% of energy-related CO_2 emissions. They contributed 0.5% of industrial GVA and represent 0.5% of industrial employment.
- 97% of industrial GVA was generated by enterprises for which *fuel* costs represented no more than 2% of direct costs. A total 14 firms have a fuel to direct cost ratio of more than 10%. These 14 accounted for 34% of fuel-related CO_2 emissions.
- 98% of industrial GVA was generated by enterprises whose *electricity* bill represented no more than 3% of direct costs accounting for 95% of industrial employment, and 73% of electricity-related CO_2 emissions.

- Regarding changes during the period 1998 and 2001, more enterprises fell into the lower energy bill/direct cost ratio categories in general in 2001 compared with 1998.
- About 3,221 enterprises producing 91% of industrial outputs (GVA) have an energy bill that is less than 10% of their operating surplus (profit). They are responsible for 45% of industrial energy-related CO_2 emissions.
- There were 79 enterprises with an energy bill to direct cost ratio above 8% and 271 enterprises with energy to profits ratios above 50%. There were only 23 that matched both criteria however. Of these, only 16 had an energy bill representing more than 10% of their direct costs. These enterprises account for a significant 20% of industrial energy-related CO_2 but represent 0.6% of industry's GVA and 0.8% of employment.

Profile of Energy-related Emissions in Industry

- 90% of industry's energy-related CO_2 in 2001 was accounted for by 859 firms (18% of the total). These companies accounted for 89% of industry GVA and 68% of industrial employment.
- Accordingly, the remaining 3,991 enterprises (82% of the total) accounted for 10% of industry's energy-related CO_2 emissions.
- Just 15 firms accounted for 30% of energy-related CO_2 and contributed 8.5% of industry GVA.
- 9 enterprises accounted for 40% of *fuel*-related emissions (and just 1.4% of value added), whereas 27 enterprises were responsible for 40% of *electricity*-related emissions.
- Regarding changes since the previous detailed analysis, 16% (788) of enterprises accounted for 90% of energy consumption in 2001 compared with 18% (814) enterprises in 1998, demonstrating an increase in concentration of energy consumption. It is anticipated that this situation will have changed since then, as a result of the closure of a number of high energy industrial consumers.
- Three of the twelve industrial sub-sectors accounted for 77% of industry GVA (thereby representing 23% of Ireland's total GDP figure for 2001) and 54% of industry's energy bill.

Trends 1998 – 2001

- Industry's final energy consumption increased by 12% over the period 1998 – 2001, reaching 2252 ktoe in 2001. The associated CO_2 emissions in 2001 were 10.6 Mt, of which 6.4 Mt (or 59%) was associated to electricity consumption.
- Over the same period, there was a 26% increase (in current prices) in industrial energy expenditure, reaching €723million in 2001. Expenditure on heat was €317m accounting for 44%, and electricity expenditure totalled €406m accounting for 56%.
- There was a 53% increase in industry GVA (in current prices) between 1998 and 2001, while over the same period energy expenditure increased by 26%.

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1 Introduction

In October 2003, SEI published a report[1] examining the profile of energy consumption, associated CO_2 emissions and costs across the entire Irish industrial sector. That profile was based on analysis of anonymised source data (micro-data) from the CSO Census of Industrial Production (CIP) for 1998.

This report provides an updated profile of energy in industry and extends the analysis in the following ways: -

- the profile is based on more recent source data from the 2001 CIP which was published in May 2004;
- the results of the sensitivity analysis are more clearly represented using graphical as well as tabular format;
- deeper insights are provided regarding the enterprises most sensitive to fuel price changes and policies and measures that affect energy prices (including emissions trading)

It is recommended that this report be read in conjunction with the 2003 report (profiling 1998 data) and with the separate annex[2] containing additional detailed results and corrections to the 1998 data.

The purpose of this report is to further inform discussions relating to measures identified in the Government's National Climate Change Strategy (NCCS) that aim to reduce energy-related CO_2 emissions within the industry sector.

In particular, the report seeks to inform the debate regarding the potential impacts of emissions trading and other policies and measures on competitiveness and CO_2 abatement in Ireland's manufacturing industry. The commercial and public services sectors are not included in this analysis.

It is noted that there have been some significant movements since 2001 – particularly in terms of the closure of some major industrial energy users, and significant price increases for oil, gas and electricity. Nevertheless, the general patterns observed can be expected to apply to Ireland's current industrial structure.

The focus of the report is on energy-related CO_2 emissions. Other emissions are not considered. Three sub-sectors within the CIP (NACE[3] codes 11, 23 and 40) are part of the energy *transformation sector*, and thus are not considered to be end use sub-sectors from an energy perspective. These include electricity, steam and gas supply and oil and gas extraction, all of which are excluded from this analysis. Construction is also excluded as it is not manufacturing industry and is not covered in the CIP. It should also be noted that industrial energy expenditure on transport, recorded in the CIP, has been filtered out for the purposes of the analyses here.

Section 2 sets out the climate change policy context relating to energy and CO_2 in Irish industry. Salient energy and CO_2 trends in industry are outlined in ***section 3.***

Section 4 presents the results of a structural analysis of energy use in industry. SEI's Energy Policy Statistical Support Unit analysed the aggregated results of the 1990, 1998 and 2001 CIP. Using electricity and fuel price information, energy consumption values and associated CO_2 emission values were produced on a sub-sectoral level. In this way it was possible to produce an aggregated profile of energy use in industry by sub-sector.

The remainder of the report is informed by an analysis of CSO micro-data from the 2001 CIP. In order to make a more detailed assessment of the structure of Irish industry in terms of contribution to energy demand and CO_2 emissions, profiling at the level of the firm was undertaken. This work, in the form of Pareto analyses, is reported in ***section 5***, and determines the proportions of energy and CO_2 emissions due to, say, the top consuming 10% of companies. Changes that have taken place since 1998 are also discussed.

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[1] SEI, 2003, *Profiling energy consumption and CO_2 emissions in industry – Sensitivity to carbon taxation and emissions trading. Available from www.sei.ie/uploads/documents/upload/publications/Industry_Energy_Profiling_Oct_03.pdf*

[2] SEI, 2004, Profiling energy consumption and CO_2 emissions in industry – Annex to 2004 report. Available at www.sei.ie.

[3] The international coding scheme used for classification of sectors and sub-sectors within the economy. See Annex.

Section 6 presents the most important results from this analysis. Expenditure on energy by firms was related to other variables derived from the CIP, in order to enable assessment of each company's sensitivity to energy price changes. The variables chosen for the purpose of revealing potential cost competitiveness sensitivities were *direct costs* and *operating surplus*, which act as proxies for overall costs and profit respectively. In this way the energy bill for a firm is expressed as a proportion of the company's overall costs and profits. This provides a useful basis for enabling potential impacts of changes in energy prices (whether due to market factors, taxation or emissions trading) on the competitiveness of industry to be assessed. Additional analysis is presented for companies, for whom the energy bill represents a high proportion of overall costs and profits. These are the companies that are likely to be most sensitive to energy price changes.

Section 7 presents some updated analysis of the industrial firms with a thermal input capacity higher than 20 MW, who will participate in the EU Emissions Trading Scheme. This analysis links the CIP analysis to information contained in Ireland's *National Allocation Plan*[4] *(NAP),* as notified to the European Commissions in March 2004. The information from the CIP relates to enterprises whereas the NAP applies to sites, so informed assumptions were applied to extend the estimates to sites.

Additional information and analysis is contained in the separate Annex to this report, which comprises:

- revised ratio analysis of industry using the 1998 CIP, based on updated information and focusing on price sensitivity in terms of energy expenditure as a proportion of direct costs;
- pareto analysis of energy consumption (as distinct from energy-related CO_2 emissions) of all industrial firms;
- ratio analysis of energy expenditure to direct costs and operating surplus for large energy users (including those liable to be involved in emissions trading), responsible for 80% of industry's energy consumption;
- ratio analysis of energy expenditure to direct costs and operating surplus for small energy users (pointing to the impacts of energy price changes on SMEs), responsible for the remaining 20% of industry's energy consumption;
- ratio analysis of energy expenditure to gross value added (representing a firm's contribution to GDP) for industry as a whole, large energy users and small energy users;
- detailed information (pareto analyses and ratio analyses) relating to the three industrial branches or sub-sectors generating the highest value added (accounting for 77% of industry's contribution to GDP). These are the pharma-chem; food, drink & tobacco; and electrical & optical sub-sectors. This provides useful insights into the structure (in energy and related CO_2 emissions terms) of these sectors and the sensitivity of the firms within these sub-sectors to energy price changes.

This is the second published report arising from collaborative work being carried out by CSO and SEI, under the auspices of the Energy Statistics Co-ordinating Group, which seeks to facilitate improved collection and analysis of energy statistics. SEI gratefully acknowledges the co-operation of the CSO in providing access to the anonymised source data that made this analysis possible.

[4] EPA, 2004, *Ireland's National Allocation Plan as notified to the Commission 31 March 2004*.

2 Energy and industry – the policy context

2.1 Energy policies relating to CO_2 abatement in industry

Ireland's target within the Kyoto Protocol is to limit annual greenhouse gas (GHG) emissions to 13% above 1990 levels by the period 2008 – 2012. This is part of an EU Burden Sharing Agreement whereby the overall EU target reduction of 8% in emissions is to be achieved through the combined efforts of the member states. Annual emission levels reached 31% above 1990 levels in 2001[5], dropping to 25% above 1990 levels in 2003[6]. Despite the recent downturn, the remaining large gap between existing emission levels and the Kyoto target for Ireland highlights the urgency attaching to the actions to limit emissions.

Energy consumption, required to meet our demand for electricity, heating (and cooling) and transportation, was responsible for 58% of Ireland's GHG emissions in 1990, rising to 66% in 2003.

The Government's *Green Paper on Sustainable Energy* in 1999 presented growth projections for energy consumption up to 2010 and set out a number of options for meeting our energy requirements in a more environmentally and economically sustainable way. At that time, industry was responsible for 27% of Ireland's energy-related CO_2 emissions. The Green Paper concluded that:

'economic instruments will have to be deployed to activate energy efficiency in industry… they should be combined with a flexible package of measures, including a potential role for regulation, which would either enhance the effectiveness of these instruments or which would combat instances of market failure'.

The *National Climate Change Strategy* (NCCS), published in 2000, further developed Government thinking regarding the measures to control GHG emissions in Industry. Industry contributes to emissions through energy consumption, but also directly arising from a number of processes such as cement manufacture and fertiliser production (the latter has since ceased in Ireland with the closure of IFI in 2003). This report considers policies directed towards limiting energy-related CO_2 emissions only. A separate suite of policies and measures are currently in place to limit energy-related transboundary pollutants including sulphur dioxide (SO_2) and nitrogen oxides[7] (or NO_x) that contribute significantly to acidification and eutrophication.

The NCCS appears to[8] project that by 2010, in a business as usual scenario, annual energy-related emissions from industry will be approximately 6 Mt CO_2. More recent projections[9] used to determine the share of emissions allocated to emissions trading, indicate the figure will be 6.5 Mt CO_2 by 2010. This compares with a level of 4.0 Mt CO_2 in 2003 (regarding the years for which detailed CIP data is available, emissions were 4.3 Mt CO_2 in 2001 and 4.4 Mt CO_2 in 1998). These figures relate to industry's on-site fuel combustion only, and thus excludes emissions associated with the generation and transmission of the mains electricity subsequently consumed by industry. The NCCS target abatement for energy-related CO_2 in industry is 1 Mt CO_2 below the projected figure by 2010.

In order to prompt the energy efficiency or carbon intensity improvements required to achieve the target, the NCCS proposed a number of policy instruments of domestic action, including targeted taxation, emissions trading and negotiated agreements.

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[5] EPA, 2004, *Ireland's Environment 2004*, http://www.epa.ie/SoE2004/default.htm

[6] EPA 2004 *Ireland's Greenhouse Gas Emissions Down for a second consecutive year.* Press release August 4th, 2004.

[7] Collective term for nitric oxide (NO) and nitrogen dioxide (NO_2)

[8] In the NCCS, expressed in Mt CO_2 equivalent, the projected figures for 2010 for "manufacturing industry and construction" are 6.013 Mt for greenhouse gas emissions (Graph 5). However, in tables A2.1 – A 2.3 the corresponding projection appears to be 4.092 Mt, of which 4.030 Mt is specifically from CO_2.

[9] ICF Consulting and Byrne Ó Cléirigh, 2004, *Determining the share of national greenhouse gas emissions for emissions trading in Ireland,* http://www.environ.ie/DOEI/DOEIPol.nsf/wvNavView/Emissions+Trading?OpenDocument&Lang=.

2.2 Carbon energy tax

The NCCS proposed introducing greenhouse gas taxation from 2002 on a phased, incremental basis across a broad range of sectors in a manner that takes account of national, economic, social and environmental objectives.

In October 2001, the Department of the Environment & Local Government (DELG) published a paper entitled *Key elements for a framework for greenhouse gas taxation.* This followed discussion with the Economic Sub-Group of the Inter-Departmental Climate Change Team. The paper recommended introducing an energy tax, based on the carbon content of fuels used, phased in over a four year period starting in 2002 / 2003.

The paper pointed out that the purpose of the taxation measure was to provide the appropriate price signals to market actors in order to promote fuel switching and energy efficiency and hence reduce projected energy-related emission levels. While short-term price elasticities in response to tax measures can be low, the paper points out that they improve over time. Focussing on achieving impact within the commitment period 2008 – 2012, the paper suggested that early introduction of a carbon tax framework will provide an opportunity to maximise these elasticities.

According to the paper, it is understood that the effect of such taxation measures by EU Member States has been to reduce CO_2 emissions by up to 7% within the span of a decade or less.

In October 2002, DELG prepared a paper for the Green Tax Group entitled *Implementing Greenhouse Gas Taxation – Proposal for a carbon energy tax.* In this paper, some of the economic consequences of not achieving our target under the Kyoto Protocol were presented. The potential recurring costs to the exchequer of such a shortfall were estimated as being in the range of €12 million to €240 million per annum, depending on the market price for a tonne of CO_2 (assumed to be in the range €2 - €20).

The paper proposed the introduction of a carbon/ energy tax of €7.50/tCO_2 in 2003 rising over 4 years to €20/tCO_2. Assuming a tax of €20/tCO_2 in 2010, the emissions reductions achievable in industry were estimated as 0.182 Mt CO_2, assuming emissions trading is also implemented with emissions subject to trading being exempt from the tax.

When introducing Budget 2003[10], the Minister for Finance stated that

> *'the Government has asked the relevant Departments to advance the plans for a general carbon energy tax, with a view to introducing this from the end of 2004. Given the many implications of such a tax, both environmental and economic, there will be full consultations with interested parties on the design of the tax and a reasonable period is being allowed for its effective introduction.'*

One element of such consultations was the publication in July 2003 by the Department of Finance of a consultation document entitled *Proposal for a Carbon Energy Tax in Ireland – Consultation Paper* inviting public comment from interested parties. The document was consistent with the originating DELG document in proposing the introduction of a tax of €7.50/tCO_2 rising over time to €20/tCO_2. By 16th September 2003, the Department received 28 submissions.

On 10th September 2004 the Government decided to abandon plans to introduce carbon tax stating that *'a carbon tax is not an appropriate policy option'* and that *'the environmental benefits would not justify the difficulties that would arise, particularly for households, from the introduction of such a tax'*. It also stated that recent energy price increases resulting from ongoing supply and demand issues in the oil market would *'give an enhanced incentive to energy conservation'*[11].

2.3 Emissions trading

Emissions trading is one of the mechanisms provided for in the Kyoto Protocol to assist in reducing greenhouse gas emissions. It is an international approach to emissions-control that includes governments being assigned

[10] McCreevy C., 2002, *Financial Statement,* 4 December. Available from http://www.budget.gov.ie/2003/downloads/Budgetspeech.doc

[11] Department of Finance Press Release 2004, *McGreevy Abandons Carbon Tax*, http://www.finance.gov.ie/viewdoc.asp?DocID=2608.

'allowances' of GHG emissions (in accordance with the targets they have committed to), which can be traded internationally. In other words, a participating country will be able to buy or sell allowances (at the going rate as markets in emissions allowances evolve) according to whether it exceeds its assigned quota of emissions (buy) or achieves reductions below its allowances (sell).

The International Emissions Trading (IET) scheme outlined above will not be in operation before 2008 at the earliest. Meanwhile, the EU has adopted Directive 2003/87/EC on emissions trading, which will apply in all EU member states from 1st January 2005. The Directive applies to all combustion installations across the EU with a rated thermal input exceeding 20 MW and a range of other activities such as steel and cement production, ceramics and glass manufacturing (subject to capacity thresholds). The operators of all installations involved in the activities listed in the Directive are required from January 2005 to hold a permit issued by a competent authority (EPA in the case of Ireland). These operators will receive an allocation of CO_2 emission allowances for the period 2005 – 2007. If actual emissions exceed the allowance allocated, the operator must purchase allowances from other operators within the EU. If emissions are lower than the allocation, the operator can sell the excess allowances to those with a shortfall. Operators must the surrender sufficient allowances to cover annual emissions, or else face a penalty of €40/tCO_2 in the period 2005 – 2007 and €100/tCO_2 in the period 2008 – 2012.

Effectively, it is a carrot and stick approach to emissions reductions: a company which fails to control its GHG emissions will have to purchase a sufficient quantity to cover the amount by which it overshoots its allocation while a company that achieves a reduction in its emissions allocation will be able to sell the surplus saved.

In Ireland the total quantity of allowances allocated by the Government to the trading sector in the period 2005 – 2007 is 67.5 Mt CO_2 (22.5 Mt per annum) representing 33% of projected total GHG emissions for that period. The Government further suggested an indicative allocation of 110.1 Mt CO_2 in the period 2008 – 2012, or 22 Mt per annum on average. This was informed by analysis suggesting that emission reductions of 3.4 Mt CO_2 per annum in the period 2008 – 2012 are achievable at a cost of €10/tCO_2. The Government also provided an indication of intent to purchase 18.5 Mt of Kyoto allowances in the same period (3.7 Mt per annum).

In March 2004, EPA submitted Ireland's National Allocation Plan (NAP) to the European Commission for approval. The NAP allocated the 67.5 Mt to 111 installations, including all fossil fuel based power generation and maintaining a 1.5% reserve for new entrants. Most of these allowances (99.25%) will be allocated free of charge and the allocation represents 98% of forecast emissions from the emissions trading sector.

In response to queries from the Commission, the Government committed to completing an operational programme for purchases by 30th November 2004, including the establishment and notification to the UNFCC of a designated national authority for the purposes of implementing a purchases programme. In addition, the allowances allocated to the emissions trading sector was reduced by 180 kt CO_2 per annum. The European Commission approved the revised NAP, based on this adjustment, in July 2004.

2.4 Negotiated agreements

The term 'negotiated agreements' is broadly applied to national or domestic (as distinct from international) agreements between firms or sectors and the relevant national authorities whereby the former agree to a scheduled reduction in emissions by means of structured programmes of action – mainly relating to increased energy efficiency - in return for certain concessions. These concessions may include grants or tax rebates for investment in energy-efficient technologies, agreement by government not to implement certain tax measures that might otherwise be pursued or actual tax reductions/ exemptions in respect of existing carbon type taxes. The NCCS variously states:

> '*Taxation will be a significant instrument, applied to all appropriate forms of production in accordance with established principles. In the case of sectoral negotiated agreements, taxation will remain a key option to tackle "free riders" and lack of progress in the effective implementation of negotiated agreements. It will also be used as a supplementary instrument where the other instruments cannot optimise greenhouse gas reduction potentials.*'

'Negotiated agreements with industry to achieve agreed global energy efficiency benchmark in all sectors will be developed. Targets for all negotiated agreements are to be significantly beyond business as usual scenarios. Where reductions are made to tax levels arising from negotiated agreements, they will only be provided to the extent that the negotiated agreement reflects and delivers best international practice in the sector concerned.'

In Ireland, while there is no system of legally binding negotiated agreements in place, a pilot project by Sustainable Energy Ireland (SEI) involving a cross-section of companies and aimed at exploring the feasibility and impacts of such agreements has been completed. Its published results[12] indicate that participation in such agreements would be feasible for up to 650 companies and yield an annual abatement of up to 0.640 Mt CO_2 at negative net cost to firms on average (including an average transaction cost of €1.10/tCO_2).

2.5 Key questions

This report tries to shed some light on some of the concerns that have been expressed by Irish Business & Employers Confederation (IBEC), Irish Small & Medium Enterprise (ISME) and others on the impacts of energy price increases on the competitiveness of industry. While some of this discussion took place within the context of the consultation regarding carbon taxation, it also relates to the impact of fuel price increases and emissions trading. The report grapples with the following key questions:

1. How sensitive is industrial competitiveness – and associated employment - to changes in energy prices, whether as a result of recent fuel price changes or associated with policies and measures such as emissions trading or carbon taxation?
2. Are there firms (possibly SMEs) with low energy usage that may be sensitive to energy price changes, or does it apply to certain high energy users?
3. What is the profile of energy consumption, costs and related CO_2 emissions across industry as a whole and across individual sub-sectors?
4. How many enterprises are responsible for the bulk of industrial energy consumption and related CO_2?

The report is not setting out to offer full answers to all these questions. Its aim is to place new information in the arena of the enterprise, environment and energy policy communities by way of new data and perspectives reflecting the realities of the energy structure of industry in Ireland. In turn this should facilitate analysts and advisers in conducting their own assessments of the possible impacts of proposed policy instruments on the competitiveness and CO_2 abatement potential of the industrial sector.

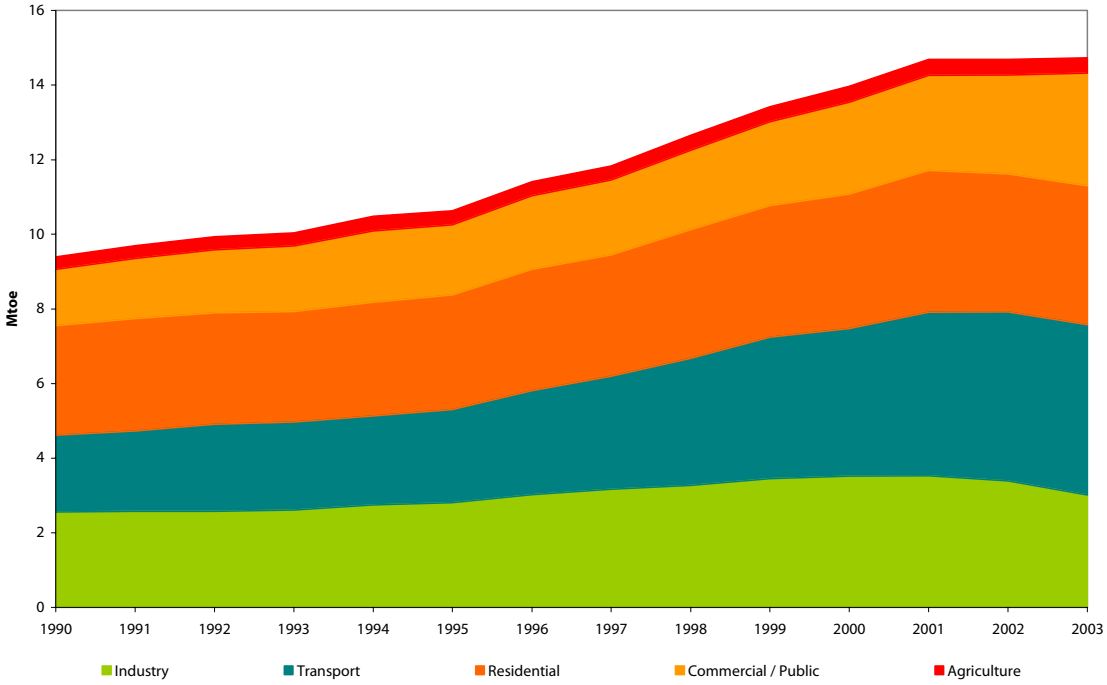
[12] SEI, 2003, *Negotiated Energy Agreements Pilot Project, Final Report*.

3 Energy trends and drivers

3.1 Energy consumption in industry

Figure 1 shows the total primary energy consumption[13] by the five principal sectors of the economy in Ireland for the period 1990 – 2003. The average annual growth rate in industrial energy consumption during this period was 1.3%, compared with 6.3% for transport, 5.5% for the commercial and public services sector and 1.8% for the residential sector. A more detailed discussion of energy trends in Ireland over the period 1990 – 2002 is available in a separate SEI publication[14].

Figure 1: Total Primary Energy Requirement by sector 1990 - 2003



Industry's relative share has fallen as a result of this faster energy demand growth in other sectors. Industry now accounts for 20% of Ireland's primary energy consumption, (3.0 Mtoe in 2003) compared with 27% in 1990 (2.6 Mtoe).

[13] Primary energy consumption includes all the fuels used directly by each sector plus the primary energy used to generate electricity attributed to each sector in proportion to its electricity demand.

[14] SEI 2004 *Energy trends in Ireland 1990 – 2002 Trends, issues and indicators.* Available from http://www.sei.ie/uploads/documents/upload/publications/EII_1990-2002_final_report.pdf

Figure 2: Industry's Energy Balance 2003 (provisional)

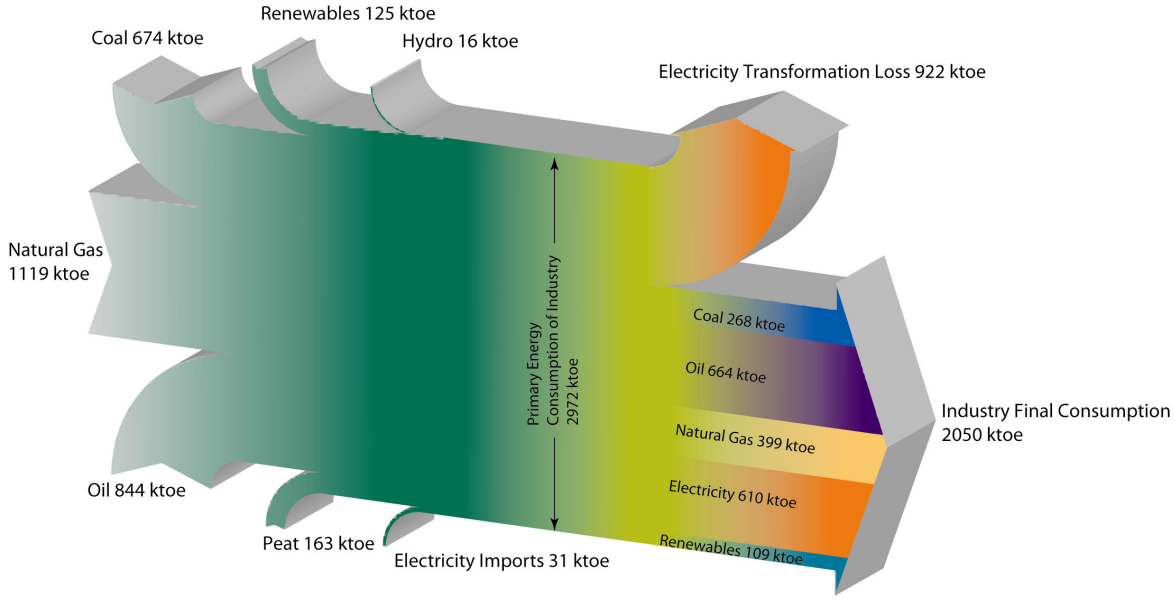


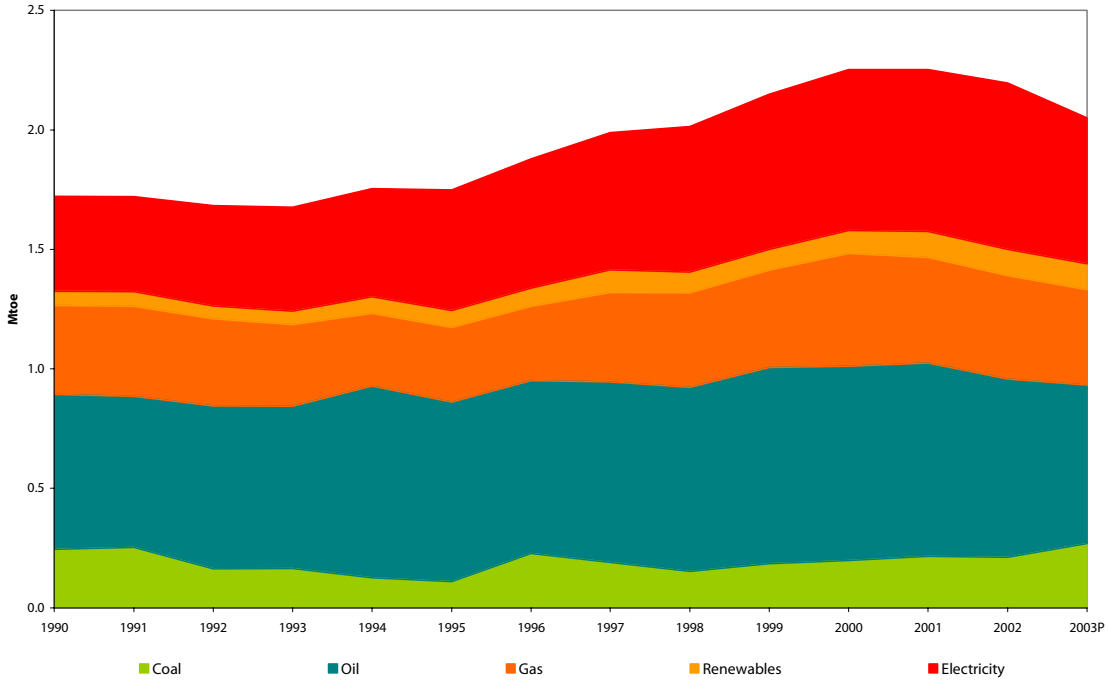
Figure 2 shows the energy balance for industry in 2003. Fuel inputs on the left include the upstream fuel used in the generation of electricity for final use in industry. It is for this reason that fuels such as hydro and peat appear as inputs but do not appear explicitly as outputs as they are included in the electricity consumption portion of final consumption. The significance of losses due to electricity generation is evident and represents 31% of the primary energy consumed by industry. Indeed the share of primary energy for industry's electricity requirements was over 51% of the total.

Total final consumption represents the amount of energy for which each sector is billed directly[15]. In the case of industry different sub-sectors use different fuels, depending on the nature of their economic activity. Most sub-sectors have enterprises using gas, oil and electricity. Some also use coal and two sub-sectors use renewable energy (NACE code 20 [wood industry] use biomass and NACE codes 15 -16 [food drink and tobacco] use biogas).

Trends in the consumption of these fuels from 1990 – 2003 are shown in figure 3 for industry as a whole (2003 figures being provisional). Over the period final energy consumption in industry grew by 19% while industrial output measured by value added (at constant 1995 prices) grew by 226%.

[15] Essentially TFC is TPER less the amount of energy lost in transformation (electricity generation, peat briquetting and oil refining).

Figure 3: Total Final Energy Consumption by fuel – Industry, 1990 - 2003



It is the on-site emissions associated with these fuels (excluding electricity) that are used in the NCCS for the projections and measures associated with industry. The NCCS treats *upstream* emissions associated with mains electricity[16] separately and does not attribute them to the individual end user sectors that consume electricity. There are advantages in such an approach from the perspective of targeting specific measures within the electricity supply industry. The associated risk however is that, in decoupling the end user from the source of the pollution arising from their demand, it may reduce the sense of end user responsibility for electricity consumption. (The NCCS target for upstream electricity emissions abatement is 5.50 Mt CO_2, whereas that for *demand side management* efficiencies by consumer action across the whole economy is 0.15 Mt CO_2.)

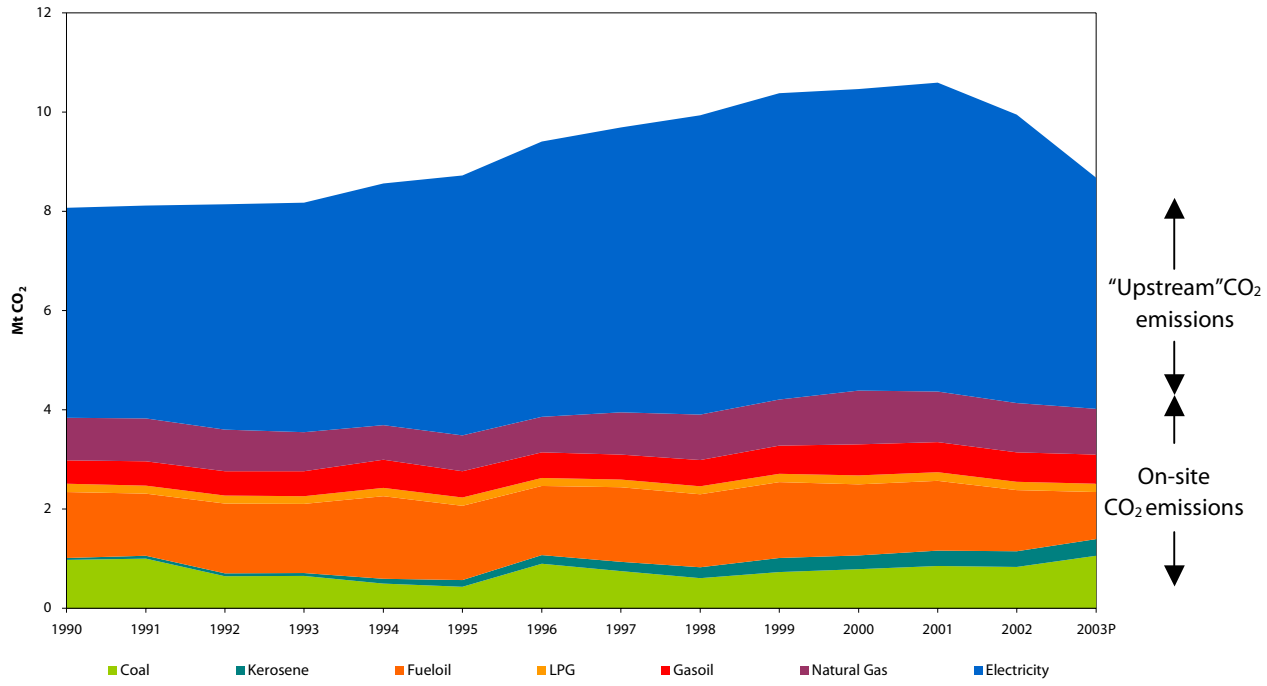
The NCCS target abatement for energy-related emissions in the industry sector is 1 Mt CO_2 below the projected 2010 *business as usual* level of 6 Mt CO_2. Energy-related CO_2 emissions, excluding those associated with electricity consumption were 4.0 Mt in 2003 (8% lower than 2001, due largely to the closure of Irish Ispat and IFI). While these closures caused a reduction in energy consumption (and related emissions) in industry, planned expansion of activity in other sectors are expected to reverse this trend. The trend in on-site emissions since 1990 is illustrated in figure 4.

The perspective is different if the upstream emissions associated with electricity consumption in industry are included (also shown in figure 4).

The trend for all fuels excluding electricity is relatively flat over the period but when the emissions associated with the electricity consumed by industry are included a pronounced increase is evident until 2001. The average annual growth rate between 1990 and 2001 for emissions from all energy forms in industry was 2.5%, but is just 1.2% if electricity is excluded. The average annual growth rate in CO_2 emissions associated with electricity alone during this period was 3.6%. The situation has changed somewhat since 2001 due to the reductions achieved in carbon intensity in the electricity transformation. The average annual growth in emissions has fallen to 0.6% for all energy forms and 0.7% for emissions from electricity consumption. From the energy balance the estimated emissions from industry's electricity usage was 4.7Mt CO_2 in 2003.

[16] In this report the term *electricity* denotes mains electricity, unless otherwise implied. Electricity self-produced by means of plant such as combined heat and power (CHP) will be reflected in a firm's on site fuel consumption. Fuel input to such plant currently represents about 9% of industrial fuel use.

Figure 4: Energy-related CO_2 emissions in industry



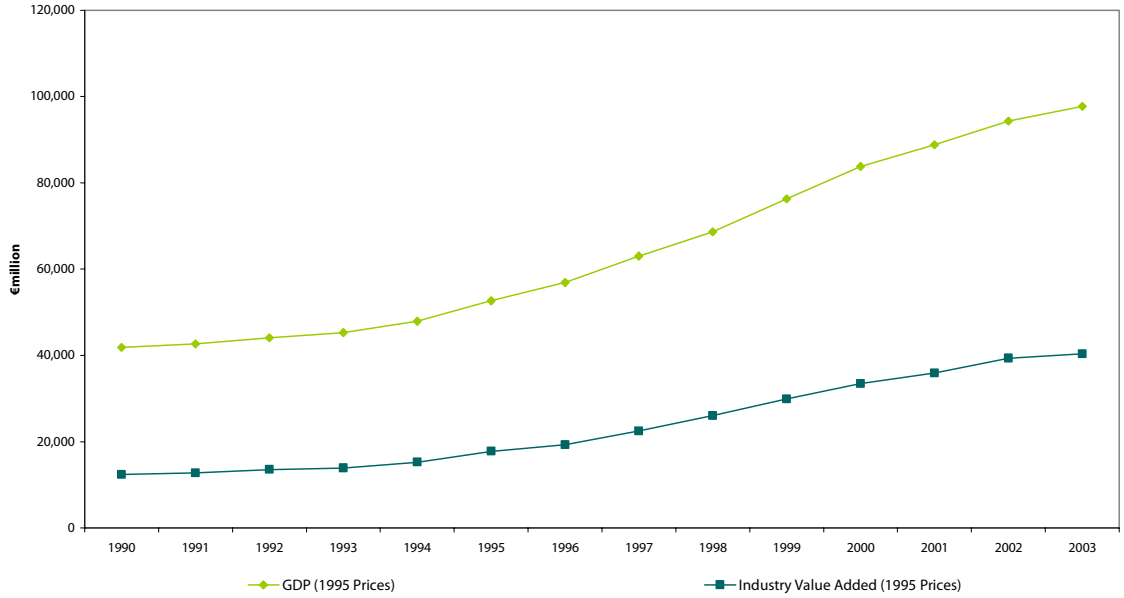
It is interesting to note the reduction in upstream emissions from electricity since 2001 (6.7% in 2002 and 19.8% in 2003). The principal reasons for this reduction was increased efficiency in electricity transformation and shifts in generation fuel mix toward lower carbon intensive fuels such as natural gas together with a reduction in final consumption of electricity in industry in 2003 of 12%.

Industry was responsible for 8.7 Mt CO_2 emissions in 2003. This represents 19% of energy-related CO_2 emissions, a lower share than either the residential (25%), transport (25%) or services (20%) sectors.

3.2 Industrial growth and energy intensity

Figure 5 shows the trend in industrial value added compared with overall GDP growth in Ireland over the period 1990 – 2003, with industry growing at a faster rate than the economy as a whole. Industry currently accounts for 27% of total employment and 41% of GDP.

Figure 5: Growth in GDP & industry's contribution to GDP

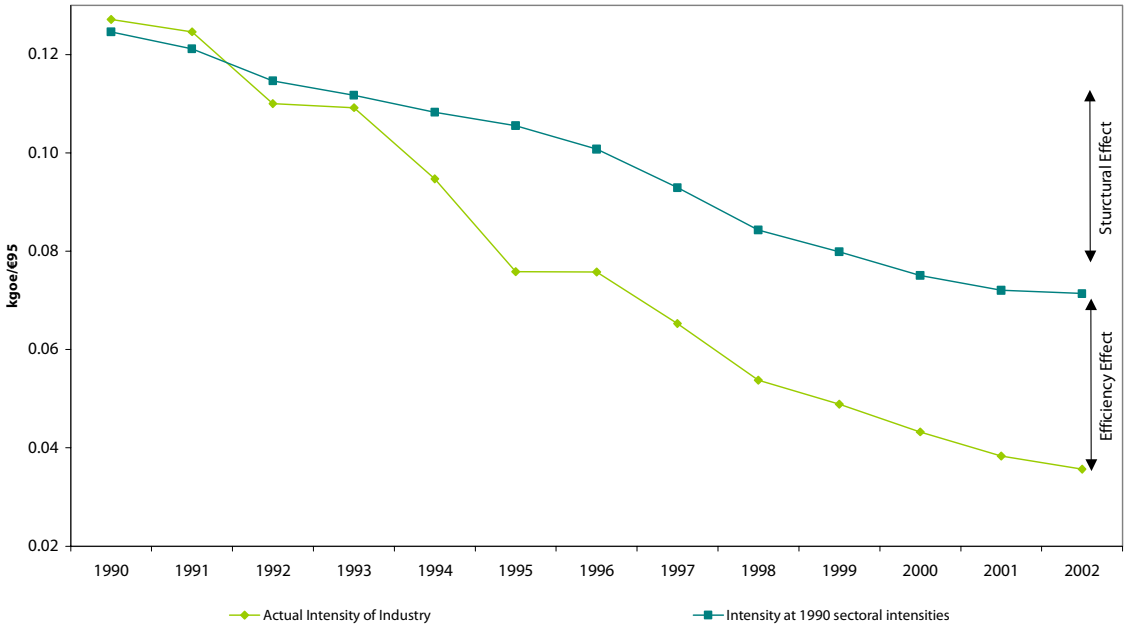


Source: Central Statistics Office.

Energy intensity is defined as the amount of energy required to produce some functional output (it represents the inverse of energy productivity in general). In the case of industry, the measure of output is generally taken to be gross value added (GVA)[17]. GVA measured in constant prices is used to remove the influence of inflation. The energy intensity measures the amount of energy required to produce one euro of value added.

Between 1990 and 2003 the value added of industry grew by some 226% whereas industrial final energy consumption grew by only 28%. This resulted in the energy intensity of Industry decreasing quite rapidly throughout the decade, as illustrated in figure 6.

Figure 6: Energy intensity of Industry (actual & at constant sectoral intensity)



[17] GVA is a measure of the extent to which an enterprise has added value to its inputs. At the sectoral level, industrial GVA is a measures of the contribution by industry to GDP.

The larger part of this decrease can be explained by changes in the structure[18] of industry by main subsector. This particularly reflects the increasing importance of the IT manufacturing sector and the pharmaceutical and other high value added, low energy consuming sectors. The growth in importance of these relatively low energy consuming, high value added sectors has pushed down the overall energy intensity of the industrial sector. In latter years these effects are becoming less pronounced.

Since 1990, structural changes contributed to a reduction in energy intensity by an average 4.5% per annum and accounted for more than half (58%) of the reduction in industrial energy intensity between 1990 and 2002. Recent, high profile, examples of the structural shifts in industry resulting in reduction in energy intensity were the closures of steel production (Irish Ispat) and fertilizer manufacture (Irish Fertilizer Industries).

3.3 Energy prices in industry

It is useful to compare trends in energy prices to industry in Ireland with prices internationally before discussing further the impact of price changes on competitiveness. The price data for Ireland is incomplete and is compared with average EU prices.

Irish industrial fuel oil prices have followed a similar trend to that of the EU average with an average price difference of 3.9% in Ireland's favour between 1990 and 1999. The significant increase (82%) in average EU fuel oil prices between 1999 and 2001 is striking in figure 7, which was followed by a 6.4% drop in 2002.

Fuel oil prices to industry in 1999 were 9.8% below 1990 levels (current prices). Such prices closely track world oil prices and accordingly a similar rise to the EU average in figure 7 can be expected to have taken place in Ireland by 2001. Average price rises of 45% for heavy fuel oil and gas oil have been experienced in the UK over the period 1999 – 2002, and similar changes would be expected to have applied in Ireland over the same period.

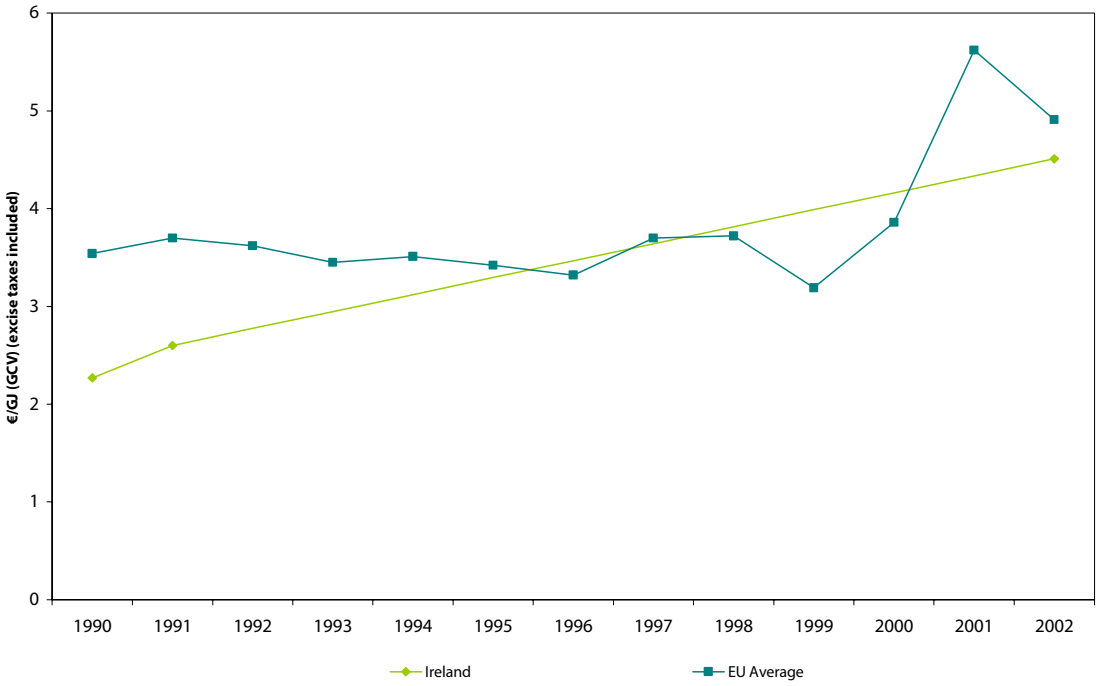
Figure 7: Fuel oil prices to industry

Source: European Commission DGTREN.

[18] The impact of these structural changes can be measured by comparing the variations of the actual intensity with that of a fictitious or notional intensity at constant sectoral intensities (using 1990 structure as a reference). For more information on this approach see Bosseboeuf D. et al (1999) *Energy Efficiency Indicators – The European experience* published by ADEME.

Natural gas prices for Ireland are only available for 1990, 1991 and 2002, as shown in figure 8. The EU average is also shown for the whole period. Gas prices in Ireland were 8% lower than the EU average in 2002, compared with a 36% gap in 1990. The manner in which gas prices follow oil prices is also evident from comparing figure 7 with figure 8. The EU average gas price to industrial consumers was 76% higher in 2001 than in 1999, before dropping 14% in 2002.

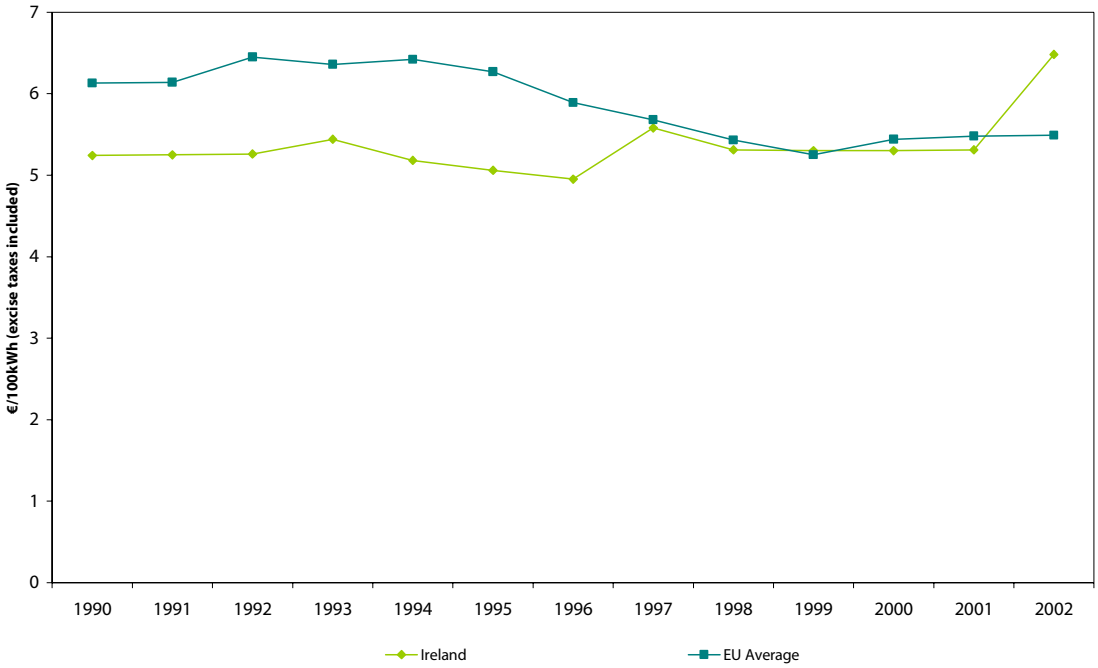
Figure 8: Natural gas prices to industry



Source: European Commission DGTREN.

Between 1990 and 1996 average electricity prices to industry in Ireland were 16.6% below the EU average. As illustrated in figure 9 the prices converged between 1997 and 2001. Electricity prices to industry in Ireland in 2000 were just 1.2% above 1990 levels (current prices), however, in 2002, electricity prices increased by 22% in Ireland compared with a 0.2% increase in average EU prices. This was due to oil and gas price increases (58% of Ireland's electricity was generated from oil and gas compared with only 24% in the EU) and investment in electricity network refurbishment and upgrading.

Figure 9: Electricity prices to industry[19]



Source: European Commission DGTREN.

[19] Prices are as of 1st January in each year shown. Prices are collected from a variety of locations in each country and are based on a standard annual consumption of 24,000 MWh.

4 Industry sectoral profiling on an aggregated basis

The analysis in this section is carried out at an aggregated sub-sectoral level using mainly published data from CSO. The analyses in sections 5 to 7 examine the effects based on interrogation of the data at the level of the individual enterprise.

The CIP comprises two annual censuses carried out by CSO of:

i) All enterprises[20] having three or more persons engaged and being wholly or principally involved in industrial production. There were 4854[21] such firms operating in Ireland in 2001 in the NACE sectors covered by the present work.

ii) All local units[22] principally engaged in industrial activity, with three or more persons engaged. In 2001, there were 5056 local units known to CSO in NACE sectors 15 - 37.

The CIP seeks a wide range of data from the respondents, for example the selling value of goods, turnover and purchases of materials. Each year one of the questions in the CIP seeks expenditure on energy, but generally in the form of a single question on the total expenditure on electricity and all fuels. In 1990, 1998 and 2001, however, the energy expenditure question in the census of industrial enterprises was disaggregated and expenditure on each fuel[23] type was sought. For this reason, the analysis in this report is conducted on the industrial enterprises, rather than on local units. The distinction is important in the context of the NAP, which deals with installations on a site basis.

4.1 Energy expenditure by sub-sector

Figure 10 shows changes in energy expenditure across nine individual or clustered sub-sectors (NACE coded – see Annex) for the years 1990,1998 and 2001. There was an average increase in energy expenditure of 42% over the period. The significant change in industry structure over the period are also evident in figure 10, with "metals & engineering" (which includes much of the Information and Communication Technology hardware industry) showing the most dramatic increases in energy expenditure.

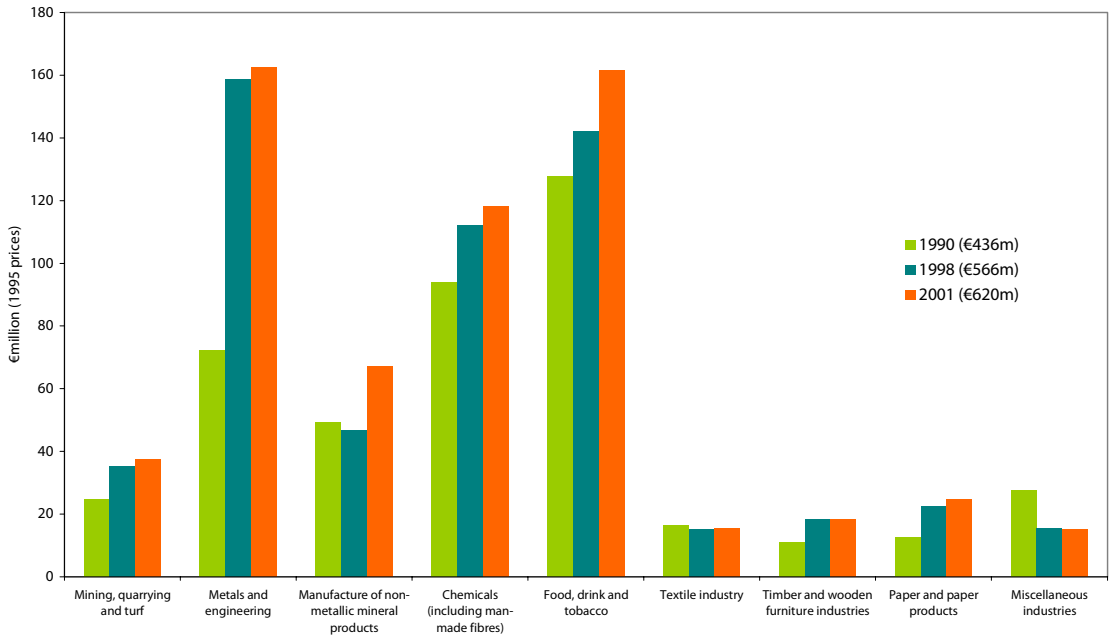
[20] Defined as the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision making, specially for the allocation of its current resources (company, partnership, individual proprietorship, etc.), also known as firm or company.

[21] Subsequent sections on Pareto and ratio analysis deals with slightly different total numbers of enterprises. The Pareto analysis excludes a number of enterprises that are classified as being in the energy transformation sector and the ratio analysis excludes a further number of enterprises on the basis that the calculation of the ratios would result in division by zero.

[22] Defined as an enterprise or part thereof situated in a geographically identified place, also known as an industrial site or installation.

[23] The surveyed energy forms or "fuels" relevant to the present analysis were: electricity, natural gas, gas oil, LPG, fuel oil, coal, coke, derived gas, heat, renewable energy and "other".

Figure 10: Industry expenditure on energy 1990, 1998 and 2001 (at 1995 prices)

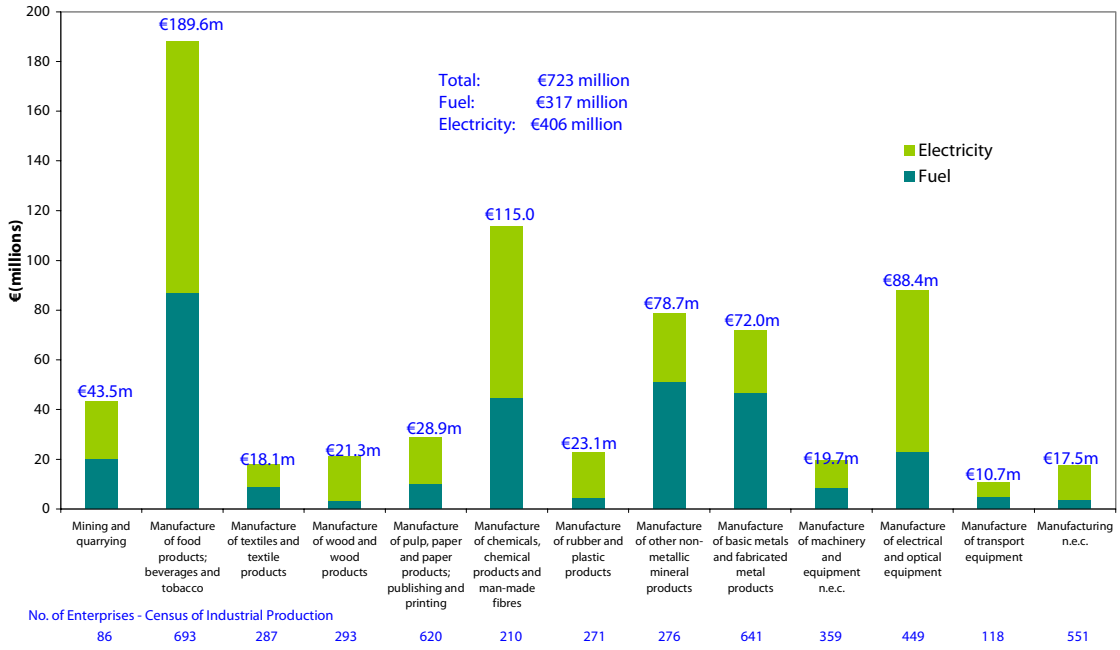


Source: Central Statistics Office.

Evidence of Ireland's buoyant property market is evident from the increase in energy expenditure in the manufacture of non-metallic mineral products (primarily cement production). Expenditure on energy in this sector fell slightly between 1990 and 1998 but grew by almost 44% (in 1995 prices) between 1998 and 2001.

Figure 11 shows the energy expenditure profile for industry in 2001, across thirteen individual or clustered (NACE coded) sub-sectors, segmented between fuel and electricity contributions. This and subsequent diagrams also show the number of enterprises for each sub-sector. It should be borne in mind that some enterprises may have several sites.

Figure 11: Industry expenditure on energy 2001 (current prices)



Source: Central Statistics Office.

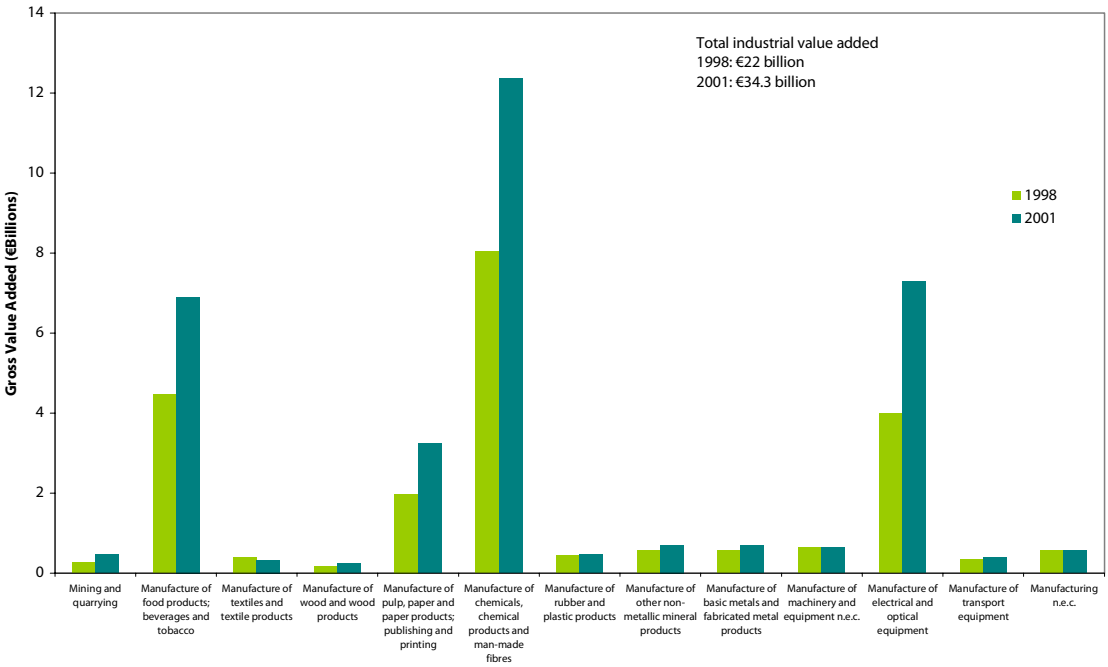
The total expenditure on energy in 2001 for industry was €723 million in current prices (26% increase on 1998), of which 56% (65% in 1998) was on electricity. One sub-sector, alone, food, drink and tobacco accounted for 26% of this bill and spent almost 65% more on energy than the next highest sub-sector, pharma-chem. The domination of certain sub-sectors is clear and five sub-sectors accounted for 75% (73% in 1998) of industry's energy bill. The three sectors with the highest absolute expenditure, accounting for 54% of industry's energy bill, were in turn: food, drink & tobacco; pharma-chem; and electrical & optical.

4.2 Sub-sectoral contribution to GDP

Figure 12 shows the contribution of individual sub-sectors to Ireland's economic growth levels (GVA represents industry's contribution to GDP) for both 1998 and 2001. The most striking feature is the 53% growth GVA for industry to €34.3[24] billion in 2001. Accompanied by an increase of 26% (current prices) in industry's energy bill, this may indicate a degree of insensitivity to energy price changes in some subsectors.

A second interesting feature is that the three sub-sectors that accounted for 54% of industry's energy bill contributed most to Ireland's GDP, accounting for 77% of industrial GVA (NACE 1-3), thereby representing 23% of Ireland's total GDP figure (current prices) for 2001.

Figure 12: Gross Value Added in industry 1998 & 2001 (current prices)



Source: Central Statistics Office.

4.3 Energy consumption by sub-sector

Based on SEI estimates for unit prices of fuel for each sub-sector as applied to the CIP expenditures, figure 13 shows the calculated values for final energy consumption in 1998 and 2001, expressed in thousands of tonnes of oil equivalent (ktoe). The total calculated energy consumption in 1998 was 2,214 ktoe and in 2001 it was 2,266 ktoe. These compare well with reported national energy balances figures of 2,015 and 2,252 ktoe for 1998 and 2001 respectively. The increase of 11.8% in energy consumption (from the energy balances) compares with an energy bill increase of 25.7% (current prices), illustrating the impact of energy price changes over the period.

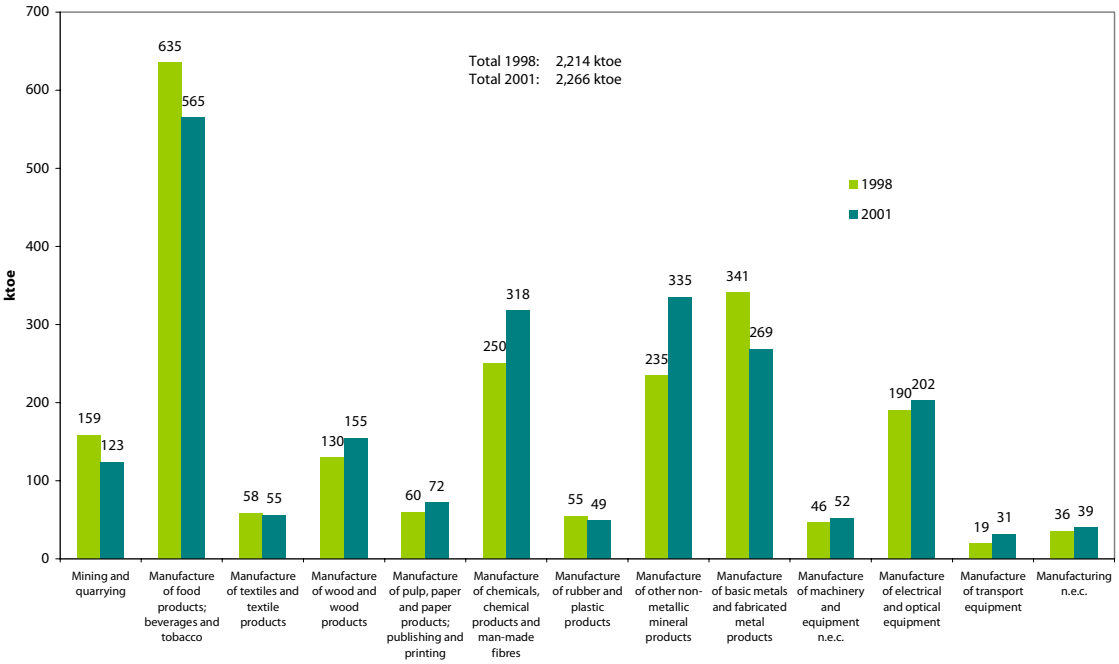
The food, drinks and tobacco sector reduced its energy consumption by 11% between 1998 and 2001 despite an increase in valued added of 54.5% (current prices), showing a very sizeable reduction in energy intensity. The pharma-chem sector also showed an improvement, with energy consumption increasing by 27.2% but value added

[24] This refers to the gross value added of industry NACE sectors 1 – 3.

growing by 53.8% (current prices) over the period. Similarly the electrical and optical equipment (ICT) sub-sector experienced high value added growth (82.1%) but low energy consumption growth (6.3%).

Again growth in energy consumption in the non-metallic minerals sector of 42.6% reflects the strong growth in consumption of cement products during these years. Value added in this sector grew by a more modest 23.6%, which demonstrates little movement in the energy intensity of this sub-sector.

Figure 13: Industrial energy consumption 1998 & 2001



Source: Based on CSO data.

4.4 Energy-related CO_2 emissions by sub-sector

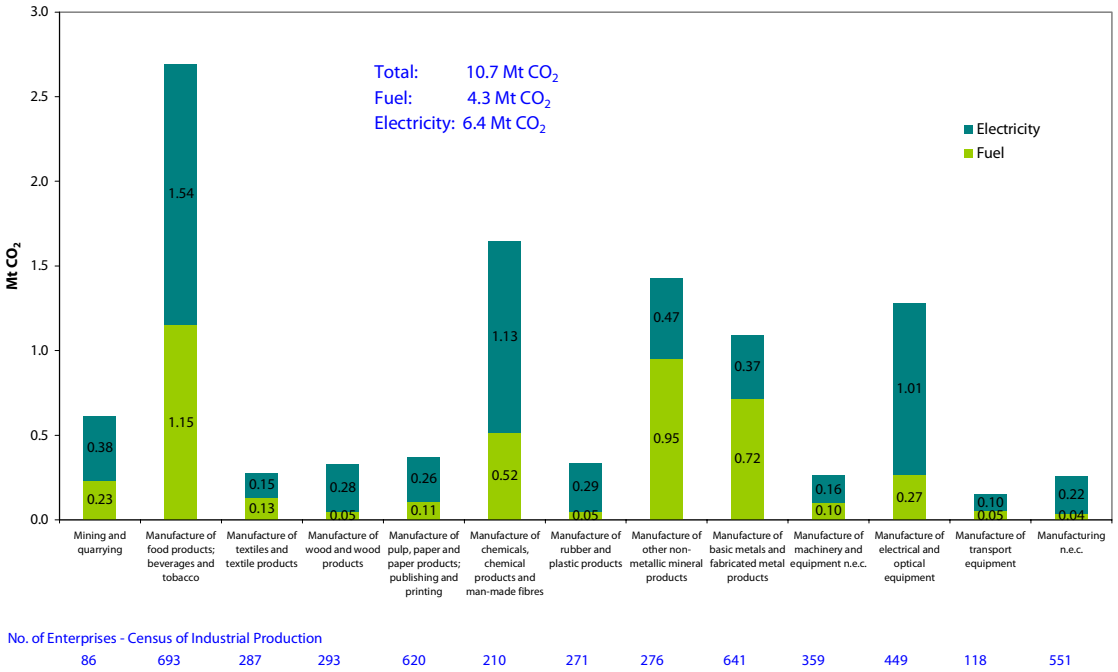
Figure 14 shows the calculated levels of energy-related CO_2 emissions for the sub-sectors. The conversion factors for each fuel are given in the Annex. It is worth reiterating the distinction between this analysis and the NCCS in terms of attributing emissions to the end use sector. In the NCCS the only energy-related CO_2 emissions attributed to industry are those from fuel combusted on site whereas emissions associated with consumed electricity are attributed to the electricity supply sector. In the present analysis the emissions associated with electricity consumed by industry are attributed to industry.

According to these calculations, industry was responsible for 10.7 Mt CO_2 emissions in 2001. This compares well with calculations of 10.6 Mt CO_2 emissions[25] based on the national energy balance. Electricity consumption accounts for 59% (6.4 Mt CO_2).

Comparing figures 13 and 14, there is general alignment between the final energy consumption and CO_2 emissions profiles. Where differences do occur, they are due to the weighting of the fuels used by each of the sub-sectors. The reason for this is clear from the Annex, which shows the variation in CO_2 emission factors (or CO_2 intensity) by energy form. In particular, when a large proportion of the energy is electricity, this will increase the amount of CO_2 emissions relative to the energy consumed.

[25] This analysis based on CIP data estimates the emissions associated with fuel and electricity at respectively equal to and 2.4% above the comparable estimates based on the national energy balance.

Figure 14: Energy-related CO_2 emissions in industry 2001 (Mt CO_2)

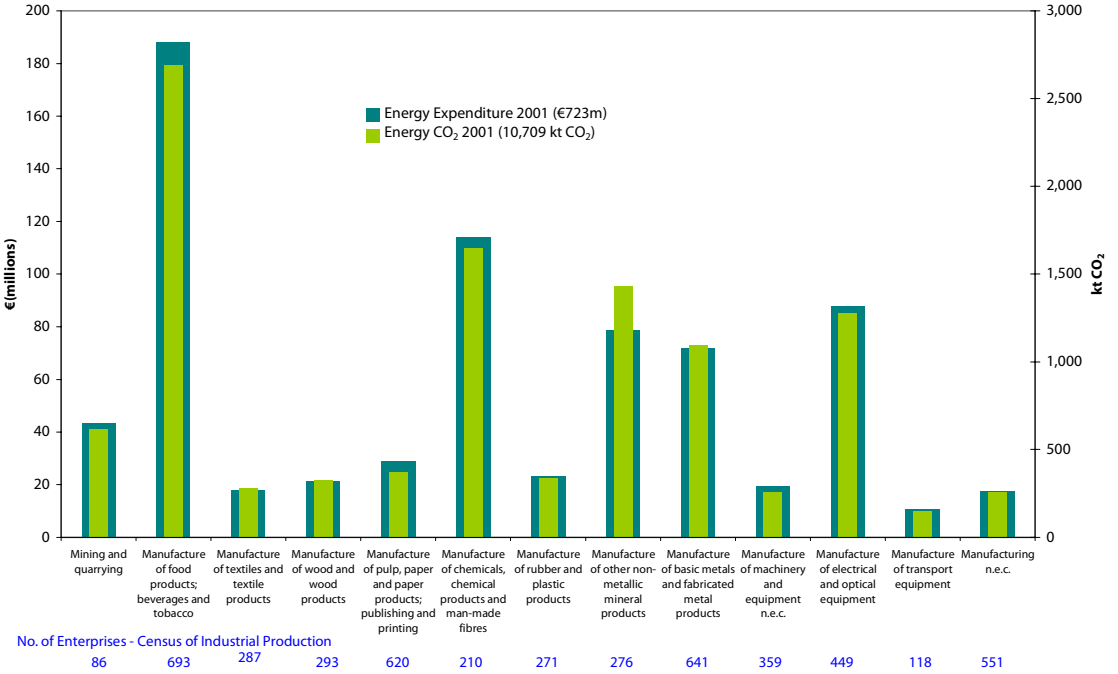


Source: Based on CSO data.

It is worth noting that the split between emissions associated with electricity and (non-electricity) fuel consumption vary greatly across the sub-sectors of industry. In the case of manufacture of rubber and plastic products, emissions associated with fuel use account for just 14.9% of CO_2 emissions arising from energy consumption in that sub-sector, whereas in the case of the non-metallic minerals subsector the figure is 66.8%.

Arising from this and the price differential between electricity and other fuels, there is closer alignment between energy-related CO_2 emissions and energy expenditure rather than energy consumption, and this is illustrated in figure 15.

Figure 15: Expenditure on energy versus CO_2 emissions 2001



Source: Based on CSO data.

4.5 Drawing inferences

On the basis of aggregated or averaged data on a branched or sub-sectoral basis across industry, it may appear self evident that energy price increases will most adversely affect the cost competitiveness of those sub-sectors with high ratios of energy in relation to other measures of output or input – such as to GVA, profit or cost - and have lesser effect on those with low ratios. The extent of this impact will depend on the comparative climate change related tax regimes in competitor states. Some analysis on sub-sectoral sensitivity was presented in the original industry profiling report with 1998 data. This was not repeated for 2001 due to the limited usefulness of this approach.

It must be recognised in seeking to model or assess the impact of fuel price increases and measures such as emissions trading on the cost base and CO_2 emissions of Irish industry, the relevant unit of application is the individual firm or site. Aggregated data in this context have a serious potential to mislead. Moving down one level of disaggregation in the NACE coding will not necessarily address this need. For this reason, SEI developed the necessary protocols with the CSO to allow appropriate access to CIP source data from the 1998, 2001 and future surveys. Analysis of this is presented in sections 5, 6 and 7.

5 Pareto analysis of energy CO_2 for individual firms

The Pareto principle suggests that a significant few within a population are responsible for the bulk of the impacts. This is sometimes expressed as the "80/20 rule" where 80% of the effects are caused by 20% of the population. In terms of Irish manufacturing industry it has been perceived for some time that a small percentage of firms are responsible for a large percentage of total industrial energy consumption and, by implication, related CO_2 emissions. The analysis in this section attempts to quantify this specific profile using the newly available data.

In interpreting these results and those of sections 6 and 7, it should be borne in mind that the data relates to the years 1998 and 2001 (the most recent year for which detailed data is available), and there have been some significant movements since that time. In relation to the high degree of concentration of energy use towards the largest industrial energy users as shown below, at least four major industrial energy users have closed down since 2001, and are most unlikely to have been replaced by any new entrants of equivalent energy intensity. The impact of this will have been to somewhat reduce the degree of concentration of energy and related CO_2 emissions across the overall industrial sector.

Using estimated price data prevailing for 2001, the energy expenditure for each firm was converted to energy consumption and subsequently to energy-related CO_2 emissions, using emission factors. The firms were then ranked in descending order in terms of energy-related emissions. The top energy consumers were grouped until their combined emissions reached a meaningful proportion (e.g. 30%) of the total for industry, or of the segment of industry concerned, and sufficiently compounded to maintain confidentiality. The remaining ranked firms were grouped in bands, each representing a further 10% in energy-related emissions.

For each band, the associated contribution to industry GVA (total €34.3 billion) and employment (total 254,172) was also determined, and reported in the tables and diagrams below. To comply with confidentiality requirements, the proportions of firms in each band in respect of these two parameters were reported in percentage terms to a single decimal place; this represented data resolution limits of €34 million GVA and 254 jobs respectively.

This exercise was carried out in turn for total energy, and separately for electricity and for fuel, resulting in three Pareto curves in each of the diagrams and three boxes in each of the tables below. This distinction should be useful to analysts considering the potential impact of emissions trading or carbon energy tax on the fuel (4.3 Mt CO_2 in 2001) or electricity (6.1 Mt CO_2 in 2001)[26] components of industry's energy-related CO_2 emissions.

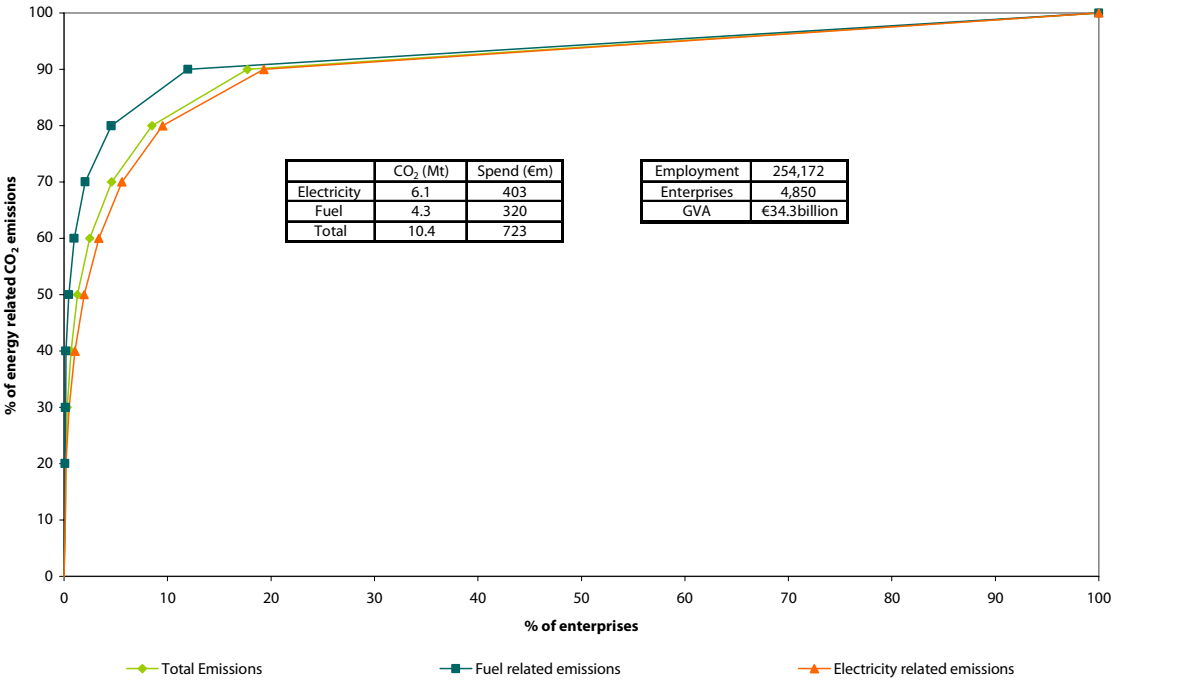
The results relating to a corresponding analysis for energy consumption, as distinct from CO_2 emissions, are presented separately in the accompanying Annex to this report.

[26] The energy-related CO_2 emissions shown here are calculated based on the anonymised individual enterprise data (2001) giving a total of 10.4 Mt. The earlier analysis of published subsectoral data (2001) from CSO gave the estimated energy-related CO_2 as 10.7 Mt. The difference arises because it was not possible to exclude some enterprises from the published data that may be in the transformation sector. In either case the figures are estimates and should not be taken as absolutes.

5.1 Profile of energy CO_2 for all industrial firms

Figure 16 shows the results of the Pareto analysis on CIP data for 2001 applied to the entire industrial sector.

Figure 16: Profile of energy CO_2 in all industry (Pareto analysis) 2001



	CO_2 (Mt)	Spend (€m)
Electricity	6.1	403
Fuel	4.3	320
Total	10.4	723

Employment	254,172
Enterprises	4,850
GVA	€34.3billion

Source: Based on CSO data.

The results are also presented in tabular form in table 1. The ranges in the left hand column represent these percentage bands of total energy-related CO_2 emissions (or in the case of the middle and lower box, percentage of total fuel-related CO_2 and total electricity-related CO_2 respectively). The second column shows the number of enterprises associated with the respective incremental percentage bands. The third column shows the number of enterprises as a cumulative figure, while columns 4 to 6 respectively show the cumulative percentage of firms, the percentage of industry GVA and employment for the band concerned. For example, from 4,850 enterprises in total, 581 enterprises (or 12%) are responsible for 90% of fuel-related CO_2 emissions in industry and thus 4,269 (column 2) enterprises (or 88%) are responsible for the final 10% of electricity-related CO_2 emissions.

The most striking features of figure 16 and table 1 are that, out of 4,850 industrial enterprises:

- A total of 859 firms (18% of the total) were responsible for 90% of industry's energy-related CO_2 in 2001. These companies accounted for 89% of industry GVA and 68% of industrial employment.
- Accordingly, the remaining 3,991 enterprises (82% of the total) accounted for just 10% of industry's energy-related CO_2 emissions.
- Moreover, 412 (or 8.5% of all) enterprises accounted for 80% of industry's energy-related CO_2, 79% of GVA and 52% of industrial employment.
- 60% of emissions are accounted for by 121 enterprises (2.5% of all industrial enterprises). These firms accounted for 57% of industry GVA and 27% of industrial employment.
- Just 15 firms accounted for 30% of energy-related CO_2 and they accounted for 8.5% of industry GVA.

Table 1: Energy CO_2 profiling of industry by individual enterprise (2001)

Total Energy-Related CO_2 Emissions	*Number of Enterprises*	*Cumulative Enterprises*	*Cumulative Enterprises %*	*% of industry GVA*	*% of industry employment*
0-30%	15	15	0.3	8.5%	5.1%
30-40%	18	33	0.7	16.6%	7.4%
40-50%	30	63	1.3	20.7%	5.5%
50-60%	58	121	2.5	10.6%	9.4%
60-70%	102	223	4.6	10.5%	11.0%
70-80%	189	412	8.5	12.2%	13.2%
80-90%	447	859	17.7	9.3%	16.8%
90-100%	3991	4850	100.0	11.5%	31.6%
Fuel-Related CO_2 Emissions	***Number of Enterprises***	***Cumulative Enterprises***	***Cumulative Enterprises %***	***% of industry GVA***	***% of industry employment***
0-40%	9	9	0.2	1.4%	2.9%
40-50%	13	22	0.5	11.9%	2.9%
50-60%	26	48	1.0	18.6%	7.1%
60-70%	51	99	2.0	17.1%	8.5%
70-80%	123	222	4.6	10.1%	12.6%
80-90%	359	581	12.0	15.5%	19.1%
90-100%	4269	4850	100.0	25.4%	46.9%
Electricity-Related CO_2 Emissions	***Number of Enterprises***	***Cumulative Enterprises***	***Cumulative Enterprises %***	***% of industry GVA***	***% of industry employment***
0-20%	10	10	0.2	8.1%	4.5%
20-30%	14	24	0.5	16.5%	6.0%
30-40%	27	51	1.1	12.9%	5.7%
40-50%	43	94	1.9	12.8%	8.3%
50-60%	69	163	3.4	10.1%	8.6%
60-70%	108	271	5.6	11.1%	9.6%
70-80%	192	463	9.5	8.5%	12.2%
80-90%	473	936	19.3	10.7%	15.3%
90-100%	3914	4850	100.0	9.2%	29.9%

Source: Based on CSO data.

The latter two points refer to what are essentially Ireland's highest energy users. A subset of these together with power plants and some service sector entities will be involved in emissions trading from January 2005 (see section 7). While these are large energy users, it cannot be automatically inferred that all will be similarly affected by energy price increases. This will depend on the relative energy sensitivities of individual firms, or how their expenditure on energy compares with profit or total costs (section 6).

Equally, not all enterprises with lower levels of absolute expenditure, and thus in the lower bands, will necessarily have low exposure to energy price changes or other policy measures. Again this depends on their expenditure relative to profit or total costs.

The Pareto profile for the fuel component is steeper than that for the electricity component, as can be seen in figure 16. Fuel consumption in industry is thus concentrated towards a smaller number of firms than is electricity consumption.

This is shown by the fact that:

- Just 9 enterprises accounted for 40% of fuel-related emissions (and just 1.4% of value added), whereas 27 enterprises were responsible for 40% of electricity-related emissions.
- Moreover, 48 firms accounted for 60% of fuel-related emissions (or 2.58 Mt CO_2). These companies represented 32% of industry GVA and 13% of industry employment. These will be required to participate in the EU emissions trading scheme.
- In contrast, 51 firms accounted for 40% of electricity-related emissions (or 2.45 Mt CO_2).
- Similarly, 90% of fuel-related emissions arise from the activities of 581 enterprises (12%) whereas 90% of electricity-related emissions arise from the activities of 936 enterprises (or 19%).

While this gives a picture for industry as a whole, it can be expected that energy price changes and policy measures will affect different sub-sectors in different ways. For this reason, further comparative Pareto analyses were carried out on three sub-sectors of industry.

The selection of these sub-sectors, pharma-chem (NACE 24, 211 firms); food, beverages and tobacco (NACE 15 – 16, 697 firms); and electrical and optical equipment (NACE 30 – 33, 451 firms) was based on two considerations:

- Referring to figure 12, these sub-sectors were the three highest in terms of GVA, and hence contribution to GDP. They accounted for 77% of industry's gross value added (NACE 1-3), 55% of industrial employment and 23% of Ireland's GDP in 2001 (current prices).
- Data on two of these sub-sectors had been interrogated to inform a separate SEI pilot project exploring negotiated energy agreements.

The results from the three sub-sectoral Pareto analyses are contained in the separate accompanying Annex to this document

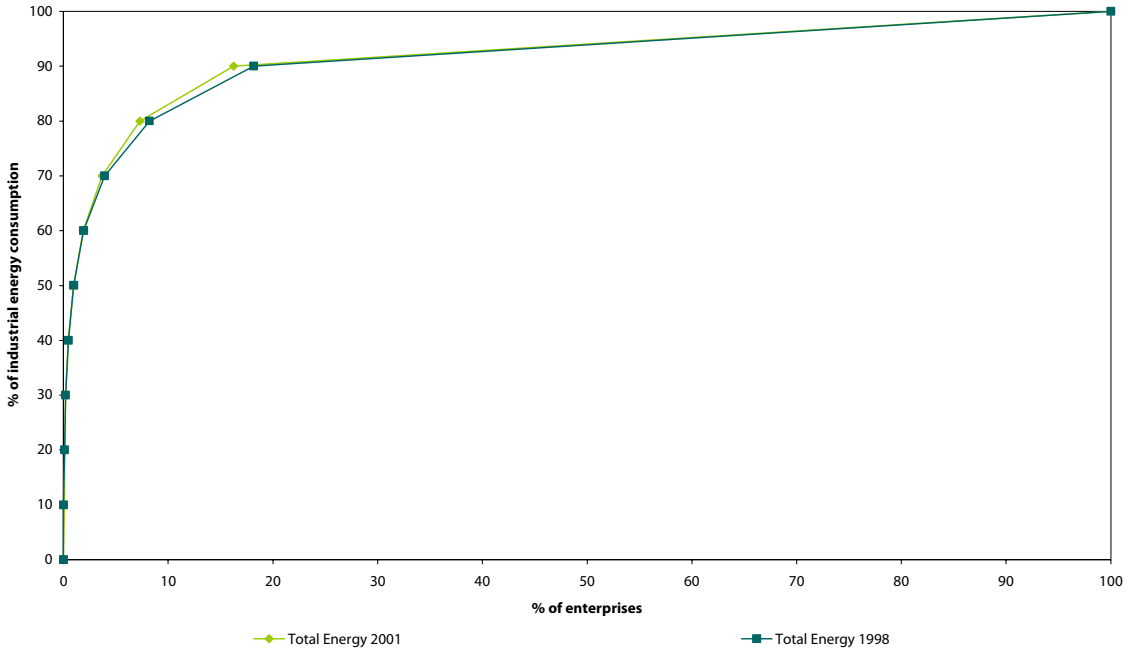
5.2 Change in industrial energy profile

Figure 17 compares the profile of overall energy consumption in industry for 1998 and 2001. The steeper curve for 2001 suggests increased concentration of energy consumption in a small percentage of enterprises.

Just 16% (788) of enterprises accounted for 90% of energy consumption in 2001 compared with 18% (814) enterprises in 1998, demonstrating this increase in concentration of energy consumption.

As previously mentioned, it is anticipated that this situation will have changed since then, as a result of the closure of a number of high energy industrial consumers.

Figure 17: Comparison of 1998 and 2001 industrial energy profiles



Source: Based on CSO data.

6 Sensitivity of enterprises to energy price increases

This section presents the results of a further Pareto analysis applied to a series of ratios. These ratios act as indicators of sensitivity to energy price changes and comprise:

- Energy expenditure relative to direct costs (a measure of a firm's cost base). A high ratio suggests sensitivity in a company's cost base to energy price changes;
- Energy expenditure relative to operating surplus (a measure of a firm's profit). The higher the ratio here, the greater the impact of energy price increase will have on a company's profitability.

It should be noted that these ratios provide an indication of sensitivity based only on direct price change impacts on energy costs. It is hoped that the results presented in this report can be fed into further work exploring also the indirect impacts of energy price changes such as inflationary effects, which in turn impact on energy costs is also important but fall beyond the scope of this analysis. The ratios are applied at the level of the individual firm to the complete industrial base of 4749 enterprises[27] in this section.

Additional analysis was also carried out and is contained in the separate Annex[28] to this report detailing;

- A ratio analysis of energy expenditure relative to GVA (a measure of a firm's value added).
- Ratio analyses of the 352 largest energy consuming firms, accounting for 80% of industrial energy consumption (and somewhat less than 80% of energy-related CO_2);
- Ratio analyses for the smaller energy consumers (or 4397 firms), responsible for the remaining 20% of industrial energy consumption (and somewhat more than 20% of energy-related CO_2 emissions);
- Ratio analyses for the three most significant value adding branches or sub-sectors, viz. Pharma-Chem (210 firms); Food, Beverages & Tobacco (688 firms); and Electronics & Optical (441 firms).

The ratios have been determined for three streams: for all energy purchases, for fuel only and for electricity only.

The relevance of considering fuel costs separately is in the context of it being potentially subject to a price imposition from any carbon energy tax which is confined to taxation of fuels - unless exempt on grounds of being within the EU emissions trading scheme. Based on the information contained in the National Allocation Plan by EPA, approximately 58 industrial enterprises will be involved in emissions trading from January 2005 on the basis of their thermal input capacity being above 20MW.

Similarly, the ratios for electricity costs would be applicable potential price carry through to industrial consumers as a result of power plant participation in the EU emissions trading scheme.

As presented, these ratios should be of assistance to analysts seeking to consider the potential impact of energy cost increases, including those arising from climate change policy instruments, on industry's cost competitiveness. The commentaries, which are by no means exhaustive, are aimed at guiding interpretation of the tables and encouraging further examination.

Note that when comparing 2001 results with 1998 results, some errors were identified in the 1998 energy spend to direct cost ratios that were presented in the 2003 report.[29] The ratio analyses for all industry, large consumers and small consumers was repeated and the corrected results are presented in a separate Annex to this report, so that valid comparisons can be made between 2001 and 1998.

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[27] This number excludes the sectors mentioned in the introduction. The number varies slightly for some of the ratio analyses, as some of the enterprises were excluded if the denominator of the ratio was zero. This avoids divide by zero errors when interrogating the data.

[28] Available at www.sei.ie.

[29] SEI 2003 *Profiling energy consumption and CO_2 emissions in industry – Sensitivity to carbon taxation and emissions trading. Available from www.sei.ie/uploads/documents/upload/publications/Industry_Energy_Profiling_Oct_03.pdf*

6.1 Sensitivity of cost base to energy price changes

The ratios of energy spend to direct costs shows the share of energy expenditure in the expenses incurred by an enterprise in conducting its business. This is a metric that should be well understood in industry and was chosen because any change in the cost of energy would affect an individual enterprise in proportion to the magnitude of the ratio.

The graphs in this section show graphically the data contained in the tables. The horizontal axis shows the cumulative percentage of enterprises in industry ranked from smallest to largest (in terms of the ratio under scrutiny) going from left to right. The green trace plots the ratio of total energy costs to direct costs for each enterprise and the scale for this trace is along the left-hand axis. The other three traces are for cumulative percentage of industrial gross value added (GVA), employment and CO_2 emissions for the corresponding enterprises and are plotted against the right-hand axis.

To assist in interpreting the graphs, a horizontal red dotted line is drawn at a pre-selected ratio of energy expenditure to direct costs ratio. Where this intersects with the green trace (marked on the graph as point 4) a vertical red dotted line is drawn to give the percentages of industrial GVA (marked on the graph as point 1), employment (marked on the graph as point 2) and CO_2 (marked on the graph as point 3) that is accounted for by enterprises with less than or equal to the chosen energy to costs ratio. Approximations of key activity data associated with any chosen ratio can be obtained in a similar manner.

The brief commentaries below relate separately to total energy costs, to fuel costs only (i.e. excluding electricity) and to electricity costs as a ratio of an enterprise's direct costs.

To aid interpretation: Based on the findings of section 8.1 of the 2003 report[30], for a 10% ratio of energy spend to direct costs the typical impact of a carbon energy tax at €20/tCO_2 would be to increase direct costs by 0.7% and 0.4% in the respective cases of larger and smaller energy users. This is the direct impact of price changes and does not take into account indirect affects, such as inflationary effects, associated with a price change.

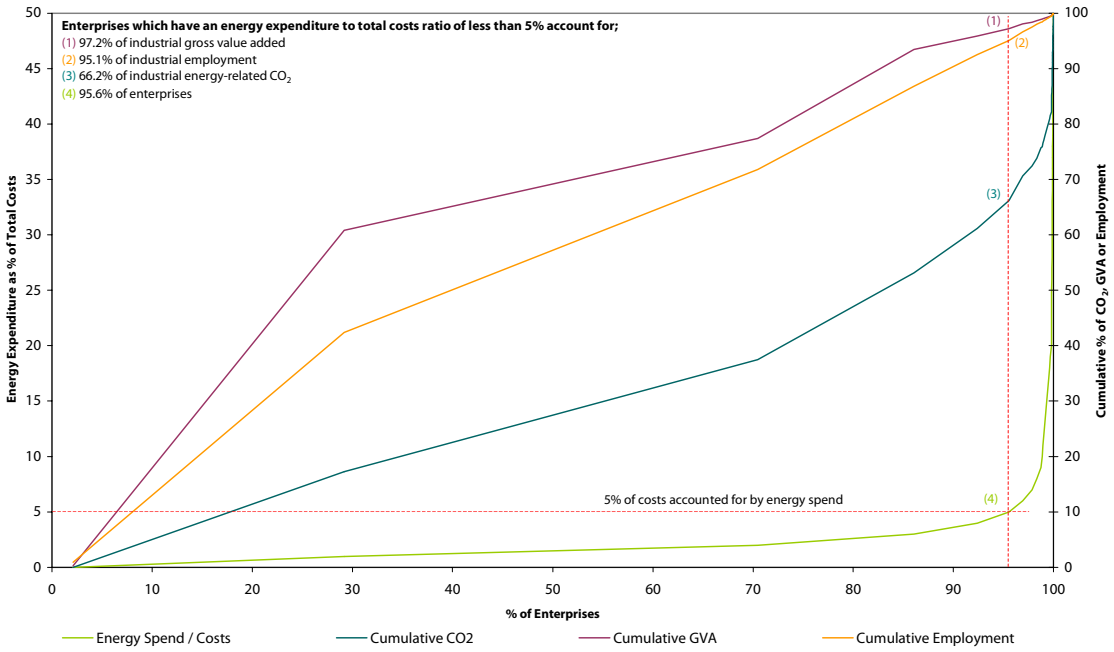
6.1.1 Ratio of total energy expenditure to direct costs

Figure 18 graphs the total energy spend to direct costs against the cumulative percentage of enterprises. The data underpinning figure 18 is presented in table 2. What strikes one immediately is the low share of costs that energy accounts for in the majority of enterprises. 96% (4538) of industrial enterprises spend 5% or less of their direct costs on energy and these enterprises account for 97% of industry's contribution to GDP and 95% of industrial employment.

With regard to industrial energy-related CO_2 emissions these 4538 enterprises only account for 66%. This means that of the remaining 4.4% (211) of enterprises with energy share of costs of greater than 5% some must be very large emitters. Indeed, table 2 shows that just 10 enterprises, with cost ratios in the range 20 – 50%, account for 18% of all industrial energy-related emissions but only account for 0.5% of value added and 0.5% of employment. This small number of enterprises accounted for 15% of industry's energy bill.

[30] SEI 2003 *Profiling energy consumption and CO_2 emissions in industry – Sensitivity to carbon taxation and emissions trading. Available from* www.sei.ie/uploads/documents/upload/publications/Industry_Energy_Profiling_Oct_03.pdf

Figure 18: Total energy expenditure to direct costs ratio analysis (2001)



Source: Based on CSO data.

Regarding the changes in the ratio of energy costs to total costs during the period 1998 and 2001, more enterprises fell into the lower ratio categories in general in 2001 compared with 1998. This would suggest that over the period energy became less significant in the cost structure of industry. Recent fuel price increases will have tended to reverse this trend.

Table 2: Total energy expenditure to direct costs ratio analysis (2001)

		Cumulative Enterprises		% of Total Industry			
Energy Spend / Costs	**No. of Enterprises**	**No.**	**%**	**Energy Spend**	**GVA**	**Employment**	**Energy Related CO_2**
≤ 0	101	101	2.1	0.0%	0.3%	0.9%	0.0%
0 - 1%	1284	1385	29.2	17.7%	60.5%	41.5%	17.3%
1 - 2%	1961	3346	70.5	21.3%	16.6%	29.4%	20.2%
2 - 3%	740	4086	86.0	16.5%	16.1%	15.0%	15.7%
3 - 4%	301	4387	92.4	8.1%	2.4%	5.7%	8.0%
4 - 5%	151	4538	95.6	5.0%	1.3%	2.5%	5.1%
5 - 6%	66	4604	96.9	4.6%	0.9%	1.6%	4.5%
6 - 7%	42	4646	97.8	1.9%	0.3%	0.9%	1.8%
7 - 8%	24	4670	98.3	1.5%	0.3%	0.5%	1.3%
8 - 9%	19	4689	98.7	2.0%	0.3%	0.4%	1.9%
9 - 10%	6	4695	98.9	0.1%	0.0%	0.0%	0.1%
10 - 20%	44	4739	99.8	6.3%	0.6%	1.0%	6.3%
20 - 50%	10	4749	100.0	15.0%	0.5%	0.5%	17.8%

Source: Based on CSO data.

Some further salient points from the full profile of industry in table 2 and shown in figures 18 are:

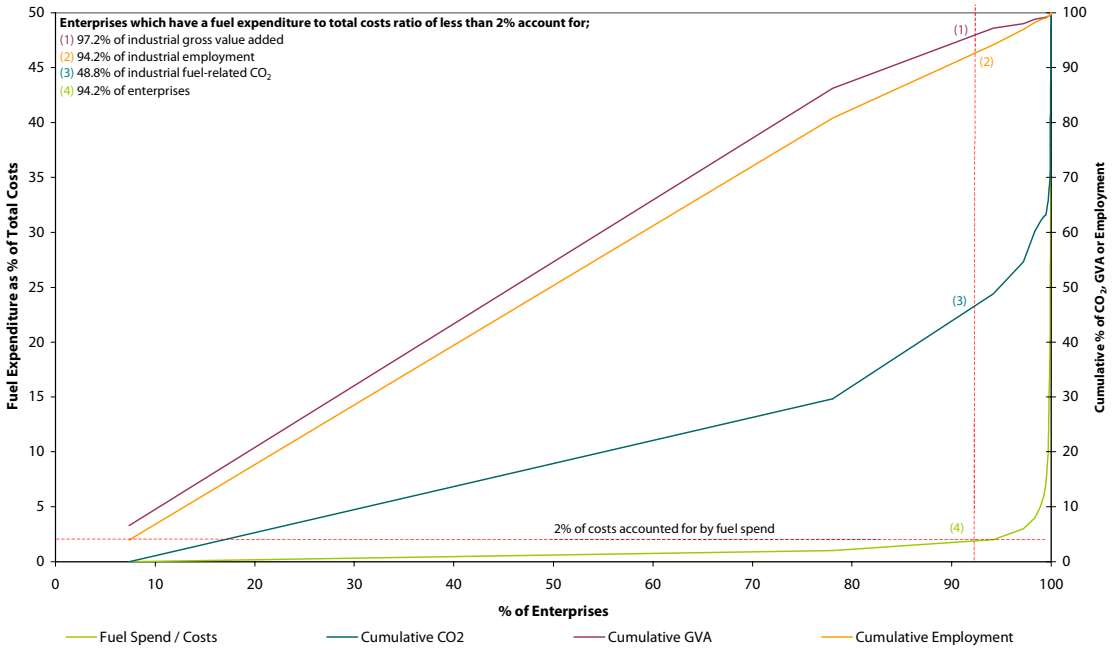
- 61% of industrial GVA was generated by enterprises for which energy costs represented no more than 1% of their direct costs. These 1385 enterprises comprised 29% of all industrial firms, representing 42% of industrial employment and 17% of energy-related CO_2.
- 70% (3346) of all industrial enterprises had an energy to direct costs ratio of less than or equal to 2%. These accounted for 20% of industry energy-related CO_2 emissions, 77% of industrial GVA and 71% of industrial employment.

- 92% (4387) of all industrial enterprises had an energy to direct costs ratio of less than or equal to 4%. These accounted for 61% of industry energy-related CO_2 emissions, 96% of industrial GVA and 92.5% of industrial employment. They also accounted for 64% of total industrial energy costs.
- 99% (4695) of industrial enterprises had a ratio of less than 10%. These accounted for 76% of industry energy CO_2, 99% of industrial GVA and 98% of industrial employment.
- 44 enterprises (0.9%) had ratios between 10% and 20%. This group of enterprises accounted for 6.3% of energy-related CO_2 emitted by all of industry, 0.6% of industrial GVA and 1% of industrial employment.
- It is interesting that the 54 firms with the highest ratio (>10%) do not include all of the 15 largest energy consuming firms highlighted in table 1 (This is clear from the GVA and employment figures). This bears out the earlier suggestion that high energy consumption in absolute terms does not in itself connote high sensitivity to energy price changes. Confidentiality constraints prevent further elaboration on the profile for these firms.
- For no firm did energy expenditure represent more than 50% of direct costs.

6.1.2 Ratio of fuel bill to direct costs

Figure 19 and table 3 present the results for the ratio of fuel costs to direct costs, which points to sensitivity to fuel price changes resulting from emissions trading for the larger fuel consumers and/or fuel price changes for all industrial consumers. This analysis also provides indications of sensitivity to fuel price changes associated with non-policy measures, such as the recent oil and gas price increases.

Figure 19: Fuel expenditure to direct costs ratio analysis (2001)



Source: Based on CSO data.

Table 3: Fuel expenditure to direct costs ratio analysis (2001)

Fuel Spend / Costs	No. of Enterprises	Cumulative Enterprises No.	Cumulative Enterprises %	% of Total Industry Fuel Spend	GVA	Employment	Fuel Related CO_2
≤ 0	350	350	7.4	0.0%	6.6%	4.0%	0.0%
0 - 1%	3357	3707	78.1	33.1%	79.6%	76.9%	29.6%
1 - 2%	766	4473	94.2	21.7%	11.0%	13.3%	19.2%
2 - 3%	144	4617	97.2	6.3%	0.8%	2.8%	5.8%
3 - 4%	54	4671	98.4	5.5%	0.8%	1.3%	5.6%
4 - 5%	26	4697	98.9	2.1%	0.2%	0.5%	1.7%
5 - 6%	17	4714	99.3	1.1%	0.1%	0.2%	0.9%
6 - 7%	10	4724	99.5	0.3%	0.0%	0.1%	0.2%
7 - 10%	11	4735	99.7	2.7%	0.2%	0.4%	2.8%
10 - 40%	14	4749	100.0	27.2%	0.6%	0.7%	34.1%

Source: Based on CSO data.

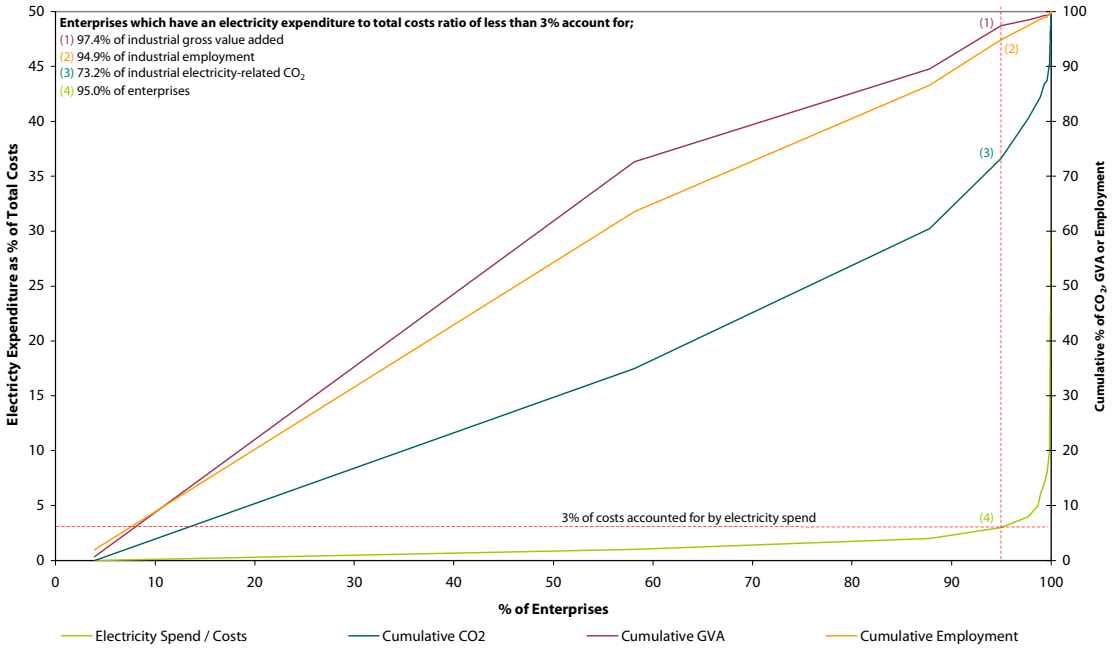
The key features of figure 19 and table 3 are:

- The profile is even more pronounced, as indicated by the shape of the green trace in figure 19 compared with that in figure 18. More than 98% of enterprises spent less than 4% of their direct costs on fuel in 2001, accounting for 60% of industry's fuel-related CO_2 emissions.
- 94% of enterprises have a share of fuel costs in total costs of less than 2%. These enterprises accounted for 97% of industrial value added, 94% of industrial employment but only 49% of industrial fuel-related CO_2 emissions.
- The fuel-related CO_2 emissions trace is lower than the energy-related emissions trace (figure 18), indicating the higher concentration of fuel-related emissions among a smaller number of enterprises.
- 86% of industrial GVA was generated by enterprises for which fuel costs represented no more than 1% of their direct costs. These represented 81% of industrial employment and 30% of fuel-related CO_2.
- No enterprise spent more than 40% of its direct costs on fuel.
- For 14 firms the ratio of fuel spend to direct costs was over 10%. These firms accounted for 34% of fuel-related CO_2, but just 0.6% of industrial GVA and 0.7% of industrial employment. Comparison with table 1 shows that these firms with the highest sensitivity do not include all of the 9 largest fuel consumers in 2001 (comparing GVA and employment figures).

6.1.3 Ratio of electricity bill to direct costs

Figure 20 and table 4 present the results for the ratio of electricity costs to direct costs, assessing sensitivity to electricity price changes associated with power plant participation in emissions trading and other price changes, including those associated with the changing cost of oil, gas and coal.

Figure 20: Electricity expenditure to direct costs ratio analysis (2001)



Source: Based on CSO data.

Table 4: Electricity expenditure to direct costs ratio analysis (2001)

Electricity Spend / Costs	No. of Enterprises	Cumulative Enterprises No.	Cumulative Enterprises %	% of Total Industry Electricity Spend	GVA	Employment	Electricity Related CO_2
≤ 0	186	186	3.9	0.0%	0.7%	1.9%	0.0%
0 - 1%	2576	2762	58.2	35.4%	72.0%	61.6%	35.0%
1 - 2%	1407	4169	87.8	26.1%	16.9%	23.1%	25.5%
2 - 3%	340	4509	94.9	12.7%	7.9%	8.3%	12.7%
3 - 4%	131	4640	97.7	7.1%	1.0%	2.6%	7.3%
4 - 5%	47	4687	98.7	3.2%	0.5%	1.0%	3.2%
5 - 6%	11	4698	98.9	0.7%	0.1%	0.2%	0.7%
6 - 7%	18	4716	99.3	2.3%	0.2%	0.3%	2.3%
7 - 8%	13	4729	99.6	0.7%	0.1%	0.1%	0.7%
8 - 10%	12	4741	99.8	3.0%	0.2%	0.5%	3.2%
10 - 30%	8	4749	100.0	8.9%	0.5%	0.5%	9.3%

The key features of figure 20 and table 4 are

- 98% of industrial value added was generated by enterprises whose electricity bill represented less than 3% of their direct costs. These enterprises accounted for 95% of industrial employment and 73% of electricity-related CO_2 emissions.
- 62 firms had a ratio to direct costs in excess of 5%, representing 16% of electricity- related CO_2, 1.1% of industrial GVA and 1.6% of industrial employment.
- It would nevertheless appear that the energy cost sensitivity of the group identified above is more associated with fuel than with electricity usage. This is indicated by the fact that the 52 firms in the high (5 – 40%) category of the fuel spend ratios accounted for approximately 38% of fuel CO_2 whereas the 60 firms in the high (5 – 30%) category of the electricity spend ratios accounted for 19% of the relevant emissions.

6.2 Sensitivity of profit base to energy price changes

This section relates levels of expenditure on energy with the profitability of the individual enterprise. Operating surplus (OS), defined as gross value added minus labour costs, is presented as a proxy for profits and the terms are used interchangeably throughout.

The assumption here is that increases in energy costs will impact on operating surplus or profit. The relative magnitude of energy expenditure and operating surplus should provide an indication of the sensitivity of enterprises' profit base to changes in their energy costs.

To aid interpretation: Based on the findings of section 8.1 of the 2003 report[31], for a 30% ratio of energy spend to operating surplus the typical impact of a carbon energy tax at €20/tCO_2 would be to proportionately reduce OS by 2.1% and 1.2% in the respective cases of larger and smaller energy users. This is the direct impact of price changes and does not take into account indirect affects, such as inflationary effects, associated with a price change.

6.2.1 Ratio of total energy bill to profit

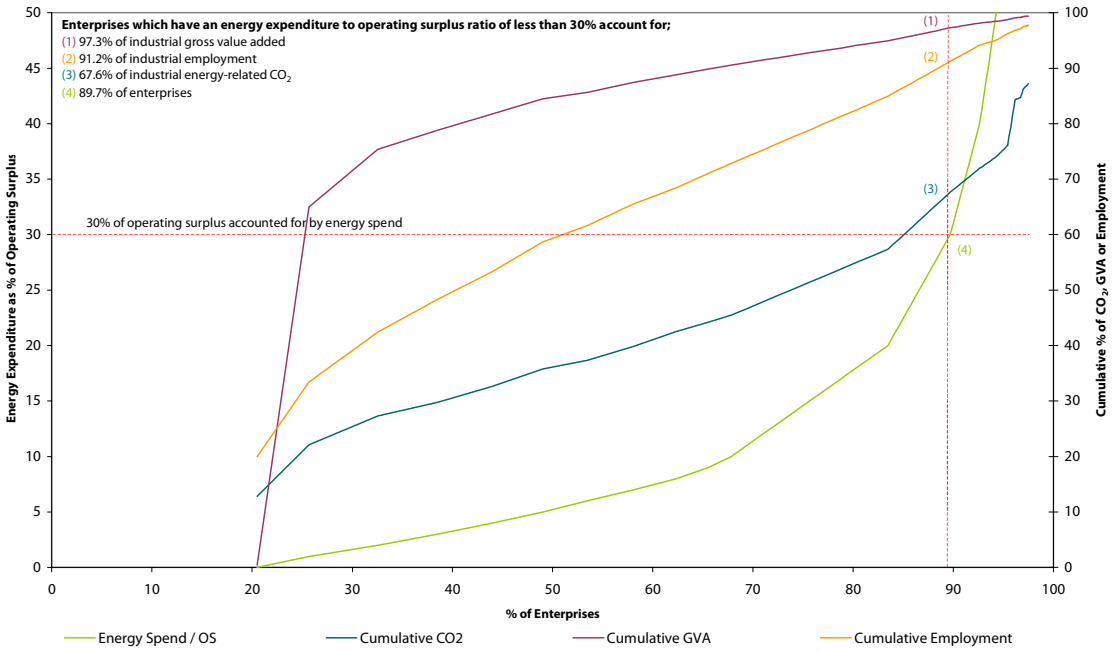
The graphs in this section relate to the data contained in the tables. The x-axis shows the cumulative percentage of enterprises in industry ranked from smallest to largest (in terms of the ratio under scrutiny) going from left to right. The green trace plots the ratio of total energy costs to operating surplus for each enterprise and the scale for this trace is along the left-hand axis. The other three traces are for cumulative percentage of industrial gross value added (GVA), employment and CO_2 emissions for the corresponding enterprises and are plotted against the right-hand axis.

To assist in interpreting the graphs, a horizontal red dotted line is drawn at a pre-selected ratio of energy expenditure to direct costs ratio. Where this intersects with the green trace (marked on the graph as point 4) a vertical red dotted line is drawn to give the percentages of industrial GVA (marked on the graph as point 1), employment (marked on the graph as point 2) and CO_2 (marked on the graph as point 3) that is accounted for by enterprises with less than or equal to the chosen energy to costs ratio. Approximations of key activity data associated with any chosen ratio can be obtained in a similar manner.

As in section 6.1, the ratios relating to the total energy bill and its individual components (namely the fuel bill and the electricity bill) are each examined separately. Figure 21 shows the results for the ratio of total energy expenditure to profit and the results are tabulated in table 5.

[31] SEI 2003 *Profiling energy consumption and CO_2 emissions in industry – Sensitivity to carbon taxation and emissions trading. Available from* www.sei.ie/uploads/documents/upload/publications/Industry_Energy_Profiling_Oct_03.pdf

Figure 21: Total energy costs to operating surplus ratio analysis (2001)



Source: Based on CSO data.

Table 5: Energy expenditure to operating surplus ratio analysis (2001)

Energy Spend / OS	No. of Enterprises	Cumulative Enterprises		% of Total Industry			
		No.	%	Energy Spend	GVA	Employment	Energy Related CO_2
≤ 0	974	974	20.5	13.0%	0.4%	20.0%	12.8%
0 - 1%	245	1219	25.7	9.3%	64.6%	13.4%	9.3%
1 - 2%	326	1545	32.5	5.7%	10.4%	9.0%	5.2%
2 - 3%	285	1830	38.5	2.5%	3.5%	5.9%	2.4%
3 - 4%	256	2086	43.9	2.9%	2.9%	5.0%	2.9%
4 - 5%	242	2328	49.0	3.4%	2.7%	5.4%	3.2%
5 - 6%	211	2539	53.5	1.6%	1.2%	2.9%	1.5%
6 - 7%	218	2757	58.1	2.7%	1.8%	3.9%	2.5%
7 - 8%	204	2961	62.3	2.7%	1.4%	2.9%	2.7%
8 - 9%	152	3113	65.6	1.8%	1.0%	2.6%	1.7%
9 - 10%	108	3221	67.8	1.4%	0.7%	1.8%	1.2%
10 - 20%	743	3964	83.5	12.2%	4.4%	12.1%	11.9%
20 - 30%	295	4259	89.7	10.5%	2.3%	6.3%	10.3%
30 - 40%	140	4399	92.6	4.3%	0.9%	2.9%	4.3%
40 - 50%	79	4478	94.3	2.3%	0.3%	0.9%	2.1%
50 - 60%	54	4532	95.4	2.0%	0.3%	1.2%	2.0%
60 - 70%	35	4567	96.2	6.3%	0.3%	0.6%	8.2%
70 - 80%	26	4593	96.7	0.4%	0.1%	0.3%	0.4%
80 - 90%	13	4606	97.0	1.9%	0.2%	0.3%	1.5%
90 - 100%	24	4630	97.5	0.8%	0.1%	0.2%	1.0%
>100%	119	4749	100.0	12.4%	0.6%	2.3%	12.8%

Source: Based on CSO data.

Some salient points from the full profile of industry in table 5 and shown in figure 21 are:

- 68% (3221) of industrial enterprises had an energy bill to OS ratio of less than or equal to 10%. This accounted for 45% of industry energy CO_2 (primary basis), 91% of industrial GVA and 73% of industrial employment.
- Approximately 83% of industrial firms had a ratio of less than 20%.

- 65% of industrial GVA was generated by companies for which energy expenditure was less than 1% of OS.
- 97% (4630) of industrial enterprises had a ratio of energy expenditure to OS of less than or equal to 100%. They accounted for 87% of industry energy CO_2, 99% of industrial GVA and 98% of industrial employment.
- A significant number of enterprises, 119 (2.5% of firms), had a ratio greater than 100%, i.e. energy costs exceeded OS. These enterprises in aggregate were large CO_2 emitters, accounting for just less than 13% of industry energy-related CO_2 emissions, but just 0.6% of industrial GVA and 2.3% of industrial employment.

A ratio of 100% or more does not imply that an enterprise is not profitable. It does indicate however, that increases in energy costs will have a significant impact on operating surplus or profits.

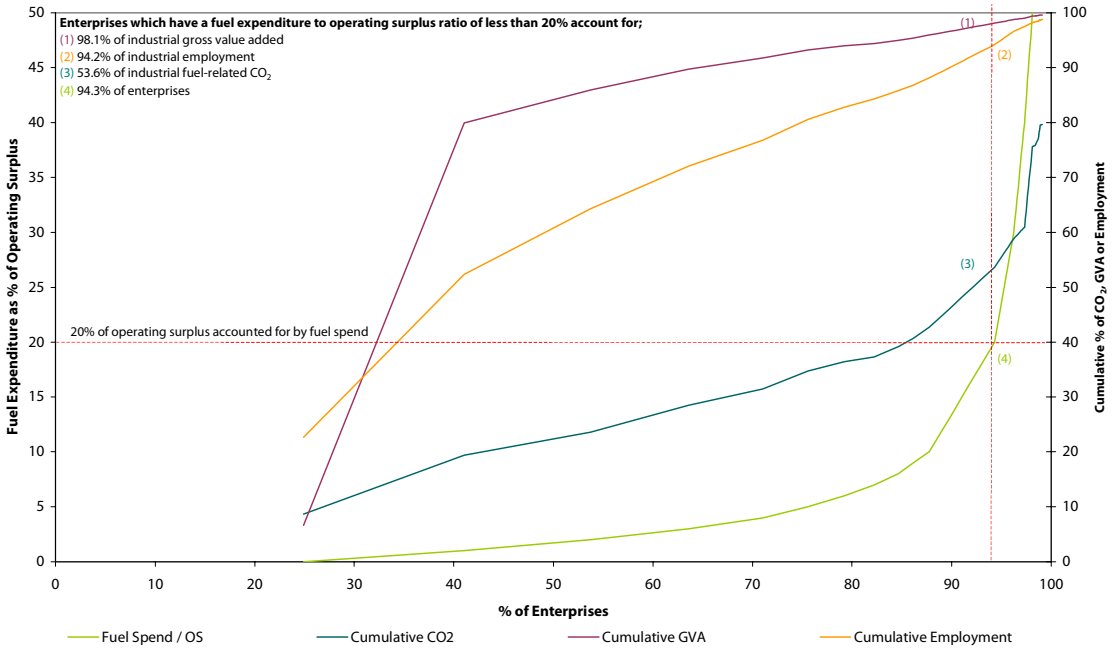
Comment is in order on the zero or negative ratios in table 5. It is seen that 974 firms (21%) have a negative or zero ratio in respect of overall energy costs (the top box). This reflects a negative or zero OS for such firms, which represented 0.4% of GVA, 20% of industrial employment and 13% of industry's energy CO_2 in 2001. The very low proportion of (net) GVA in this band explains the negative OS, since OS is defined as GVA less labour costs.

At face value, these figures would be a cause for concern in terms of vulnerability of employment. However there is no evidence to suggest an association between the low profitability and energy expenditure. Such firms were slightly below average in level of energy usage.

6.2.2 Ratio of fuel bill to profit

Figure 22 presents the analysis of the ratios of fuel bill to operating surplus and table 6 tabulates the results.

Figure 22: Fuel expenditure to operating surplus ratio analysis (2001)



Source: Based on CSO data.

Table 6: Fuel expenditure to operating surplus ratio analysis (2001)

Fuel Spend / OS	No. of Enterprises	Cumulative Enterprises		% of Total Industry			
		No.	%	Fuel Spend	GVA	Employment	Fuel Related CO_2
≤ 0	1183	1183	24.9	9.8%	6.6%	22.6%	8.6%
0 - 1%	765	1948	41.0	12.5%	73.3%	29.7%	10.8%
1 - 2%	604	2552	53.7	5.1%	6.0%	12.0%	4.2%
2 - 3%	468	3020	63.6	5.6%	3.8%	7.7%	4.9%
3 - 4%	354	3374	71.0	3.5%	2.0%	4.7%	3.0%
4 - 5%	216	3590	75.6	3.2%	1.5%	3.8%	3.2%
5 - 6%	172	3762	79.2	1.9%	0.7%	2.2%	1.8%
6 - 7%	144	3906	82.2	1.2%	0.4%	1.5%	0.9%
7 - 8%	113	4019	84.6	2.1%	0.6%	1.5%	1.9%
8 - 9%	73	4092	86.2	1.7%	0.4%	1.0%	1.5%
9 - 10%	76	4168	87.8	2.3%	0.6%	1.3%	2.0%
10 - 20%	311	4479	94.3	11.1%	2.1%	6.1%	10.9%
20 - 30%	92	4571	96.3	5.2%	0.7%	2.4%	5.2%
30 - 40%	51	4622	97.3	2.2%	0.2%	0.8%	2.1%
40 - 50%	38	4660	98.1	9.8%	0.4%	0.8%	14.7%
50 - 60%	14	4674	98.4	0.3%	0.0%	0.1%	0.3%
60 - 70%	14	4688	98.7	0.8%	0.0%	0.2%	1.2%
70 - 90%	9	4697	98.9	2.9%	0.1%	0.2%	2.5%
90 - 100%	10	4707	99.1	0.2%	0.0%	0.1%	0.1%
>100%	42	4749	100.0	18.4%	0.4%	1.2%	20.4%

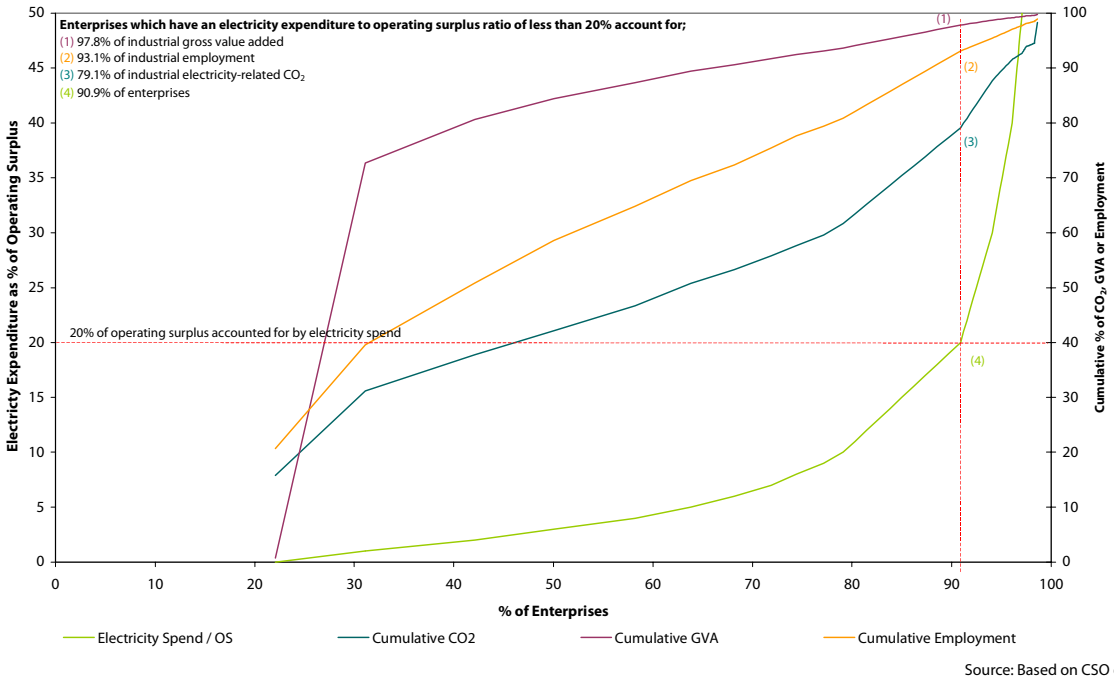
Source: Based on CSO data.

In the case of up to 42 of these firms, expenditure on fuel alone exceeded OS. These firms represented less than 0.4% of GVA, 1.2% of industrial employment, 18% of fuel expenditure and 20% of fuel-related CO_2 for industry in 2001.

6.2.3 Ratio of electricity bill to profit

Figure 23 presents the analysis of the ratios of electricity bill to operating surplus and table 7 tabulates the results.

Figure 23: Electricity expenditure to operating surplus ratio analysis (2001)



Source: Based on CSO data.

Table 7: Electricity expenditure to operating surplus ratio analysis (2001)

Electricity Spend / OS	No. of Enterprises	Cumulative Enterprises		% of Total Industry			
		No.	%	Electricity Spend	GVA	Employment	Electricity Related CO_2
≤ 0	1048	1048	22.1	15.6%	0.8%	20.7%	15.8%
0 - 1%	429	1477	31.1	15.4%	71.9%	18.9%	15.4%
1 - 2%	523	2000	42.1	6.7%	8.0%	11.3%	6.6%
2 - 3%	376	2376	50.0	4.4%	3.8%	7.8%	4.4%
3 - 4%	389	2765	58.2	4.6%	2.9%	6.2%	4.5%
4 - 5%	265	3030	63.8	4.1%	2.1%	4.7%	4.1%
5 - 6%	208	3238	68.2	2.5%	1.1%	2.8%	2.5%
6 - 7%	176	3414	71.9	2.6%	1.1%	3.1%	2.5%
7 - 8%	121	3535	74.4	1.9%	0.7%	2.3%	1.9%
8 - 9%	128	3663	77.1	2.0%	0.6%	1.7%	1.9%
9 - 10%	94	3757	79.1	2.2%	0.6%	1.4%	2.1%
10 - 20%	560	4317	90.9	17.6%	4.2%	12.3%	17.4%
20 - 30%	151	4468	94.1	8.1%	0.9%	2.3%	8.6%
30 - 40%	95	4563	96.1	3.9%	0.5%	1.6%	3.9%
40 - 50%	47	4610	97.1	1.2%	0.2%	0.7%	1.1%
50 - 60%	21	4631	97.5	1.2%	0.1%	0.4%	1.2%
60 - 70%	15	4646	97.8	0.2%	0.0%	0.1%	0.2%
70 - 80%	18	4664	98.2	0.3%	0.0%	0.2%	0.3%
80 - 90%	5	4669	98.3	0.1%	0.0%	0.1%	0.1%
90 - 100%	15	4684	98.6	3.8%	0.2%	0.4%	3.8%
>100%	65	4749	100.0	1.8%	0.2%	1.1%	1.7%

Source: Based on CSO data.

In the case of up to 65 of these firms, expenditure on electricity alone exceeded OS. These firms represented less than 0.2% of GVA, 1.1% of industrial employment, 1.8% of electricity expenditure and 1.7% of electricity-related CO_2 for industry in 2001.

With reference to table 6 above, the 1183 firms having a zero or negative ratio of fuel costs to OS can be attributed to the fact that several firms may have a zero or negative "fuel" spend either because of self supply (e.g. wood waste) or, more likely, because their sole energy source is electricity.

In respect of the electricity costs, it is seen that 1048 more firms had zero or negative ratios than was the case with ratios in respect of total energy costs. This may reflect the use of combined heat and power with the power generation component being on average for the firm's own use or a net electricity exporter.

6.3 Analysis of enterprises most sensitive to energy price change

The ratios presented in sections 6.1 and 6.2 provide useful insights into the sensitivity of individual enterprises to changes in energy prices. The enterprises that are most likely to be adversely affected by increasing energy prices are those with a high energy bill to direct costs and energy bill to profit ratio. This section presents additional analysis of these more highly sensitive enterprises.

For the purposes of establishing a threshold for the analysis, only those enterprises with an energy bill to costs ratios greater than 8% and an energy bill to profits ratios greater than 50% were considered. These thresholds appear to act as a reasonable cut-off for analysis of the most sensitive enterprises.

A summary of the results is presented in table 8. Confidentiality constraints do not allow further disaggregation or the presentation separately of fuel and electricity data for this analysis. In each table section, the enterprises are ranked in terms of increasing bill to total costs ratio and then grouped in appropriate bands. The bands are shown in the left hand column and the number of enterprises in each in the second column. Taking the first row as an

example, there were 7 enterprises with an energy bill to profit ratio greater than 50% and whose energy bill represented between 8% and 10% of their direct costs.

The third and fourth columns show the range and average 'bill to profits ratio' for this group of enterprises. Taking the first row again as an example, this shows that for the 7 enterprises with an energy bill to direct costs ratio of between 8% and 10%, a range of energy bill to profits ratio of 50 – 85% and the average was 65%.

The final three columns show the contribution from each band of enterprises to industrial GVA, employment and energy or fuel-related CO_2.

Table 8: Costs Ratio >8% and profits ratio >50%[32]

Energy Spend/Costs	***Frequency***	***Ratio of energy spend to operating surplus (profits)***		***% of industrial***		
		Range	***Average***	***GVA***	***Employment***	***Energy-related CO_2***
8 – 10%	7	50 – 85%	65%	< 0.1%	0.1%	0.5%
10 – 50%	16	50 – 750%	159%	0.6%	0.8%	19.6%

Source: Based on CSO data.

It is clear from table 2 that there were 79 enterprises with energy to costs ratios above 8% and from table 5 that there were 271 enterprises with energy to profits ratios above 50%. Table 8 shows however, that there were only 23 that matched both criteria. Of these 23, only 16 had an energy bill representing more than 10% of their direct costs. The range of energy to profit ratio for these 16 enterprises was 50 to 750% but the average is 159%.

Of these 23 enterprises, there are 16 that have an energy bill to costs ratios of between 10 and 50%. These enterprises account for a significant 20% of industrial energy-related CO_2 but are insignificant in terms of contribution to industrial economic output and employment representing 0.6% and 0.8% of each respectively.

[32] Note that the ranges given for ratios of energy and fuel to costs and operating surplus are beyond the maximum and minimum values.

7 EU emissions trading: potential industry participation

The 2003 report[33] estimated that 46 sites (associated with 42 enterprises) would have a rated thermal input exceeding 20 MW and therefore be included in the EU Emissions Trading Scheme under Directive 2003/87/EC.

The estimated number of sites was derived from energy data (based on energy expenditure data in the 1998 CIP and using fuel prices by sub-sector) together with estimates of a) annual hours of operation and b) load factors of plant utilisation. Three separate scenarios were considered, each showing different load factors and utilisation hours resulting in three estimates for the number of enterprises likely to participate in the scheme

- scenario 1 – plant utilisation 24x7x48; load factor 60% - 24 enterprises
- scenario 2 – plant utilisation 18x6x48; load factor 60% - 42 enterprises
- scenario 3 – plant utilisation 18x6x48; load factor 45% - 58 enterprises

Analysis of the EPA's National Allocation Plan (NAP)[34] shows GHG permits were issued to 80 sites in the industrial sector under the 20 MW thermal input criterion. These sites represented 57 enterprises, suggesting scenario 3 best represents the average plant utilisation and load factor parameters. It should be pointed out that this SEI analysis was based on 1998 data whereas the NAP referred to average emissions in 2002 and 2003. It does however provide a degree of confidence in choosing a load factor to be used for subsequent analysis for the purpose of estimating the captured emissions.

The 2003 report also indicated that other sites would also be included in emissions trading: the thermal power plants, a number of public service sites (universities and hospitals) and other sites of enterprises in the industrial sector that are included based on activity (production of cement clinker, glass manufacturing and ceramic products). The report concluded that the energy-related emissions from sites included in emissions trading would total approximately 19 Mt CO_2. The total NAP figure for 2000 was 20 Mt although this includes non energy-related emissions.

The effective load factor refers to the equivalent average percentage of time that the full installed capacity is running. Comparing the 2003 report with the NAP suggests that the effective load factor of the thermal plant of the largest energy consumers in industry is less than 30%. Some of the reasons for this might be enterprises having spare capacity in terms of cold and hot standby plant or the capacity of the running plant might have been over specified resulting in it running on part load. In any case there may be scope for improving efficiency by increasing load factor.

7.1 Thermal capacity profile scenario analysis

For this report the analysis was repeated on the 2001 CIP data. The same three load factor and plant utilisation scenarios were assessed as for the 1998 data and the results are presented in table 9.

This shows the capacity ranges with the estimated number of enterprises within these ranges, and their corresponding annual thermal energy consumption, in MWh. For information, the proportion of thermal capacity accounted for by natural gas is given and the corresponding electricity consumption (for comparison only) of each cohort is shown. The final three columns give an estimate of the associated CO_2 emissions, both thermal and (again for comparison only) electricity (on a primary energy basis).

[33] SEI 2003 *Profiling energy consumption and CO_2 emissions in industry – Sensitivity to carbon taxation and emissions trading. Available from* www.sei.ie/uploads/documents/upload/publications/Industry_Energy_Profiling_Oct_03.pdf

[34] EPA 2004 *Ireland's National Allocation Plan 2005 – 2007 – as notified to the Commission 31 March 2004* available from http://www.epa.ie/Licensing/EmissionsTrading/FirstDraftoftheNationalAllocationPlan/FileUpload,39,en.pdf

Table 9: Results from scenario analysis of thermal input capacities 2001

Scenario 1

24x7x48 with 60% Load Factor			(Effective Load Factor 55%)				
Thermal input capacity	***No. of companies***	***MWh_{TH}***	***of which Gas***	***Elec (MWh)***	***Total $ktCO_2$***	***Fuel $ktCO_2$***	***Elec $ktCO_2$***
>20MW	24	8,311,198	2,280,980	1,692,607	3,485	2,175	1,310
15-20MW	9	732,356	398,762	206,148	330	170	160
10-15MW	22	1,279,856	410,595	728,260	874	311	564

Scenario 2

18x6x48 with 60% Load Factor			(Effective Load Factor 36%)				
Thermal input capacity	***No. of companies***	***MWh_{TH}***	***of which Gas***	***Elec (MWh)***	***Total $ktCO_2$***	***Fuel $ktCO_2$***	***Elec $ktCO_2$***
>20MW	38	9,398,366	2,790,512	2,168,718	4,111	2,433	1,679
15-20MW	19	1,020,905	347,485	505,387	637	246	391
10-15MW	21	782,396	352,087	273,849	401	189	212

Scenario 3

18x6x48 with 45% Load Factor			(Effective Load Factor 27%)				
Thermal input capacity	***No. of companies***	***MWh_{TH}***	***of which Gas***	***Elec (MWh)***	***Total $ktCO_2$***	***Fuel $ktCO_2$***	***Elec $ktCO_2$***
>20MW	57	10,419,271	3,137,997	2,674,105	4,748	2,679	2,070
15-20MW	14	554,411	238,413	202,687	293	136	157
10-15MW	28	796,206	327,380	291,632	415	190	226

Source: Based on CSO data.

These tables refer to Industry (excluding transformation sectors of electricity and oil refining).

MWh_{TH} is the non electricity fuel consumption for each criterion.

The electricity column shows the related electrical consumption for each criterion.

Note also that this analysis refers to "enterprises" and not sites.

Scenario 3 again provides the closest indication of the number of industrial enterprises in industry that will be involved in emissions trading based on the thermal input criterion, in this case matching the number of enterprises within the NAP.

As emissions trading relates to thermal energy consumed on-site then the quantity of CO_2 emissions captured by the scheme within industry is 2.68 Mt CO_2. This represents 62% of industry's fuel-related CO_2.

The level of emissions from installations above 20 MW rated thermal output will have since fallen from the above estimated level in absolute terms, owing to the closures of three major plants since 2001. It is therefore assumed that fuel-related CO_2 emissions from this category of installations are likely to have fallen to a level below 60% of the total for industry as a whole.

8 Conclusions and next steps

This report is presented as a discussion document, acting as a window to further exploration rather than providing a set of answers to certain questions relating to current climate change policy options for application in industry.

It provides an update and extension of the analysis published in 2003 (based on 1998 data), using more recently available (2001) data. The next CIP containing questions on energy expenditure by fuel will contain 2004 data and this analysis will be updated when that data becomes available (possibly during 2006).

The report presents new data and perspectives on the aspects of Ireland's industrial energy consumption, costs and CO_2 emissions that it addresses. This information is intended to facilitate others in carrying out further energy and economic analyses, in particular evaluating the potential impacts of energy price increases, including policy instruments such as carbon energy tax and emissions trading, on industrial competitiveness.

Comments from the energy, environment, enterprise and economic policy community are most welcome.

SEI gratefully acknowledges the co-operation of the CSO in providing access to the anonymised source data that made this analysis possible.

9 Data Sources

Central Statistics Office, Skehard Road, Cork.

Department of Communications, Marine and Natural Resources, Dublin.

Environmental Protection Agency, Johnstown Castle Estate, Wexford.

Eurostat, Luxembourg.

10 Glossary of Terms

Carbon Dioxide (CO_2): A compound of carbon and oxygen formed when carbon is burned. Carbon dioxide is one of the main greenhouse gases. Units used in this report are *t* CO_2 – tonnes of CO_2, *kt* CO_2 – kilo-tonnes of CO_2 (10^3 tonnes) and *Mt* CO_2 – mega-tonnes of CO_2 (10^6 tonnes).

Carbon Intensity (kg CO_2/kWh): This is the amount of carbon dioxide that will be released per kWh of energy of a given fuel. For most fossil fuels the value of this is constant, however in the case of electricity it will depend on the fuel mix used to generate the electricity and also on the efficiency of the technology employed. Renewable sources of electricity generation, such as hydro and wind, have zero carbon intensity.

Energy Intensity: The amount of energy used per unit of activity. Examples of activity used in this report are gross domestic product (GDP), value added, number of households, employees etc. Where possible, the monetary values used are in constant prices. When this is the case the intensity is displayed as "€xx" where xx is the base year. So for instance in the case of final intensity the units are *kgoe/€95 – kilograms of oil equivalent per euro in constant 1995 prices*.

Energy Units:

joule (J): Joule is the international (S.I.) unit of energy.

kilowatt hour (kWh): The conventional unit of energy that electricity is measured and charged for commercially.

tonne of Oil Equivalent (toe): This is a conventional standardized unit of energy and is defined on the basis of a tonne of oil having a net calorific value of 41686 kJ/kg. A related unit is the *kilogram of oil equivalent (kgoe)*, where 1 kgoe = 10^{-3} toe.

Gross and Net Calorific Value (GCV & NCV): The gross calorific value (GCV) gives the maximum theoretical heat release during combustion, including the heat of condensation of the water vapour produced during combustion. This water is produced by the combustion of the hydrogen in the fuel with oxygen to give H_2O (water). The net calorific value (NCV) excludes this heat of condensation because it cannot be recovered in conventional boilers. For natural gas, the difference between GCV and NCV is about 10%, for oil it is approximately 5%.

Gross Domestic Product: The gross domestic product represents the total output of the economy over a period.

Structural Effect: As it affects energy intensity, structural change is a change in the shares of activity accounted for by the energy consuming sub-sectors within a sector. For instance, in industry the structural effect caused by the change in emphasis of individual sub-sectors such as pharmaceuticals, electronics, textiles, steel etc in their contribution to gross domestic product.

Total Final Consumption (TFC): This is the energy used by the final consuming sectors of industry, transport, residential, agriculture and tertiary. It excludes the energy sector such as electricity generation and oil refining etc.

Total Primary Energy Requirement (TPER): This is the total requirement for all uses of energy, including energy used to transform one energy form to another (eg burning fossil fuel to generate electricity) and energy used by the final consumer.

Value Added: Value added is an economic measure of output. The value added of industry, for instance, is the additional value created by the production process through the application of labour and capital. It is defined as the value of industry's output of goods and services less the value of the intermediate consumptions of goods (raw materials, fuel, etc) and services.

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Sustainable Energy Ireland
Energy Policy Statistical Support Unit
Building 2200
Cork Airport Business Park
Co. Cork
Ireland
t +353 21 454 7050
f +353 21 454 7059
e info@sei.ie
w www.sei.ie

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland
t +353 1 836 9080
f +353 1 837 2848
e info@sei.ie
w www.sei.ie

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